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2019 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee

Data and Evaluations

This document is approved for public release per review by:

Peter J. Kortman	3/13/19
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2019 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee

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Prepared by the
Water Resources Restoration Program
UCOR, an AECOM-led partnership with Jacobs

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ACRONYMS

See Appendix G for listing of conversion factors, units, and chemical and radionuclide names and abbreviations.

AM	Action Memorandum
aMSL	above Mean Sea Level
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
BCBG	Bear Creek Burial Ground
BCK	Bear Creek kilometer
BCV	Bear Creek Valley
BFK	Brushy Fork kilometer
bgs	below ground surface
BMAP	Biological Monitoring and Abatement Program
BORCE	Black Oak Ridge Conservation Easement
BSWTS	Big Spring Water Treatment System
BTEX	benzene, toluene, ethylbenzene, and xylenes
BV	Bethel Valley
BVBG	Bethel Valley Burial Ground
BYBY	Boneyard/Burnyard
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
CMP	Comprehensive Monitoring Plan
CMTS	Central Mercury Treatment System
CNF	Central Neutralization Facility
CNS	Consolidated Nuclear Security, LLC
COC	contaminant of concern
CR	Chestnut Ridge
CRK	Clinch River kilometer
CRM	Clinch River mile
CRSDB	Chestnut Ridge Sediment Disposal Basin
CRSP	Chestnut Ridge Security Pits
CWA	Clean Water Act of 1972
CWTS	Chromium Water Treatment System
CY	calendar year
D&D	decontamination and decommissioning
DARA	Disposal Area Remedial Action
DCS	Derived Concentration Standard
DGT	downgradient trench
DHC	*Dehalococcoides* sp.
DNAPL	dense non-aqueous phase liquid
DOE	U.S. Department of Energy
DOECAP	DOE Consolidated Audit Program
DPT	direct push technology
DQO	data quality objective
DSWM	Division of Solid Waste Management
EC&P	Environmental Compliance and Protection
ECRWP	East Chestnut Ridge Waste Pile
EEVOC	East End Volatile Organic Compound
EFK	East Fork Poplar Creek kilometer

EFPC	East Fork Poplar Creek
ELCR	excess lifetime cancer risk
EM	Environmental Management
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
EPP	excavation/penetration permit
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ESD	Explanation of Significant Differences
ETTP	East Tennessee Technology Park
EU	exposure unit
FCAP	Filled Coal Ash Pond
FCK	First Creek kilometer
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FFA	Federal Facility Agreement
FFK	Fifth Creek kilometer
FS	feasibility study
FY	fiscal year
FYR	Five-Year Review
GHK	Gum Hollow Branch kilometer
GWPP	Groundwater Protection Program
HCDA	Hazardous Chemical Disposal Area
HCK	Hinds Creek kilometer
HI	hazard index
HQ	Hazard Quotient
HRE	Homogeneous Reactor Experiment
IHP	Intermediate Holding Pond
IP	integration point
IPIP	Integrated Performance Indicator Program
IW	interception well
K-25 Site	Oak Ridge Gaseous Diffusion Plant
KHQ	Kerr Hollow Quarry
LEFPC	Lower East Fork Poplar Creek
LGWO	Liquid and Gaseous Waste Operations
LLLW	liquid low-level waste
LLW	low-level waste
LUC	land use control
LUCAP	Land Use Control Assurance Plan
LUCIP	Land Use Control Implementation Plan
LUM	Land Use Manager
LWBR	Lower Watts Bar Reservoir
MBK	Mill Branch kilometer
MBWEIR	Melton Branch Weir
MCK	McCoy Branch kilometer
MCL	maximum contaminant level
MCL-DC	maximum contaminant level derived concentration
MCLG	maximum contaminant level goal
MEK	Melton Branch kilometer
MIK	Mitchell Branch kilometer
M-K	Mann-Kendall
MMS	Moment Magnitude Scale

MSRE	Molten Salt Reactor Experiment
MTF	Mercury Treatment Facility
MV	Melton Valley
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NFA	No Further Action
NNSA	National Nuclear Security Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSC	Non-Significant Change
NT	North Tributary
ORAU	Oak Ridge Associated Universities
OREIS	Oak Ridge Environmental Information System
OREM	Oak Ridge Office of Environmental Management
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Office
ORR	Oak Ridge Reservation
OU	operable unit
PCCR	Phased Construction Completion Report
PCK	Poplar Creek kilometer
PCM	Poplar Creek mile
PCP	Post-Closure Permit
PCR	Post-Construction Report
PEMS	Project Environmental Measurement System
PHK	Pinhook Branch kilometer
PNNL	Pacific Northwest National Laboratory
POC	point-of-compliance
PRG	Preliminary Remediation Goal
PWTC	Process Waste Treatment Complex
QAPP	Quality Assurance Project Plan
RA	remedial action
RAIS	Risk Assessment Information System
RAO	remedial action objective
RAR	Remedial Action Report
RAWP	Remedial Action Work Plan
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act of 1976
RDR	Remedial Design Report
RER	Remediation Effectiveness Report
RI	Remedial Investigation
RmAR	Removal Action Report
RmSE	Removal Site Evaluation
ROD	Record of Decision
S&M	surveillance and maintenance
SAP	sampling and analysis plan
SCF	South Campus Facility
SCR	Scarboro Creek
SDWA	Safe Drinking Water Act of 1974
SE	standard error
SFD	South French Drain
SIOU	Surface Impoundments Operable Unit
SMO	Sample Management Office

SNS	Spallation Neutron Source
SSF	Solids Storage Facility
STP	Sewage Treatment Plant
SWPP	Storm Water Pollution Prevention
SWSA	Solid Waste Storage Area
TDEC	Tennessee Department of Environment and Conservation
TDOT	Tennessee Department of Transportation
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
TRE	Toxicity Reduction Evaluation
TRM	Tennessee River mile
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
UEFPC	Upper East Fork Poplar Creek
UGT	upgradient trench
UNC	United Nuclear Corporation
UT-B	University of Tennessee-Battelle, LLC
UU/UE	unlimited use/unrestricted exposure
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	Waste Area Grouping
WBIWG	Watts Bar Interagency Working Group
WBK	Walker Branch kilometer
WCK	White Oak Creek kilometer
WCWEIR	White Oak Creek Weir
WEMA	West End Mercury Area
WOC	White Oak Creek
WOCE	White Oak Creek Embayment
WOD	White Oak Dam
WOL	White Oak Lake
WP	Work Plan
WRRP	Water Resources Restoration Program
WWSY	White Wing Scrap Yard
Y-12	Y-12 National Security Complex

ACKNOWLEDGEMENTS

Primary tasks of the U.S. Department of Energy (DOE) Oak Ridge Office of Environmental Management (OREM) are contracted to various entities. UCOR, an AECOM-led partnership with Jacobs, conducts environmental cleanup for DOE OREM at sites on the Oak Ridge Reservation (ORR) with Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as the primary regulatory authority and at impacted sites off the reservation (e.g., Lower East Fork Poplar Creek). UCOR implements DOE OREM's Water Resources Restoration Program (WRRP), a comprehensive, integrated environmental monitoring program for the Oak Ridge National Priority List Site, and prepares the annual Remediation Effectiveness Report (RER). Consolidated Nuclear Security, LLC (CNS) operates the Y-12 National Security Complex (Y-12), which manages the production and refurbishment of nuclear weapon components for the DOE National Nuclear Security Administration program. A partnership between the University of Tennessee-Battelle, LLC (UT-B) manages and operates the Oak Ridge National Laboratory (ORNL) for the DOE Office of Science Program.

The UCOR WRRP acknowledges the contributions and efforts of many organizations and individuals on the ORR for providing support in preparation of the 2019 RER, including:

- the Aquatic Ecology Group of the Environmental Sciences Division (UT-B) at ORNL for providing field support, biological data, and technical interpretations included in the biological monitoring sections;
- UT-B's Environmental Protection Services Division;
- the CNS Environmental Compliance Department including the Groundwater Protection Program at Y-12;
- UCOR's Environmental Compliance and Protection organization at East Tennessee Technology Park (ETTP) for providing National Pollution Discharge Elimination System Clean Water Act data; and
- UCOR subcontractor RSI EnTech, LLC sampling and support personnel for their efforts in completing much of the field work for the WRRP monitoring program.

Information used in the RER to verify implementation of land use controls is collected and compiled in conjunction with the UCOR surveillance and maintenance programs, CNS's Liquid Waste Operations at Y-12, and UT-B's Facilities Management Division, as well as UCOR's Radiation Protection Program at ETTP. The Tennessee Valley Authority provided historical sampling results that were used to construct some graphs depicting offsite data.

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EXECUTIVE SUMMARY

Under the requirements of the *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014) established between the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Tennessee Department of Environment and Conservation (TDEC), all environmental restoration activities on the Oak Ridge Reservation (ORR) are performed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). This *2019 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*:

- evaluates the effectiveness, based on environmental media monitoring, of completed remedial actions (RAs) or environmental media removal actions, and
- verifies identified and approved land use controls (LUCs) are implemented for completed actions.

First issued in 1997, the Remediation Effectiveness Report (RER) has been issued annually to update the performance of completed actions. Because most of the completed RAs and environmental media removal actions do not allow unlimited use/unrestricted exposure (UU/UE), these sites require performance monitoring and/or LUCs to protect human health and the environment from physical hazards, residual contamination, and wastes remaining following remediation. Generally, the data reported in the 2019 RER were collected prior to or in fiscal year (FY) 2018.

Remedial decisions on the ORR have been made at the watershed-scale in recognition of surface water being the major pathway for offsite contaminant transport. The overall strategy is tied to the anticipated end use of the area being addressed and ensures that the evaluation considers the cumulative resources needed for cleanup. Initially, single-project actions were performed primarily to mitigate immediate risks and to reduce further migration of contaminants offsite.

The watershed-scale Records of Decision (RODs) contain performance objectives to be met and a series of RAs designed to achieve them. Environmental media monitoring information used to assess performance was compiled by the DOE Oak Ridge Office of Environmental Management (OREM) through the Water Resources Restoration Program (WRRP). The WRRP was established to implement a comprehensive, integrated environmental monitoring and assessment program for the ORR and to minimize duplication of field, analytical, and reporting efforts. Environmental media monitoring includes monitoring of groundwater, surface water, and biota, to assess performance (performance monitoring). Because all planned RAs have not been completed, environmental media monitoring also is used for baseline data assessments (baseline monitoring) of watershed conditions and trends, which are summarized in the RER, as appropriate. Criteria that are not decision document goals are cited as screening levels and are used for comparative purposes only.

The RER reports on monitoring and LUCs by watershed-scale decision area at each of the three major DOE facilities, Oak Ridge National Laboratory (ORNL), Y-12 National Security Complex (Y-12), and East Tennessee Technology Park (ETTP); at areas outside of the ORR and downstream of these facilities that have received contamination over the years; and at other sites located on the ORR. Each RER chapter identifies completed single-project actions and completed watershed-scale actions with performance monitoring or LUCs.

A summary of the effectiveness evaluation is presented below for each chapter. The definition of an RER trackable issue and the issues and recommendations identified from this year's evaluation are summarized in Chapter 1. Issues identified this year and unresolved issues carried forward from a previous RER are summarized in Table 1.2. Issues that are closed in this RER are summarized in Table 1.3. More detailed discussion of the issues and recommendations are in each chapter.

Remedy protectiveness is also assessed and reported every five years in the CERCLA Five-Year Review (FYR). The *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2) includes a compendium of all CERCLA decisions and, as the latest finalized CERCLA FYR, is referenced in this RER. Open and closed issues from the 2016 FYR are included in Table 1.4 and Action Plans based on the 2016 FYR are in Appendix C of this RER.

ORNL – Bethel Valley

The following is a summary of the Bethel Valley (BV) assessment.

The CERCLA actions completed to date in BV include some RA and building decontamination and decommissioning (D&D) projects under the BV Interim ROD (not all remediation activities in the BV Interim ROD have been implemented) and several single-project CERCLA actions.

- Sr-90 at 7500 Bridge weir, the BV watershed integration point (IP), met the ROD goal of 37 pCi/L with an annual average value of 36.7 pCi/L in the continuous, flow-paced composite samples. Consistent with recent years, non-point Sr-90 seepage to White Oak Creek (WOC) and discharges from the Process Waste Treatment Complex (PWTC) were the two main sources contributing Sr-90 to WOC. Ungauged groundwater contamination influxes to WOC may be associated with the former Surface Impoundments Operable Unit (SIOU) and the PWTC.
- The Corehole 8 Extraction System met its performance goal based on Sr-90 flux reduction at First Creek during FY 2018. The system's interception of the Corehole 8 plume was effective at protecting surface water quality in First Creek. At well 4570, which monitors the Corehole 8 plume at about 220 ft below ground surface (bgs), Sr-90 concentrations fluctuated between about 15,000 and 20,000 pCi/L during FY 2018 and U-233/234 concentrations fluctuated between about 1,000 – 1,500 pCi/L. An increasing groundwater concentration trend for Sr-90 and U-233/234 in deep well 4570, following the Tank W-1A excavation, appears to have moderated in the FY 2015 through FY 2018 period.
- Three wells in Solid Waste Storage Area (SWSA) 3 (0482, 0491, and 0492) have chronically not met target groundwater elevations because of either well construction and/or location conditions. These wells are constructed with the majority of their screened intervals extending into bedrock. Since these deeper wells are prone to responding to groundwater levels affected by conditions outside the hydrologic isolation area, they are not good indicators of hydrologic isolation effectiveness. While the target groundwater elevations have not been met in these three wells, the SWSA 3 hydrologic isolation remedy has achieved reduced contaminant discharges into surface water as well as reductions in groundwater contamination in area monitoring wells. Surface water discharges of Sr-90 in Northwest Tributary and Raccoon Creek have decreased significantly as a result of the hydrologic isolation of shallow buried waste at SWSA 3 and the Contractor's Landfill. Groundwater contaminant trend evaluations for the previous 10-year and 5-year periods show that the number of groundwater contaminants that occur at concentrations near or above Primary Drinking Water maximum contaminant levels (MCLs) has decreased since site remediation and the remaining contaminants are decreasing, stable, or indeterminate. While monitoring and reporting of groundwater levels at wells 0482, 0491, and 0492 will continue, it is recommended that for these three wells, alternative performance indicators such as groundwater contaminant trends and contaminant fluxes in Northwest Tributary and Raccoon Creek, be used to evaluate the hydrologic isolation effectiveness at SWSA 3. This is a new issue in this RER and alternative performance indicators will be discussed with the Project Team.

- During FY 2018, a sample collected at the 7500 Bridge in September 2018 had an elevated mercury concentration of 93.5 ng/L. The suspected source of that elevated mercury was discharges from the PWTC which was undergoing construction activities. CERCLA actions at Building 4501 to re-route and pre-treat mercury contaminated building sump water are shown to be effective at reducing mercury concentrations in the receiving reach of WOC. Mercury concentrations measured at WOC-105, located a short distance downstream from the former storm drain discharge from Building 4501, were less than the ambient water quality criteria (AWQC) level in FY 2018 samples.
- Wells 4645, 4646, and 4647 monitor groundwater in the Raccoon Creek headwater area. These exit pathway wells did not contain contaminant concentrations above drinking water criteria in FY 2018. At wells 4645 and 4646, Sr-90 was not detected in FY 2018. At well 4647, the shallowest of these wells, Sr-90 was detected at 0.479 J and 3.02 pCi/L in the December 2017 and June 2018 samples, respectively. Well 4647 is used to sample groundwater from the soil/bedrock interface near Raccoon Creek and has fairly consistently exhibited the presence of Sr-90 at low levels.
- Volatile organic compound (VOC) contaminants in groundwater in the BV 7000 area continue to show benefits of the increased dehalogenating microbial stimulation from the treatability study activities conducted in FY 2011.
- The observed improvement in redbreast sunfish mercury concentrations to levels below the EPA-recommended fish-based AWQC for mercury (0.3 µg/g) continued in WOC, although concentrations in largemouth bass from White Oak Lake (WOL) exceeded the AWQC value in 2018 (the AWQC value is not a ROD goal, but is used as a screening level). Polychlorinated biphenyl (PCB) concentrations remain elevated in redbreast sunfish from WOC, and, like mercury, the highest PCB levels are in largemouth bass from WOL (1.90 µg/g). Biological monitoring of the BV watershed indicates moderate ecological recovery since 1987.

All LUCs in BV specified for protection of the environment and/or human health are in place and have been maintained. Additionally, the *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (BV RAR CMP; DOE/OR/01-2478&D3) was issued November 2016 and identifies LUCs, their objectives, and their verification requirements. The BV RAR CMP serves as the BV Land Use Control Implementation Plan (LUCIP), and, therefore, BV is now included in the certification in Appendix A of this RER.

ORNL – Melton Valley

The following is a summary of the Melton Valley (MV) assessment.

During FY 2018, the annual average of the monthly composite surface water samples at White Oak Dam (WOD) met the *Record of Decision for Interim Actions for the Melton Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (MV Interim ROD; DOE/OR/01-1826&D3) goals; monthly composite samples exceeded the goal at WOD for Sr-90 in June 2018 and for Cs-137 in November 2017 and September 2018. Although WOC contaminant discharges from BV into MV decreased in FY 2018 compared to FY 2017,operational problems at the ORNL PWTC and ungauged Sr-90 discharges in BV contributed to the June monthly composite sample at WOD exceeding the MV Interim ROD goal for Sr-90 as evidenced by the elevated June 2018 Sr-90 concentration at the 7500 Bridge. Tributary water quality monitoring results showed MV Interim ROD goal attainment in the MV tributaries that flow into WOC.

MV Interim ROD groundwater performance evaluation includes groundwater level control within hydrologically isolated units; and water quality evaluation near the Seepage Pits and Trenches, SWSA 6, in the MV onsite groundwater exit pathway wells, and in offsite monitoring wells adjacent to MV. MCL values are used as screening criteria and are not a specified ROD goal.

- Groundwater level control monitoring within the hydrologically isolated waste units during FY 2018 shows that seven of 52 wells used for performance evaluation did not meet their goals. Two of the wells are located in SWSA 6 and the remaining five wells are located in SWSA 4. The wells not meeting the MV Interim ROD goals are RER issues. The status of the RER issues and ongoing activities are as follows:

  — Wells 0955 and 0958, which are located near the SWSA 4 downgradient trench (DGT), have exhibited recurring exceedances of their target groundwater elevations. During FY 2018, six of the 12 monthly groundwater level measurements at well 0955 exceeded the target elevation goal, and three of the four quarterly groundwater level measurements at well 0958 exceeded their target elevation goal. Beginning in late FY 2015, DOE implemented an enhanced frequency of maintenance and operations inspections of the SWSA 4 downgradient groundwater collection trench, which contributes to better overall groundwater level suppression in the collection trench and adjacent areas. Additionally, an on-going hydrologic evaluation to identify potential additional improvements to SWSA 4 DGT performance continued in FY 2018. This evaluation noted several system enhancements for more continuous operation of the pumps in the DGT; this evaluation is ongoing. These actions are expected to lower groundwater elevations at these wells to attain the target elevation. It is also recommended that well 0955 have continuous water level readings to further support system evaluation and performance. This issue for wells 0955 and 0958 is carried forward in this RER.

  — Well 1071 near the western portion of SWSA 4 and wells 4544 and 4545 near the center of the SWSA 4 cap experienced target groundwater elevation exceedances during FY 2018. Well 1071 is screened in bedrock between 784.96 and 800.71 ft above Mean Sea Level (aMSL) and is located approximately 60 ft inside of the upgradient storm diversion drain which has a bottom elevation of approximately 806 ft aMSL. Based on this construction geometry, the upgradient trench (UGT) would not be capable of controlling groundwater from the upslope side of Lagoon Road from affecting the groundwater elevation measured at well 1071. Target groundwater elevation exceedances in wells 4544 and 4545 are thought to be related to either hydrologic isolation cap defects or seepage from the upgradient stormflow diversion trench area. DOE is in the process of evaluating groundwater level control at SWSA 4 and will discuss well performance with the Project Team. The issues associated with these three wells are carried forward in this RER.

  — Two wells in SWSA 6 (4127 and 0850) have chronically not met target groundwater elevations because of well construction or location conditions. Both of these wells are constructed with the majority of their screened intervals extending into bedrock. These deeper wells are prone to responding to groundwater levels affected by conditions outside the hydrologic isolation area such as groundwater recharge in confined to semi-confined zones that extend beneath the waste units. As a result, these wells are not good indicators of hydrologic isolation effectiveness. DOE samples a number of locations along the edge of SWSA 6 to understand changes in groundwater contaminant conditions following MV Interim ROD RA. Three sampling locations (well 0838, the South French Drain (SFD), and surface water location WAG6 MS3) provide definitive evidence that the SWSA 6 hydrologic isolation remedy is effective. While monitoring and reporting of groundwater levels at wells 4127 and 0850 will continue, it is recommended that alternative performance indicators be used to evaluate the hydrologic isolation effectiveness at SWSA 6. These measures include the continued monitoring of tritium concentrations at 0838, SFD, and WAG6 MS3. This issue is carried forward in this RER and alternative performance indicators will be discussed with the Project Team.

- At the Seepage Pits and Trenches, the maximum detected radionuclide concentrations show that in most cases the maximum measured concentrations have decreased over time. Although Tc-99 shows an increasing trend in the most recent 5-year data evaluation for well 1756 in Trench 5, its FY 2018 maximum concentration remained less than the residential 1E-4 Preliminary Remediation Goal (PRG) concentration. The causes for increases in radionuclide concentrations near the grouted seepage trenches is not known although changes in groundwater recharge and flow patterns following the trench grouting and area capping are the probable causes. Surface water sampling in adjacent stream valleys has not detected increases in radionuclide concentrations in the nearby discharge areas.

- Groundwater monitoring at SWSA 6 during FY 2018 shows that VOC concentration trends are consistent with levels measured during the past several years. Lead was detected in a sample from well 4317 at 0.018 mg/L (which is greater than the 0.015 mg/L MCL action level) in October 2017. Well 4317 was re-developed following that sampling event in an attempt to remove sediment from the sampling interval. Tritium concentrations show decreasing concentrations in groundwater in and around SWSA 6.
- In the MV offsite exit pathway monitoring program, the number of onsite sampling locations that exhibit regulated constituents at greater than 80% of their respective MCLs or maximum contaminant level derived concentrations (MCL-DCs) has decreased. Several constituents that are considered to be of natural origin (fluoride, barium, total radium alpha) have increasing concentration trends in deep wells that are exhibiting very slow recovery from well installation and well development processes. Other constituents that are considered to be of anthropogenic origin and that have exceeded the threshold concentrations of 80% of their respective MCLs exhibit trends that are mostly decreasing to stable, or not statistically significant.
- Contaminant concentrations and Cs-137 activity in fish from Melton Branch are low, with only mercury in Melton Branch fish higher than fish from the reference stream. Monitoring of the fish and invertebrate communities indicate that Melton Branch and lower WOC downstream of Melton Branch are impaired relative to reference sites. Since introduction of additional native fish species in the watershed, fish communities have improved steadily in both species richness and abundance, although the numbers are still below reference sites. The invertebrate communities in Melton Branch and WOC downstream of Melton Branch, as measured by the number of pollution-intolerant taxa, are higher today than in the 1980s, but are below peak years in the 2005 – 2010 time frame and similar to numbers observed in the 1990s. There is substantial annual variation in the invertebrate community metrics from the monitoring sites which is common in stressed systems.

All LUCs in MV specified in the MV RAR for protection of the environment and/or human health are in place and have been maintained. Certification of approved LUCs for FY 2018 are in Appendix A of this RER.

The WOD gates, as specified in the *Removal Action Report for Corrective Actions at White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (WOD RmAR; DOE/OR/01-2509&D1), have been experiencing some operational problems. An evaluation of the gates including their purpose and use was ongoing in FY 2018.

Y-12 – Bear Creek Valley

The following is a summary of the Bear Creek Valley (BCV) assessment.

Remediation activities in the *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, (BCV Phase I ROD; DOE/OR/01-1750&D4) have not been fully implemented. A final ROD for the BCV watershed addressing remaining area soil characterization for hot spot contamination, ecological issues, surface water, and groundwater will be prepared after a decision for the Bear Creek Burial Grounds (BCBGs) has been reached and RAs completed.

During FY 2018, the BCV Phase I ROD (DOE/OR/01-1750&D4) performance goals were partially met. In summary:

- In Zone 1, the goal to maintain clean groundwater and surface water conditions that are compatible with unrestricted use was met.
- Uranium discharges in Bear Creek from Zone 3 exceeded the ROD goals for annual flux and average U-238 concentration. The ROD goal for annual uranium flux measured at the Zone 3 IP (Bear Creek kilometer [BCK] 9.2) is 34 kg/yr and during FY 2018 the measured uranium discharge was 91.7 kg. During FY 2018, the measured average U-234 and U-235 concentrations were less than their respective goals, however the average U-238 concentration was 14.4 pCi/L which is approximately twice the ROD goal for human health protectiveness. Approximately 52% of the uranium discharged in Bear Creek at the Zone 3 IP originates as groundwater seepage into the headwater of North Tributary (NT)-8 at the western end of the BCBG. The surface water goals for uranium not being met in NT-8, and consequently at BCK 9.2, the IP, is an RER issue carried forward from the 2016 RER. This issue will continue to exist until a future source control ROD for the BCBGs and implementation of a remedy address the contamination source.
- Cadmium discharges into the Bear Creek headwaters near the S-3 Ponds consistently exceed the 0.25 μg/L AWQC at sample locations NT-1 and BCK 12.34. The surface water goals not being met for cadmium near the S-3 Ponds is an RER issue carried forward from the 2016 RER. Future prioritization and sequencing of an RA for S-3 Ponds Pathway 3 as stipulated by the BCV Phase I ROD (DOE/OR/01-1750&D4) will address the issue.
- During FY 2018, the Boneyard/Burnyard (BYBY) remedy met its performance goal of <4.3 kg of uranium discharge to Bear Creek with a measured uranium flux of approximately 2.8 kg at the mouth of NT-3. Mercury concentrations in NT-3 surface water samples were less than the AWQC level of 51 ng/L, which met the ROD goal.
- Available groundwater monitoring results suggest that groundwater quality in Zone 2 partially meets the BCV Phase I ROD goal, although no wells exist either in the Maynardville Limestone to the west of the SS-5 Spring or in the Maryville Limestone/Nolichucky Shale west of NT-8 at depths matching the dense non-aqueous phase liquid (DNAPL) contaminated interval in BCBG in western Zone 3. The ROD goal for Zone 2 is to improve groundwater quality consistent with eventually achieving conditions compatible with unrestricted use.
    - Wells GW-077 through GW-080 show groundwater conditions that meet MCL screening values.
    - At well GW-683 and GW-684, concentrations of uranium isotopes decreased slightly during FY 2018. Wells GW-683 and GW-684 sample groundwater in the nitrate and uranium plume that originates at the S-3 Ponds site.
- Mann-Kendall (M-K) trend evaluation of groundwater contaminants in Zone 3 indicate that although many of the contaminants that have exceeded their respective MCL concentrations in the 10-year evaluation and continue to exceed the MCLs in the FY 2018 maximum values, the groundwater conditions have shown gradual improvement over the past decade.
- Mean mercury concentrations in rock bass in Bear Creek at BCK 3.3 and BCK 9.9 are above the EPA-recommended fish-based AWQC, and PCBs in rock bass also exceed TDEC guidelines. The EPA-recommended fish-based AWQC and TDEC guideline values are not ROD-specified goals but are used as screening levels.
- Cadmium, uranium, and PCB concentrations in stoneroller minnows in 2018 continued the long-term

trend of elevated levels in Bear Creek, especially in the middle to upper sections. Fish and benthic macroinvertebrate communities also reflect a spatial pattern of impairment, with the upper Bear Creek site and NT-3 exhibiting greatest impairment relative to reference conditions. Stream communities are slowly recovering from regional drought in the fall of 2016 with more normal flows in fall of 2017 and spring of 2018.

All LUCs in BCV determined necessary for protection of the environment and/or human health are in place and have been maintained.

Y-12 – Chestnut Ridge

The following is a summary of the Chestnut Ridge assessment.

United Nuclear Corporation (UNC) Disposal Site. Low concentrations of nitrate and gross beta activity continue to be detected in two downgradient monitoring wells, however, the levels remain well below screening criteria based on drinking water standards and much less than levels estimated to be possible in the feasibility study (FS) for the site. The only FY 2018 Sr-90 detection at the UNC site occurred in August at downgradient surface water sampling location UNC SW-1 at a concentration of 0.601 J pCi/L.

Kerr Hollow Quarry (KHQ). During FY 2018, carbon tetrachloride was detected in GW-144 at an estimated concentration (0.7 J µg/L) substantially below the drinking water MCL (5 µg/L). Other VOCs were not detected in the sample.

Filled Coal Ash Pond (FCAP)/Upper McCoy Branch. The FCAP wetland continues to reduce arsenic concentrations in effluent surface water when compared to pre-remediation conditions; however, there is decreasing arsenic removal effectiveness over time. The arsenic concentrations in wetland effluent exceed the AWQC screening concentration of 0.01 mg/L.

Biota monitoring indicates arsenic levels in Rogers Quarry fish are near background. However, selenium and mercury concentrations remain higher in fish relative to typical background concentrations for selenium and relative to federal AWQC guidelines for mercury, suggesting continuing low-level inputs from either the FCAP or stream, quarry ash deposits downstream, or ash deposits historically deposited in Rogers Quarry.

The 2016 FYR identified the performance of FCAP wetland and health of the Rogers Quarry fish population as an issue. Because of this issue, the FYR deferred the protectiveness statement for the FCAP ROD, stating that, “a protectiveness statement for aquatic life cannot be made at this time.” To address this issue, DOE initiated investigations in FY 2017 that concluded during FY 2018, including evaluations of wetland conditions and the sedimentation basin. A report of the result of those investigations is included as Appendix C.1 of this RER. This closes the FYR issues regarding the FCAP investigations. Key elements and findings of the investigation included:

- A physical survey of the wetland confirmed excessive accumulation of material in the center of the wetland that causes channelization of flow around the area perimeter,
- Installation of flow measurement flumes (McCoy Branch kilometer [MCK] 2.0 and MCK 2.05) upstream and downstream of the wetland allowed for measurement of flow volumes and supported composite sampling to evaluate dissolved and particulate fluxes passing through the wetland,
- A dye tracer test documented the relatively short residence time of water in the wetland under current conditions (90^{th} percentile of tracer mass passed out of the wetland at about 4.6 hours elapsed time),

- Collection of wet season and dry season baseflow and storm event composite samples allowed for the determination of time and flow averaged metals concentrations under varying seasonal and flow conditions. Flux calculations determined that arsenic reduction in the wetland was variable and that the wetland at times served as a source of arsenic in both wet and dry seasons,
- Collection of bulk water samples during a stormflow event showed a "first flush" behavior of ash erosion from the FCAP top surface, no ash movement through the wetland, and a small percentage of ash in sediment transported into Rogers Quarry,
- Fish from McCoy Branch and Rogers Quarry were collected for metals analysis (fillets and ovaries) and for a closer examination of fish health parameters. FY 2018 fish sampling in Rogers Quarry found no deformed fish and only one emaciated fish, suggesting that detrimental exposures to selenium are transitory (only older fish were negatively affected) and there is an overall positive trend, and
- An investigation of other regional quarries without coal ash impacts was conducted in an effort to evaluate if quarries in general resulted in food limitation and poor largemouth bass condition. Based on the investigation, there is no evidence that the general conditions of quarries are a cause of deformities or highly emaciated conditions in fish.

Chestnut Ridge Security Pits (CRSPs). Four VOCs were detected in the groundwater sample collected from CRSP well GW-322 in July 2018: 1,1,1-trichloroethane (TCA; 3.3 J μg/L), perchloroethene (PCE; 4 J μg/L), 1,1-dichloroethene (DCE; 20 μg/L), and 1,1-dichloroethane (DCA; 39 μg/L). Only the 1,1-DCE concentration exceeds the 7 μg/L MCL screening level.

Historical results show PCE detected at CRSP well GW-798 at concentrations either slightly above or below the drinking water MCL (5 μ/L), with the concentration for the sample collected in July 2018 (2.7 μ/L) being the lowest evident since January 2001 (2 μ/L).

East Chestnut Ridge Waste Pile (ECRWP). Several analytes (barium, chloride, iron, nitrate, sulfate, and gross beta) were detected in point-of-compliance (POC) wells GW-161, GW-296, and GW-298 during FY 2018. Statistical analysis of the respective semiannual groundwater sampling/analysis results does not indicate any statistically significant differences between the concentrations of the analytes detected in the POC wells and upgradient/background well GW-294. Accordingly, the FY 2018 groundwater monitoring results do not provide evidence potentially indicating the release of contaminants derived from wastes in the ECRWP.

Leachate sample results collected from the ECRWP during FY 2018 are consistent with previous annual leachate sampling/analysis data. These results do not indicate any significant change in the chemical characteristics of the leachate or the need to add any parameters/constituents to the analytes the East Fork Poplar Creek/Chestnut Ridge (EFPC/CR) RAR CMP specifies for groundwater monitoring at the ECRWP.

All LUCs determined necessary for protection of the environment and/or human health are in place and have been maintained.

Y-12 – Upper East Fork Poplar Creek

The CERCLA actions completed to date in Upper East Fork Poplar Creek (UEFPC) include the Big Springs Water Treatment System (BSWTS) and West End Mercury Area (WEMA) storm drain projects under the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area* (UEFPC Phase I ROD; DOE/OR/01-1951&D3). Implementation of additional actions under the UEFPC Phase I ROD and the *Strategic Plan for Mercury Remediation at the Y-12 National*

Security Complex, Oak Ridge, Tennessee (DOE/OR/01-2605&D2), is planned, including a new Outfall 200 Water Treatment Facility to reduce the mercury concentration in water exiting the Y-12 site.

- The mercury discharge measured at Station 17 (the surface water IP for the UEFPC watershed) was approximately 12.4 kg for FY 2018. The average total mercury concentration at Station 17 was 1,858 ng/L compared to the UEFPC Phase I ROD goal of 200 ng/L. The FY 2018 results show an increase compared to FY 2017 levels that is attributed to mercury discharges in the Outfall 163 storm drain network related to D&D activities at the COLEX facility.
- The FY 2018 mercury discharge measured at Outfall 200A6 was approximately 10.2 kg, with an average total mercury concentration of 5,378 ng/L. Outfall 200A6 serves as an IP for contamination leaving the WEMA. At Outfall 200A6, approximately 76% of the mercury was dissolved (largely because chlorinated water discharges into the upstream storm drains facilitate dissolution and transport of mercury), while at Station 17, only approximately 9% of the mercury was dissolved. Downstream of storm drain dechlorinators, dissolved mercury is subject to sorption on stream sediment and materials in the channel. Stormflow suspension and transport of contaminated sediment account for much of the mercury flux measured at Station 17.
- BSWTS operated throughout FY 2018 with a mercury removal effectiveness of approximately 99%. All of the FY 2018 weekly composite samples of BSWTS effluent had mercury concentrations less than the performance standard of 200 ppt (200 ng/L). The average mercury concentration in effluent from the Central Mercury Treatment System (CMTS) met the National Pollutant Discharge Elimination System (NPDES) Permit limit of 2 μg/L.
- The CMTS met its NPDES discharge limit requirements in all FY 2018 samples.
- The performance standard for uranium at Station 17 is to monitor the trend. The uranium flux measured at Station 17 during FY 2018 (134 kg) decreased somewhat in comparison to FY 2016 and FY 2017 levels (141 and 147 kg), respectively.
- Aquatic biological monitoring shows that mercury concentrations in rock bass at Station 17 over the 2017 – 2018 time period are relatively low in spring (approximately 0.6 ppm), but higher in fall (approximately 0.9 ppm). These levels in fish are 2 – 3 times higher than screening levels from EPA's fish-based criteria. Mercury concentrations in fish at the uppermost site in EFPC remain higher than prior to the storm drain cleanout. Overall, mercury and PCBs concentrations in fish remain well above reference stream values.
- Fish and invertebrate communities are much improved over the last 20 years in the lower part of the creek (Peterson et al., 2011), but stream communities remain impacted at upstream sites. Notable, since flow augmentation ended, is that there have been declines in fish abundance in the upstream part of the creek, despite similar numbers of species over the years (Peterson, personal communication). This is not unexpected given the lower water volumes in the creek after the end of flow augmentation in the spring of 2014. A fish kill was observed in UEFPC in July and August of 2018, failed toxicity tests were provided to TDEC as part of Y-12 NPDES Permit requirements. An NPDES-required Toxicity Identification Evaluation/Toxicity Reduction Evaluation (TIE/TRE) was initiated, with studies conducted in the field and laboratory through fall-winter of 2018 – 2019 to identify the causes of toxicity. Results of these studies will be provided in Y-12 FY 2019 TIE/TRE reporting and in future RERs.

East End Volatile Organic Compound (EEVOC) Plume. The EEVOC air stripper demonstrated a high effectiveness for VOC removal during FY 2018. Only short term shutdowns occurred for maintenance of system components or electrical power outages. The offsite groundwater VOC concentrations continued to show that offsite migration of the plume is largely contained by the EEVOC system.

All LUCs in UEFPC determined necessary for protection of the environment and/or human health are in place and have been maintained.

Offsite

The following is a summary of the offsite actions assessment.

Lower East Fork Poplar Creek (LEFPC). Monitoring at Station 17 is conducted to measure the concentration and mass flux of mercury that is discharged from the UEFPC watershed into LEFPC. During FY 2018, the flow-paced continuous monitoring detected an average concentration of 1,860 ng/L, up from 856 ng/L in FY 2017, and a mass flux of 12.4 kg mercury, up from 8.3 kg in FY 2017. The levels of mercury in fish tissue in LEFPC have remained elevated in comparison to fish from reference streams. In fall 2017 in LEFPC, fish concentrations were higher (up to approximately 50% higher at some sites, ranging from 1.2 – 1.4 µg/g depending on species) than they have been in recent years (approximately 0.8-1.0 µg/g).

Clinch River/Poplar Creek. Performance monitoring of the Clinch River and Poplar Creek continues to indicate an overall downward trend in fish PCB concentrations. The decreasing PCB trends in fish are some of the most dramatic observed by the long-running Oak Ridge biological monitoring programs. Large striped bass from the Clinch River appear to be the species of greatest concern relative to PCBs. Mercury concentrations in fish at monitored sites continue to indicate the influence of mercury sources from EFPC, with elevated levels in fish in Poplar Creek and lower levels downstream. The ROD goal of evaluating changes in fish contaminant levels and how those levels compare to fish advisory limits continues to be addressed with monitoring.

Lower Watts Bar Reservoir (LWBR). Performance monitoring results from LWBR obtained during FY 2018 continue to indicate that PCB levels in fish are decreasing from historical levels.

All LUCs in offsite areas determined necessary for protection of the environment and/or human health are in place and have been maintained.

ETTP

The following is a summary of the ETTP assessment.

Groundwater. The data screen and M-K trend assignments show that contaminant concentration trends are highly variable across the site as numerous remediation activities are underway.

- VOC concentrations in wells monitored downgradient of K-1070-C/D show that a broad area is affected by releases from the past disposal of liquid VOCs at G-Pit. While concentrations in wells UNW-114 and UNW-064 continue to decrease, very high VOC concentrations affect wells DPT-K1070-5 and DPT-K1070-6. The persistent, very high concentrations of these VOCs suggest an ongoing contaminant source.
- Contaminant conditions in the groundwater exit pathway areas are generally stable and similar to conditions in recent years. In the K-31/K-33 area, chromium continues to be measured at levels near or slightly above screening level MCLs although during FY 2018 all chromium results were less than the 0.1 mg/L MCL. Nickel is present in groundwater samples from one well (UNW-043) at concentrations greater than the state of Tennessee screening criterion of 0.1 mg/L.
- In the K-1064 Peninsula, arsenic exceeded its screening level MCL in groundwater samples collected during FY 2018. TCE concentrations continued to decrease with a maximum detected concentration less than the screening level MCL in FY 2018.

- In the K-27/K-29 area, chromium continues to exceed its 0.1 mg/L MCL screening level in unfiltered samples from wells UNW-038 and UNW-096 although concentrations in filtered samples are less than the MCL screening level. Nickel exceeds the state of Tennessee water quality screening criterion in wells UNW-038 and UNW-096. TCE continues to gradually decrease in wells UNW-038 and UNW-096.
- Samples from spring PC-0, which discharges groundwater into Poplar Creek, had TCE concentrations greater than the 5 µg/L screening level MCL during November 2017 and February 2018, but concentrations were less than the MCL in April 2018. At spring 10-895, TCE was detected at concentrations less than the MCL screening level during FY 2018.
- In the K-770 area, alpha activity concentrations have decreased to levels less than the 15 pCi/L screening level. At wells near the K-1007-P1 Holding Pond, alpha activity was detected at a concentration less than the 15 pCi/L screening concentration in well UNW-108 and TCE was not detected although in previous years it was measured at concentrations greater than its 0.005 mg/L screening concentration.
- Monitoring results from wells in the K-1407-B/C ponds area are generally consistent with results from previous years and show several fold concentration fluctuations in seasonal and longer term periods. The detection of VOCs at concentrations well above 1,000 µg/L and the steady concentrations over recent years suggest the presence of DNAPL in the vicinity of well UNW-003.

Surface water. Contaminant levels are generally stable and consistent with levels in recent years. All surface water radiological data were well below the screening level of 4% of the sum of fraction of the Derived Concentration Standard (DCS) concentrations that results in an effective dose equivalent of 4 mrem as a general drinking water level comparison.

- VOC concentrations in Mitchell Branch in FY 2018 remained well below the applicable AWQC and the benchmark values for potential surface water toxicity.
- Collection and treatment of groundwater containing hexavalent chromium is ongoing and is protective of water quality in Mitchell Branch, as levels in Mitchell Branch are below AWQC.
- Surface water measurements for PCBs and mercury periodically continued to exceed the AWQC in some storm water outfalls and surface water locations. The long-term mercury trend at the K-1700 weir Mitchell Branch exit pathway location shows a continuing decline from peak levels in FY 2010.

Biological monitoring. Fish have not attained remediation goals at K-1007-P1 and K-901-A ponds. A FYR issue (Table 1.4) identified additional management actions for both ponds with annual reporting in the RER and the next FYR (2021). In FY 2018, PCB concentrations in caged clams increased in SD-100. Concentrations in fish collected from the K-720 Slough were comparable to concentrations in recent years.

LUCs. All LUCs at ETTP specified in the *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan Oak Ridge, Tennessee* (ETTP RAR CMP; DOE/OR/01-2477&D3) for the protection of the environment and/or human health have been implemented. Cleaning the fish grates may be as frequent as bimonthly.

Additionally, a revised ETTP RAR CMP was issued November 2016 and identifies LUCs, their objectives, and their verification requirements. The ETTP RAR CMP serves as the ETTP LUCIP, and, therefore, ETTP is now included in the certification in Appendix A of this RER.

Other Sites

The following is a summary of the assessment of other sites on the ORR – the White Wing Scrap Yard (WWSY) site and the Oak Ridge Associated University South Campus Facility (ORAU SCF) site.

WWSY. No performance monitoring is required at the WWSY site.

ORAU SCF. The *Record of Decision for Oak Ridge Associated Universities South Campus Facility, Oak Ridge, Tennessee* (ORAU SCF ROD; DOE/OR/02-1383&D3) specified groundwater monitoring at a VOC contaminated area and defined LUCs that include a groundwater use restriction. Low concentrations of VOCs continue to be detected in groundwater at ORAU SCF; however, all detections in FY 2018 were less than drinking water standards used as screening levels. No VOCs were detected in surface water at the site during FY 2018.

All LUCs at the WWSY and ORAU SCF determined necessary for protection of the environment and/or human health are in place and have been maintained.

REFERENCES

DOE/OR/01-1750&D4. *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1826&D3. *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1951&D3. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2477&D3. *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2478&D3. *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2509&D1. *Removal Action Report for Corrective Actions at White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2605&D2. *Strategic Plan for Mercury Remediation at the Y-12 National Security Complex, Oak Ridge, Tennessee*, 2014, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1383&D3. *Record of Decision for Oak Ridge Associated Universities South Campus Facility, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR-1014. *Federal Facility Agreement for the Oak Ridge Reservation*, 1992, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Peterson, M.J., R.A. Efroymson, and S.M. Adams. 2011. *Long-Term Biological Monitoring of an Impaired Stream; Synthesis and Environmental Management Implications*. Environmental Management 47:6: 1125-1140.

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1. INTRODUCTION

1.1 PURPOSE

The purposes of the annual Remediation Effectiveness Report (RER) are to:

- evaluate the effectiveness, based on environmental media monitoring, of completed remedial actions (RAs) or environmental media removal actions, and
- verify land use controls (LUCs) are implemented for completed actions.

Because most of the completed RAs and environmental media removal actions across the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) do not allow unlimited use/unrestricted exposure (UU/UE), these sites require performance monitoring and/or LUCs to protect human health and the environment from physical hazards, residual contamination, and wastes remaining following remediation. Environmental monitoring and verification of LUCs are used to assess the performance of completed Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) actions in which residual contamination is left that does not allow for UU/UE.

Environmental media monitoring includes monitoring of groundwater, surface water, and biological media, e.g., fish, biota surveys, etc., to assess performance (performance monitoring). Because all planned RAs have not been completed, environmental media monitoring also is used for baseline data assessments (baseline monitoring) of watershed conditions and trends, which are summarized in the RER, as appropriate. Data and information presented in this 2019 RER focuses on fiscal year (FY) 2018, historical trends are also included from prior years.

New in this RER are the substantive requirements of three prior Resource Conservation and Recovery Act of 1976 (RCRA) post-closure permits (PCPs): (1) *RCRA Post-closure Permit for the Chestnut Ridge Hydrogeologic Regime* (TNHW-128), 2) *RCRA Post-Closure Permit for the Bear Creek Hydrogeologic Regime* (TNHW-116), and 3) *RCRA Post-Closure Permit for the Upper East Fork Poplar Creek Hydrogeologic Regime* (TNHW-113). It was agreed on February 28, 2018 that the substantive requirements of these three PCPs be integrated into this 2019 RER and captured in the CERCLA Five-Year Review (FYR), as appropriate. Additionally, reporting of monitoring for Solid Waste Storage Area (SWSA) 6 at the Oak Ridge National Laboratory (ORNL) that was previously performed under RCRA is also included in the 2019 RER. Sites associated with RCRA PCPs are included on figures in subsequent chapters.

1.2 COMPLETED ACTIONS ADDRESSED IN THE RER

The completed actions with monitoring or LUC requirements addressed in this RER are located at three major DOE Program facilities on the ORR, as well as outside the DOE boundary (Figure 1.1):

- The ORNL and associated waste disposal areas within Bethel Valley (BV) and Melton Valley (MV).
- The Y-12 National Security Complex (Y-12) and associated waste disposal areas that fall within Upper East Fork Poplar Creek (UEFPC), Chestnut Ridge, and Bear Creek Valley (BCV). An approximate boundary is shown for the Chestnut Ridge area where there is no existing watershed-scale decision but a future Record of Decision (ROD) is planned.

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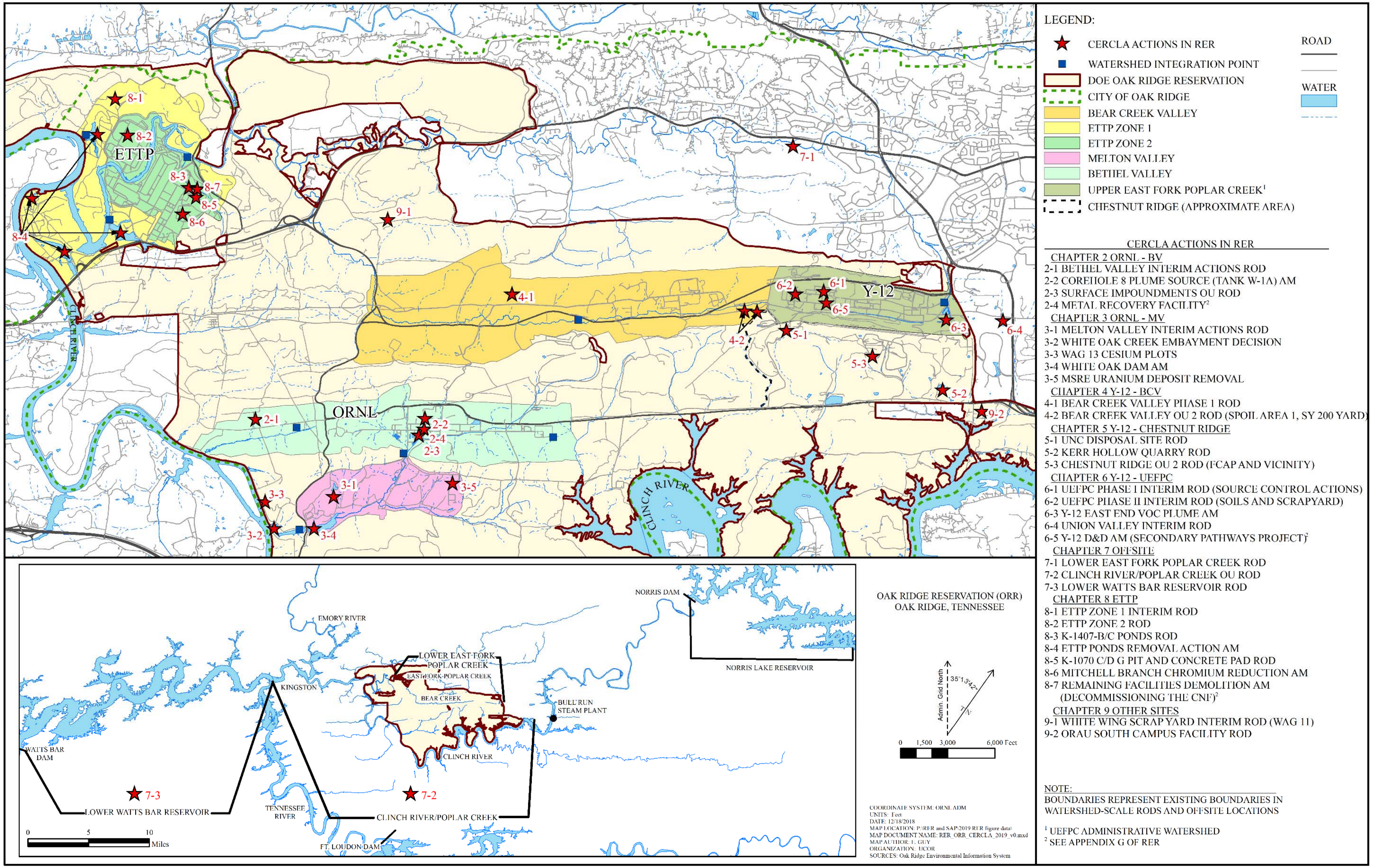

Figure 1.1. Location of CERCLA actions in the RER.

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- The former Oak Ridge Gaseous Diffusion Plant (K-25 Site), now referred to as the East Tennessee Technology Park (ETTP), and waste disposal areas within the ETTP boundary.
- Areas that are outside of the DOE boundary but which lie downgradient of the facilities and, thus, have received contamination from the facilities. These primary areas are as follows:
  - Lower East Fork Poplar Creek (LEFPC), which runs from Y-12 through the city of Oak Ridge and eventually into Poplar Creek near ETTP;
  - the Clinch River/Poplar Creek and Lower Watts Bar Reservoir (LWBR) surface water system, which is downgradient of all facilities and the ultimate receiving water bodies for all contaminants leaving the Oak Ridge National Priorities List (NPL) Site (Oak Ridge Site); and
  - Union Valley, the location of a groundwater plume that exited the east end of the Y-12 site.

1.3 REMEDIATION STRATEGY

In Oak Ridge, DOE and its predecessor agencies have had a mission of uranium enrichment, weapons production, and energy research since the 1940s, which has resulted in a legacy of hundreds of contaminated areas on the ORR. These contaminated areas associated with the federal mission were placed on the CERCLA NPL in 1989. The *Federal Facility Agreement for the Oak Ridge Reservation* (FFA; DOE/OR-1014), signed by DOE, U.S. Environmental Protection Agency (EPA), and Tennessee Department of Environment and Conservation (TDEC) in 1991, and implemented on January 1, 1992, describes how remediation decisions under CERCLA will be made and performed. The Oak Ridge NPL Site (Oak Ridge Site) was identified in the FFA as the *Oak Ridge Reservation* for NPL locational information. As shown in Figure 1.2, much of the approximately 32,465 acre DOE-owned ORR has been determined to be clean and not part of the contaminated areas that comprise the Oak Ridge Site. The Oak Ridge Site within the DOE-owned Reservation is approximately 12,281 acres (approximately one third of the ORR) and includes the areas described above as well as additional scattered small areas that have been identified as requiring additional CERCLA investigation and/or remediation.

In the mid-1990s, DOE, EPA, and TDEC agreed to make remedial decisions at a watershed-scale using consensus end uses developed by the citizen stakeholders for each identified watershed to develop publically acceptable future land end uses. Such end uses would define the applicable exposure scenarios from which protective, risk-based remediation levels are developed. DOE commissioned the End Use Working Group Stewardship Committee to recommend end uses, and they published *The Oak Ridge Reservation Stakeholder Report on Stewardship* (ORR End Use Working Group Stewardship Committee 1998) documenting these recommendations. When surface water is addressed in the watershed decisions, the stream classification, e.g., recreational, fish and aquatic life, domestic water supply, etc., is acknowledged. Groundwater has not been included in the existing watershed decisions. However, groundwater is addressed in a few CERCLA decisions on the ORR, e.g., Union Valley Interim ROD, Corehole 8 Plume, etc. When groundwater is included in future decisions, all federal and state applicable or relevant and appropriate requirements (ARARs) will be addressed.

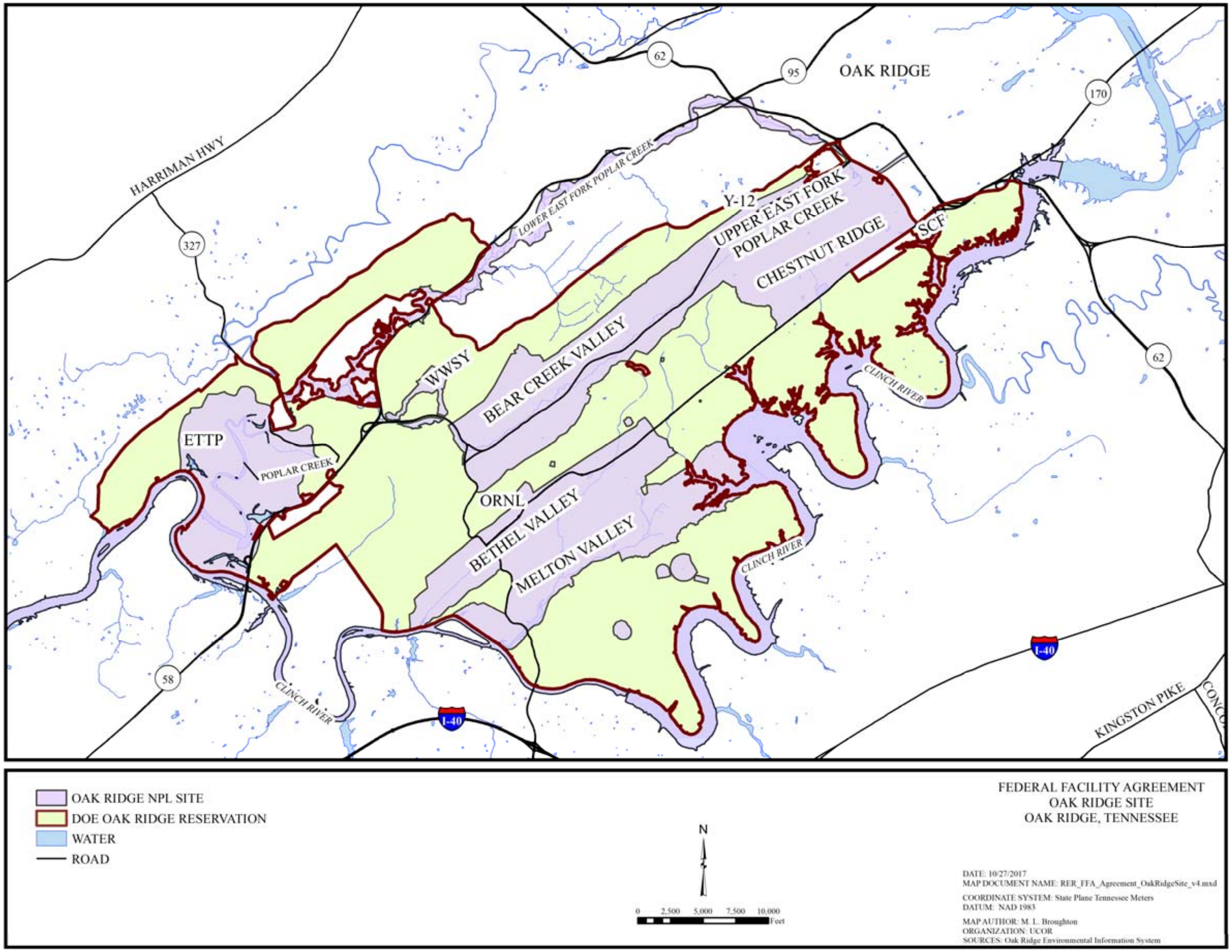

Figure 1.2. FFA Oak Ridge Site.

The watersheds are used as a basis for decision making because the primary pathway for offsite contaminant transport is via surface water. The ORR is partially bounded by the Clinch River, and there are active creeks that flow down the valleys to the Clinch River (Figure 1.1). These surface water systems are fed by runoff from rainfall and by the groundwater that continually discharges to the surface streams via springs and seeps. In areas underlain by predominantly clastic bedrock (such as shaley formations of the Conasauga Group in MV and BCV), as much as 90% of the water entering the groundwater system flows rapidly through highly porous, shallow soil. In contrast, in areas underlain by soluble, massive carbonate bedrock units, such as the Knox Group and Maynardville Limestone of Chestnut Ridge/BCV, a larger fraction of the water that reaches the groundwater system passes through deeper flow pathways via conduit flow. The location of contaminant sources in the subsurface (as shallow land burial sources vs. dense liquids that sink downward through fractures, or deeply injected wastes) affects the likely contaminant flow pathways. Consequently, the primary pathway for contaminant migration of near-surface sources in clastic bedrock outcrop areas is through shallow groundwater to surface water that then flows offsite, while contamination from deep sources or sources in the massive carbonate terrains has greater potential for longer distance, deep groundwater migration. Because of abundant rainfall (an average of 54 in./yr), contaminant transport by shallow subsurface flow to surface waters, and the presence of contaminated sites in defined watersheds, a watershed strategy became the basis for remedial decision making.

Watershed remedial decision making is an integrated, holistic approach to restore and protect ecosystems and to protect human health by focusing on hydrologically defined drainage basins. Watershed remedial decision making is applied to environmental restoration on the ORR by grouping contaminated sites into the following five watersheds (Figure 1.1): BV, MV, BCV, UEFPC, and ETTP. Note that in some cases, (e.g., BCV), rather than form a single defined hydrologic watershed, an area may comprise several individual sub-watersheds but is treated as a single administrative unit for watershed-scale decision-making and performance assessment purposes. Additionally, decisions have been made and/or actions taken offsite (LEFPC, Clinch River/Poplar Creek, Union Valley, and LWBR) and onsite, within Chestnut Ridge, White Wing Scrap Yard (WWSY) and Oak Ridge Associated Universities South Campus Facility (ORAU SCF).

The watershed-scale RODs contain performance objectives to be met and a series of RAs designed to achieve them. Completed CERCLA actions in the watershed are gauged against their action-respective goals through performance monitoring. However, when CERCLA actions have yet to be fully implemented within a watershed, monitoring of baseline conditions are conducted, against which the effectiveness of the actions can be evaluated in the future. Contaminants released from the source sites accumulate in floodplain soils and aquatic sediments. Contaminants not retained, or those remobilized, are released to the surface waters and potentially offsite to the Clinch River. Therefore, the surface water acts as an integrator of contaminant flux, and integration points (IPs; Figure 1.1) are identified in each watershed at which contaminant releases can be measured, assessed, tracked, and prioritized. Surface water contaminant IPs are points at which upstream contaminant releases converge to exit the watershed (or subwatershed). Once the baseline monitoring and characterization are completed and the cleanup objectives are defined, the contribution of each RA toward achieving the objectives can be evaluated and assessed at the watershed IP. Through surface water monitoring, both the specific performance of each action and the cumulative progress toward achieving the cleanup objectives can be assessed.

Since the Oak Ridge Site was placed on the NPL in 1989, the following risk-based prioritization has been used:

- mitigate immediate onsite and offsite risks,
- reduce further migration of contaminants offsite,
- address sources of offsite surface water and groundwater contamination,

- address remaining onsite contamination, and
- address demolition of facilities.

The execution priority may alter the sequence of work. For example, a building may first have to be demolished in order to address remaining onsite contamination.

Single-project actions were performed consistent with the above risk-based prioritization, primarily to mitigate immediate risks and to reduce further migration of contaminants offsite. In addition, interim watershed RODs have been signed for BV (DOE/OR/01-1862&D4), MV (DOE/OR/01-1826&D3), UEFPC (DOE/OR/01-1951&D3 and DOE/OR/01-2229&D3), BCV (DOE/OR/01-1750&D4) and Zone 1 at ETTP (DOE/OR/01-1997&D2) for sources and soil (Figure 1.1). This allowed remediation of sources and soil while deferring the more complex decisions on topics such as groundwater, surface water, sediment, ecological protection, and final LUCs until the source terms are remediated and there is a better understanding of the contaminant pathways. These interim watershed RODs are also considered interim for the sources and may be changed in the final RODs. The framework for remediation typically has been considered linear, progressing from identification of a potentially contaminated site through completion of remediation. However, because residual contamination on ORR will remain for long periods, a framework (NRC 2002) is needed that recognizes the iterative process of remediation based on the immergence of new or improved remediation technologies, the performance of completion actions, and the results of monitoring (Figure 1.3).

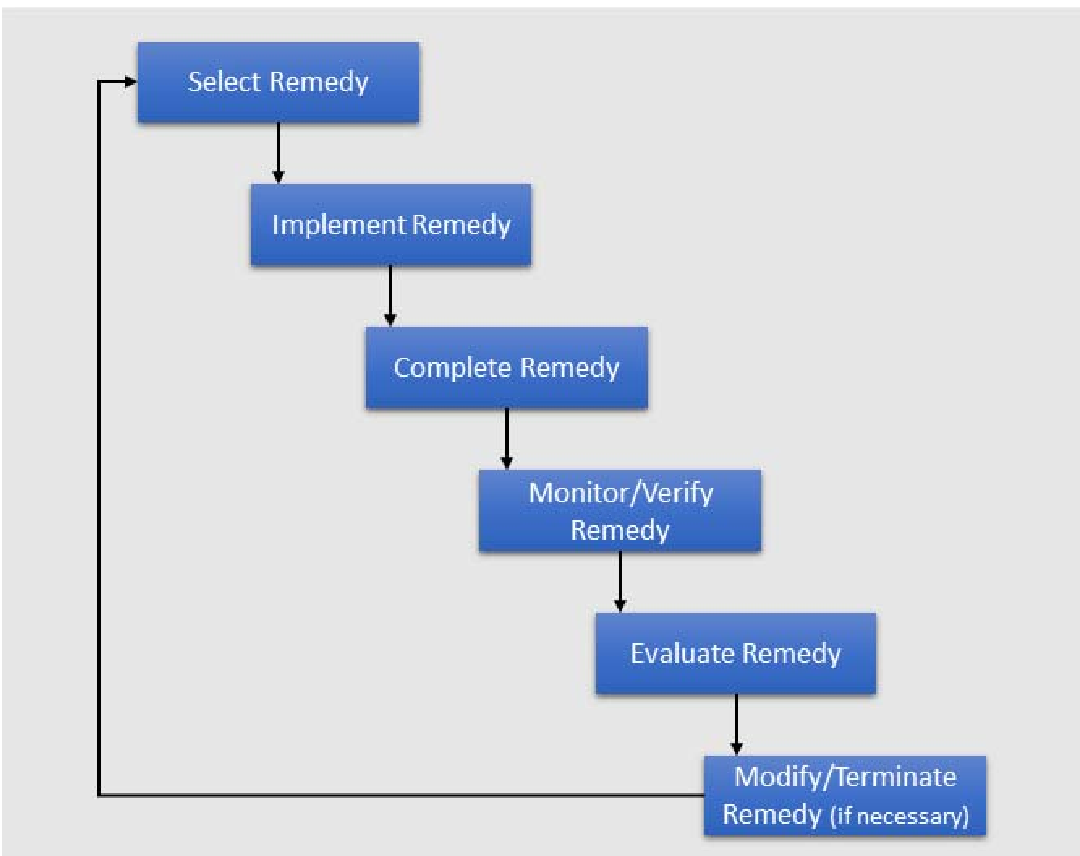

Figure 1.3. Framework for remediation.

The Water Resources Restoration Program (WRRP) was established by DOE in 1996 to implement a consistent approach to long-term environmental monitoring and verification of the completed CERCLA response actions across the ORR. The WRRP provides a central administrative and reporting function for the DOE Oak Ridge Office of Environmental Management (OREM). The WRRP integrates and coordinates the numerous activities associated with this monitoring and verification, including watershed-specific Remedial Action Report Comprehensive Monitoring Plans (RAR CMPs; Section 1.4) and data quality assurance (Section 1.5.1), to minimize duplication of field, analytical, and reporting efforts.

1.3.1 ORR Groundwater Strategy

No watershed-scale final groundwater decisions have been made on the ORR to date, although several groundwater RAs have been undertaken. RAs that have been successful at prevention of the spread of groundwater contamination have included containment pump-and-treat systems and hydrologic isolation of wastes left in place by capping and in situ stabilization. The full delineation of the nature and extent of groundwater contamination is incomplete in many areas of the ORR.

Development of an interagency approach for addressing ORR groundwater contamination was completed in FY 2013 and resulted in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (ORR Groundwater Strategy; DOE/OR/01-2628&D2). The FFA parties (DOE, EPA, and TDEC) agreed to the strategy in FY 2014. The ORR Groundwater Strategy provides a comprehensive framework for early actions and long-term implementation to support CERCLA decision making for ORR groundwater.

In FY 2018, OREM continued to implement projects under the ORR Groundwater Strategy. In September 2018, the *Phase I Melton Valley/Bethel Valley Exit Pathway Remedial Investigation Work Plan* (DOE/OR/01-2756&D1) was completed and issued for regulator review. The plan provides details about fieldwork that will be performed to install three new onsite wells west of ORNL near the Clinch River. Monitoring of the new wells will supplement current exit pathway monitoring in BV near the ORR boundary. The plan also describes an exit pathway groundwater flow model that was constructed using the recently completed regional model framework.

Also in FY 2018, work on a BV Final ROD Remedial Investigation Work Plan (RIWP) for groundwater was initiated. This plan will outline an investigation strategy to support a future, final groundwater decision for BV.

The *Offsite Groundwater Assessment Remedial Site Evaluation, Oak Ridge, Tennessee* (DOE/OR/01-2715&D2_R) was approved by EPA and TDEC in FY 2018. While no unacceptable health risk related to possible DOE groundwater contamination was reported in the study, groundwater monitoring of select offsite locations will continue for three years. This monitoring was detailed in the *Remedial Site Evaluation Phase 2 Offsite Detection Monitoring Work Plan* (DOE/OR/01-2788&D1) that was prepared for regulator review in August 2018.

The FFA parties will continue to work together in the future to identify projects that improve the understanding of groundwater flow pathways and contaminant migration based on a continually refined groundwater strategy.

1.3.2 Onsite Waste Treatment, Storage, and Disposal Facilities

During the implementation of CERCLA response actions on the ORR, DOE may utilize State of Tennessee-permitted onsite facilities for the treatment, storage, or disposal of waste streams generated by these response actions. These State of Tennessee-permitted facilities commonly receive wastes from both

CERCLA response actions and operational activities associated with ORNL and Y-12. Below is a list of the State of Tennessee-permitted onsite treatment and disposal facilities:

- Y-12 Landfills
  - Industrial Landfill IV, Permit IDL-01-103-0075
  - Industrial Landfill V, Permit IDL-01-103-0083
  - Construction and Demolition Landfill VII, Permit DML-01-103-0045
- Y-12 National Pollutant Discharge Elimination System (NPDES) Permit TN0002968
  - Central Pollution Control Facility, Outfall 501
  - West End Treatment Facility, Outfall 502
  - Groundwater Treatment Facility, Outfall 512
  - Central Mercury Treatment Facility (MTF), Outfall 551
- ORNL NPDES Permit: TN0002941
  - Process Waste Treatment Complex (PWTC), Outfall X12
  - Sewage Treatment Plant (STP), Outfall X01

There was no waste from CERCLA response actions completed in FY 2018 stored in State of Tennessee-RCRA-permitted storage unit facilities.

The completion documents for CERCLA response actions in FY 2018 contain the waste volumes and disposal locations. Appendix H provides a list of all completed CERCLA actions for each watershed and the corresponding completion documents.

1.4 RAR CMPS

The watershed-specific sampling and analysis plans (SAPs) for the Oak Ridge Site are contained in RAR CMPs. The RAR CMPs are primary documents under the FFA, for which approval authority is provided to TDEC and the EPA. The RAR CMPs contain CERCLA required monitoring requirements for all media, additionally, TDEC and EPA requested in 2015 that all non-monitoring controls necessary to ensure remedy protectiveness be included in the RAR CMPs. Therefore, DOE determined that all RAR CMPs would henceforth identify LUCs, their objectives, and their verification requirements, as well as serve as the watershed Land Use Control Implementation Plan (LUCIP). Revision of the RAR CMPs to include LUCs has been completed for two of the RAR CMPs and is underway or planned for others. Table 1.1 lists the primary document title of each of the RAR CMPs, document number through the current reporting year, the status of addition of LUCs, as well as the previous document title in the footnote.

Either a ROD for an RA or Action Memorandum (AM) for a removal action defines the selected remedy. These decision documents contain the statutory decision for the response actions and may specify monitoring and LUCs. Remedial action objectives (RAOs) and performance objectives for CERCLA actions are contained in CERCLA decision documents and/or detailed in post-decision documents.

A purpose of the RAR CMP is to assemble all of these requirements into a single primary document and then document subsequent changes to these requirements through revision approvals to the single watershed RAR CMP. If DOE Program agencies proposed activities, the annual RER, or the FYR recommends modifications or termination of LUC objectives, the changes (once approved by EPA and TDEC) will be captured in the applicable RAR CMP and not in the underlying completion document or documents. This approach recognizes that, if a prescriptive component of a ROD is recommended for change, the ROD will need to be revised prior to the change being made to the RAR CMP.

1.5 PERFORMANCE MONITORING

Results of performance monitoring required by approved CERCLA decision or post-decision documents for completed actions are presented in this report to evaluate remediation effectiveness. As discussed in Section 1.4, the RAR CMPs are the primary documents where all performance monitoring requirements are identified and contained. A discussion of performance monitoring objectives, performance measures, and results is presented in each RER chapter. While performance monitoring is a principal focus of the RER, some baseline monitoring data is also included, as appropriate, to track changes in contaminant concentrations, relative to a baseline condition, where CERCLA actions have yet to be fully implemented. Baseline monitoring (i.e., trend monitoring) is typically conducted at exit pathways where contaminants in groundwater or surface water have the potential to flow through and ultimately exit the watershed or subwatershed to discharge offsite. Baseline monitoring can also include interior monitoring locations near known (or potential) contaminant sources used to detect concentration changes in primary groundwater plumes.

All data used in the RER are collected in accordance with the watershed-specific RAR CMPs and the *Quality Assurance Project Plan for the Water Resources Restoration Program* (WRRP QAPP; UCOR-4049 [see Section 1.5.1]), or, for data collected by other programs, outside of the WRRP, in accordance with a quality plan that meets the specific program requirements.

Primary performance objectives for CERCLA actions are identified in decision documents and are used for performance monitoring. Performance objectives include:

- specific media concentrations (i.e., risk-based or regulations-based remedial goals),
- contaminant-specific migration reduction goals (i.e., percent flux reduction),
- risk-based criteria (i.e., specified risk level associated with a given exposure scenario which necessitates a calculation using risk assessment protocols), and
- target groundwater elevations (long-term water table elevation goals associated with SWSAs).

The first two types of performance objectives are codified in the RODs and are fixed, pending formal actions to make changes to RODs. However, the third objective is addressed by calculating media concentrations applicable to the watershed-specific risk-based criterion using the Risk Assessment Information System chemical and radionuclide calculators, consistent with the exposure scenarios associated with the future end uses evaluated in the CERCLA documentation for the watershed in question. Media concentrations developed with the Preliminary Remediation Goal (PRG) calculator are done so using the third PRG output option (i.e., no progeny with decay).

In each RER chapter, a section identifying specific performance monitoring goals and objectives for the CERCLA action is presented prior to the evaluation of performance monitoring results. Additional screening criteria (e.g., ambient water quality criteria [AWQC] and Safe Drinking Water Act [SDWA] maximum contaminant levels [MCLs]) are used in some of the results evaluations for comparative purposes, but are not performance objectives or goals unless explicitly stated in the report.

Table 1.1. RAR CMPs and status of addition of LUCs

Document number	Primary document title	Status of addition of LUCs
DOE/OR/01-1982&D3[a]	Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan	Planned[e]
DOE/OR/01-2457&D3[b]	Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee	An erratum approved by the regulators in December 2017 incorporated the substantive requirements of the *RCRA Post-Closure Permit for the Bear Creek Hydrogeologic Regime* (TNHW-116) into the BCV RAR CMP. An extensive revision of the RAR CMP to include the tenets of the LUCIP, as well as additional site-specific LUCs is in preparation.
DOE/OR/01-2466&D4[c]	East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee	An erratum approved by the regulators in December 2017 incorporated the substantive requirements of the *RCRA Post-closure Permit for the Chestnut Ridge Hydrogeologic Regime* (TNHW-128) and the *RCRA Post-Closure Permit for the Upper East Fork Poplar Creek Hydrogeologic Regime* (TNHW-113) into the EFPC/CR RAR CMP. An extensive revision of the RAR CMP to include the tenets of the LUCIP, as well as additional site-specific LUCs is planned.
DOE/OR/01-1820&D3[d]	Lower Watts Bar Reservoir and Clinch River/ Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee	Planned
DOE/OR/01-2477&D3	East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee	Completed incorporation of LUCs and LUCIP into RAR CMP; approved by regulators in January 2017.
DOE/OR/01-2478&D3	Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee	Completed incorporation of LUCs and LUCIP into RAR CMP; approved by regulators in January 2017.

[a]Previous title: *Water Resources Restoration Program Sampling and Analysis Plan for the Melton Valley Watershed, Oak Ridge Reservation, Oak Ridge, Tennessee.*

[b]Previous title: *Water Resources Restoration Program Sampling and Analysis Plan for the Bear Creek Valley Watershed, Oak Ridge Reservation, Oak Ridge, Tennessee.*

[c]Previous title: *Water Resources Restoration Program Sampling and Analysis Plan for the Upper East Fork Poplar Creek and Chestnut Ridge Watersheds, Oak Ridge Reservation, Oak Ridge, Tennessee.*

[d]Previous title: *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee.*

[e]A stand-alone *Land Use Control Implementation Plan for Melton Valley, Oak Ridge, Tennessee* (DOE/OR/01-1977&D6) was implemented in May 2006 and is certified annually. The requirements of this plan are scheduled to be incorporated into the existing CMP to supersede the existing LUCIP.

BCV = Bear Creek Valley
CMP = Comprehensive Monitoring Plan
CR = Chestnut Ridge
EFPC = East Fork Poplar Creek

Table 1.1. RAR CMPs and status of addition of LUCs (cont.)

LUC = land use control
LUCIP = Land Use Control Implementation Plan
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976

Throughout the document, unless specifically noted as federal AWQC, the acronym AWQC is referencing the Tennessee water quality criteria in TDEC Chapter 0400-40-03 (formerly Chapter 1200-04-03). Tennessee has surface water use classifications listed in TDEC, Chapter 0400-40-04 (formerly Chapter 1200-04-04), and assigns one or more of those uses to each surface water body in the state. Numeric and narrative AWQC are listed in Chapter 0400-40-03-.03 for each of these designated uses. For the designated uses set for streams on the ORR, only *Fish and Aquatic Life, Recreational Use* and *Domestic Water Supply* (e.g., Clinch River) have specific numeric AWQC provided for particular compounds. Unless stated otherwise, the most stringent of the applicable AWQC for the assigned designated uses for ORR surface waters were used in the RER for comparison to the surface water data.

Cleanup goals for groundwater on the ORR have yet to be determined and will be established under future CERCLA decisions for ORR watershed actions. The CERCLA National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires that federal SDWA MCLs and non-zero maximum contaminant level goals (MCLGs) be attained for all RAs for groundwaters that are current or potential sources of drinking water, where the MCLs/non-zero MCLGs are relevant and appropriate under the circumstances of the release [40 *Code of Federal Regulations* (CFR) 300.430(e)(2)(i)(B)-(C)]. Unless stated otherwise, the most stringent of the state or federal MCLs for ORR groundwater were used in the RER for comparison to groundwater data. Future groundwater RODs will determine use classification and/or cleanup goals for ORR groundwaters.

Select biological monitoring data are also collected and used to assess performance. The data provide a usable measure of overall improvements in aquatic conditions. However, unless indicated otherwise, these data are not intended to imply any conclusions regarding the status of ecological risk. The risk to ecological receptors for most watersheds will be evaluated in future studies such as RIs and addressed by final decisions for each of the watersheds.

1.5.1 Data Quality

The WRRP provides a framework of plans, procedures, and protocols to ensure that all data collected are managed in a manner consistent with CERCLA to support the evaluation of remediation effectiveness and human and ecological protectiveness. In accordance with this overall objective, the WRRP has developed the WRRP QAPP to identify and implement quality assurance requirements for use in sample collection, laboratory analysis, and data management of groundwater, surface water, sediment, and biota monitoring activities. These requirements ensure that appropriate levels of quality assurance and quality control are achieved and maintained. The *Data Management Implementation Plan for the Water Resources Restoration Program, Oak Ridge, Tennessee* (UCOR-4160) serves as the project-level plan for managing all data collected by the WRRP. Together, these plans identify the procedures that are followed in the collection, custody, and handling of samples, as well as verification, validation, and retention of environmental and laboratory data used by the WRRP in preparation of the annual RER and the CERCLA FYR. The WRRP occasionally uses data collected by other organizations on the ORR, e.g., the ORNL and Y-12 prime contractors, who have developed equivalent quality management systems in support of DOE program requirements defined in DOE Order 414.1D, *Quality Assurance* and 10 CFR 830, subpart A, *Quality Assurance Requirements*. Additional details of these organizations' data quality standards are provided in the WRRP QAPP.

Data quality objectives (DQOs) are prescribed to the WRRP by the respective CERCLA documentation of each remedial/removal action, along with any respective RAO or performance goal. These DQOs and RAOs are translated into performance monitoring requirements that are included in watershed-wide CMPs (i.e., the watershed RAR CMP), which includes the sample location, sampling frequency, number of samples, analytical and field parameters, quality assurance samples (e.g., field duplicates), and list of parameters for each monitoring location. This list of parameters is tied to the WRRP QAPP Appendix D, which provides the analyte, Chemical Abstracts Service number for each analyte (as applicable), the analytical method, a requested reporting limit, and the units for each parameter. The WRRP implements the monitoring plan in accordance with the sampling procedures included in the QAPP.

Samples are shipped to Sample Management Office (SMO) approved analytical laboratories that participate in the DOE Consolidated Audit Program (DOECAP). Under this program, qualified laboratories undergo rigorous onsite audits of their quality systems and programs. Laboratory performance is continually monitored using the Integrated Performance Indicator Program (IPIP). The IPIP includes criteria for meeting holding times, turnaround times, sample disposition, contract compliance verification, data deliverables, data validation performance, single-blind performance evaluation program, double-blind performance program, as well as audit performance/findings, responses, and corrective action close-out. Samples are processed and analyzed at the selected laboratory in accordance with the analytical methods specified in the statement of work to the requested project quantitation limit, if possible, for that sample. A data deliverable is generated by the laboratory and sent to the SMO.

Upon receipt of the data deliverable from the laboratory, the SMO analytical data manager, or designee, verifies the electronic data against the record copy of the results and conducts the contract compliance verification on each data package received. The SMO analytical project manager, who initially established the statement of work with the analytical laboratories to implement the requirements of the RAR CMPs, is also responsible for ensuring that the samples designated for validation in the monitoring plan are validated. Data validation is performed to ensure that the quality of the analytical data is adequate for their intended use and are performed on a certain percentage of the CERCLA-required data to the level necessary to minimize the potential of using false-positive or false-negative concentrations in the decision-making process (i.e., to ensure accurate identification of detected versus non-detected compounds). Where applicable, screens of incoming data versus historical data are completed and significantly different values are identified to evaluate potential data problems. The analytical data manager, or designee, is responsible for input of validation qualifiers into the analytical database, Project Environmental Measurements System (PEMS). Data are uploaded to the final, long-term repository of electronic environmental data, the Oak Ridge Environmental Information System (OREIS), within 30 days of submittal of the D1 to the regulators per the FFA.

1.6 LUCS

Verification of LUCs, which are part of remediation strategies, is performed to ensure the integrity of remedies is maintained until determined to be no longer necessary to maintain protection. The RAR CMPs are the primary documents where all implemented LUCs will be identified. Note that, as discussed in Section 1.4, there are some watersheds for which LUCs have not yet been added to the RAR CMP. For these cases, the decision document remains the reference for LUCs until the process of updating the RAR CMP is complete.

The RAR CMPs state:

> *The CERCLA remedy evaluation process begins with the expectation that treatment will be used to address principal threat wastes and that groundwater will be returned to its beneficial use. Because most of the remediation decisions for the ORR do not allow for UU/UE, LUCs are required at these sites.*
>
> *LUCs are any restriction or control, arising from the need to protect human health and the environment, that limits use of and/or exposure to any portion of that property, including water resources. LUCs encompass institutional controls (EPA 2000), such as property record restrictions, property record notices, zoning notices, Excavation/Penetration Permit Programs*

(EPPPs), easements, covenants, well drilling prohibitions, land use restrictions, zoning, permits, advisories, and other legal restrictions (EPA 2000) and access restrictions achieved by engineered barriers such as a fence or by human means such as security guards.

Note also that there are some DOE Programmatic controls (e.g., excavation/penetration permit [EPP] programs and access controls) presently in place that are maintained by the relevant Oak Ridge DOE Program. If these programmatic controls are no longer required by the relevant Program, they will be evaluated to determine if they are still necessary for the protection of human health and the environment. If deemed required, they will be added to the RAR CMP as a LUC. For simplicity in this RER, these DOE controls are covered under the term “LUC.”

The definitions encompassing LUCs have evolved over time, and earlier decision documents used the term “institutional controls.” This term “institutional controls” is used throughout this document when using citations directly from these earlier decision documents. Similar to property record restriction, the term “deed restriction” is used in older CERCLA decision documents for sites such as the Filled Coal Ash Pond (FCAP) and Kerr Hollow Quarry (KHQ) on Chestnut Ridge, and Spoil Area 1 and SY-200 Yard in BCV.

1.6.1 Tracking LUCs

Information about LUCs used in this document was collected and/or compiled by DOE OREM through the WRRP in conjunction with surveillance and maintenance (S&M) programs at ETTP, ORNL, and Y-12. Additionally, LUCs are coordinated with the National Nuclear Security Administration (NNSA) and DOE’s Office of Science through their contractors Consolidated Nuclear Security, LLC (CNS) and University of Tennessee-Battelle, LLC (UT-B), respectively.

Site-specific inspections to assess the condition of the remedies and the required controls are performed by the DOE OREM S&M programs in accordance with site-specific S&M plans. System operating plans and/or procedures are used to maintain other operating systems by CNS and UT-B. Inspection checklists are completed electronically for each location and with the exception of the ORNL sites that use their own maintenance process, the checklists are linked to any needed maintenance request forms in the Land Use Manager (LUM) web-based application. This documentation is maintained electronically in LUM and hard copies are ultimately filed in the OREM contractor managed Document Management Center. The WRRP routinely reviews the status of these checklists in LUM to monitor effectiveness and to summarize verification of LUCs annually in the RER.

Documentation verifying the implementation of LUCs, i.e., property record restrictions, property record notices, access controls, and EPP programs, is obtained from many sources, including the County Register of Deeds offices for property record restrictions and property record notices, the City Planning Commission for zoning notices, and project engineers for the EPP program. Copies of this documentation are obtained by the WRRP and maintained with the project files.

The *Memorandum of Understanding for Implementation of a Land Use Control Assurance Plan (LUCAP) for the United States Department of Energy Oak Ridge Reservation* (LUCAP; DOE/OR/01-1824&D1/A2) requires that the Manager, DOE Oak Ridge Operations (ORO), annually verify in the RER that approved LUCs have been or are being implemented on the Oak Ridge Site. Only approved LUCs for MV, BV, and ETTP currently require an annual certification, and this annual certification is in Appendix A. The Manager of the OREM is now identified as the designated official for this certification.

1.6.1.1 LUM tracking system

In 2013, a new electronic data entry and tracking system was implemented in the field to help consolidate the more than 200 data and progress tracking spreadsheets that were being generated each year for LUCs. The LUM software streamlines the stewardship tracking process for more than 90 ORR CERCLA and RCRA sites and generates consistent, real-time information. LUM went live in 2014 and serves as the administrative record for site inspection checklists.

Advantages of LUM include centralized data storage; standardized content and reports; easy access in field; paperless or standard inspection template; accountable record of CERCLA/RCRA required inspections; efficient tracking of LUCs (helps ensure nothing is missed); query function; and automatic e-mail reminders and notifications regarding upcoming inspections, outstanding issues, site maintenance requests, and corrective actions. This new tracking process facilitates the monitoring and implementation of LUC activities across the ORR.

1.7 ORR RAINFALL

The quantity, duration, and intensity of rainfall affect contaminant concentrations in groundwater and surface water across the ORR. Because of this, general rainfall trends for FY 2018 are summarized to provide a general context for the remainder of this document.

Details of rainfall distribution for FY 2018 are illustrated in Figure 1.4. Mean monthly rainfall values for FY 2018 range from approximately 2 in./mo. to 10.4 in./mo. During FY 2018, the greatest monthly rainfall occurred in February 2018 during which approximately 10.4 in. of rainfall fell across the ORR. The lowest monthly rainfall occurred during January 2018 with approximately 2.02 in. of rain. During FY 2018, rainfall distribution was somewhat uneven with three months (October, February, and September) experiencing rainfall more than one inch greater than the long-term monthly average, and four months (November, December, January, and May) experiencing rainfall more than one inch less than the long-term monthly average. The remainder of the months experienced nearly average rainfall levels.

Total average rainfall in the ORR area during FY 2018 (Figure 1.5) was 58.89 in. based on a composite of four rain gauge stations located throughout the ORR and one located in Oak Ridge. As shown in Figure 1.6, one of the rain gauges is located at ETTP (K-1209RG), two of the rain gauges are located at Y-12 (Y-12_RG-West and TOWY [TOWE data was used prior to 2006 when TOWY was constructed]); one rain gauge is located at ORNL (formerly TOWC which was replaced by newly constructed TOWD at essentially the same location); and the Oak Ridge Townsite rain gauge (KOQT) is located at the Federal Office Building. The total rainfall during FY 2018 was nearly 4 in. more than the long-term mean of 54 in./yr. The somewhat above average annual rainfall is reflected in somewhat increased contaminant flux values at several monitoring locations.

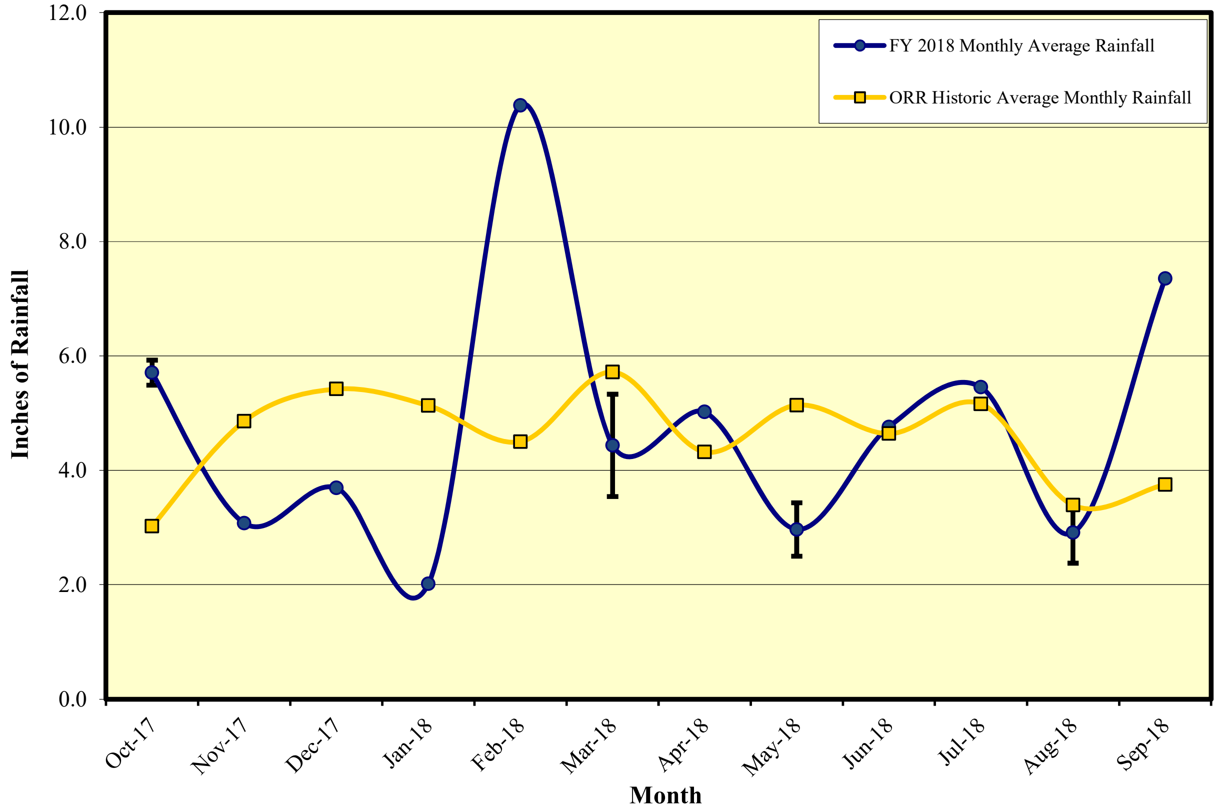

Figure 1.4. FY 2018 monthly average rainfall from five rain gauges in the ORR area.

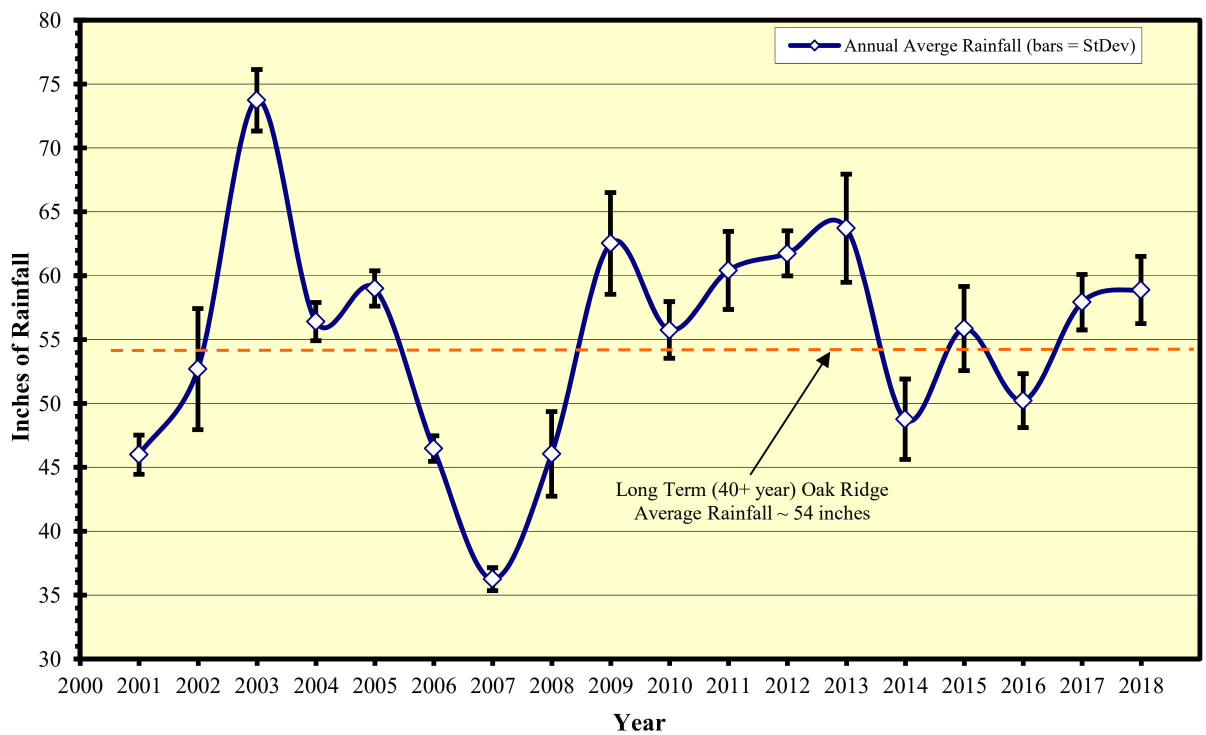

Figure 1.5. Mean annual rainfall from five rain gauges in the ORR area, FY 2001 – 2018.

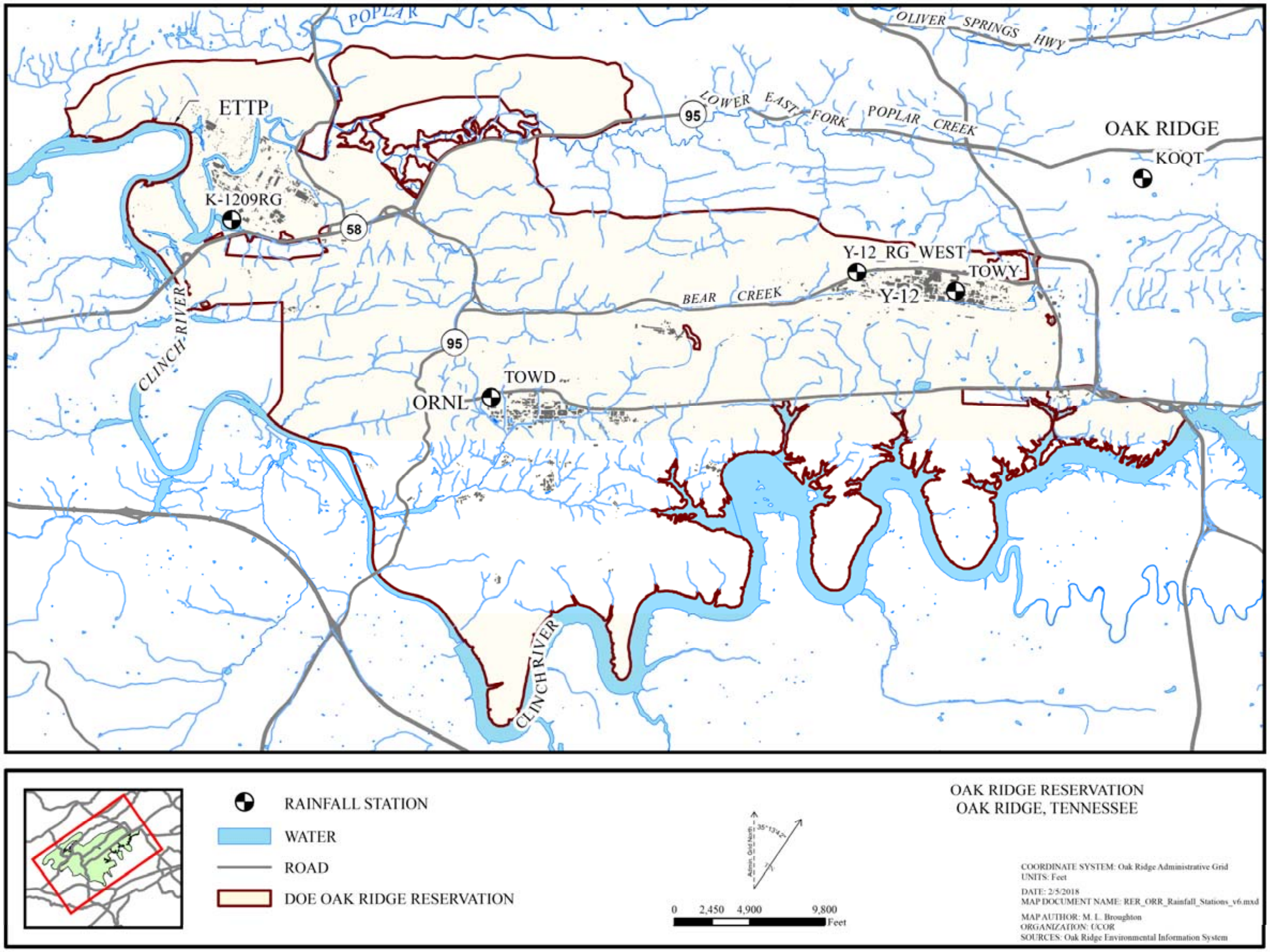

Figure 1.6. Location of rain gauge stations.

1.8 DOCUMENT ORGANIZATION

The RER contains the chapters listed below. Figure 1.1 shows the location of CERCLA actions evaluated in the RER by chapter.

Two CERCLA actions (Waste Area Grouping [WAG] 13 Cesium Plots and White Oak Creek Embayment [WOCE] Sediment Retention Structure) are located outside of the existing decision boundary for MV, but are included in Chapter 3 because of their proximity to other MV actions. The Union Valley Interim ROD action addresses an offsite area east of the ORR, but the action is included in Chapter 6 along with the associated East End Volatile Organic Compounds (EEVOCs) plume action at Y-12 in the UEFPC decision area. The offsite actions downstream of the ORR, LEFPC, Clinch River/Poplar Creek, and LWBR, are evaluated in Chapter 7. Two other sites (WWSY and ORAU SCF) that are located on the ORR but outside the watershed-scale decision areas are evaluated in Chapter 9.

Each chapter identifies completed watershed-scale actions and completed single-project actions with monitoring or LUCs. For each chapter, the following information is provided:

- Update on FY 2018 activities;
- Assessment summary (summary of the performance monitoring evaluations and verification of LUCs contained in the chapter);
- Description of the completed actions;
- Description of required performance monitoring and effectiveness evaluations for completed actions (When insufficient data exist to assess the impact of the completed actions, a preliminary evaluation is made of early indicators of effectiveness at the watershed-scale, such as contaminant trends at surface water IPs);
- Description of LUCs and verification for completed actions (includes facility operations and site inspection and maintenance);
- Issues and recommendations.

Actions that do not have monitoring or LUCs or have been terminated or superseded by subsequent actions are not discussed.

The *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2) includes a compendium of all CERCLA decisions.

1.9 ISSUES AND RECOMMENDATIONS

To track issues through their resolution, Table 1.2 is a compilation of the issues and recommendations identified by DOE in subsequent chapters of this RER and unresolved issues carried forward from a previous RER. Beginning with the 2015 RER, a trackable RER issue is defined as an item identified in the effectiveness evaluation that:

- is for a completed CERCLA action, and

- does not meet a performance standard or goal specified in a ROD, or completion document (e.g., RAR, phased construction completion report [PCCR], etc.), as appropriate. For example, monitoring results exceed a performance level over a period of time or LUCs were not implemented or maintained as specified and a timely repair was not able to be made, and

- does not already have an identified path forward through planned remedy maintenance actions or designated future CERCLA actions.

Other factors may be considered when determining if an item is a trackable RER issue (e.g., unusual climatic conditions, intermittent nature of exceedance, etc.). Observations from monitoring data (e.g., trends) and LUC verification are highlighted in the Executive Summary of the RER.

Table 1.3 identifies those issues that are completed/resolved in this RER and will no longer be tracked in future RERs. Table 1.4 is a summary of open and closed issues and recommendations from the 2016 FYR.

An issue that is carried forward from a previous year's RER is only discussed in the respective chapter of the text if FY 2018 assessment clarifies, modifies, or otherwise impacts the issue in any way. For example, because issues in Table 1.2 may require completion of future actions, those particular issues will remain in the table for tracking purposes, but generally will not be discussed in any detail in the respective chapter.

Table 1.2. 2019 RER issues and recommendations
(New issues identified in this RER are in blue text.)

Issue[a]	Recommendation/resolution	Responsible parties	Target response date
ORNL – BV			
1. Three wells in SWSA 3 have chronically not attained the ROD goal for groundwater level control within hydrologically isolated areas. (2019 RER)	1. Three wells in SWSA 3 (0482, 0491, and 0492) have chronically not met target groundwater elevations because of well construction or location conditions. These wells are constructed with the majority of their screened intervals extending into bedrock. These deeper wells are prone to responding to groundwater levels affected by conditions outside the hydrologic isolation area. As a result, these wells are not good indicators of hydrologic isolation effectiveness. While the target groundwater elevations have not been met in these three wells, the SWSA 3 hydrologic isolation remedy has achieved reduced contaminant discharges into surface water as well as reductions in groundwater contamination in area monitoring wells. Surface water discharges of Sr-90 in Northwest Tributary and Raccoon Creek have decreased significantly as a result of hydrologic isolation of shallow buried waste at SWSA 3 and the Contractor's Landfill. Groundwater contaminant trend evaluations for the previous 10-year and 5-year periods show that the number of groundwater contaminants that occur at concentrations near or above Primary Drinking Water MCLs has decreased since site remediation and the concentration trends for the remaining contaminants are decreasing, stable, or indeterminate. While monitoring and reporting of groundwater levels at wells 0482, 0491, and 0492 will continue, it is recommended that for these three wells, alternative performance indicators such as groundwater contaminant trends and contaminant fluxes in Northwest Tributary and Raccoon Creek, be used to evaluate the hydrologic isolation effectiveness at SWSA 3.This is a new issue in this RER and alternative performance indicators will be discussed with the Project Team.	DOE	2020 RER (2037 is the FFA Appendix J date for a BV Final ROD to address groundwater)
ORNL – MV			
1. Two wells in SWSA 4 have chronically not attained the ROD goal for groundwater level control within hydrologically isolated areas. (2015 RER)	1. Two wells in SWSA 4 (0955 and 0958) have not attained the ROD goal for groundwater level control inside hydrologically isolated areas. Wells 0955 and 0958, which are located near the SWSA 4 DGT, have exhibited recurring exceedances of their target groundwater elevations. During FY 2018, six of the 12 monthly groundwater level measurements at well 0955 exceeded the target elevation goal, and three of the four quarterly groundwater level measurements at well 0958 exceeded their target elevation goal. Beginning in late FY 2015, DOE implemented an enhanced frequency of maintenance and	DOE	2020 RER (2036 is the FFA Appendix J date for a MV Final ROD to address groundwater)

Table 1.2. 2018 RER issues and recommendations (cont.)
(New issues identified in this RER are in blue text.)

Issue[a]	Recommendation/resolution	Responsible parties	Target response date
	operations inspections of the SWSA 4 downgradient groundwater collection trench, which probably contributes to better overall groundwater level suppression in the collection trench and adjacent areas. Additionally an on-going hydrologic evaluation has been implemented and is ongoing to identify potential additional improvements to SWSA 4 DGT performance continued in FY 2018. This evaluation noted several system enhancements for more continuous operation of the pumps in the DGT; this evaluation is ongoing. These actions are expected to lower groundwater elevations at well 0955 and 0958 to attain the target elevation. It is also recommended that well 0955 have continuous water level readings to further support system evaluation and performance. This issue for wells 0955 and 0958 is carried forward in this RER.		
2. Groundwater levels at one well located near the western portion of SWSA 4 and two wells located near the center of the SWSA 4 cap exceeded the ROD goal for groundwater level control within hydrologically isolated areas. (2015 RER and 2018 RER)	2. Well 1071 near the western portion of SWSA 4 and wells 4544 and 4545 near the center of the SWSA 4 cap experienced target groundwater elevation exceedances during FY 2018. Well 1071 is screened in bedrock between 784.96 and 800.71 ft aMSL and is located approximately 60 ft inside of the upgradient storm diversion drain which has a bottom elevation of approximately 806 ft aMSL. Based on this construction geometry, the UGT would not be capable of controlling groundwater from the upslope side of Lagoon Road from affecting the groundwater elevation measured at well 1071. Target groundwater elevation exceedances in wells 4544 and 4545 are thought to be related to either hydrologic isolation cap defects or seepage from the upgradient stormflow diversion trench area. DOE is in the process of evaluating groundwater level control at SWSA 4 and will discuss well performance with the Project Team. The issues associated with these three wells continue to be an issue in this RER.	DOE	2020 RER (2036 is the FFA Appendix J date for a MV Final ROD to address groundwater)
3. Two wells near SWSA 6 have chronically not attained the ROD goal for groundwater level control within hydrologically isolated areas. (2015 RER)	3. Two wells in SWSA 6 (0850 and 4127) have not attained the ROD goal for groundwater level control inside hydrologically isolated areas. Wells 4127 and 0850 have chronically not met target groundwater elevations because of well construction or location conditions. Both of these wells are constructed with the majority of their screened intervals extending into bedrock. These deeper wells are prone to responding to groundwater levels affected by conditions outside the hydrologic isolation area such as groundwater recharge in confined to semi-confined zones that extend beneath the waste units. As a result, these wells are not good indicators of hydrologic isolation effectiveness. DOE samples a number of locations along the edge of SWSA 6 to understand changes in groundwater contaminant conditions	DOE	2020 RER (2036 is the FFA Appendix J date for a MV Final ROD to address groundwater)

Table 1.2. 2018 RER issues and recommendations (cont.)
(New issues identified in this RER are in blue text.)

Issue[a]	Recommendation/resolution	Responsible parties	Target response date
	following MV Interim ROD RA. Three sampling locations (well 0838, the SFD, and surface water location WAG6 MS3) provide definitive evidence that the SWSA 6 hydrologic isolation remedy is effective. While monitoring and reporting of groundwater levels at wells 4127 and 0850 will continue, it is recommended that alternative performance indicators be used to evaluate the hydrologic isolation effectiveness at SWSA 6. These measures include the continued monitoring of tritium concentrations at 0838, SFD, and WAG6 MS3. This issue is carried forward in this RER and alterative performance indicators will be discussed with the Project Team.		
	Y-12 – BCV		
1. Surface water goals are not met for cadmium near S-3 Ponds. (2016 RER)	1. Prioritize/Sequence RA as stipulated by the BCV Phase I ROD.	FFA Parties	Sequencing is discussed yearly by the FFA Parties
2. Surface water goals are not met for uranium in NT-8 and consequently at BCK 9.2. (2016 RER)	2. Approve source control ROD for BCBGs and implement a remedy.	FFA Parties	Sequencing is discussed yearly by the FFA Parties

[a]The year of the RER in which the issue originated is provided in parentheses, e.g., (2013 RER).

aMSL = above Mean Sea Level
BCBG = Bear Creek Burial Ground
BCK = Bear Creek kilometer
BCV = Bear Creek Valley
BV = Bethel Valley
DGT = downgradient trench
DOE = U.S. Department of Energy
FFA = Federal Facility Agreement
FY = fiscal year
MCL = maximum contaminant level
MV = Melton Valley
NT = North Tributary
ORNL = Oak Ridge National Laboratory
RA = remedial action
RER = Remediation Effectiveness Report
ROD = Record of Decision
SFD = South French Drain
SWSA = Solid Waste Storage Area
UGT = upgradient trench
Y-12 = Y-12 National Security Complex

Table 1.3. RER issues completed/resolved in FY 2018

Issue	Recommendation/resolution	Responsible parties	Target response date
		Primary/support	
No RER issues were completed/resolved in FY 2018.			

FY = fiscal year
RER = Remediation Effectiveness Report

Table 1.4. 2016 FYR summary of open and closed issues/recommendations and follow-up actions[a]

DOE FYR Issue # [CERCLIS OU #]	Issue or additional finding	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b]	
						Current	Future
			MV Actions				
Closed MV-1 [OU 29]	MV ROD: Performance issues with the MV extraction system have continued, and review of the system for upgrades and reduced maintenance is recommended.	A preliminary review of the performance of the MV extraction system was recommended and was completed based on information collected during the 2016 FYR Site Visit (06/10/15), Site Manager Interview (05/7/15), and SmartSite checklist review meeting (02/17/16). This recommended additional assessment was completed in FY 2017 and is included in Appendix B.6 of the 2018 RER. In summary, an increased frequency of inspections is now implemented on the system and an engineering evaluation has been completed. Recommendations from the engineering evaluation included reconfiguration and reprogramming of pump controls, rewiring of indicator lights, replacement of existing compressed air pumps with continuous duty pumps, and maintaining an inventory of required materials. The long term documentation of MV groundwater extraction system performance is maintained in the LUM, a web-based data management application for implementing, maintaining, and verifying engineering controls, as provided by system operations personnel.	DOE	EPA/TDEC	9/30/2018 RER. Status: The 2018 RER closed this FYR issue. The Project Team was briefed on October 18, 2017, about the path forward for repair and potential upgrades of system components performed under this maintenance activity.	N	N
			BCV Actions				
Open BCV-1 [OU 32]	BCV ROD: The surface water goals for uranium are not being met at BCK 9.2, the IP. NT-8 near the BCBGs continues to be the largest contributor of uranium to Bear Creek and BCK 9.2. Additionally, Bear Creek concentrations exceed AWQC for aquatic life.	It is recommended that implementation of excess flux contributions to Bear Creek be evaluated in the final BCV ROD and/or BCBG ROD. The S-3 Ponds Pathways 1-3 will address Bear Creek concentrations that exceed aquatic life standards	DOE	EPA/TDEC	Final BCV ROD: Start 09/30/2038, ROD 09/30/2039, RAR 09/30/2042 BCBG ROD: Start 09/30/2031, ROD 09/30/2034, RAR 09/30/2042 Status: This issue will continue to exist until a future source control ROD for the BCBGs and implementation of a remedy address the contamination source.	Y	Y

Table 1.4. 2016 FYR summary of closed issues and recommendations and follow-up actions[a] (cont.)

DOE FYR Issue # [CERCLIS OU #]	Issue or additional finding	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b]	
						Current	Future
		Chestnut Ridge Actions					
Closed CR-1 [OU 26]	FCAP ROD: A protectiveness statement for aquatic life cannot be made at this time. Additionally, the effectiveness of the passive wetland system may be diminishing over time. Water flow across the wetlands is channelized along the outer edges, rather than flowing across the entire wetland due to buildup of sediment or organic matter, and an invasive plant species is displacing the indigenous cattail community.	The recommendations from the 2016 FYR are now complete. These included investigations to accurately estimate the fish population and health in Rogers Quarry, better quantification and source of the selenium exposure in the quarry, and reexamination of the wetland to determine if improvements to the physical conditions are necessary to increase efficiency. Enhanced surface water monitoring determined that hydrologic residence time in the wetland was limited and that material transport was heavily influenced by the intensity and duration of precipitation events. Composite flow-paced monitoring is recommended for the passive treatment wetland to account for temporal and seasonal variations in wetland treatment conditions. Maintenance activities are planned in FY 2019 to improve the physical conditions within the wetland. An additional dye trace is recommended following reestablishment of the wetland to evaluate changes in hydrologic treatment time. The FCAP and Upper McCoy Branch remain as potential source contributors of ash-containing materials. Monitoring of surface and streambank erosion is recommended to estimate the potential volume of transported material. Annual variations in fish health monitored through additional biologic monitoring indicated that fish exposures to selenium were transitory. Additional monitoring to augment routine biological monitoring is recommended to evaluate changes in fish health and selenium exposure.	DOE	EPA/TDEC	09/30/2019 RER. Status: This 2019 RER presents the conclusions of the FCAP investigations that were conducted based on the recommendations from the 2016 FYR. The investigations to address this issue began in FY 2017 and were reported in Appendix C.1 of the 2018 RER. The additional biological monitoring, evaluation of the physical condition of the wetland and the assessment of material transport within the system continued through FY 2018 and is presented in Appendix C.1 of this 2019 RER. This closes the FYR issues regarding the FCAP investigations.	N	N

Table 1.4. 2016 FYR summary of closed issues and recommendations and follow-up actions[a] (cont.)

DOE FYR Issue # [CERCLIS OU #]	Issue or additional finding	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b]	
						Current	Future
UEFPC Actions							
Open UEF-1 [OU 28]	UEFPC Phase I ROD: Mercury concentrations at Station 17 are above the 200 ppt performance goal. Hg concentrations in fish in EFPC have yet to respond to reductions of mercury from historical response actions.	Remedial measures have not been completed under the UEFPC Phase I ROD. Implementation of actions under the Phase I ROD and the Mercury Mitigation Strategy are planned, including the Outfall 200 MTF.	DOE	EPA/TDEC	Outfall 200 MTF Construction Start 09/30/2018 Status: In FY 2018, an *Remedial Design Report/Remedial Action Work Plan for Water Treatment at Outfall 200 in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (RDR/RAWP; DOE/OR/01-2735&D2) for the facility was finalized and early site preparation including the construction of the necessary utilities and the demolition of existing structures was started. The scope of the RA includes the construction and operation of the facility with a treatment capacity for 3000 gpm of influent surface water. The facility will also store up to 2 million gal of additional storm water collected during higher storm flow conditions. The contract to build the treatment facility was awarded in November 2018.	Y	Y
Additional findings							
Closed [OU 02]	The Mercury RmA was successful in removing the mercury from the storm drains; over 25 lb of a mercury waste stream was removed. Since 2014, no mercury has been removed from the traps.	It was recommended and (recommendation) implemented that further efforts to maintain and monitor the mercury traps be terminated. A RmAR revision was submitted to terminate this removal action as the original removal is complete. The revised RmAR documents that the objectives of the *Action Memorandum for Time-Critical Removal Action for the Removal of Mercury from the Storm Sewer System at the Y-12 National Security Complex, Oak Ridge, Tennessee* (DOE/OR/01-2574&D1) have been met and the removal action terminated.	DOE	EPA/TDEC	Status: Closed. A revision to the *Removal Action Report for the Mercury Reduction Project at the Y-12 National Security Complex, Oak Ridge, Tennessee* (DOE/OR/01-2595&D1/R1) was approved in FY 2017.	NA	NA

Table 1.4. 2016 FYR summary of closed issues and recommendations and follow-up actions[a] (cont.)

DOE FYR Issue # [CERCLIS OU #]	Issue or additional finding	Recommendation and follow-up action	Party responsible	Oversight agency	Milestone date	Affects Protectiveness? (Y/N)[b] Current	Affects Protectiveness? (Y/N)[b] Future
Open Additional Finding [OU 21]	ETTP Ponds RmA: Performance monitoring at the **K-1007-P1 Holding Pond** suggests that PCB concentrations in fish and clams are declining and the "remediation levels are trending toward a successful endpoint." However, there is some evidence of population increases in less desirable fish species (e.g., largemouth bass, gizzard shad) and reduction of plant cover in 2016. Furthermore, monitoring at the **K-901-A Holding Pond** indicates the common carp and gizzard shad fish have not attained the PCB concentration goals identified in the RmAR.	**K-1007-P1 Holding Pond**: Additional management actions identified in the RmAR for the Ponds RmA (DOE/OR/01-2456&D1R1) were recommended. and implemented. After discussions with EPA and TDEC, DOE agreed to conduct additional management actions at the K-1007-P1 Holding Pond and the K-901-A Holding Pond in FY 2017 and FY 2018 in an effort to decrease human and ecological risks from PCBs in fish. The additional activities are specified in letters from DOE to EPA and TDEC dated December 29, 2016 (for the K-1007-P1 Holding Pond), and September 7, 2017 (for the K-901-A Holding Pond). The additional actions included fish management (including fish removals and stocking) and plant management (including within pond and riparian areas). Performance monitoring will also be conducted during the period from 2017 through the next FYR in 2021. Results assessing recent management actions will be reported in the annual RERs and the next FYR.	DOE	EPA/TDEC	Report on additional management actions and performance monitoring in the 2018 to 2021 RER and 2021 FYR Status: Results of management actions for FY 2017 were included in Appendix C.2 of the 2018 RER. Results for FY 2018 are included in Appendix C.2 of this 2019 RER.	NA	NA
Closed Additional Finding [OU 47]	The Mitchell Branch hexavalent chromium groundwater concentrations in the IWs and plume MWs have declined significantly	Based on the combination of lower hexavalent chromium concentrations with increased operational challenges, a re-evaluation was recommended and completed on the management of the groundwater contaminated with chromium to determine if the current response action is the optimum long-term action. The re-evaluation performed in October 2016 concluded that the instream concentration of hexavalent chromium has decreased dramatically and is likely to drop below AWQC in the next two to three years. When the future ROD that addresses groundwater and surface water is prepared, the need for the IW should be re-evaluated.	DOE	EPA/TDEC	ETTP Sitewide ROD Status: Closed. A re-evaluation was performed in October 2016 and documented in the *Addendum to the Removal Action Report for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee, for the Test Plan to Turn Off the Interception Wells* (DOE/OR/01-2598&D2/A1/R1).	N	N

[a]Issues, recommendations, and additional findings are from the 2016 FYR, (DOE/OR/01-2718&D2), status as of September 30, 2018.
[b]Assumes that the proposed recommendation has not been implemented.

AWQC = ambient water quality criteria
BCBG = Bear Creek Burial Grounds
BCK = Bear Creek kilometer
BCV = Bear Creek Valley

Table 1.4. 2016 FYR summary of closed issues and recommendations and follow-up actions[a] (cont.)

CERCLIS = Comprehensive Environmental Response, Compensation, and Liability Information System
CR = Chestnut Ridge
DOE = U.S. Department of Energy
EFPC = East Fork Poplar Creek
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park
FCAP = Filled Coal Ash Pond
FY = fiscal year
FYR = Five-Year Review
IP = integration point
IW = interception well
LUM = Land Use Manager
MTF = Mercury Treatment Facility
MV = Melton Valley
MW = monitoring well
N = No
NA = not applicable
NT = North Tributary
OU = operable unit
PCB = polychlorinated biphenyl
RA = remedial action
RAR = Remedial Action Report
RAWP = Remedial Action Work Plan
RDR = Remedial Design Report
RER = Remediation Effectiveness Report
RmA = removal action
RmAR = Removal Action Report
ROD = Record of Decision
TDEC = Tennessee Department of Environment and Conservation
UEFPC = Upper East Fork Poplar Creek
Y = Yes

1.10 REFERENCES

DOE/OR/01-1750&D4. *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1824&D1/A2. *Memorandum of Understanding for Implementation of a Land Use Control Assurance Plan (LUCAP) for the United States Department of Energy Oak Ridge Reservation.* Attachment: *Land Use Control Assurance Plan for the Oak Ridge Reservation,* Oak Ridge, TN, 2010, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1826&D3. *Record of Decision for Interim Actions in the Melton Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1862&D4. *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1951&D3. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1977&D6. *Land Use Control Implementation Plan for Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2006, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1997&D2. *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee,* 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2229&D3. *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek, Oak Ridge, Tennessee*, 2006, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2628&D2. *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, 2014, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2715&D2_R. *Offsite Groundwater Assessment Remedial Site Evaluation, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2756&D1. *Phase 1 Melton Valley/Bethel Valley Exit Pathway Remedial Investigation Work Plan for the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2788&D1. *Remedial Site Evaluation Phase 2 Offsite Detection Monitoring Work Plan, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR-1014. *Federal Facility Agreement for Oak Ridge Reservation*, 1992, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

NRC 2002. *Environmental Cleanup at Navy Facilities: Adaptive Site Management*, National Academy Press, Washington, D.C.

TNHW-113. *RCRA Post-Closure Permit for the Upper East Fork Poplar Creek Hydrogeologic Regime*, 2003, Y-12 National Nuclear Security Complex, Oak Ridge, Tennessee, EPA I.D. No. TN3 89 009 0001, September 2003, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

TNHW-116. *RCRA Post-Closure Permit for the Bear Creek Hydrogeologic Regime*, 2003, Y-12 National Nuclear Security Complex, Oak Ridge, Tennessee, EPA I.D. No. TN3 89 009 0001, September 2003, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

TNHW-128. *RCRA Post-closure Permit for the Chestnut Ridge Hydrogeologic Regime*, 2006, Y-12 National Nuclear Security Complex, Oak Ridge, Tennessee, EPA I.D. No. TN3 89 009 0001, September 2006, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

UCOR-4049. *Quality Assurance Project Plan for the Water Resources Restoration Program, U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*, latest revision, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

UCOR-4160. *Data Management Implementation Plan for the Water Resources Restoration Program, Oak Ridge, Tennessee*, latest revision, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

2. ORNL – BV

2.1 INTRODUCTION AND STATUS

2.1.1 Introduction

The BV watershed, located in the southwestern portion of the ORR, is the site of the main plant area of ORNL. Figure 2.1 shows locations of CERCLA actions in BV that require monitoring and/or LUCs and illustrates ROD-designated end uses. In subsequent sections, the effectiveness of each completed action is assessed by reviewing performance monitoring objectives and results and verifying LUCs.

Completed CERCLA actions in the BV watershed are gauged against their respective action-specific goals. However, because all planned CERCLA actions have not been completed, monitoring of baseline conditions is conducted against which the effectiveness of the actions can be evaluated in the future. The collected data provide a preliminary evaluation of the early indicators of effectiveness at the watershed-scale.

Table H.1 in Appendix H lists all completed CERCLA actions in BV and the corresponding completion documents and identifies whether monitoring or LUCs are required. Figure H.1 in Appendix H is a location map of the actions and illustrates ROD-designated end uses in BV. For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions in the watershed within the context of a contaminant release conceptual model is provided in Chapter 6 of Volume 1 of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2). This information is updated in the annual RER and every fifth year in the CERCLA FYR.

2.1.2 Status Update

The *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (BV Interim ROD; DOE/OR/01-1862&D4) includes a combination of RAs and facility decontamination and decommissioning (D&D) projects. No work under the BV Interim ROD was completed in FY 2018.

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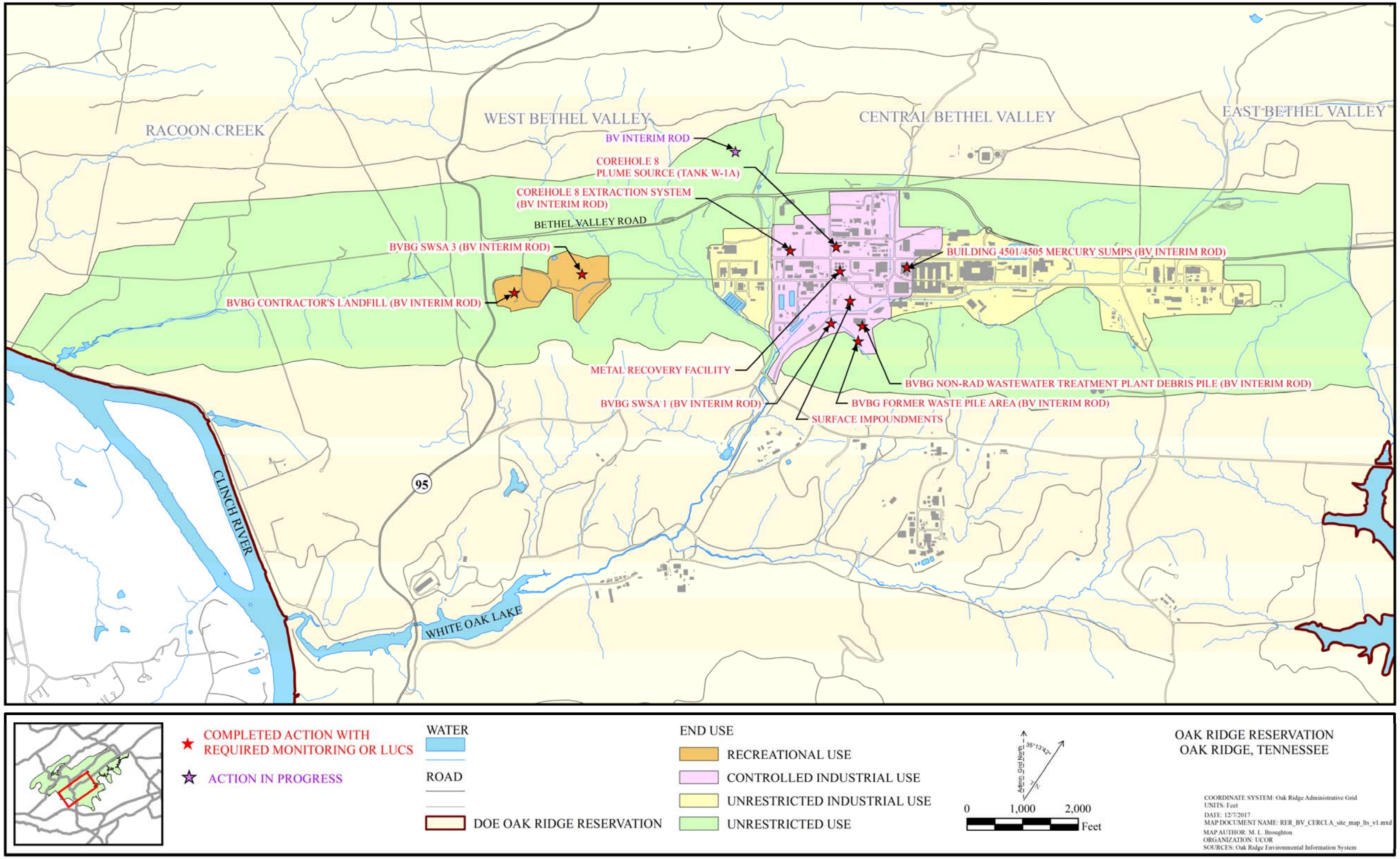

Figure 2.1. Completed CERCLA actions with required monitoring or LUCs in BV and end uses in BV.

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2.2 ASSESSMENT SUMMARY

A summary of the BV assessment for FY 2018 is provided below, followed by more detailed evaluations.

2.2.1 Performance Summary

The CERCLA actions completed to date in BV include some RA and building D&D projects under the BV Interim ROD (not all remediation activities in the BV Interim ROD have been implemented) and several single-project CERCLA actions intended to reduce contaminant mass and subsequent migration as measured at various assessment points.

- Sr-90 at 7500 Bridge weir, the BV watershed IP, met the ROD goal of 37 pCi/L with an annual average value of 36.7 pCi/L in the continuous, flow-paced composite samples. Consistent with recent years, non-point Sr-90 seepage to White Oak Creek (WOC) and discharges from the PWTC were the two main sources contributing Sr-90 to WOC. Ungauged groundwater contamination influxes to WOC may be associated the former Surface Impoundment Operable Unit (SIOU) and the PWTC.

- The Corehole 8 Extraction System met its performance goal based on Sr-90 flux reduction at First Creek during FY 2018. The system's interception of the Corehole 8 plume was effective at protecting surface water quality in First Creek. At well 4570, which monitors the Corehole 8 plume at about 220 ft below ground surface (bgs), Sr-90 concentrations fluctuated between about 15,000 and 20,000 pCi/L during FY 2018 and U-233/234 concentrations fluctuated between about 1,000 – 1,500 pCi/L. An increasing groundwater concentration trend for Sr-90 and U-233/234 in deep well 4570 following the Tank W-1A excavation appears to have moderated in the FY 2015 through FY 2018 period.

- Three wells in SWSA 3 (0482, 0491, and 0492) have chronically not met target groundwater elevations because of either well construction and/or location conditions. These wells are constructed with the majority of their screened intervals extending into bedrock. Since these deeper wells are prone to responding to groundwater levels affected by conditions outside the hydrologic isolation area, they are not good indicators of hydrologic isolation effectiveness. While the target groundwater elevations have not been met in these three wells, the SWSA 3 hydrologic isolation remedy has achieved reduced contaminant discharges into surface water as well as reductions in groundwater contamination in area monitoring wells. Surface water discharges of Sr-90 in Northwest Tributary and Raccoon Creek have decreased significantly as a result of the hydrologic isolation of shallow buried waste at SWSA 3 and the Contractor's Landfill. Groundwater contaminant trend evaluations for the previous 10-year and 5-year periods show that the number of groundwater contaminants that occur at concentrations near or above Primary Drinking Water MCLs has decreased since site remediation and the remaining contaminants are decreasing, stable, or indeterminate. While monitoring and reporting of groundwater levels at wells 0482, 0491, and 0492 will continue, it is recommended that for these three wells, alternative performance indicators, such as groundwater contaminant trends and contaminant fluxes in Northwest Tributary and Raccoon Creek, be used to evaluate the hydrologic isolation effectiveness at SWSA 3. This is a new issue in this RER and alternative performance indicators will be discussed with the Project Team.

- During FY 2018, a sample collected at the 7500 Bridge in September 2018 had an elevated mercury concentration of 93.5 ng/L. The suspected source of that elevated mercury was discharges from the PWTC which was undergoing construction activities. CERCLA actions at Building 4501 to re-route and pre-treat mercury contaminated building sump water are shown to be effective at reducing mercury concentrations in the receiving reach of WOC. Mercury concentrations measured at WOC-105, located a short distance downstream from the former storm drain discharge from Building 4501, were less than the AWQC level in FY 2018 samples.

- Wells 4645, 4646, and 4647 monitor groundwater in the Raccoon Creek headwater area. These exit pathway wells did not contain contaminant concentrations above drinking water criteria in FY 2018. At wells 4645 and 4646, Sr-90 was not detected in FY 2018. At well 4647, the shallowest of these wells, Sr-90 was detected at 0.479 J and 3.02 pCi/L in the December 2017 and June 2018 samples, respectively. Well 4647 is used to sample groundwater from the soil/bedrock interface near Raccoon Creek and has fairly consistently exhibited the presence of Sr-90 at low levels.

- Volatile organic compound (VOC) contaminants in groundwater in the BV 7000 area continue to show benefits of the increased dehalogenating microbial stimulation from the treatability study activities conducted in FY 2011.

- The observed improvement in redbreast sunfish mercury concentrations to levels below the EPA-recommended fish-based AWQC for mercury (0.3 µg/g) continued in WOC, although concentrations in largemouth bass from White Oak Lake (WOL) exceeded the AWQC value in 2018 (the AWQC value is not a ROD goal, but is used as a screening level). Polychlorinated biphenyl (PCB) concentrations remain elevated in redbreast sunfish from WOC, and, like mercury, the highest PCB levels are in largemouth bass from WOL (1.90 µg/g). Biological monitoring of the BV watershed indicates moderate ecological recovery since 1987.

2.2.2 LUC Protectiveness

All LUCs in BV specified for protection of the environment and/or human health are in place and have been maintained.

2.3 ROD FOR INTERIM ACTIONS IN BV

2.3.1 Performance Monitoring

2.3.1.1 Performance monitoring goals and objectives

The remedy in the BV Interim ROD includes actions to address contaminated buildings and other facilities designated for demolition, buried waste, underground liquid low-level waste (LLLW) tanks, accessible underground process and LLLW transfer pipelines, accessible contaminated surface and subsurface soil, contaminated sediment and surface water, contaminated groundwater, and groundwater monitoring wells and piezometers no longer needed for monitoring. The scope does not include active facilities (e.g., Building 4500N) and infrastructure that have ongoing missions, nor does it include contaminated media and sources that are inaccessible due to the presence of the active facilities and associated infrastructure. The final groundwater and soils decision will be made after source control actions are complete, their effectiveness is monitored, and necessary characterization data are collected.

The BV Interim ROD stipulated RAOs for BV are shown in Table 2.1. Figure 2.1 illustrates the future end use areas.

Table 2.1. RAOs for BV[a]

Issue	*Protection goals*
Future end use	*Protect human health for: (1) controlled industrial use in ORNL's main plant area, (2) unrestricted industrial use in the remainder of the ORNL developed areas, (3) recreational use of selected burial grounds, and (4) unrestricted use in the undeveloped areas, all to a risk level of 1 × 10^{-4}*
Protection of surface water bodies	*Achieve AWQC for designated stream uses in all waters of the state*
	Achieve at least 45% risk reduction from 1994 levels at 7500 Bridge
	Maintain surface water and achieve sediment recreational risk-based limits to a goal of 1 × 10^{-4}
Groundwater protection	*Minimize further impacts to groundwater*
	Prevent groundwater from causing surface water exceedances in all waters of the state
Protection of ecological receptors	*Maintain protection for area populations of terrestrial organisms; protect reach-level populations of aquatic organisms*

[a]*Record of Decision Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4).

AWQC = ambient water quality criteria
BV = Bethel Valley
ORNL = Oak Ridge National Laboratory
RAO = remedial action objective

RAOs for surface water include attainment of a 45% risk reduction from 1994 baseline levels at the 7500 Bridge for Sr-90 and Cs-137 (i.e., 37 pCi/L for Sr-90 and 33 pCi/L for Cs-137) to aid the MV remedy in meeting the risk-based goals at WOD, and attainment of AWQC for designated stream uses in all Waters of the State (fish and aquatic and recreational [organisms only]). In addition, the BV Interim ROD specifies to maintain surface water and achieve sediment recreational risk-based limits to a goal of 1 x 10^{-4} excess lifetime cancer risk (ELCR) and a hazard index (HI) less than 1. The RAOs for groundwater are to minimize further impacts to groundwater and prevent groundwater from causing surface water exceedances in all waters of the state.

The BV Interim ROD includes specific performance objectives and performance measures that form the basis of remediation effectiveness monitoring. These performance objectives provide a quantitative basis to evaluate the effectiveness of remedial activities including the attainment of AWQC numeric and narrative goals related to contaminant discharges to surface water, and the evaluation of hydrologic isolation at limiting contaminant releases from buried waste by monitoring groundwater fluctuation within hydrologic isolation areas. The ROD did not specify ARAR-based groundwater remediation levels and meeting such ARAR-based levels is not a performance objective of the ROD. The ROD includes the requirements to monitor groundwater exit pathway wells and to monitor groundwater near contaminant source control areas to measure effectiveness of contaminant source control actions. All monitoring required by CERCLA decision and primary post-decision documents are included in the *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (BV RAR CMP; DOE/OR/01-2478&D3), as well as baseline monitoring agreed to by all parties to the FFA. As additional actions are completed, post-remediation monitoring and LUCs will be developed in the PCCR and included in the BV RAR CMP.

Table 2.2 lists the performance objectives and performance measures for the defined RAs at completion. Figure 2.2 shows monitoring locations and Table 2.3 lists performance-monitoring requirements for completed CERCLA actions in BV.

Table 2.2. Performance measures for major actions in BV[a]

Waste type	*Unit*	*Remedial actions*	*Performance objective (protection goals)*	*Performance measure (demonstration of effectiveness)*
Facilities D&D (buildings and appurtenances)	*Multiple (53) structures*	*Remove facilities to grade. Remaining structures at or below grade will undergo decontamination and stabilization or removal depending on cost effectiveness and underlying soil contamination*	*Protect human health for industrial use; minimize further impacts to groundwater*	*Contamination removed to protect industrial worker to 0.6 m (2 ft) or 3 m (10 ft). Loose contamination in subsurface removed to the extent practicable*
	Graphite Reactor building	*Stabilize Graphite Reactor core*	*Protect human health for industrial use and visitors*	*Negative pressure in building interior no longer needed*
Buried waste	*SWSA 1*	*Install a cap*	*Protect human health for controlled industrial use; minimize further impacts to groundwater*	*Entire area of buried waste covered by cap; infiltration limited by cap*
	Former Waste Pile Area	*Install and/or maintain soil cover*	*Protect human health for controlled industrial use*	*All debris and contamination above remediation levels covered*
	NRWTP Debris Pile	*Install and/or maintain soil cover*	*Protect human health for controlled industrial use*	*All debris and contamination above remediation levels covered*
	SWSA 3	*Install multilayer cap and upgradient surface water and groundwater diversion trench*	*Protect human health through access controls; minimize further impacts to groundwater*	*Entire area of buried waste covered by cap designed to meet relevant RCRA landfill cover requirements; stable or decreasing surface water concentrations; stable groundwater concentrations*
	Contractor's Landfill	*Install and maintain soil cover*	*Protect human health through access controls*	*All contamination above remediation levels covered*
Tank sludge and linings	*Tank contents*	*Remove sludge and liquid from S-424, T-1, T-2, and HFIR*	*Minimize further impact to groundwater*	*Sludge removed to the extent practicable*
	Tank shells	*Fill the four tanks with grout*	*Minimize further impacts to groundwater*	*Tanks filled to the extent practicable*
Inactive LLLW pipelines	*Inside main plant area*	*Stabilize pipelines and add trench barriers*	*Maintain surface water recreational risk-based limits; achieve at least 45% risk reduction at 7500 Bridge; minimize further impacts to groundwater*	*Surface water goals met. Pipelines filled to the extent practicable*
	Outside main plant area	*Remove pipelines and contaminated bedding material [estimated at 1000 lin m (4000 lin ft)]*	*Protect human health for unrestricted industrial use*	*Meet remediation levels to 3 m (10 ft)*

Table 2.2. Performance measures for major actions in BV[a] (cont.)

Waste type	*Unit*	*Remedial actions*	*Performance objective (protection goals)*	*Performance measure (demonstration of effectiveness)*
Contaminated soil impacting worker protection	*Main plant area*	*Remove contaminated surface soil [estimated at 9000 m^3 (12,000 yd^3)]. Up to 10% of area may be covered.*	*Protect human health for controlled industrial use*	*Meets remediation levels to 0.6 m (2 ft). Substitutions of covers for removal determined on a case-by-case analysis during design*
	Outside main plant area	*Remove contaminated soil to 3 m (10 ft) [estimated at 500 m^3 (700 yd^3)]*	*Protect human health for unrestricted industrial use*	*Meets remediation levels to 3 m (10 ft)*
	Vicinity of SWSA 3 (multiple contaminated locations)	*Remove soil [estimated at 17,500 m^3 (22,900 yd^3)]*	*Protect human health for unrestricted use*	*Meets remediation levels*
Contaminated soil impacting groundwater	*Bethel Valley*	*Remove contaminated soil [estimated at 1500 m^3 (2000 yd^3)]*	*Minimize further impacts to groundwater*	*No soil above trigger levels and not contributing above 10^{-4} industrial risk from groundwater*
Sediment and floodplain soils	*White Oak Creek, First Creek and Fifth Creek*	*Remove contaminated sediment to depth of deposition and floodplain soils to a maximum depth of 0.6 m (2 ft) [estimated at 13,500 m^3 (17,600 yd^3)]*	*Achieve recreational risk-based limits in sediment, achieve at least 45% risk reduction at 7500 Bridge (primarily ^{137}Cs); protect human health for controlled industrial use; protect reach-level benthic invertebrate populations*	*Meets remediation levels and results in healthy benthic invertebrate populations. Meets surface water goals of at least 45% risk reduction at 7500 Bridge[b]*
Groundwater	*Core Hole 8 Plume*	*Extract groundwater from four wells and from sumps at seven stormwater junction boxes [estimated at combined rate of 380 L/min (100 gal/min)]*	*Prevent groundwater from causing surface water exceedances (at least 45% risk reduction at 7500 Bridge); minimize further impacts to groundwater*	*Controls plume growth; collect highly contaminated groundwater to extent practicable; effluent meets surface water goals and plant NPDES permit*
	^{90}Sr-contaminated sumps	*Pump from 27 existing sumps [estimated at combined rate of 360 L/min (81 gal/min)]; continue to treat to remove ^{90}Sr*	*Prevent groundwater from causing surface water exceedances (recreational risk-based) levels and at least 45% risk reduction at 7500 Bridge)*	*Streams meet surface water goals (recreational risk and at least 45% risk reduction at 7500 Bridge[b]); effluent meets surface water goals and plant NPDES permit*
	Mercury-contaminated sumps	*Pump from four existing sumps at a combined rate of 34 L/min (9 gal/min); add treatment to remove mercury*	*Prevent groundwater from causing surface water exceedances (meet AWQC)*	*Streams meet AWQC in surface water; effluent meets surface water goals and plant NPDES permit*
	VOC Plume	*Implement enhanced in situ anaerobic bioremediation*	*Minimize further impacts to groundwater*	*Biodegradation occurs and reduces VOC mass and concentration*
	Well P&A	*Grout obsolete or poor quality monitoring wells and piezometers and abandon in*	*Protect human health for the specified industrial use; minimize*	*No unacceptable risk to workers. Consistent with TDEC plugging and*

Table 2.2. Performance measures for major actions in BV[a] (cont.)

Waste type	*Unit*	*Remedial actions*	*Performance objective (protection goals)*	*Performance measure (demonstration of effectiveness)*
		place (estimated at 229 wells); in areas designated for unrestricted industrial or unrestricted use, remove to depth of 3 m (10 ft)	*further impacts to groundwater*	*abandonment standards [1200-4-6-.09(16)[c]]*

[a]Table 2.37 of *Record of Decision Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4).

[b]A *Notification of Non-Significant Change to the Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4/R2) clarified the target concentration levels for Sr-90 (37 pCi/L) and Cs-137 (33 pCi/L) and compliance sampling techniques for measuring the 45% risk reduction.

[c]Tennessee Code subsequently revised to TDEC Chapter 0400-45-06-.09.

AWQC = ambient water quality criteria
BV = Bethel Valley
D&D = decontamination and decommissioning
HFIR = high flux isotope reactor
LLLW = liquid low-level (radioactive) waste
NPDES = National Pollutant Discharge Elimination System
NRWTP = Nonradiological Wastewater Treatment Plant
P&A = plugging and abandonment
RCRA = Resource Conservation and Recovery Act of 1976
SWSA = solid waste storage area
TDEC = Tennessee Department of Environment and Conservation
VOC = volatile organic compound

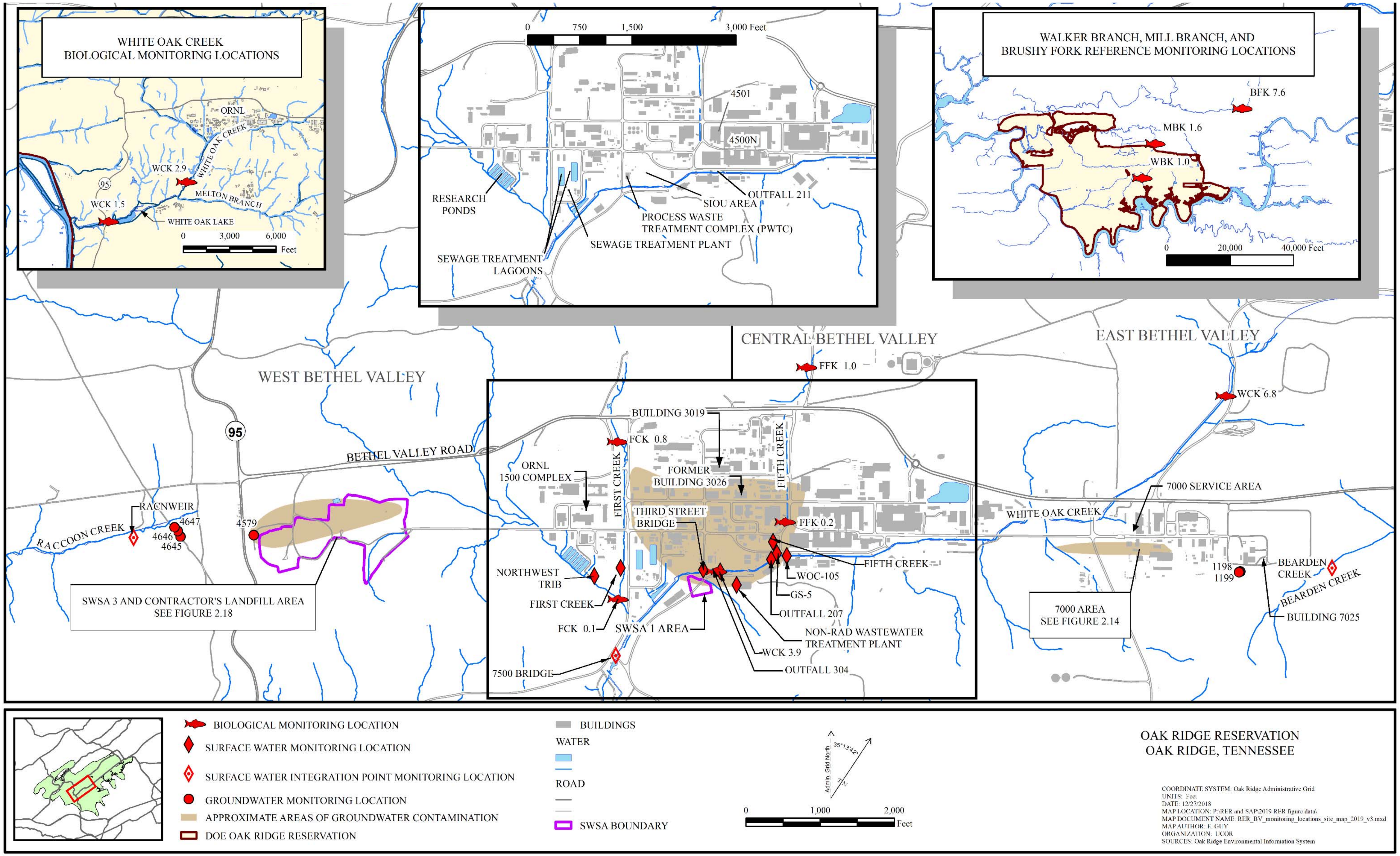

Figure 2.2. Monitoring locations in BV and associated reference locations.

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Table 2.3. Performance monitoring requirements for completed CERCLA actions in BV*[a]

Media	Monitoring location	Schedule and type of sample	Parameters	Performance standard
Performance monitoring				
Surface water	7500 Bridge Weir	Continuous flow-proportionate monthly composite sample	Sr-90, gamma activity[b]	Achieve (BV Interim Actions ROD): • 45% risk reduction from 1994 levels at 7500 Bridge for Sr-90 and Cs-137 (i.e., 37 pCi/L of Sr-90 and 33 pCi/L of Cs-137) • AWQC for all designated stream uses in all waters of the state (FYR)
	First Creek Weir	Continuous flow-proportionate monthly composite sample	COCs (Sr-90, gross alpha, gamma activity[b])	None specified (BV Interim Actions ROD)
	NWT Weir	Continuous flow-proportionate monthly composite sample	COCs (Sr-90)	
	Raccoon Creek Weir	Continuous flow-proportionate monthly composite sample	COCs (Sr-90)	
	7500 Bridge Weir	Monthly grab sample Semiannual grab sample (Hg snapshot) Annual grab sample (prior to FYR)	Total mercury Total mercury AWQC	51 ppt (ng/L) Hg (BV Mercury Sumps) 51 ppt (ng/L) Hg (BV Mercury Sumps) AWQC (BV Mercury Sumps)
	WOC-105	Semiannual grab sample (Hg snapshot)	Total mercury	51 ppt (ng/L) Hg (BV Mercury Sumps)
	First Creek	Continuous flow-proportionate monthly composite monitoring	Sr-90	Document quantity of Sr-90 discharging from Corehole 8 plume to First Creek as it contributes to WOC (PCCR for Corehole 8 Extraction System)
	SWSA 3 Sediment Basin (BVBGs BASIN OUT)	Semiannual grab monitoring	Metals, VOCs, Sr-90, and tritium	Basin will access UGT as a potential source of contaminants and can be compared to the recreational goal of 1 x 10^{-4} risk for swimmers (BVBGs action)

Table 2.3. Performance monitoring requirements for completed CERCLA actions in BV*[a] (cont.)

Media	Monitoring location	Schedule and type of sample	Parameters	Performance standard
Biota	WCK 6.8 WCK 3.9 FCK 0.1 FCK 0.8 FFK 0.2 FFK 1.0	Fish and benthic macroinvertebrate species surveys	Richness and density survey	Comparison to reference location to evaluate whether aquatic populations are being protected (BV Interim Actions ROD)
Groundwater	4579-01 4579-02 4579-03	Semiannual grab samples[c]	Gross alpha and gross beta activity, Sr-90	Exit pathway (West BV/Raccoon Creek area) monitoring trend to determine if contaminants are leaving known contaminated areas (BVGWES)
	Well 4411	Quarterly grab sample	Sr-90	To monitor contaminant concentration trends (PCCR for Corehole 8 Extraction System)
	Well 4570	Semiannual grab sample	Sr-90	Sample groundwater down-dip to the southwest of the Corehole 8 Plume source (PCCR for Corehole 8 Extraction System)
	Wells 4571 and 4572	Semiannual grab sample	Sr-90	Installed west along geologic strike to detect potential underflow of First Creek (PCCR for Corehole 8 Extraction System)
	Wells:[d] **0482**, **0483**, **0484**, **0491**, **0492**, **0493**, 0692, 0693, **0694**, 0698, 0699, 0700, 0702, 0706, 0790, 0985, 0986, 0987, 0988, 0990, 0991, 0992, 0993, 0994, 0995, **0996**, **0997**, 0998, 1247, 1248, 4579-01, 4579-02, 4579-03, 4645, 4646, 4647, 4670, 4671, 4672, 4673, 4674, 4675	Quarterly synoptic monitoring	Water levels	Intent of the SWSA 3—CSMA cap is to limit the amount of water that encounters buried wastes by reducing or eliminating percolation of precipitation and through-flow of shallow groundwater. Therefore, water table elevations are expected to decline under the cap over time (See Table 7-2 of BVBGs PCCR [DOE/OR/01-2533&D2] for long-term water table elevation goals for SWSA 3).
	Wells 0706, 0995 Well 0985 Wells 4645, 4646, 4647 Wells 0992, 0993, 0994, 0997, 4579-01, 4579-02 , 4579-03	Semiannual grab samples	Sr-90, tritium VOCs, Sr-90, tritium Metals, Sr-90, tritium Metals, VOCs, Sr-90, tritium, gross alpha, and gross beta	Downward trend in Sr-90 concentration towards 8 pCi/L (BVBGs PCCR)

*Source: *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2478&D3).

Table 2.3. Performance monitoring requirements for completed CERCLA actions in BV*[a] (cont.)

[a]Table presents current requirements for monitoring included in the Interim Actions ROD for the BV, post-decision primary documents, or any subsequent errata that have received concurrence/approval from the EPA and TDEC. Additional monitoring requirements will be developed and approved during the remedial design process for actions yet to be implemented.

[b]Gamma scan provides Cs-137, Co-60, and K-40 activity.

[c]Per the *Engineering Study Report for the Groundwater Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-2219&D2), semiannual grab samples in each monitoring zone were recommended for two years (starting in FY 2006), which provided a total of six baseline values. If analytical results are consistent, monitoring will be reduced to high- and low-base sampling every three years. If those results are consistent for a period of nine years (through FY 2016), monitoring will be reduced to high- and low-base sampling every five years. Monitoring at this frequency will continue until a statistically valid decreasing trend is clearly demonstrated. Note that monitoring has not been reduced due to the presence of contamination.

[d]**Bold** values represent wells included in Table 7-2 of the *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2533&D2) and listed in Table 2.11 of this report which specifies long-term water table elevation goals for nine wells.

AWQC = ambient water quality criteria
BV = Bethel Valley
BVBG = Bethel Valley Burial Ground
BVGWES = Bethel Valley Groundwater Engineering Study
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC = contaminant of concern
CSMA = Closed Scrap Metal Area
EPA = Environmental Protection Agency
FCK = First Creek kilometer
FFK = Fifth Creek kilometer
FY = fiscal year
FYR = Five-Year Review
NWT = Northwest tributary
PCCR = Phased Construction Completion Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation
UGT = upgradient trench
VOC = volatile organic compound
WCK = White Oak Creek kilometer
WOC = White Oak Creek

2.3.1.2 Evaluation of performance monitoring data

2.3.1.2.1 Surface water

2.3.1.2.1.1 Surface water quality goals and monitoring requirements

The following excerpts (italicized) from Section 2.12.7.3 of the BV Interim ROD include the specific concentration goals for the principal surface water contaminants of concern (COCs).

Remediation levels for surface water

Remediation levels for surface water are established for each of the three surface water protection or remediation goals stated in the RAO (Sect. 2.8.2). These three goals and a brief explanation of their origin are given below.

1. *Achieve AWQC for designated stream uses in all waters of the state. White Oak Creek is classified for Fish and Aquatic Life, Recreation, and Livestock Watering and Wildlife uses, but not for Domestic or Industrial Water Supply or Irrigation*[1]*. All other named and unnamed surface waters in the valley are also classified for Irrigation by default under the Rules of the TDEC Chap. 1200-4-4*[2]*. Both numeric AWQC and narrative criteria for the protection of human health and aquatic organisms will be met. Numeric AWQC exist for selected compounds under the Recreation and Fish and Aquatic Life use classifications. Consistent with EPA guidance, compliance with numeric AWQC for Recreation and Fish and Aquatic Life classifications is sufficiently stringent to ensure protection of other uses for which there are narrative, but not numeric, criteria (i.e., Irrigation or Livestock Watering and Wildlife).*

2. *Maintain surface water risk below the recreational risk-based limit of 1 x 10^{-4}. This goal is a more explicit statement on how the narrative criteria portion of the AWQC goal described above will be achieved for Bethel Valley. The CERCLA risk assessment process is used for quantifying remediation levels to address the narrative AWQC for recreational use.*

3. *Achieve at least 45% risk reduction in surface water exiting Bethel Valley. This goal is a direct corollary of a goal in the Melton Valley watershed ROD to protect an off-site resident user of surface water within 10 years from completion of actions in Melton Valley and Bethel Valley. To protect the off-site resident, the Melton Valley watershed ROD established remediation levels at the confluence of White Oak Creek with the Clinch River to achieve an annual average ELCR of 1 x 10^{-4} and an HI of 1 for a residential exposure scenario (i.e., general household use). The Melton Valley watershed FS (DOE 1998c) estimated that the risk at White Oak Dam was 6.4 x 10^{-4} ELCR under a hypothetical residential scenario and 1994 baseline conditions. Of this total risk, Bethel Valley contributed approximately 20% (1.3 x 10^{-4} ELCR), primarily in the form of ^{90}Sr and ^{137}Cs. Assuming the Melton Valley remedy achieves at least an 82% reduction of the Melton Valley contribution to the risk at White Oak Dam, then Bethel Valley must achieve at least a 45% risk reduction in surface water exiting Bethel Valley to meet the Melton Valley watershed ROD goal of protection of the off-site resident.*

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[1]The use classifications for White Oak Creek (WOC) has changed since the *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4) was signed. This surface water body is currently classified for Fish and Aquatic Life, Recreation, and Irrigation uses and is no longer classified for Livestock Watering and Wildlife use.

[2]The Tennessee Code subsequently revised to Tennessee Department of Environment and Conservation (TDEC) Chapter 0400-40-04 (Use Classifications for Surface Waters).

Remediation levels for the three goals are summarized in Table 2.4 (*Table 2.38 in ROD) and explained in more detail in the following three subsections: Numeric AWQC, Narrative Criteria, and Risk Reduction for Off-Site Releases. The surface water remediation levels will be met within 10 years from completion of source actions in Bethel Valley.*

Numeric AWQC*. The Bethel Valley RI/FS noted numeric AWQC exceedances for cadmium, chromium, copper, iron, and mercury in White Oak Creek, First Creek, and Fifth Creek (Remedial Investigation/Feasibility Study for Bethel Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee, DOE/OR/01-1748&D2, Oak Ridge, Tennessee). However, AWQC will be met for all site-related contaminants in all waters of the state. The numeric AWQC for (1) Fish and Aquatic Life and (2) Recreation (organisms only) use classifications are tabulated in Rules of the TDEC Chap. 1200-4-3.03*[3]*. Compliance will be based on statistically valid data assessments. The initial sampling locations proposed for determining compliance were shown previously in* Figure 2.2 (Figure 2.36 in ROD)*; these sampling locations will be finalized in a post-ROD Sampling Plan. The locations are generally at the downstream end of individual reaches but before any confluence with other major streams. Samples taken from such locations would essentially integrate contamination entering the reach from any sources upstream of the sampling location.*

Narrative criteria*. The CERCLA risk assessment process is used to address the narrative criteria for waters of the state. A recreational risk scenario considered representative of the surface water use classifications is used to calculate cumulative risk from measured concentrations of surface water contaminants or, conversely, to derive allowable concentrations from risk-based limits.*

Based on the human health risk assessment in the Bethel Valley RI/FS, no waters of the state exceeded recreational risk-based limits. Therefore, no surface water risk-based COCs were identified for which allowable concentrations need to be derived at this time. However, if in the course of periodic surface water monitoring, consistently unacceptable recreational risks are found and new significant COCs are identified, then the risk assessment process will be used to derive allowable concentrations for the new surface water COCs.

Waters of the state must achieve an annual average ELCR less than 1×10^{-4} and an HI less than 1 for a recreational exposure scenario. This goal applies only to surface water and only to those COCs, such as radionuclides, that do not have numeric AWQC. The numeric AWQC for individual contaminants is generally equivalent to risk levels ranging up to 10^{-5}. The annual average risk goal of 1×10^{-4} meets the intent of the AWQC because, when multiple contaminants are present in the surface water, their individual risk levels would be roughly equivalent to the AWQC-equivalent risk of 10^{-5}. A lower risk goal could require individual contaminant risks to be below the AWQC-equivalent risk of 10^{-5}.

Under this ROD, the recreational scenario is defined as a wading scenario in the streams. It does not include fishing because the streams are too small to support fishable fish. The initial sampling locations proposed for determining conformity with these levels are shown in Figure 2.2 (Fig. 2.36 in ROD)*; these sampling locations will be finalized in a post-ROD sampling plan. The locations are at the downstream end of individual reaches (i.e., First Creek, Fifth Creek, NWT, Raccoon Creek, White Oak Creek between 7500 Bridge and First Creek, White Oak Creek between First Creek and Fifth Creek, and White Oak Creek above Fifth Creek) but before any confluence with other major*

[3]The Tennessee Code subsequently revised to TDEC Chapter 0400-40-03-.03 (Criteria for Water Uses).

streams. Samples taken from such locations would essentially integrate contamination entering the reach from any sources upstream of the sampling location.

Risk reduction for offsite releases*. Surface water exiting Bethel Valley must achieve at least 45% risk reduction from a 1994 baseline. This 45% risk reduction will be based on the combined risk from* ^{90}*Sr and* ^{137}*Cs, the two principal risk contributors, and is in addition to that reduction attributable to radioactive decay from 1994. The 45% reduction in total residential ELCR must be achieved within 10 years from completion of source actions selected in this ROD in Bethel Valley.*

A *Notification of Non-Significant Change to the Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4/R2) clarified the target concentration levels and compliance sampling techniques for measuring the 45% risk reduction as follows:

. . .DOE is therefore adding to the BV ROD the specific target concentration levels for ^{90}*Sr and* ^{137}*Cs of 37 pCi/L and 33 pCi/L, respectively, to meet the 45% risk reduction goal. . .DOE is issuing this non-significant change to clarify that sampling is done in the following manner based on the following approach:*

A monthly flow-paced composite sample at the 7500 Bridge will be taken and used for the average concentration parameter in the risk calculation to demonstrate compliance with the 45% risk reduction goal. This sampling approach produces an average (arithmetic mean) annual constituent concentration result that inherently accounts for impacts of flow rate on concentrations over time. This sampling approach is also conservatively reflective of how a surface water intake system for a public water supply would be sampled.

Surface water remediation levels are outlined in Table 2.4.

Table 2.4. Surface water remediation levels in BV[*]

Bethel Valley	***Numeric AWQC***	***Narrative criteria[a]***	***Risk Reduction for off-site releases***
Receptor	*Hypothetical recreational user: fish and aquatic life*	*Hypothetical recreational user*	*Hypothetical off-site resident*
Areas affected	*All waters of the state*	*All waters of the state*	*Confluence of WOC with the Clinch River*
Anticipated compliance locations	*See Fig. 2.36* (Figure 2.2)	*See Fig. 2.36* (Figure 2.2) *(remediation levels are applied to selected reaches[b])*	*7500 Bridge or equivalent integration point*
Remediation level	*Levels established in Rules of the TDEC Chap. 1200-4-3-.03[c]*	*Annual average ELCR* $<1 \times 10^{-4}$ *and HI <1*	*Surface water risk (based on* ^{90}*Sr and* ^{137}*Cs only) will be at least 45% less than the 1994 baseline*
Exposure scenarios	*NA (numeric criteria tabulated in regulation; no separate calculation using exposure scenarios needed)*	*Hypothetical recreational wading for waters of the state (the exposure scenario does not include fish ingestion)*	*Hypothetical residential (i.e., general household use) scenario at confluence of WOC with the Clinch River translated to a risk reduction of at least 45 percent in surface water exiting Bethel Valley (i.e., 7500 Bridge) from a 1994 baseline*

[*]Table 2.38 of the *Record of Decision Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4).

[a]*Unacceptable risks in surface water do not exist in Bethel Valley based on the RI/FS analysis. If unacceptable risks are encountered in the future, then the narrative criteria will be achieved by developing remediation levels based on a hypothetical recreational receptor.*

[b]*Surface water reaches: First Creek, Fifth Creek, Northwest Tributary, Raccoon Creek, WOC between 7500 Bridge and First Creek, WOC between First Creek and Fifth Creek, and WOC above Fifth Creek.*

[c]Tennessee Code subsequently revised to TDEC Chapter 0400-40-03-.03.

Table 2.4. Surface water remediation levels in BV* (cont.)

AWQC = ambient water quality criteria
BV = Bethel Valley
ELCR = excess lifetime cancer risk
FS = feasibility study
HI = hazard index
NA = not applicable
RI = remedial investigation
TDEC = Tennessee Department of Environment and Conservation
WOC = White Oak Creek

2.3.1.2.1.2 Surface water monitoring results

This section presents the surface water monitoring results of watershed-scale contaminant discharge monitoring and single-project action monitoring results related to completed CERCLA projects. Watershed-scale surface water and groundwater monitoring provides an ongoing data record against which to determine the effectiveness of RAs, as well as verifying reduction of offsite releases of contaminants.

The BV administrative watershed (Figure 2.2) lies in portions of three hydrologic watersheds. The WOC hydrologic watershed encompasses all of the ORNL main campus area as well as most of the SWSA 3 and Contractor's Landfill area, and all but the easternmost portion of facilities at the 7000 Services area. The western portion of SWSA 3 and all of the Contractor's Landfill lie in the headwater of the Raccoon Creek watershed which is wholly included in the BV administrative watershed which drains directly to the Clinch River. The easternmost portion of the 7000 Services Area lies in the Bearden Creek watershed which drains directly into Melton Hill Reservoir.

Surface water monitoring in BV includes both continuous, flow-paced monitoring by the Environmental Management (EM) Program at key instream locations and routine collection of grab samples, as well as ORNL facility discharge monitoring conducted by UT-B for the DOE Office of Science.

The BV Interim ROD stipulates that AWQC be met in surface water within 10 years from completion of source actions in BV. DOE evaluates the status of AWQC attainment in each CERCLA FYR. For the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2), DOE performed comprehensive surface water sampling to evaluate compliance with AWQC in FY 2015. An evaluation of results is presented in the 2016 FYR document. During FY 2012 through 2017, all of the mercury sample concentrations at 7500 Bridge were below the AWQC value of 51 ng/L. During FY 2018, a sample collected at the 7500 Bridge in September had an elevated mercury concentration of 93.5 ng/L. The suspected source of that elevated mercury was discharges from the PWTC which was undergoing construction activities. Mercury concentrations were less than the AWQC limit in both of the semiannual samples collected at WOC-105.

2.3.1.2.1.3 Watershed-scale surface water monitoring results

Radiological discharges to WOC

Historic and ongoing discharges of Sr-90 and Cs-137 in surface water in the central part of BV are principal COCs that directly impact the condition of the stream and are performance metrics for the BV Interim ROD. Tritium discharges in the BV reach of WOC originate primarily from groundwater collected in MV and transferred to the PWTC in BV via the groundwater collection and treatment system.

Figure 2.2 shows locations in the ORNL main plant area in BV where contaminant concentrations and flows are measured to estimate the discharge fluxes from various contributing areas or outfalls. Sr-90 is the principal radiological COC in surface water in BV because it is a widely distributed contaminant in buried waste, in contaminated soils related to LLLW pipeline leaks, and in groundwater. Three CERCLA actions included in the BV Interim ROD were completed during FY 2012 that are reducing Sr-90 discharges to surface water – the Bethel Valley Burial Grounds (BVBGs) RA at SWSAs 1 and 3, installation of additional groundwater extraction wells in the Corehole 8 plume, and completion of the excavation of Tank W-1A and associated contaminated soils.

Cs-137 is a significant surface water contaminant in WOC, and its sources include discharges from the PWTC and soils on the WOC floodplain contaminated from the former SIOU area downstream to the 7500 Bridge Weir. While actions that will directly address several known source areas of Cs-137 have not yet been completed, ongoing measurement of these contaminants is conducted to track baseline discharge conditions.

The 7500 Bridge is the primary exit pathway for surface water to discharge from the upper portion of the WOC watershed in BV into the lower WOC watershed area in MV. Table 2.5 lists the average annual Sr-90 and Cs-137 activities calculated from the flow-paced monthly composite samples collected at the 7500 Bridge for the baseline year (FY 1994) and for the period FY 2001 through FY 2018. The BV Interim ROD goals for Sr-90 and Cs-137 based on the 45% risk-reduction requirement are included in the table column headers. As shown in Table 2.5 and on Figure 2.3, the annual average Sr-90 and Cs-137 activities in continuous, flow-paced samples attained their ROD goal in FY 2018. The annual average radionuclide activities shown on Figure 2.3 summarize the variable levels measured in the monthly composite samples. To reflect the variability in parameter levels, the graphs include the annual average activity and the average plus one standard deviation of the mean. For years when the mean plus one standard deviation show a wider range, there was more measured variation than for years when these results show a narrower range.

During FY 2018, the majority of Sr-90 discharges measured at the 7500 Bridge watershed IP are attributed to ungauged groundwater inflows into the WOC channel. During FY 2018, the Sr-90 contributions measured at the PWTC decreased to about 0.05 Ci from the FY 2017 measured contribution of 0.15 Ci when a number of facility upset conditions occurred. The ungauged Sr-90 sources contributed about 67% of the total 0.24 Ci measured at the 7500 Bridge Weir. Figure 2.4 shows the relative contributions of gauged and ungauged sources of Sr-90 flux to the 7500 Bridge Weir IP for FY 2018. The principal source of the ungauged flux is attributed to discharges that occurred through storm drain outfalls and from non-point groundwater discharges directly to WOC. During FY 2015 through 2018, storm drain outfall monitoring identified Sr-90 discharges from Outfall 304 that exceeded the 1,100 pCi/L DOE Derived Concentration Standard (DCS).

The flow volume of Outfall 304 is normally less than 1 gpm and the flux discharge from this outfall contributes a very small fraction (0.3%) of the total Sr-90 flux at the 7500 Bridge Weir (approximately 2.0E-6 Ci/d at OF-304 compared to approximately 6.0E-4 Ci/d at 7500 Bridge). Monitoring data show that since about 2008 there have been several episodes of elevated Sr-90 discharge from Outfall 304, with peak measured concentrations of 29,000 pCi/L in September 2015. Monitoring through FY 2018 shows that Sr-90 concentrations have essentially stabilized at levels greater than the DCS with an FY 2018 average value of about 1,500 pCi/L. Sampling at Outfall 304 occurs as a monthly baseflow grab sample. The cause of the persistent ungauged flux contributions at 7500 Bridge and elevated Sr-90 concentrations at OF-304 is attributed to residual groundwater contaminant discharges from past leaks from deteriorating waste management infrastructure in the central campus area near the former SIOU.

An engineering evaluation of the Main Plant Area process waste drain network is in progress during fiscal quarter 4 of FY 2018 and fiscal quarter 1 of FY 2019. Conclusions drawn from that evaluation may provide some direction on improving management of the aging liquid waste handling infrastructure at ORNL.

Tritium concentrations in surface water in the BV reach of WOC upstream of 7500 Bridge increased in 2006 as a result of collection and transfer for treatment of former groundwater discharges in MV and remain at elevated levels. As shown on Figure 2.3, during FY 2018 tritium activity at 7500 Bridge Weir remained approximately equivalent to levels measured during FY 2016 and FY 2017. Tritium concentrations in surface water throughout WOC remain below the DOE DCS level for tritium (1.9×10^6 pCi/L; DOE-STD-1196-2011).

Table 2.5. 7500 Bridge risk-reduction goal evaluation

Year	Average Sr-90 (Goal = 37 pCi/L)[b]	Average Cs-137 (Goal = 33 pCi/L)[b]
FY 1994[a]	67	59
FY 2001	37	**219**
FY 2002[c]	37	**116**
FY 2003	37	**41**
FY 2004	**78**	**47**
FY 2005	**70**	**78**
FY 2006	35	33
FY 2007	27	17
FY 2008	27	<6
FY 2009	**40**	12
FY 2010	**42**	10
FY 2011	**54**	<16
FY 2012	33	<15
FY 2013	33	<24
FY 2014	33	<15
FY 2015	35	24
FY 2016	**44**	16
FY 2017	**53**	8
FY 2018	36.7	8

Bold values indicate years during which annual average concentration exceeded the ROD risk-based goal.

[a] *Record of Decision Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4) baseline year.
[b] Goal = 45% reduction in average concentrations compared to concentrations during baseline year.
[c] Approval of *Record of Decision Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4).

FY = fiscal year
ROD = Record of Decision

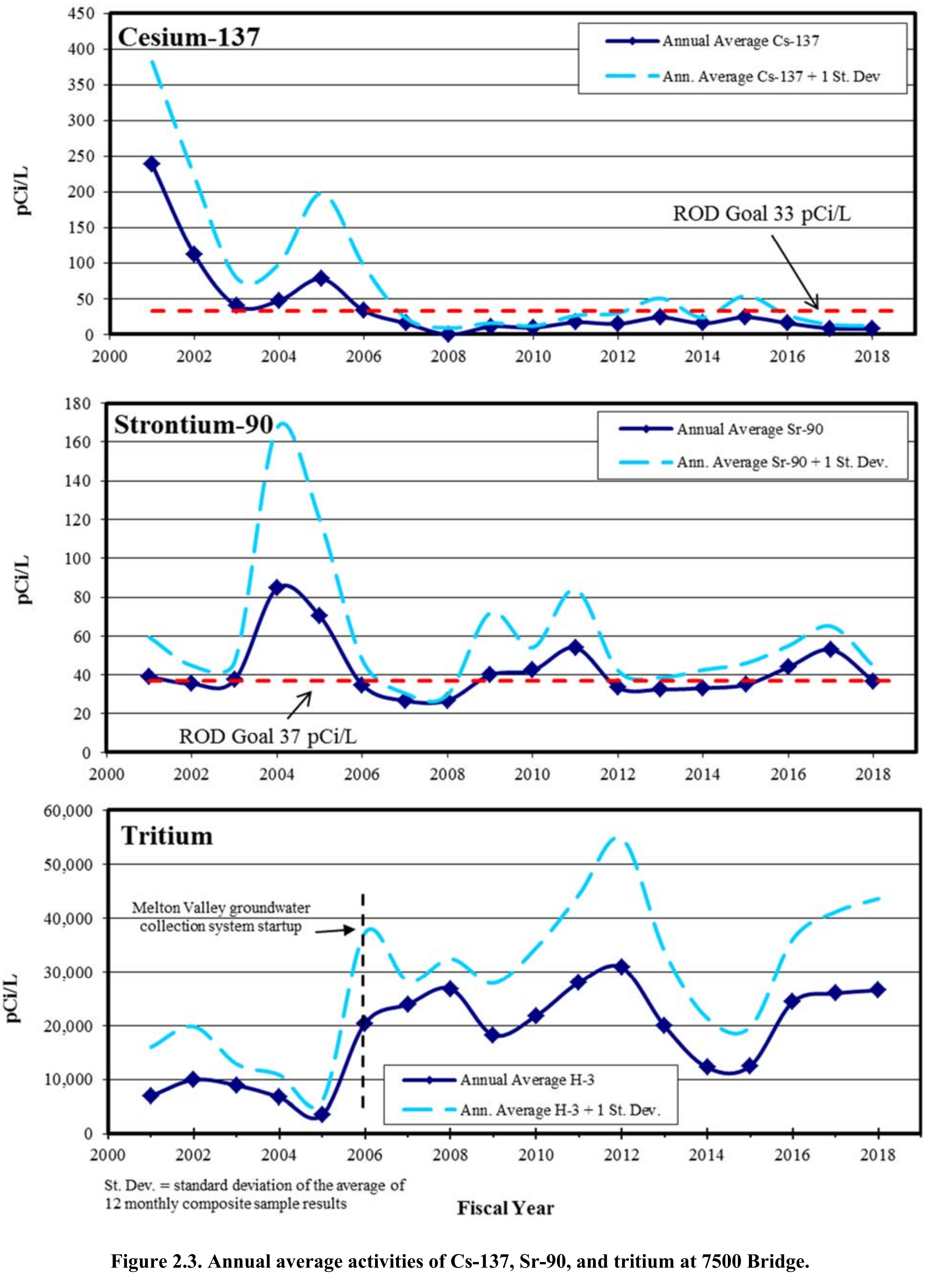

Figure 2.3. Annual average activities of Cs-137, Sr-90, and tritium at 7500 Bridge.

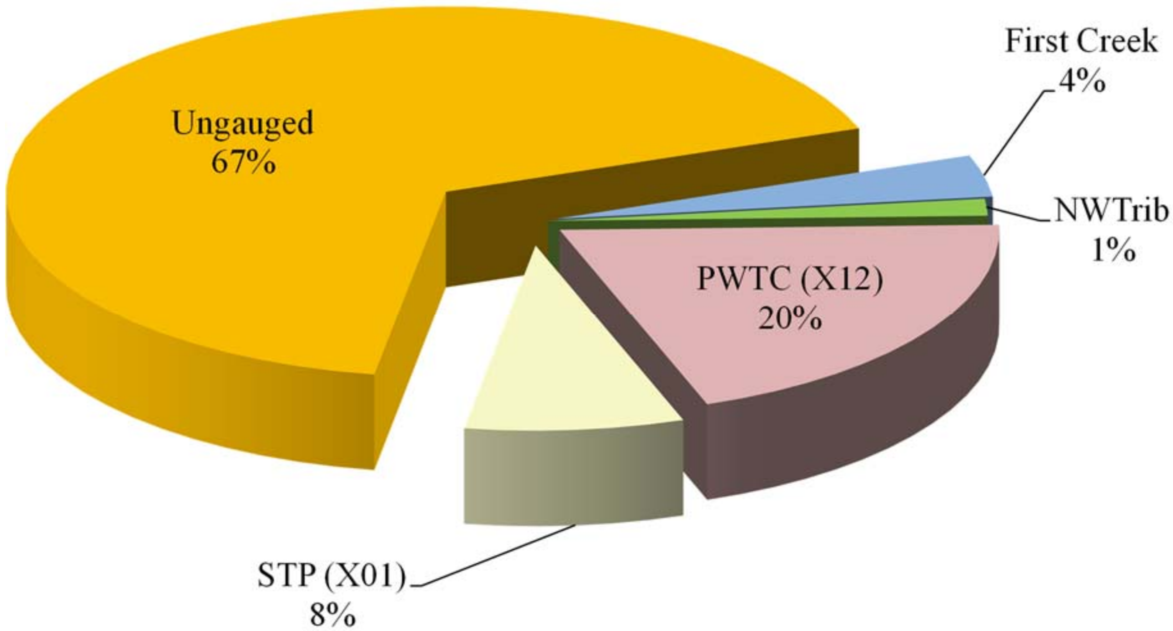

Figure 2.4. Percentage contributions of gauged and ungauged sources flux to the 7500 Bridge watershed FY 2018 total Sr-90 discharge.

Radiological discharges to Raccoon Creek and Bearden Creek

Raccoon Creek and Northwest Tributary (SWSA 3 area). Surface water in the western end of BV is monitored to measure contaminant discharges to Raccoon Creek, which flows directly into the Clinch River via a western exit pathway. Figure 2.2 shows locations where BV exit pathway sampling is conducted. Contaminated groundwater originating in SWSA 3 seeps to the headwaters of Raccoon Creek, a short distance to the west of Tennessee Highway 95. The seepage pathway from SWSA 3 to Raccoon Creek was discovered in the early 1980s and monitoring has been conducted at the Raccoon Creek Weir since the 1990s. The principal contaminant detected in the Raccoon Creek headwaters is Sr-90. The annual flux of Sr-90 discharging via Raccoon Creek has been measured since 1999, with the exception of FY 2005, 2006, and part of 2007, when problems with flow measurements at the site prevented estimating flux.

Table 2.6 summarizes annual Sr-90 detection frequency and maximum value; total annual flow volume for months with detectable Sr-90; average Sr-90 activity from continuous flow-paced samples containing detectable levels at the Raccoon Creek Weir; and the calculated, flow-weighted Sr-90 flux for months with detectable Sr-90 and periods when reliable station flow data were available. Since completion of the SWSA 3 hydrologic isolation in 2011, the Sr-90 activity levels in the Raccoon Creek headwaters have decreased by 50 – 60% from values measured during the previous several years. This decrease is attributed to the effect of hydrologic isolation of buried waste in SWSA 3 and the Contractor's Landfill. The long-term surface water flux monitoring of Raccoon Creek shows that the Raccoon Creek Sr-90 flux is less than 10% of the flux measured at Northwest Tributary.

Table 2.6. Sr-90 data from Raccoon Creek Weir

Year	Detection frequency and maximum value (No. detects/No. samples) Maximum pCi/L	Total annual flow volume for months with detected Sr-90[a] (L)	Average[a] detected Sr-90 (pCi/L)	Flow-weighted Sr-90 flux[b] (Ci)
FY 1999 Total	(8/12) 55.9	84,336,484	20.86	3.72E-04
FY 2000 (11 months)	(8/11) 39.49	51,633,000	14.31	5.23E-04
FY 2001	(8/13) 8.15	98,040,000	4.62	4.53E-04
FY 2002[c]	(7/12) 25.1	29,410,921	13.17	4.99E-04
FY 2003 (11 months)	(10/11) 17.9	240,650,588	6.43	9.72E-04
FY 2004	(12/12) 26.9	254,073,297	9.56	1.68E-03
FY 2005	(12/12) 64.8	--[d]	16.78	--[d]
FY 2006	(12/12) 77.2	--[d]	30.95	--[d]
FY 2007 (February – September)	(10/12) 44.6	160,919,136[e]	14.50	2.21E-03[e]
FY 2008	(12/12) 59.6	117,209,419	15.50	6.47E-04
FY 2009	(8/12) 35.6	150,003,288	10.71	6.2E-04
FY 2010	(5/12) 18.4	20,509,344	11.52	1.9E-04
FY 2011[f]	(9/12) 18.3	148,822,416	6.07	5.1E-04
FY 2012	(7/12) 9.05	146,306,405	4.49	4.3E-04
FY 2013	(6/12) 12.0	100,717,704	6.17	5.9E-04
FY 2014	(9/12) 12.9	118,965,412	4.88	3.7E-04
FY 2015	(12/12) 3.46	224,091,518	2.22	3.5E-04
FY 2016	(10/12) 3.88	259,724,894	1.91	1.9E-04
FY 2017	(11/11) 6.21	285,184,584	1.94	3.9E-04
FY 2018	(10/12) 6.38	175,614,883	1.80	1.7E-04

[a]Activity value represents average activity for all monthly flow composite samples with detected Sr-90. Since FY 2015, lower detection limits for many analytes, including Sr-90, allowed detection at lower levels than previous years. Therefore, more monthly flow composite samples had Sr-90 detections.

[b]Flow-weighted flux is based on sum of monthly data for months during which Sr-90 was detected.

[c]Approval of *Record of Decision Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4).

[d]The FY 2005 and 2006 flow and flux data are not reported as the data have been deemed unusable due to problems associated with the weir.

[e]Station was returned to full operation at end of January 2007. Reported flows and fluxes are calculated for the months when flow was present after station maintenance.

[f]The SWSA 3 hydrologic isolation was completed during FY 2011.

-- = not applicable
FY = fiscal year
No. = number
SWSA = Solid Waste Storage Area

Northwest Tributary (SWSA 3 RA)

The Northwest Tributary of WOC surface water basin receives surface runoff from the area generally west of First Creek and east of the WOC/Raccoon Creek watershed divide and from the northern slope of Haw Ridge to the south and the southern slope of Chestnut Ridge to the north. The Northwest Tributary surface water monitoring station is shown in Figures 2.2 and 2.5. Dry season baseflow discharge in the Northwest Tributary comes from groundwater and from discharges from the constructed ponds associated with the ORNL 1500 complex. The eastern karst discharge pathway from beneath SWSA 3 contributes flow to the Northwest Tributary and is a groundwater transport pathway for Sr-90 from SWSA 3 to the stream. The principal COC in surface water related to SWSA 3 is Sr-90. Surface water monitoring has been conducted for many years at the Northwest Tributary Weir. Continuous flow-paced surface water composite sampling is conducted with a monthly composite period to measure average Sr-90 activity level and discharge flux. Figure 2.6 shows the monthly Sr-90 activity levels and discharge fluxes for FYs 2005 through 2018. The period during which SWSA 3 remediation occurred is also shown.

Figure 2.5. Northwest Tributary surface water monitoring station.

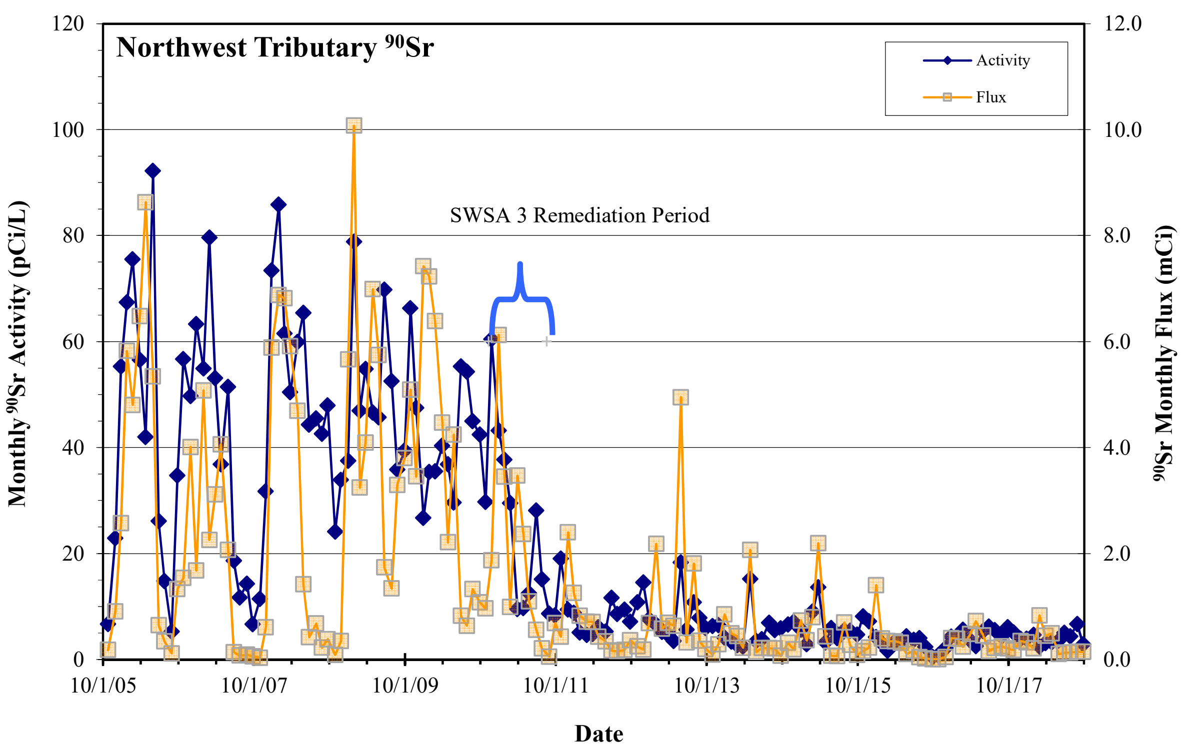

Figure 2.6. Northwest Tributary Sr-90 monitoring results, FY 2005 – FY 2018.

Activity levels and discharge fluxes of Sr-90 decreased during the construction period and have reached a new, lower level with an associated lower fluctuation range subsequent to completion of the RA. Comparison of Northwest Tributary average Sr-90 activity levels and fluxes between the pre-remediation period (December 2008 through December 2010) and the remediation and post-remediation period (March 2011 through September 2018) shows a 75% reduction. Average Sr-90 activity before remediation was 46 pCi/L (standard deviation 13 pCi/L) while during- and post-remediation average Sr-90 activity has been 6.3 pCi/L (standard deviation 4.3 pCi/L). The pre-remediation average monthly Sr-90 discharge flux was 3.98 mCi/mo. (standard deviation 2.48 mCi/mo.) while during- and post-remediation average monthly flux has been 0.56 mCi/mo. (standard deviation 0.77 mCi/mo).

Surface water sampling in the SWSA 3 Sediment Basin was conducted semi-annually during FY 2018. Alpha activity was not detected in December 2017 but was detected in May 2018 at 2.18 J pCi/L which is much less than the 15 pCi/L MCL. Strontium-90 was not detected in the December 2017 sample but was detected in the May 2018 sample at 0.442 J pCi/L which is much less than the 8 pCi/L maximum contaminant level derived concentration (MCL-DC) for Sr-90. Tritium and VOCs were not detected in either sample.

Bearden Creek (7000 area). The eastern surface water exit pathway near the ORNL site is in Bearden Creek which lies to the east of the ORNL 7000 Services Area (Figure 2.2). Surface water is sampled in a tributary of Bearden Creek at the eastern end of the ORNL area in BV to evaluate contaminant discharges to surface water east of the 7000 Services Area. The principal contaminant source that affects this area is the former tritium handling facility at Building 7025 (Figure 2.2). Tritium has been detected in groundwater and surface water in the area, as described below. The 7000 Services Area is also the site of a VOC plume in groundwater that migrates westward from its source toward WOC.

Surface water monitoring has been conducted in the Bearden Creek tributary near the 7000 Services Area since the mid-1990s. Parameters included in analytical suites have varied over the monitoring history and have included metals, VOCs, and radionuclides. Metals, VOCs, and gross alpha and beta activity have not exceeded drinking water criteria with the exception of aluminum, which may be related to suspended solids as indicated by elevated turbidity levels in field measurements. Of 40 results obtained since the mid-1990s, 16 contained detectable activities of tritium. During 1998 and 1999, two samples were reported to contain tritium at activities greater than the drinking water MCL-DC (20,000 pCi/L)[4]; however these results are considered suspect because of possible laboratory problems. During the period 2000 through 2005, seven of 10 samples contained detectable tritium at activities ranging from 417 pCi/L to 949 pCi/L. A hiatus in sampling at the Bearden Creek location occurred between 2005 and 2009. Of 17 semiannual samples collected since sampling resumed in 2009, only two detections of tritium have occurred including activities of 511 pCi/L in July 2010 and 173 J pCi/L in February 2018.

The BV Interim ROD is an interim decision that addresses sources contributing to groundwater contamination and the contaminated groundwater's contribution to surface water contamination. Groundwater cleanup levels have not yet been established in a groundwater decision document. Drinking water MCLs are used here only as reference or screening levels when discussing detected groundwater contaminants. All of the tritium sample results, excluding the suspect 1998 – 1999 results, have been either non-detect values or were less than 10% of the drinking water MCL-DC.

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[4]This maximum contaminant level derived concentration (MCL-DC) is listed in 40 *Code of Federal Regulations* (CFR) 141.66(d)(2), Table A, as the "Average Annual Concentration Assumed to Produce a Total Body or Organ Dose of 4 mrem/yr," which is the maximum contaminant level (MCL) for beta particle and photon radioactivity.

Surface water mercury monitoring

Mercury is a COC in surface water because of its strong bioaccumulation tendency in fish. Mercury sampling has been conducted for many years at the 7500 Bridge. Since the winter of 2008, semiannual sampling of mercury has been conducted at First Creek, Northwest Tributary, Raccoon Creek, Fifth Creek, in WOC at the Third Street Bridge, and at WOC-105 upstream of the Fifth Creek confluence. Monitoring results for Raccoon Creek, Northwest Tributary, and First Creek indicate that they are not significant contributors of mercury, as each of these sites has routinely contained less than 5 ng/L of total mercury. Mercury discharges to WOC in BV originate predominantly from discharges directly to WOC upstream of Fifth Creek, from sources to Fifth Creek, and from treated wastewater effluent discharged from the ORNL PWTC. The most stringent applicable AWQC concentration for mercury is 51 ng/L.

Fifth Creek contains mercury at concentrations that have ranged from <10 ng/L to >100 ng/L. During the past several years, there have been a few mercury detections at levels several times the 51 ng/L AWQC value. ORNL and OREM staffs have worked collaboratively to locate the sources of mercury discharge into Fifth Creek. During FY 2018, the CERCLA monitoring program collected two samples from Fifth Creek for mercury analysis. The sample collected in November 2017 contained 25.9 ng/L total mercury, while the sample collected in June 2018 contained 33 ng/L total mercury.

Additional mercury monitoring results related to the RA for mercury discharges from Building 4501 are discussed below. DOE has completed actions stipulated by the BV Interim ROD for treatment of basement sump groundwater at Building 4501. Other sources of mercury contamination in soil throughout the site will be addressed in future actions under the BV Interim ROD. Monitoring of mercury in surface water in Fifth Creek and other locations in BV will continue.

Building 4501 mercury contaminated sump discharges

In December 2007, the first RA specified in the BV Interim ROD was partially completed by re-routing mercury-contaminated basement sump water at Building 4501 to treatment at the PWTC. In October 2009, the Building 4501 sump system was completed with the installation of an ion exchange system for the collected sump water to remove particle-associated mercury and dissolved mercury from the wastewater stream prior to its final treatment and discharge at the PWTC. This system installation includes a pre-filter and ion exchange located in the basement of Building 4501 that serves to pre-treat the sump water which is then routed to the PWTC.

Mercury monitoring is conducted at several surface water sampling locations in BV, and two locations are key to measuring the effectiveness of the Building 4501 sump water re-route. These locations include the watershed IP surface water sampling location at the 7500 Bridge and an in-stream sampling location (WOC-105) that is located approximately 250 ft downstream of the Outfall 211 storm drain (Figure 2.2). Prior to the 2007 basement sump discharge re-routing in Building 4501, some of the mercury contaminated basement sump discharges were routed to the storm drain that discharges at Outfall 211. Residual mercury contamination, including elemental mercury, remains in sediment accumulations in the upper portion of the storm drain. This residual mercury contamination is thought to be the primary source of ongoing mercury discharges to WOC at Outfall 211.

Figure 2.7 shows the mercury concentration history for the WOC-105 and 7500 Bridge locations. As shown on Figure 2.7, after 4501 basement sump water was routed to the PWTC, the frequency of AWQC exceedances for total mercury at 7500 Bridge decreased, with infrequent spikes that exceed the AWQC level. At the WOC-105 location, a similar dramatic decrease in mercury concentrations followed the removal of Building 4501 basement sump water discharges from Outfall 211.

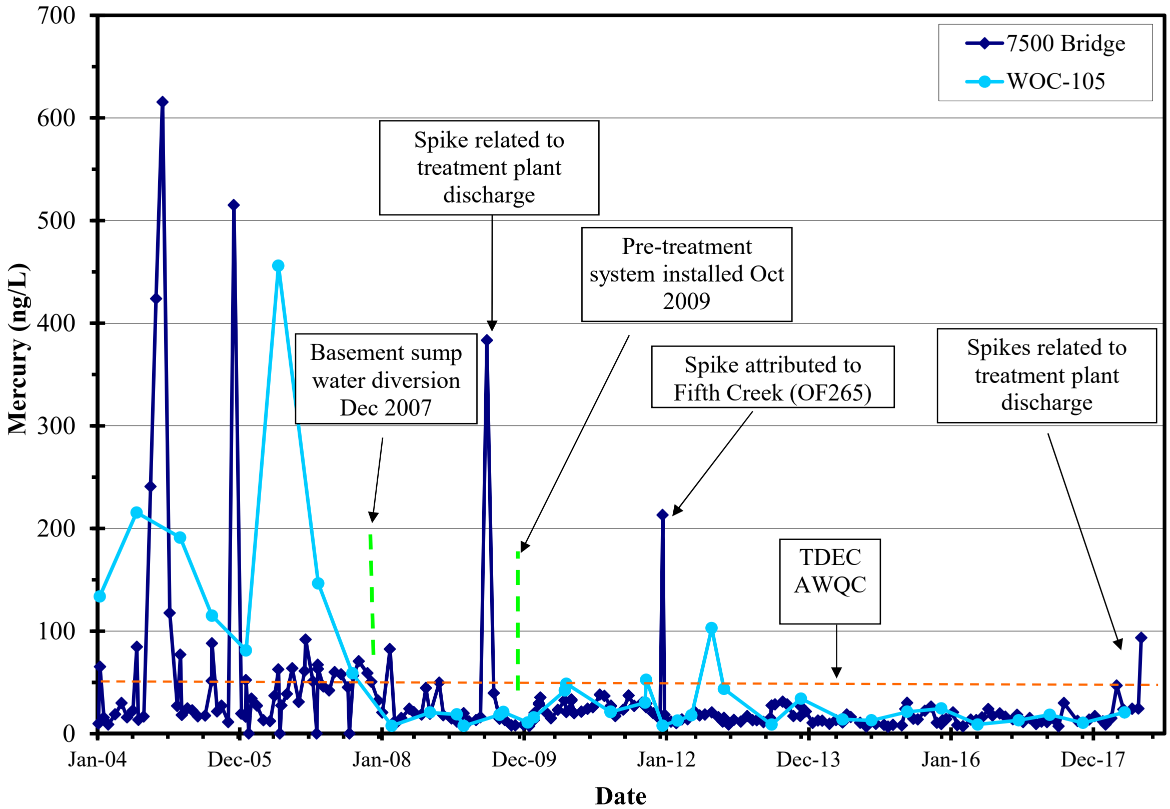


Figure 2.7. Mercury concentration history at 7500 Bridge and WOC-105 monitoring locations.

During FY 2018, a sample collected at the 7500 Bridge in September had an elevated mercury concentration of 93.5 ng/L. The suspected source of that elevated mercury was discharges from the PWTC which was undergoing construction activities. Mercury concentrations were less than the AWQC limit in both of the semiannual samples collected at WOC-105.

Corehole 8 extraction system

In 1991, CERCLA characterization efforts identified a plume of Sr-90 contaminated groundwater in the western portion of the ORNL main plant area, referred to as the Corehole 8 plume (Figure 2.8). Note that the Corehole 8 plume source (Tank W-1A) is addressed as a separate action in Section 2.4.1. A Removal Site Evaluation (RmSE) performed in 1994 concluded that contaminated groundwater seeping into the storm drain system was being discharged into First Creek. First Creek is a tributary to WOC and ultimately to the Clinch River. Further investigation showed that contaminated groundwater entered the storm water collection system by in-leakage to three catch basins in the western part of ORNL.

Since the time that seepage into First Creek was discovered, the Corehole 8 Plume has been addressed through a series of actions beginning with the initial Corehole 8 (Plume Collection) removal action completed in 1994. Performance monitoring and LUCs for that removal action have been superseded by the *Phased Construction Completion Report for the Bethel Valley (Corehole 8) Extraction System at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (BV Corehole 8 PCCR; DOE/OR/01-2534&D1) approved in 2012. This action was completed under the BV Interim ROD.

Figure 2.9 is a simplified conceptual block diagram of the Corehole 8 plume that shows the plume confined within a dipping limestone bed that is approximately 10 ft thick. Contaminants seep into the weathered limestone bed beneath the North Tank Farm near Tank W-1A. Groundwater seepage within the dipping bed carries contamination downward and westward, as shown by the flowlines in Figure 2.9. A portion of the flow rises to discharge into the base of the soil profile near the western edge of the ORNL central campus near First Street, where the plume collection system was installed during implementation of the removal action. Contaminant concentrations are attenuated along the seepage pathway with approximately 100-fold reduction in concentration measured between well 4411 (near the source area) and at well 0812 and in the collection system at the western end of the plume. The full vertical and lateral extent of the Corehole 8 Plume has not been confirmed but will be determined by investigations leading to a final groundwater decision for BV.

Evaluation of plume collection performance monitoring data

During FY 2018, the Corehole 8 plume interceptor system achieved the performance goal for reduction of Sr-90 discharge to First Creek, as discussed below. During FY 2009 – FY 2011, the electrical control systems on the original groundwater collection sumps became increasingly unreliable and numerous operational outages occurred. In 2010, DOE issued the *Remedial Design Report/Remedial Action Work Plan for the Bethel Valley (Corehole 8) Extraction System at Oak Ridge National Laboratory, Oak Ridge Tennessee* (DOE/OR/01-2469&D2) that included design details for extraction system expansion including the addition of bedrock plume extraction wells, testing and repair of existing delivery piping, and replacement of the existing pumps and the entire system controls. In mid-March of FY 2012, the refurbished collection system was placed in operation. Upon completion of the refurbishment, the BV Corehole 8 PCCR was approved that documents the work performed and the system configuration upon completion.

First Creek is the receiving surface water body for discharge of contaminated groundwater in the Corehole 8 plume. Continuous flow-paced monitoring of First Creek has been ongoing since before the Corehole 8 plume removal action was completed in 1994. Table 2.7 includes the FY 2018 monthly flow volumes, Sr-90 activities, and Sr-90 fluxes, as well as similar startup of the Corehole 8 groundwater collection system. Table 2.8 shows the history of Sr-90 fluxes and flux reduction factors in First Creek from calendar year (CY) 1993 through FY 2018.

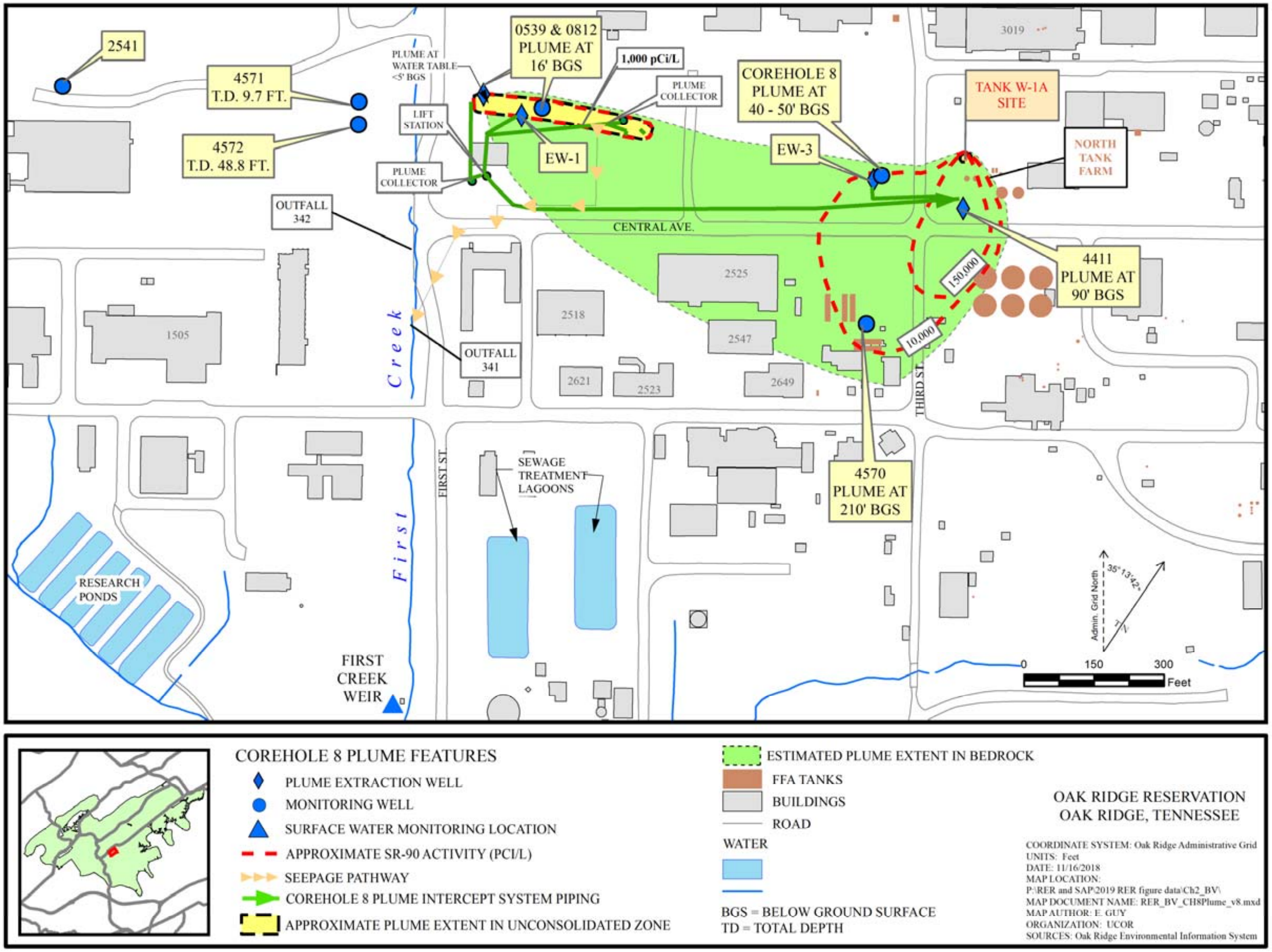


Figure 2.8. Location and features of the Corehole 8 Plume.

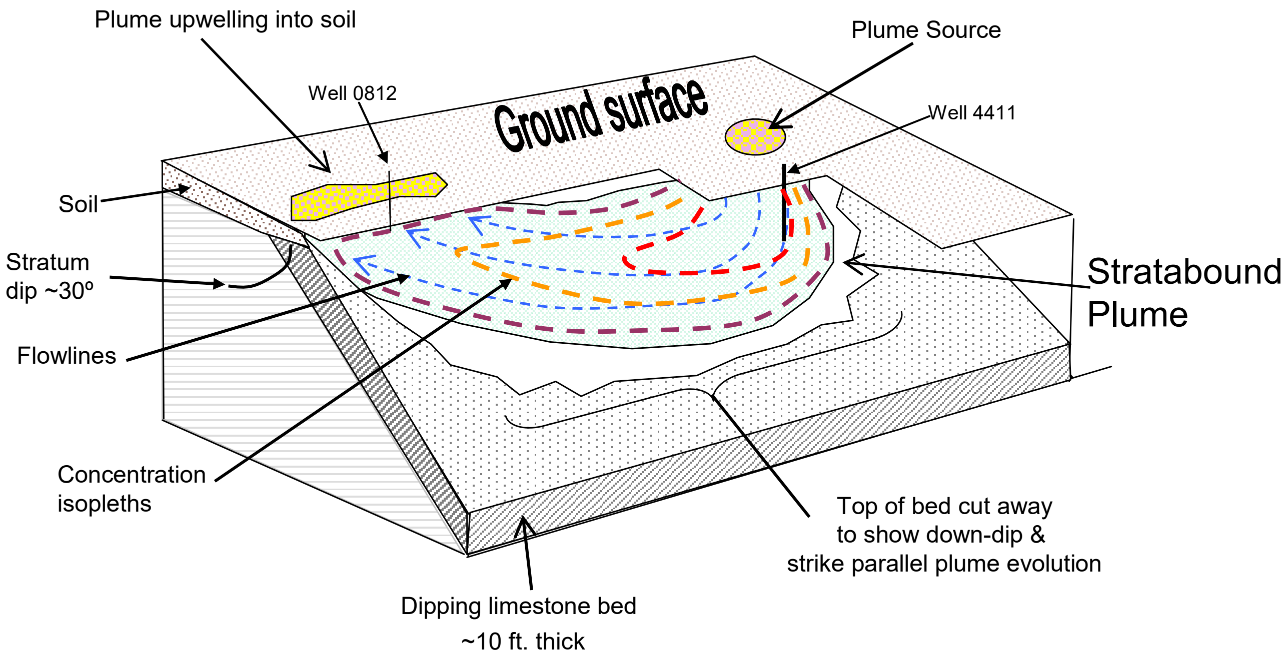


Figure 2.9. Conceptual block diagram of the Corehole 8 Plume.

Table 2.7. First Creek Sr-90 fluxes pre-action and in FY 2018

Month	CY 1994 (pre-action)[a]			Month	FY 2018		
	Sr-90 (pCi/L)	Flow volume (L)	Sr-90 flux (Ci)		Sr-90 (pCi/L)	Flow volume (L)	Sr-90 flux (Ci)
January 1994	124.4	102,893,891	0.0128	October 2017	4.04	37,660,090	0.00015
February 1994	95.6	126,569,038	0.0121	November 2017	11.8	83,202,869	0.00098
March 1994	89.2	228,699,552	0.0204	December 2017	5.43	78,302,938	0.00043
April 1994	105.4	166,982,922	0.0176	January 2018	3.33	51,496,762	0.00017
May 1994	236.5	41,437,632	0.0098	February 2018	13.8	248,850,533	0.00343
June 1994	297.3	32,963,337	0.0098	March 2018	10.5	139,385,563	0.00146
July 1994	324.4	25,585,697	0.0083	April 2018	5.81	137,260,771	0.00080
August 1994	378.4	30,919,662	0.0117	May 2018	2.26	62,370,000	0.00014
September 1994	364.9	26,586,673	0.0097	June 2018	2.29	34,821,158	0.00008
October 1994	133.6	24,700,599	0.0033	July 2018	12.5	37,155,341	0.00046
November 1994	260.9	37,178,996	0.0097	August 2018	3.82	28,045,570	0.00011
December 1994	179.8	66,740,823	0.012	September 2018	2.74	51,569,525	0.00014
Total		911,258,822	0.137	Total		990,121,120	0.0084

[a]1994 was the baseline for the *Remedial Action Report for the Corehole 8 [CH] Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1380&D1).

CY = calendar year
FY = fiscal year

Table 2.8. Sr-90 flux changes at First Creek Weir, 1993 – 2018

Year	Sr-90 flux (Ci)	Percent reduction from CY 1994[a]
CY 1993	0.13	NA
CY 1994	0.137	NA
CY 1995[b]	0.067	51.1
FY 1996	NA	NA
FY 1997	0.036[c]	73.7
FY 1998	0.044[d]	67.9
FY 1999	0.044[d]	67.9
FY 2000	0.026	81.0
FY 2001	0.035	74.8
FY 2002	0.034	75.0
FY 2003	0.016	88.0
FY 2004	0.016	88.5
FY 2005	0.019	86.2
FY 2006	0.011	92.0
FY 2007	0.014	89.2
FY 2008	0.022	84.0
FY 2009	**0.119**	12.9
FY 2010	**0.131**	5.0
FY 2011	**0.116**	8.5
FY 2012	0.059	43.1
FY 2013	0.042	69.5
FY 2014	0.013	90.8
FY 2015	0.0074	94.6
FY 2016	0.006	95.6
FY 2017	0.0052	96.2
FY 2018	0.0086	93.7

[a]Remedy effectiveness (20 – 50% reduction from 1994 flux). 1994 was the baseline for the *Remedial Action Report for the Corehole 8 [CH] Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1380&D1).
[b]Corehole 8 Removal Action performance started.
[c]Represents 10 months of data.
[d]Represents 11 months of data.

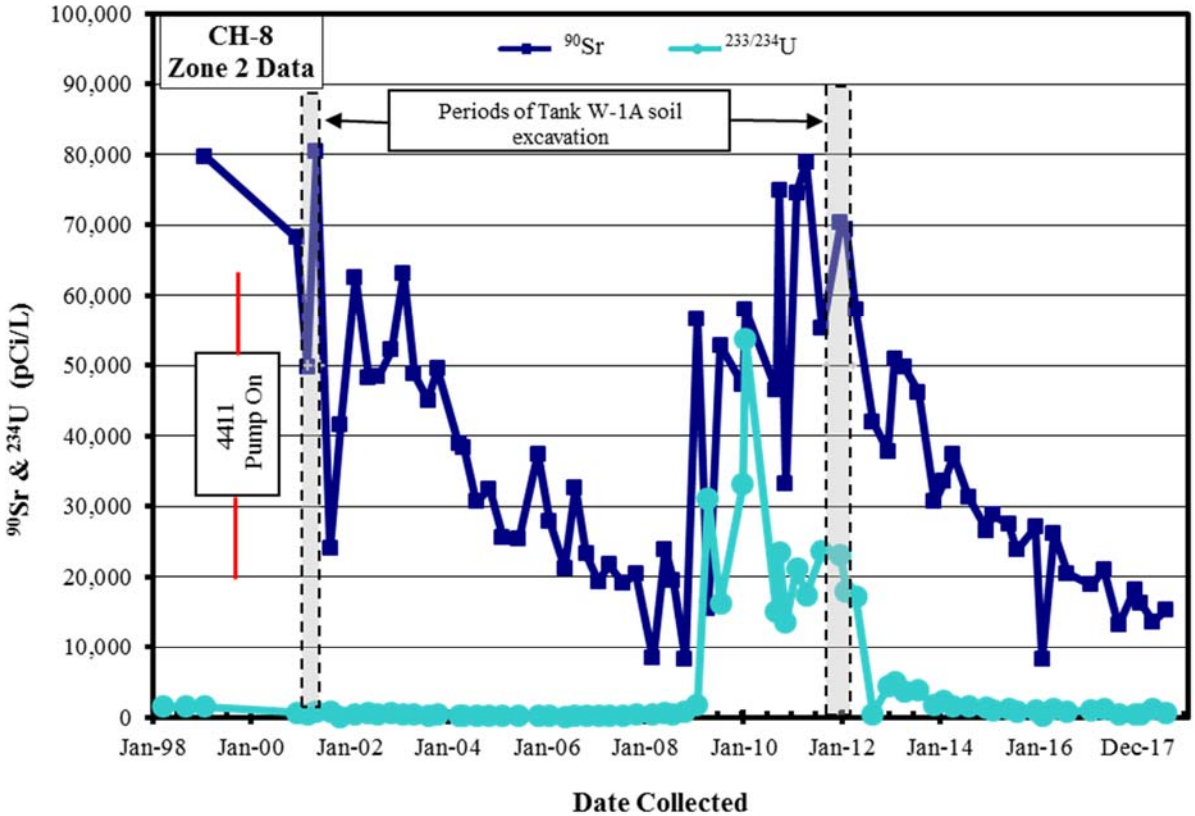
Bold table entries indicate years when the remedy has not achieved the performance goal.

CY = calendar year
FY = fiscal year
NA = not applicable

Performance evaluation data summarized in Table 2.8 show that the Corehole 8 plume collection system effectively reduced contaminant discharge to First Creek through FY 2008, but that performance deteriorated in FY 2009 and remained poor through FY 2011. The system performance goal was not met during FY 2009 through FY 2011. Despite the system being out of service for half the FY 2012 due to construction, the remedy goal of Sr-90 reduction in First Creek was met during FY 2012 and subsequent years including FY 2018. During FY 2018, the Corehole 8 plume collection system experienced minimal operational problems.

Figure 2.10 shows the historical Sr-90 and U-233/234 activities measured in groundwater at wells 4411 and Corehole 8 Zone 2. Well 4411 (Figure 2.8) is a plume extraction well that intersects the plume at a depth of approximately 90 ft bgs in a location approximately 120 ft south of the former Tank W-1A location, where leakage from a broken LLLW pipeline created the plume source (Figure 2.8). Samples from well 4411 are taken at the wellhead and represent contaminant concentrations in extracted groundwater that is being pumped to the PWTC for treatment. Corehole 8 is a 50 ft deep well in which a Westbay® multizone sampling system was installed to allow sampling of discrete intervals in the well. Zone 2 of the Corehole 8 location is the second zone from the bottom of the well, and its sampling interval spans the depth of 41.2 – 43.2 ft bgs (Figure 2.8). During well installation and initial sampling, this zone was found to produce the highest activities of contaminants in the well and for that reason it has become the focal point for ongoing monitoring at that location. Data presented in Figure 2.10 show that at Corehole 8 during FY 2018, Sr-90 and U-233/234 activities continued the decreasing trend that started in 2012 coincident with completion of Tank W-1A and associated contaminated soil removal. Similar to Corehole 8, Sr-90 and U-233/234 activities in well 4411 continued to gradually decline during FY 2018.

Figure 2.11 shows the Corehole 8 groundwater collection sump Sr-90 and alpha activity data from system startup in 1995 through FY 2018. Notations on the figure show approximate dates when extraction of contaminated groundwater via well 4411 started, as well as the approximate dates during which contaminated soil was excavated from the North Tank Farm. The data demonstrate that both actions had visible benefits in reducing contaminant activities in the plume collection system that is located in the western end of the plume. Table 2.9 includes Corehole 8 collection system monthly and year-end total flow volumes collected and strontium flux captured and sent to the PWTC for FY 1997 and FY 2018. Figure 2.12 shows the annual flux of Sr-90 collected by the Corehole 8 groundwater collection system along with total annual rainfall. The long-term average annual rainfall for Oak Ridge is approximately 54 in./yr. As shown on Figure 2.12, FY 2003 – FY 2005 and FY 2009 – FY 2013 were years of above average rainfall. FY 2003 was an especially unusual year in that the annual rainfall was approximately 35% above the long-term average. The rainfall for FY 2018 (58.89 in.) was slightly above average.



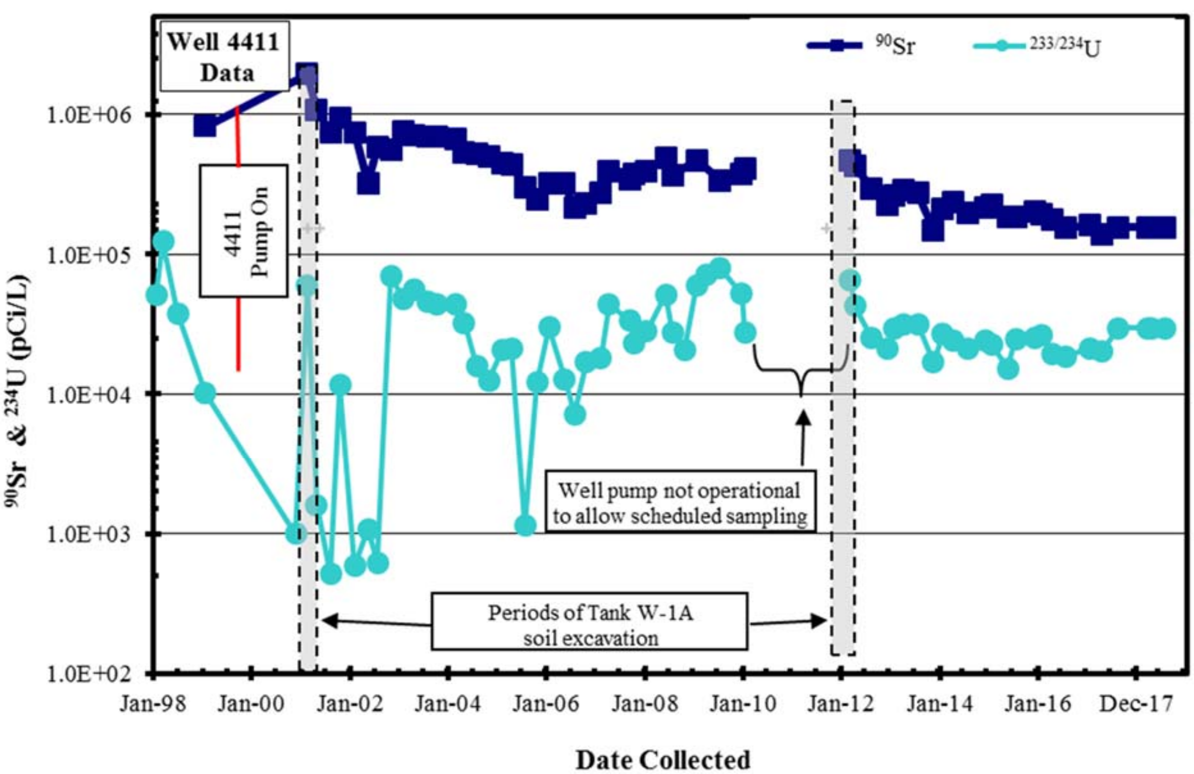


Figure 2.10. Contaminant activities in well 4411 and Corehole 8 Zone 2.

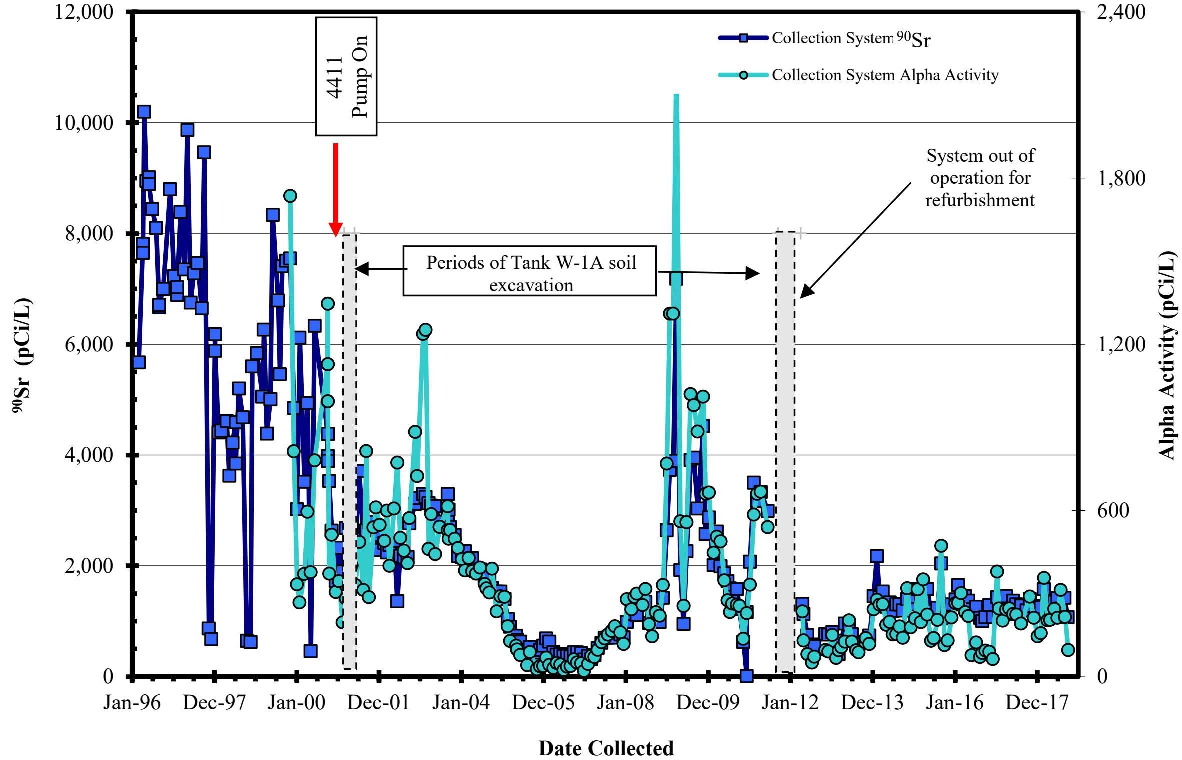


Figure 2.11. Sr-90 and alpha activity in collected Corehole 8 Plume groundwater.

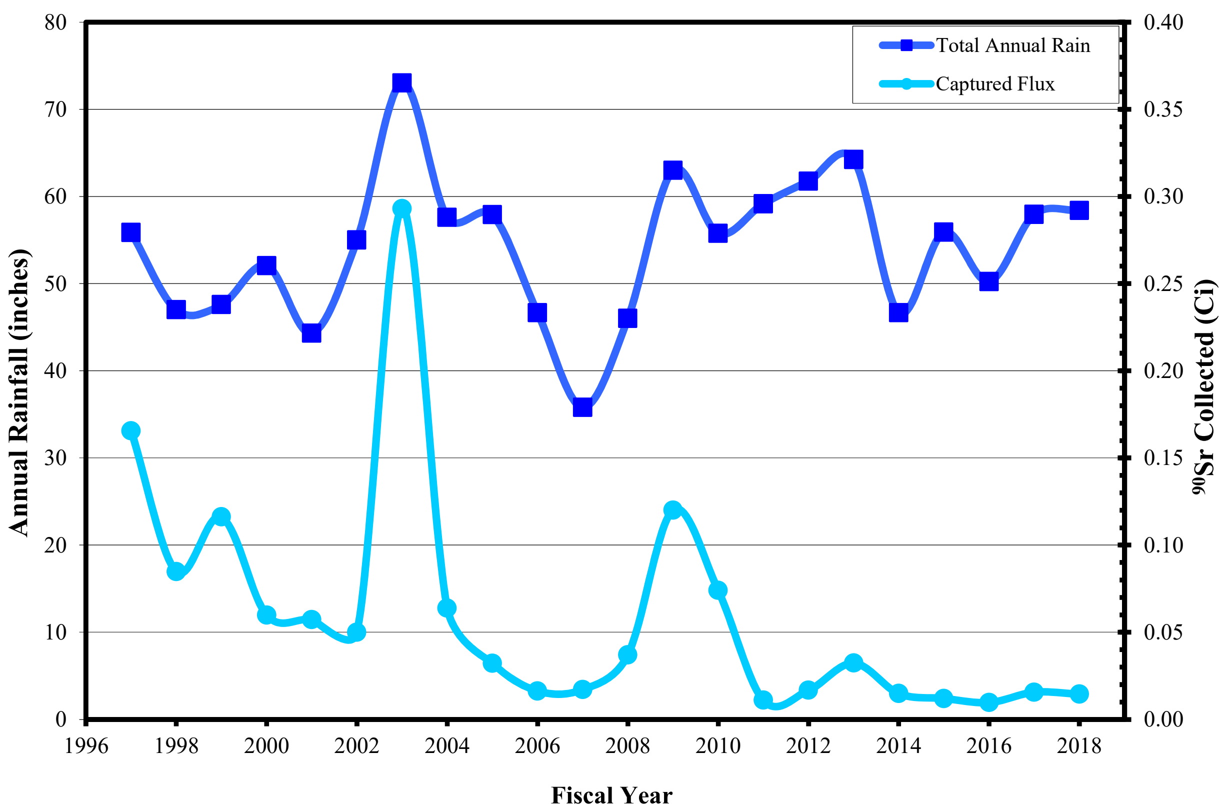


Figure 2.12. Corehole 8 Plume groundwater collector annual intercepted Sr-90 flux and rainfall.

Table 2.9. Corehole 8 groundwater collection system Sr-90 flux

Month	FY 1997[a]			Month	FY 2018		
	Sr-90 (pCi/L)	Flow volume (L)	Sr-90 flux (Ci)		Sr-90 (pCi/L)	Flow volume (L)[b]	Sr-90 flux (Ci)
October 1996	8,700	933,000	0.0081	October 2017	1,190	806,328	0.0010
November 1996	8,800	1,845,000	0.0162	November 2017	1,400	782,237	0.0011
December 1996	7,230	2,595,000	0.0188	December 2017	1,270	740,693	0.0009
January 1997	6,890	1,711,000	0.0118	January 2018	1,210	823,018	0.0010
February 1997	8,390	1,858,000	0.0156	February 2018	1,250	989,323	0.0012
March 1997	7,350	2,162,000	0.0159	March 2018	1,580	895,594	0.0014
April 1997	9,870	1,946,000	0.0192	April 2018	1,240	496,426	0.0006
May 1997	6,750	1,697,000	0.0115	May 2018	1,150	1,516,853	0.0017
June 1997	7,280	2,631,000	0.0192	June 2018	1,350	1,294,906	0.0017
July 1997	7,463	1,705,000	0.0127	July 2018	1,410	790,416	0.0011
August 1997	6,647	1,131,000	0.0075	August 2018	1,230	1,051,214	0.0013
September 1997	9,465	953,000	0.009	September 2018	1,420	1,102,968	0.0016
Total		21,167,000	0.1655	Total		11,938,666	0.0154

[a] FY 1997 was the first year of recorded flow-paced composite radiological strontium sampling and analysis.
[b] A 2012 change in the flow monitoring equipment and sampling system triggering mechanism caused a non-systematic reduction of the apparent collection system flow total volumes compared to prior results.

FY = fiscal year

Figure 2.13 shows Sr-90 and U-233/234 activities measured at well 4570 (Figure 2.8) since its installation as recommended in the *Engineering Study Report for Groundwater Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-2219&D2). Well 4570 (Figure 2.8) was drilled to evaluate down-dip extent of the plume in the stratabound limestone unit. During construction of the well, samples of the drilling return water were collected periodically and screened for beta activity as an indicator of the presence of Sr-90. Beta activity levels increased at approximately 200 ft bgs, which was the projected depth of the limestone bed at that location. Contaminant activities have declined from initial concentrations since the beginning of monitoring this well, although both contaminants exhibited increasing concentrations following Tank W-1A excavation to FY 2015. Concentrations of Sr-90 and U-233/234 appear to have moderated during FY 2015 through 2018. The cause of the increase is uncertain, although the extensive disturbances of contaminated media during excavation may have mobilized contamination into the local groundwater.

Wells 4571 and 4572 (Figure 2.8) are monitored semiannually to evaluate the potential extension of the plume west of First Creek. Well 4571 samples groundwater from the top of bedrock at a depth of 9.7 ft, while well 4572 samples shallow bedrock groundwater at a depth of 48.8 ft bgs. Sr-90 was not detected in any of the semi-annual samples collected from wells 4571 and 4572 during FY 2018.

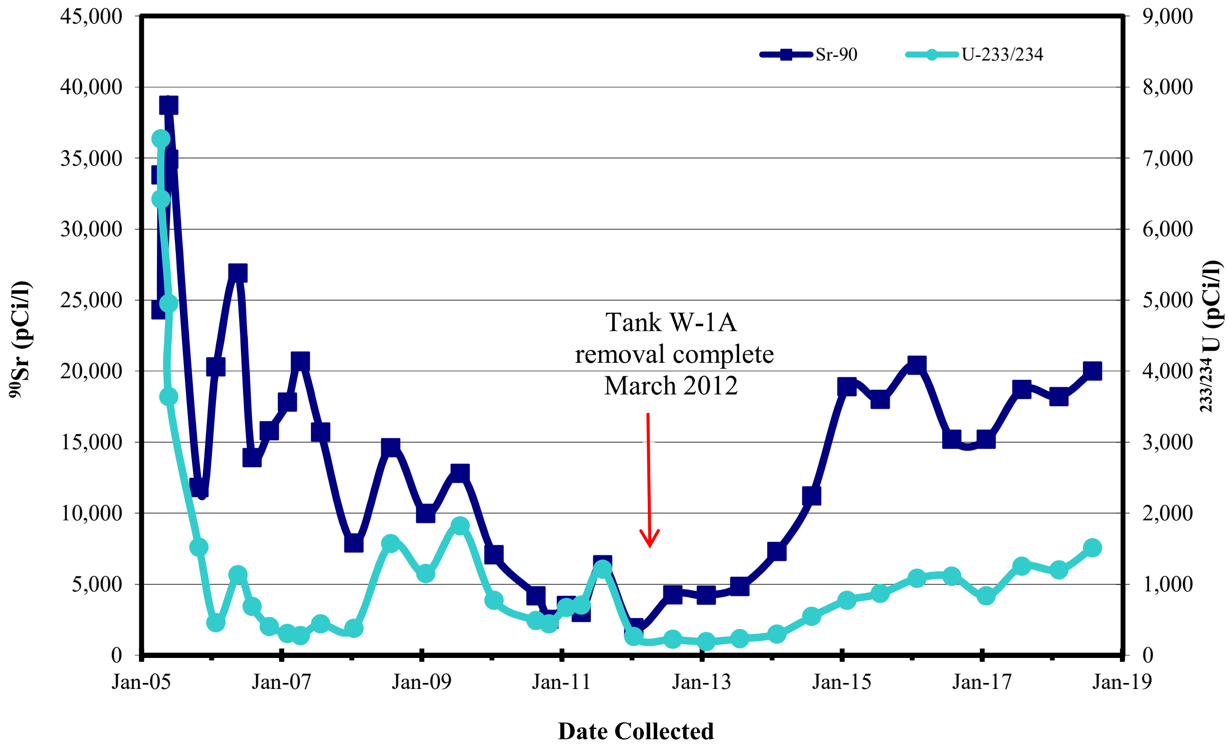


Figure 2.13. Sr-90 and U-233/234 activities in well 4570.

DOE samples three zones of multi-zone well 2541 located approximately 640 ft west of wells 4571 and 4572. The deepest and intermediate sampled zones (2541-02 [226 ft bgs = elevation 589 ft above Mean Sea Level (aMSL)] and 2541-03 [101 ft bgs = elevation 714 ft aMSL]) are geologically correlative with Rockdell formation bedrock that would project to bedrock underlying Buildings 3026 and 3019. The shallowest sampled zone (2541-05 [49 ft bgs = 766 ft aMSL]) is correlative with the limestone underlying Corehole 8. The deeper zones have intermittently exhibited Sr-90 contamination greater than the 8 pCi/L MCL-DC, fluoride greater than the MCL, and possibly naturally-occurring benzene, toluene, ethylbenzene, and xylene (BTEX) compounds with benzene greater than the 5 µg/L MCL (Table 2.10). During FY 2018, Sr-90 was not detected in 2541-02. In 2541-03, Sr-90 was detected at 7.92 pCi/L in January, but was not detected in the September sample. Sr-90 was not detected in either sample collected from the shallowest zone (2541-05) in either the January or September samples. Fluoride was detected at concentrations of 6.93 and 7.1 mg/L in zone 2541-02 (greater than the 4 mg/L MCL) and at concentrations less than the MCL in sample zones 2541-03 and 2541-05. Cis-1,2-dichloroethene (DCE) was detected at trace concentrations (0.53 J and 0.46 J µg/L) in sample zone 2541-05 in January and September, respectively. Benzene was detected at concentrations of 8.76 and 4.94 µg/L in sample zone 2541-03 in January and September, respectively. Ethylbenzene was detected at concentrations of 1.48 and 1.45 µg/L (much less than the 700 µg/L MCL for ethylbenzene) in the January and September samples. Benzene and ethylbenzene are common petroleum hydrocarbons that are constituents of crude oil and fuels. Underground fuel tanks were used at numerous locations at ORNL to support emergency generators and some fuel leaks were known to have occurred. Additionally, natural crude oil pockets have been encountered in boreholes in BV which demonstrates that some of the petroleum hydrocarbon compounds detected in bedrock wells may be from natural sources.

DOE has compiled the analytical data for monitored groundwater contaminants in the Corehole 8 plume to evaluate environmental responses to the RA. Monitoring data are compared to EPA's National Primary Drinking Water Regulations MCLs or MCL-DCs for radionuclides. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants that may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. Mann-Kendall (M-K) trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations.

Table 2.10 provides a summary of the Corehole 8 plume groundwater contaminant concentrations and M-K trends for principal groundwater contaminants that have exceeded 80% of their MCLs or MCL-DCs within the past decade. As indicated in preceding discussions and graphs, the overall trends for Sr-90, the principal contaminant in the Corehole 8 plume, have been decreasing or no trend can be assigned in the locations where the highest concentrations are measured. Alpha activity in the Corehole 8 plume is primarily derived from U-233 with subordinate concentrations of U-235 and U-238. Alpha activity trends have been predominantly decreasing. The only well location that shows increasing Sr-90 and alpha activity trends is well 4570 which are apparent in Figure 2.13.

Plume collection performance summary. The Corehole 8 plume collection system met its performance goal during FY 2018 based on Sr-90 flux reduction in First Creek (Table 2.8). Contaminant activity levels in the plume rose to high levels in the 2009 – 2010 period and have decreased significantly following refurbishment of the plume collection system, as shown on graphs for well 4411, Corehole 8 Zone 2, and in the collected groundwater in the Corehole 8 collection system. The Corehole 8 Zone 2 and well 4411 monitoring locations are both relatively close to the former Tank W-1A site and sample groundwater from approximately 40 and 80 ft below the top of bedrock, respectively. The radiological contaminant levels in groundwater in these areas remain very high although the concentration trends are decreasing. The groundwater pumping rate at well 4411 is restricted to a continuous 1 gal/min based on waste processing factors. The hydraulic conditions at these two monitoring locations are regarded as fairly steady state. The monthly Sr-90 concentration and estimated monthly and annual flux of Sr-90 captured during FY 2018 are summarized in Table 2.9. At well 4570, concentration trends over the past five years have been categorized as increasing for alpha activity and no statistically significant trend for Sr-90. The period of rapidly increasing Sr-90 concentrations in well 4570 ended in January 2015 as shown on Figure 2.13.

Table 2.10. Summary of Corehole 8 plume 10-year and 5-year groundwater contaminant trends (FY 2009 – FY 2018)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Alpha activity	0812	pCi/L	40 / 40	20 / 20	--	**1,980**	**1,310**	**828**	15	40 / 40	20 / 20	40 / 40	20 / 20	Down	No trend
	4411	pCi/L	31 / 31	19 / 19	--	**55,600**	**55,600**	**55,600**	15	31 / 31	19 / 19	31 / 31	19 / 19	Down	No trend
	4570	pCi/L	20 / 20	10 / 10	--	**1,410**	**1,410**	**1,410**	15	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Up
	2541-02	pCi/L	6 / 20	3 / 10	4.98	**37**	2.71	2.48	15	1 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	CH8-2	pCi/L	40 / 40	20 / 20	--	**56,100**	**2,220**	**649**	15	40 / 40	20 / 20	40 / 40	20 / 20	Down	Down
Benzene	2541-03	mg/L	11 / 11	10 / 10	--	**0.016**	**0.016**	**0.009**	0.005	10 / 11	9 / 10	11 / 11	10 / 10	Down	Down
Fluoride	2541-02	mg/L	20 / 20	10 / 10	--	**7.5**	**7.5**	**7.1**	4	19 / 20	10 / 10	19 / 20	10 / 10	Up	No trend
Strontium-90	0812	pCi/L	40 / 40	20 / 20	--	**7,970**	**2,000**	**1,710**	8	40 / 40	20 / 20	40 / 40	20 / 20	Down	Stable
	4411	pCi/L	31 / 31	19 / 19	--	**466,000**	**235,000**	**170,000**	8	31 / 31	19 / 19	31 / 31	19 / 19	Down	Down
	4570	pCi/L	20 / 20	10 / 10	--	**20,400**	**20,400**	**20,000**	8	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
	2541-02	pCi/L	9 / 20	4 / 10	2.25	**44.8**	4.21	ND	8	1 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	2541-03	pCi/L	6 / 17	5 / 10	2.17	**8**	7.92	7.92	8	0 / 17	0 / 10	2 / 17	1 / 10	No trend	No trend
	2541-05	pCi/L	8 / 20	4 / 10	2.57	**50.1**	5.14	0.27	8	2 / 20	0 / 10	2 / 20	0 / 10	No trend	No trend
	CH8-2	pCi/L	40 / 40	20 / 20	--	**78,900**	**37,300**	**18,100**	8	40 / 40	20 / 20	40 / 40	20 / 20	Down	Down
Technetium-99	4411	pCi/L	7 / 27	6 / 19	1,360	**1,180**	**1,180**	163	900	1 / 27	1 / 19	1 / 27	1 / 19	No trend	No trend
	CH8-2	pCi/L	10 / 35	7 / 20	256	**1,380**	52.1	12.9	900	1 / 35	0 / 20	1 / 35	0 / 20	No trend	No trend

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[b]MCL or MCL-DC as of May 2018.

[c]Significant linear trend from the M-K test at the 0.05 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
M-K = Mann-Kendall
ND = not detected

2.3.1.2.2 Groundwater

The BV Interim ROD identified groundwater COCs in subregions of the BV watershed based on human health risk-based goals. No human health COCs were identified in the ROD for the Raccoon Creek and West BV subareas. The ORNL Central Campus Area was subdivided into several subareas reflecting the diversity of past onsite activities and associated contamination of soils and groundwater. For the purpose of this overview summary, the COCs identified in the ORNL Central Campus subareas have been combined. The East BV Area where the 7000 area is located also has groundwater COCs. Table 2.11 identifies radionuclide, organic, metal, and anion COCs in groundwater from the ROD.

Table 2.11. BV watershed groundwater COCs

Area	Radionuclides		Organics	Metals	Anions
Central BV Area	Am-241	Ra-226	Pyridine	Arsenic	Fluoride
	Bi-212	Ra-228	Trichloroethene	Beryllium	
	C-14	Sr-89	Vinyl Chloride	Chromium	
	Ca-45	Sr-90		Manganese	
	Ce-144	Tc-99		Uranium	
	Cs-137	Th-228			
	Cu-244	Th-232			
	H-3	U-232			
	K-40	U-234			
	Ni-63	U-235			
	Pb-210	U-236			
	Pb-212	U-238			
	Pm-147	Zn-65			
	Pu-242				
East BV (7000) Area	H-3		1,1-Dichloroethene		
			1,2-Dichloroethene		
			Benzene		
			Tetrachloroethene		
			Trichloroethene		
			Vinyl chloride		

Source: Table 2.5 of the *Record of Decision Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4).

BV = Bethel Valley
COC = contaminant of concern

CERCLA groundwater monitoring in BV for actions under the BV Interim ROD includes exit pathway well monitoring, ongoing monitoring related to the 7000 Area VOC Plume Treatability Study (conducted in 2011), and monitoring related to the SWSA 3 RA. The ongoing groundwater monitoring activities focus on the predominant COCs identified in the monitored areas. Exit pathway wells in the western and eastern ends of the ORNL area in BV are monitored to determine if contaminants discharge to Raccoon Creek and Bearden Creek, respectively. Results of surface water monitoring in these two subwatersheds were discussed in Section 2.3.1.2.1.3. Figure 2.2 shows locations where BV exit pathway sampling is conducted. Bearden Creek Exit Pathway groundwater monitoring well results (wells 1198 and 1199) are discussed later in this section. Wells 4579, 4645, 4646, and 4647 in the Raccoon Creek headwaters are discussed along with the SWSA 3 monitoring results.

ORNL 7000 Area VOC Plume Treatability Study

The 7000 area VOC plume is predominantly a trichloroethene (TCE) plume, with several transformation products that are formed by microbial degradation of the TCE. Principal degradation products include cis-1,2-DCE, 1,1-DCE, and vinyl chloride (VC). The plume mostly occurs in fractured, karst bedrock of the Ordovician age Witten formation. The Witten formation is comprised of interbedded argillaceous limestone (containing a high clay/silt fraction) and relatively pure limestone beds. In the 7000 area, the lower half of the Witten formation contains two relatively distinct pure limestone members locally referred to as the "Little Lime" and the "Big Lime" (which is not correlative with the Mississippian age *Big Lime* that is a prominent petroleum producing formation beneath the Cumberland Plateau and Mountains). The core portion of the plume occurs in the "Little Lime" which is also suspected to be a key groundwater contaminant pathway for radionuclides at SWSA 3. The source of the TCE is suspected to have been released from a small-parts cleaning facility that was dismantled prior to CERCLA site investigations. The principal known discharge location for groundwater affected by the plume is a small spring that forms the head water of a small tributary of WOC.

The report for the *Treatability Study for the Bethel Valley 7000 Area Groundwater Plume, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (Treatability Study report; DOE/OR/01-2566&D1) was issued in May 2012. The report presented the results of field and laboratory tests that were used to design a field scale biostimulation pilot test. The report also summarized monitoring results for a one-year period following the injection of materials that allowed native dehalogenating microbes and other native microbes to increase their population numbers with resulting degradation of TCE and its transformation products.

Sampling and analysis are ongoing at seven monitoring wells (0752, 1201, 4576, 4577, 4581, 4582, and 4583) and one spring (SP-200) in the study area to document the sustainability of the treatment and measure ongoing trends in VOC concentrations and microbial populations (Figure 2.14). In addition, sampling is periodically conducted for VOCs at additional wells in the vicinity of the study area. These include well 0754, and three zones in the multi-port well 4575.

Figure 2.14 provides the plume maps, projected to the surface, prior to and after injection of the biostimulant materials, and includes a cross-section showing the TCE plume (with VC concentrations also indicated on the cross-section) based on the December 2010 groundwater data (pre-treatability study) and based on the fiscal quarter 4 (July – September 2018) groundwater data (7.5 years after biostimulation).

Following injection of the emulsified vegetable oil and hydrogen releasing compound into four wells in the study area, the endemic community of microbes, including the native *Dehalococcoides* sp. (DHC), grew rapidly producing strongly anaerobic groundwater conditions in the vicinity. TCE concentrations declined fairly rapidly and the daughter products increased in proportion in the area where the biostimulant altered the groundwater chemistry and the microbial community flourished. Figures 2.15, 2.16, and 2.17 show the monitored trends of VOCs pre-biostimulation through FY 2018.

At injection wells 4583 and 0752 near the upgradient end of the test area, TCE concentrations decreased by well over two orders of magnitude (very rapidly at 4583 and more gradually at 0752) following injection of the biostimulant before beginning to rebound through inflow of upgradient dissolved phase plume water. During FY 2018, the VOC concentrations in both these wells showed fluctuating concentrations but remained approximately three orders of magnitude lower than at the initial concentrations prior to the treatability test.

At injection wells 1201 and 4582, located near the middle of the test area, TCE concentrations remain very low at levels of approximately 1 µg/L which is a dramatic decrease from pre-treatment concentrations. Well 1201 underwent re-development in late August 2018 because the well screened interval and pump had become fouled by microbial growth. The redevelopment effect on the area groundwater is thought to have drawn in groundwater with very high cis-1,2-DCE and VC as shown in the early September data on Figure 2.16. Ethylene, a final stage degradation product in the TCE degradation chain, remains present in the tens to hundreds of µg/L which indicates the biodegradation process is continuing in the area. At well 4582, cis-1,2-DCE and VC concentrations have continued to decrease along with the decrease in TCE.

Field parameter data collected contemporaneous with sampling events shows that redox conditions remain consistently reductive (negative millivolt values) in wells 0752, 1201, 4576, 4581, 4582, and 4583 which, combined with the persistent presence of high methane concentrations and presence of ethylene, is evidence of the continuing biodegradation of the VOCs within and downgradient of the injection area.

The ORNL 7000 Area VOC Plume Treatability Study was undertaken as a project of two-year duration to test the feasibility of bioremediation of the TCE-dominated plume. Monitoring conducted during FY 2011 was the fulfillment of planned broad scale monitoring. The final Treatability Study report issued in April 2012 recommended continued monitoring as a "near-term" activity. Beginning in FY 2016, DOE continued monitoring all wells included in the treatability study for only VOCs and standard field parameters. A 7000 Area Characterization Plan/SAP will be included in the BV Final ROD RIWP (a FY 2020 milestone) that will describe the characterization work needed to design a plan for full-scale bioremediation of the 7000 Area TCE plume. Following characterization, an engineering design phase for full-scale plume remediation (Remedial Design Report/Remedial Action Work Plan ([RDR/RAWP]) will be completed. The RDR/RAWP will establish the required monitoring associated with the RA and will follow the CERCLA process.

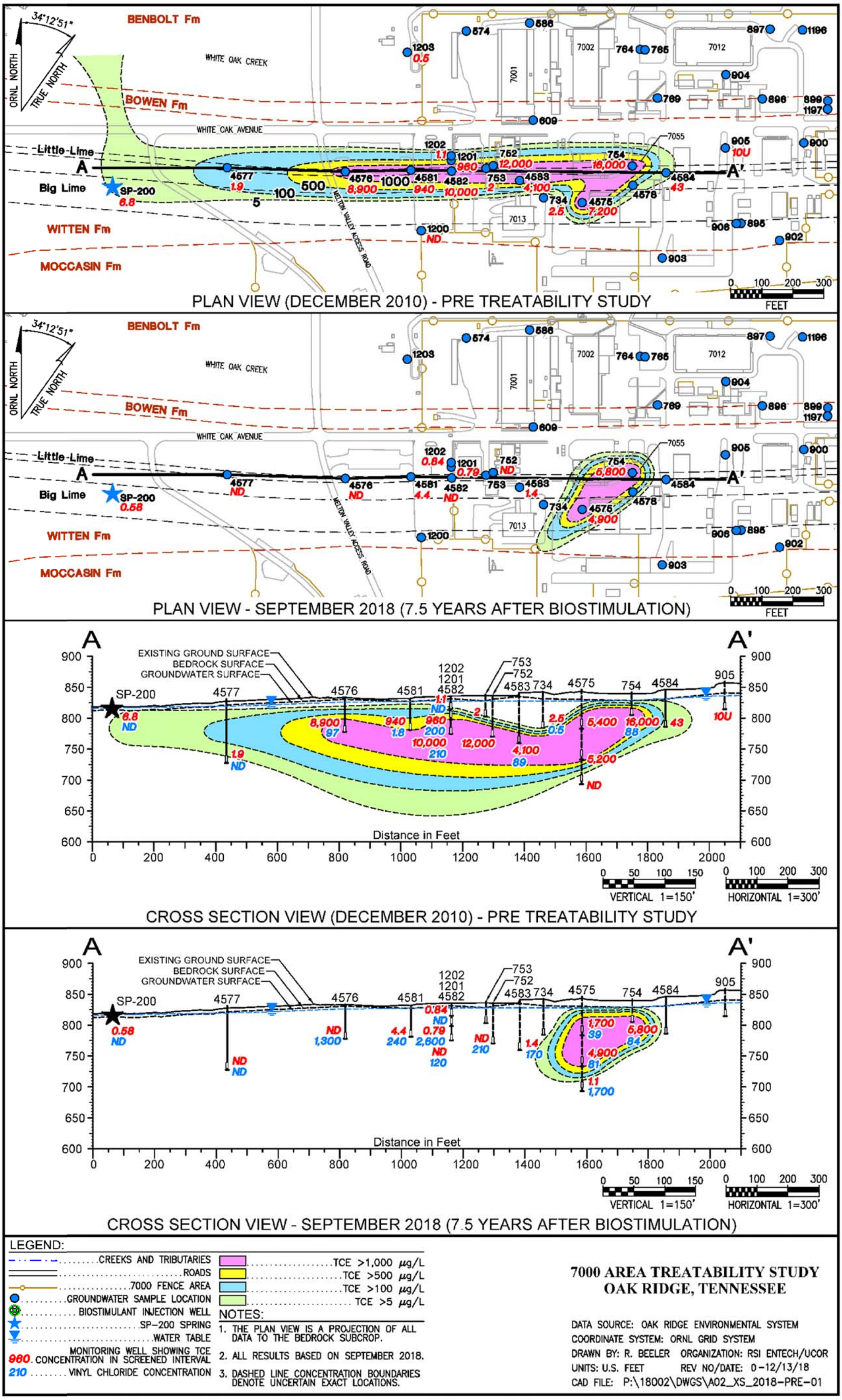


Figure 2.14. ORNL 7000 Area VOC plume plan and section views pre-treatability study and 7.5 years after biostimulation July 2018.

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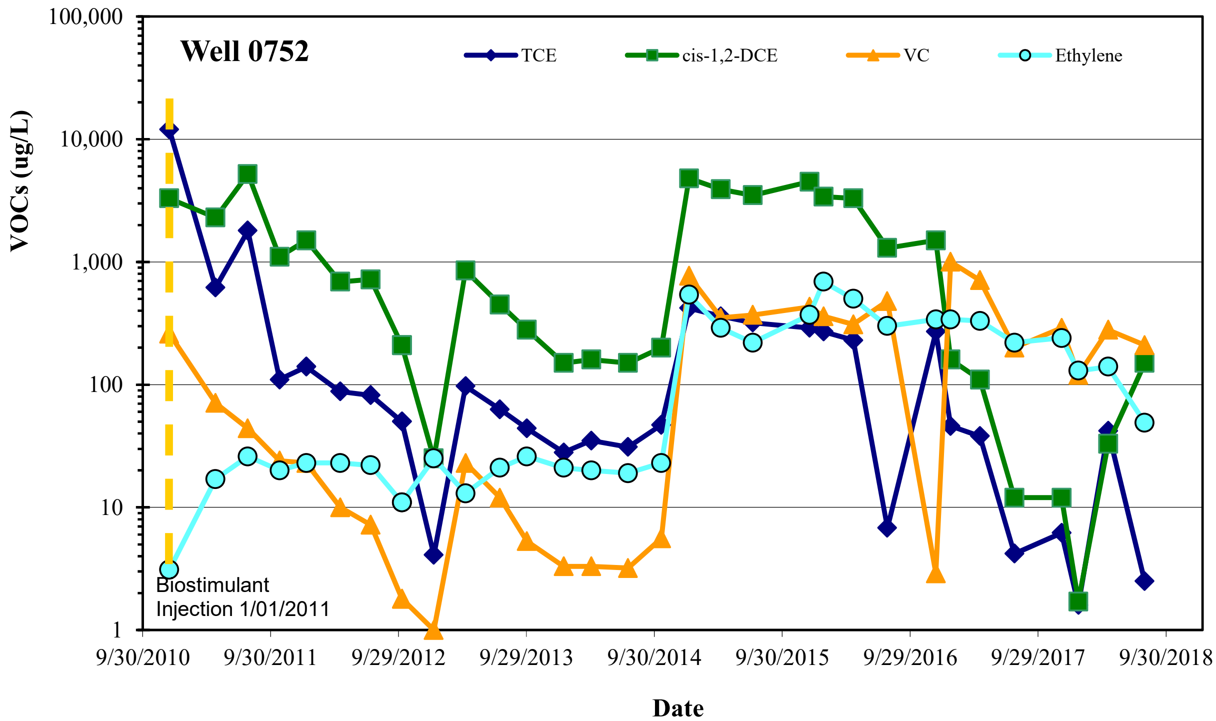


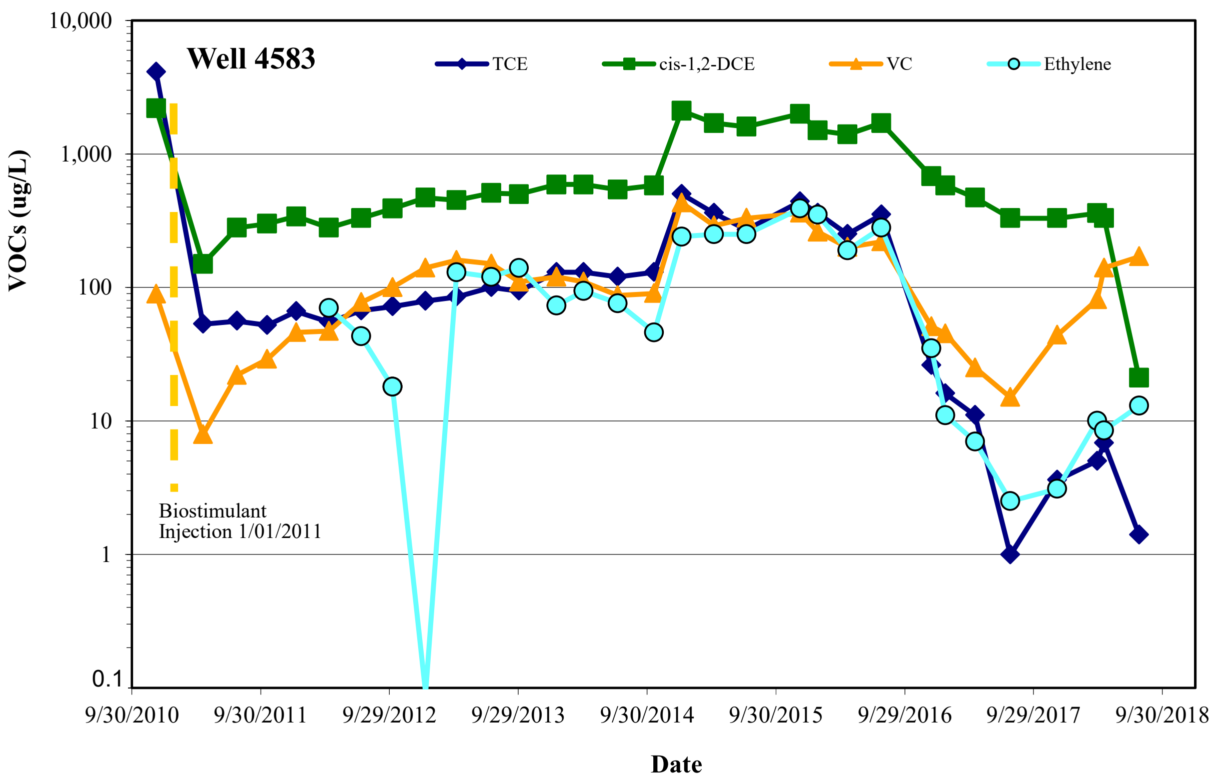
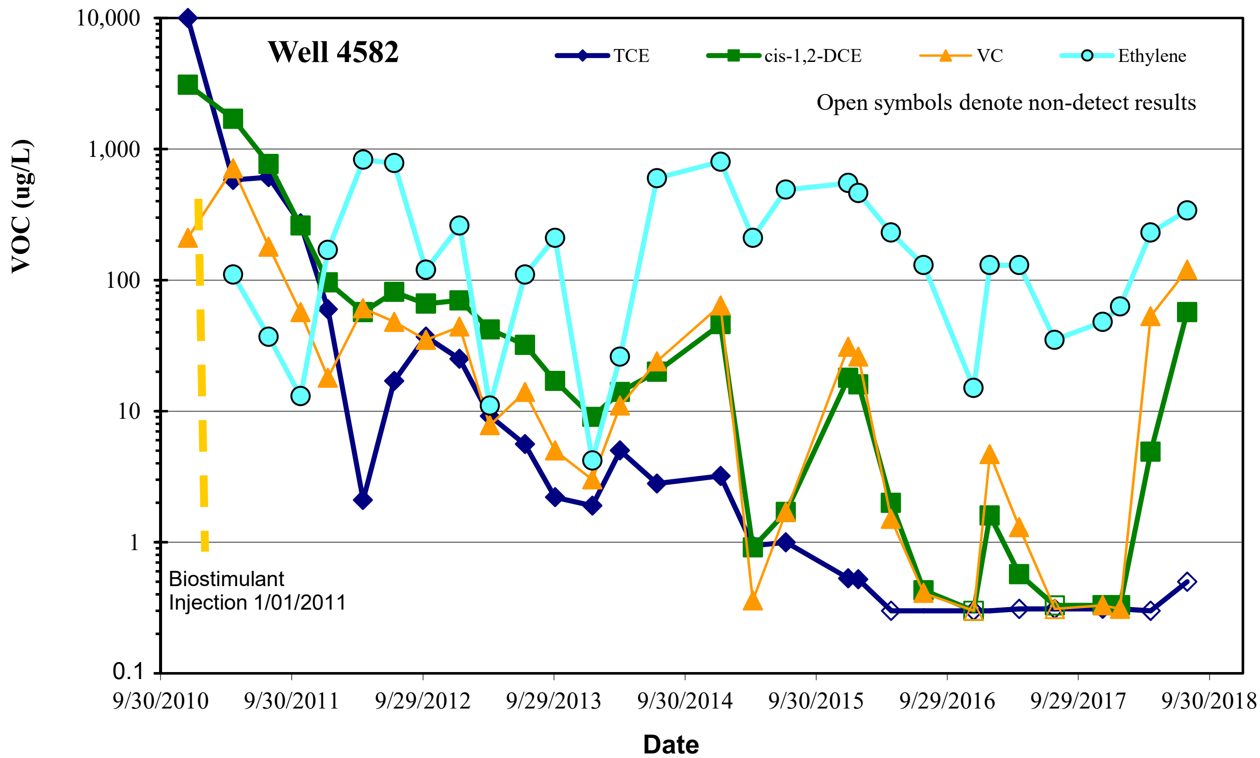


Figure 2.15. Well 0752 and 4583 trends for VOCs.



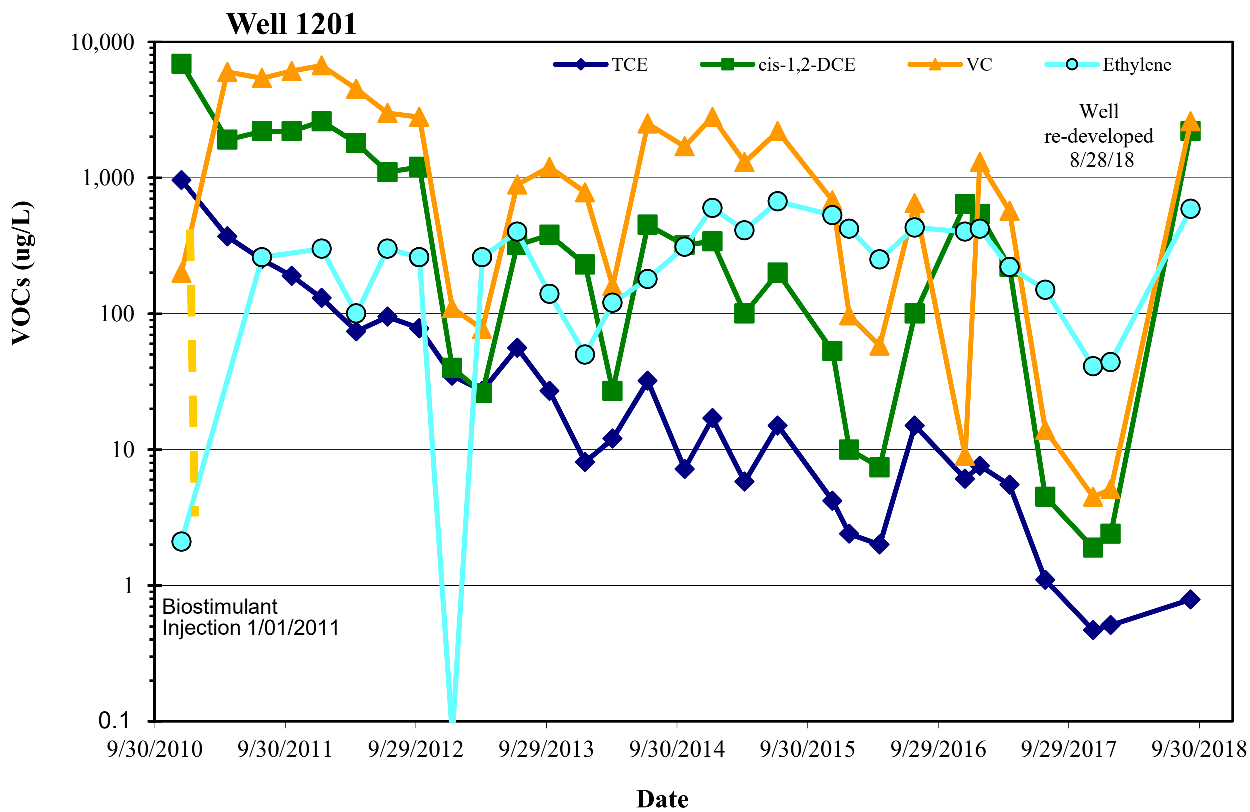
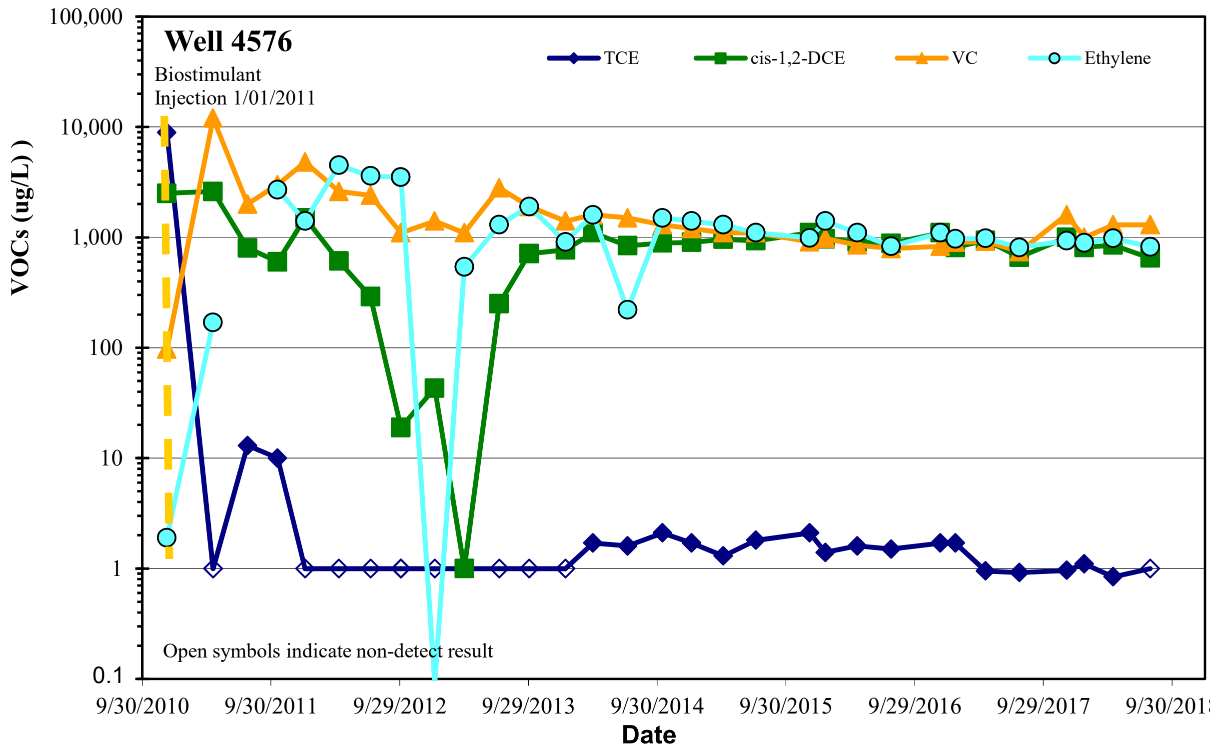


Figure 2.16. Well 4582 and 1201 trends for VOCs.



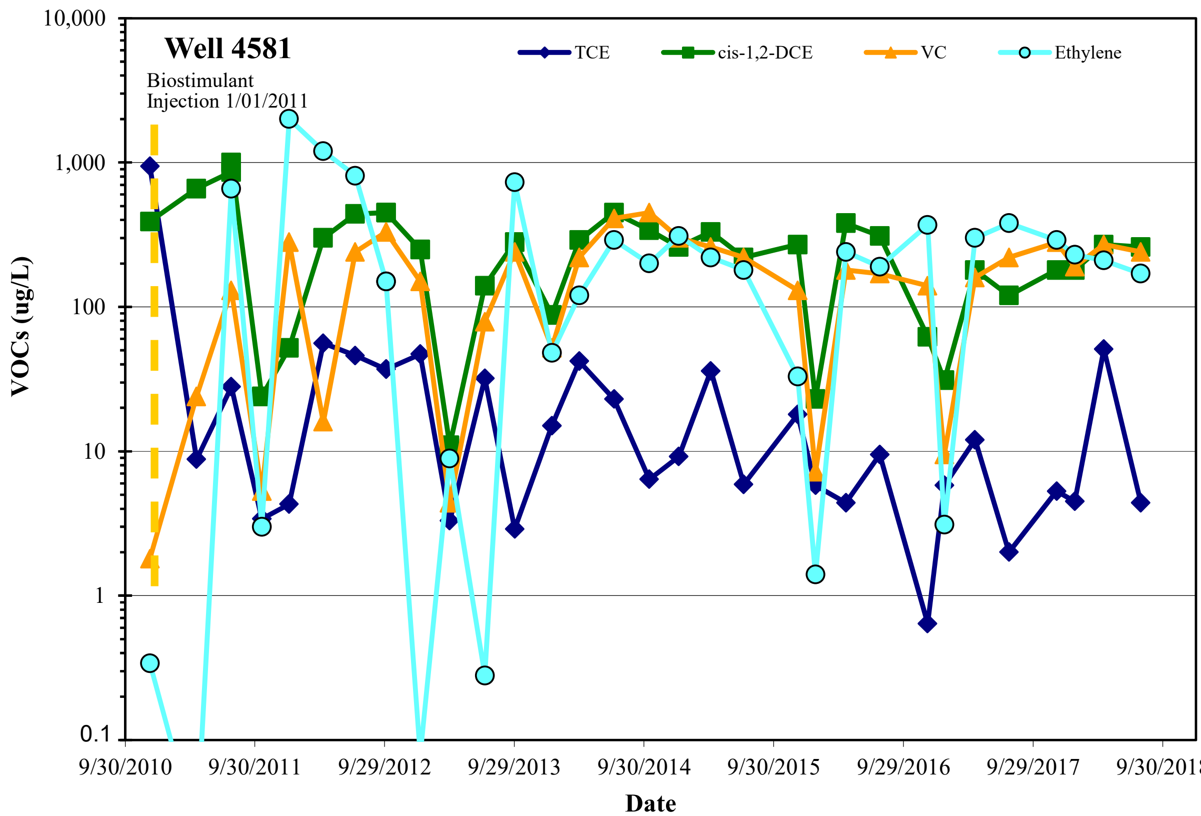


Figure 2.17. Well 4576 and 4581 trends for VOCs.

SWSA 3 and Raccoon Creek Exit Pathway

SWSA 3 was the third area used for mixed radioactive and hazardous waste disposal at ORNL. The site also received waste materials from Y-12, ETTP (the former K-25 Gaseous Diffusion Plant), and offsite sources since it was designated as a regional disposal site for radioactive waste by the Atomic Energy Commission. The 6.1 acre mixed waste disposal area received wastes for below-grade disposal between 1946 and 1951; however, the area was used as an above ground contaminated equipment storage area until 1979. Other waste management units in the vicinity of SWSA 3 included a four-acre scrap metal disposal area and a seven-acre Contractor's Landfill. The BVBGs RA conducted between 2010 and 2012 constructed upgradient shallow groundwater/stormflow diversion trenches along the upslope (southern) edge of the scrap metal storage area and SWSA 3 with a multi-layer hydrologic isolation cap over both units (Figure 2.18). A soil cover was constructed over the Contractor's Landfill. The SWSA 3 and scrap metal area cap and the Contractor's Landfill soil cover are contiguous features and the two areas are demarcated by a narrow gravel roadway corridor.

The three disposal units were constructed in clay-rich residual soils derived from weathering of the underlying Witten formation argillaceous (containing significant amount of clay and silt) limestone. Waste disposal trenches in SWSA 3 were excavated into the clay-rich soil and it is not known how much soil buffer was left between the base of disposed waste and the top of the limestone bedrock. Emplacement of contaminated waste on a fractured or karst bedrock surface creates an immediate pathway for contaminated groundwater to enter bedrock formations. Local areas consist of colluvial soils derived from residuum of the Rome and Moccassin formations that underlie the northern slope of Haw Ridge to the south of the disposal units. Bedrock to the north of the disposal units is the Bowen formation, a thin (approximately 30 ft thick) siliceous shale with a thin limestone zone in its mid-section, and the Benbolt formation which is another mixed argillaceous and pure limestone formation. Because of its siliceous nature, the Bowen formation is somewhat less susceptible to chemical weathering and thus may act as an aquitard between the overlying and underlying limestone-rich bedrock formations. The bedrock beneath the disposal areas is the Witten formation which contains interbeds of argillaceous limestone and relatively pure limestone. Site investigations at SWSA 3 conducted in the late 1970s and early 1980s documented the existence of karst conditions at SWSA 3 as evidenced by cavities encountered in bedrock boreholes and rapid movement of groundwater. Three groundwater tracing activities were conducted at SWSA 3 and groundwater seepage velocities in karst pathways were documented to range from about 120 ft/d to over 43,000 ft/d. The tracer tests documented shallow groundwater movement at rapid velocities emerging at springs and seeps in the headwaters of both the Northwest Tributary to the east and Raccoon Creek to the west (Figure 2.19). A tracer injected in well 0493 in the western portion of SWSA 3 was observed in both streams with a migration velocity of about 240 ft/d to the east into the Northwest Tributary and a velocity of about 120 ft/d to the west into the Raccoon Creek headwater. Tracer migration both east and west from the injection point suggests the existence of the groundwater divide for shallow groundwater in the vicinity of the injection point location. The presence of the shallow groundwater divide at greater depths beneath the SWSA 3 area has not been physically verified although groundwater modeling shows it to be present.

The *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge Tennessee* (BVBG PCCR; DOE/OR/01-2533&D2) specifies groundwater level measurement locations and frequencies, as well as sampling locations for analysis of site related contaminants. Figure 2.18 shows the monitoring locations and indicates the types and frequencies of monitoring required. The synoptic groundwater level measurements are useful to prepare piezometric surface maps and to evaluate local vertical head gradients between shallow wells constructed in the soil or near top of bedrock zone compared to deeper wells constructed in bedrock. Groundwater elevations measured in the synoptic surveys are tabulated in Table 2.12. Figure 2.19 shows a piezometric surface map drawn based on average 2018 groundwater elevation data from water table wells. The map shows the major groundwater elevation contours as well as locations where groundwater tracing studies were conducted in the early 1980s. The inferred tracer trajectories (Figure 2.19) for the tracer injected at well 0493 to the points of emergence in the adjacent stream heads suggests that the “Little Lime” member of the Witten Formation may be a conductive pathway for both the tracer and the co-located Sr-90 discharges. There is an apparent area of low groundwater level beneath the northeastern portion of the SWSA 3 cap. This area appears to be co-located with the inferred subcrop of the “Little Lime” member of the Witten formation beneath the burial ground. Groundwater elevations in the wells within the closed 810 ft piezometric contour are the lowest in the area but are slightly higher than the elevation in Northwest Tributary where the Sr-90 and tracer entered the stream. The piezometric contours show gradients from both the north side (Bowen/Benbolt formations) and south (upper Witten and Moccasin formations) toward a low water level trend in the lowermost Witten formation. This is a result of the karst drainage network in that area. A groundwater divide having an elevation between 810 and 815 ft aMSL is shown on Figure 2.19 beneath the western end of the SWSA 3 cap, which is based on the combination of groundwater elevation data obtained during post-remediation monitoring and the historic tracer behavior.

Table 2.12. SWSA 3 groundwater target elevation attainment summary

Well	Bedrock Elevation (ft aMSL)[a]	Groundwater Elevation goal (ft aMSL)	FY 2018 average groundwater elevation (ft aMSL)
0482	~ 830	823[b]	**826.62**
0483	~ 834	835	828.99
0484	~ 823	824	816.66
0491	~ 823	816[b]	**823.58**
0492	~ 826	818.5[b]	**822.73**
0493	~ 831	829	820.99
0694	838.33	838.33	836.79
0996	814.31	814.31	808.21
0997	818.64	818.64	811.83

[a]Bedrock elevations preceded by “~” are estimates based on average depth to bedrock (approximately 14 ft bgs) from documented pre-RA well logs on the SWSA 3 perimeter

[b]Groundwater target elevation is significantly below bedrock surface and below bottom of buried waste zone.

Bold table entries indicate wells that have not attained their groundwater elevation goal.

aMSL = above mean sea level
bgs = below ground surface
FY = fiscal year
RA = remedial action
SWSA = Solid Waste Storage Area

The BVBG PCCR states *“…the goal for SWSA 3 is a declining trend in the average water elevations to approximately the elevation of bedrock…”* Table 7-2 of the PCCR specified average groundwater elevation goals for nine wells at SWSA 3. The long-term water table elevation goals and progress toward their attainment are included in Table 2.12. Since installation of the cap and upgradient stormflow diversion trench in 2011, three of the nine wells assigned target groundwater elevations have not attained the elevation goal to date. The three wells are located in the eastern portion of SWSA 3. Table 2.12 lists known or estimated bedrock elevations for each well along with the PCCR-designated groundwater target elevations and the FY 2018 average groundwater elevations. As noted, the three wells where target groundwater elevations have not been attained have assigned target elevations between 5 – 10 ft below the bedrock surface. The anecdotal records for waste burial trench depths at SWSA 3 indicate the trenches were no deeper than about 15 ft. That depth is consistent with not excavating into bedrock for waste disposal. Although the groundwater elevations at wells 0482, 0491, and 0492 continue to exceed the

PCCR-designated target elevations the groundwater levels appear to be below, or coincident with the bedrock surface throughout the hydrologic isolation area. As a result, these wells are not good indicators of hydrologic isolation effectiveness. While monitoring and reporting of groundwater levels at wells 0482, 0491, and 0492 will continue, it is recommended that for these three wells, alternative performance indicators, such as groundwater contaminant trends and contaminant fluxes in Northwest Tributary and Raccoon Creek, be used to evaluate the hydrologic isolation effectiveness at SWSA 3.This is a new issue in this RER and alternative performance indicators will be discussed with the Project Team. Hydrographs for the wells with continuous groundwater level monitoring are included in Appendix B.1.

As indicated in Figure 2.18, sampling and analysis for contaminants of interest are required for groundwater wells and surface water at the SWSA 3 sediment basin. The sediment basin surface water is sampled because discharges from the upgradient shallow groundwater/stormflow diversion trench drain into the basin. Contaminants specified for analysis in the BVBG PCCR include Sr-90 and tritium, VOCs, and metals. Results of FY 2018 sediment basin sampling are discussed in the surface water section.

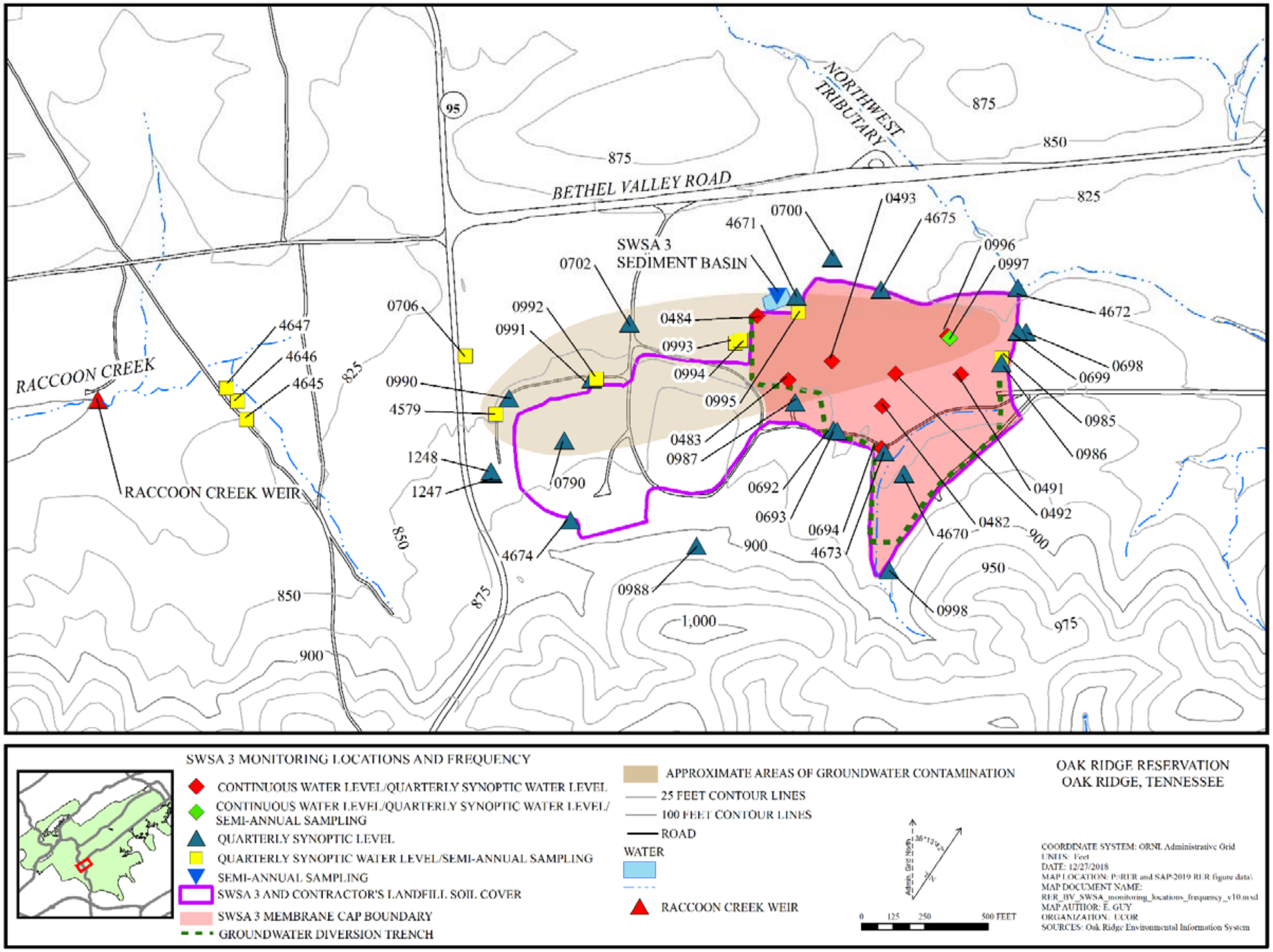


Figure 2.18. SWSA 3 monitoring locations.

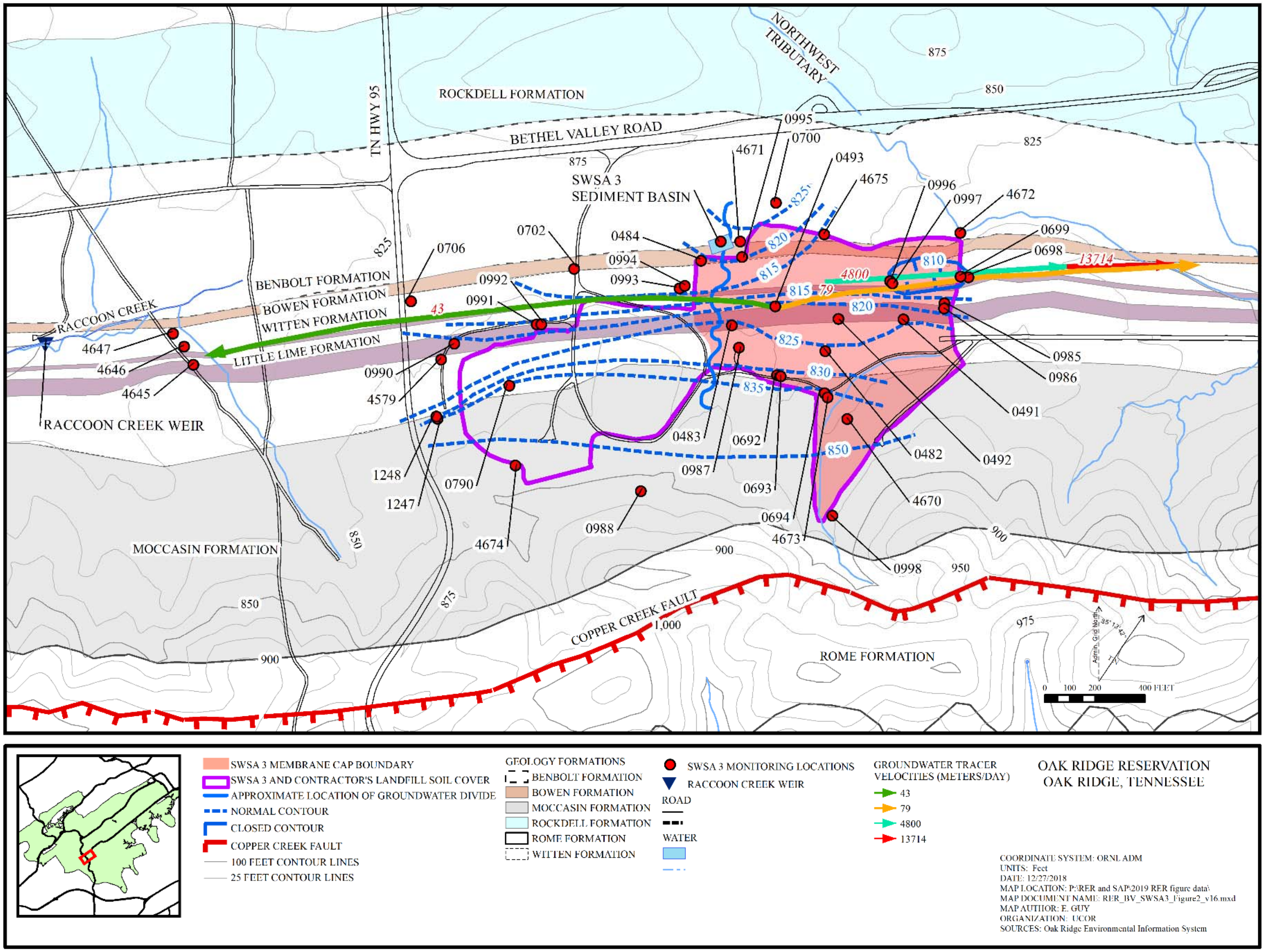


Figure 2.19. SWSA 3 area geology and piezometric surface map.

DOE has compiled the analytical data for groundwater contaminants in the SWSA 3 area to evaluate environmental responses to the RA. Data from wells specified in the PCCR to be monitored pre- and post-action are compared to EPA's National Primary Drinking Water Regulations MCLs or MCL-DC for radionuclides. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants that may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations.

SWSA 3 contaminant screening and trend evaluations are summarized on Table 2.13 for wells specified for groundwater sampling (Figure 2.18). Only contaminants with concentrations greater than or equal to 80% of the MCL/MCL-DC within the past 10 years are presented. Maximum detected concentrations of groundwater contaminants that exceed the MCL/MCL-DC levels are highlighted in bold text. Although there have been a number of Sr-90 detections in wells 4645 and 4646 during their monitoring history, none of the measured concentrations have reached the 6.4 pCi/L threshold (80% of 8 pCi/L) to be included in the summary presented in Table 2.13. Their trend evaluations indicate that no trend can be assigned based on currently available data. Well 0706 has not exhibited screening level contaminant exceedances in its monitoring history and Sr-90 was not detected at that location in FY 2018 and no trend can be assigned based on currently available data.

Since the SWSA 3 RA was conducted in 2010 and 2011 the 5-year to 10-year data evaluation includes pre-remediation groundwater sampling results. As shown in Table 2.13, groundwater contaminant concentration trends in the vicinity of SWSA 3 have generally been downward, stable, or no trend can be assigned. Review of Table 2.13 shows that most of the screening level exceedances occurred more than five years ago either prior to the RA or soon after the remedy was complete. The single increasing trend noted near SWSA 3 is fluoride detected in well 4579-02. Since fluoride concentrations in groundwater samples from wells within the SWSA 3 footprint do not approach the 4 mg/L MCL, the fluoride occurrence at well 4579 cannot be attributed to a problem with the SWSA 3 remedy. Fluoride is widely distributed in bedrock and groundwater in the East Tennessee region as well as having been a waste stream constituent at ORNL. Broader investigations of ORNL area geochemistry are one aspect of work to be conducted as part of the BV final groundwater ROD.

Bearden Creek Exit Pathway

Groundwater monitoring data from wells 1198 and 1199 that are located southwest of Building 7025 (the former Tritium Target Facility) have exhibited detectable tritium concentrations since 1991 (Figure 2.2). Both wells monitor groundwater in bedrock, with well 1198 being a shallower well, screened from about 28 − 43 ft bgs, and well 1199 being a deeper well, screened from about 53 to 73 ft bgs. Tritium concentrations in these wells have decreased steadily since the inception of monitoring when peak tritium activities of about 8,000 pCi/L were measured in well 1199 and about 15,000 pCi/L in well 1198. During FY 2018, tritium was detected in February in well 1198 at 288 J pCi/L and at 250 J pCi/L in August. In well 1199, tritium activity was measured at 865 pCi/L in January and 776 pCi/L in August. Analyses for metals and VOCs have been conducted throughout the monitoring history at both wells. Lead has been detected in samples from wells 1198 and 1199 in five out of 84 samples collected since 1991. The highest measured lead was 47 µg/L in well 1199 in August 2008. Two additional detections have occurred at well 1199 with 3.4 and 5.8 µg/L in September 2010 and July 2016, respectively. Lead has been detected twice in samples from well 1198 with results of 2 J µg/L in January 2015 and 1.6 J µg/L in August 2018.

Table 2.13. Summary of SWSA 3 10-year and 5-year groundwater contaminant trends (FY 2009 – FY 2018)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. > MCL[b]		Freq. > 80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Alpha activity	4579-01	pCi/L	4 / 36	0 / 20	19	**32.7**	ND	ND	15	3 / 36	0 / 20	3 / 36	0 / 20	No trend	--
	4579-02	pCi/L	7 / 36	2 / 20	4.95	**49.7**	6.17	ND	15	1 / 36	0 / 20	1 / 36	0 / 20	No trend	No trend
	4579-03	pCi/L	8 / 36	4 / 20	4.83	**16.2**	**16.2**	8.16	15	1 / 36	1 / 20	1 / 36	1 / 20	No trend	No trend
Arsenic	4579-01	mg/L	7 / 37	7 / 20	0.005	0.009	0.009	0.005	0.01	0 / 37	0 / 20	1 / 37	1 / 20	No trend	No trend
Benzene	4579-01	mg/L	35 / 35	20 / 20	--	**0.013**	**0.01**	**0.008**	0.005	32 / 35	17 / 20	33 / 35	18 / 20	Down	Down
	4579-02	mg/L	34 / 35	20 / 20	0.001	**0.012**	**0.009**	**0.008**	0.005	23 / 35	14 / 20	27 / 35	17 / 20	Stable	Stable
Fluoride	4579-01	mg/L	21 / 21	8 / 8	--	**13**	**13**	**11.1**	4	20 / 21	8 / 8	20 / 21	8 / 8	Up	No trend
	4579-02	mg/L	21 / 21	8 / 8	--	**4.26**	**4.26**	**4.26**	4	3 / 21	1 / 8	18 / 21	7 / 8	No trend	Up
Nickel	0985	mg/L	2 / 3	--	0.01	**0.11**	ND	ND	0.1	1 / 3	--	1 / 3	--	No trend	--
	4647	mg/L	5 / 17	2 / 10	0.01	**0.104**	0.004	0.004	0.1	1 / 17	0 / 10	1 / 17	0 / 10	No trend	No trend
	4579-03	mg/L	33 / 37	19 / 20	0.01	**0.1**	0.029	0.016	0.1	0 / 37	0 / 20	1 / 37	0 / 20	Down	Stable
Strontium-90	0985	pCi/L	5 / 16	4 / 10	2.05	**41.4**	**41.4**	**41.4**	8	1 / 16	1 / 10	1 / 16	1 / 10	No trend	No trend
	0992	pCi/L	17 / 17	10 / 10	--	**64**	**28.8**	**12.8**	8	17 / 17	10 / 10	17 / 17	10 / 10	Down	Down
	0993	pCi/L	17 / 17	10 / 10	--	**103**	**41.9**	**35.8**	8	17 / 17	10 / 10	17 / 17	10 / 10	Stable	No trend
	0994	pCi/L	17 / 17	10 / 10	--	**560**	**163**	**125**	8	17 / 17	10 / 10	17 / 17	10 / 10	Down	Down
	0995	pCi/L	5 / 15	4 / 10	2.09	**200**	**200**	ND	8	1 / 15	1 / 10	1 / 15	1 / 10	No trend	No trend
	0997	pCi/L	15 / 15	10 / 10	--	**16.7**	**13.1**	**9.68**	8	13 / 15	9 / 10	15 / 15	10 / 10	Stable	No trend
	4647	pCi/L	13 / 17	8 / 10	2.4	7.52	3.45	3.02	8	0 / 17	0 / 10	1 / 17	0 / 10	Stable	No trend
	4579-01	pCi/L	18 / 37	11 / 20	2.51	**146**	**13.2**	0.689	8	5 / 37	2 / 20	6 / 37	3 / 20	No trend	No trend
	4579-02	pCi/L	15 / 37	9 / 20	2.5	**177**	7.71	0.48	8	2 / 37	0 / 20	3 / 37	1 / 20	No trend	No trend
	4579-03	pCi/L	35 / 37	18 / 20	0.932	**20.7**	**16.1**	1.8	8	10 / 37	2 / 20	13 / 37	3 / 20	Down	Down
Thallium	0992	mg/L	3 / 17	2 / 10	0.001	**0.002**	0.00010	0.00002	0.002	1 / 17	0 / 10	1 / 17	0 / 10	No trend	No trend
	4579-03	mg/L	2 / 37	0 / 20	0.001	**0.004**	ND	ND	0.002	2 / 37	0 / 20	2 / 37	0 / 20	No trend	--

Table 2.13. Summary of SWSA 3 10-year and 5-year groundwater contaminant trends (FY 2009 – FY 2018) (cont.)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. > MCL[b]		Freq. > 80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Trichloroethene	0985	mg/L	14 / 16	8 / 10	0.001	**0.007**	0.002	0.00049	0.005	2 / 16	0 / 10	2 / 16	0 / 10	Down	Down
	4579-01	mg/L	5 / 35	3 / 20	0.003	**0.042**	0.002	0.00035	0.005	1 / 35	0 / 20	1 / 35	0 / 20	No trend	No trend
	4579-02	mg/L	1 / 35	0 / 20	0.003	**0.016**	ND	ND	0.005	1 / 35	0 / 20	1 / 35	0 / 20	No trend	--
Vinyl chloride	0997	mg/L	7 / 15	3 / 10	0.01	**0.004**	**0.003**	0.001	0.002	2 / 15	1 / 10	3 / 15	1 / 10	Stable	No trend

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[b]MCL or MCL-DC as of May 2018.

[c]Significant linear trend from the M-K test at the 0.05 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is >0 but confidence is <90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
M-K = Mann-Kendall
ND = not detected
SWSA = Solid Waste Storage Area

The recent detections of lead in wells 1198 and 1199 have been less than the 15 µg/L action level for determination of identification of lead sources in public water supplies. A specific source of lead that may affect well 1199 is uncertain, however, historically lead was stored outdoors in the 7000 area and metals contamination of soils is one possible source. VOCs have occasionally been detected in well 1199. No VOCs were detected in either well in the two FY 2018 sampling events.

2.3.1.2.3 Aquatic biological monitoring in WOC

Biological monitoring data are available for several locations in the WOC watershed, including five locations in WOC proper (White Oak Creek kilometer [WCK] 6.8, WCK 3.9, WCK 2.6, WCK 2.3, and WCK 1.5), and sites in First Creek (First Creek kilometer [FCK] 0.8 and FCK 0.1) and Fifth Creek (Fifth Creek kilometer [FFK] 1.0 and FFK 0.2) (Figure 2.2). Bioaccumulation monitoring results from WCK 2.3 and WCK 1.5, which are technically in MV, are presented here so that spatial trends in contaminant exposure and uptake can be evaluated. The goal of BV biological monitoring is to evaluate watershed trends and the effectiveness of watershed-scale decisions defined in the BV Interim ROD. Biological monitoring data for the WOC watershed includes contaminant accumulation in fish, fish community surveys, and benthic macroinvertebrate surveys. The species richness trending data provided in the RER affords an annual, high level assessment of changing stream ecological conditions across the ORR. More detailed biological evaluations, including the use of density data, taxa-specific metrics, and statistical approaches are most often found in the ORR facilities' environmental compliance reports, technical team presentations to TDEC, and scientific manuscripts (e.g., McManamay et al., 2016, McManamay et al., 2017, ORNL 2017, Peterson 2017).

Mercury concentrations in fish collected from all stream sections of WOC did not change significantly in 2018, remaining below the EPA recommended fish-based mercury AWQC of 0.3 µg/g (Figure 2.20). The overall downward trend in mercury concentrations in fish in this stream from 2007 – 2018 is likely due to the decreases in aqueous mercury concentrations seen as a result of the *Phased Construction Completion Report for the Bethel Valley Mercury Sumps Groundwater Action Completion at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (BV Mercury Sumps PCCR; DOE/OR/01-2472&D1) in 2008. While mercury concentrations in fish collected from WOL have fluctuated significantly during the same time period, concentrations in bluegill and largemouth bass collected from WOL remained similar to recent years, averaging 0.09 µg/g and 0.42 µg/g, respectively (Figure 2.20).

Mean total PCB concentrations (defined as the sum of Aroclors 1248, 1254, and 1260) in redbreast sunfish from the WOC watershed remained within historical ranges despite slight decreases at all stream sites in 2018, with mean concentrations of 0.19 $\pm$ 0.05 µg/g at WCK 3.9, 0.21 $\pm$ 0.03 µg/g at WCK 2.9, and 0.20 $\pm$ 0.03 µg/g at WCK 2.3 (compared to 0.32 µg/g at WCK 3.9, 0.46 µg/g at WCK 2.9, and 0.31 µg/g at WCK 2.3, respectively in 2017; Figure 2.21). In contrast, mean PCB concentrations in largemouth bass collected from WCK 1.5 (1.90 µg/g) increased in 2018, while mean concentrations in bluegill decreased (0.58 µg/g; Figure 2.21).

Evaluations of PCB concentrations in fish must carefully consider the species of fish sampled and the assumptions used in any risk analyses. PCBs in sunfish, for example, provide a meaningful evaluation of spatial and temporal trends, but may not represent the maximum PCB concentrations relevant to human or wildlife risk. (Largemouth bass and catfish, for example, are typically larger, older, and fattier.) Regulatory guidance and human health risk levels have varied widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criterion for total PCBs is 0.00064 µg/L under the recreation designated use classification and is the target for PCB-focused Total Maximum Daily Loads (TMDLs), including for local reservoirs (Melton Hill, Watts Bar, and Fort Loudon; TDEC 2010a,b,c). In the state of Tennessee, assessments of impairment for water body segments, as well as public fishing advisories, are based on fish tissue concentrations. Historically, the Food and Drug Administration (FDA) threshold limit of 2 µg/g in fish fillet was used for advisories, and then for many years an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as the fish species and size. Most recently, the water quality criterion (0.00064 µg/L for total PCBs; TDEC 2015) has been used by TDEC to calculate the fish tissue concentration triggering impairment and a TMDL, and this concentration is 0.02 µg/g in fish fillet (TDEC 2010a,b,c). TMDLs are used to develop controls for reducing pollution from both point and non-point sources in order to restore or maintain the quality of a water body and ensure it meets the applicable water quality standards. The fish PCB concentrations in the WOC watershed are still well above the calculated TMDL concentration.

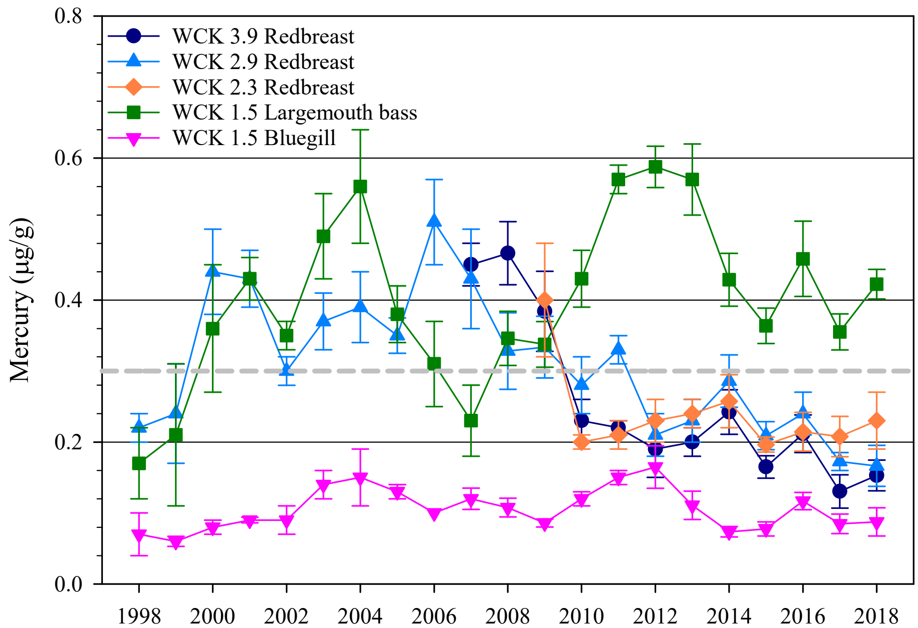


Figure 2.20. Mean concentrations of mercury (µg/g, ± SE, N = 6) in muscle tissue of sunfish and bass from WOC (WCK 2.3, WCK 2.9, and WCK 3.9) and WOL (WCK 1.5), 1998 – 2018.

Dashed gray line indicates EPA's recommended AWQC (0.3 µg/g mercury in fish fillet).

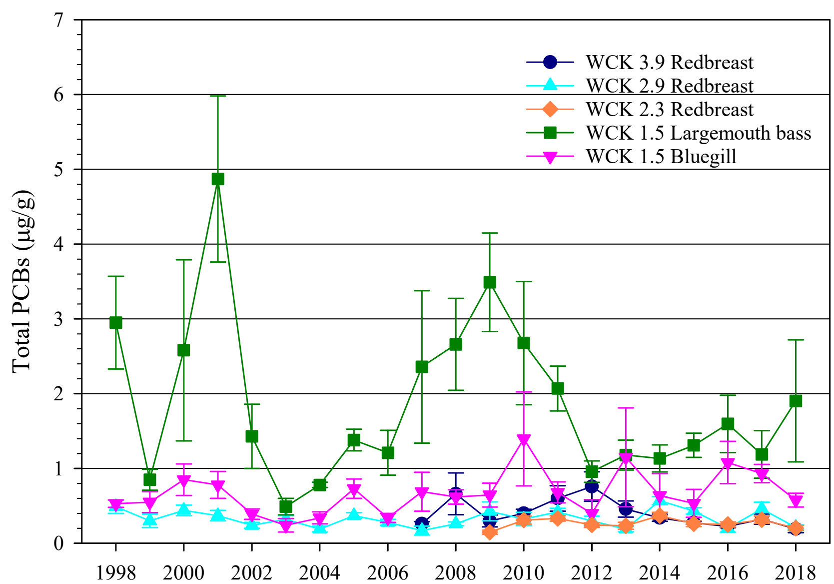


Figure 2.21. PCB concentrations (µg/g, ± SE, N = 6) in fish fillet collected from the WOC watershed, 1998 – 2018.

Fish and benthic communities in WOC remained negatively impacted relative to local reference sites in 2018, although improvements have occurred since the mid-1980s. The fish communities in WOC have been relatively stable in terms of overall numbers of species in recent samples, with numbers of fish species being well below the larger Brushy Fork reference site (Brushy Fork kilometer [BFK] 7.6). The number of species at WCK 3.9 tends to be similar to or greater than the number of fish species found at the smaller Mill Branch reference site (Mill Branch kilometer [MBK] 1.6), while species numbers at the most upstream WOC site (WCK 6.8) still remain fairly low (Figure 2.22). Habitat availability in smaller headwater systems can be a limiting factor for both species richness and density, which may partially explain the low diversities observed at WCK 6.8. Additionally, these sites have had developmental and industrial impacts which coupled with numerous fish passage barriers in the watershed, are likely causes contributing to the low diversity.

Fish introductions of native species into the WOC watershed have been successful with continuing reproduction observed in five of the six introduced species and expanded distributions for three species. These expansions have included lower tributary sites such as First Creek and even above potential fish passage barriers into upper WOC and the Melton Branch. The introduced species fill in missing groups of fish, including sensitive species such as darters and suckers, and are helping the overall richness of the fish fauna in WOC become more comparable with area reference streams. Samples collected in 2018 at WCK 3.9 included two darter species and high densities of striped shiners, all of which are introduced species. The fish introductions are a management tool to compensate for the isolation of WOC watershed by dams and weirs that prevent natural upstream fish passage.

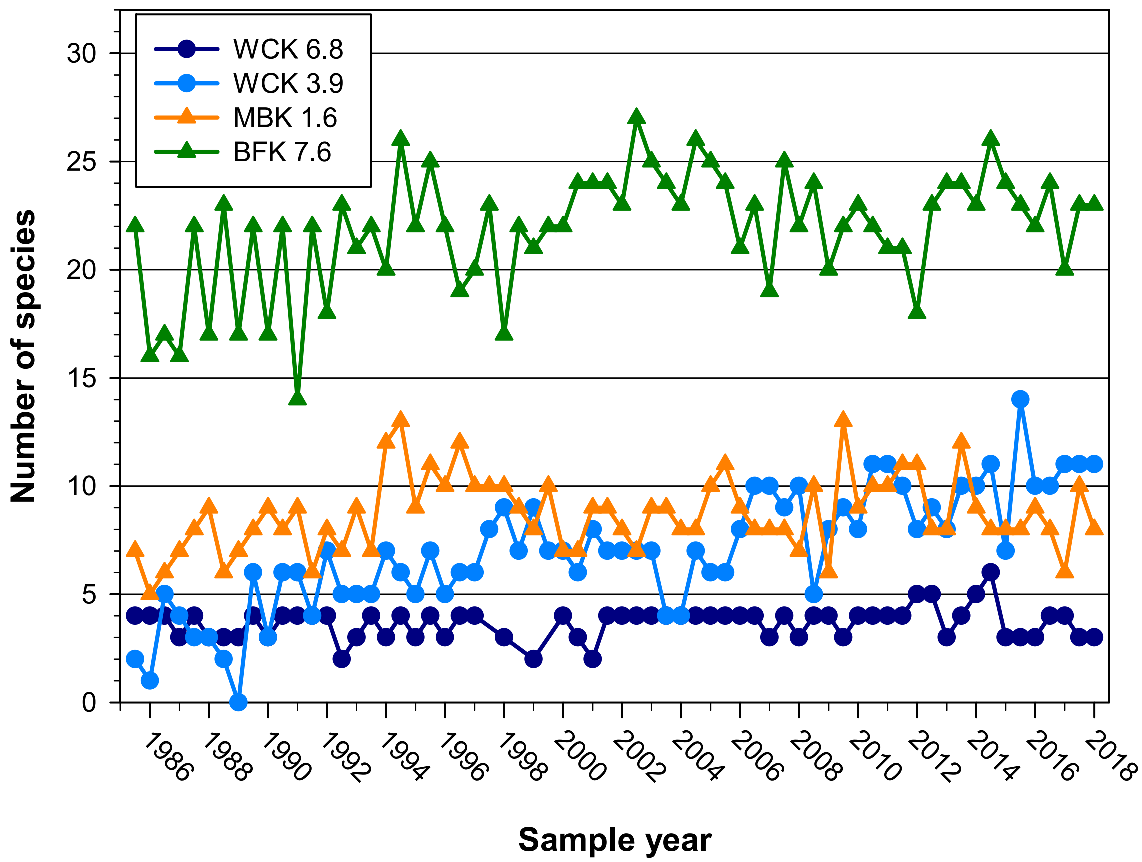


Figure 2.22. Species richness (number of species) in samples of the fish community in upper WOC and reference streams, BFK and MBK, 1985 – 2018.

Fish density is often a better indicator of stream impacts in small tributaries that generally lack high species diversity. The two small second order tributaries that flow through the main ORNL facility into WOC (First Creek and Fifth Creek) have improved since 1985. First Creek, which has had historical impacts associated with development activities, has stabilized in recent years and densities at FCK 0.1 are comparable with an upstream reference site (FCK 0.8; Figure 2.23). Moderate increases in density at the lower site since 2011 are correlated with increased diversity associated with fish introduction efforts mentioned above. Fish densities in Fifth Creek are much more variable and reflect a stream that has likely been stressed by chronic chlorine inputs, which exacerbated seasonal impacts such as droughts or flooding (Figure 2.24).

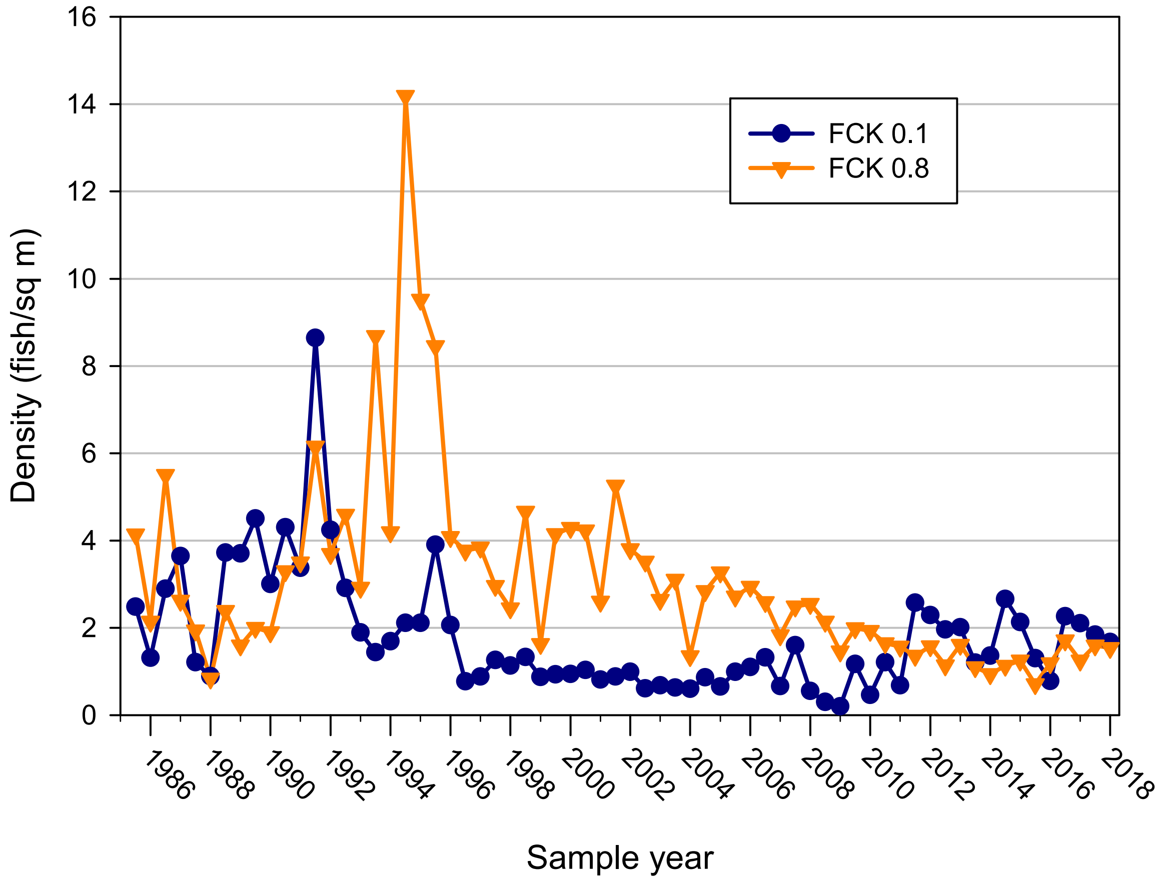


Figure 2.23. Fish density (fish/m^2) in samples of the fish community in First Creek, 1985 – 2018.

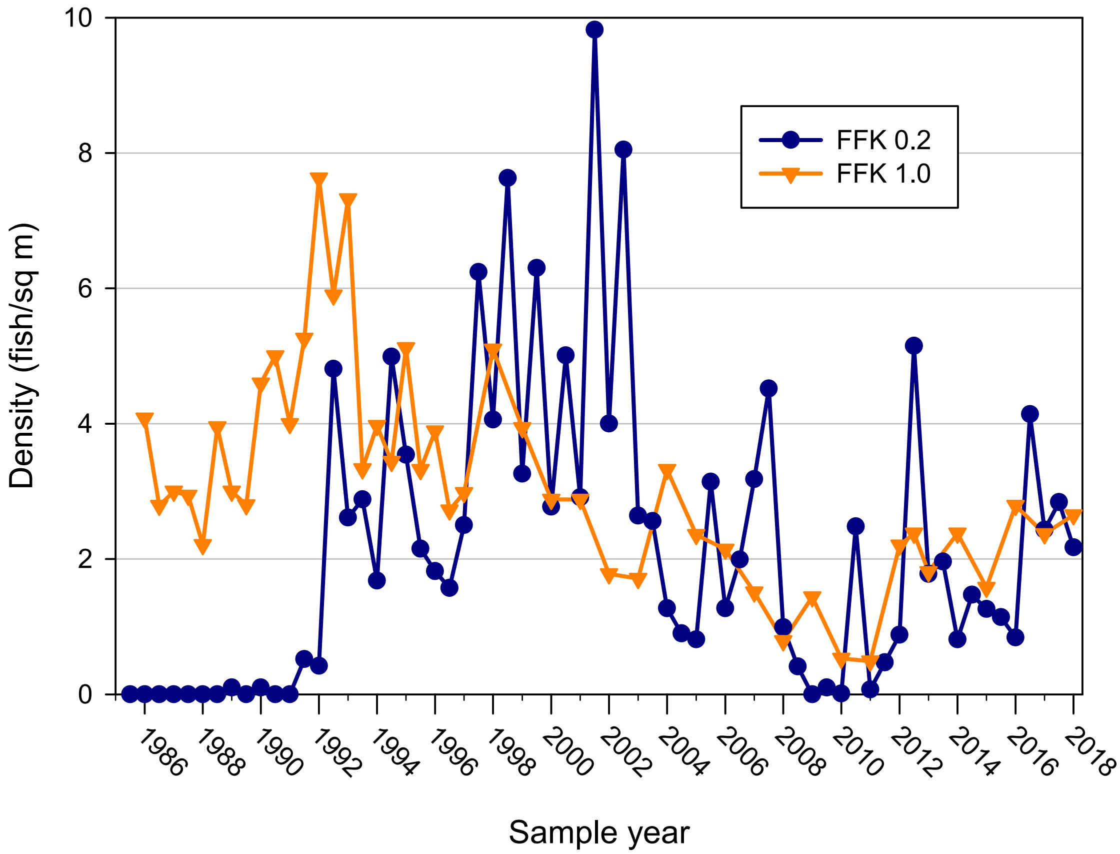


Figure 2.24. Fish density (fish/m²) in samples of the fish community in Fifth Creek, 1985 – 2018.

As in past years, species richness of the pollution intolerant taxa (Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa) at WCK 3.9, FFK 0.2, and FCK 0.8 in 2017 remained well below that of reference sites (WCK 6.8, FFK 1.0, and FCK 0.8, respectively) (Figures 2.25 − 2.27). Additionally, EPT richness has displayed more year-to-year variability in reference sites than impacted sites. Historically, EPT richness increased from the mid-1980s through 2011 at both sites. For the last four to six years, however, EPT richness at WCK 3.9 and FCK 0.8 have displayed noticeable and consistent declines. In FCK 0.1, notable recent declines in EPT richness were first apparent in 2012, followed by a second significant drop in EPT richness in 2014. Although EPT increased subsequently in 2015, values have remained at mid-1990s levels. In WCK 3.9, reductions in EPT richness have steadily declined since 2014. The reason behind these declines are not fully known, although recent discussions have inferred that new water quality issues (i.e., discharges) have arisen or existing conditions have worsened in some locations near central WOC watershed. Long-term trends in EPT taxa richness at WCK 6.8, including results from 2016, show that conditions of the macroinvertebrate community at that site are comparable to those at the Walker Branch reference site (Walker Branch kilometer [WBK] 1.0). WCK 6.8 is located downstream of most Spallation Neutron Source (SNS) outfalls to WOC; thus, effluent discharges into WOC upstream of this site appear to be having no detectable negative effects on the macroinvertebrate community.

After 2003, there was a decrease in the number of EPT taxa at FFK 0.2 that persisted through 2009 (Figure 2.26). A similar trend was not apparent at any other site in the upper WOC watershed during that same period. After 2009, on the other hand, the number of EPT taxa per sample increased to levels comparable to those observed from 1993 through 2002. Even with the recent increase at FFK 0.2, the number of EPT taxa clearly remains much lower at that site compared with the upstream reference site, FFK 1.0.

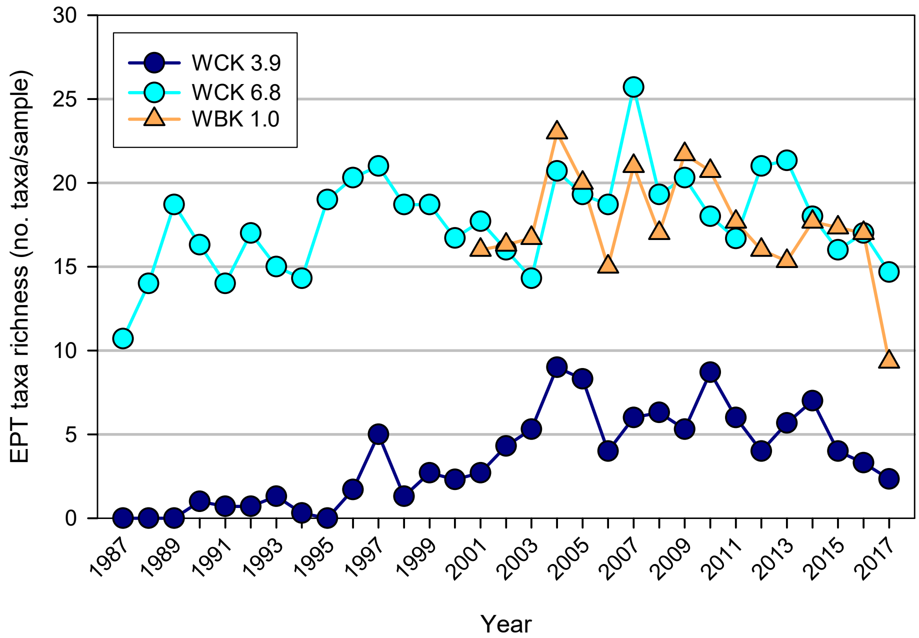


Figure 2.25. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate community at sites in upper WOC and Walker Branch, April sampling periods, 1987 – 2017.[a,b]

[a]WBK = Walker Branch kilometer. WCK = White Oak Creek kilometer. EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.

[b]Samples collected in 2018 have not yet been processed. Data were not available for Walker Branch from 1988 – 2000.

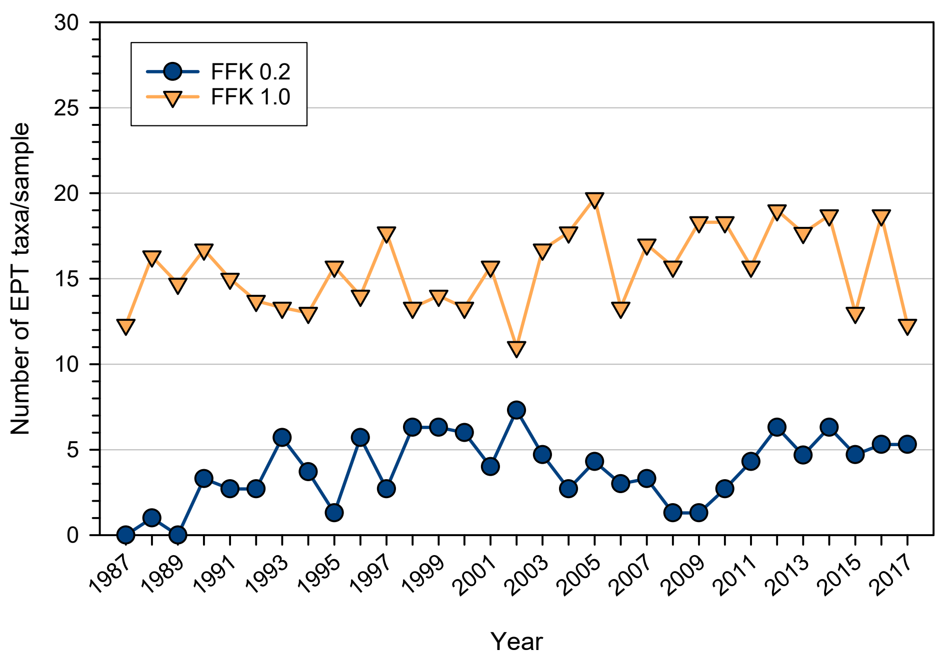


Figure 2.26. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate community at sites in Fifth Creek, April sampling periods, 1987 – 2017.[a,b]

[a]FFK = Fifth Creek kilometer. EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.

[b]Samples collected in 2018 have not yet been processed.

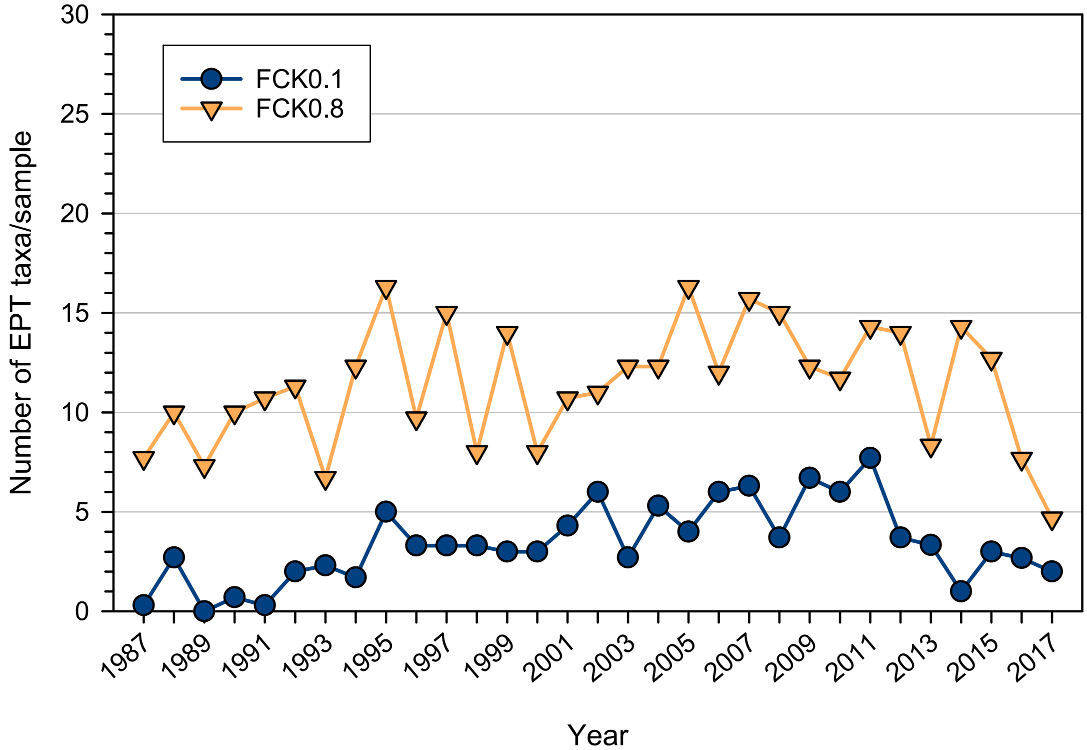


Figure 2.27. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate community at sites in First Creek, April sampling periods, 1987 – 2017.[a,b]

[a]FCK = First Creek kilometer. EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.
[b]Samples collected in 2018 have not yet been processed.

2.3.2 LUCs

LUCs for BV watershed actions are listed in Table 2.14 and described below.

Watershed-scale LUCs

The BV RAR CMP includes interim LUCs to protect against unacceptable exposures to contamination during and after remediation. These interim LUCs will remain in effect until permanent LUCs are established in a future, final remedial decision. The following excerpts (italicized) from the BV RAR CMP provide the objectives of the interim LUCs.

- *Prevent access to or use of groundwater unless approved by DOE, EPA, and TDEC.*
- *Prohibit unauthorized excavation inconsistent with the LUCs described in Sect. 5.3* [LUCs].
- *Prohibit the development and use of the area that is inconsistent with remediation levels, e.g., residential housing, elementary and secondary schools, playgrounds, and child care facilities.*
- *Maintain the integrity of any current or future RA where waste remains in place or required monitoring systems have been implemented.*

The LUCs (property record restrictions [deeds], property record notices, EPP program, and access controls are listed in Table 2.14. The implementation and maintenance of these LUCs are specified in the BV RAR CMP. Additionally, the engineered remedies are included in Table 2.14 to be all inclusive of necessary verifications.

Building 4501 MTF system integrity

The BV Mercury Sumps PCCR includes maintenance of the mercury pretreatment system in Building 4501, which began operation on October 23, 2009. Specifically, maintenance of the pump, replacement of the cartridge prefilter, as needed, replacement of the ion exchange resin annually, and collection of system performance and operational data.

Corehole 8 plume extraction system integrity and LUCs

The BV Corehole 8 PCCR includes the following maintenance of the extraction system − routine walkdowns of the system to determine if the indicator lights are in the correct position, annual pressure testing of the line, and visual inspections of the indicator lights on the arrestors following severe thunderstorms. Operational reliability is tracked through monthly status reporting by the facility manager. Significant system outages will be reported to DOE for concurrence on implementation of actions deemed necessary to restore reliable operation.

Additionally, the approved LUCs at the Corehole 8 plume extraction system site are consistent with the BV Interim ROD designated land use of "Controlled Industrial." *The LUC objective for this area is to prevent unauthorized access to restricted areas or any use of groundwater (except for the purpose of monitoring, testing, or treatment of groundwater); control excavation or penetrations below 2 ft or depths below the groundwater table; prevent unauthorized access; protect industrial workers; and preclude uses of the area that are inconsistent with the current industrial uses.*

Table 2.14. LUCs for the BV watershed

LUCs[a,g] – Watershed-scale requirements				
Type of control	**Duration**	**Implementation**	**Affected areas[b]**	**Verification frequency**
***Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2478&D3)**				
1. Property Record Restrictions[c] *A. Land use* *B. Groundwater*	*Until the concentrations of hazardous substances are at such levels to allow for UU/UE CERCLA groundwater use prohibitions are in place until the final decision is made on groundwater*	*Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office.*	*All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions:* *A. 5100, 5300, 5600, 5700, and 5800* *B. None*	*Five Years*
2. Property Record Notices[d]	*Until the concentrations of hazardous substances are at such levels to allow for UU/UE CERCLA groundwater use prohibitions are in place until the final decision is made on groundwater*	*Notice recorded by DOE in accordance with state law at County Register of Deeds office and copied to the appropriate zoning office:* *A. As soon as practicable after signing of the ROD or* *B. Upon completion of RAs when appropriate*	*All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions:* *A. All BV (land use and groundwater)* *B. BVBGs (SWSA 1 and 3)*	*Five Years*
3. EPPP[e]	*Until the concentrations of hazardous substances are at such levels to allow for UU/UE; unauthorized groundwater use prohibitions are in place*	• *Implemented by DOE and its contractors* • *Initiated by permit request*	*Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions:* *All BV (groundwater), BVBGs (no penetration), Corehole 8 Extraction System, Surface Impoundments, Metal Recovery Facility, Corehole 8 Plume Source (Tank W-1A), EU 2 (excluding 2026 complex and SW corner)*	*Monitor annually to ensure the permit program is functioning properly*
4. Access Controls[f] (e.g., fences, gates, portals, signs, surveillance patrols)	*Until the concentration of hazardous substances are at such levels to allow for UU/UE; CERCLA groundwater use prohibitions are in place until the final decision is made on groundwater*	*Controls maintained by DOE*	*Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions:* *BVBGs, Corehole 8 Extraction System, Metal Recovery Facility*	*Verify annually that controls are being implemented*

Table 2.14. LUCs for the BV watershed (cont.)

LUCs[a,g] – Watershed-scale requirements				
Type of control	**Duration**	**Implementation**	**Affected areas[b]**	**Verification frequency**
5. Engineered Remedy[g] (e.g., engineered caps, soil covers, treatment systems)	Until the concentration of hazardous substances are at such levels to allow for UU/UE; maintain integrity of the CERCLA remedy until final decision is made	Remedy maintained by DOE through operations, surveillance, and maintenance	Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions: BV Mercury Sumps, Corehole 8 Extraction System, BVBGs, Metal Recovery Facility	Verify annually that the remedies are being maintained

[a]*Affected areas – The specific locations to which LUCs apply are documented in post-ROD documents.*

[b]Source for LUCs # 1-4: *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2478&D3).

[c]*Property Record Restrictions—Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of DOE and its predecessor agencies.*

[d]*Property Record Notices—Refers to any non-enforceable, purely informational document recorded along with the original property acquisition records of DOE and its predecessor agencies that alerts anyone searching property records to important information about residual contamination/waste disposal areas on the property.*

[e]*Excavation/Penetration Permit Program—Refers to the internal DOE/DOE contractor administrative program(s) that requires permit requester to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.*

[f]*Access Controls—Physical barriers or restrictions to entry.*

[g]Engineered Remedy is included in this table to be all inclusive of necessary verifications.

BV = Bethel Valley
BVBG = Bethel Valley Burial Ground
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE = U.S. Department of Energy
EPPP = excavation/penetration permit program
EU = exposure unit
LUC = land use control
RA = remedial action
ROD = Record of Decision
SW = southwest
SWSA = Solid Waste Storage Area
UU/UE = unlimited use/unrestricted exposure

BVBG remedy integrity and LUCs

The BV Interim ROD stated that the capped area at SWSA 3 would have a recreational end use designation and the areas to be remediated outside the SWSA 3 cap, Contaminated Soil Area Number 2 and Contaminated Soil Area Number 3, as well as buried waste in the Closed Scrap Metal Area, would have an unrestricted end use designation. An *Explanation of Significant Differences from the Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee, Bethel Valley Burial Grounds* (DOE/OR/01-2446&D2) documented that the SWSA 3 cap was extended to cover these areas and, in consequence of the expanded SWSA 3 cap, the designated end use of Contaminated Soil Area Number 2, Contaminated Soil Area Number 3, and the Closed Scrap Metal Area was changed to recreational. With the exception of SWSA 3 land use changes, LUCs for the BVBGs are the same as those specified in the BV Interim ROD. The primary controls used to limit unauthorized activities in the remediated areas include appropriate signage and administration of an EPP program.

Additionally, maintenance of the BVBGs areas (SWSA 1, Former Waste Pile Area, Nonradioactive Wastewater Treatment Plant Debris Pile, SWSA 3, and Contractor's Landfill) is specified in the BVBG PCCR and includes the long-term caps and covers integrity maintenance. Specifically, actions are to control erosion, to cap or cover settlement, to maintain run-on and run-off control system, to maintain trench drains, to prevent rodent infestation, to control vegetative covers to prevent tree growth, and to maintain monitoring wells and survey benchmarks. The BVBG PCCR provides details on the inspection schedules, procedures, and corrective actions.

2.3.3 Status of LUCs

Status of Watershed-scale LUCs

Appendix A contains the Certification of Land Use Control Implementation Fiscal Year 2018. The Manager, DOE OREM, annually verifies in the RER that all approved RAR CMPs/LUCIPs are being implemented on the ORR. A summary of the implementation verification and status of the BV watershed LUCs follows:

Property record restrictions (deeds)

- Property Record Restrictions have been recorded by DOE at the Roane County Register of Deeds office for four parcels in BV that have been transferred for private sector development. Information on these four parcels is contained in the 2016 FYR. It was verified in FY 2018 that the DOE BV Property Record restrictions remain properly recorded at the Roane County Register of Deeds office.

Property record notices

- Notice of land use restrictions must be filed in accordance with Tennessee statute *Tennessee Code Annotated* 68-212-225 when a RA includes land use restrictions. Land use restrictions, per the statute, may apply to activities on, over, or under the land, including groundwater and property use. The DOE filed the BV Property Record Notice with the Roane County Register of Deeds office on September 30, 2016. It is titled, "Final Property Record Notice [Bethel Valley Record of Decision Area Restrictions]," and was filed as an Environmental Notation in Book 1585, pages 857 – 860. The notice requires restrictions that apply specifically to the BV watershed and prevent: 1) residential use in area designated in the ROD for recreational/industrialized use, and/or 2) access or use of groundwater and surface water unless permitted by DOE for monitoring or research operational use.

- Additionally, the DOE filed a second BV Property Record Notice with the Roane County Register of Deeds office on September 30, 2016 titled, “Final Property Record Notice [Solid Waste Storage Areas 1 & 3 and Adjacent Waste Disposal Areas Land Use Restrictions].” It was filed as an Environmental Notation in Book 1585, pages 845-856. This Property Record Notice includes the principal contaminants left in place in SWSA 1 and SWSA 3, and restrictions on the property. Survey plats for each of the waste units were attached to the Property Record Notice that delineated property that will be restricted in its future use. It was verified in FY 2018 that the DOE BV Property Record notices remain properly recorded at the Roane County Register of Deeds office.

EPP program

An existing EPP program currently administered by DOE contractors requires workers/developers to obtain authorization before beginning subsurface excavation/penetration activities. DOE and/or its agent will maintain responsibility for the EPP program for contamination handling and locations for ongoing federal government activities at the site and for transferred land until the concentrations of hazardous substances are at levels to allow for UU/UE.

- In FY 2018, it was verified that the EPP program functioned according to established procedures and plans.

Access controls

DOE and/or its agent will maintain responsibility for the access controls until the concentrations of hazardous substances are at levels to allow for UU/UE. In the event of property transfer, DOE will document access controls in the transfer documents and deed and will verify they are maintained.

- All major access points to BV remain guarded or locked at all times, and interior gates are selectively locked. Specifically, access is restricted by security portals at the east and west ends of BV Road. Access controls are in place at the BVBGs and meet the intent of the LUC objectives. In FY 2018, signs were maintained to control access and surveillance patrols were conducted as part of routine S&M inspections.

- In FY 2018 DOE verified that the access controls documented for transferred properties were maintained.

Status of Building 4501 MTF system integrity

Inspections of the Building 4501 pretreatment system were conducted weekly in FY 2018 by the UT-B Facility Manager in accordance with the operating manual. Monthly system status updates were submitted to the WRRP documenting system operations, monthly pumped/treated volume, and influent/effluent concentrations. In FY 2018, routine maintenance consisted of inlet filter changes. Additional maintenance included changing the feed pump, backwashing the ion exchange column, replacing the level probe, replacing the pump, and changing the ion exchange resin. The system treated 5.3 million gal of water, and removed 200 g of mercury in FY 2018.

Status of Corehole 8 plume extraction system integrity and LUCs

Routine inspections were conducted in FY 2018 of the Corehole 8 plume extraction system and documented on monthly status reports. Maintenance of the system included repairing flow indicator on Lift Station #1. Additional maintenance included replacing the pump in Lift Station #2, restoring level sensor on Lift Station #2, and repairing a leak on Well 4411. Liquid and Gaseous Waste Operations (LGWO) storage issues due to heavy rainfall caused several system shutdowns in March, June, and September. See Section 2.3.1.2.1.3 for performance of the extraction system in FY 2018.

The primary controls used to limit unauthorized activities at the Corehole 8 plume extraction system site include appropriate signage and administration of an EPP program. Access by the general public is restricted by the portal guard stations at the east and west ends of BV road; the Corehole 8 extraction system is not individually fenced and gated. While there are no physical controls to preclude access to the Corehole 8 extraction system by ORNL workers and visitors, appropriate signage and procedural controls are in place to warn of potential hazards.

Status of BVBG remedy integrity and LUCs

Inspections of the BVBGs were conducted semiannually in FY 2018 in accordance with the BVBG PCCR. Inspection items included cover system, gas vents, access roads and culverts, survey benchmarks, drainage system, facility signs, and presence of unauthorized materials. All caps received vegetation control (spraying with herbicides).

Per the BVBG PCCR, a survey plat documenting use restrictions and information about residual contamination and waste management areas was prepared. It was verified in FY 2018 that the Final Property Record Notice ("Solid Waste Storage Areas 1 & 3 and Adjacent Waste Disposal Areas Land Use Restrictions") remains properly recorded at the Roane County Register of Deeds office.

2.4 SINGLE-PROJECT ACTIONS IN BV WATERSHED

2.4.1 Tank W-1A

The location of the former Tank W-1A site (the Corehole 8 plume source) is shown on Figure 2.1. The *Removal Action Report for the Core Hole 8 Plume Source (Tank W-1A) at the Oak Ridge National Laboratory* (Core Hole 8 Tank W-1A RmAR; DOE/OR/01-1969&D3), approved in November 2012, documents completion of the non-time critical removal action to address the source of contaminants being released to groundwater. This action removed Tank W-1A, contaminated soils surrounding the tank, tank saddles along with associated piping, valve pits and appurtenances in the area of the excavation. This report documents the actions taken toward removal of the Core Hole 8 plume source (Tank W-1A) as prescribed in the *Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A)* (DOE/OR/01-1749&D1). The removal action objective of reducing offsite releases of contaminants at White Oak Dam (WOD) by addressing the source area was met.

2.4.1.1 LUCs

The only LUC specified in the Core Hole 8 Tank W-1A RmAR is that no excavation can be performed at the site unless an EPP is obtained.

2.4.1.2 Status of LUCs

Excavation at all areas at ORNL, including the former Tank W-1A site, remained controlled in FY 2018 through the EPP program. The site underwent an annual inspection in FY 2018 by the ORNL S&M Program to check for evidence of unauthorized excavation/penetration without a valid permit.

2.4.2 Surface Impoundments

The location of the Surface Impoundments is provided on Figure 2.1. This action removed contaminated water, sediment, and the upper 0.1 to 0.2 ft of subimpoundment soil (clay). The action was implemented in two phases. The first phase removed contaminated water and sediment and backfilled impoundments C and D, which were small, lined impoundments. The second phase removed and treated discrete batches of contaminated sediment and backfilled impoundments A and B, which were larger, unlined impoundments. Upon completion, all four impoundments were covered with gravel and asphalt and are currently used as parking areas.

2.4.2.1 LUCs

The *Remedial Action Report on the Surface Impoundments Operable Unit at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2086&D2) states that no institutional controls are needed at the site; however, the report requires that institutional controls that limit excavation remain in place for potential residual subsurface contamination around the site.

2.4.2.2 Status of LUCs

The site underwent an annual inspection in FY 2018 by the ORNL S&M Program to check for evidence of unauthorized excavation/penetration without a valid permit. In addition, an EPP program with procedures is in place that does not allow unauthorized excavations/penetrations in this area.

2.5 BV WATERSHED ISSUES AND RECOMMENDATIONS

Issues and recommendations for the BV watershed are in Table 2.15.

Table 2.15. BV watershed issues and recommendations

Issue[a]	Action/recommendation	Responsible parties Primary/support	Target response date
New issue			
1. Three wells in SWSA 3 have chronically not attained the ROD goal for groundwater level control within hydrologically isolated areas. (2019 RER)	1. Three wells in SWSA 3 (0482, 0491, and 0492) have chronically not met target groundwater elevations because of well construction or location conditions. These wells are constructed with the majority of their screened intervals extending into bedrock. These deeper wells are prone to responding to groundwater levels affected by conditions outside the hydrologic isolation area. As a result, these wells are not good indicators of hydrologic isolation effectiveness. While the target groundwater elevations have not been met in these three wells, the SWSA 3 hydrologic isolation remedy has achieved reduced contaminant discharges into surface water as well as reductions in groundwater contamination in area monitoring wells. Surface water discharges of Sr-90 in Northwest Tributary and Raccoon Creek have decreased significantly as a result of hydrologic isolation of shallow buried waste at SWSA 3 and the Contractor's Landfill. Groundwater contaminant trend evaluations for the previous 10-year and 5-year periods show that the number of groundwater contaminants that occur at concentrations near or above Primary Drinking Water MCLs has decreased since site remediation and the concentration trends for the remaining contaminants are decreasing, stable, or indeterminate. While monitoring and reporting of groundwater levels at wells 0482, 0491, and 0492 will continue, it is recommended that for these three wells, alternative performance indicators such as groundwater contaminant trends and contaminant fluxes in Northwest Tributary and Raccoon Creek, be used to evaluate the hydrologic isolation effectiveness at SWSA 3.This is a new issue in this RER and alternative performance indicators will be discussed with the Project Team.	DOE	2020 RER (2037 is the FFA Appendix J date for a BV Final ROD to address groundwater)
Issue carried forward			
None			
Completed/resolved issues[b]			
None			

[a]A "New Issue" is an issue identified during evaluation of FY 2018 data for inclusion in the 2019 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution.
[b]The year in which the issue originated is in parentheses, e.g., (2013 RER).

BV = Bethel Valley
DOE = U.S. Department of Energy
FFA = Federal Facility Agreement
FY = fiscal year
MCL = maximum contaminant level
RER = Remediation Effectiveness Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area

2.6 REFERENCES

DOE/OR/01-1380&D1. *Remedial Action Report for the Corehole 8 [CH] Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1749&D1. *Action Memorandum for the Core Hole 8 Plume Source (Tank W-1A) Removal Action at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 1998, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1862&D4. *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee,* 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1862&D4/R2. *Notification of Non-Significant Change to the Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee,* 2013, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1969&D3. *Removal Action Report for the Core Hole 8 Plume Source (Tank W-1A) at the Oak Ridge National Laboratory, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2086&D2. *Remedial Action Report on the Surface Impoundments Operable Unit at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2004, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2219&D2. *Engineering Study Report for Groundwater Actions in Bethel Valley, Oak Ridge Tennessee*, 2005, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2446&D2. *Explanation of Significant Differences from the Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee, Bethel Valley Burial Grounds*, 2010, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2469&D2. *Remedial Design Report/Remedial Action Work Plan for the Bethel Valley (Corehole 8) Extraction System at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2010, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2472&D1. *Phased Construction Completion Report for the Bethel Valley Mercury Sumps Groundwater Action Completion at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2010, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2478&D3. *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2533&D2. *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2534&D1. *Phased Construction Completion Report for the Bethel Valley (Corehole 8) Extraction System at Oak Ridge National Laboratory, Oak Ridge, Tennessee,* 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2566&D1. *Treatability Study for the Bethel Valley 7000 Area Groundwater Plume, Oak Ridge National Laboratory, Oak Ridge, Tennessee,* 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE-STD-1196-2011. *Derived Concentration Technical Standard*, 2011, U.S. Department of Energy, Washington, D.C.

Helsel, D.R. 2005, *Nondetects and Data Analysis: Statistics for Censored Environmental Data,* John Wiley & Sons, New York, 250 p.

McManamay, R.A., J.G. Smith, R.T. Jett, T.J. Mathews, and M.J. Peterson 2017. *Identifying non-reference sites to guide stream restoration and long-term monitoring*. Science of the Total Environment 621:1208-1223.

McManamay, R.A., R.T. Jett, M.G. Ryon, S.M. Gregory, S.H. Stratton, and M.J. Peterson 2016. *Dispersal limitations on fish community recovery following long-term water quality remediation*. Hydrobiologia 771 (1):45-65.

ORNL 2017. *Oak Ridge National Laboratory Water Quality Protection Plan Annual Report for 2017*, DOE Letter Report Submitted to TDEC on October 30, 2017. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Peterson, M.J. 2017. *Using an Investigative Approach to Water Quality Compliance in Oak Ridge, Tennessee*, Proceedings of the National Association of Environmental Professionals, Durham, North Carolina.

TDEC 2010a. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee.

TDEC 2010b. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, Meigs, Morgan, Rhea, and Roane Counties, Tennessee.

TDEC 2010c. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Fort Loudon Reservoir: Fort Loudon Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee.

TDEC 2015. State of Tennessee Water Quality Standards, Chapter 0400-40-03, General Water Quality Criteria, April 2015. Tennessee Department of Environment and Conservation, Division of Water Pollution Control.
URL: http://sharetngov.tnsosfiles.com/sos/rules/0400/0400-40/0400-40-03.20150406.pdf.

3. ORNL – MV

3.1 INTRODUCTION AND STATUS

3.1.1 Introduction

The MV watershed, located in the southwestern portion of the ORR, contains several large waste disposal areas that received waste from past activities at ORNL. Figure 3.1 shows locations of CERCLA actions in MV that require monitoring or LUCs and illustrates ROD-designated end uses. Two CERCLA actions (WAG 13 Cesium Plots and WOCE Sediment Retention Structure) are located outside of the existing decision boundary for MV but are included in Chapter 3 because of their proximity to other MV actions. In subsequent sections, the effectiveness of each completed action is assessed by reviewing performance monitoring objectives and results and verifying LUCs.

Completed CERCLA actions in the MV watershed are gauged against their respective action-specific goals. All actions under the *Record of Decision for Interim Actions for the Melton Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (MV Interim ROD; DOE/OR/01-1826&D3) are complete; however, future remedial decisions are planned. As a result, monitoring of baseline conditions is conducted against which the effectiveness of future actions can be evaluated. The collected data provides an evaluation of the indicators of effectiveness at the watershed-scale.

Table H.2 in Appendix H lists all completed CERCLA actions in MV and the corresponding completion documents and identifies whether monitoring or LUCs are required. Figure H.2 in Appendix H is a location map of the actions and illustrates ROD-designated end uses in MV. For a complete discussion of background information and performance metrics for each remedy, a compendium of all completed CERCLA decisions in the watershed within the context of a contaminant release conceptual model is provided in Chapter 5 of Volume 1 of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (DOE/OR/01-2718&D2). The information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

3.1.2 Status Update

<u>Watershed-scale actions</u>

The interim RAs in the MV Interim ROD have been completed and documented in the *Remedial Action Report for the Melton Valley Watershed, Oak Ridge, Tennessee* (MV RAR; DOE/OR/01-2343&D1). These interim RAs included a wide range of activities to reduce contaminant releases from the site, demolish unneeded facilities, plug and abandon unneeded wells, and remediate contaminated soils to prescribed risk levels. Selected remedies for sediments, floodplain soil exhibiting radiation <2500 µR/hr, surface water, and groundwater are not included in the MV Interim ROD. Future remedial decisions will select the remedies for these areas and will finalize or modify the interim RAs addressed under the MV Interim ROD. Currently, source releases in BV and contaminated sediments prevent WOC from meeting its stream use classifications (e.g., recreation). Performance monitoring of completed MV Interim ROD actions continued in FY 2018 in accordance with the *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (MV RAR CMP; DOE/OR/01-1982&D3).

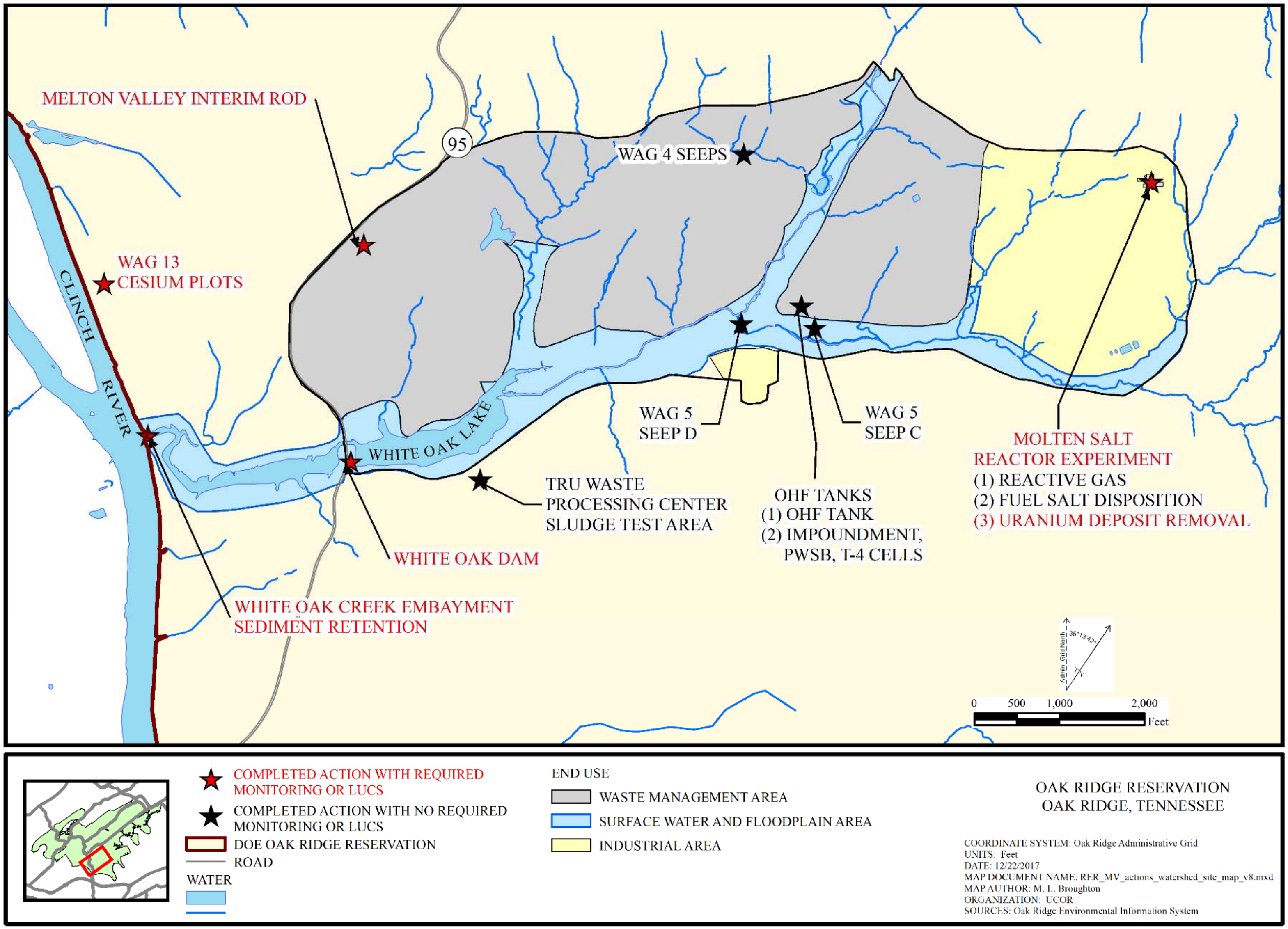


Figure 3.1. Completed CERCLA actions with required monitoring or LUCs in MV and end uses in MV.

In addition, sampling offsite wells to evaluate potential groundwater communication beneath the Clinch River between the ORR and an area of offsite groundwater use continued in accordance with the MV RAR CMP.

Single-project actions

In 2014, the *Addendum to Waste Handling Plan for the Molten Salt Reactor Experiment Remediation of Secondary Low-Level Waste under the Melton Valley Closure Project at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2200&D1/A1) was approved to address the disposition of waste that remained from the earlier actions. The addendum includes a schedule for characterizing and dispositioning 74 waste items. The Molten Salt Reactor Experiment (MSRE) was a graphite-moderated, liquid-fueled test reactor that operated at ORNL from June 1965 until December 1969. In FY 2018, all items were disposed and characterized per the schedule (Figure 3.2).

Figure 3.2. MSRE waste being loaded for shipment.

3.2 ASSESSMENT SUMMARY

A summary of the MV assessment for FY 2018 is provided below, followed by more detailed evaluations.

3.2.1 Performance Summary

In FY 2018, the annual average of the monthly composite surface water samples at WOD met the MV Interim ROD goals; monthly composite samples exceeded the goal at WOD for Sr-90 in June 2018 and for Cs-137 in November 2017 and September 2018. Although WOC contaminant discharges from BV into MV decreased in FY 2018 compared to FY 2017, operational problems at the ORNL PWTC and ungauged Sr-90 discharges in BV contributed to the June monthly composite sample at WOD exceeding the MV Interim ROD goal for Sr-90 as evidenced by the elevated June 2018 Sr-90 concentration at the 7500 Bridge. Tributary water quality monitoring results showed MV Interim ROD goal attainment in the MV tributaries that flow into WOC.

MV Interim ROD groundwater performance evaluation includes groundwater level control within hydrologically isolated units; and water quality evaluation near the Seepage Pits and Trenches, SWSA 6, in the MV onsite groundwater exit pathway wells, and in offsite monitoring wells adjacent to MV. MCL values are used for the water quality evaluation as a screening criteria and are not a specified ROD goal.

- Groundwater level control monitoring within the hydrologically isolated waste units during FY 2018 shows that seven of 52 wells used for performance evaluation did not meet their goals. Two of the wells are located in SWSA 6 and the remaining five wells are located in SWSA 4. The wells not meeting the MV Interim ROD goals are RER issues (Table 3.15). The status of the RER issues and ongoing activities are as follows:

  — Wells 0955 and 0958, which are located near the SWSA 4 downgradient trench (DGT), have exhibited recurring exceedances of their target groundwater elevations. During FY 2018, six of the 12 monthly groundwater level measurements at well 0955 exceeded the target elevation goal, and three of the four quarterly groundwater level measurements at well 0958 exceeded their target elevation goal. Beginning in late FY 2015, DOE implemented an enhanced frequency of maintenance and operations inspections of the SWSA 4 downgradient groundwater collection trench, which contributes to better overall groundwater level suppression in the collection trench and adjacent areas. Additionally, an on-going hydrologic evaluation to identify potential additional improvements to SWSA 4 DGT performance continued in FY 2018. This evaluation noted several system enhancements for more continuous operation of the pumps in the DGT; this evaluation is ongoing. These actions are expected to lower groundwater elevations at these wells to attain the target elevation. It is also recommended that well 0955 have continuous water level readings to further support system evaluation and performance. This issue for wells 0955 and 0958 is carried forward in this RER.

  — Well 1071 near the western portion of SWSA 4 and wells 4544 and 4545 near the center of the SWSA 4 cap experienced target groundwater elevation exceedances during FY 2018. Well 1071 is screened in bedrock between 784.96 and 800.71 ft aMSL and is located approximately 60 ft inside of the upgradient storm diversion drain that has a bottom elevation of approximately 806 ft aMSL. Based on this construction geometry, the upgradient trench (UGT) would not be capable of controlling groundwater from the upslope side of Lagoon Road from affecting the groundwater elevation measured at well 1071. Target groundwater elevation exceedances in wells 4544 and 4545 are thought to be related to either hydrologic isolation cap defects or seepage from the upgradient stormflow diversion trench area. DOE is in the process of evaluating groundwater level control at SWSA 4 and will discuss well performance with the Project Team. The issues associated with these three wells are carried forward in this RER.

  — Two wells in SWSA 6 (4127 and 0850) have chronically not met target groundwater elevations because of well construction or location conditions. Both of these wells are constructed with the majority of their screened intervals extending into bedrock. These deeper wells are prone to responding to groundwater levels affected by conditions outside the hydrologic isolation area such as groundwater recharge in confined to semi-confined zones that extend beneath the waste units. As a result, these wells are not good indicators of hydrologic isolation effectiveness. DOE samples a number of locations along the edge of SWSA 6 to understand changes in groundwater contaminant conditions following MV Interim ROD RA. Three sampling locations (well 0838, the South French Drain (SFD), and surface water location WAG6 MS3) provide definitive evidence that the SWSA 6 hydrologic isolation remedy is effective. While monitoring and reporting of groundwater levels at wells 4127 and 0850 will continue, it is recommended that alternative performance indicators be used to evaluate the hydrologic isolation effectiveness at SWSA 6. These measures include the continued monitoring of tritium concentrations at 0838, SFD, and WAG6 MS3. This issue is carried forward in this RER and alternative performance indicators will be discussed with the Project Team.

- At the Seepage Pits and Trenches, the maximum detected radionuclide concentrations show that in most cases the maximum measured concentrations have decreased over time. Although Tc-99 shows an increasing trend in the most recent 5-year data evaluation for well 1756 in Trench 5, its FY 2018 maximum concentration remained less than the residential 1E-4 PRG concentration. The causes for increases in radionuclide concentrations near the grouted seepage trenches is not known although changes in groundwater recharge and flow patterns following the trench grouting and area capping are the probable causes. Surface water sampling in adjacent stream valleys has not detected increases in radionuclide concentrations in the nearby discharge areas.

- Groundwater monitoring at SWSA 6 during FY 2018 shows that VOC concentration trends are consistent with levels measured during the past several years. Lead was detected in a sample from well 4317 at 0.018 mg/L (which is greater than the 0.015 mg/L MCL action level) in October 2017. Well 4317 was re-developed following that sampling event in an attempt to remove sediment from the sampling interval. Tritium concentrations show decreasing concentrations in groundwater in and around SWSA 6.

- In the MV offsite exit pathway monitoring program, the number of onsite sampling locations that exhibit regulated constituents at greater than 80% of their respective MCLs or MCL-DCs has decreased. Several constituents that are considered to be of natural origin (fluoride, barium, total radium alpha) have increasing concentration trends in deep wells that are exhibiting very slow recovery from well installation and well development processes. Other constituents that are considered to be of anthropogenic origin and that have exceeded the threshold concentrations of 80% of their respective MCLs exhibit trends that are mostly decreasing to stable, or not statistically significant.

- Contaminant concentrations and Cs-137 activity in fish from Melton Branch are low, with only mercury in Melton Branch fish higher than fish from the reference stream. Monitoring of the fish and invertebrate communities indicate that Melton Branch and lower WOC downstream of Melton Branch are impaired relative to reference sites. Since introduction of additional native fish species in the watershed, fish communities have improved steadily in both species richness and abundance, although the numbers are still below reference sites. The invertebrate communities in Melton Branch and WOC downstream of Melton Branch, as measured by the number of pollution-intolerant taxa, are higher today than in the 1980s, but are below peak years in the 2005 – 2010 time-frame and similar to numbers observed in the 1990s. There is substantial annual variation in the invertebrate community metrics from the monitoring sites that is common in stressed systems.

3.2.2 LUC Protectiveness

All LUCs in MV specified in the MV RAR for protection of the environment and/or human health are in place and have been maintained. Certification of approved LUCs for FY 2018 are in Appendix A of this RER.

The WOD gates as specified in the *Removal Action Report for Corrective Actions at White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (WOD RmAR; DOE/OR/01-2509&D1) have been experiencing some operational problems as identified in LUM. An evaluation of the gates including their purpose and use was ongoing in FY 2018.

3.3 ROD FOR INTERIM ACTIONS FOR MV WATERSHED

3.3.1 Performance Monitoring

3.3.1.1 Performance goals and monitoring objectives

The MV Interim ROD includes actions for the hydrologic isolation of burial grounds, removal of impoundments, grouting of Homogeneous Reactor Experiment (HRE) fuel wells, remediation of inactive waste pipelines, *in situ* grouting of Seepage Trenches 5 and 7, removal of contaminated soil and sediment, demolition of buildings, plugging and abandonment of wells, monitoring, and LUCs. It also stipulates RAOs for MV based on the industrial use area (east of SWSA 5), the Waste Management Area, the Surface Water and Floodplain Area, and for human receptors and ecological populations (Figure 3.1 and Table 3.1). The MV RAR CMP provides the monitoring approach for the MV Interim ROD and assembles all monitoring requirements for the watershed into a single primary document. Table 3.2 includes the performance objectives and measures stated in the MV Interim ROD for those elements of the remedy that specified post-remediation monitoring. These performance objectives provide a quantitative basis to evaluate the effectiveness of hydrologic isolation at limiting contaminant releases from buried waste by monitoring groundwater fluctuation within hydrologic isolation areas. Additionally, the performance measure for surface water quality is to achieve the AWQC numeric and narrative goals related to contaminant discharges originating from MV within two years after completion of remediation. Also included in Table 3.2 are goal attainment dates and references to sections in this RER where the annual status of performance for each metric is discussed. Figure 3.3 shows principal monitoring locations in MV.

3.3.1.2 Evaluation of performance monitoring data

This section evaluates the monitoring data in terms of meeting the goals of the MV Interim ROD. Performance monitoring includes surface water monitoring, groundwater monitoring, and biological monitoring. Principal monitoring locations in MV are provided on Figure 3.3.

3.3.1.2.1 Surface water

This section presents the results of remedy effectiveness evaluation of surface water monitoring in the MV watershed. Section 3.3.1.2.1.1 summarizes the remediation goals for surface water; Section 3.3.1.2.1.2 presents information concerning major radionuclide concentrations and fluxes at the surface water IP monitoring stations; and Section 3.3.1.2.1.3 presents data obtained at the tributary sampling locations.

Table 3.1. RAOs for the MV watershed selected remedy[a]

Area/receptor	***Goal***
Waste management area (includes SWSA 4, 5, and 6 and Seepage Pits and Trenches)	• *Manage waste disposal sites as a restricted waste management area* • *Protect maintenance workers* • *Meet AWQC in surface water in a reasonable amount of time* • *Mitigate further impact to groundwater*
Industrial use area (generally the area east of SWSA 5)	• *Manage areas generally east of SWSA 5 as an industrial area* • *Protect industrial workers* • *Meet AWQC in surface water in a reasonable amount of time* • *Mitigate further impact to groundwater*
Surface water and floodplain area	• *Achieve numeric and narrative AWQC for waters of the state in a reasonable amount of time* • *Remediate contaminated floodplain soils to 2500 µR/hour[b]* • *Protect an off-site resident user of surface water at the confluence of White Oak Creek with the Clinch River from contaminant sources in Melton Valley* • *Make progress toward meeting Clinch River's stream use classification as a drinking water source at confluence of White Oak Creek with the Clinch River*
Human receptors	• *Protect maintenance workers, industrial workers, and off-site resident users of surface water (at the confluence of White Oak Creek with the Clinch River) to a 10^{-4} to 10^{-6} excess lifetime cancer risk and a HI of 1* • *Protect hypothetical recreational users of waters of the state[c]*
Ecological receptors	• *Protect ecological populations[d]*

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1826&D3), Table 1.1.

[b]*A future CERCLA decision will be prepared to determine whether additional actions are required for floodplain soil <2500 µR/h.*

[c]*This remedy addresses water quality but does not fully address fish consumption or sediment/floodplain soil contact or exposure under the recreational scenario. This remedy protects the hypothetical recreational user through a combination of RAs including LUCs. A future CERCLA decision will be prepared to assess whether any additional actions are required.*

[d]*The selected remedy enhances overall protection of valley-wide ecological populations and sub-basin-level populations over a majority of the valley. However, portions of the valley that are not addressed by the selected remedy may pose potential unacceptable risks to ecological receptors. Additional data collection and evaluation will be conducted as part of this remedy to further assess the status of ecological receptors in these areas. Results of this ecological monitoring and any additional actions, as necessary, will be included in a future remedial decision.*

AWQC = ambient water quality criteria
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
HI = hazard index
LUC = land use control
MV = Melton Valley
RA = remedial action
RAO = remedial action objective
SWSA = Solid Waste Storage Area

Table 3.2. Performance measures for major actions in the MV watershed[a]

Unit type/unit names project scope	*Performance objectives*	*Performance measure[b]* (Attainment schedule) [RER section]
SWSA 4 • *SWSA 4* • *Liquid Seepage Pit 1 & Secondary Media* • *Inactive Waste Transfer Lines @ Lagoon Road* • *Pilot Pits Area* • *Shallow Well P&A*	• *Contain disposed & contaminated materials* • *Meet RAO for the waste management use area* [soil]	• *Prevent releases from SWSA 4 from causing AWQC exceedances in waters of the state within 2 years after SWSA 4 construction is complete* (Fall 2006).[c] [See Section 3.3.1.2.1.3] • *Reduce SWSA 4 contaminant releases to surface water by approximately 80% to meet computed 1 X 10^{-4} total residential risk at the confluence of White Oak Creek with Clinch River in ~10 years after all ROD actions are complete* (2016).[c] [See Section 3.3.1.2.1.3] • *Reduce groundwater through flow in buried waste units by >75% as measured by >75% decrease in water level fluctuations in selected monitoring locations inside the contained area* [See Section 3.3.1.2.2]
SWSA 5 South • *SWSA 5 South* • *Stabilized OHF Pond and Tanks* • *Stabilized subsurface OHF facilities* • *Contaminated soils at OHF site* • *Shallow Well P&A*	• *Contain disposed materials* • *Meet RAO for the waste management use area* [soil]	• *Prevent releases from SWSA 5 South from causing AWQC exceedances in waters of the state in Melton Branch, Lower HRE Tributary, and SWSA 5 D1 within 2 years after SWSA 5 South construction is complete* (Fall 2008).[c] [See Section 3.3.1.2.1.3] • *Reduce SWSA 5 contaminant releases to surface water by approximately 80% to meet computed 1 X 10^{-4} total residential risk at the confluence of White Oak Creek with Clinch River in ~10 years after all ROD actions are complete (2016).*[c] [See Section 3.3.1.2.1.3] • *Reduce groundwater throughflow in buried waste units by >75% as measured by >75% decrease in water level fluctuations in selected monitoring locations inside the contained area.* [See Section 3.3.1.2.2]
SWSA 5 North 4 trenches	• *Contain disposed materials* • *Meet RAO for the waste management use area* [soil]	• *Verify that groundwater does not contact the buried waste through water level monitoring in and adjacent to the trenches after capping.* [See Section 3.3.1.2.2.2]
SWSA 6 • *SWSA 6* • *Shallow Well P&A*	• *Contain disposed materials* • *Meet RAO for the waste management area* [soil]	• *Prevent releases from SWSA 6 from causing AWQC exceedances in waters of the state within 2 years after SWSA 6 construction is complete* (Fall 2006).[c] [See Section 3.3.1.2.1.3] • *Comply with RCRA postclosure requirements for designated RCRA areas (Ongoing).*[c] [See Section 3.3.2] • *Reduce groundwater throughflow in buried waste units by >75% as measured by >75% decrease in water level fluctuations in selected monitoring locations inside the contained area.* [See Section 3.3.1.2.2]
Pits 2, 3, and 4 and Trench 6 • *Liquid seepage pits* • *Inactive waste pipelines*	• *Contain disposed materials* • *Meet RAO for the waste management use area* [soil]	• *Prevent releases from Liquid Waste Seepage Pits 2, 3, and 4, and Trench 6 from causing AWQC exceedances in waters of the state*

Table 3.2. Performance measures for major actions in the MV watershed[a] (cont.)

Unit type/unit names project scope	*Performance objectives*	*Performance measure[b]* **(Attainment schedule) [RER section]**
• *Shallow well P&A*		*within 2 years after construction is complete* (Fall 2006).[c] [See Section 3.3.1.2.1.3] • *Reduce groundwater throughflow in the contained area by >75% as measured by >75% decrease in water level fluctuations in selected monitoring locations inside the contained area.* [See Section 3.3.1.2.2]
Trenches 5 and 7 • *Liquid seepage trenches* • *Inactive waste pipelines* • *Shallow well P&A*	• *Immobilize disposed materials* • *Meet RAO for the waste management use area* [soil]	• *Prevent releases from Seepage Trenches 5 and 7 from causing AWQC exceedances in waters of the state within 2 years after ISV is complete* (Fall 2006).[d] [See Section 3.3.1.2.1.3] • *Vitrify any additional contaminated soils that cause contamination of groundwater leading to surface water exceedances.*
Surface water quality	• *Meet TDEC numeric AWQC and narrative (risk-based) water quality criteria in all waters of the state for specified uses.* • *Meet risk levels for hypothetical recreational water use (contact and consumption under the recreational exposure scenario)*	• *Achieve numeric AWQC and narrative (risk-based) water quality criteria in waters of the state within 2 years after completion of all actions that are part of the selected remedy. Meet recreation use criteria for water contact and consumption, excluding fish consumption* (Fall 2006).[c] [See Section 3.3.1.2.1.2] • *Reduce contaminant releases to meet water quality conditions that would allow hypothetical residential use (risk level of 1 X 10^{-4} for water only – no fish consumption or sediment contact scenarios) at confluence with the Clinch River in ~10 years after completion of all ROD actions. Reductions in ^{90}Sr and tritium of 75-80% are required.* [See Section 3.3.1.2.1.3]

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1826&D3), Table 2.17.

[b]*To meet a target post-remediation risk level of 1 X 10^{-4} for surface water under the residential scenario at the mouth of White Oak Creek an 80% reduction of risk from the sum of individual contaminants from combined sources in Melton Valley is required. This calculation includes anticipated reductions in surface water contaminant risk that originate in Bethel Valley. Reduction of releases from individual source areas in Melton Valley as a result of remedial actions may vary somewhat. For all remediated areas, post-construction surveillance and maintenance monitoring will be implemented, which includes inspection of cap integrity, proper functioning and maintenance of surface water and groundwater flow control features, and conformance with land use control requirements.*

[c]As discussed in Section 1.1, the CERCLA program provides RCRA-equivalent post-closure care of the unit through compliance with RCRA substantive requirements.

[d]Indicates date by which goal is to be attained.

Note: Non-italicized text within table references sections in the current document.

AWQC = ambient water quality criteria
HRE = Homogeneous Reactor Experiment
ISV = *in situ* vitrification
MV = Melton Valley
OHF = Old Hydrofracture Facility
P&A = plugging and abandonment
RAO = remedial action objective
RCRA = Resource Conservation and Recovery Act
RER = Remediation Effectiveness Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation

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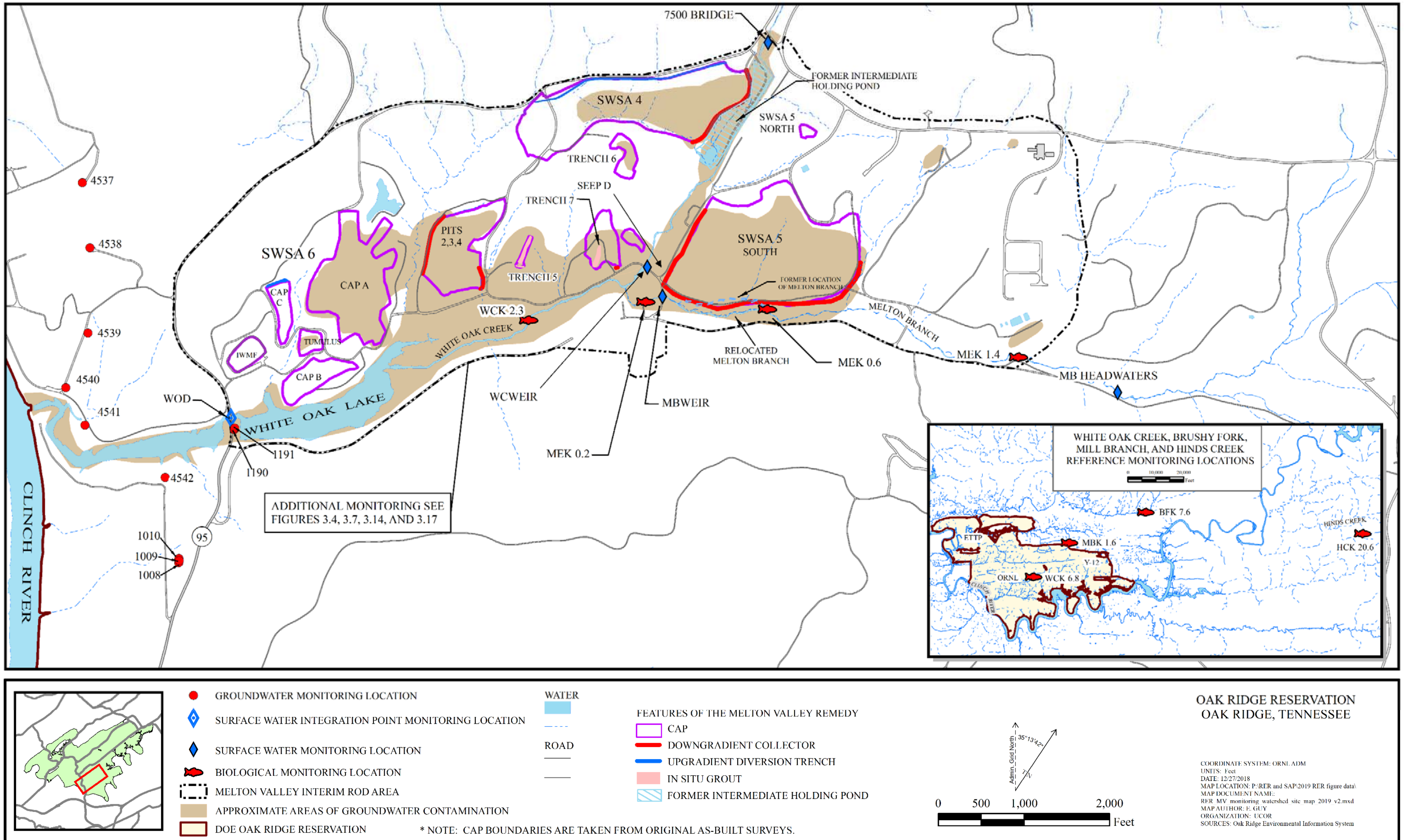

Figure 3.3. Principal monitoring locations in MV.

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3.3.1.2.1.1 Surface water quality goals and monitoring requirements

Surface water goals include protection of the Clinch River to meet its stream use classification (e.g., such as a domestic water supply) and to achieve AWQC in waters of the state. The MV Interim ROD includes specific surface water remediation levels. Table 3.3 includes excerpts from the MV Interim ROD that provide specific concentration goals for the principal surface water COCs in the watershed. Locations where surface water monitoring occurs to evaluate the remedy performance are shown on Figure 3.4.

Table 3.3. Surface water remediation levels for the MV watershed[a]

Melton Valley watershed	***Goal: AWQC in waters of the state***		***Residential risk***
	Numeric AWQC	***Narrative AWQC/recreational risk***	
Receptor	*Hypothetical recreational user; fish and aquatic life*	*Hypothetical recreational user*	*Hypothetical off-site resident*
Areas affected	*All waters of the state*	*All waters of the state*	*Confluence of White Oak Creek with Clinch River*
Anticipated compliance locations	See Figure 3.4 of RER	See Figure 3.4 of RER	*Confluence of White Oak Creek with Clinch River*
Remediation level	*Levels established in Rules of the TDEC Chapter 1200-4-3-.03[b]*	See Table 3.5 of RER	See Table 3.4 of RER
Exposure scenarios	*N/A (numeric criteria tabulated in regulation; no separate calculation using exposure scenarios needed)*	*Hypothetical recreational swimming for White Oak Lake and White Oak Creek Embayment; recreational wading for White Oak Creek, Melton Branch, and other waters of the state. The exposure scenarios do not take into account fish ingestion and sediment contact*	*Hypothetical residential (i.e., general household use)*

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1826&D3), Table 2.18.
[b]Tennessee Code subsequently revised to TDEC Chapter 0400-40-03.03.

Note: Non-italicized text within table is referencing figures and tables in the current document.

AWQC = ambient water quality criteria
MV = Melton Valley
N/A = not applicable
RER = Remediation Effectiveness Report
TDEC = Tennessee Department of Environment and Conservation

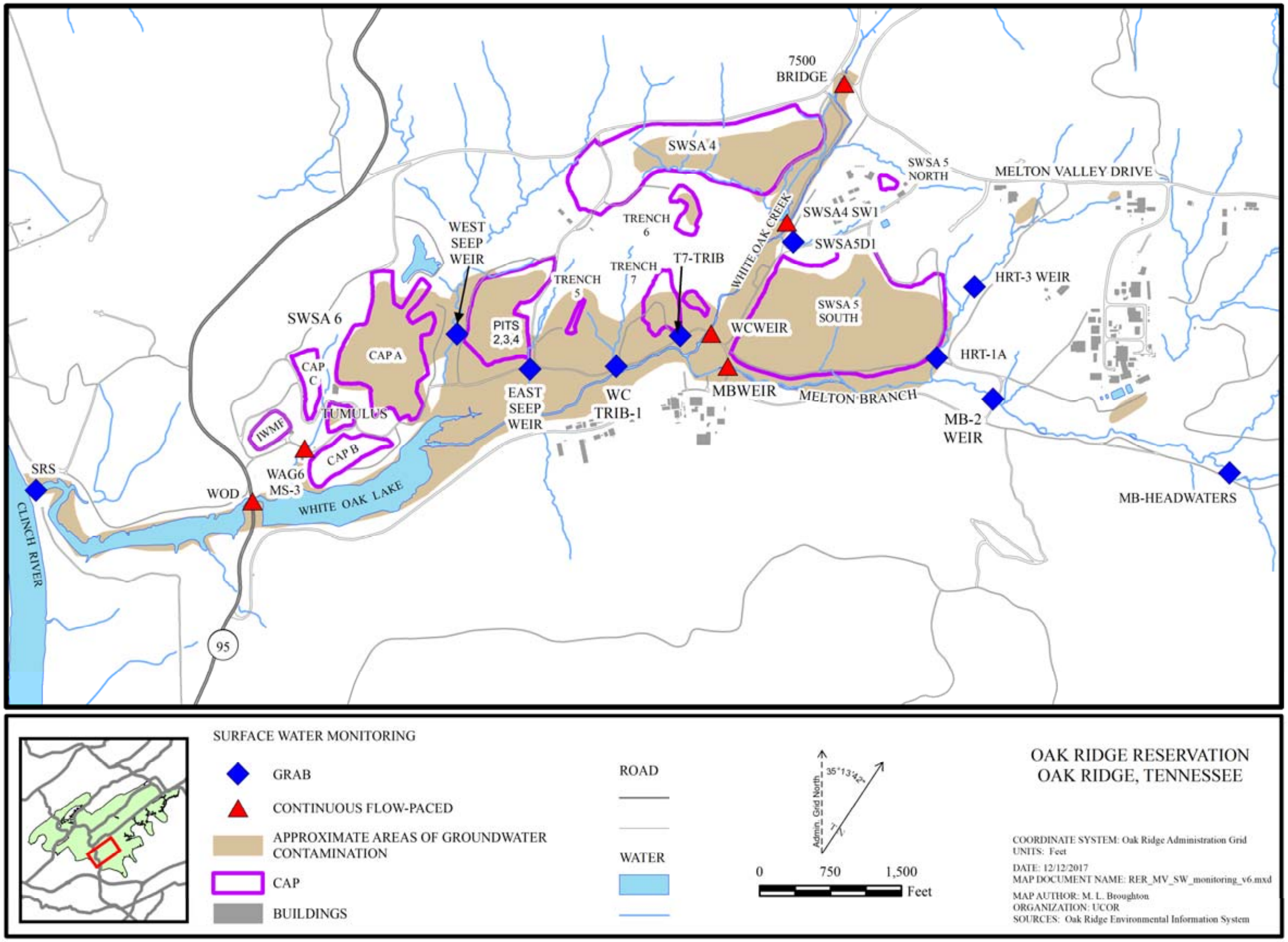


Figure 3.4. Principal MV surface water monitoring locations and associated reference locations.

Protect Clinch River to meet its stream use classification

This goal protects the Clinch River as a domestic water supply (e.g., meets SDWA MCLs), which is the most stringent of the use classifications assigned to the Clinch River, from contaminated surface water coming from MV. This goal provides residential risk-based limits for surface water at the confluence of WOC with the Clinch River. This goal will be met within 10 years (Table 3.2) from completion of actions in MV (BV is upgradient of MV and attainment of the MV ROD goal is highly dependent on BV RAs being completed). Remediation levels at the confluence of WOC with the Clinch River will achieve an annual average ELCR less than 1 X 10^{-4} and a HI less than one for a residential exposure scenario (i.e., general household use). Samples to demonstrate compliance with these remediation levels may be taken from the WOCE and/or WOD. Table 3.4 lists the remediation levels for the contaminants contributing to residential risk at WOD.

Table 3.4. Residential risk-based surface water remediation concentrations for the MV watershed[a]

Contaminants at White Oak Dam[b]	*Units*	*Reference concentration[c]*	*Minimum detection limit[d]*	*Concentrations based on a residential scenario[e] (for WOCE and/or White Oak Dam)*
Arsenic	*mg/L*	*ND*	*0.003*	*0.0056*
Chloroform	*mg/L*	*ND*	*0.001*	*0.021*
1,2-dichloroethane	*mg/L*	*ND*	*0.001*	*0.016*
PCBs	*mg/L*	*ND*	*0.001*	*0.011*
Cesium-137+D	*pCi/L*	*40*	*10.0*	*150*
Cobalt-60	*pCi/L*	*ND*	*10.0*	*250*
Strontium-90+D	*pCi/L*	*ND*	*2.0*	*85*
Tritium	*pCi/L*	*1626*	*300*	*58,000*

Note: The remediation levels are calculated at 1 X 10^{-4} excess lifetime cancer risk or hazard index of 1 using standard risk assessment protocols for a general household use scenario. These values apply to single contaminants only. To account for the total risk from multiple contaminants, sum of ratios calculations may be applied to all contaminants that are present above background. Actual remediation concentrations when multiple contaminants are present will therefore likely be lower than the single contaminant concentrations listed in the table. Concentrations for other contaminants not listed in the table will be determined as necessary and in a manner similar to that followed above.

[a]Source*: Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1826&D3), Table 2.20.

[b]*Beryllium was identified as a contaminant of concern in the Feasibility Study but was not included here because the Environmental Protection Agency has since revised its position on the carcinogenicity of beryllium [see Record of Decision for Interim Actions for the Melton Valley Watershed (DOE/OR/01-1826&D3) Table 2.5]. Also, some of these contaminants have Safe Drinking Water Act maximum contaminant levels. The selected remedy will make progress toward protecting Clinch River as a drinking water source (i.e., meet Safe Drinking Water Act maximum contaminant levels).*

[c]*Reference concentrations equal twice the arithmetic mean of the background; these concentrations were used for surface water analyte screening in the Melton Valley watershed risk assessment.*

[d]*The minimum detection limits are based on existing regulatory methodology and current laboratory instrument capabilities.*

[e]*The residential scenario assumes a 70-kg adult receptor, an exposure frequency of 350 days/year, an exposure duration of 30 years, an ingestion rate of 2 L/day, and a skin surface area (for dermal exposure) of 1.94 m^2.*

D = daughter products
MV = Melton Valley
ND = not detected or analyzed
PCB = polychlorinated biphenyl
WOCE = White Oak Creek Embayment

Achieve AWQC in waters of the state

White Oak Creek and Melton Branch are classified for Fish and Aquatic Life, Recreation, and Livestock Watering and Wildlife uses, but not for Domestic or Industrial Water Supply or Irrigation. All other named and unnamed surface waters in the watershed are also classified for Irrigation by default under the Rules of the TDEC Chapter 1200-4-4[1]*. Numeric AWQC and narrative criteria for the protection of human health (based on ELCR of 1 X* 10^{-4} *and HI less than 1 for recreational exposure scenario) and aquatic organisms will be met for site-related contaminants in all waters of the state in MV in ~10 years from completion of source actions in MV. Numeric AWQC exist for selected compounds under the Recreation and Fish and Aquatic Life Classifications. Consistent with EPA guidance, compliance with numeric AWQC for Recreation and Fish and Aquatic Life Classifications is sufficiently stringent to ensure protection of other uses for which there are narrative, but not numeric, criteria (i.e., Irrigation or Livestock Watering and Wildlife). A recreational risk scenario considered representative of the surface water classifications is used to calculate cumulative risk from measured concentrations of surface water contaminants or conversely to derive allowable concentrations from risk-based limits.*

AWQC in Waters of the State—Numeric AWQC

The numeric AWQC for (1) Fish and Aquatic life and (2) Recreation (organisms only) apply to waters of the state in MV and are tabulated in Rules of the TDEC Chapter 1200-4-3-.03[2] *for most of the COCs. Compliance will be based on statistically valid data assessments, and take into account frequency of detection and data trends. The sampling locations for the selected remedy will be finalized in a post-ROD sampling plan. The locations are generally at the downstream end of individual reaches but upstream of any confluence with other major streams. Samples taken from such locations would essentially integrate contamination entering the reach from any sources upstream of the sampling location.*

AWQC in Waters of the State—Narrative Criteria

In accordance with EPA guidance, the CERCLA risk assessment process is used to address the narrative criteria for waters of the state. A recreational risk scenario considered representative of the surface water classifications is used to calculate cumulative risk from measured concentrations of surface water contaminants or conversely to derive allowable concentrations from risk-based limits. However, DOE does not reasonably foresee actual recreational use of MV surface water in the future.

Waters of the state containing COCs that do not have numeric AWQC will achieve an annual average ELCR less than 1 X 10^{-4} *and an HI less than 1 for a recreational exposure scenario. This goal applies only to surface water and only to those contaminants of concern that do not have numeric AWQC, such as radionuclides. The numeric AWQC for individual contaminants is generally equivalent to risk levels ranging up to* 10^{-5}*. The annual average risk goal of 1 X* 10^{-4} *meets the intent of the AWQC because when multiple contaminants are present in the surface water, as is likely, their individual risk levels would be roughly equivalent to the*

[1]The Tennessee Code subsequently revised to TDEC Chapter 0400-40-04 (Use Classifications for Surface Waters).

[2]The Tennessee Code subsequently revised to TDEC Chapter 0400-40-03-.03 (Criteria for Water Uses).

AWQC-equivalent risk of 10^{-5}. A lower risk goal could routinely require individual contaminant risks to be below the AWQC-equivalent risk of 10^{-5}.

Under this ROD, the recreational scenario is defined as a swimming scenario for the impounded water bodies, such as White Oak Lake and the WOCE, and a wading scenario for streams such as WOC and MB. Since contaminated sediments are left in place under the remedy in this ROD, the swimming or wading scenarios do not include external exposure to or contact with sediment. Also, the scenarios do not include fish consumption because some contaminants in fish may be linked to contaminated sediments. Table 3.5 *lists the remediation levels for the recreational surface water COCs identified in the FS...The sampling locations for the selected remedy will be finalized in a post-ROD sampling plan.*

Table 3.5. Recreational risk-based surface water remediation concentrations for the MV watershed[a]

COCs identified in the FS[b]	***Units***	***Reference Concentration[c]***	***Minimum Detection Limit[d]***	***Concentrations based on a recreational swimming scenario[e] (for White Oak Lake and WOCE)***	***Concentrations based on a recreational wading scenario[f] (for White Oak Creek, Melton Branch, and other waters of the state)***
Arsenic	*mg/L*	*ND*	*0.003*	*NA[g]*	*NA[g]*
Tetrachloroethylene	*mg/L*	*ND*	*0.001*	*NA[g]*	*NA[g]*
Vinyl chloride	*mg/L*	*ND*	*0.001*	*NA[g]*	*NA[g]*
Cesium-137+D	*pCi/L*	*40*	*10.0*	*4.69E+04*	*2.37E+05*
Cobalt-60	*pCi/L*	*ND*	*10.0*	*7.84E+04*	*3.92E+05*
Radium-228+D	*pCi/L*	*ND*	*0.5*	*5.97E+03*	*2.99E+04*
Strontium-90+D	*pCi/L*	*ND*	*2.0*	*2.65E+04*	*1.33E+05*
Tritium	*pCi/L*	*1,626*	*300*	*2.07E+07*	*1.04E+08*
Uranium-234	*pCi/L*	*ND*	*0.5*	*3.34E+04*	*1.67E+05*

***Note**: The remediation levels are calculated at 1 X 10^{-4} excess lifetime cancer risk or hazard index of 1 using standard risk assessment protocols for a swimming or wading scenario. These values apply to single contaminants only. To account for the total risk from multiple contaminants, sum of ratios calculations may be applied to all contaminants that are present above background. Actual remediation concentrations when multiple contaminants are present will therefore likely be lower than the single contaminant concentrations listed in the table. Concentrations for other site-related contaminants not listed in the table will be determined as necessary and in a manner similar to that followed above.*

[a]Source: *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1826&D3), Table 2.19.

[b]*Beryllium was identified as a contaminant of concern in the Feasibility Study but was not included here because Environmental Protection Agency has since revised its position on the carcinogenicity of beryllium [see Record of Decision for Interim Actions for the Melton Valley Watershed (DOE/OR/01-1826&D3) Table 2.5].*

[c]*Reference concentrations equal twice the arithmetic mean of the background; these concentrations were used for surface water analyte screening in the Melton Valley watershed risk assessment.*

[d]*The minimum detection limits are based on existing regulatory methodology and current laboratory instrument capabilities.*

[e]*The recreational swimming scenario assumes a 70-kg adult receptor, an exposure frequency of 45 hours/year, an exposure duration of 30 years, an ingestion rate of 0.05 L/hour, and a skin surface area (for dermal exposure) of 1.94 m^2.*

[f]*The recreational wading scenario assumes a 70-kg adult receptor, an exposure frequency of 45 hrs/yr, an exposure duration of 30 years, an ingestion rate of 0.01 L/hour, and a skin surface area (for dermal exposure) of 0.632 m^2.*

[g]*Risk-based concentrations to meet the narrative criteria were not derived for these contaminants of concern since numeric ambient water quality criteria exist for them.*

COC = contaminant of concern
D = daughter products
FS = feasibility study
MV = Melton Valley
NA = not applicable
ND = not detected or analyzed
WOCE = White Oak Creek Embayment

3.3.1.2.1.2 IP monitoring results

This section provides an evaluation of the surface water quality data collected at surface water IPs on WOC and Melton Branch during FY 2018 compared to the MV Interim ROD goals and performance metrics. Surface water monitoring locations are shown on Figure 3.4.

The principal surface water IP monitoring station in MV is at WOD where WOC discharges from WOL. Continuous, flow-paced sampling is conducted at WOD to provide an ongoing record of radiological discharges from the watershed. The monitoring integrates measurements of radionuclide activities on samples collected during each month and the flow volume passing through the monitoring station to derive a flux value. Similar monitoring is conducted at three upstream IP surface water monitoring stations – the White Oak Creek Weir (WCWEIR), the Melton Branch Weir (MBWEIR), and the 7500 Bridge. Table 3.6 displays the activities of Cs-137, Sr-90, and tritium from the monthly flow-paced composite samples obtained at these main stem IPs.

Comparison of Cs-137, Sr-90, and tritium activities measured at WOD (Table 3.6) with the MV Interim ROD goal (Table 3.4) is the basis for remedy effectiveness evaluation for protection of the Clinch River.

Figure 3.5 shows the annual average and average-plus-one standard deviation activities of Cs-137, Sr-90, and tritium from monthly composite samples collected at WOD for FY 2001 through FY 2018. Total annual rainfall at the ORNL is provided to enable long-term comparison of contaminant response to rainfall. MV Interim ROD goals for these three contaminants for protection of the Clinch River as a public water supply are also shown. The monthly flow-paced sampling provides continuous sampling of surface water at each sample station to ensure the best available measure of the time- and flow-weighted average contaminant activity.

Comparison of Cs-137, Sr-90, and tritium activities (Table 3.6) measured at WCWEIR and MBWEIR, which are upstream integration monitoring locations, with the MV Interim ROD goal for a recreational scenario (Table 3.5) indicates that all annual average surface water concentrations in MV for FY 2018 are below the risk-based goals for these constituents.

In FY 2018, the annual average of the monthly composite surface water samples at WOD met the MV Interim ROD goals for discharges to the Clinch River; however, one Sr-90 and two Cs-137 monthly composite samples exceeded the goal at WOD (Table 3.6). Strontium-90 exceeded the 85 pCi/L MV Interim ROD goal during June 2018 while Cs-137 equaled the MV Interim ROD goal of 150 pCi/L in November 2017 and exceeded the goal in September 2018. Data in Table 3.6 show that during June the Sr-90 concentration was elevated at 7500 Bridge which indicates that an increased Sr-90 contribution from BV added to the MV Sr-90 sources which lead to the 97 pCi/L monthly concentration at WOD. Cesium is a contaminant that is very strongly adsorbed to soil and sediment particles. Sediment disturbances in WOL near the lake’s outlet have historically been shown to cause suspension of sediment that is reflected in the monthly composite samples from that location.

Figure 3.6 shows the annual radionuclide flux for Cs-137, Sr-90, and tritium measured at WOD and the ORNL site total annual rainfall from FY 2001 through FY 2018. During FY 2018, rainfall was 9% greater than the long-term average of 54 in. The total fluxes of Cs-137, Sr-90, and tritium measured during FY 2018 remained low and comparable to the FY 2007 through FY 2017 values. The FY 2018 Sr-90 flux at WOD of 0.6 Ci decreased slightly from 0.8 Ci measured FY 2017. The flux decrease is attributed to both the 0.1 Ci reduction in the BV Sr-90 flux and decreased fluxes from the Melton Branch watershed and non-point Sr-90 sources in the lower WOC watershed.

In addition to compliance at WOD, the MV Interim ROD requires that DOE meet AWQC in surface water in a reasonable amount of time. DOE evaluates the status of AWQC attainment in each CERCLA FYR. Sampling for AWQC comparison was completed in FY 2015 as part of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2); an evaluation of results is presented in the 2016 FYR document.

3.3.1.2.1.3 Tributary surface water monitoring results

Tributary monitoring locations (Figure 3.4) are sampled to evaluate the effect of remediation on water quality in tributaries to WOC and Melton Branch. Samples are obtained by the grab method, except at WAG 6 MS-3 and SWSA 4 SW1 where flow-paced composite sampling is performed. Radiological remediation level goals for surface water in the MV tributaries are in Table 3.5. Table 3.7 includes a comparison of the FY 2018 maximum result to MV Interim ROD goals for each radionuclide at each monitoring location. All results are well below the MV Interim ROD recreational goals for surface water.

Table 3.6. Summary of FY 2018 monthly composite sample radiological contaminant levels at surface water IPs in MV

Monthly composite date	7500 Bridge			WCWEIR			MBWEIR			WOD		
	Sr-90	Tritium	Cs-137	Sr-90	Tritium	Cs-137	Sr-90	Tritium	Cs-137	Sr-90	Tritium	Cs-137
25-Oct-17	**44.3**	38,400	4.2 U	49	35,000	10	43	3,700	<1.2	58	25,000	33
29-Nov-17	**39.4**	24,400	6.9 JU	46	21,000	6.8	30	3,200	<1.6	67	11,000	**150**
27-Dec-17	30.2	20,500	13.3	40	19,000	8.3	30	2,300	<3.3	60	16,000	15
31-Jan-18	32.8	15,900	8.19	37	11,000	6.8	29	1,200	<-0.11	62	8,600	11
28-Feb-18	28.3	7,530	2.53 U	30	8,400	7.7	23	1,600	6.2	42	6,900	13
28-Mar-18	32.4	12,200	7.61 JU	29	12,000	9.6	25	2,900	4	45	9,200	16
28-Apr-18	32.4	6,010	3.7 JU	31	6,100	12	26	2,500	3.3	42	3,900	25
31-May-18	26.1	19,900	3.82 JU	34	23,000	13	23	4,900	4.3	45	20,000	15
28-Jun-18	**50.4**	33,500	15.7	48	30,000	11	26	1,600	1.6	**97**	22,000	26
26-Jul-18	**42.8**	31,600	10.2	41	40,000	11	18	3,100	5	49	32,000	29
29-Aug-18	**40.9**	42,400	7	47	39,000	14	27	5,800	6.4	68	31,000	23
27-Sep-18	**40.6**	65,900	11.2	44	58,000	13	11	2,600	<1.9	51	48,000	**200**
Average activity (pCi/L)	36.7	26,500	< 7.9	40	25000	10	26	3,000	<3.2	57	19,000	46
ROD goal[a]	*37[b]*	*1.04E+8*	*33[b]*	*1.33E+5*	*1.04E+8*	*2.37E+5*	*1.33E+5*	*1.04E+8*	*2.37E+5*	85	58,000	150

[a]MV Interim ROD goals per Tables 3.4 and 3.5.
[b]BV Interim ROD goals.

Bold value indicates sample concentration exceeds *Melton Valley or Bethel Valley Interim ROD goal.*
Activity values are pCi/L.

BV = Bethel Valley
FY = fiscal year
IP = integration point
MBWEIR = Melton Branch Weir
MV = Melton Valley
ROD = Record of Decision
U = not detected
UJ = not detected and the detection limit is approximate
WCWEIR = White Oak Creek Weir
WOD = White Oak Dam

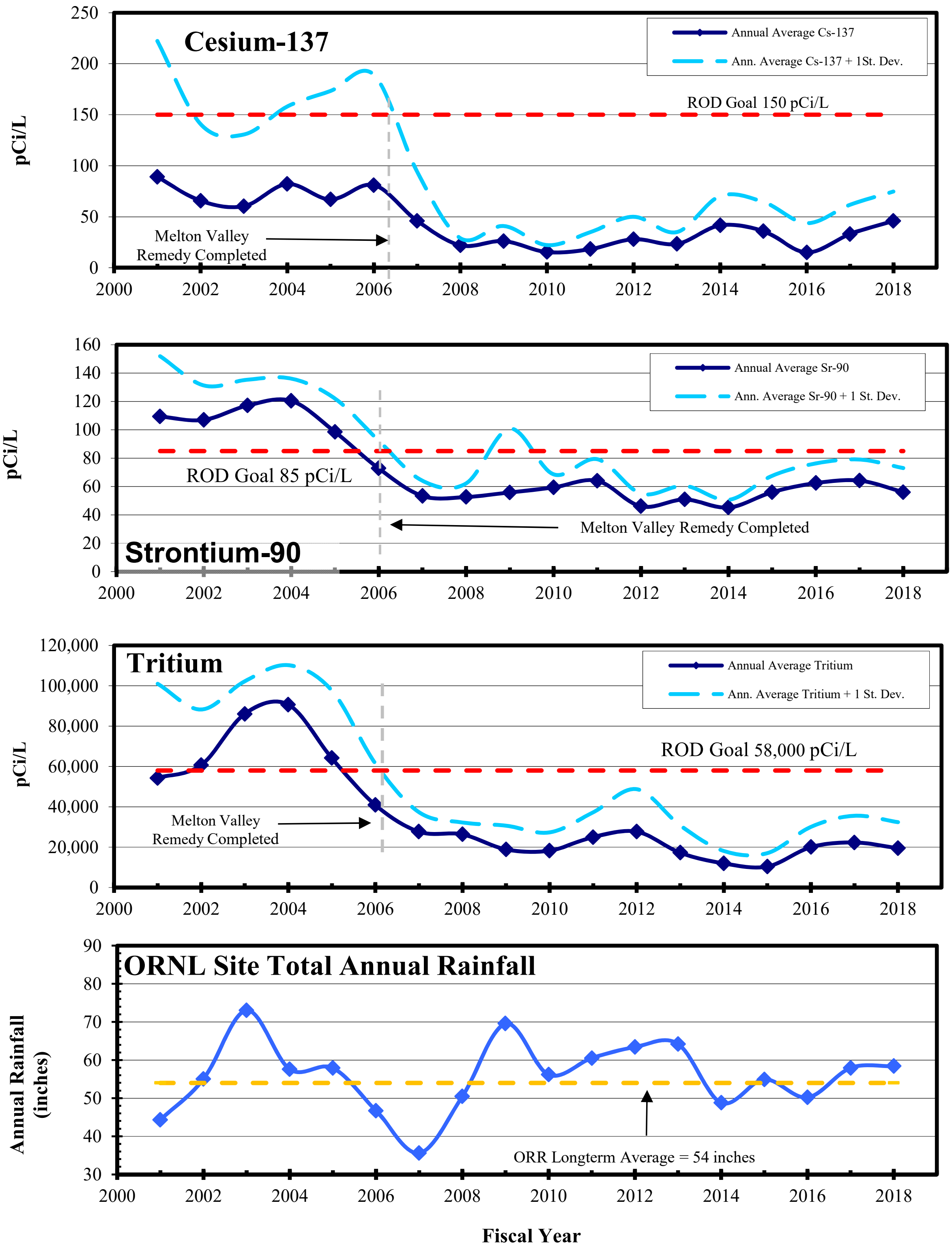


Figure 3.5. Annual average monthly surface water composite sample activities of Cs-137, Sr-90, and tritium at WOD.

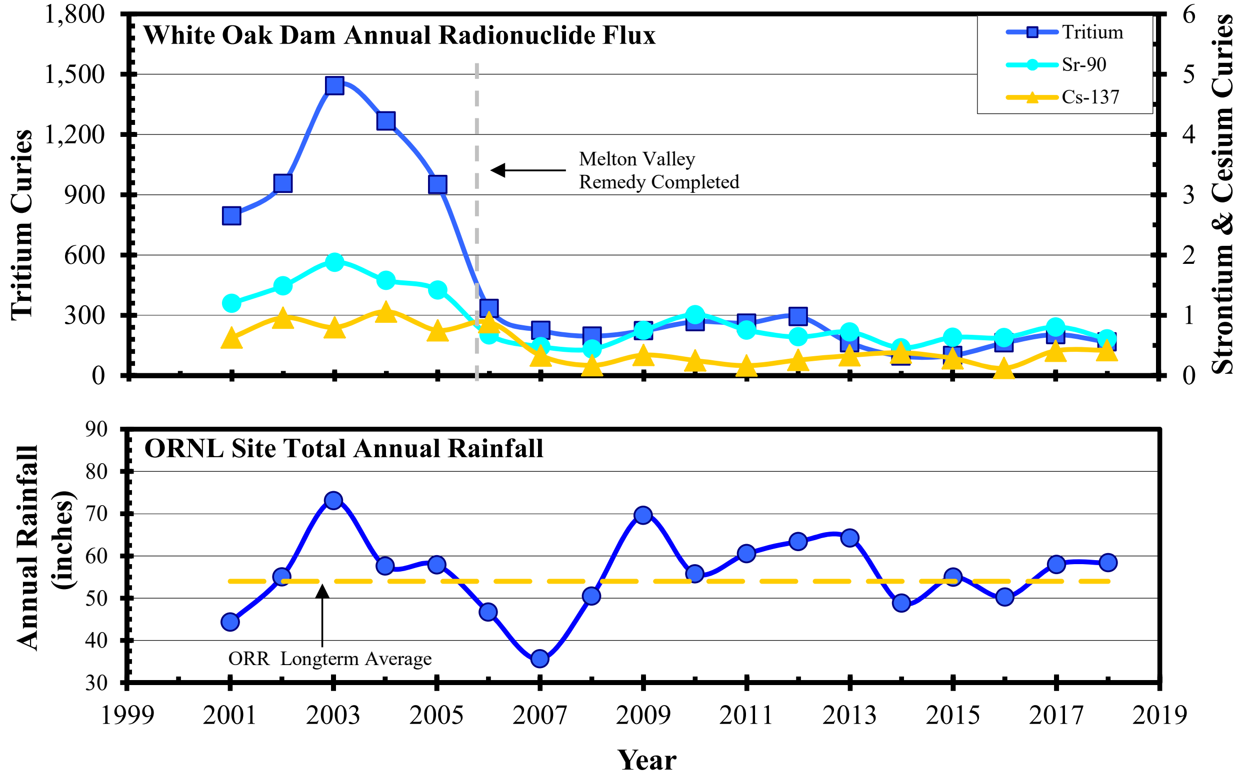


Figure 3.6. Annual radionuclide fluxes at WOD and annual rainfall at the ORNL.

Table 3.7. Comparison of tributary surface water radiological COC FY 2018 maximum results to MV Interim ROD goals

COCs identified in the FS	*ROD Goal (pCi/L)[a]*	**East Seep Weir**	**HRT-3 Weir**	**SWSA4 SW1 Weir**	**SWSA5 D-1 Tributary**	**WAG6 MS-3 Weir**	**West Seep Weir**
Cesium-137+D	*2.37E+05*	2.49 U	1.99 U	3.52 U[b]	3.26 U	3.26 U[b]	2.49 U
Cobalt-60	*3.92E+05*	4.45 U	2.01 U	2.65 U[b]	1.79 U	2.07 U[b]	451 UJ
Strontium-90+D	*1.33E+05*	2.85	196	267[b]	8.3	95.8[b]	12.3
Tritium	*1.04E+08*	4,380	520	66,600[b]	3,670	72,900[b]	2,510
Uranium-234	*1.67E+05*	20.7	0.554	1.05	16	--	31.4

[a]Risk-based goals for recreational wading scenario (from Table 3.5 of RER).
[b]Maximum value from monthly flow-paced composite samples.

-- = not applicable, not available, or insufficient data to calculate the statistic
COC = contaminant of concern
D = daughter products
FS = feasibility study
FY = fiscal year
J = estimated value
MV = Melton Valley
RER = Remediation Effectiveness Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
U = not detected
UJ = not detected and the detection limit is approximate
WAG = Waste Area Grouping

3.3.1.2.2 Groundwater monitoring

3.3.1.2.2.1 Groundwater quality goals and monitoring requirements

The MV Interim ROD does not include a specific RAO for groundwater and therefore does not include specific RAs for groundwater. However, mitigation of further groundwater impacts from the MV CERCLA units was a goal of hydrologic isolation of buried waste, *in situ* grouting of Liquid Waste Seepage Trenches 5 and 7, and excavation of contaminated soils and pond sediment per the MV Interim ROD. The performance metric for hydrologic isolation effectiveness is based on reduction of groundwater contact with principal threat source materials in shallow land waste burial units (Table 3.2). Groundwater level control in hydrologic isolation areas is discussed in Section 3.3.1.2.2.2. Thus, an indirect RAO of actions in the waste management and industrial land use areas is to mitigate further impact to groundwater (Table 3.1). The MV Interim ROD did not specify ARAR-based groundwater remediation levels and meeting such ARAR-based levels is not a performance objective of the ROD although MCLs and radiological risk-based contaminant concentrations are used as comparative metrics in the following discussions.

Since access to the MV area is restricted and the area is designated for long-term use as a waste management and industrial area, the groundwater risk evaluation screened the watershed sub-basin areas based on hypothetical recreational exposure risk levels. A future, final ROD for MV will determine the ultimate groundwater goals for MV. The MV RI tabulated groundwater COCs based on calculated carcinogenic risk and non-carcinogenic Hazard Quotient (HQ). Cumulative carcinogenic risk exceeded 1E-4 in several areas in SWSAs 4 and 5 and in the Lower WOC sub-basin. Table 3.8 includes a summary of groundwater COCs identified in the MV RI. Specific groundwater contaminant remediation levels were not specified in the MV Interim ROD, however continued monitoring of groundwater quality in certain areas is required. These requirements are provided in the MV RAR CMP.

Table 3.8. Summary of MV RI groundwater COCs

Radiological/metal	Contributes to cumulative risk[a] >1E-4	Organic	Contributes to cumulative risk[a] >1E-4 or HQ >1
Am-241	SWSA 4,5	1,1-dichloroethene	SWSA 4,5, Lower WOC
C-14	SWSA 5	carbon tetrachloride	SWSA 5
Cs-137	SWSA 4,5	di-n-oxyl phthalate	SWSA 6
K-40	SWSA 5	PCB-1254	SWSA 6
Pa-234m	SWSA 5	perchloroethene	SWSA 5, 6, Lower WOC
Pu-238	SWSA 5	vinyl chloride	SWSA 4,5
Sr-90	Widespread		
Th-230	SWSA 5		
H-3	SWSA 4,5, lower WOC		
U-233/234	SWSA 4,5		
Arsenic	SWSA 4, 5, lower WOC		

Source: Table 3.7 of the *Remedial Investigation Report on the Melton Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1546/V1&D2).

[a]A hypothetical recreational exposure scenario was used to evaluate potential groundwater risk levels.

COC = contaminant of concern

Table 3.8. Summary of MV RI groundwater COCs (cont.)

HQ = Hazard Quotient
MV = Melton Valley
PCB = polychlorinated biphenyl
RI = remedial investigation
SWSA = Solid Waste Storage Area
WOC = White Oak Creek

The MV Interim ROD stipulates that groundwater be monitored in the exit pathway along the western edge of the valley, in the vicinity of the hydrofracture waste injection sites, and in the vicinity of contaminant source control areas (MV RAR CMP). Monitoring results obtained to date in these areas, including SWSA 6, are discussed in Section 3.3.1.2.2.3.

3.3.1.2.2.2 Groundwater level control in hydrologic isolation units

Minimization of surface water infiltration and groundwater inflows into buried waste to reduce contaminant releases is key to the concept of hydrologic isolation. Prior to remediation, groundwater levels were observed to rise into waste burial trenches in many areas of MV. In some areas, waste trenches were known to completely fill with water during winter months allowing contaminated water to run overland to adjacent streams. Contact of rainfall percolation water with buried waste materials was the source of contaminated leachate that subsequently seeped downward into the groundwater and laterally to adjacent seeps, springs, and streams.

The MV remedy utilizes multilayer caps to prevent vertical infiltration of rainwater into buried waste along with upgradient storm flow interceptor trenches to prevent shallow subsurface seepage from entering the areas laterally. Downgradient seepage collection trenches were constructed in several locations along downgradient perimeters of buried waste units. Most of the laterally-flowing shallow groundwater (<10 ft) emanating from capped waste areas is collected by downgradient interceptor trenches at SWSA 5 South; along the eastern edge of SWSA 4; southeast of Trench 7; along the eastern and western sides of Pits 2, 3, and 4; and at Seep D. The system includes 28 sumps with pumps that are operated based on automated level controls in the groundwater collection areas. The collected groundwater is all routed to an equalization tank located at SWSA 4 before transfer to the ORNL PWTC prior to discharge to WOC in BV. Water at the equalization tank is sampled to verify that the wastewater meets the facility’s waste acceptance criteria (WAC).

Since an impermeable cutoff wall was not part of the design of the SWSA 4 DGT, continuous pumping from the trench is required to maintain a groundwater capture gradient in the three-section trench to prevent contaminant discharge to the former Intermediate Holding Pond (IHP) area. At the other MV DGT locations, bentonite slurry walls were constructed adjacent to the groundwater capture trenches to eliminate inflows from outside the contained area.

The MV Interim ROD includes the performance goal of reducing groundwater level fluctuations within hydrologically isolated areas by >75% from preconstruction fluctuation ranges (Table 3.2). The performance goal of attaining a >75% reduction in groundwater level fluctuations created a design requirement to minimize, as much as possible, the contact of groundwater with buried waste to reduce the contaminated leachate formation process. As such, the fluctuation range is most relevant in cases where groundwater levels rise into the waste burial elevation zone. Groundwater level fluctuations at elevations below the contaminant sources have less importance to the overall remedy effectiveness. During the remedial design of each hydrologic isolation area, wells were selected for monitoring the post-remediation groundwater level fluctuations. Pre-remediation baseline fluctuation ranges were evaluated for the wells and target post-remediation groundwater elevations were determined to indicate that groundwater levels had dropped to below the 75% fluctuation range elevation.

Figure 3.7 shows the locations where groundwater level monitoring is conducted pursuant to the requirements of the MV RAR to evaluate hydrologic isolation performance. Although caps are shown at

Seepage Trenches 5 and 7, the principal threat wastes (fission products) within those units were stabilized by in-situ grouting technology that effectively encapsulated the highly contaminated trench backfill materials. Hydraulic isolation caps were constructed over the grouted trench areas and to cover contaminated soils in the vicinity of the trenches and at LLLW line leak sites to minimize further spread of contamination from those sources. Caps were constructed over those trenches and surrounding secondarily contaminated soils and wastes placed in the ravine area to the east of Trench 7 as agreed during the MV Closure Project. However, groundwater level control target elevations were not stipulated in the approved RAR for these areas. At the Interim Waste Management Facility in the SWSA 6 area, waste materials are contained in concrete vaults that were placed on a reinforced concrete slab with an internal above slab drainage system and a below slab drain. All of that structure was capped using a multi-layer cap and the RAR stipulated periodic sampling of the drains.

Wells shown within capped areas (52 wells) and along the northern edge of SWSA 4 where the upgradient stormflow diversion trench is located (three wells within or upgradient of the trench) are used to evaluate hydrologic isolation effectiveness. Six wells (in addition to the other 55 wells used to monitor caps) were specified in MV closure documentation to monitor groundwater levels at the SWSA 4 downgradient groundwater collection trench. Since remedy operation started in 2006, DOE has increased the number of wells used to monitor the SWSA 4 downgradient to a total of 14 wells to provide thorough data coverage of the area. As shown on the inset in Figure 3.7, groundwater elevation monitoring of six wells along the SWSA 4 DGT was required in the MV RAR. DOE also monitors water level in eight additional wells along the DGT on a discretionary basis to better understand and manage the groundwater collection at that site. Symbol shape and color on Figure 3.7 indicate locations where the maximum observed groundwater elevation attains (is lower than) or exceeds (is greater than) the target groundwater level specified in the MV Interim ROD. Review of hydrographs for additional SWSA 4 wells with no target elevations (see Appendix B.2) shows an overall favorable response to the MV RAs.

During FY 2018, seven of the 52 wells located beneath caps and used to monitor hydrologic isolation effectiveness did not meet their target groundwater elevations. Two of the wells that did not meet the goal – wells 0850 and 4127 are in SWSA 6, and the remaining five wells 0955, 0958, 1071, 4544, and 4545 are in SWSA 4. Since monitoring for the MV Interim ROD goals was initiated, four of the listed wells (0850, 4127, 0955, and 1071) have typically had some exceedance of their target elevations each year. Wells 4544 and 4545 in SWSA 4 lie near the middle of the capped area. The following discussions describe the conditions that cause the wells to exceed MV Interim ROD goals.

Three general sets of conditions prevail related to the wells that do not meet their desired metrics:

- The first condition pertains to wells (wells 0955 and 0958) near the SWSA 4 downgradient groundwater collection trench that exceed their desired groundwater elevation targets during periods of pump failures or pumping system shutdown caused by excessive groundwater collection that exceeds the ability to store and treat at the PWTC.
- The second of these conditions pertains to wells potentially indicating inadequate performance of a hydrologic cap or upgradient drain. This condition exists at SWSA 4 where wells 1071, 4544, and 4545 show exceedances of their target elevations.
- The third of these conditions pertains to wells at SWSA 6 that are not good indictors of hydraulic isolation effectiveness and should no longer be used as a performance measurement. These wells are screened in bedrock at levels deeper than the base of nearby buried waste and respond to bedrock groundwater fluctuations outside the waste unit boundary. This condition applies to wells 0850 and 4127 in SWSA 6.

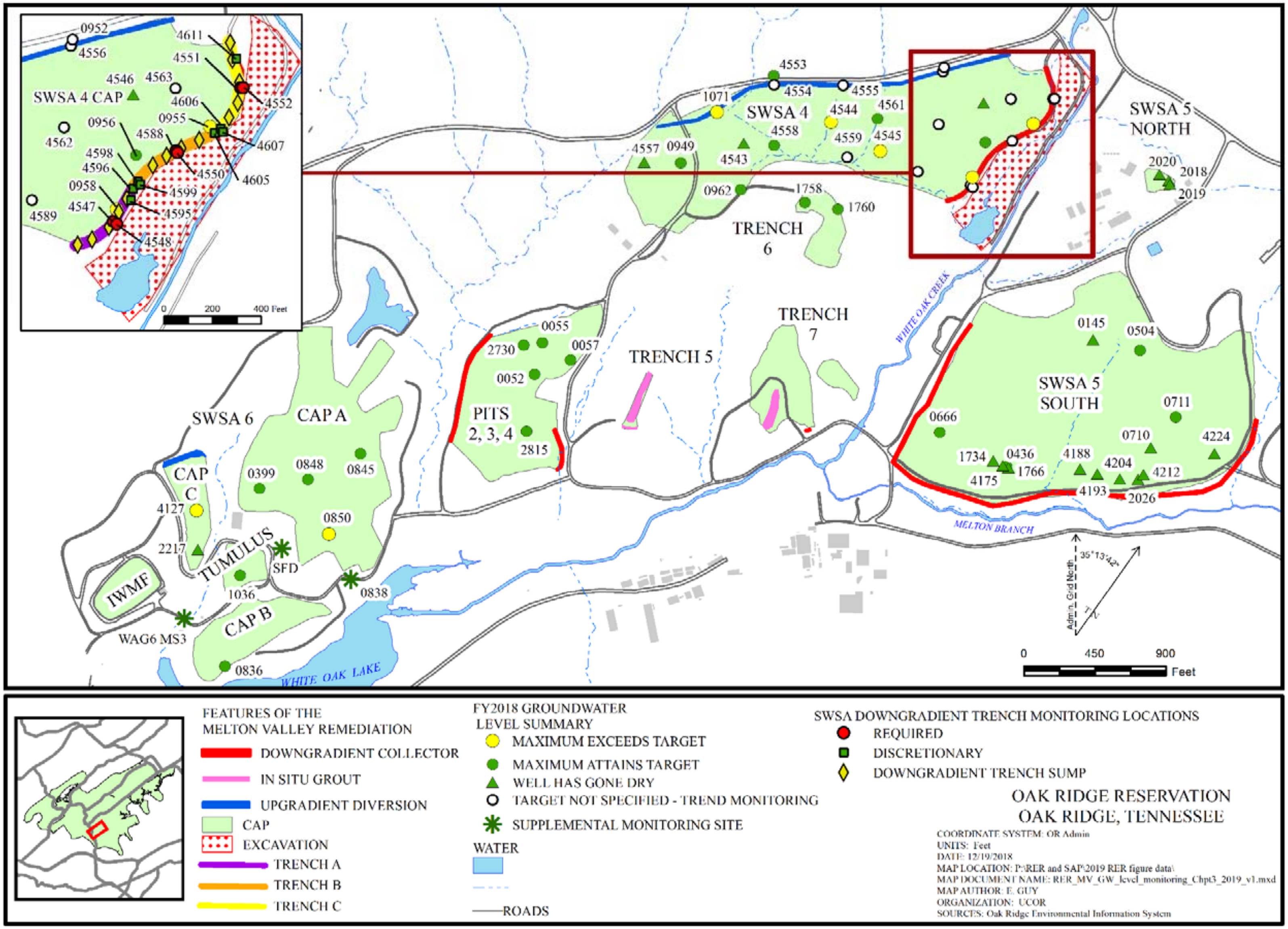


Figure 3.7. Summary of groundwater level monitoring results for MV hydrologic isolation areas in FY 2018.

SWSA 4 – Wells 0955 and 0958

Wells 0955 and 0958 are located in eastern SWSA 4 beneath the hydrologic isolation cap on the burial ground side of the downgradient groundwater interceptor trench (Figure 3.7). The design intention of the DGT is to maintain a lower groundwater level in the trench than beneath the former IHP area to the east. The reason wells 0955 and 0958 frequently exceed their target groundwater levels is because groundwater levels in the area are directly tied to the groundwater levels in the nearby DGT. Water levels in the trench cycle up and down based on the cycling of the extraction pumps. Seasonal fluctuations in groundwater influx combined with increased inflows from high water levels in the IHP cause water levels to rise in the collection trench, which overwhelms the pumping capacity of the extraction wells in the trench. During FY 2018, six of the 12 monthly groundwater level measurements at well 0955 exceeded the target elevation goal, and three of the four quarterly measurements at well 0958 exceeded their target elevation goal.

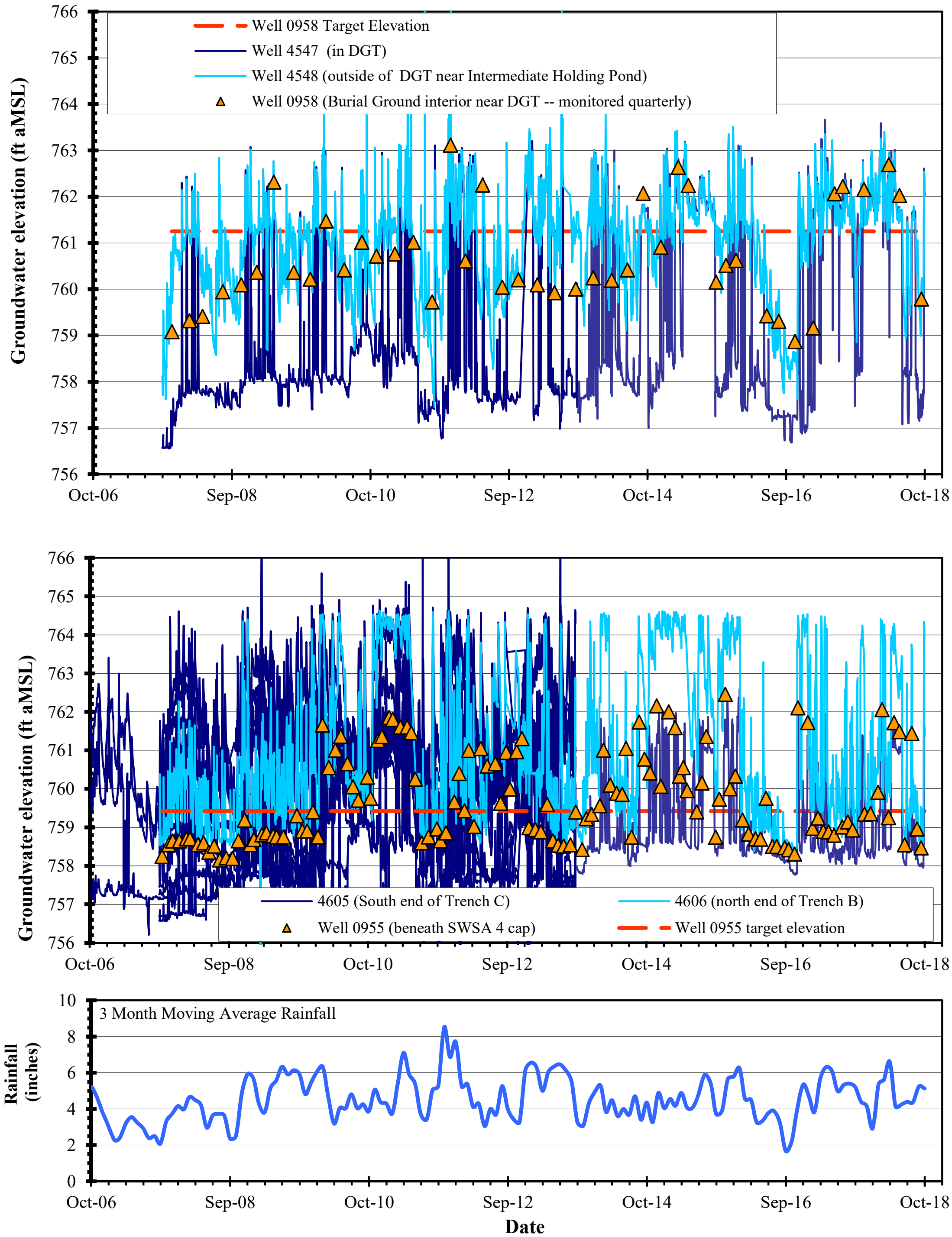
As shown on Figure 3.8, wells 0955 and 0958 have experienced frequent target elevation exceedances throughout their monitoring records. Beginning in late FY 2015, DOE implemented an enhanced frequency of maintenance and operations inspections of the SWSA 4 downgradient groundwater collection trench, which contributes to better overall groundwater level suppression in the collection trench and adjacent areas.

By design, the operation of the SWSA 4 DGT relies upon maintaining lower groundwater levels within the trench compared to levels beneath the former IHP area to the east and beneath the hydrologic isolation cap to the west. If the groundwater extraction pumps installed in the gravel backfilled trench cannot pump enough water, some groundwater can escape into the surface water in the IHP area. Figure 3.9 shows hydrographs for FY 2018 from wells constructed in the DGT and in the IHP area. During the winter months, groundwater recharge is much greater than during the growing season and all the groundwater collection systems produce much more flow. Groundwater levels in the SWSA 4 DGT rose to levels essentially the same as levels in the IHP area. Well hydrographs showing groundwater level responses during FY 2007 through FY 2018 are also included in Appendix B.2.

An on-going hydrologic evaluation to identify potential additional improvements to SWSA 4 DGT performance continued in FY 2018. This evaluation noted several system enhancements for more continuous operation of the pumps in the DGT; this evaluation is ongoing. It is also recommended that well 0955 have continuous water level readings to further support system evaluation and performance. This issue for wells 0955 and 0958 is carried forward in this RER (Table 3.15).

SWSA 4 – Wells 1071, 4544, and 4545

Well 1071 is located in the western portion of SWSA 4. This well encountered bedrock at an elevation of about 799.46 ft. The top of the well screen is at the 800.71 ft elevation and the bottom of the wells lies at 784.96 ft aMSL. The well is located approximately 60 ft inside of the upgradient stormflow diversion drain, which has a bottom elevation of approximately 806 ft in the immediate area. Based on this construction geometry the UGT would not be capable of controlling groundwater from the upslope side of Lagoon Road from affecting the groundwater elevation measured at well 1071. As shown on Figure 3.10, since about 2011 groundwater elevations in well 1071 have fluctuated in the range of about 802.5 to 803.5. The fluctuation range appears to have stabilized with both seasonal and rainfall event signatures on the hydrograph. The reason this well exceeds its target groundwater elevation is thought to be influenced by groundwater elevations in bedrock beneath the upgradient storm water diversion drain. The groundwater levels in well 1071 remain approximately 3 ft below the diversion drain base level. Monitoring and reporting of groundwater levels at well 1071 will continue. DOE is in the process of evaluating groundwater level control and will discuss well performance with the Project Team. This issue associated with this well is carried forward in this RER (Table 3.15). A future, final ROD for MV will address groundwater, including revising target groundwater elevations, as appropriate.



DGT - downgradient trench IHP = Intermediate Holding Pond SWSA = solid waste storage area

Figure 3.8. Hydrographs of wells 0955 and 0958 in SWSA 4 and wells in nearby DGT and former IHP area.

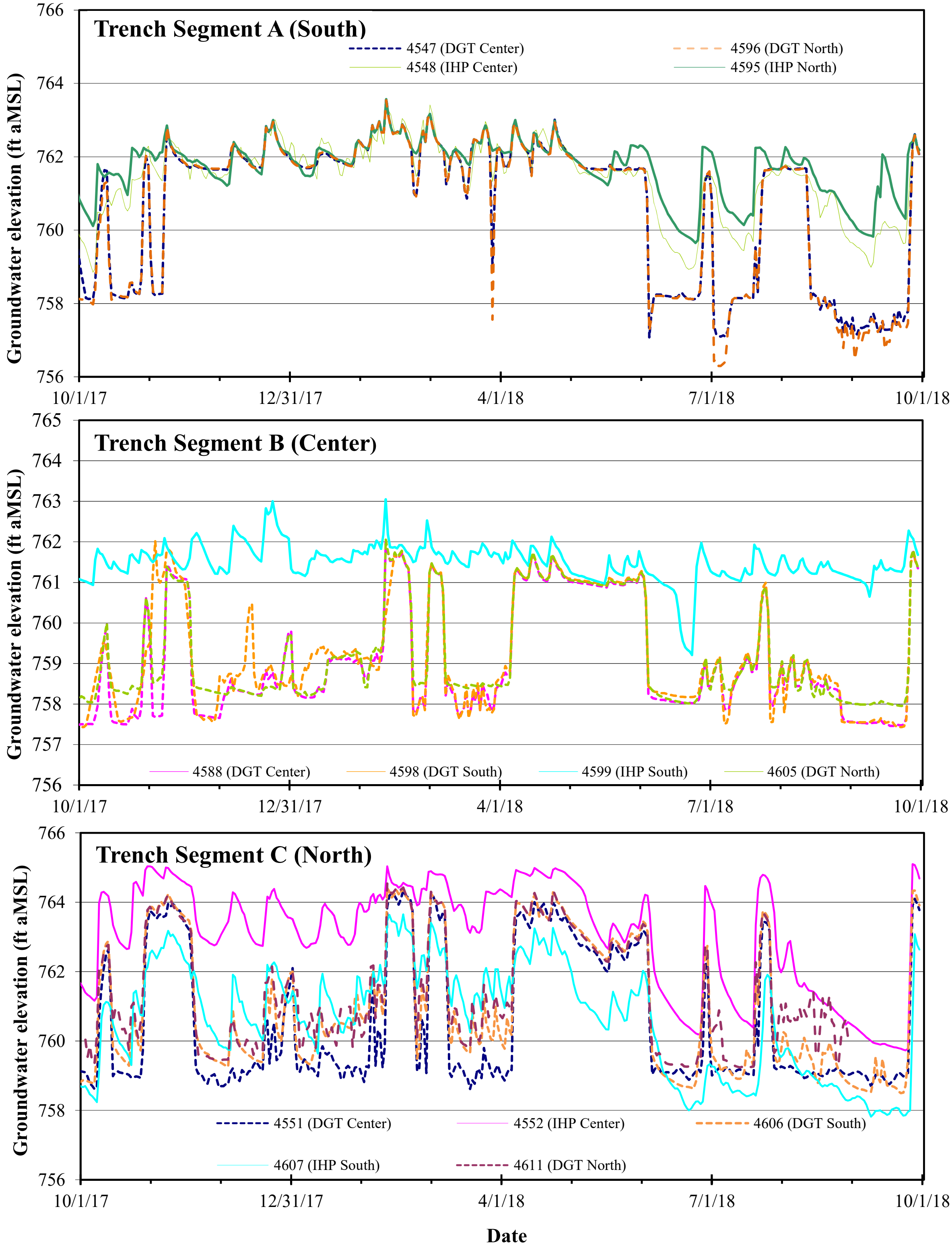
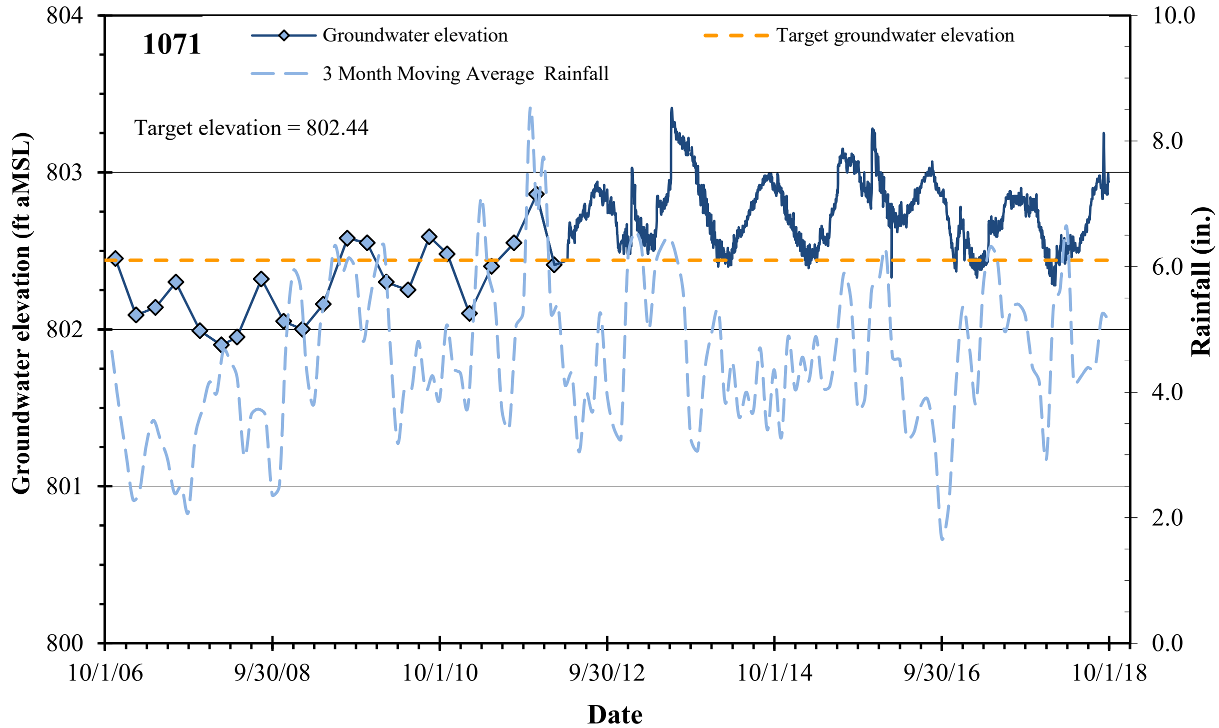


Figure 3.9. Hydrographs from piezometers monitoring the SWSA 4 DGT performance (FY 2018).



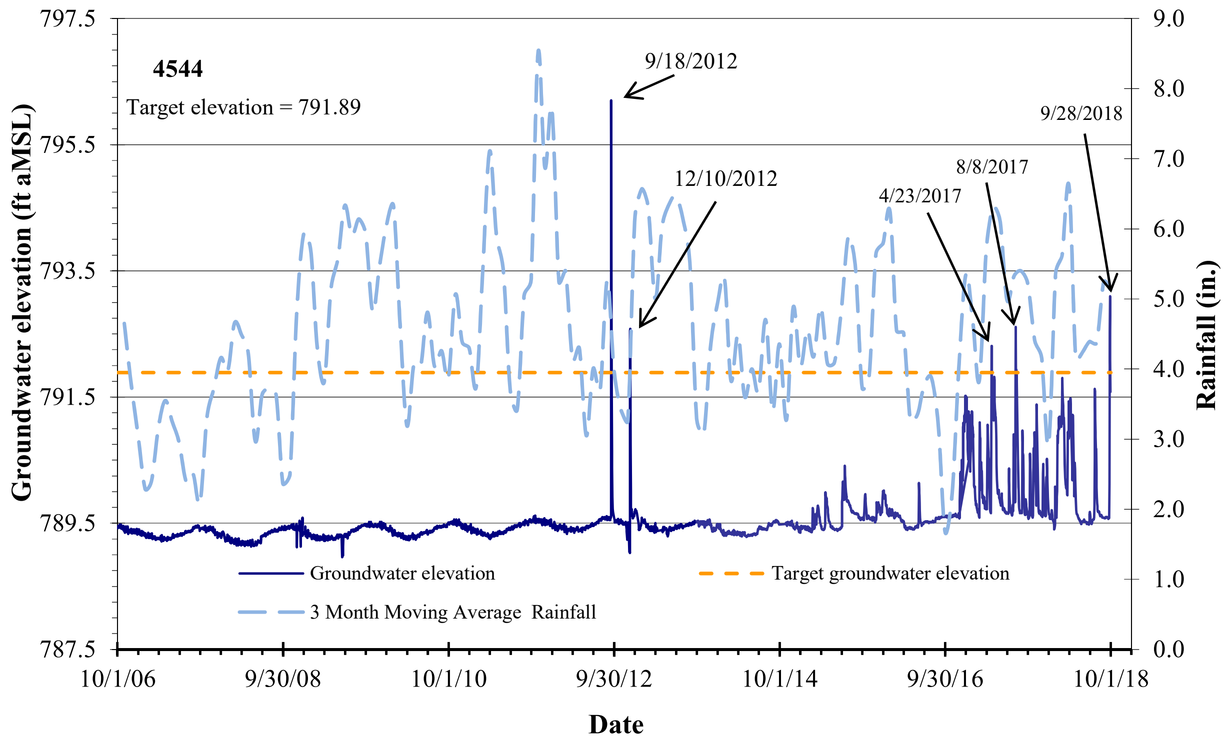


Figure 3.10. Hydrographs for wells 1071 and 4544.

Well 4544 is located near the center of SWSA 4. Figure 3.10 shows the hydrograph for well 4544 from October 2006 through September 2018. The well experienced seasonal groundwater level fluctuations from the initiation of monitoring in 2006 until September 2012, when a water level spike was observed following passage of a tropical storm system that dumped 4.3 in. of rainfall on the ORNL site over a two-day period. Following that initial groundwater level spike, a second event occurred in December in association with a 1.01 in. rainfall event. The well behavior returned to relative quiescence until February 2015, after which the well hydrograph has shown more frequent responses to rainfall events. During FY 2018 heavy rainfall that occurred in the last week of September caused a groundwater level spike that exceeded the well 4544 target elevation. The well 4544 groundwater level exceedances have been identified as an issue in previous RERs as well as in CERCLA Project Team meetings. Groundwater elevations measured in well 4545 during FY 2018 also exceeded the target elevation for that location (Figure 3.11). DOE is in the process of evaluating groundwater level control at SWSA 4. The exceedances at wells 4544 and 4545 continue to be an issue in this RER (Table 3.15). DOE is in the process of evaluating groundwater level control and will discuss well performance with the Project Team. A future, final ROD for MV will address groundwater, including revising target groundwater elevations, as appropriate.

SWSA 6 – Wells 0850 and 4127

Wells 0850 and 4127 are not good indicators of hydrologic isolation effectiveness. Figure 3.12 shows well hydrographs and target groundwater elevations for SWSA 6 wells 0850 and 4127. Well 0850 is located in a low valley area which tends to retain groundwater beneath the cap. The well screen is open for approximately 1.5 ft above the top of bedrock, which was encountered at 762.5 ft aMSL and the bottom of the screen lies 15.5 ft down into the bedrock. Groundwater levels fluctuate seasonally, and, to a lesser degree, in response to storm events.

Well 4127 is a 44 ft deep bedrock well in which bedrock was encountered at an elevation of 762.73 ft. The top of the well screen lies at 756.86 ft, and the bottom of the screen lies at 741.73 ft. As shown in Figure 3.12, groundwater typically fluctuates in the range of approximately 772 – 774.5 ft. Evaluation of the site topography shows that the ground surface elevations are slightly below the 775 ft elevation in surface water drainage ways adjacent to the relatively small capped area. Available information suggests that the bottom of waste burial trenches approximately 50 ft upslope from well 4127 lie at about the 770 ft elevation. Two factors are thought to cause the observed groundwater elevations in well 4127. First, the groundwater elevations beneath the adjacent drainage ways may be the controlling factors for water levels in the area, and second, the well may be responding to an artesian head condition since the entire screen lies in bedrock. In either of these scenarios, the groundwater levels in the well may be higher than the actual water table level outside the well casing in the buried waste zone.

As shown in Figure 3.12, the behavior of groundwater at wells 0850 and 4127 is a chronic condition determined by the well depths and locations. DOE samples a number of locations along the downgradient edge of SWSA 6 to understand changes in groundwater contaminant conditions following MV Interim ROD RAs. Three locations provide definitive evidence that the SWSA 6 hydrologic isolation remedy is effective for containment of shallow buried waste: beneath the central and western parts of Cap A, at Cap C, and at the Tumulus site. The three locations (shown on Figure 3.7) include well 0838, the SFD, and surface water monitoring location WAG6 MS3. Well 0838 is a shallow monitoring well located adjacent to the surface water drainage way downslope of well 0850. Well 0838 is sampled semi-annually. The SFD was a shallow groundwater interceptor trench installed along the eastern side of a group of waste burial trenches known as the 49-trench area. The drain was installed at an elevation approximately equivalent to the adjacent waste burial trenches. The SFD is sampled semi-annually. Surface water at WAG6 MS3 is sampled using flow-paced continuous monitoring with analysis of monthly composite samples.

Tritium is a key contaminant at SWSA 6 and is a good indicator of changes in water interactions with buried waste. Figure 3.13 shows the history of tritium concentration changes in surface water at WAG6 MS3, at the SFD, and in well 0838. In addition to the monitoring data, the natural tritium decay curve is shown for the time period January 2004 through September 2018 for an assumed 1,000,000 pCi/L source similar to WAG6 MS3 concentrations in 2004. The dramatic decreases in tritium concentration are indicative the effectiveness of the hydrologic isolation. Additional discussion of groundwater contaminant trends at SWSA 6 and elsewhere in MV is presented in section 3.3.1.2.2.3.

Wells 0850 and 4127 are carried forward as an issue in the RER (Table 3.15). It is recommended that alternative performance indicators be used to evaluate the hydrologic isolation effectiveness at SWSA 6. These measures include the continued monitoring of tritium concentrations at 0838, SFD, and WAG6 MS3.

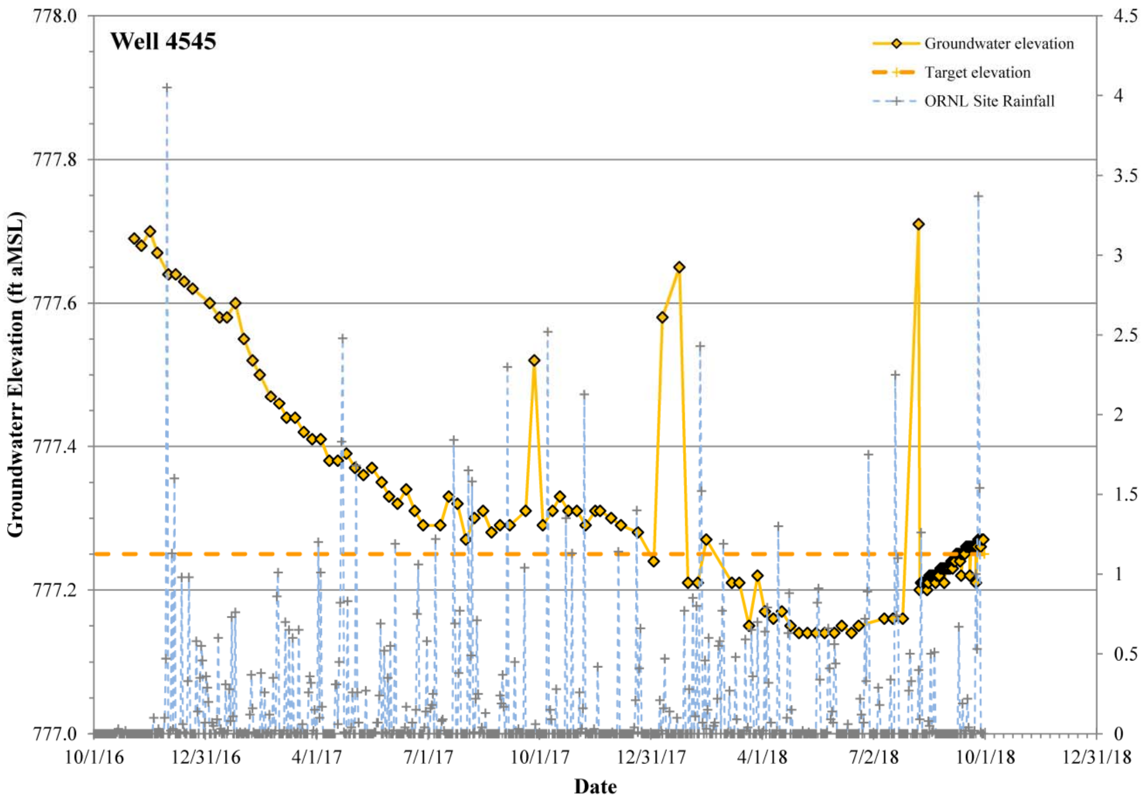


Figure 3.11. Hydrograph for well 4545.

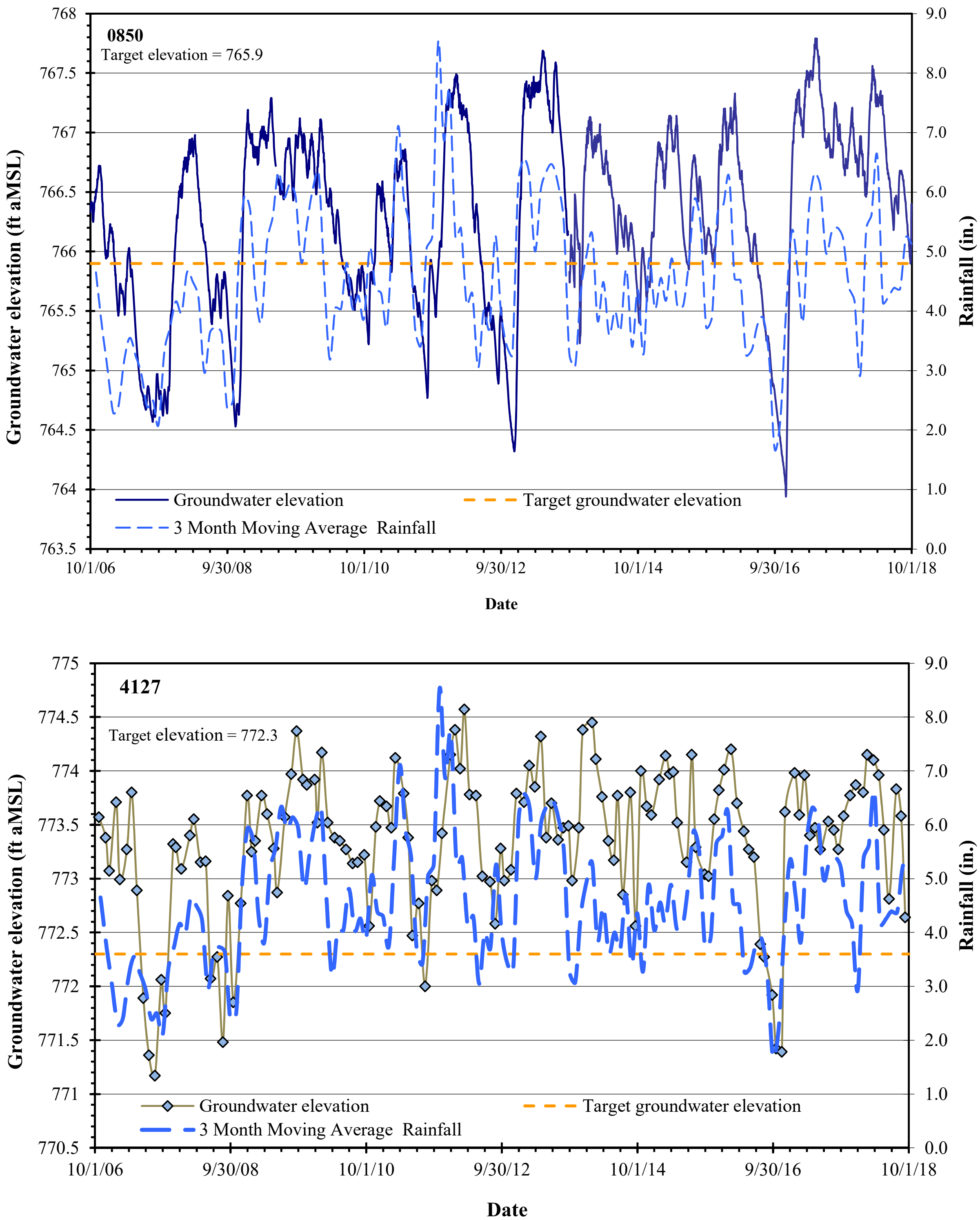


Figure 3.12. Hydrographs for wells 4127 and 0850, FY 2007 – FY 2018.

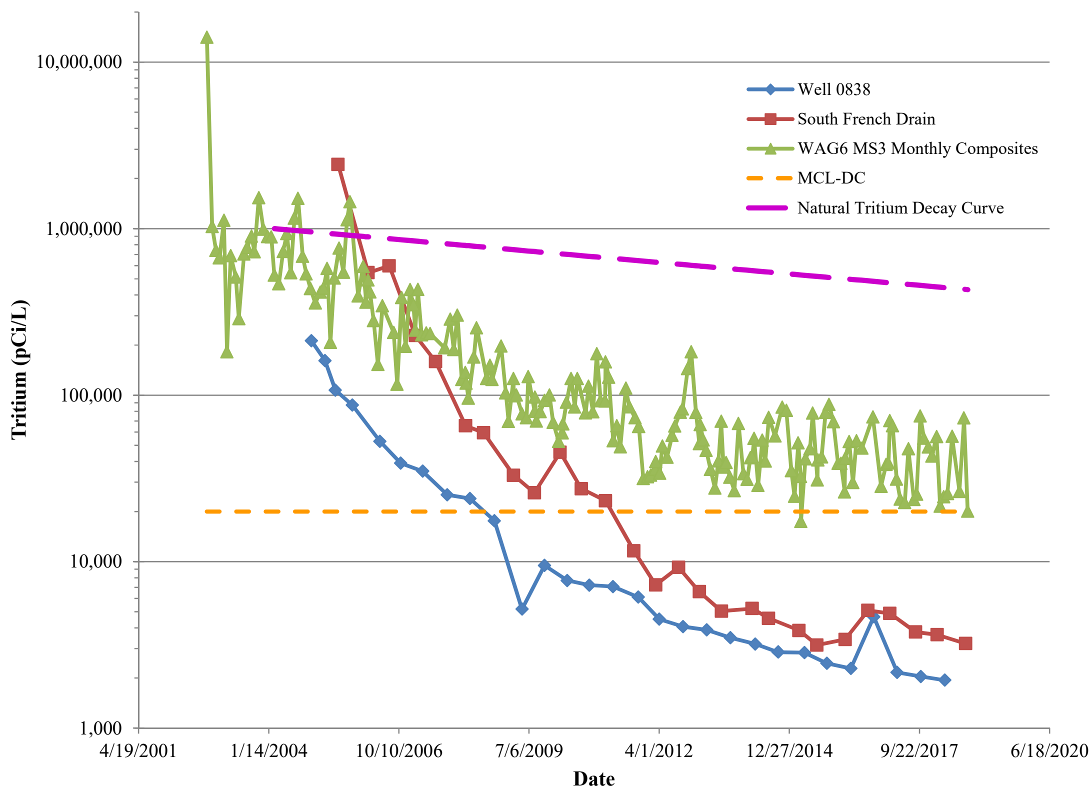


Figure 3.13. Tritium concentration history at WAG 6 MS 3, South French Drain, and well 0838.

MV groundwater extraction system

System performance of the wells and extraction pumps within the MV groundwater extraction system was identified as an issue in the 2016 FYR, and as a result an assessment on the overall system was completed. In FY 2017, an engineering evaluation was performed that recommended potential system enhancements through operational reconfiguration and hardware upgrades. An update on FY 2018 maintenance activities to address the results of the engineering evaluation was included in the 2018 RER. To address performance issues related to control instrumentation the engineering evaluation recommended reconfiguration and reprogramming of pump controls and rewiring of indicator lights to provide operational feedback during pump operation. The frequency of preventative inspection and maintenance on the overall extraction system was increased to a quarterly schedule during FY 2015. In August FY 2018, the inspection frequency for the SWSA 4 DGT sumps increased to a weekly basis. Electrical concerns associated with erroneously tripping breakers were observed at that time. A path forward to identify and isolate those issues was implemented including potential replacement of electrical and pump components and the addition of data logging devices to monitor operational conditions. To provide additional operational feedback for the trench pumps, the installation of magnetic flow meters is planned for locations with ongoing performance problems. The long-term documentation of MV groundwater extraction system performance is maintained in the LUM, a web-based data management application for implementing, maintaining, and verifying engineering controls, as provided by system operations personnel. The Project Team will continue to evaluate and pursue approaches for improved documentation of ongoing maintenance activities and will be updated as additional system upgrades are executed.

3.3.1.2.2.3 Groundwater quality

Groundwater monitoring is conducted for CERCLA remediation effectiveness evaluation in MV exit pathway wells, near the Seepage Pits and Trenches (Pits 2, 3 and 4; Trenches 5 and 7), and around the Tumulus low-level solid waste disposal facility in SWSA 6 (Figure 3.14). Additionally, groundwater monitoring is conducted at SWSA 6 under CERCLA. As discussed in Section 1.1, the CERCLA program provides RCRA-equivalent post-closure care of the unit through compliance with RCRA substantive requirements.

Seepage Pits and Trenches area groundwater quality

Groundwater monitoring is conducted in wells located around the perimeter of the Seepage Pits and Trenches area (formerly referred to as WAG 7), as well as in the immediate proximity of LLLW Seepage Trenches 5 and 7.

The Seepage Pits and Trenches were used to dispose of pH-treated LLLW generated in various ORNL radiochemical processes. Sodium hydroxide was used to raise the liquid waste pH to approximately pH 13 which caused chemical precipitation of strontium, cesium, and most of the other radionuclides. The pH treatment occurred in the ORNL Gunite Tanks in BV where sludge resulted from settling of the chemical precipitation. The tank supernate from the chemical precipitation and settling step was pumped via buried pipelines to the MV Seepage Pits and Trenches. Much of the liquid is known to have seeped laterally downslope away from the pits and trenches, leaving highly contaminated residues in the pits and trenches and adsorbed in surrounding soils.

Figure 3.14 shows the locations of wells that are monitored at the Pits and Trenches area. During the design process for *in situ* grouting of Liquid Waste Seepage Trenches 5 and 7, a groundwater quality monitoring plan was prepared and implemented to monitor wells near those two units for water quality evaluation. Monitoring of these wells was started prior to conducting the MV Interim ROD RAs. At Pits 2, 3, and 4, the remedy consisted of constructing a multi-layer hydraulic isolation cap over the three large seepage basins and constructing groundwater collection trenches along the western and eastern cap edges to collect contaminated groundwater. At Trenches 5 and 7, *in situ* grouting was used to fill voids in the gravel-filled trenches and reduce permeability of the surrounding soil. After grouting was complete, hydrologic isolation caps were constructed over the trench area at Trench 5 and over the trench and adjacent contaminated soil areas at Trench 7 (Figure 3.4). A small groundwater seepage collection trench was constructed at the mouth of a valley on the east side of Trench 7 where a radiologically contaminated seep had previously existed.

Groundwater COCs at the Seepage Pits and Trenches are primarily radionuclides. Principal radionuclides detected at the Seepage Pits and Trenches include C-14, Co-60, Sr-90, Tc-99, tritium, U-232, U-233/234, and U-238. C-14 was a constituent of the LLLW disposed in the seepage trenches and, because the chemical treatment used to immobilize strontium and cesium had little effect on carbon, this contaminant is detected in many wells near the Pits and Trenches. The highest levels of groundwater contamination in the Seepage Pits and Trenches area occur in the immediate vicinity of Trenches 5 and 7. Table 3.9 includes a summary of radiological contaminants for 15 wells in the Pits and Trenches area where radiological contaminants exceed screening levels.

The MV Interim ROD did not specify target groundwater contaminant levels or ARAR-based performance goals but stated that the remedy should "Mitigate further impact to groundwater" (Table 3.1). To provide a sense of risk levels associated with the detected radionuclides, contaminant levels are compared to 1E-4 risk equivalent activities for residential and industrial (based on Risk Assessment Information System [RAIS] risk calculator) water use scenarios.

DOE has compiled the analytical data for groundwater contaminants in the Seepage Pits and Trenches area to evaluate environmental responses to the RA. Data from wells specified in the PCCR to be monitored pre- and post-action are compared to industrial and residential PRGs calculated for 1E-4 carcinogenic risk from consumption of the groundwater. M-K trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations.

Table 3.9 summarizes the results of Seepage Pits and Trenches area groundwater radiological contaminant screening and trend evaluation. Radionuclides detected in groundwater at concentrations greater than or equal to the residential PRG concentration at any time in the past 10 years are included in Table 3.9. Groundwater contaminant concentrations greater than or equal to the industrial PRG levels are highlighted in bold font. As shown in Table 3.9, the 10-year trend evaluation shows predominantly decreasing radionuclide concentration trends with notable increasing trends for U-232, U-233/234, and U-238 at wells located in the immediate vicinity of Seepage Trenches 5 and 7. The most recent 5-year trend evaluation shows continuation of downward concentration trends at many locations with stabilization of trends or contaminant concentration signatures for which no trend assignment can be made with statistical confidence because the concentration variability is relatively high within the past five years. Inspection of the maximum detected radionuclide concentrations for the 10-year, 5-year, and FY 2018 time periods shows that in most cases the maximum measured concentrations have decreased over time. The increasing trends noted in the 10-year evaluation period all became no trend determinations in the most recent 5-year evaluation period. Although Tc-99 shows an increasing trend in the most recent 5-year data evaluation for well 1756 in Trench 5, its FY 2018 maximum concentration remained less than the residential 1E-4 PRG concentration.

The causes for increases in radionuclide concentrations near the grouted seepage trenches is not known although changes in groundwater recharge and flow patterns following the trench grouting and area capping are the probable causes. Surface water sampling in adjacent stream valleys has not detected increases in radionuclide concentrations in the nearby discharge areas.

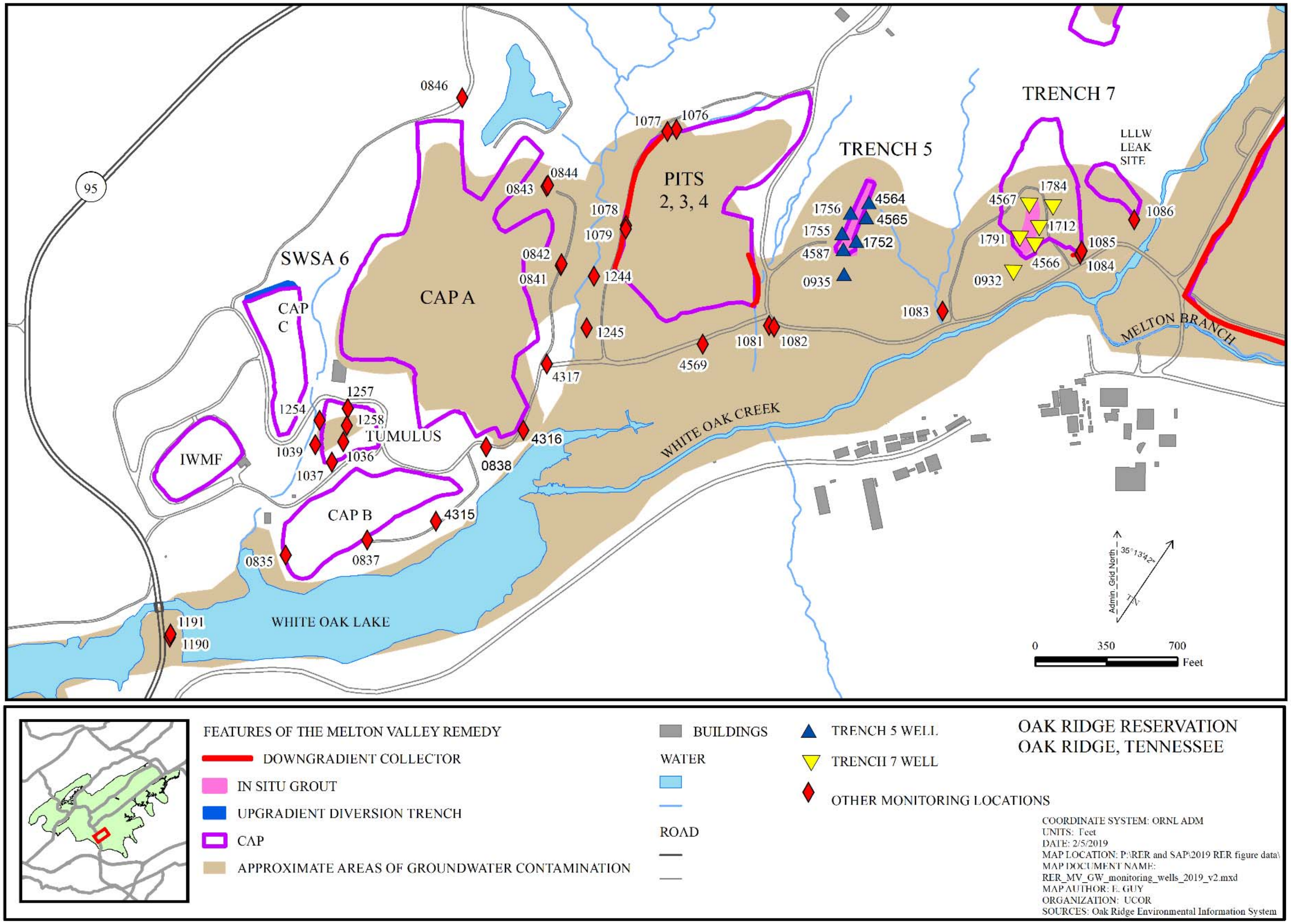


Figure 3.14. Locations of wells monitored in the vicinity of the Seepage Pits and Trenches and SWSA 6.

Table 3.9. Summary of 10-year and 5-year groundwater radiological contaminant trends at Seepage Pits and Trenches

Chemical	Well	Units	Freq. of detection		Maximum detected			Res. PRG[a]	Ind. PRG[b]	Freq. >Res. PRG[b]		Freq. >Ind. PRG[b]		Significant trend[c]	
			10 yr	5 yr	10 yr	5 yr	FY 2018			10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Carbon-14	1084	pCi/L	20 / 20	10 / 10	**9,680**	**8,330**	5,320	3,367	8,264	20 / 20	10 / 10	3 / 20	1 / 10	Down	Stable
	1712	pCi/L	19 / 19	10 / 10	**35,900**	**32,000**	**26,100**	3,367	8,264	19 / 19	10 / 10	19 / 19	10 / 10	Down	Down
	1752	pCi/L	20 / 20	10 / 10	**109,000**	**89,400**	**63,200**	3,367	8,264	20 / 20	10 / 10	20 / 20	10 / 10	Down	Down
	1755	pCi/L	20 / 20	10 / 10	**45,300**	**34,900**	**34,900**	3,367	8,264	20 / 20	10 / 10	20 / 20	10 / 10	Down	Stable
	1756	pCi/L	20 / 20	10 / 10	**30,400**	**22,800**	**14,300**	3,367	8,264	17 / 20	9 / 10	13 / 20	6 / 10	Stable	Stable
	1784	pCi/L	20 / 20	10 / 10	**8,650**	**8,650**	7,180	3,367	8,264	20 / 20	10 / 10	1 / 20	1 / 10	Stable	Stable
	1791	pCi/L	20 / 20	10 / 10	**20,800**	**14,700**	**11,200**	3,367	8,264	20 / 20	10 / 10	19 / 20	9 / 10	Down	Down
	4565	pCi/L	20 / 20	10 / 10	**30,800**	**17,900**	**12,500**	3,367	8,264	20 / 20	10 / 10	16 / 20	9 / 10	No trend	No trend
	4566	pCi/L	20 / 20	10 / 10	**61,100**	**61,100**	**50,900**	3,367	8,264	20 / 20	10 / 10	20 / 20	10 / 10	No trend	No trend
Cobalt-60	1752	pCi/L	20 / 20	10 / 10	621	265	85.2	331	813	6 / 20	0 / 10	0 / 20	0 / 10	Down	Down
	1755	pCi/L	20 / 20	10 / 10	436	142	78.2	331	813	2 / 20	0 / 10	0 / 20	0 / 10	Down	Down
	1756	pCi/L	20 / 20	10 / 10	185	89.1	16.8	331	813	0 / 20	0 / 10	0 / 20	0 / 10	Down	Stable
	1791	pCi/L	20 / 20	10 / 10	498	213	168	331	813	5 / 20	0 / 10	0 / 20	0 / 10	Down	Down
	4566	pCi/L	20 / 20	10 / 10	**1,740**	692	448	331	813	20 / 20	10 / 10	8 / 20	0 / 10	Down	Down
Strontium-90	1756	pCi/L	16 / 20	9 / 10	3.59	2.87	1.58	70	173	0 / 20	0 / 10	0 / 20	0 / 10	Down	Stable
Technetium-99	1752	pCi/L	20 / 20	10 / 10	**10,600**	**6420**	3,820	1,898	4,651	20 / 20	10 / 10	10 / 20	3 / 10	Down	Stable
	1755	pCi/L	20 / 20	10 / 10	2,970	1,590	1,590	1,898	4,651	7 / 20	0 / 10	0 / 20	0 / 10	Down	No trend
	1756	pCi/L	20 / 20	10 / 10	2,240	1,240	1,240	1,898	4,651	1 / 20	0 / 10	0 / 20	0 / 10	Stable	Up
	1791	pCi/L	20 / 20	10 / 10	**18,000**	**16,000**	**12,300**	1,898	4,651	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Down
	4565	pCi/L	20 / 20	10 / 10	2,880	2,010	227	1,898	4,651	3 / 20	1 / 10	0 / 20	0 / 10	Down	No trend
	4566	pCi/L	20 / 20	10 / 10	2,190	1,680	983	1,898	4,651	2 / 20	0 / 10	0 / 20	0 / 10	Down	Down
Tritium	1079	pCi/L	20 / 20	10 / 10	112,000	79,500	53,000	103,093	252,525	4 / 20	0 / 10	0 / 20	0 / 10	Down	Down
	1756	pCi/L	20 / 20	10 / 10	20,500	15,700	2,150	103,093	252,525	0 / 20	0 / 10	0 / 20	0 / 10	Stable	Stable
Uranium-232	1712	pCi/L	16 / 16	10 / 10	**282**	**282**	43.6	18	44	15 / 16	10 / 10	10 / 16	7 / 10	No trend	Down
	1752	pCi/L	19 / 19	10 / 10	**597**	**597**	**172**	18	44	19 / 19	10 / 10	18 / 19	10 / 10	Up	No trend
	1755	pCi/L	20 / 20	10 / 10	**814**	**814**	**454**	18	44	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
	1756	pCi/L	16 / 16	9 / 9	**95.5**	**86.2**	**69**	18	44	13 / 16	6 / 9	9 / 16	3 / 9	Stable	No trend

Table 3.9. Summary of 10-year and 5-year groundwater radiological contaminant trends at Seepage Pits and Trenches (cont.)

Chemical	Well	Units	Freq. of detection		Maximum detected			Res. PRG[a]	Ind. PRG[b]	Freq. >Res. PRG[b]		Freq. >Ind. PRG[b]		Significant trend[c]	
			10 yr	5 yr	10 yr	5 yr	FY 2018			10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Uranium-233/234	1079	pCi/L	20 / 20	10 / 10	**282**	**252**	**213**	74	181	20 / 20	10 / 10	18 / 20	8 / 10	Down	Stable
	1712	pCi/L	19 / 19	10 / 10	**853**	**853**	**477**	74	181	18 / 19	10 / 10	13 / 19	9 / 10	Up	No trend
	1752	pCi/L	20 / 20	10 / 10	**1,680**	**1,680**	**1,340**	74	181	20 / 20	10 / 10	19 / 20	10 / 10	Up	No trend
	1755	pCi/L	20 / 20	10 / 10	**3,540**	**3,540**	**3,540**	74	181	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
	1756	pCi/L	20 / 20	10 / 10	**849**	**523**	**427**	74	181	17 / 20	9 / 10	14 / 20	6 / 10	No trend	No trend
Uranium-235/236	1756	pCi/L	18 / 20	10 / 10	10.5	10.5	5.33	73	178	0 / 20	0 / 10	0 / 20	0 / 10	Stable	Stable
Uranium-238	1752	pCi/L	20 / 20	10 / 10	**169**	**169**	130	60	147	13 / 20	10 / 10	1 / 20	1 / 10	Up	No trend
	1755	pCi/L	20 / 20	10 / 10	**287**	**287**	**287**	60	147	18 / 20	9 / 10	3 / 20	2 / 10	Up	No trend
	1756	pCi/L	20 / 20	10 / 10	91.4	49.1	43.7	60	147	2 / 20	0 / 10	0 / 20	0 / 10	Stable	No trend

[a]Residential PRG = residential scenario 1 x 10^{-4} risk-based activity (tap water ingestion at 2.5 L/day).
[b]Industrial PRG = industrial scenario 1 x 10^{-4} risk-based activity (tap water ingestion at 1.25 L/day).
[c]Significant linear trend from the M-K test at the 0.10 significance level.

Bold table entries indicate results that exceed industrial PRG values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

CV = coefficient of variation
Freq. = frequency
FY = fiscal year
M-K = Mann-Kendall
PRG = Preliminary Remediation Goal

SWSA 6 groundwater monitoring results

SWSA 6 is a closed shallow land burial site for low-level waste (LLW) and other waste types. SWSA 6 was included in the EPA NPL for cleanup under CERCLA. Portions of SWSA 6 were determined to have received hazardous waste after November 1980 and, therefore, those portions of the site have been regulated under RCRA since 1986, when the determination was made that hazardous materials had been disposed.

The site was placed in interim status under RCRA awaiting final closure in a comprehensive action (the MV Closure Project) that addressed both the RCRA and CERCLA waste units in SWSA 6. To reduce contaminant releases from the RCRA units during the interim status period, in 1988 – 1989 the areas were capped with synthetic membrane caps to prevent rainwater percolation into the buried waste.

Final site closure was accomplished in 2006 when CERCLA RAs specified in the MV Interim ROD, including closure of SWSA 6, were completed. The RAs at SWSA 6 included construction of permanent caps over all the RCRA waste disposal units, as well as most other buried waste units within the waste disposal area. The cap design and construction are RCRA compliant. SWSA 6 closure design and as-built constructed features are documented in the *Phased Construction Completion Report for Hydrologic Isolation at Solid Waste Storage Area 6 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2285&D1).

As discussed in Section 1.1, annual reporting for SWSA 6 has been discontinued under RCRA but is included in the 2019 RER. Former RCRA groundwater monitoring requirements for SWSA 6 have been incorporated into the CERCLA watershed-scale monitoring plan (MV RAR CMP). Annual reporting of the groundwater monitoring results for SWSA 6 will focus on monitoring results where COCs are detected.

Groundwater monitoring at SWSA 6, conducted by the WRRP, is a continuation of the monitoring previously prescribed for the site by RCRA requirements. The SWSA 6 groundwater monitoring program consists of sampling 10 wells formerly used for RCRA monitoring (Figure 3.14) around the perimeter of SWSA 6 with analysis for VOCs and lead that were designated as hazardous constituents regulated under RCRA. Well 0838 on the SWSA 6 perimeter is sampled to monitor groundwater quality at the mouth of a small valley near the location of a now inactive former surface water monitoring station and was not included in former RCRA monitoring. In addition, radiological constituents and other constituents are analyzed in selected wells at the site to monitor site discharges. Well 0846 is the designated upgradient well for SWSA 6 monitoring. The principal detected contaminants are the VOCs, carbon tetrachloride and its degradation product chloroform, 1,2-dichloroethane (DCA), and TCE and its degradation products cis-1,2-DCE. VOCs were disposed in a number of areas in SWSA 6. One area in the eastern portion of the site is the likely source of VOCs detected since site perimeter groundwater monitoring started in the late 1980s. These constituents are detected regularly in wells 0841 and 0842, located on the eastern boundary of SWSA 6. Wells 0841 and 0842 comprise a well pair that includes a bedrock well and a shallower well that monitors groundwater at and above the soil/bedrock interface. Well 0841 monitors groundwater in bedrock at the depth of 36.5 to 56.5 ft bgs, while well 0842 is shallower with a screened interval between 8 and 28 ft bgs.

The probable source area for the VOCs detected in wells 0841 and 0842 is releases from the auger holes area that lies at the crest of the hill to the west of this well pair. Various types of waste including organic solvents were disposed in these holes drilled into the saprolitic soils. In 1988/1989 RCRA corrective action membrane caps were placed over the auger holes and other RCRA units throughout SWSA 6. During FY 2005 and 2006 the MV Closure Project constructed a large multi-layer cap over the area that substantially expanded the capped footprint. Figure 3.15 includes monitoring results of VOCs in well 0841 as well as the TCE monitoring history from well 0842. TCE, 1,2-DCA, and carbon tetrachloride are the three chlorinated VOCs in well 0841 that have exceeded their MCLs. In the early monitoring history of well 0841, none of these VOCs were detected, however, in the late 1990s TCE became detectable followed by 1,2-DCA and carbon tetrachloride. TCE concentrations increased rapidly in 2000 and 2001, but declined to a range between 40 and 70 µg/L through 2011. Since 2012, TCE levels have varied seasonally within a range of about 80 µg/L to 130 µg/L. The 1,2-DCA and carbon tetrachloride fluctuate at concentrations 1 – 2 times their 5 µg/L MCLs. Other VOCs that are detected in well 0841 at concentrations less than their MCLs include chloroform, tetrachloroethene (PCE), and cis-1,2-DCE, which have MCL concentrations of 80, 5, and 70 µg/L, respectively. Figure 3.15 shows that TCE concentrations in the shallower zone monitored by well 0842 decreased rapidly for a time following the corrective action capping and that groundwater in the adjacent bedrock well (0841) was relatively uncontaminated. Both wells show apparent seasonal TCE concentration fluctuations. No known actions occurred prior to arrival of the TCE contamination in well 0841 in about year 2000. Similarly, the broader concentration undulations apparent in the graph may show some multi-year rainfall influence, however, there are no obvious human or natural mechanisms that explain them.

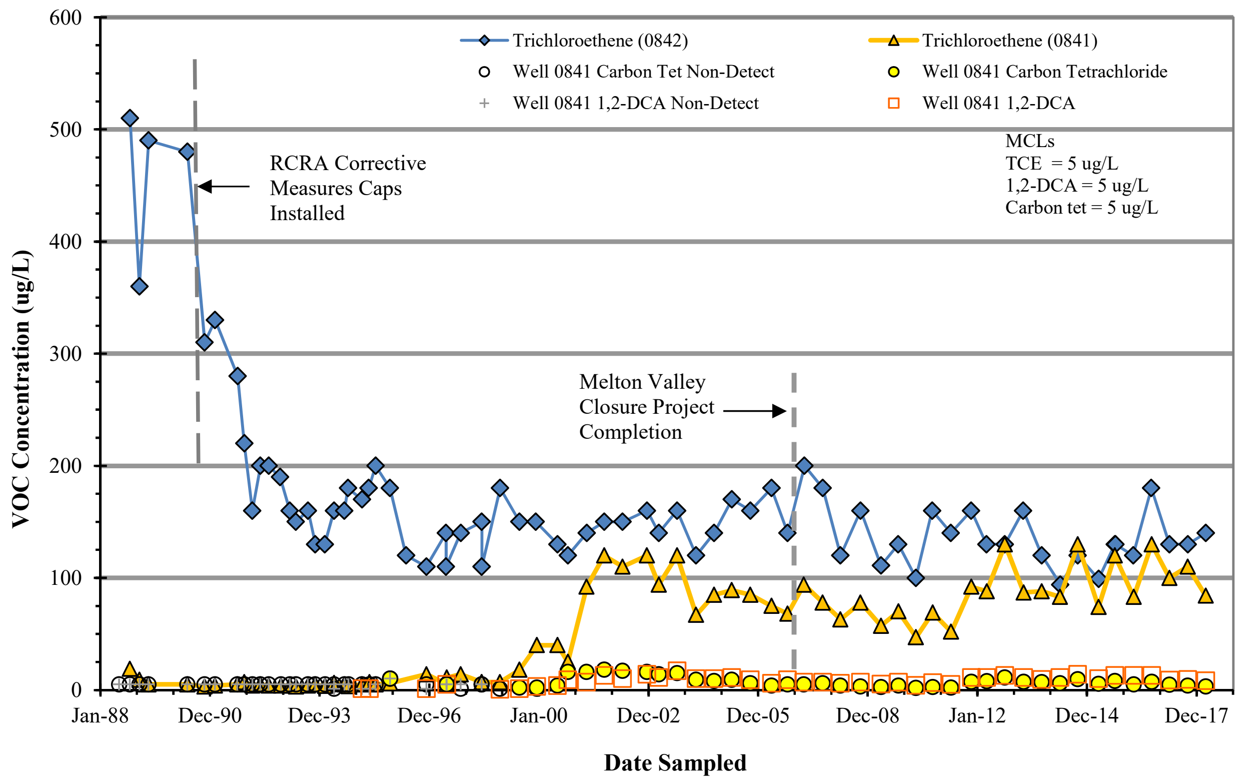


Figure 3.15. Long-term monitoring results for VOCs in SWSA 6 well 0841 and TCE in well 0842.

The only other wells monitored at the perimeter of SWSA 6 that contained measureable chlorinated VOCs were wells 0838 (not a former RCRA monitoring location) and 0843. During FY 2018, detected VOCs in well 0838 included carbon tetrachloride and chloroform (0.94 J and 2.2 µg/L, respectively in October 2017). At well 0843, cis-1,2-DCE was detected at 2.4 and 1.4 µg/L in October and April, respectively, and TCE was detected at 0.67 J and 0.34 J µg/L in October and April, respectively.

DOE has compiled the analytical data for groundwater contaminants in the former RCRA monitoring well network at SWSA 6 to evaluate environmental responses to the RA. Data from wells specified in the PCCR to be monitored post-action are compared to EPA's National Primary Drinking Water Regulations MCLs or MCL-DC for radionuclides. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants the may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations.

The trend evaluations for regulated chemicals and radionuclides that have been detected at concentrations greater than, or equal to 80% of their respective MCLs or MCL-DCs are summarized in Table 3.10. The trend evaluations and maximum detected contaminant concentrations summarized in Table 3.10 show that in most locations contaminant trends are decreasing or that no trend can be assigned in the 10-year evaluation period. The maximum detected concentration in the 5-year evaluation period have mostly shown decreases although the data variability within the past five years has been great enough to prevent assignment of trend directions with statistical confidence. Therefore, no trend is often assigned in Table 3.10 for the 5-year evaluation period. Exceptions to the general decreasing trend conditions in the SWSA 6 boundary wells are increases for 1,2-DCA and TCE in well 0841 in the 10-year evaluation and an increasing trend for TCE in well 0842 in the 5-year evaluation. These contaminants in wells 0841 and 0842 are suspected to originate from solvent compounds that seeped downward into bedrock from the auger hole disposal area upslope of the wells. With reduced groundwater recharge flowing through the area after hydrologic isolation was implemented it would be expected for dissolved constituent concentrations to increase for contaminants that occur below the groundwater table. Emanation of higher dissolved concentrations at the edge of the cap is the inferred process that is causing the increased trends in wells 0841 and 0842. Based on the data screening at 80% of MCL or MCL-DC concentrations, this data evaluation has not identified newly emerging groundwater contaminants approaching their MCLs that were not previously known to be present in groundwater along the boundary of SWSA 6. Figure 3.16 shows the long term concentration histories for TCE, carbon tetrachloride, and 1,2-DCA in well 0842.

Lead is also a COC in SWSA 6 because of disposal of lead (not lead used as a shielding material). Lead has been detected in groundwater at low concentrations occasionally along the southern edge of SWSA 6. Samples from the SWSA 6 perimeter wells were analyzed for lead and it was detected in the October 2017 samples from wells 0842 (3.7 µg/L), 0844 (1.3 J µg/L), 4316 (2.8 J µg/L) and from well 4317 (18 µg/L) and in the April 2018 samples from well 4315 (4.3 µg/L). The action level for lead in drinking water is 15 µg/L. Well 4317 lies in the alignment of the haul road on the southeastern corner of SWSA 6 where vehicle traffic may cause vibrations that may disturb soils around the screened interval leading to particle invasion of the well. Lead in well 4317 is identified in Table 3.10 because of its MCL exceedance history. The lead detection frequency is relatively low and its variability prevents assignment of statistically significant trend directions. The well has experienced turbidity problems in the past and a redevelopment process was completed prior to the April 2018 sampling event during which lead was not detected.

Table 3.10. Summary of 10-year and 5-year groundwater contaminant trends in former RCRA monitoring locations at SWSA 6

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,2-Dichloroethane	0841	mg/L	20 / 20	10 / 10	--	**0.014**	**0.014**	**0.009**	0.005	18 / 20	10 / 10	20 / 20	10 / 10	No trend	Stable
	0842	mg/L	20 / 20	10 / 10	--	**0.017**	**0.017**	**0.016**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	No trend	No trend
Alpha activity	0838	pCi/L	5 / 20	4 / 10	3.67	12.7	12.7	3.43	15	0 / 20	0 / 10	1 / 20	1 / 10	Up	No trend
	4316	pCi/L	12 / 20	5 / 10	4.5	**28.4**	3.91	2.84	15	3 / 20	0 / 10	3 / 20	0 / 10	Down	Stable
	4317	pCi/L	15 / 19	10 / 10	2.71	**21.2**	**21.2**	3.22	15	2 / 19	1 / 10	2 / 19	1 / 10	No trend	Stable
Carbon tetrachloride	0841	mg/L	20 / 20	10 / 10	--	**0.011**	**0.01**	0.004	0.005	10 / 20	6 / 10	12 / 20	8 / 10	No trend	Down
	0842	mg/L	20 / 20	10 / 10	--	**0.021**	**0.015**	**0.013**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	No trend
Lead	4317	mg/L	3 / 15	3 / 10	0.003	**0.018**	**0.018**	**0.018**	0.015	1 / 15	1 / 10	2 / 15	2 / 10	No trend	No trend
Strontium-90	0835	pCi/L	2 / 20	1 / 10	2.59	6.69	0.606	ND	8	0 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
Trichloroethene	0841	mg/L	20 / 20	10 / 10	--	**0.13**	**0.13**	**0.11**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
	0842	mg/L	20 / 20	10 / 10	--	**0.18**	**0.18**	**0.14**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Up
Tritium	0838[d]	pCi/L	20 / 20	10 / 10	--	17,600	4,660	2,040	20,000	0 / 20	0 / 10	1 / 20	0 / 10	Down	Down
	0841	pCi/L	20 / 20	10 / 10	--	**34,300**	7,820	6,850	20,000	6 / 20	0 / 10	6 / 20	0 / 10	Down	Down
	0843	pCi/L	20 / 20	10 / 10	--	**456,000**	**257,000**	**139,000**	20,000	20 / 20	10 / 10	20 / 20	10 / 10	Down	Down
	0844	pCi/L	20 / 20	10 / 10	--	**1,340,000**	**1,180,000**	**882,000**	20,000	20 / 20	10 / 10	20 / 20	10 / 10	Down	Down
	4316	pCi/L	20 / 20	10 / 10	--	**62,600**	**39,000**	**20,400**	20,000	17 / 20	7 / 10	19 / 20	9 / 10	Down	Down

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.
[b]MCL or MCL-DC as of May 2018.
[c]Significant linear trend from the M-K test at the 0.10 significance level.
[d]Well 0838 was not included in the former RCRA permit-required monitoring.

Bold table entries indicate results that exceed MCL or MCL-DC values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year

Table 3.10. Summary of 10-year and 5-year groundwater contaminant trends in former RCRA monitoring locations at SWSA 6 (cont.)

MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration (tritium MCL-DC = 20,000 pCi/L and Sr-90 MCL-DC = 8 pCi/L)
M-K = Mann-Kendall
ND = not detected
RCRA = Resource Conservation and Recovery Act of 1976
SWSA = Solid Waste Storage Area

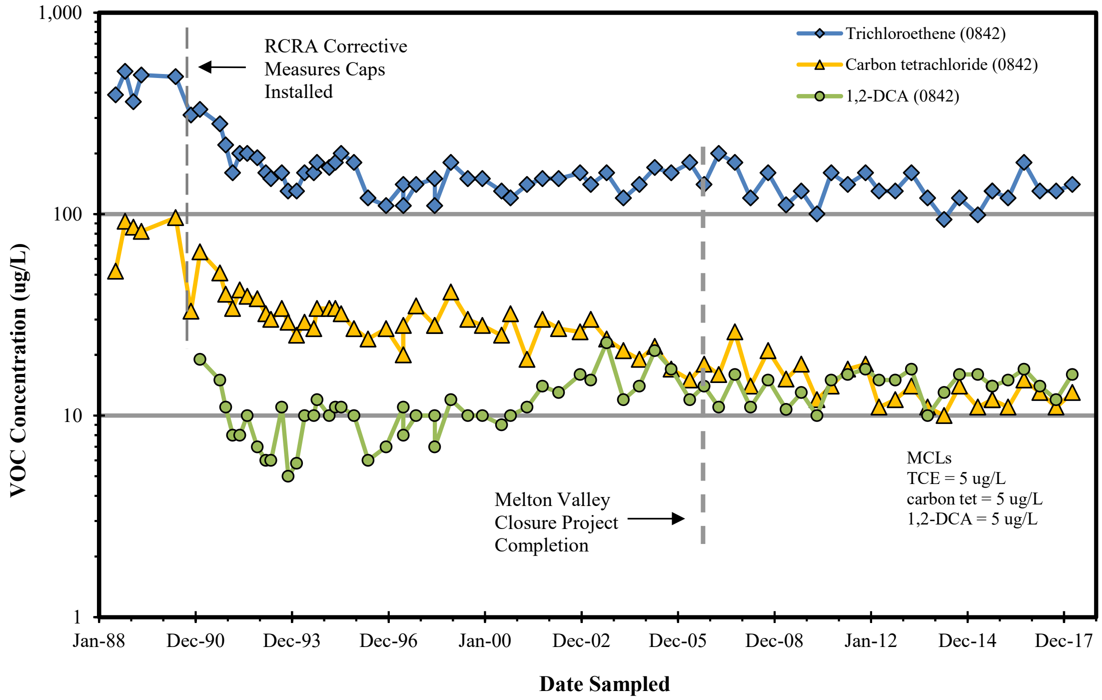


Figure 3.16. Long-term monitoring results for VOCs in SWSA 6 well 0842.

CERCLA radiological monitoring of groundwater is also conducted in these wells. The principal and most mobile radionuclide detected in groundwater is tritium. The highest tritium activities in the RCRA well network are measured in wells 0841, 0843, 0844, and 4316 along the eastern site boundary. Tritium activity trends in these wells exhibit decreases in both the 10-year and 5-year evaluation period (Table 3.10). In addition, tritium levels in wells 0841 and 0842 have decreased to below the MCL-DC of 20,000 pCi/L. Tritium in well 0844 exhibited a long-term increasing trend from 1995 through the spring of 2011 but has decreased through FY 2018. Tritium activity in well 4316 doubled in the period between 1994 and 2008 and has decreased nearly 70% from levels measured in 2008 (near 60,000 pCi/L). The April 2018 sample in well 4316 yielded 16,600 pCi/L. Graphs that show the tritium concentration history in wells along the eastern side of SWSA 6 are included in Appendix B.3. The groundwater contaminant trends along the eastern edge of SWSA 6 suggest that contamination in bedrock wells is susceptible to trends that started long before the MV Closure Project and those trends are slowly responding to the burial ground capping.

Tritium is also monitored in groundwater around the Tumulus low-level solid waste disposal facility where historic discharges from containerized waste created a groundwater tritium plume. Six wells (Figure 3.14) at the Tumulus are sampled to measure the groundwater tritium trends. DOE has compiled the analytical data for groundwater contaminants in the Tumulus facility vicinity to evaluate environmental responses to the RA (Table 3.11). Data from wells specified in the PCCR to be monitored are compared to EPA's National Primary Drinking Water Regulations MCL-DC for radionuclides. Two screening levels were used – the full MCL-DC concentrations and an arbitrary value of 80% of the MCL-DC. The 80% level was selected to indicate the presence of contaminants the may be approaching the MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations.

Table 3.11. Summary of 10-year and 5-year trends for Sr-90 and tritium in groundwater around the Tumulus waste disposal facility

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Strontium-90	1036	pCi/L	4 / 20	3 / 10	2.47	6.48	6.48	ND	8	0 / 20	0 / 10	1 / 20	1 / 10	No trend	No trend
	1037	pCi/L	2 / 20	1 / 10	2.12	4.36	1.22	1.22	8	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
	1039	pCi/L	3 / 20	2 / 10	2.44	6.45	6.45	ND	8	0 / 20	0 / 10	1 / 20	1 / 10	No trend	No trend
	1254	pCi/L	4 / 20	4 / 10	2.15	**21.9**	**21.9**	ND	8	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
	1257	pCi/L	6 / 20	4 / 10	2.73	7.49	2.13	ND	8	0 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	1258	pCi/L	2 / 20	2 / 10	2.35	0.744	0.744	ND	8	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
Tritium	1036	pCi/L	20 / 20	10 / 10	--	**224,000**	**224,000**	**139,000**	20,000	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Down
	1037	pCi/L	20 / 20	10 / 10	--	**32,500**	17,000	8,420	20,000	5 / 20	0 / 10	10 / 20	1 / 10	Down	Down
	1039	pCi/L	20 / 20	10 / 10	--	**57,300**	**57,300**	**31,900**	20,000	9 / 20	5 / 10	10 / 20	6 / 10	No trend	No trend
	1254	pCi/L	20 / 20	10 / 10	--	4,880	4,880	4,140	20,000	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
	1257	pCi/L	20 / 20	10 / 10	--	6,240	4,600	3,610	20,000	0 / 20	0 / 10	0 / 20	0 / 10	Down	Stable
	1258	pCi/L	20 / 20	10 / 10	--	**136,000**	**83,900**	**58,500**	20,000	20 / 20	10 / 10	20 / 20	10 / 10	Down	Down

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[b]MCL and MCL-DC as of May 2018.

[c]Significant linear trend from the M-K test at the 0.10 significance level.

Bold entries denote values that exceed MCL-DC concentrations.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration (tritium MCL-DC = 20,000 pCi/L and Sr-90 MCL-DC = 8 pCi/L)
M-K = Mann-Kendall
ND = not detected

Graphs of the Tumulus area groundwater tritium monitoring data are included in Appendix B.3. Tritium levels in wells 1037, 1254, and 1257 have been less than the MCL-DC (20,000 pCi/L) since the end of FY 2011. Well 1037 tritium levels have continued a steady decline from a high value of about 80,000 pCi/L in 2003 to a value less than 6,000 pCi/L in August 2018. Since about 2009, tritium levels in wells 1254 and 1257 have been measured at levels of about 5,000 pCi/L or less. Wells 1036 and 1258 continue to exhibit the highest tritium levels in the area with continuing decreasing trends. Tritium concentrations in both wells started increasing in 2006 following RA. The tritium concentration in well 1036 reached its peak level (224,000 pCi/L) in February 2014 and has subsequently decreased to 131,000 pCi/L in August 2018. At well 1258, tritium reached its peak concentration (136,000 pCi/L) in September 2010 and has subsequently decreased to 52,100 pCi/L in August 2018. The overall behavior of tritium in groundwater beneath and adjacent to the Tumulus cap indicates that tritium levels have stabilized beneath the capped area and levels are decreasing near and outside of the cap.

The reduction in tritium discharges from the Tumulus is a significant component of the decrease in tritium measured in surface water at continuous flow-paced monitoring location WAG 6 MS3 which is located nearby (Figure 3.4).

MV onsite exit pathway and offsite wells

This section discusses groundwater monitoring in the groundwater exit pathway region at the southwestern end of MV, both on and off of the DOE ORR. The discussions include descriptions of the geologic conditions in the area as relevant to groundwater flow, groundwater head gradients which are expected to influence flow directions near the Clinch River, followed by a discussion of groundwater quality monitoring and concentration trends for detected contaminants.

Onsite exit pathway and offsite groundwater monitoring includes monitoring of wells 1190 and 1191 that are located on WOD, monitoring of six deep onsite exit pathway wells plus a cluster of three wells between the Clinch River and the western edge of SWSA 6, and monitoring of offsite wells located southwest of the Clinch River (Figure 3.17).

- Wells 1190 and 1191 are about 47 and 26 ft deep, respectively, and are located near the centerline of WOD. Well 1190 is constructed to monitor groundwater in bedrock at elevation 708 – 718 ft aMSL. The well 1190 screen extends from a depth of 37.2 to 47.2 ft bgs and bedrock was encountered at 29.1 ft bgs. Well 1191 samples water from the interface between the bedrock surface and the sediment/soil fill zone beneath the dam at elevations from 724 – 743 ft aMSL. The well 1191 screen extends from 15.8 to 25.8 ft bgs and bedrock was encountered at 26.2 ft bgs. Tritium and Sr-90 are the principal contaminants detected in these wells. Figure 3.18 shows the activity histories from about 1990 through FY 2018 and Figures 3.14 and 3.17 show the location of the wells. In the past, tritium levels in well 1191 were much higher than those in well 1190 and the concentrations have been decreasing in both wells. Since 2012, the tritium concentrations in both wells have been very similar at levels about 1.5 times the 20,000 pCi/L MCL-DC, with higher variability in well 1191. This convergence of tritium concentrations between the shallower well and the deeper well, and the continuing decrease, are indications of the overall, long-term reduction of tritium that is present in the WOC aquatic system. The well 1191 tritium data show a nearly 10-fold decrease in levels since the early 1990s. Sr-90 has only been sporadically detected in well 1190, which is the deeper, bedrock well. In well 1191, Sr-90 has attained near steady-state concentrations since about 2004 at an average of about 150 pCi/L (8 pCi/L MCL-DC) with a standard deviation of about 25 pCi/L.

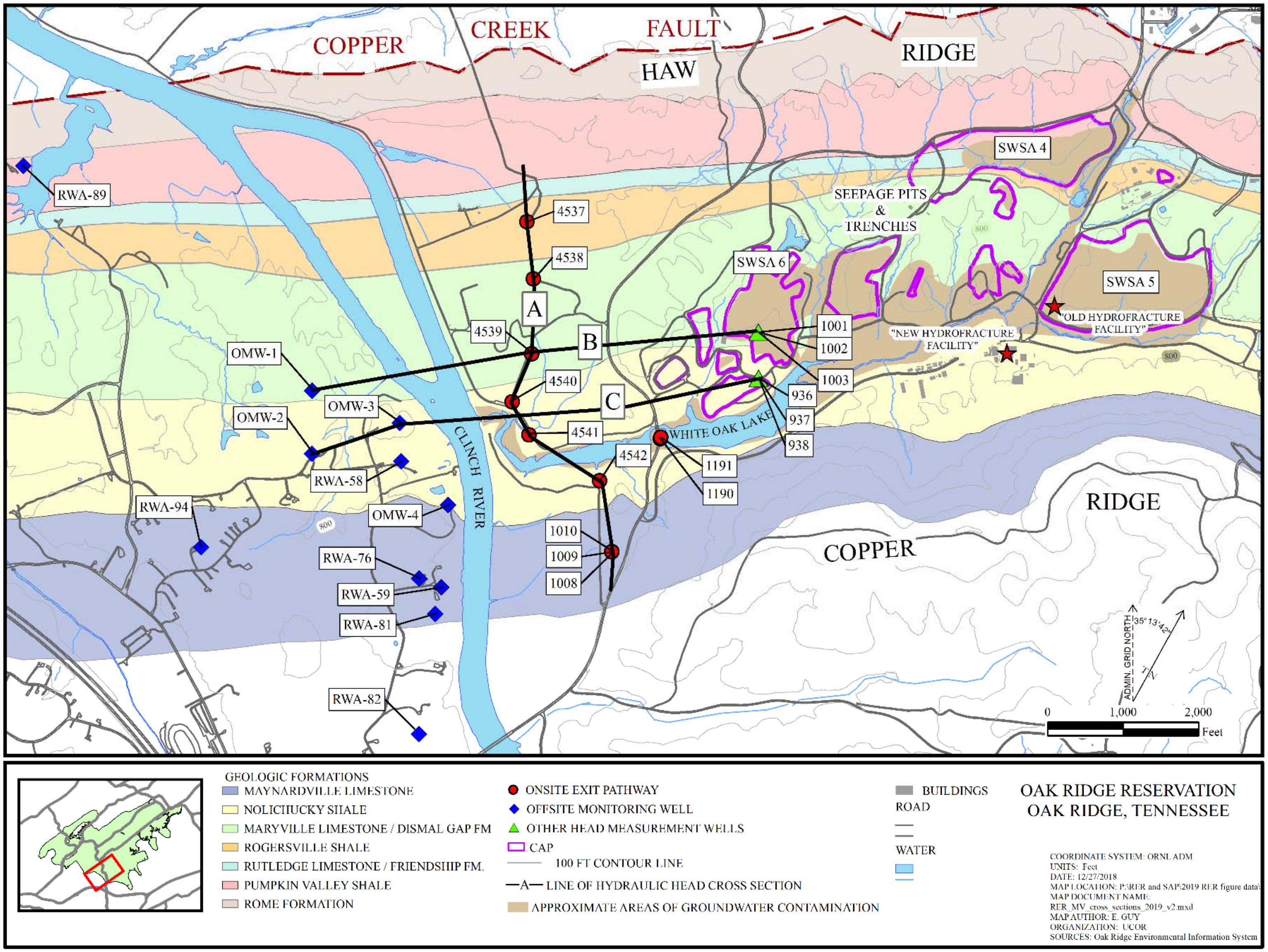


Figure 3.17. Locations of MV onsite exit pathway and offsite wells.

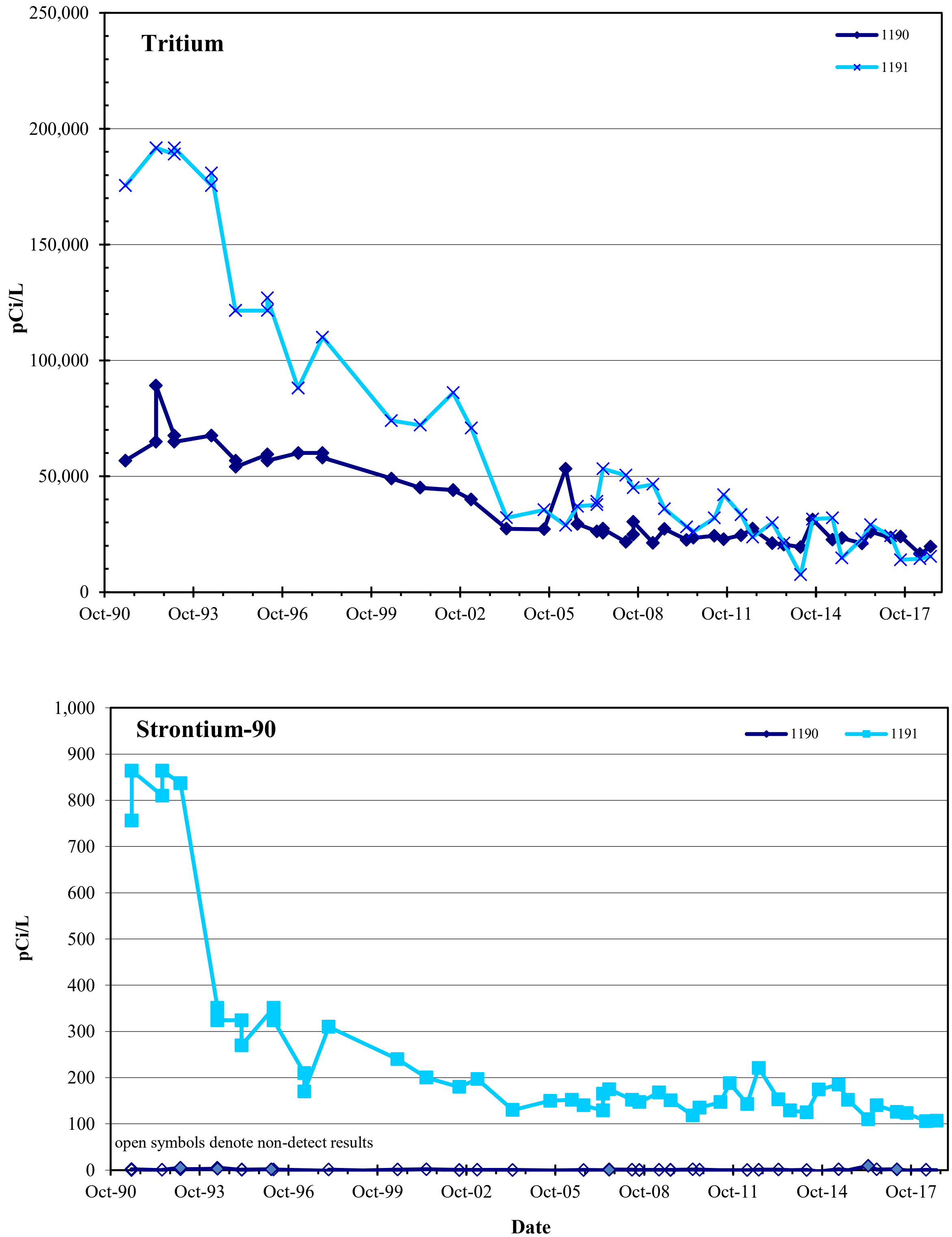


Figure 3.18. WOD groundwater tritium and Sr-90 activity histories at wells 1190 and 1191.

- As part of the MV Interim ROD, in 2004 six groundwater monitoring wells (4537, 4538, 4539, 4540, 4541, and 4542) were installed in the western end of MV to serve as onsite exit pathway wells to detect site-related contaminants that may seep toward the Clinch River. These six deep, multizone monitoring wells were constructed in a line extending from the toe of Haw Ridge southward to the south side of the WOCE near WOD. Locations of these wells are shown on Figure 3.17. Three additional single zone wells (1008, 1009, and 1010), that are in a previously constructed well cluster near the southern end of the line of onsite exit pathway wells are also included in the MV Exit Pathway monitoring program. Onsite exit pathway wells near the Clinch River on the ORR side were drilled to bottom elevations of about 250 ft aMSL and completed in the geochemical transition zone above the fresh water/brine interface. Based on test results, a total of 36 sampling zones were created by installation of Westbay® multizone sampling systems. Subsequent to installation, each zone was purged in preparation for sampling. Over FY 2005 and FY 2006, baseline samples were collected and analyzed to evaluate the stabilization of groundwater quality in the sampled zones.

- In FY 2010, offsite groundwater monitoring was initiated west of the Clinch River across from the MV waste management areas. This action was taken in response to detection of site-related contaminants in some of the onsite exit pathway well monitoring zones in FY 2007 through FY 2009, and because of concern that increasing groundwater withdrawals on the western side of the Clinch River could potentially pull groundwater beneath the river. As a precaution, DOE pays to have water provided to residents in the area and funded the extension of county utility water supplies to minimize groundwater withdrawals near the Clinch River.

- The offsite groundwater monitoring project included installation and sampling of two well clusters (OMW-1 and OMW-2) containing five wells each on a ridgecrest west of the river, modification and sampling of two existing wells (OMW-3 and OMW-4) near the river to create three sampling intervals within each borehole, and sampling of seven existing domestic wells in the vicinity. Locations of the offsite wells are shown on Figure 3.17. Goals of this continued monitoring effort are: 1) to allow measurement of groundwater levels to determine the potential flow directions on the west side of the river in comparison to those on the DOE side of the river and, 2) to allow groundwater sampling from discrete elevation ranges that match elevations where samples are collected from multizone wells on the DOE side of the river. In addition to constructing the offsite wells to sample groundwater from elevations correlative to those on the DOE side of the river, to the extent feasible, the offsite wells were constructed in locations where sample intervals would be in approximately correlative hydrostratigraphic zones on both sides of the river. For example, well 4539 on the DOE side of the river and offsite well cluster OMW-1 intersect the upper portion of the Maryville Limestone stratigraphic unit. Similarly, wells 4540 and 4541 intersect strata also sampled in offsite well cluster OMW-2. In the offsite monitoring network, the deepest wells in the two ridgecrest clusters were drilled to allow sampling in the elevation range between 200 – 300 ft aMSL, comparable to the base of multizone wells on the DOE side of the river. Shallower target monitoring elevations are within the 400 – 500, 500 – 600, and 700 – 750 ft aMSL ranges. Modified offsite wells near the Clinch River that were converted to three-zone nested sampling wells were constructed to allow additional head monitoring and groundwater sampling in the nominal 400 – 500, 550 – 600, 600 – 650, 650 – 700, and 700 – 750 ft aMSL ranges. The seven existing domestic offsite wells that are monitored are typical open borehole water wells and groundwater from long bedrock intervals is included in the monitoring.

The deep groundwater monitoring data are discussed in terms of sample zone elevation because the local area has surface topographic relief of 200 – 300 ft between Clinch River elevation and the crests of ridges. Therefore, depth references related to different monitoring locations are not directly comparable. Beneath MV, relatively fresh groundwater extends from the water table downward to an elevation of approximately 350 – 400 ft aMSL. In the freshwater interval, bicarbonate is the dominant anion and calcium and sodium are the dominant cations, with sodium concentrations increasing with increasing depth. Beneath the fresh water zone, groundwater contains rapidly increasing concentrations of dissolved solids that include residual components of the naturally-occurring ancient brine contained in the bedrock. This deep groundwater is non-potable because of natural salinity and wells constructed in the bedrock at these elevations produce very little water. At elevations ranging from about 250 – 300 ft aMSL beneath MV (450 – 500 ft below the level of the Clinch River), the groundwater is saline brine that contains extremely high dissolved solids concentrations dominated by sodium and chloride, but also containing calcium, magnesium, potassium, barium, lithium, strontium, and other metal ions. Monitoring data show that there is a transition zone of rapidly increasing chloride concentrations from about 1,000 mg/L at about the 300 ft elevation to 100,000 mg/L or more at about the 200 ft elevation. The brine has a high density (1.2 – 1.3 g/cc compared to densities near 1.0 g/cc for the overlying groundwater) because of the high concentrations of dissolved ions. This strong density contrast between the brines at depth and the overlying fresher groundwater and reduced permeability with depth inhibit the mixing of constituents between the two zones. The onsite exit pathway wells and offsite wells were designed and installed to sample groundwater above the non-potable brine zone.

MV onsite exit pathway and offsite wells groundwater level monitoring results

Groundwater level monitoring is conducted continuously in the two installed offsite well clusters and two modified existing offsite OMW wells. The purpose of making detailed groundwater level measurements is to provide head data over the range of elevations monitored. The head data are used to develop hydraulic head cross sections that indicate potential directions of groundwater movement based on the relative head differences along the section lines. Groundwater seepage occurs from areas of higher hydraulic head to those of lower hydraulic head. In porous media such as sand and gravel aquifers, groundwater seepage normally occurs in the direction of maximum observed gradient. However, in geologically complex bedrock, with folds, fractures, and faults such as that observed at Oak Ridge, lines of maximum apparent gradient can indicate barriers to flow because of a lower density of interconnected fractures along that direction compared to another direction where geologic conditions predispose flow to occur. Most plumes in this area tend to follow flow pathways parallel to geologic strike and many occur in confined to semiconfined bedrock zones that have either preferential fracturing (including bedding plane partings), preferential weathering because of bedrock type, or both. The MV onsite exit pathway wells include numerous sample zones from Westbay® multizone wells. The nomenclature associated with these wells includes the well identification number followed by the sample zone number (e.g. 4537-01).

The location of three hydraulic head cross sections (A, B, and C) are shown on Figure 3.17. Figure 3.19 shows the average FY 2018 hydraulic head and total dissolved solids in the MV onsite exit pathway wells along Cross Section A which is parallel to the Clinch River. Areas of relatively low hydraulic head occur in the Rutledge Limestone (Friendship Formation) at the northern end of the cross section and in the Nolichucky Shale beneath the mouth of WOC in the southern part of the section. The low head area in the Rutledge Limestone contains fairly fresh water and is thought to discharge to the Clinch River through openings in the carbonate bedrock. The relatively low head observed near the mouth of WOC aligns with the lowest part of MV where WOC and WOL are located. Areas of relatively higher head occur near the center of the section in the Maryville Limestone (Dismal Gap Formation) and at the southern end of the section at the toe of Copper Ridge. The area of higher head in the Maryville Limestone zone aligns with the knobs in the middle of MV where most of the ORNL shallow land burial grounds and the liquid waste seepage pits and trenches are located. Groundwater recharge on the knobs maintains groundwater head in the bedrock in the Maryville Limestone outcrop belt. Although the head gradients indicated on Cross Section A suggest the potential for groundwater flow from higher head areas in the mid-valley (near wells 4538 and 4539) toward lower elevations near WOC and WOL or toward Haw Ridge to the north, most of the groundwater in bedrock flows through interconnected fractures that are essentially perpendicular to this cross section and groundwater flow is toward the Clinch River (toward the viewer of this figure) as inferred from gradients in Figures 3.20 and 3.21.

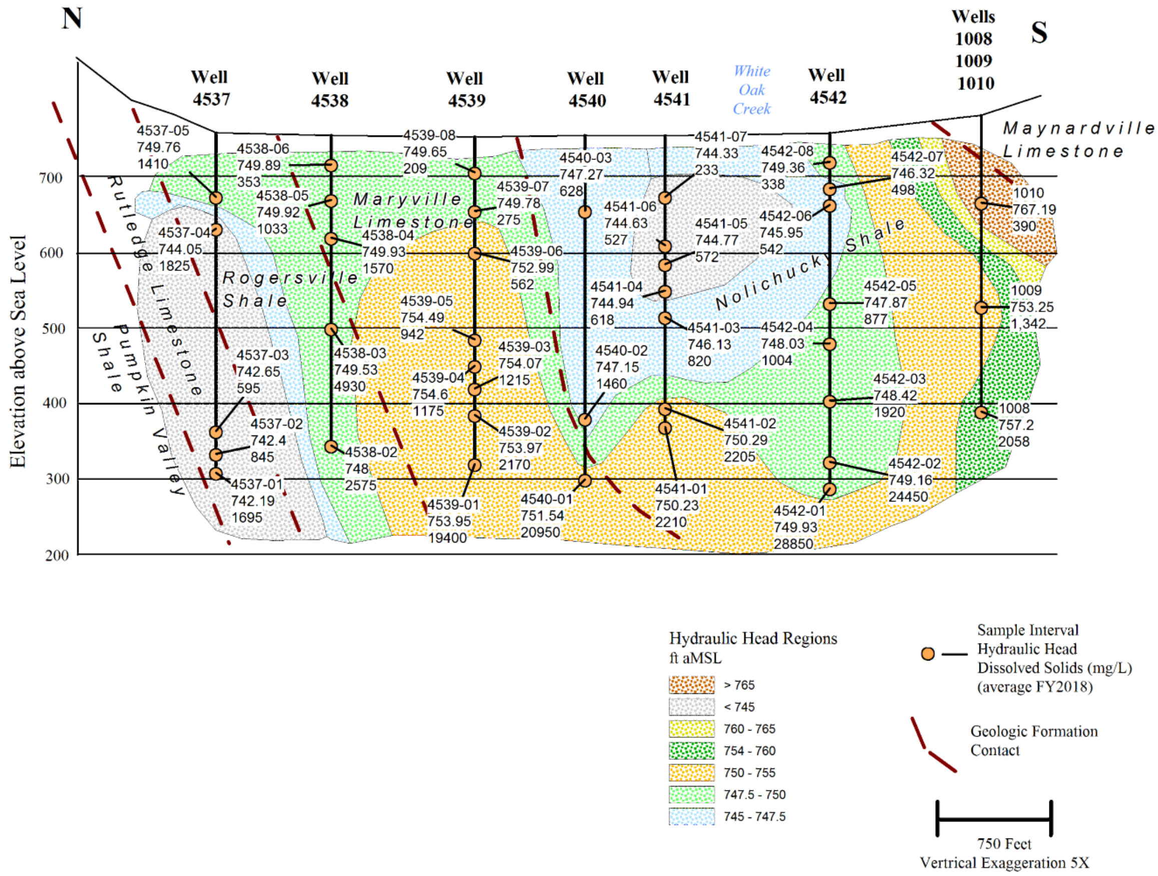


Figure 3.19. Hydraulic head cross section A.

Figure 3.20 shows the average FY 2018 hydraulic head and total dissolved solids in the wells along Cross Section B that has its western end on the ridgecrest at OMW-1 and its eastern end near the center of SWSA 6. This section is drawn essentially parallel to geologic strike in the Maryville Limestone as shown on Figure 3.17. The hydraulic head variations along Cross Section B show that a region of head ranging from 775 to >800 ft aMSL exists beneath the ridgecrest on the western side of the Clinch River. The downward head gradient beneath the ridge indicates that this is a recharge area for groundwater and the gradient, and flow direction, is toward the Clinch River, which has winter and summer pool elevations of about 737 and 742 ft aMSL, respectively. The lowest head region on Cross Section B occurs beneath the Clinch River, suggesting discharge to the river. On the eastern side of the Clinch River, the hydraulic head profile shows increasing head levels in the limestone beneath the SWSA 6 area where the profile terminates. Head levels measured at the eastern end of Cross Section B are lower than those beneath the offsite ridgecrest at the western terminus. The general head variations along this profile indicate that groundwater recharge occurs on the upland areas both east and west of the Clinch River where rainfall percolation to the groundwater table maintains the water table head. This head pressure, and associated groundwater movement, translates through interconnected fractures mostly parallel to geologic strike in the bedrock and head pressure is relieved in the discharge area at the Clinch River. The zone beneath the Clinch River acts as a hydraulic sink, as depicted by the <750 ft hydraulic head region which has higher head regions on both east and west sides.

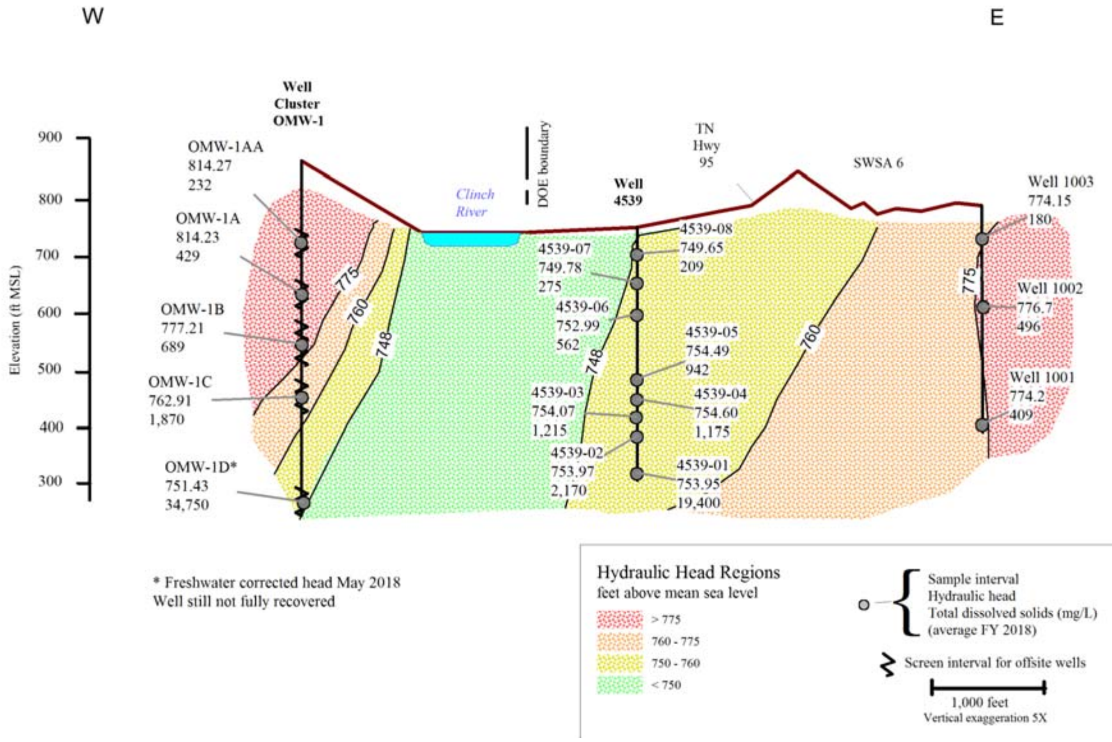


Figure 3.20. Hydraulic head cross section B.

The deepest well in offsite cluster OMW-1 (OMW-1D) is constructed in a very low-yield bedrock zone and, although the screened interval is about 100 ft in length, the well has not fully recovered in 87 mo. since the well development was completed. Because of the slow recovery, weekly water level measurements were conducted prior to early August 2014 when a continuous monitoring device was installed. The groundwater level continues to rise steadily with a current recovery rate of about 0.25 ft/mo. The well has recovered from an initial water level of about 510 ft aMSL after construction and development in July 2010 to freshwater corrected head of approximately 751 ft aMSL as of the end of May 2018. The head level in well OMW-1D is now higher than the Clinch River surface water elevation, with continuing recovery. A number of deep investigative wells in the MV waste disposal areas exhibited similar extremely slow recovery, which is indicative of the low hydraulic conductivity of much of the bedrock at depth.

Figure 3.21 shows the average FY 2018 hydraulic head and total dissolved solids profile along Cross Section C (Figure 3.17), which has its western terminus at offsite well cluster OMW-2 and its eastern terminus at wells on a knoll in the southern part of SWSA 6 at well 0938. This section is aligned approximately along geologic strike in the Nolichucky Shale. Similar to Cross Section B, the hydraulic head measured beneath the ridgecrest on the west side of the Clinch River ranges from 775 to >800 ft aMSL in the upper part of the groundwater system. Also similar to Cross Section B, there is a downward gradient measured between the individual wells within the OMW-2 well cluster. Similar to the behavior of well OMW-1D, the water level measured in the deepest OMW-2 cluster (well OMW-2D) has not recovered to a stable head condition. Although head in well OMW-2D is not fully recovered, the heads at the end of FY 2018 were more than 20 ft higher than the Clinch River water level, which indicates underflow of the ridgecrest in that area is very unlikely.

The overall head distribution in Cross Section C is similar to that in Cross Section B with the lowest observed hydraulic head lying beneath the Clinch River. This section is drawn to coincide with the low groundwater region that underlies WOC and WOL in the Nolichucky Shale outcrop band. Heading east from the Clinch River, the hydraulic head elevation increases gradually but does not reach the levels observed in Cross Section B at a similar distance east of the river. This more gradual gradient is attributed to the more subdued topography along the section line and the observation that groundwater enters bedrock fractures along this profile at lower head elevations than at the eastern end of Cross Section B. Similar to Cross Section B, that area beneath the Clinch River has lower hydraulic head than areas to the east and west, indicating groundwater discharges into the Clinch River from both sides.

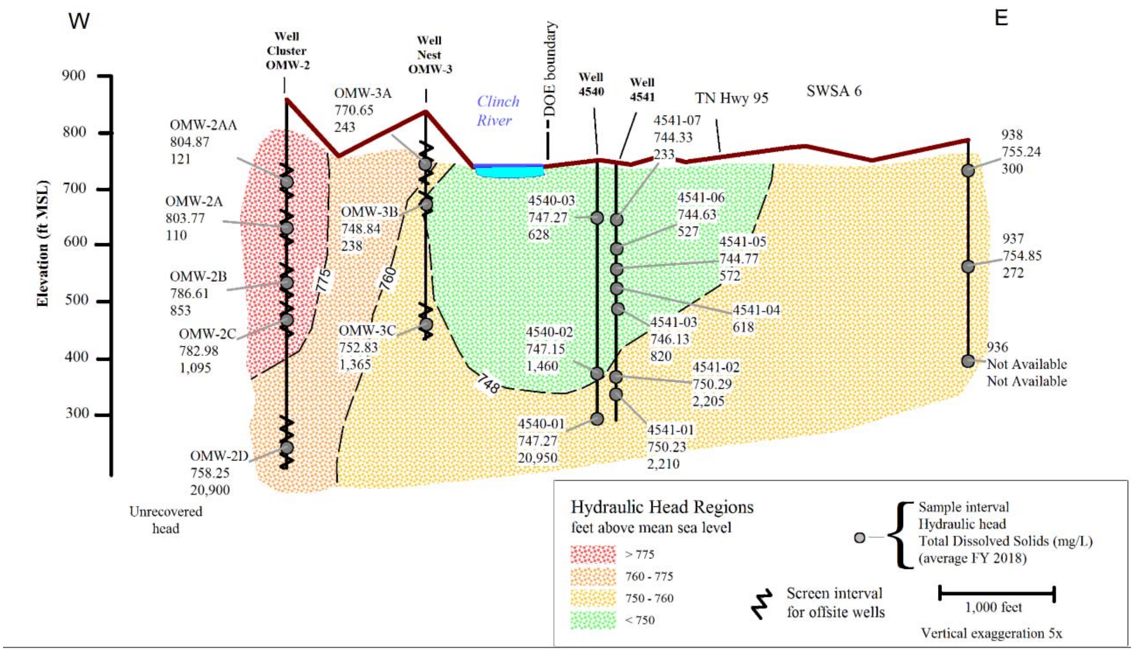


Figure 3.21. Hydraulic head cross section C.

The head data profiles summarized in Figures 3.20 and 3.21 combined with lower topography further to the west suggest that a groundwater seepage boundary occurs beneath the ridgecrest on the western side of the Clinch River near well clusters OMW-1 and OMW-2. The zone of elevated head beneath the ridgeline that extends downward, apparently to the deepest levels monitored, provides a natural barrier to groundwater seepage from east to west. Well hydrographs for the offsite wells are included in Appendix B.4.

MV onsite exit pathway and offsite wells groundwater quality monitoring results

Groundwater quality monitoring has been conducted in the MV onsite exit pathway wells since 2006 and four rounds of samples were collected in the offsite wells between July 2010 and the end of FY 2011. Sampling of the offsite wells has occurred either annually or semiannually during FY 2012 through FY 2018. Revised sampling frequency and parameters were agreed upon in FY 2013 by DOE, EPA, and TDEC and are documented in the MV RAR CMP.

Analytical results for unfiltered samples from each of the MV onsite exit pathway wells and offsite wells have been compared to EPA SDWA primary MCLs, which are used only as screening criteria. The MV Interim ROD did not specify MCLs as ARAR-based performance goals for groundwater.

DOE has compiled the analytical data from groundwater monitoring of wells in the onsite MV exit pathway to evaluate concentration trends for regulated contaminants. Data from each well or Westbay® sampling zone are compared to EPA's National Primary Drinking Water Regulations MCL or MCL-DC for radionuclides. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants the may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations. The trend evaluations for regulated chemicals an radionuclides that have been detected at concentrations greater than, or equal to 80% of their respective MCLs or MCL-DCs within the past 10 years are summarized in Table 3.12.

MV Onsite Exit Pathway Data Trends

The M-K trend evaluations for the MV onsite exit pathway monitoring network in Table 3.12 indicate the following:

The number of locations that exhibit regulated constituents at greater than 80% of their respective MCLs or MCL-DCs has decreased over the 10-year and 5-year trend evaluations culminating in FY 2018. Some of the regulated constituents such as alpha activity, barium, benzene, fluoride, thallium, and radium are suspected to be of natural origins in the MV groundwater. Other constituents such as Sr-90, TCE, and VC are man-made constituents. Chromium, lead, and nickel may be associated with DOE waste disposal sites or may be derived from bedrock weathering processes.

The number of locations in the MV onsite exit pathway monitoring program that have exhibited alpha activity exceedances of the 15 pCi/L screening level has decreased from 16 in the 10-year trend evaluation to only four locations in FY 2018. At those four locations, the maximum detected alpha activity concentrations have generally decreased although at one location, 4542-01, the maximum detected concentration of 109 J pCi/L occurred in FY 2018. That alpha activity result was produced by the standard gas proportional counting method of alpha activity analysis that can be sensitive to effects of elevated total solids in the sample. A separate analysis of an aliquot of this sample conducted by an alternative lab method that reduces sample matrix interferences resulted in a value of 58.3 pCi/L which is also greater than the 15 pCi/L screening level but is a valid, unqualified result for the sample. Alpha activity trends for the most recent 5-year dataset show no statistically significant trends to stable trend conditions.

Within the past 10 years arsenic has been detected at concentrations greater than 80% of its 0.01 mg/L MCL in groundwater samples from seven locations in the onsite MV onsite exit pathway monitoring network. Trend evaluations for arsenic show decreasing to stable, or no statistically significant trends in the 10-year and 5-year evaluation periods. Arsenic is often not detected in field filtered sample aliquots. Only one of the monitoring locations, 4538-02, had an arsenic concentration (13 µg/L) that exceeded the MCL in FY 2018. That result was from an unfiltered sample aliquot collected in October 2017. Arsenic was not detected in a field-filtered aliquot from the same sample and arsenic was not detected in either the unfiltered or filtered aliquots from the April 2018 sampling event at well 4538-02. The absence of detectable arsenic in the filtered sample aliquot leads to the conclusion that the arsenic may have been associated with suspended particles in the sample. Westbay zone 4538-02 had 78 and 127 mg/L suspended solids in the October and April samples, respectively.

Table 3.12. Summary of MV onsite exit pathway wells M-K trend evaluations

Chemical	Well	Units	Freq. of detection[a]		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. > MCL[a,c]		Freq. > 80% of MCL[a,c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Alpha activity	1008	pCi/L	1 / 15	1 / 10	10.3	**15.4**	**15.4**	ND	15	1 / 15	1 / 10	1 / 15	1 / 10	No trend	No trend
	4537-01	pCi/L	6 / 15	3 / 10	12.6	**25.5**	7.59	2.52	15	1 / 15	0 / 10	1 / 15	0 / 10	No trend	No trend
	4537-04	pCi/L	2 / 15	1 / 10	12.1	**26.4**	7.13	ND	15	1 / 15	0 / 10	1 / 15	0 / 10	No trend	No trend
	4537-05	pCi/L	3 / 15	3 / 10	10.7	**15**	**15**	ND	15	0 / 15	0 / 10	1 / 15	1 / 10	No trend	No trend
	4538-02	pCi/L	7 / 15	2 / 10	15	**53**	**24.4**	8.48	15	5 / 15	1 / 10	5 / 15	1 / 10	Down	No trend
	4538-03	pCi/L	4 / 18	1 / 11	48.9	**22**	**22**	ND	15	2 / 18	1 / 11	2 / 18	1 / 11	No trend	No trend
	4539-01	pCi/L	13 / 19	9 / 10	57.8	**77.4**	**77.4**	**63.4**	15	11 / 19	8 / 10	12 / 19	9 / 10	Up	No trend
	4539-02	pCi/L	14 / 21	6 / 10	12.6	**82.5**	**82.5**	7.29	15	4 / 21	3 / 10	8 / 21	5 / 10	No trend	No trend
	4539-04	pCi/L	10 / 19	5 / 10	11.1	12.8	6.62	4.33	15	0 / 19	0 / 10	1 / 19	0 / 10	No trend	No trend
	4540-01	pCi/L	14 / 19	9 / 10	46.4	**82.4**	**82.4**	**32.5**	15	13 / 19	9 / 10	14 / 19	9 / 10	Up	Stable
	4540-02	pCi/L	8 / 19	3 / 10	8.88	**24.9**	5.25	ND	15	1 / 19	0 / 10	2 / 19	0 / 10	Down	No trend
	4541-01	pCi/L	4 / 15	2 / 10	15.8	**17.2**	5.36	ND	15	1 / 15	0 / 10	1 / 15	0 / 10	No trend	No trend
	4542-01	pCi/L	15 / 18	10 / 10	41.8	**109**	**109**	**109**	15	14 / 18	9 / 10	14 / 18	9 / 10	Up	Stable
	4542-02	pCi/L	14 / 18	10 / 10	75.9	**70.1**	**70.1**	**66.3**	15	14 / 18	10 / 10	14 / 18	10 / 10	Up	No trend
Arsenic	1009	mg/L	1 / 15	1 / 10	0.005	**0.011**	**0.011**	ND	0.01	1 / 15	1 / 10	1 / 15	1 / 10	Stable	Stable
	1009(F)	mg/L	0 / 15	0 / 10	0.005	ND	ND	ND	0.01	0 / 15	0 / 10	0 / 15	0 / 10	--	--
	4537-01	mg/L	11 / 15	9 / 10	0.005	**0.011**	**0.011**	0.00026	0.01	1 / 15	1 / 10	2 / 15	1 / 10	No trend	No trend
	4537-01(F)	mg/L	3 / 15	0 / 10	0.005	0.006	ND	ND	0.01	0 / 15	0 / 10	0 / 15	0 / 10	Stable	--
	4537-02	mg/L	16 / 16	10 / 10	--	**0.019**	**0.019**	0.005	0.01	3 / 16	1 / 10	7 / 16	3 / 10	Down	Down
	4537-02(F)	mg/L	14 / 16	9 / 10	0.005	**0.012**	**0.01**	0.007	0.01	1 / 16	0 / 10	2 / 16	1 / 10	Stable	Stable
	4537-04	mg/L	1 / 15	1 / 10	0.005	0.009	0.009	ND	0.01	0 / 15	0 / 10	1 / 15	1 / 10	Stable	Stable
	4537-04(F)	mg/L	1 / 15	0 / 10	0.005	0.002	ND	ND	0.01	0 / 15	0 / 10	0 / 15	0 / 10	No trend	--
	4538-02	mg/L	5 / 15	3 / 10	0.005	**0.013**	**0.013**	**0.013**	0.01	1 / 15	1 / 10	2 / 15	2 / 10	Stable	Stable
	4538-02(F)	mg/L	1 / 15	1 / 10	0.005	0.006	0.006	ND	0.01	0 / 15	0 / 10	0 / 15	0 / 10	No trend	Stable
	4539-01	mg/L	14 / 19	8 / 10	0.005	**0.076**	0.001	0.00064	0.01	4 / 19	0 / 10	4 / 19	0 / 10	Down	No trend
	4539-01(F)	mg/L	4 / 20	0 / 10	0.05	**0.083**	ND	ND	0.01	3 / 20	0 / 10	3 / 20	0 / 10	No trend	--
	4540-01	mg/L	8 / 19	3 / 10	0.005	**0.052**	0.008	0.00006	0.01	4 / 19	0 / 10	5 / 19	1 / 10	Down	No trend
	4540-01(F)	mg/L	4 / 19	0 / 10	0.005	**0.076**	ND	ND	0.01	4 / 19	0 / 10	4 / 19	0 / 10	Down	--
	4541-01	mg/L	3 / 15	2 / 10	0.032	**0.011**	**0.011**	ND	0.01	1 / 15	1 / 10	1 / 15	1 / 10	Stable	Stable
	4541-01(F)	mg/L	2 / 15	2 / 10	0.005	0.007	0.007	ND	0.01	0 / 15	0 / 10	0 / 15	0 / 10	No trend	Stable
	4542-01	mg/L	6 / 19	3 / 11	0.005	**0.062**	0.002	ND	0.01	2 / 19	0 / 11	2 / 19	0 / 11	No trend	No trend
	4542-01	mg/L	3 / 18	0 / 10	0.01	**0.061**	ND	ND	0.01	3 / 18	0 / 10	3 / 18	0 / 10	No trend	--
	4542-02	mg/L	7 / 18	3 / 10	0.008	**0.09**	0.001	ND	0.01	2 / 18	0 / 10	2 / 18	0 / 10	No trend	No trend
	4542-02(F)	mg/L	4 / 18	1 / 10	0.01	**0.047**	0.005	ND	0.01	1 / 18	0 / 10	2 / 18	0 / 10	No trend	Stable

Table 3.12. Summary of MV onsite exit pathway wells M-K trend evaluations (cont.)

Chemical	Well	Units	Freq. of detection[a]		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. > MCL[a,c]		Freq. > 80% of MCL[a,c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Barium	4539-01	mg/L	19 / 19	10 / 10	--	**22.2**	**22.2**	**22.2**	2	19 / 19	10 / 10	19 / 19	10 / 10	Up	Up
	4539-01(F)	mg/L	19 / 19	10 / 10	--	**22**	**22**	**22**	2	19 / 19	10 / 10	19 / 19	10 / 10	Up	Up
	4539-02	mg/L	21 / 21	10 / 10	--	**3.27**	**3.27**	0.71	2	2 / 21	2 / 10	3 / 21	3 / 10	Up	No trend
	4539-02(F)	mg/L	20 / 20	10 / 10	--	0.611	0.611	0.611	2	0 / 20	0 / 10	0 / 20	0 / 10	Up	Up
	4540-01	mg/L	19 / 19	10 / 10	--	**37.2**	**37.2**	**37.2**	2	19 / 19	10 / 10	19 / 19	10 / 10	Up	Up
	4540-01(F)	mg/L	19 / 19	10 / 10	--	**35.4**	**35.4**	**35.4**	2	19 / 19	10 / 10	19 / 19	10 / 10	Up	No trend
	4542-01	mg/L	18 / 18	10 / 10	--	**41.7**	**27**	**27**	2	18 / 18	10 / 10	18 / 18	10 / 10	Up	Up
	4542-01(F)	mg/L	18 / 18	10 / 10	--	**27.3**	**27.3**	**27.3**	2	18 / 18	10 / 10	18 / 18	10 / 10	Up	Up
	4542-02	mg/L	18 / 18	10 / 10	--	**20.8**	**20.8**	**20.8**	2	18 / 18	10 / 10	18 / 18	10 / 10	Up	No trend
	4542-02(F)	mg/L	18 / 18	10 / 10	--	**20.1**	**20.1**	**20**	2	18 / 18	10 / 10	18 / 18	10 / 10	Up	No trend
Benzene	4540-02	mg/L	18 / 19	10 / 10	3.0E-04	**0.005**	0.004	0.004	0.005	0 / 19	0 / 10	1 / 19	0 / 10	No trend	No trend
Beryllium	4539-02	mg/L	13 / 21	7 / 10	0.002	**0.005**	**0.005**	0.00024	0.004	2 / 21	2 / 10	2 / 21	2 / 10	No trend	No trend
	4539-02(F)	mg/L	2 / 20	2 / 10	0.001	0.00038	0.00038	ND	0.004	0 / 20	0 / 10	0 / 20	0 / 10	No trend	Stable
Chromium	4538-02	mg/L	15 / 15	10 / 10	--	**0.125**	0.041	0.032	0.1	1 / 15	0 / 10	1 / 15	0 / 10	Stable	Stable
	4538-02(F)	mg/L	7 / 15	5 / 10	0.005	0.007	0.007	ND	0.1	0 / 15	0 / 10	0 / 15	0 / 10	Stable	Stable
	4539-02	mg/L	19 / 21	9 / 10	0.04	**0.252**	**0.252**	0.009	0.1	2 / 21	2 / 10	3 / 21	3 / 10	No trend	No trend
	4539-02(F)	mg/L	9 / 20	7 / 10	0.005	0.012	0.012	0.004	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	Stable
Fluoride	1008	mg/L	15 / 15	10 / 10	--	**7.69**	**7.69**	**7.5**	4	15 / 15	10 / 10	15 / 15	10 / 10	Stable	Stable
	1009	mg/L	15 / 15	10 / 10	--	**9.89**	**9.64**	**9.64**	4	15 / 15	10 / 10	15 / 15	10 / 10	Down	Stable
	4537-04	mg/L	15 / 15	10 / 10	--	**4.19**	**4.19**	3.96	4	3 / 15	3 / 10	10 / 15	8 / 10	No trend	Down
	4537-05	mg/L	15 / 15	10 / 10	--	**5.58**	**5.57**	**5.57**	4	15 / 15	10 / 10	15 / 15	10 / 10	No trend	No trend
	4538-04	mg/L	16 / 16	10 / 10	--	**5.06**	**5.06**	**4.91**	4	16 / 16	10 / 10	16 / 16	10 / 10	Up	Stable
	4538-05	mg/L	15 / 15	10 / 10	--	**5.07**	**5.07**	**5.07**	4	15 / 15	10 / 10	15 / 15	10 / 10	Up	No trend
	4539-02	mg/L	19 / 19	10 / 10	--	**5.36**	**5.36**	3.14	4	14 / 19	5 / 10	17 / 19	8 / 10	Stable	**Down**
	4539-03	mg/L	15 / 15	10 / 10	--	**5.55**	**5.55**	**5.31**	4	14 / 15	9 / 10	14 / 15	9 / 10	Stable	No trend
	4539-04	mg/L	19 / 19	10 / 10	--	**5.9**	**5.9**	**5.49**	4	19 / 19	10 / 10	19 / 19	10 / 10	Stable	Stable
	4539-05	mg/L	18 / 18	10 / 10	--	**13.4**	**11.9**	**11.6**	4	18 / 18	10 / 10	18 / 18	10 / 10	No trend	Stable
	4539-06	mg/L	18 / 18	10 / 10	--	**5.87**	**5.87**	**5.67**	4	18 / 18	10 / 10	18 / 18	10 / 10	No trend	Stable
	4540-02	mg/L	19 / 19	10 / 10	--	**5.76**	**5.76**	**5.43**	4	19 / 19	10 / 10	19 / 19	10 / 10	No trend	No trend
	4540-03	mg/L	18 / 18	10 / 10	--	**6.99**	**6.99**	**6.99**	4	18 / 18	10 / 10	18 / 18	10 / 10	Stable	Stable
	4541-01	mg/L	15 / 15	10 / 10	--	**4.87**	**4.87**	**4.86**	4	15 / 15	10 / 10	15 / 15	10 / 10	Up	Stable
	4541-02	mg/L	18 / 18	10 / 10	--	**4.76**	**4.76**	**4.58**	4	13 / 18	10 / 10	18 / 18	10 / 10	Up	Stable
	4541-03	mg/L	18 / 18	10 / 10	--	**6.26**	**6.12**	**6.12**	4	18 / 18	10 / 10	18 / 18	10 / 10	No trend	No trend
	4542-01	mg/L	10 / 18	5 / 10	3.3	**5.67**	1.9	1.9	4	1 / 18	0 / 10	1 / 18	0 / 10	No trend	No trend
	4542-03	mg/L	15 / 15	10 / 10	--	**5.64**	**5.37**	**4.99**	4	15 / 15	10 / 10	15 / 15	10 / 10	Down	Stable
	4542-04	mg/L	19 / 19	10 / 10	--	**10.5**	**10.5**	**9.7**	4	19 / 19	10 / 10	19 / 19	10 / 10	No trend	Stable
	4542-05	mg/L	18 / 18	10 / 10	--	**9.36**	**7.95**	**7.95**	4	18 / 18	10 / 10	18 / 18	10 / 10	No trend	Stable
	4542-07	mg/L	15 / 15	10 / 10	--	**9.76**	0.52	0.52	4	1 / 15	0 / 10	1 / 15	0 / 10	Down	No trend

Table 3.12. Summary of MV onsite exit pathway wells M-K trend evaluations (cont.)

Chemical	Well	Units	Freq. of detection[a]		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. > MCL[a,c]		Freq. > 80% of MCL[a,c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Lead	4538-02	mg/L	15 / 15	10 / 10	--	**0.018**	0.005	0.004	0.015	1 / 15	0 / 10	1 / 15	0 / 10	Down	Stable
	4538-02(F)	mg/L	2 / 15	1 / 10	0.002	8.1E-04	8.1E-04	ND	0.015	0 / 15	0 / 10	0 / 15	0 / 10	Stable	Stable
	4539-02	mg/L	17 / 21	8 / 10	0.01	**0.044**	**0.044**	0.001	0.015	3 / 21	3 / 10	3 / 21	3 / 10	No trend	No trend
	4539-02(F)	mg/L	4 / 20	4 / 10	0.002	0.002	0.002	ND	0.015	0 / 20	0 / 10	0 / 20	0 / 10	No trend	Stable
	4540-02	mg/L	11 / 19	4 / 10	0.003	0.013	0.001	ND	0.015	0 / 19	0 / 10	2 / 19	0 / 10	Down	Stable
	4540-02(F)	mg/L	1 / 19	0 / 10	0.003	0.00069	ND	ND	0.015	0 / 19	0 / 10	0 / 19	0 / 10	Stable	--
Methylene chloride	4539-08	mg/L	1 / 18	0 / 10	0.002	**0.005**	ND	ND	0.005	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--
Nickel	4539-02	mg/L	21 / 21	10 / 10	--	**0.157**	**0.157**	0.005	0.1	2 / 21	2 / 10	2 / 21	2 / 10	No trend	No trend
	4539-02(F)	mg/L	16 / 20	9 / 10	0.01	0.005	0.005	0.002	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	Stable
Selenium	4539-01	mg/L	6 / 19	3 / 10	0.006	**0.228**	0.025	0.025	0.05	2 / 19	0 / 10	2 / 19	0 / 10	No trend	No trend
	4539-01(F)	mg/L	6 / 20	2 / 10	0.12	**0.249**	0.028	0.028	0.05	2 / 20	0 / 10	2 / 20	0 / 10	No trend	No trend
	4540-01	mg/L	8 / 19	4 / 10	0.006	**0.167**	0.014	0.014	0.05	3 / 19	0 / 10	4 / 19	0 / 10	No trend	No trend
	4540-01(F)	mg/L	7 / 19	2 / 10	0.006	**0.245**	0.014	ND	0.05	3 / 19	0 / 10	4 / 19	0 / 10	Down	No trend
	4542-01	mg/L	6 / 19	3 / 11	0.006	**0.241**	0.026	0.026	0.05	2 / 19	0 / 11	2 / 19	0 / 11	No trend	No trend
	4542-01(F)	mg/L	7 / 18	4 / 10	0.006	**0.223**	0.031	0.031	0.05	2 / 18	0 / 10	2 / 18	0 / 10	No trend	No trend
	4542-02	mg/L	7 / 18	3 / 10	0.006	**0.235**	0.027	0.027	0.05	2 / 18	0 / 10	2 / 18	0 / 10	No trend	No trend
	4542-02(F)	mg/L	7 / 18	2 / 10	0.006	**0.124**	0.027	0.027	0.05	1 / 18	0 / 10	1 / 18	0 / 10	No trend	No trend
Strontium-90	4537-01	pCi/L	3 / 15	2 / 10	3.17	**27.9**	3.37	0.201	8	1 / 15	0 / 10	1 / 15	0 / 10	No trend	No trend
	4537-02	pCi/L	4 / 16	1 / 10	4.4	**10.2**	1.1	1.1	8	1 / 16	0 / 10	1 / 16	0 / 10	No trend	No trend
	4539-03	pCi/L	1 / 15	1 / 10	5	**13.2**	**13.2**	ND	8	1 / 15	1 / 10	1 / 15	1 / 10	No trend	No trend
	4542-01	pCi/L	1 / 18	1 / 10	3.94	**9.84**	**9.84**	**9.84**	8	1 / 18	1 / 10	1 / 18	1 / 10	No trend	No trend
	4542-02	pCi/L	2 / 18	1 / 10	4.2	6.77	4.92	4.92	8	0 / 18	0 / 10	1 / 18	0 / 10	No trend	No trend
Thallium	4538-02	mg/L	9 / 15	7 / 10	6.0E-04	**0.003**	0.002	0.00074	0.002	1 / 15	0 / 10	2 / 15	1 / 10	No trend	No trend
	4538-02(F)	mg/L	1 / 15	1 / 10	6.0E-04	0.001	0.001	ND	0.002	0 / 15	0 / 10	0 / 15	0 / 10	No trend	No trend
	4539-01	mg/L	3 / 19	2 / 10	0.003	**0.007**	0.001	ND	0.002	1 / 19	0 / 10	1 / 19	0 / 10	No trend	No trend
	4539-01(F)	mg/L	0 / 19	0 / 10	0.003	ND	ND	ND	0.002	0 / 19	0 / 10	0 / 19	0 / 10	--	--
	4539-02	mg/L	3 / 21	3 / 10	0.006	**0.002**	**0.002**	ND	0.002	0 / 21	0 / 10	1 / 21	1 / 10	No trend	No trend
	4539-02(F)	mg/L	0 / 20	0 / 10	0.001	ND	ND	ND	0.002	0 / 20	0 / 10	0 / 20	0 / 10	--	--
	4542-03	mg/L	1 / 15	0 / 10	6.0E-04	**0.011**	ND	ND	0.002	1 / 15	0 / 10	1 / 15	0 / 10	No trend	--
	4542-03(F)	mg/L	2 / 15	1 / 10	0.012	0.011	0.008	ND	0.05	0 / 15	0 / 10	0 / 15	0 / 10	Stable	Stable

Table 3.12. Summary of MV onsite exit pathway wells M-K trend evaluations (cont.)

Chemical	Well	Units	Freq. of detection[a]		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. > MCL[a,c]		Freq. > 80% of MCL[a,c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Total Radium Alpha	4538-02	pCi/L	15 / 15	10 / 10	--	4.25	2.3	1.18	5	0 / 15	0 / 10	2 / 15	0 / 10	Down	Stable
	4538-04	pCi/L	4 / 17	2 / 11	0.495	**65.2**	0.321	0.321	5	1 / 17	0 / 11	1 / 17	0 / 11	No trend	No trend
	4539-01	pCi/L	17 / 19	9 / 10	38.8	**9.13**	**9.13**	3.78	5	3 / 19	2 / 10	4 / 19	3 / 10	No trend	No trend
	4539-02	pCi/L	18 / 21	9 / 10	41.9	**5.5**	**5.5**	0.862	5	1 / 21	1 / 10	4 / 21	4 / 10	No trend	No trend
	4539-04	pCi/L	16 / 19	10 / 10	44	**8.52**	**8.52**	**8.52**	5	1 / 19	1 / 10	1 / 19	1 / 10	No trend	No trend
	4540-01	pCi/L	19 / 19	10 / 10	--	**20.6**	**20.6**	**20.6**	5	15 / 19	9 / 10	16 / 19	9 / 10	Up	No trend
	4540-02	pCi/L	12 / 19	3 / 10	0.495	**5.02**	0.388	ND	5	1 / 19	0 / 10	1 / 19	0 / 10	Down	Stable
	4541-01	pCi/L	11 / 14	7 / 9	47.8	**5.65**	**5.65**	ND	5	1 / 14	1 / 9	1 / 14	1 / 9	No trend	Down
	4542-01	pCi/L	18 / 18	10 / 10	--	**16.3**	**16.3**	**16.3**	5	10 / 18	6 / 10	11 / 18	7 / 10	No trend	No trend
	4542-02	pCi/L	18 / 18	10 / 10	--	**15.9**	**15.9**	**11.2**	5	9 / 18	6 / 10	9 / 18	6 / 10	No trend	No trend
Trichloroethene	4537-03	mg/L	1 / 15	0 / 10	3.3E-04	0.113	ND	ND	0.005	**1 / 15**	0 / 10	**1 / 15**	0 / 10	No trend	--
	4539-02	mg/L	2 / 19	0 / 10	3.3E-04	**0.007**	ND	ND	0.005	1 / 19	0 / 10	1 / 19	0 / 10	No trend	--
	4539-08	mg/L	1 / 18	0 / 10	3.3E-04	**0.031**	ND	ND	0.005	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--
	4541-02	mg/L	1 / 18	0 / 10	3.3E-04	**0.04**	ND	ND	0.005	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--
Vinyl chloride	4537-03	mg/L	1 / 15	0 / 10	3.3E-04	0.007	ND	ND	0.002	**1 / 15**	0 / 10	**1 / 15**	0 / 10	No trend	--
	4541-02	mg/L	2 / 18	0 / 10	5.0E-04	**0.003**	ND	ND	0.002	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--

[a]Regular and field duplicate samples collected on different dates were treated as two separate samples.

[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[c]MCL or MCL-DC as of May 2018.

[d]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL-DC = maximum contaminant level derived concentration (tritium MCL-DC = 20,000 pCi/L and Sr-90 MCL-DC = 8 pCi/L)
MCL = maximum contaminant level
M-K = Mann-Kendall
MV = Melton Valley
ND = not detected

Barium occurs at high concentrations in the naturally occurring geologic brine fluid that is present deeper than elevations of 200 – 250 ft aMSL (approximately 450 – 500 ft below Clinch River elevation) beneath the MV area. Barium concentrations greater than the 2 mg/L MCL are seen in the deepest sample zones near the central and southern MV (wells 4539-01, 4539-02, 4540-01, and 4542-01). Barium concentrations in these deep sampling zones have gradually increased over time as the highly saline groundwater has displaced lower dissolved solids drilling-related water in the well bores. Barium concentrations in the field filtered sample aliquots from these sample zones are typically nearly the same as levels in the unfiltered aliquots with the exception of levels in 4539-02 where the field filtered aliquots exhibit much lower barium concentrations than in the unfiltered aliquots.

Benzene is a constituent of petroleum hydrocarbons including crude oil and many refined petroleum fuel products. Benzene is also a solvent that is frequently used in laboratory and chemical processes. Small quantities of crude oil have been encountered in bedrock core drilling at ORNL in BV and benzene is sometimes detectable in groundwater in deep bedrock wells elsewhere on the ORR. Benzene has been detected at a concentration equal to its 0.005 mg/L MCL at well 4540-02 within the past 10 years was not detected in the past five years. The FY 2018 maximum detected benzene concentration was 0.004 mg/L and no statistically significant trend is determined for benzene in Westbay® sample zone 4540-02.

Beryllium is detected in 13 of 21 unfiltered samples over the past 10 years and in seven of 10 samples in the past five years from Westbay® zone 4539-02. Beryllium is not detected in the field filtered sample aliquots which indicates that beryllium is associated with filterable solids in the samples. The 0.004 mg/L MCL concentrations has been exceeded twice in the past five years and its maximum detected concentration was 0.005 mg/L. In FY 2018, beryllium was detected in one of four unfiltered sample aliquots from 4539-02 and was not detected in any of the four filtered aliquots. Although beryllium is frequently present in sample zone 4539-02 there is not a statistically significant trend assigned.

Chromium has been detected in all unfiltered samples from Westbay® zone 4538-02 and at 4539-02 chromium has been detected in 19 of 21 samples within the past 10 years and in nine of 10 samples collected within the past five years. At well 4538-02 the chromium trend is assigned as stable while at 4539-02 no statistically significant trend is assigned. Chromium has not been detected in the field filtered sample aliquots indicating that it is associated with filterable solids in the samples.

Fluoride has exceeded 80% of its 4 mg/L MCL at 20 sample locations in the MV onsite exit pathway groundwater monitoring network within the past 10 years. Fluoride concentrations have been relatively constant over time as determined by trend evaluations for the past five years of groundwater monitoring. Of the 20 sample locations that exceeded 80% of the fluoride MCL, 12 locations are assigned stable trends, seven locations have no statistically significant trend, and one location has a decreasing trend.

Lead has been detected at greater than 80% of its 0.015 mg/L screening level in unfiltered sample aliquots at three locations in the MV onsite exit pathway monitoring network – 4538-02, 4539-02, and 4540-02. These three sample locations are all positioned near the interface between deep, saline groundwater and the fresher overlying groundwater zone. Similar to some of the other regulated metals, lead has not been detected above 80% of its MCL in the field filtered sample aliquots from these locations indicating that lead is associated with filterable solids in the groundwater samples. During FY 2018, no samples had lead concentrations of 80% of the MCL and trend assignments for these sample locations showed decreasing trends at 4538-02 and 4540-02 over the 10-year period with stable trends over the most recent five years. The trend assigned to lead at 4539-02 is stable for both the 10-year and 5-year evaluation periods.

Methylene chloride was detected one time within the past 10 years and prior to the most recent five years at location 4539-08 with a concentration equal to its 0.005 mg/L MCL. There have been no subsequent detections and trend evaluation cannot be conducted on a single result.

Nickel is always present in unfiltered samples collected at monitoring location 4539-02 although it has not been detected in the field filtered sample aliquots above 80% of its MCL. Two sample results for nickel have exceeded its 80% of its 0.1 mg/L state of Tennessee water quality standard. Although nickel is always present in the unfiltered samples at sample location 4539-02, its concentration variability is large enough to prevent assignment of a statistically significant trend to its data history.

As an indication of the presence and concentration of radium in groundwater in the MV onsite exit pathway, DOE analyzes for total radium alpha activity. Total radium alpha activity has exceeded 80% of its 5 pCi/L MCL in 10 of the MV onsite exit pathway monitoring network wells. Radium is a natural constituent of bedrock and is also present at elevated concentrations (hundreds of pCi/L) in the deep geologic brine fluids. Because of its geochemical characteristics and its association with the deep, saline groundwater, radium is often seen at concentrations approaching or exceeding the MCL level in deeper sampling zones where chloride, barium, and other alkaline earth metals are present at higher concentrations. Although the total radium alpha concentrations measured in FY 2018 are generally lower than the 10-year and 5-year maximum concentrations, no statistically significant trend is assigned to the datasets for seven of the 10 wells, two of the wells have stable trends, and one well has a decreasing total radium alpha concentration trend.

Three sample locations in the MV onsite exit pathway monitoring network have exhibited selenium concentrations greater than 80% of the 0.05 mg/L MCL within the past 10 years – 4539-01, 4540-01, and 4542-01. All three of these locations are deep sample zones where groundwater is in the geochemical transition zone between the deep saline groundwater and the overlying fresher groundwater. Although selenium continues to be detectable, no sample results have been as high as 80% of the MCL within the past five years and no statistically significant trend can be assigned to the data at either the 10-year or 5-year evaluation periods.

Strontium-90 has been detected at concentrations greater than 80% of its 8 pCi/L MCL-DC at five locations in the MV onsite exit pathway monitoring network – 4537-01, 4537-02, 4539-03, 4542-01, and 4542-02. These sample locations are all relatively deep although their groundwater geochemistries vary. Sr-90 detections in the MV Exit Pathway have been rather sporadic both spatially and temporally as suggested by the low detection frequencies shown in Table 3.12. Given this sporadic detection characteristic, no statistically significant trends are assigned to the Sr-90 behavior.

Thallium has been detected at concentrations greater than its 0.001 mg/L MCL in unfiltered sample aliquots at four monitoring locations – 4538-02, 4539-01, 4539-02, and 4542-03. Thallium is generally not detected in the field filtered aliquots from the these locations which indicates that the thallium is associated with filterable suspended solids in the groundwater. The thallium detection frequencies are relatively low except at 4538-02 (nine of 15 samples over 10 years and seven of 10 samples over the most recent five years) and the number of exceedances of the 80% MCL level is lower. No statistically significant trend is assigned to the thallium data histories.

TCE and VC both have very low detection frequencies (maximum of two of 19 and two of 18 samples, respectively). No detections of these contaminants have occurred within the past five years and no trends are assigned because of such a sparse detection history.

MV Offsite Exit Pathway Data Trends

Data screening and trend evaluations for samples collected in the MV offsite exit pathway offsite monitoring network are summarized in Table 3.13. The constituents that have exceeded the 80% of MCL screening criteria in the offsite wells are very similar to those detected onsite with the differences being detections of antimony, cadmium, cis-1,2-DCE, and uranium at higher concentrations offsite than onsite.

The two deepest sample zones offsite (OMW-1D and OMW-2D) both exhibit alpha activities greater than 80% of the 15 pCi/L MCL. At OMW-1D an increasing trend is assigned for both the 10-year and 5-year evaluation periods. At well OMW-2D an increasing trend was assigned at the 10-year period while no statistically significant trend could be assigned at the 5-year period. The increasing alpha activity trends are thought to be associated with increasing total dissolved constituents in the deep, saline groundwater that is entering the wells during the long recovery process following well construction and well development pumping drawdown.

In contrast to conditions in the onsite exit pathway wells where antimony does not approach the MCL concentration (0.006 mg/L), antimony has exceeded the 80% screening level of its 0.006 mg/L MCL in three offsite monitoring locations – OMW-1D, OMW-2C, and OMW-3C. Antimony detection frequencies have increased in the most recent 5-year period compared to the full 10-year evaluation period, partly as a result of more stringent detection limits in recent years. Antimony trends are mixed with a downward trend followed by a stable trend at OMW-1D and antimony not detected in FY 2018. Antimony is detected in both the unfiltered and field filtered sample aliquots from OMW-2C and OMW-3C above 80% of its MCL which indicates that antimony is present as a dissolved constituent at those locations. At well OMW-2C no statistically significant trend has been assigned at the 10-year and 5-year evaluation periods and maximum detected antimony concentrations have been equal to the 0.006 mg/L MCL in the full 10-year evaluation with maximum values of 0.005 mg/L in the 5-year and FY 2018 data screening results. In OMW-3C, the antimony trend in the 10-year evaluation period was increasing; however, in the 5-year evaluation period antimony was decreasing although the FY 2018 detection of 0.008 mg/L exceeded the MCL.

Arsenic has exceeded 80% of its 0.01 mg/L MCL within the past 10 years at eight of the offsite monitoring locations. Detection frequencies have been high and review of the maximum detected concentrations show decreasing to stable concentrations at the 10-year, 5-year, and FY 2018 periods. Similarly, trend assignments are mostly decreasing to stable or no statistically significant trend assigned.

Barium, which is associated with deep, saline groundwater has exhibited increasing trends in the deepest offsite monitoring locations – OMW-1D and OMW-2D. The reason that these wells exhibit the increasing trends for barium is because the wells have are completed in very low permeability, deep bedrock. Permeability is so low that full recovery of the groundwater levels to stable conditions has not occurred although the wells were completed in 2011. Chloride and sodium concentrations have gradually increased during the very slow inflow of deep saline groundwater into these wells.

Benzene is routinely detected in well OMW-2D, and although its highest concentration (0.012 mg/L) occurred longer than five years ago, no statistically significant trend is assigned to its data history.

Beryllium was detected one time between five and 10 years ago at concentrations greater than the 0.004 mg/L MCL in wells OMW-1C and OMW-1D. With only one detection per well no trend can be assigned for beryllium offsite.

Cadmium has been infrequently detected at concentrations greater than the 0.005 mg/L MCL in wells OMW-1C and OMW-1D. With only 1 detection, no trend can be assigned for OMW-1C. In well OMW-1D, cadmium was detected at concentrations greater than 80% of the MCL one time, over five years ago; the five-year trend is stable.

Chromium is relatively frequently detected in wells OMW-1D and OMW-2C although the frequency of detection at concentrations of 80% of the 0.1 mg/L MCL are low. Chromium trends in these wells have been no trend to stable at well OMW-1D, and decreasing to stable at well OMW-2C for the past 10-year and 5-year evaluations periods.

Table 3.13. Summary of MV offsite exit pathway wells M-K trend evaluations

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Alpha activity	OMW-1D	pCi/L	11 / 17	10 / 10	70	**179**	**179**	**131**	15	10 / 17	9 / 10	11 / 17	10 / 10	Up	Up
	OMW-2D	pCi/L	10 / 17	9 / 10	79.4	**69.4**	**69.4**	**49.7**	15	8 / 17	8 / 10	9 / 17	8 / 10	Up	No trend
Antimony	OMW-1D	mg/L	11 / 17	4 / 10	0.01	**0.016**	0.004	ND	0.006	5 / 17	0 / 10	6 / 17	0 / 10	Down	Stable
	OMW-2C	mg/L	16 / 18	9 / 10	0.02	**0.006**	0.005	0.005	0.006	0 / 18	0 / 10	6 / 18	3 / 10	No trend	No trend
	OMW-3C	mg/L	11 / 18	9 / 10	0.003	**0.013**	**0.013**	**0.008**	0.006	9 / 18	9 / 10	9 / 18	9 / 10	Up	Down
Arsenic	OMW-1A	mg/L	18 / 18	10 / 10	--	**0.017**	0.006	0.006	0.01	5 / 18	0 / 10	7 / 18	0 / 10	Down	No trend
	OMW-1B	mg/L	18 / 18	10 / 10	--	**0.023**	**0.023**	**0.02**	0.01	17 / 18	10 / 10	18 / 18	10 / 10	No trend	Stable
	OMW-1C	mg/L	18 / 18	10 / 10	--	**0.011**	**0.011**	**0.011**	0.01	1 / 18	1 / 10	4 / 18	3 / 10	No trend	Stable
	OMW-1D	mg/L	17 / 17	10 / 10	--	**0.028**	0.006	0.002	0.01	4 / 17	0 / 10	4 / 17	0 / 10	Down	Stable
	OMW-2B	mg/L	18 / 18	10 / 10	--	**0.011**	0.006	0.003	0.01	1 / 18	0 / 10	4 / 18	0 / 10	Down	Down
	OMW-2C	mg/L	18 / 18	10 / 10	--	**0.016**	**0.016**	**0.013**	0.01	8 / 18	5 / 10	14 / 18	10 / 10	Up	No trend
	OMW-2D	mg/L	14 / 17	9 / 10	0.005	**0.056**	0.005	0.001	0.01	2 / 17	0 / 10	2 / 17	0 / 10	Down	Down
	RWA-94	mg/L	9 / 16	8 / 10	0.005	0.009	0.009	0.009	0.01	0 / 16	0 / 10	2 / 16	2 / 10	Stable	No trend
Barium	OMW-1D	mg/L	17 / 17	10 / 10	--	**32.6**	**32.6**	**32.6**	2	13 / 17	10 / 10	13 / 17	10 / 10	Up	Up
	OMW-2D	mg/L	17 / 17	10 / 10	--	**52.7**	**52.7**	**52.7**	2	14 / 17	10 / 10	14 / 17	10 / 10	Up	Up
Benzene	OMW-2D	mg/L	15 / 17	9 / 10	3.0E-04	**0.012**	**0.012**	**0.008**	0.005	8 / 17	6 / 10	9 / 17	6 / 10	No trend	No trend
Beryllium	OMW-1C	mg/L	1 / 18	0 / 10	0.001	**0.004**	ND	ND	0.004	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--
	OMW-1D	mg/L	1 / 17	0 / 10	0.002	**0.015**	ND	ND	0.004	1 / 17	0 / 10	1 / 17	0 / 10	No trend	--
Cadmium	OMW-1C	mg/L	1 / 18	0 / 10	0.00030	0.004	ND	ND	0.005	0 / 18	0 / 10	1 / 18	0 / 10	No trend	--
	OMW-1D	mg/L	5 / 17	4 / 10	0.003	**0.016**	0.00096	ND	0.005	1 / 17	0 / 10	1 / 17	0 / 10	No trend	Stable
Chromium	OMW-1D	mg/L	7 / 17	4 / 10	0.02	0.091	0.012	ND	0.1	0 / 17	0 / 10	1 / 17	0 / 10	No trend	Stable
	OMW-2C	mg/L	12 / 18	4 / 10	0.003	0.082	0.004	0.003	0.1	0 / 18	0 / 10	1 / 18	0 / 10	Down	Stable
Cis-1,2-Dichloroethene	OMW-1B	mg/L	1 / 18	0 / 10	0.00033	**0.081**	ND	ND	0.07	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--
Fluoride	OMW-1B	mg/L	18 / 18	10 / 10	--	**6.58**	**6.58**	**5.78**	4	18 / 18	10 / 10	18 / 18	10 / 10	Stable	Stable
	OMW-1C	mg/L	18 / 18	10 / 10	--	**4.25**	**4.25**	3.88	4	2 / 18	2 / 10	17 / 18	10 / 10	No trend	Stable
	OMW-2B	mg/L	18 / 18	10 / 10	--	**7.99**	**7.99**	**7.9**	4	18 / 18	10 / 10	18 / 18	10 / 10	Up	No trend
	OMW-2C	mg/L	18 / 18	10 / 10	--	**4.98**	**4.98**	**4.98**	4	12 / 18	10 / 10	15 / 18	10 / 10	Up	No trend
	OMW-4C	mg/L	18 / 18	10 / 10	--	**4.9**	**4.9**	**4.9**	4	5 / 18	5 / 10	10 / 18	10 / 10	Up	Up

Table 3.13. Summary of MV offsite exit pathway wells M-K trend evaluations (cont.)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Lead	OMW-1C	mg/L	2 / 18	0 / 10	0.002	**0.023**	ND	ND	0.015	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--
	OMW-1D	mg/L	4 / 17	0 / 10	0.005	**0.1**	ND	ND	0.015	1 / 17	0 / 10	1 / 17	0 / 10	No trend	--
Selenium	OMW-2D	mg/L	7 / 17	2 / 10	0.006	**0.05**	0.038	0.038	0.05	0 / 17	0 / 10	1 / 17	0 / 10	No trend	No trend
Thallium	OMW-1C	mg/L	1 / 18	0 / 10	0.001	**0.003**	ND	ND	0.002	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--
	OMW-1D	mg/L	2 / 17	1 / 10	0.005	**0.01**	**0.003**	ND	0.002	2 / 17	1 / 10	2 / 17	1 / 10	No trend	No trend
Total Radium Alpha	OMW-1D	pCi/L	16 / 17	10 / 10	0.551	**25.7**	**25.7**	**16.3**	5	9 / 17	6 / 10	10 / 17	7 / 10	Up	No trend
	OMW-2D	pCi/L	14 / 17	8 / 10	6.44	**15.2**	**15.2**	**15.2**	5	2 / 17	2 / 10	3 / 17	3 / 10	Up	Up
Trichloroethene	OMW-1B	mg/L	1 / 18	0 / 10	0.00033	**0.081**	ND	ND	0.005	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--
Uranium	OMW-1C	mg/L	16 / 18	10 / 10	0.004	0.028	0.002	0.002	0.03	0 / 18	0 / 10	1 / 18	0 / 10	No trend	Up
	OMW-1D	mg/L	4 / 17	0 / 10	0.004	**0.2**	ND	ND	0.03	1 / 17	0 / 10	1 / 17	0 / 10	No trend	--
Vinyl chloride	OMW-1B	mg/L	1 / 18	0 / 10	0.00050	**0.003**	ND	ND	0.002	1 / 18	0 / 10	1 / 18	0 / 10	No trend	--

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[b]MCL or MCL-DC as of May 2018.

[c]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL-DC = maximum contaminant level derived concentration (tritium MCL-DC = 20,000 pCi/L and Sr-90 MCL-DC = 8 pCi/L)
MCL = maximum contaminant level
M-K = Mann-Kendall
MV = Melton Valley
ND = not detected

Cis-1,2-DCE, TCE, and VC were detected one time in a sample from well OMW-1B between five and 10 years ago and no trend is assigned for a single data value results.

Fluoride is nearly always measurable in groundwater and five of the offsite monitoring locations have exhibited fluoride concentrations greater than the 80% of the 4 mg/L MCL. At one well (OMW-4C), with a maximum fluoride concentration of 4.9 mg/L measured in FY 2018, an increasing trend is assigned to fluoride for the 10-year and 5-year evaluation periods. The other wells in this group exhibit stable to no statistically significant trend assignment and FY 2018 maximum fluoride concentrations have ranged from 3.88 to 7.9 mg/L.

Lead was detected twice at well OMW-1C and four times at OMW-1D between five and 10 years ago. One lead value at each location exceeded the MCL concentration of 0.015 mg/L and no statistically significant trend is assigned for either well.

At well OMW-2D, selenium was detected in seven of 17 samples in the 10-year data evaluation period and in two of 10 samples in the most recent 5-year evaluation period. One result exceeded the MCL of 0.05 mg/L and no statistically significant trend is assigned.

Thallium was detected in unfiltered sample aliquots in one of 18 samples from well OMW-1C and in two of 17 samples from well OMW-1D. Thallium is not detected in the field filtered aliquots from these locations which indicates that the thallium is associated with filterable suspended solids in the groundwater. Although all three of these results exceeded the 0.002 mg/L MCL, no trend is assigned to such sparse detections.

Total radium alpha activity is nearly always detected in samples from wells OMW-1D and OMW-2D. Similar to barium, the radium alpha activity is associated with the deep, saline groundwater that continues to be built up in the well during its long term recovery from the well installation process. Total radium alpha trends in both wells was increasing in the 10-year data evaluation. At well OMW-1D the most recent 5-year data evaluation gave a no statistically significant trend assignment while at OMW-2D the most recent 5-year evaluation resulted a continued increasing trend.

Uranium was detected at concentrations greater than 80% of the 0.03 mg/L MCL at wells OMW-1C and OMW-1D in one of 18, and one of 17 samples, respectively. The uranium detection frequency in samples from well OMW-1C is 16 of 18 in the 10-year evaluation and 10 of 10 in the most recent 5-year data evaluation while at OMW-1D the uranium detection frequency as four of 17 in the 10-year evaluation and zero of 10 in the most recent 5-year data evaluation. The maximum uranium concentration in samples from OMW-1C during FY 2018 was 0.002 mg/L and uranium was not detected at OMW-1D during FY 2018. An upward trend assignment was made for uranium at well OMW-1C for the most recent 5-year evaluation based on very low concentrations of uranium in the groundwater.

The offsite MV Exit Pathway monitoring trend summarization shows that for regulated constituents considered to be of natural origin (fluoride, barium, and total radium alpha) there are increasing concentration trends in deep wells that are exhibiting very slow recovery from well installation and well development processes. The other constituents that have exceeded the threshold concentrations of 80% of their respective MCLs exhibit mostly trends with FY 2018 maximum concentrations that are less than their respective MCLs.

3.3.1.2.2.4 PWTC WAC compliance for collected groundwater

Groundwater collected in the downgradient seepage interceptor systems at Seepage Pits and Trenches, SWSA 4, and SWSA 5 is pumped to the equalization tank located at SWSA 4 prior to being pumped via pipeline to the PWTC in BV for treatment. Samples of the collected groundwater are obtained monthly at the equalization tank and analyses include metals, radionuclides, and VOCs. WAC for the PWTC have been developed for radionuclides and metals. The only constituent detected near the PWTC WAC was tritium. The DOE DCS for tritium is 1.9×10^6 pCi/L (DOE-STD-1196-2011) and the average and maximum tritium concentrations measured in FY 2018 in the collected groundwater were about 440,000 and 900,000 pCi/L, respectively, which are lower than the values measured during FY 2017. During FY 2018, none of the monthly samples contained tritium at concentrations greater than the WAC. The highest tritium concentration was measured in September 2018, during the dry late summer season. The portion of the MV groundwater collection system that collects the most tritium is at SWSA 5. The PWTC discharge was compliant with the required discharge limit for tritium in all of the continuous, flow-paced samples collected and analyzed by UT-B at the point of discharge.

3.3.1.2.3 Aquatic biological monitoring

The monitoring of fish and benthic macroinvertebrate communities provides a useful measure of watershed trends and whether MV Interim ROD goals of achieving narrative AWQC and protecting ecological populations are met. Aquatic biological monitoring locations used to gauge the conditions of the MV watershed, as well as their reference sites, are shown on Figure 3.3. As is the case for most watershed units, biological monitoring data in Melton Branch include contaminant accumulation in fish, fish community surveys, and benthic macroinvertebrate surveys. In addition to Melton Branch, fish and benthic macroinvertebrate monitoring results include a site in WOC just downstream of the Melton Branch confluence (WCK 2.3). WOL fish bioaccumulation data are discussed in Chapter 2 so that spatial trends in WOC can be evaluated.

Redbreast sunfish were collected from lower Melton Branch kilometer (MEK) 0.2 and fillets were analyzed for mercury, PCBs, metals, and Cs-137. Mean (± standard error [SE]) mercury concentrations in these fish remained similar to those seen in 2017 (average 0.14 ± 0.02 µg/g), below the EPA-recommended AWQC (0.3 µg/g mercury in fish) but higher than typical of reference site concentrations in this species. PCB concentrations were below detection limits, similar to the Hinds Creek reference site. As expected, most metals (arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, and thallium) were below detection limits or at levels similar to those in fish from the Hinds Creek reference site. Cs-137 was not detected in sunfish samples from MEK 0.2.

Monitoring in Melton Branch and WOC downstream of the Melton Branch confluence continues to indicate negative impacts to fish communities relative to uncontaminated sites, but most stream sites are much improved relative to their ecological status in the mid-1980s (Figures 3.22 and 3.23). Both Melton Branch sites remained stable in regard to fish diversity in 2017 – 2018 compared with 2016 – 2017 results. After a period of mostly stable numbers of fish species, some improvement in diversity has occurred at the downstream sites as a result of a fish introduction program in 2008 – 2012 and 2014. Two darter species and an additional minnow species are now routinely found in Melton Branch contributing to historically high species richness values at both the lower and upper Melton Branch sites. In addition, four or five of the introduced fish species are regularly found at the lowest WOC site, WCK 2.3. In recent collections, an increased number of juvenile fish from introduced species has been observed, indicating their continued colonization of the watershed. The apparent success of these introduced sensitive species is additional evidence that water quality in MV has improved since the 1980s.

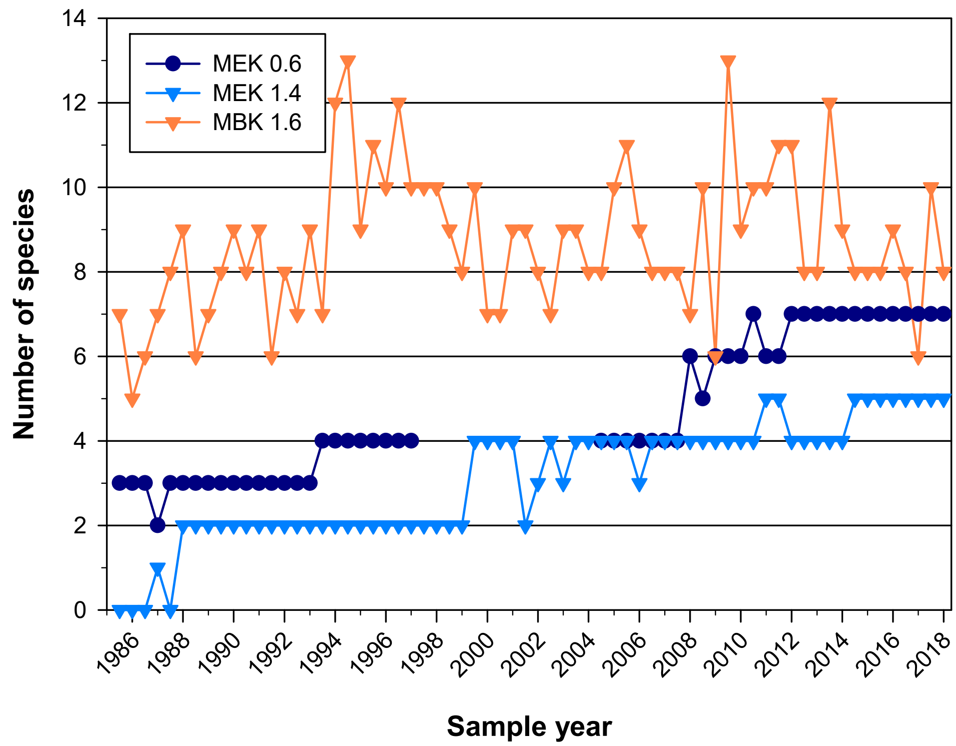


Figure 3.22. Species richness (number of species) in samples of the fish community in Melton Branch (MEK) and a reference stream, Mill Branch (MBK), 1985 – 2018.[a]

[a]Symbols not joined by lines show periods when samples were not collected.

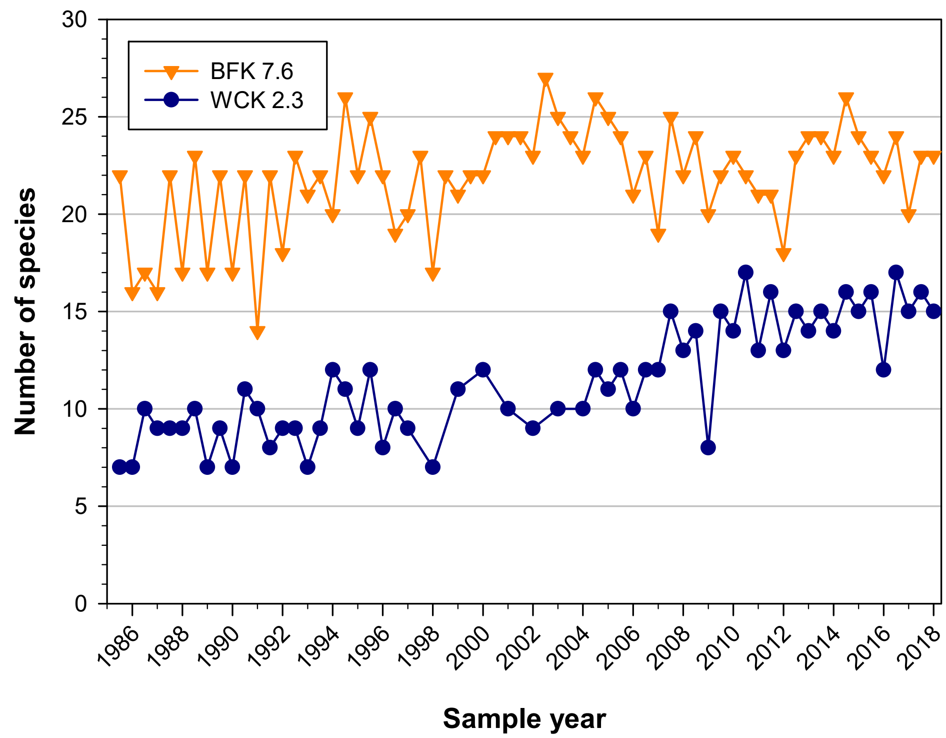


Figure 3.23. Species richness (number of species) in samples of the fish community in lower WOC (WCK 2.3) and a reference stream, Brushy Fork (BFK), 1985 – 2018.

The benthic macroinvertebrate community in Melton Branch (MEK 0.6) and lower WOC (WCK 2.3), as measured by the number of pollution-intolerant taxa (i.e., EPT taxa richness), remains moderately degraded relative to a similar sized reference site and the headwater site in WOC (MBK 1.6 and WCK 6.8, respectively). At WCK 2.3, EPT richness was as low as 3 – 4 taxa in the late 1980s but improved substantially over the years such that 10 – 15 EPT taxa were observed on a regular basis between 2002 – 2013. Over the last three years, EPT taxa numbers at WCK 2.3 were in the 5-7 range, similar to the 1990s. Similarly, the macroinvertebrate community in lower Melton Branch (MEK 0.6) has also shown improvement since the 1980s, with the number of pollution intolerant taxa peaking in the 2006 – 2010 time-period and declining since then. The 2017 EPT numbers at MEK 0.6 were substantially lower than previous years and are comparable to the number of EPT observed at that site in the early 1990s (Figure 3.24). The reasons for the apparent declines in pollution-intolerant taxa in recent years is unknown.

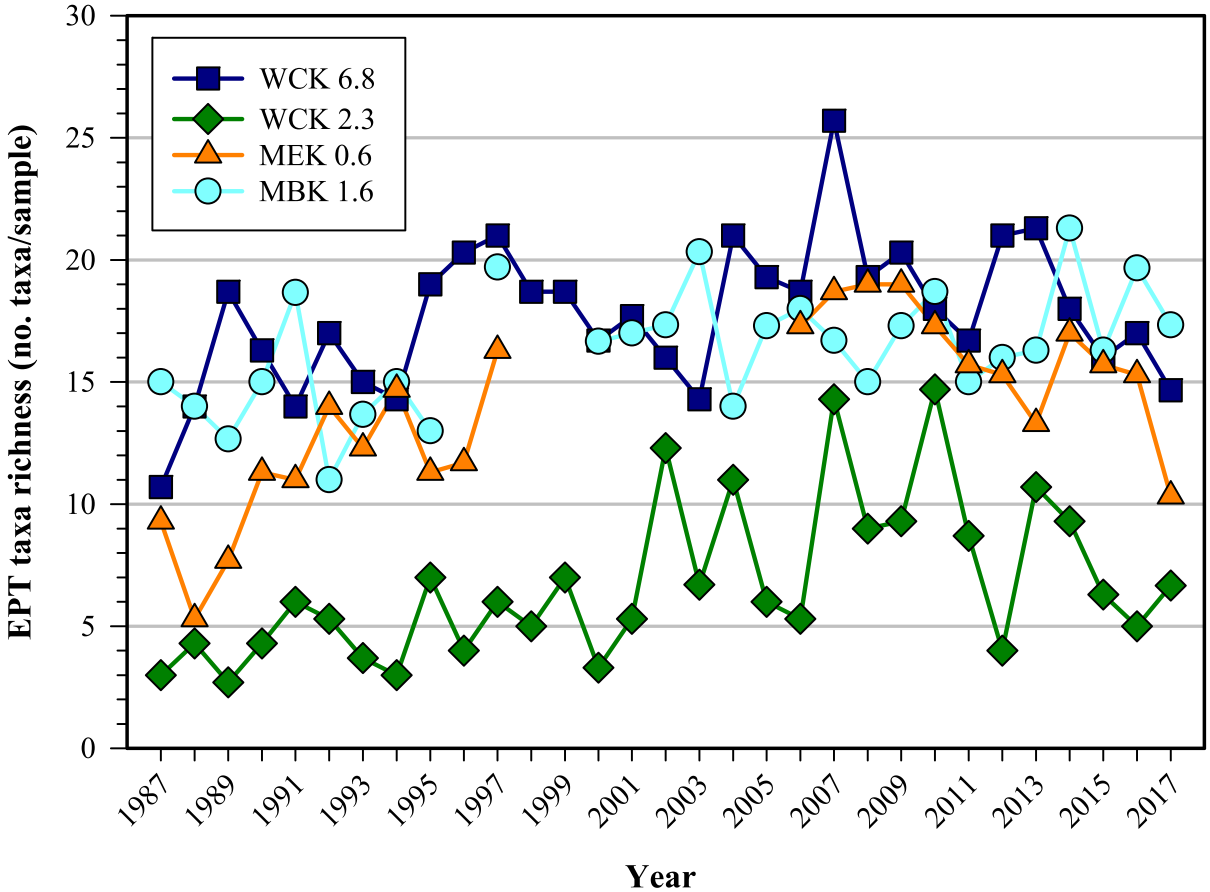


Figure 3.24. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate communities in lower WOC (WCK 2.3), lower Melton Branch (MEK 0.6), and reference sites in upper WOC (WCK 6.8) and Mill Branch (MBK 1.6), April sampling periods, 1987 – 2017.[a,b]

[a]WOC watershed invertebrates are processed in the FY following collection thus samples collected in spring of 2017 have not yet been processed.

[b]Symbols not joined by lines show periods when samples were not collected.

3.3.2 LUCs

LUCs for MV watershed actions are listed in Table 3.14 and described below.

The MV Interim ROD requires LUCs to protect against unacceptable exposures to contamination during and after remediation (Table 3.14). Following the completion of the required remedial activities, affected area LUCs were imposed that will remain in effect until final LUCs are established in future, final remedial decisions. The following excerpts (italicized) from the MV Interim ROD provide the LUC objectives necessary to ensure the protectiveness of the selected remedy:

- ***Industrial area****: prevent unauthorized access to or use of groundwater, control excavations, or penetrations below prescribed contamination cleanup depths; prevent unauthorized access; and preclude uses of the area that are inconsistent with the LUCs.*

- ***Waste management area****: prevent unauthorized access to or use of groundwater; prevent unauthorized contact, removal, or excavation of source material; prevent unauthorized access; and preclude alternate uses of the area (e.g., additional waste disposal or development).*

- ***Surface water and floodplain area****: prevent unauthorized access to surface water, sediment, floodplain soils, or underlying groundwater; prevent fish consumption; and preclude uses of the media that are inconsistent with LUCs.*

Table 3.14. LUCs for the MV watershed

LUCs[a] – Watershed-scale requirements					
Type of control	**Description of control**	**Controlled industrial area**	**Waste management area**	**Surface water and floodplain area**	**Frequency/ implementation**
Record of Decision for Interim Actions for the Melton Valley Watershed, Oak Ridge National Laboratory, Oak Ridge, Tennessee **(DOE/OR/01-1826&D3)**					
1. DOE land notation (property record restrictions)[b] *A. Land use* *B. Groundwater*	*Restrict use of property by imposing limitations. Prohibit uses of groundwater. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. It was recorded by DOE in accordance with state law at the County Register of Deeds office.*	*DOE land notation will be developed on a Melton Valley-wide basis in accordance with the final approved LUCIP.*	*DOE land notation, including boundary survey plats, will be generated for SWSA 4, SWSA 5 (North and South), SWSA 6 (Caps A - E), and Pits and Trenches (Seepage Pits, Trenches 5 through 7, and 7A Leak Site). No additional unit-specific requirements.*	*DOE land notation will be developed on a Melton Valley-wide basis in accordance with the final approved LUCIP.*	*DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s).*
2. Property record notices[c]	*Provide notice to anyone searching records about the existence and location of a hazardous waste landfill(s) and contaminated areas, and limitations on their use. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. Notice will be provided by DOE Environmental Management to the public. This notice will be supplemented with the DOE land notation after completion of remediation (see above).*	*DOE property record notices will be developed on a Melton Valley-wide basis in accordance with the final approved LUCIP and documented in the RAR. No additional unit-specific requirements.*			*DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s).*

Table 3.14. LUCs for the MV watershed (cont.)

LUCs[a] – Watershed-scale requirements					
Type of control	**Description of control**	**Controlled industrial area**	**Waste management area**	**Surface water and floodplain area**	**Frequency/ implementation**
3. Zoning notices[d]	*Provide notice to City Planning Commission about the existence and location of hazardous waste landfill(s) and/or PTSM contamination areas and providing use limitations information for zoning/planning purposes if/when MV areas are transferred out of DOE federal control.*	*The ORR including Melton Valley wide area is currently zoned as a federal controlled industrial/research (FIR) area with the City Planning Commission. Zoning notices, use limitations information, and boundary survey plat will be filed with the City Planning Commission if/when areas are to be transferred out of DOE federal control.*	*RCRA Subtitle C hazardous waste landfill(s) Property Record notice(s) will be filed according to TDEC Chapter 1200-1-11.05 and/or 1200-1-11.06*[e] *with the City Planning Commission. Zoning notice, use limitations information, and boundary survey plat will be filed with the City Planning Commission if/when areas are to be transferred out of DOE federal control.*	*The ORR including the Melton Valley floodplain area is currently zoned as a federal controlled industrial/research (FIR) area with the City Planning Commission. Zoning notices, use limitations information, and boundary survey plat will be filed with the City Planning Commission if/when areas are to be transferred out of DOE federal control.*	*DOE official (or its contractors) will verify no less than annually that information is properly maintained with the City Planning Commission.*
4. EPP program[f]	*Provide notice to worker/developer on the extent of contamination and prohibit or limit excavation/penetration activity. As long as the property remains under DOE control, including transferred property, it remains subject to the EPP program. Implemented by DOE and its contractors; initiated by permit request.*	*Existing DOE/Contractor EPP program remains in effect to provide worker protection.*			*DOE official (or its contractors) will verify no less than annually the functioning of permit program against existing procedure*
5. State advisories postings[g] *(e.g., no fishing or contact advisory)*	*Provide notice to resource users of contamination and risks associated with uses. Duration is indefinite, or until use conditions change as determined by the state. Although not a requirement, advisories and postings may be established by TDEC in the future.*	*Not applicable to controlled industrial areas or waste management areas.*		*Applicable to White Oak Lake and the White Oak Creek Embayment*	*DOE official (or its contractors) will conduct field survey no less than annually and assess signs condition (i.e., remain intact, erect, and legible)* *DOE official (or its contractors) will verify no less than annually information with Tennessee Wildlife Resources Agency official*

Table 3.14. LUCs for the MV watershed (cont.)

LUCs[a] – Watershed-scale requirements					
Type of control	**Description of control**	**Controlled industrial area**	**Waste management area**	**Surface water and floodplain area**	**Frequency/ implementation**
6. Access controls[h] *(e.g., fences, gates, and portals)*	*Control and restrict access to workers and the public to prevent unauthorized uses. Control will last until concentrations of hazardous substances in the environmental media are at levels to allow for unrestricted use and exposure. Maintained by DOE.*	*Access controls are in place in Melton Valley and maintained by DOE.*			*DOE official (or its contractors) will conduct field survey no less than annually of all controls to assess condition (i.e., remain erect, intact, and functioning)*
7. Signs[i]	*Provide notice or warning to prevent unauthorized access. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. Signage maintained by DOE at 20 locations throughout the Melton Valley Watershed near major access points.*	*Signs have been posted on a Melton Valley-wide basis at 20 locations throughout the Melton Valley Watershed near major access points in accordance with the final approved LUCIP. No additional unit-specific requirements.*			*DOE official (or its contractors) will conduct field survey no less than annually of all signs to assess condition (i.e., remain erect, intact, and legible)*
	Provide notice to resource users of contamination and prohibit fishing/contact. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. Signage maintained by DOE at 6 locations around the White Oak Lake and White Oak Creek Embayment at major access points.	*Not applicable to controlled industrial areas or waste management areas.*		*Signs have been posted at 6 of the 20 access locations around White Oak Lake and the White Oak Creek Embayment*	*DOE official (or its contractors) will conduct field survey no less than annually of all signs to assess condition (i.e., remain erect, intact, and legible)*
8. Surveillance patrols	*Control and monitor access by workers/ public. Control will last until the concentrations of hazardous substances in the environmental media are at such levels to allow for unrestricted use and exposure. Established and maintained by DOE.*	*Surveillance patrols will be implemented on a Melton Valley-wide basis in accordance with the final approved LUCIP. No additional unit-specific requirements.*			*DOE official (or its contractors) will verify no less than annually against procedures/plans that routine patrols conducted*

Table 3.14. LUCs for the MV watershed (cont.)

LUCs[a] – Watershed-scale requirements					
Type of control	**Description of control**	**Controlled industrial area**	**Waste management area**	**Surface water and floodplain area**	**Frequency/ implementation**
9. Engineered Remedy[j] (e.g., engineered caps, soil covers, treatment systems)	Remedy maintained by DOE through operations, surveillance, and maintenance. Until the concentration of hazardous substances are at such levels to allow for UU/UE; maintain integrity of the CERCLA remedy until final decision is made.	Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions: SWSA 4, SWSA 5, SWSA 6, Seepage Pits and Trenches Area, WOCE, WAG 13 Cesium Plots, MSRE D&D Uranium Deposit Removal, WOD, MV Groundwater Extraction System.			DOE official (or its contractors) will verify annually that the remedies are being maintained

[a]Source for LUCs # 1-8: *Remedial Action Report for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2343&D1) and 2009 errata. Source of Frequency/Implementation for LUCs # 1-8: *Land Use Control Implementation Plan for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1977&D6).

[b]DOE land notation (property record restriction) – includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with the original property acquisition records of DOE and its predecessor agencies. This DOE land notation may be referred to as property record restrictions in some ORR RODs.

[c]Property Record Notices – includes conditions that inform, restrict, or prohibit certain uses of real property. They serve also to alert anyone searching for property information about residual contamination/waste disposal areas on the property.

[d]Zoning notices – includes information on the location of hazardous waste disposal areas and residual contamination depicted on a survey plat, which is provided to a zoning authority (i.e., the City Planning Commission) for consideration in appropriate zoning decisions for non-DOE property.

[e]Tennessee Code subsequently revised to TDEC Chapter 0400-12-01-.05 and Chapter 0400-12-01-.06.

[f]EPP program – refers to the internal DOE/DOE contractor administrative program(s) that requires the permit requester to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or, in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.

[g]State advisories/postings – refers to health advisory information provided by the TDEC Division of Water Resources related to use or restrictions thereon of surface waters that currently do not meet the designated uses established in Rules of the TDEC Chapter 0400-40-04. Although not required, TDEC may provide advisories and postings in the future. Currently such information is included on signs maintained by DOE that are placed along WOL and WOCE to provide notice to potential users of contamination and prohibit fishing/water contact.

[h]Access controls – physical barriers or restrictions to entry.

[i]Signs – DOE posted command, warning, or direction.

[j]Engineered Remedy is included in this table to be all inclusive of necessary verifications.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
D&D = decontamination and decommissioning
DOE = U.S. Department of Energy
EPP = excavation/penetration permit
FIR = federal controlled industrial/research
LUC = land use control
LUCIP = Land Use Controls Implementation Plan
MSRE = Molten Salt Reactor Experiment
MV = Melton Valley
ORR = Oak Ridge Reservation
PTSM = principal threat source material
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TDEC = Tennessee Department of Environment and Conservation
UU/UE = unlimited use/unrestricted exposure
WAG = Waste Area Grouping
WOCE = White Oak Creek Embayment
WOD = White Oak Dam
WOL = White Oak Lake

The LUCs (property record restrictions [deeds], property record notices, zoning notices, EPP program, state advisories/postings, access controls, signs, and surveillance patrols) are listed in Table 3.14. The implementation and maintenance of these LUCs are specified in the *Land Use Control Implementation Plan for the Melton Valley Watershed, Oak Ridge, Tennessee* (MV LUCIP; DOE/OR/01-1977&D6). Because of the similarity in interim LUC objectives among the three remediation areas, LUC objectives apply throughout the watershed.

Additionally, the engineered remedies are included in Table 3.14 to be all inclusive of necessary verifications. While the completion documents for individual remediation projects within the MV watershed do not require additional LUCs, the hydrologic isolation projects require DOE to ensure the integrity of the 14 separate waste caps. Maintaining the integrity of the caps is addressed in the *Melton Valley Surveillance and Maintenance Plan, Oak Ridge, Tennessee* (DOE/OR/01-2342&D1) that is attached to the MV RAR. Inspections and maintenance of the caps began immediately upon completion and are implemented in accordance with the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC/OR-2288).

3.3.2.1 Status of LUCs

Appendix A contains the Certification of Land Use Control Implementation Fiscal Year 2018. The Manager, DOE OREM, annually verifies in the RER that all approved LUCIPs are being implemented on the ORR. A summary of the implementation verification and status of the MV watershed LUCs follows:

Property record restrictions (deeds)

- There have been no property transfers in MV to date.

Property record notices

- Notice of land use restrictions must be filed in accordance with TN statute *Tennessee Code Annotated* 68-212-225 when an RA includes land use restrictions. Land use restrictions, per the statute, may apply to activities on, over, or under the land, including groundwater and property use. The DOE filed the initial MV Property Record Notice with the Roane County Register of Deeds office on August 21, 2008. It is titled, "Notation on Ownership Record for Notification of Closure of Melton Valley Burial Grounds," and was filed as an Environmental Notation in Book 1290, pages 727 – 748. The Property Record Notice includes the principal contaminants left in place and restrictions on the property. Survey plats for each of the waste units were attached to the Property Record Notice that delineated property that will be restricted in its future use. It was verified in FY 2018 that the 2008 DOE MV Property Record notice remains properly recorded at the Roane County Register of Deeds office. A Final Property Record Notice for the MV Interim ROD Area Restrictions was filed with the Roane County Register of Deeds office on September 30, 2016. This modification to the 2008 notice provided restrictions on groundwater and surface water use.

Zoning notices

- For FY 2018, the areas remain under federal control and no Zoning Notice has been filed to date.

EPP program

The MV Interim ROD requires that an EPP program be in place throughout MV to provide notice to the worker/developer, i.e., permit requestor, on the extent of contamination and to prohibit or limit unauthorized excavation/penetration activity, as appropriate. The MV LUCIP requires a DOE official (or its contractor) to verify no less than annually the functioning of the permit program against existing procedures.

- In FY 2018, there were no excavation permits requested for MV remediation areas.

State advisories/postings

- For FY 2018, a field survey was conducted by the WRRP and the S&M Program that verified signs are maintained by DOE that provide notice to potential users of contamination and prohibit fishing/water contact. These signs were in place, in good condition, and legible.

Access controls

- All major access points remain guarded or locked at all times, and interior gates are selectively locked. Specifically, access is restricted by security portals at the east and west ends of BV road. There also is a locked gate at the junction of the MV Haul Road and the MV Access Road. Perimeter roads around MV have gates that allow access for maintenance activities. Conditions at two locations have changed since 2006; access controls are in place at these locations and meet the intent of the LUC objectives.

Signs

- Signs were in place around the MV watershed and at the WOL and WOCE to provide notice of contamination or warning to prevent unauthorized access. These signs remain in good condition and are legible. Additional signs have been posted at locations around WOL and WOCE and on the Sediment Retention Structure to provide notice to potential resource users of contamination and to prohibit fishing/swimming. In FY 2018, six new signs replaced faded signs on all of the gates at the WOD.

Surveillance patrols

- Patrols may be performed as part of the required, routine S&M site inspections to ensure that incompatible uses have not occurred for units/areas requiring land use restrictions. In FY 2018, surveillance patrols were performed by the ORNL S&M Program as part of routine site inspections and inspections of the capped areas within MV were performed on a semiannual basis. In addition, routine patrols of various areas within MV are performed no less than quarterly.

In addition to implementing the LUCs, i.e., access controls, signs, and surveillance patrols, as detailed above, the S&M Program also performed surveillance of the MV hydrologic isolation areas to inspect components of each of the engineered remedies that are included in Table 3.14.

In FY 2018, inspections were performed semiannually by the S&M Program according to the *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual* (BJC/OR-2288).

Maintenance during FY 2018 included fixing signs and repairing gas vents that became unattached. Some areas of the caps received vegetation control (spraying with herbicides) as needed, and were mowed a minimum of once during the year.

3.4 SINGLE-PROJECT ACTIONS

3.4.1 WOCE Sediment Retention Structure

Location of the WOCE Sediment Retention Structure is shown on Figure 3.1. The scope of this action was the construction of a sediment retention structure at the mouth of WOC to contain the sediments in lower WOCE and minimize contaminant transport offsite to the Clinch River and Watts Bar Reservoir. The Sediment Retention Structure uses rip-rap-filled wire gabions to slow water movement, preventing scour of sediment out of the embayment during changes in WOC flow and fluctuation of Watts Bar Reservoir levels.

3.4.1.1 Remedy integrity

Remedy integrity activities include inspection and maintenance of the sediment retention structure.

3.4.1.2 Status of remedy integrity

The site was inspected monthly in FY 2018 by the S&M Program to check the fence and gate to ensure they were preventing access, inspect the condition of the warning signs, determine if excessive debris or vegetation had built up on the Sediment Retention Structure, and identify any evidence that there had been any movement or shift of the embayment structure. During a storm event in 2017, some of the fencing material covering the rip rap became torn and rolled up. No harm to the embayment structure occurred, but an engineering evaluation was completed that recommended the fencing cover be removed. A work order is in place to complete this recommendation.

3.4.2 WAG 13 Cesium Plots

The location of the WAG 13 Cesium Plots is shown on Figure 3.1. The scope of this action involved excavation of contaminated soil from the plots, placement of a permeable liner in each excavated plot and backfill with clean, compacted fill material and topsoil layer.

3.4.2.1 Remedy integrity

Remedy integrity activities include long-term inspection and maintenance of the fenced enclosure.

3.4.2.2 Status of remedy integrity

The site underwent quarterly inspections in FY 2018 conducted by the S&M Program to verify that all gates to the site were closed and locked, the fence was not damaged, vegetation within the fenced area was cut, vegetation growth along fence line was acceptable, radiological postings were in place, point-of-compliance (POC) signs were in place, and the site was clear of unauthorized materials.

3.4.3 MSRE Uranium Deposit Removal

The location of the MSRE is shown on Figure 3.1. The scope of this action involved the break up and removal of nongranular uranium-laden charcoal and vacuuming of the remaining loose charcoal and chips from the auxiliary charcoal bed to ensure that less than a critical mass remains.

3.4.3.1 Remedy integrity

Remedy integrity activities are specified in the *Removal Action Report for Uranium Deposit Removal at the Molten Salt Reactor Experiment at Oak Ridge National Laboratory, Oak Ridge, Tennessee*

(DOE/OR/01-1918&D2), and include inspection and maintenance for the interim storage of the collector canister holding the uranium-laden charcoal removed from the auxiliary charcoal bed. Specifically, requirements include periodic pressure measurements (daily checks of the pressure gauge and hourly recorder data) and venting of the canister, as necessary, to maintain a pressure of less than 50 psig.

3.4.3.2 Status of remedy integrity

Inspections were conducted daily in FY 2018 of the uranium-laden charcoal canister, in accordance with MSRE procedures. These inspections included periodic pressure measurements and periodic venting of the canister to reduce pressure when needed.

3.4.4 WOD

The location of the WOD is shown on Figure 3.1. The goal of this time-critical removal action was to maintain the containment of contaminated sediment in WOL and improve the stability of the highway embankment that makes up part of WOD.

3.4.4.1 Remedy integrity

The remedy integrity activities associated with the WOD RmAR include periodic inspections by DOE, Federal Emergency Management Agency (FEMA) and Tennessee Department of Transportation (TDOT) to ensure the integrity of the dam and ensure it remains effective. The modifications to WOD completed under this removal action require no active operation or maintenance; the improved armoring of the upstream and downstream slopes of the dam uses stone and large rip-rap that has been designed to perform this function without active maintenance; similarly, the grouted box culvert requires no active operation or maintenance. Periodic inspections will be performed in accordance with FEMA guidelines for dam safety. Dams located on federal property are self-regulated by the federal agency managing that property. DOE regulates all dams on DOE property from DOE Headquarters Office of Corporate Safety Programs. UCOR, an AECOM-led partnership with Jacobs, and its subcontractors have overall responsibility for operating and maintaining the WOD and contiguous property on behalf of DOE OREM, including routine inspections of the WOD to ensure dam safety. The UT-B has responsibilities at the dam for monitoring the water flow and water level, environmental sampling, and for responding to abnormal incidents. The TDOT controls road closure and inspection, operation, and maintenance of the bridge and highway.

The *Management Plan for White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee* (UCOR-4178) delineates responsibilities for the operation, maintenance, routine inspections, and response to abnormal conditions for the WOD and associated facilities, and provides the schedule and content of routine and post-event dam inspections. Routine inspections and maintenance of the WOD include: repairs to fences; maintenance of signage and postings; maintenance of pole-mounted overhead lights at the site; testing, lubrication and maintenance of the lift gates; vegetation control; and any needed repair of any observed subsidence, erosion damage, animal holes, or other damage to the dam surface (except for the roadway pavement which is the responsibility of the state of Tennessee). Special events that require inspections include: overtopping or an event such as an earthquake that exceeds 4.0 on the Moment Magnitude Scale (MMS), a serious vehicle accident on the dam that goes beyond the roadway, and aircraft crash into the dam, a tornado that could have damaged the dam, or high water going onto the roadway (754.8 ft aMSL).

3.4.4.2 Status of remedy integrity

In FY 2018, the site underwent required quarterly inspections by S&M Program craft personnel and annual inspections by the facility manager in accordance with the *Management Plan for White Oak Dam, Oak*

Ridge National Laboratory, Oak Ridge, Tennessee (UCOR-4178). Operations of the WOD gates as specified in the WOD RmAR have been experiencing some operational problems. An evaluation of the gates including their purpose and use was ongoing in FY 2018.

3.5 MV WATERSHED ISSUES AND RECOMMENDATIONS

The issues and recommendations for the MV watershed are in Table 3.15.

Table 3.15. MV watershed issues and recommendations

Issue[a]	Action/recommendation	Responsible parties Primary/support	Target response date
New issue(s)			
See Footnote [b] and the first issue carried forward below.			
Issue(s) carried forward			
1. Two wells in SWSA 4 have chronically not attained the ROD goal for groundwater level control within hydrologically isolated areas. (2015 RER)	1. Two wells in in SWSA 4 (0955 and 0958) have not attained the ROD goal for groundwater level control inside hydrologically isolated areas.[b] Wells 0955 and 0958, which are located near the SWSA 4 DGT, have exhibited recurring exceedances of their target groundwater elevations. During FY 2018, six of the 12 monthly groundwater level measurements at well 0955 exceeded the target elevation goal, and three of the four quarterly groundwater level measurements at well 0958 exceeded their target elevation goal. Beginning in late FY 2015, DOE implemented an enhanced frequency of maintenance and operations inspections of the SWSA 4 downgradient groundwater collection trench, which probably contributes to better overall groundwater level suppression in the collection trench and adjacent areas. Additionally an on-going hydrologic evaluation has been implemented and is ongoing to identify potential additional improvements to SWSA 4 DGT performance continued in FY 2018. This evaluation noted several system enhancements for more continuous operation of the pumps in the DGT; this evaluation is ongoing. These actions are expected to lower groundwater elevations at well 0955 and 0958 to attain the target elevation. It is also recommended that well 0955 have continuous water level readings to further support system evaluation and performance. This issue for wells 0955 and 0958 is carried forward in this RER.	DOE	2020 RER (2036 is the FFA Appendix J date for a MV Final ROD to address groundwater)
2. Groundwater levels at one well located near the western portion of SWSA 4 and two wells located near the center of the SWSA 4 cap exceeded the ROD goal for groundwater level control within hydrologically isolated areas. (2015 RER and 2018 RER)	2. Well 1071 near the western portion of SWSA 4 and wells 4544 and 4545 near the center of the SWSA 4 cap experienced target groundwater elevation exceedances during FY 2018. Well 1071 is screened in bedrock between 784.96 and 800.71 ft aMSL and is located approximately 60 ft inside of the upgradient storm diversion drain which has a bottom elevation of approximately 806 ft aMSL. Based on this construction geometry, the UGT would not be capable of controlling groundwater from the upslope side of Lagoon Road from affecting the groundwater elevation measured at well 1071. Target groundwater elevation exceedances in wells 4544 and 4545 are thought to be related to either hydrologic isolation cap defects or seepage from the upgradient stormflow diversion trench area. DOE is in the process of evaluating groundwater level control at SWSA 4 and will discuss well	DOE	2020 RER (2036 is the FFA Appendix J date for a MV Final ROD to address groundwater)

Table 3.15. MV Watershed issues and recommendations (cont.)

Issue[a]	Action/recommendation	Responsible parties Primary/support	Target response date
	performance with the Project Team. The issues associated with these three wells continue to be an issue in this RER.		
3. Two wells near SWSA 6 have chronically not attained the ROD goal for groundwater level control within hydrologically isolated areas. (2015 RER)	3. Two wells in SWSA 6 (0850 and 4127) have not attained the ROD goal for groundwater level control inside hydrologically isolated areas. Wells 4127 and 0850 have chronically not met target groundwater elevations because of well construction or location conditions. Both of these wells are constructed with the majority of their screened intervals extending into bedrock. These deeper wells are prone to responding to groundwater levels affected by conditions outside the hydrologic isolation area such as groundwater recharge in confined to semi-confined zones that extend beneath the waste units. As a result, these wells are not good indicators of hydrologic isolation effectiveness. DOE samples a number of locations along the edge of SWSA 6 to understand changes in groundwater contaminant conditions following MV Interim ROD RA. Three sampling locations (well 0838, the SFD, and surface water location WAG6 MS3) provide definitive evidence that the SWSA 6 hydrologic isolation remedy is effective. While monitoring and reporting of groundwater levels at wells 4127 and 0850 will continue, it is recommended that alternative performance indicators be used to evaluate the hydrologic isolation effectiveness at SWSA 6. These measures include the continued monitoring of tritium concentrations at 0838, SFD, and WAG6 MS3. This issue is carried forward in this RER and alterative performance indicators will be discussed with the Project Team.	DOE	2020 RER (2036 is the FFA Appendix J date for a MV Final ROD to address groundwater)
Completed/resolved issue(s)			
None			

[a]A "New issue(s)" is an issue identified during evaluation of FY 2018 data for inclusion in the 2019 RER. An "Issue(s) carried forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level. The year in which the issue originated is in parentheses, e.g., (2015 RER).
[b]A The target groundwater exceedances for well 0958 is a new issue identified in this RER.

aMSL = above Mean Sea Level
DGT = downgradient trench
DOE = U.S. Department of Energy
FFA = Federal Facility Agreement
FY = fiscal year
MV = Melton Valley
RA = remedial action
RER = Remediation Effectiveness Report
ROD = Record of Decision
SFD = South French Drain
SWSA = Solid Waste Storage Area
UGT = upgradient trench

3.6 REFERENCES

BJC/OR-2288. *Oak Ridge National Laboratory Surveillance & Maintenance Program Facility Inspection and Training Manual*, 2006, Bechtel Jacobs Company LLC, Oak Ridge, TN.

DOE/OR/01-1546/V1&D2. *Remedial Investigation Report on the Melton Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1826&D3. *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1918&D2. *Removal Action Report for Uranium Deposit Removal at the Molten Salt Reactor Experiment at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2001, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1977&D6. *Land Use Control Implementation Plan for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* 2006, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1982&D3. *Melton Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee,* 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2200&D1/A1. *Addendum to the Waste Handling Plan for the Molten Salt Reactor Experiment Remediation of Secondary Low-Level Waste under the Melton Valley Closure Project at Oak Ridge, National Laboratory, Oak Ridge, Tennessee*, 2014, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2285&D1. *Phased Construction Completion Report for Hydrologic Isolation at Solid Waste Storage Area 6 at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2006, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2342&D1. *Melton Valley Surveillance and Maintenance Plan*, *Oak Ridge, Tennessee,* 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2343&D1. *Remedial Action Report for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* 2009, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2509&D1. *Removal Action Report for the Corrective Actions at White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE-STD-1196-2011. *Derived Concentration Technical Standard*, 2011, U.S. Department of Energy, Washington, D.C.

Helsel, D.R. 2005, *Nondetects and Data Analysis: Statistics for Censored Environmental Data,* John Wiley & Sons, New York, 250 p.

UCOR-4178. *Management Plan for White Oak Dam, Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2012, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

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4. Y-12 – BCV

4.1 INTRODUCTION AND STATUS

4.1.1 Introduction

The BCV watershed is located within the north-central portion of the ORR. It extends from the west end of Y-12 main plant westward to SR 95 and contains closed and active waste disposal facilities. Figure 4.1 shows the locations of CERCLA actions that have required monitoring or LUCs and illustrates ROD-designated end uses in BCV. In subsequent sections, the effectiveness of each completed action is assessed by reviewing performance monitoring objectives and results and verifying LUCs.

Completed CERCLA actions in the BCV watershed are gauged against their respective action-specific goals. However, because all CERCLA actions within BCV have not been completed, monitoring of baseline conditions is conducted against which the effectiveness of the actions can be evaluated in the future. The collected data provides a preliminary evaluation of the early indicators of effectiveness at the watershed-scale.

The Environmental Management Waste Management Facility (EMWMF) is an operating CERCLA waste disposal facility located in the BCV watershed. Operation of the EMWMF is an ongoing CERCLA action to dispose waste from CERCLA response actions on the ORR and associated sites. The status of the EMWMF CERCLA action is not reported in this document but is evaluated in the EMWMF annual PCCR.

Table H.3 in Appendix H lists all completed CERCLA actions in BCV and the corresponding completion documents, and identifies whether monitoring or LUCs are required. Figure H.3 in Appendix H is a location map of the actions and illustrates ROD-designated end uses in BCV. For a complete discussion on background information and performance metrics for each remedy, a compendium of all CERCLA decisions in the watershed within the context of a contaminant release conceptual model is provided in Chapter 8 of Volume 1 of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

4.1.2 Status Update

In May of 2017, DOE requested from TDEC-Division of Solid Waste Management (DSWM) that the re-application of the *RCRA Post-Closure Permit for the Bear Creek Hydrogeologic Regime (*Bear Creek PCP; TNHW-116) be denied and the applicable substantive requirements for post-closure care, monitoring, and reporting for the relevant units be integrated into the CERCLA process. The relevant units associated with the Bear Creek Hydrogeologic Regime include: 1) the Bear Creek Burial Grounds (BCBGs; A-North, A-South, and C-West)/Walk-In Pits, 2) the S-3 Ponds Site, and 3) the Oil Landfarm. The TDEC-DSWM granted the request on February 23, 2018. Substantive requirements for post-closure care and monitoring will be managed in the *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (BCV RAR CMP; DOE/OR/01-2457&D3). Reporting of post-closure care and monitoring are integrated into this 2019 RER and will be captured in the CERCLA FYR, as appropriate. No additional CERCLA actions were implemented or completed during FY 2018.

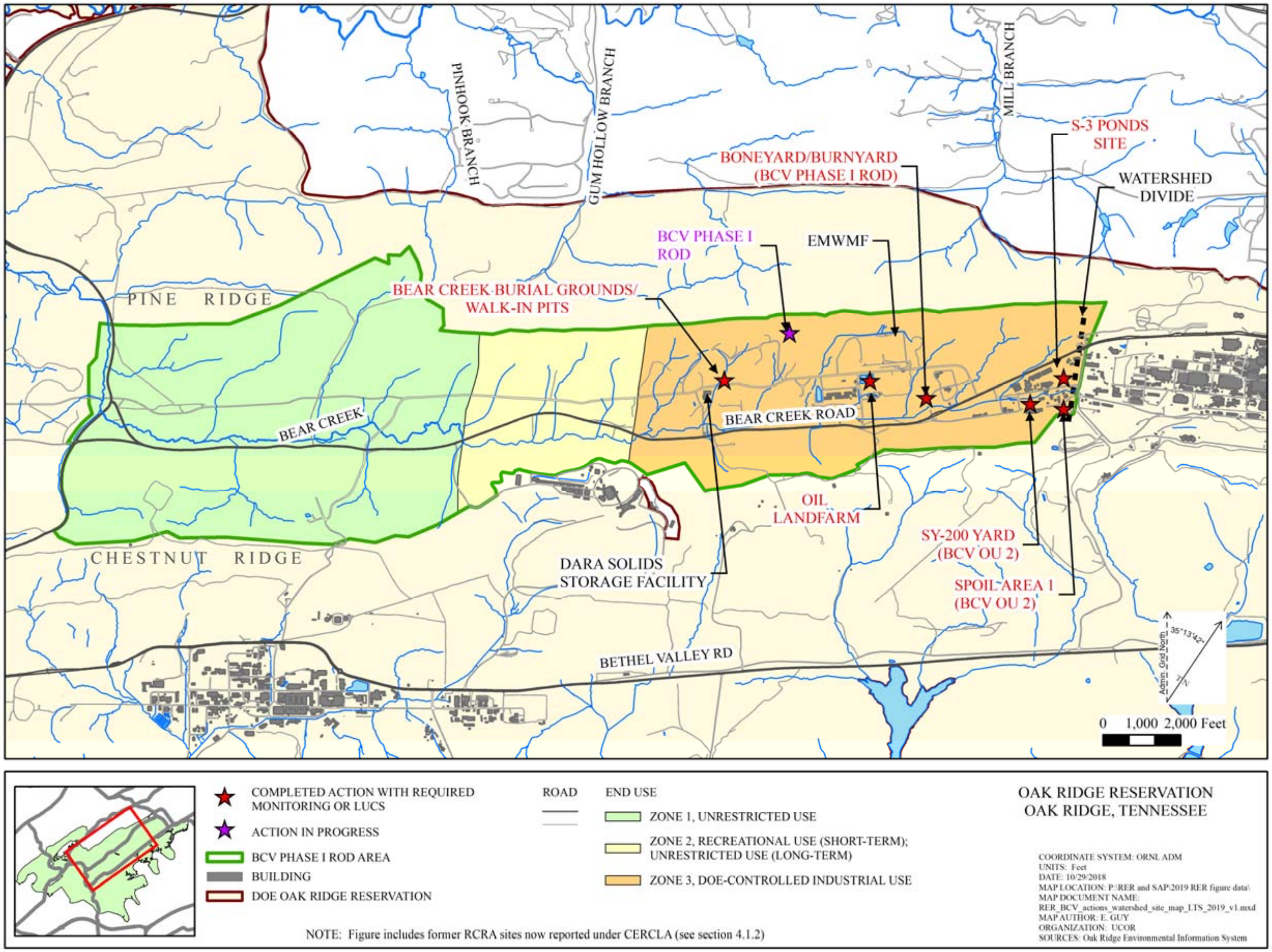

Figure 4.1. Completed CERCLA actions with required monitoring or LUCs in BCV and end uses in BCV.

4.2 ASSESSMENT SUMMARY

A summary of the BCV assessment for FY 2018 is provided below, followed by more detailed evaluations.

4.2.1 Performance Summary

Remediation activities in the BCV Phase I ROD have not been fully implemented. A final ROD for the BCV watershed addressing remaining area soil characterization for hot spot contamination, ecological issues, surface water, and groundwater will be prepared after a decision for the BCBGs has been reached and RAs completed.

- In Zone 1, the goal to maintain clean groundwater and surface water conditions that are compatible with unrestricted use was met.

- Uranium discharges in Bear Creek from Zone 3 exceeded the ROD goals for annual flux and average U-238 concentration. The ROD goal for annual uranium flux measured at the Zone 3 IP (BCK 9.2) is 34 kg/yr and during FY 2018 the measured uranium discharge was 91.7 kg. During FY 2018, the measured average U-234 and U-235 concentrations were less than their respective goals, however the average U-238 concentration was 14.4 pCi/L which is approximately twice the ROD goal for human health protectiveness. Approximately 52% of the uranium discharged in Bear Creek a the Zone 3 IP originates as groundwater seepage into the headwater of North Tributary (NT)-8 at the western end of the BCBG. The surface water goals for uranium not being met in NT-8, and consequently at Bear Creek kilometer (BCK) 9.2, the IP, is an RER issue carried forward from the 2016 RER (Table 4.14). This issue will continue to exist until a future source control ROD for the BCBGs and implementation of a remedy address the contamination source.

- Cadmium discharges into the Bear Creek headwaters near the S-3 Ponds consistently exceed the 0.25 µg/L AWQC at sample locations NT-1 and BCK 12.34. The surface water goals not being met for cadmium near the S-3 Ponds is an RER issue carried forward from the 2016 RER (Table 4.14). Future prioritization and sequencing of an RA for S-3 Ponds Pathway 3 as stipulated by the BCV Phase I ROD will address the issue.

- During FY 2018, the Boneyard/Burnyard (BYBY) remedy met its performance goal of <4.3 kg of uranium discharge to Bear Creek with a measured uranium flux of approximately 2.8 kg at the mouth of NT-3. Mercury concentrations in NT-3 surface water samples were less than the AWQC level of 51 ng/L, which met the ROD goal.

- Available groundwater monitoring results suggest that groundwater quality in Zone 2 partially meets the BCV Phase I ROD goal, although no wells exist either in the Maynardville Limestone to the west of the SS-5 Spring or in the Maryville Limestone/Nolichucky Shale west of NT-8 at depths matching the dense non-aqueous phase liquid (DNAPL) contaminated interval in BCBG in western Zone 3. The ROD goal for Zone 2 is to improve groundwater quality consistent with eventually achieving conditions compatible with unrestricted use.

  — Wells GW-077 through GW-080 show groundwater conditions that meet MCL screening values.

  — At well GW-683 and GW-684, concentrations of uranium isotopes decreased slightly during FY 2018. Wells GW-683 and GW-684 sample groundwater in the nitrate and uranium plume that originates at the S-3 Ponds site.

- M-K trend evaluation of groundwater contaminants in Zone 3 indicate that although many of the contaminants that have exceeded their respective MCL concentrations in the 10-year evaluation and continue to exceed the MCLs in the FY 2018 maximum values, the groundwater conditions have shown gradual improvement over the past decade.

- Mean mercury concentrations in rock bass in Bear Creek at BCK 3.3 and BCK 9.9 are above the EPA recommended fish-based AWQC, and PCBs in rock bass also exceed TDEC guidelines. The EPA recommended fish-based AWQC and TDEC guideline values are not ROD-specified goals but are used as screening levels.

- Cadmium, nickel, uranium, and PCB concentrations in stoneroller minnows in 2018 continued the long-term trend of elevated levels in Bear Creek, especially in the middle to upper sections. Fish and benthic macroinvertebrate communities also reflect a spatial pattern of impairment, with the upper Bear Creek site and NT-3 exhibiting greatest impairment relative to reference conditions. Stream communities are slowly recovering from regional drought in the fall of 2016 with more normal flows in fall of 2017 and spring of 2018.

4.2.2 LUC Protectiveness

All LUCs determined necessary for protection of the environment and/or human health are in place and have been maintained.

4.3 BCV PHASE I ROD

4.3.1 Performance Monitoring

4.3.1.1 Performance goals and monitoring objectives

The remedy in the BCV Phase I ROD includes source control and migration control strategies that reduce contaminant migration in shallow groundwater and surface water. These actions are expected to result in a reduction of contamination levels in groundwater and surface water downstream of the waste areas over time.

Several single-project decisions within BCV watershed predate the BCV Phase I ROD. These earlier actions do not contain specific performance criteria for reduction of contaminant flux or risk reduction at the watershed-scale. The BCV Phase I ROD, a watershed-scale decision, incorporates the preceding single-project actions and sets specific performance standards for contaminant flux and risk reduction for the entire watershed. The BCV Phase I ROD also includes expected outcomes for the selected remedy against which effectiveness of individual actions is measured. The BCV Phase I ROD addresses groundwater and surface water by dividing the valley into three zones and establishing performance standards for each zone in terms of resource uses and risks. Monitoring locations and end-use zones in BCV are shown in Figure 4.2. Contaminant plumes in BCV (courtesy of Y-12 Groundwater Protection Program [GWPP]) are shown in Figure 4.2.

This section presents the remediation goals, performance metrics, and progress toward achieving the goals in the BCV watershed. Annual performance measurements obtained during FY 2018 are presented along with historic monitoring results.

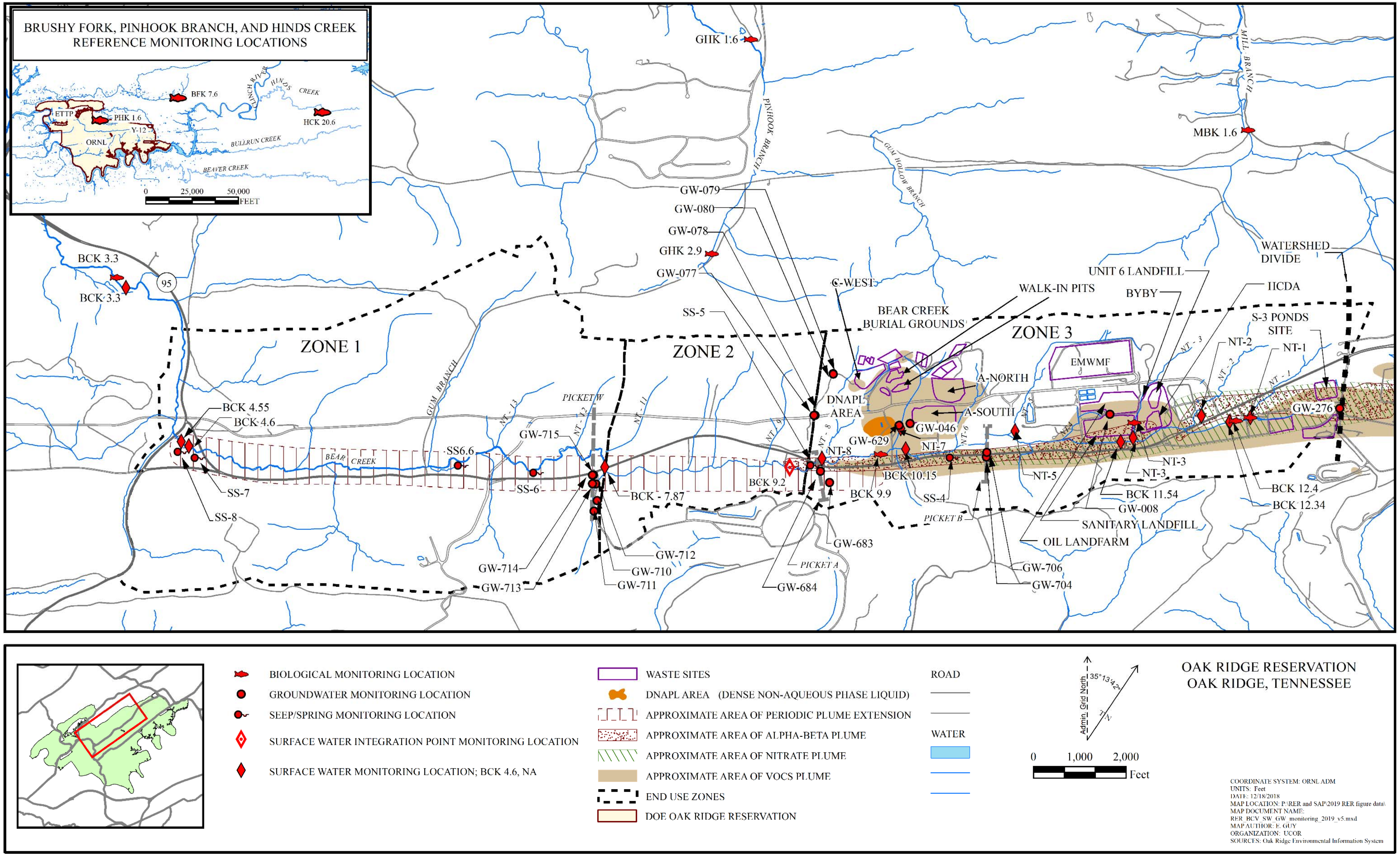

Figure 4.2. Monitoring locations in BCV and associated reference locations.

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The RAOs for the BCV Phase I ROD are to:

- *Protect future residential users of the valley in Zone 1 from risks from exposure to groundwater, surface water, soil, sediment, and waste sources;*
- *Protect a passive recreational user in Zone 2 from unacceptable risks from exposure to surface water and sediment; and*
- *Protect industrial workers and maintenance workers in Zone 3 from unacceptable risks from exposure to soil and waste.*

The three end use zones in the BCV watershed are identified on Figures 4.1 and 4.2. Consistent with the RAOs, the Phase I ROD also establishes water quality goals for each zone, as stated in Table 4.1, although chemical-specific ARAR-based performance criteria are not included for groundwater.

Table 4.1. Groundwater and surface water goals, BCV watershed[a]

***Area of the valley* (see Figure 4.2)**	***Current situation***	***Goal***
Zone 1 – western half of Bear Creek Valley	*No unacceptable risk posed to a resident or a recreational user. AWQC and groundwater MCLs are not exceeded.*	*Maintain clean groundwater and surface water so that this area continues to be acceptable for unrestricted use* *Land use: Unrestricted*
Zone 2 – a 1-mile-wide buffer zone between zones 1 and 3	*No unacceptable risk posed to a recreational user. Risk to a resident is within the acceptable risk range except for a small area of groundwater contamination. Groundwater MCLs are exceeded, but AWQC are not.*	*Improve groundwater and surface water quality in this zone consistent with eventually achieving conditions compatible with unrestricted use* *Land use: recreational (short-term); unrestricted (long-term)*
Zone 3 – eastern half of Bear Creek Valley	*Contains all the disposal areas that pose considerable risk.* *Groundwater MCLs and AWQC are exceeded.*	*Conduct source control actions to (1) achieve AWQC in all surface water, (2) improve conditions in groundwater to allow Zones 1 and 2 to achieve the intended goals, and (3) reduce risk from direct contact to create conditions compatible with future industrial use.* *Land use: controlled industrial*

[a]Source: Table 2.1 of *Record of Decision for the Phase 1 Activities in Bear Creek Valley, Oak Ridge, Tennessee* ([DOE/OR/01-1750&D4] page 2-13).

AWQC = ambient water quality criteria
BCV = Bear Creek Valley
MCL = maximum contaminant level

The BCV RI identified risk to human health and the environment in portions of the watershed due to contaminant releases, particularly in Zone 3. The key risk drivers for human health are uranium and nitrate, and the two largest sources of these contaminants were the BYBY and the S-3 Ponds Site. In addition to the watershed-wide water quality goals, the BCV Phase I ROD provides site-specific water quality goals for the S-3 Ponds Site Pathway 3 and the BYBY actions (Table 4.2).

Table 4.2. Site-specific goals for RAs at the S-3 Ponds Site Pathway 3 and the BYBY[a]

Remedial action goals for S-3 Site Pathway 3[b]	*Remedial action goals for BY/BY*[c]
• *Prevent expansion of the nitrate plume into Zone 1* • Reduce concentration of cadmium in NT-1 and upper Bear Creek to meet AWQC (0.25 µg/L)[d] at Bear Creek/NT-1 confluence • *Prevent future increase in release of uranium to Bear Creek to maintain annual flux below 27.2 kg total Uranium at BCK 12.34* • *Reduce seasonal nitrate flux at NT-1/Bear Creek confluence by 40%. The seasonal nitrate flux benchmark will be defined by the FFA parties in remedial design.*	• *Reduce flux of uranium in NT-3 at confluence with Bear Creek to 4.3 kg/yr* • *Reduce concentration of mercury in NT-3 to meet AWQC (51 ng/L)*[e]

[a]Source: Table 2.2 of *Record of Decision for the Phase 1 Activities in Bear Creek Valley, Oak Ridge, Tennessee* ([DOE/OR/01-1750&D4] page 2-14).

[b]Action not implemented.

[c]Action implemented.

[d]The *Record of Decision for the Phase 1 Activities in Bear Creek Valley, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4) originally established the cadmium concentration performance standard as 3.9 µg/L. This standard changed to 0.25 µg/L due to a change in the promulgated AWQC.

[e]The *Record of Decision for the Phase 1 Activities in Bear Creek Valley, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4) originally established the mercury concentration performance standard as 12 ng/L. This standard changed to 51 ng/L due to a change in the promulgated AWQC.

AWQC = ambient water quality criteria
BCK = Bear Creek kilometer
BYBY = Boneyard/Burnyard
FFA = Federal Facility Agreement
NT = North Tributary
RA = remedial action

The source removal actions related to waste materials and associated impacted soils and sediments and groundwater control actions specified in the BCV Phase I ROD were intended to attain the stated water quality goals. The following components of the selected remedy are listed in the ROD:

- **S-3 Ponds Site.** Install trench at Pathway 3 for passive in situ treatment of shallow groundwater.
- **Oil Landfarm area.** Actions in the Oil Landfarm Area include:
  - — Remove waste stored in Oil Landfarm Soil Containment Pad for disposal and dismantle structure.
  - — Excavate source areas in BYBY and contaminated floodplain soils and sediments and dispose of waste. Install clay cap over uncapped disposal areas at BYBY, and maintain existing caps.
  - — Implement hydraulic isolation measures at BYBY, including reconstruction of NT-3, elimination of stagnation points, and installation of drains or well points.
- **Other** sites. Remove and dispose of waste stored in the Disposal Area Remedial Action (DARA) Solids Storage Facility (SSF) (Figure 4.1 and Figure 4.3) and dismantle structure.

Field implementation of actions under the BCV Phase I ROD was initiated in FY 2000. RAs in the Oil Landfarm Area are complete (BYBY and Oil Landfarm Soil Containment Pad). Other key components of the remedy (S-3 Pathway 3 and DARA SSF) have not yet been implemented. An approved Non-Significant Change (NSC) to the BCV Phase 1 ROD allows approximately 4,000 yd^3 of waste stored at DARA SSF to be disposed at the onsite EMWMF. An early action addressing S-3 Pathways 1 and 2 was terminated. Response actions for all three components (i.e., Pathways 1, 2, and 3) will be included in the future design considerations for Pathway 3 or in the final groundwater decision for BCV.

The ROD included expected outcomes, target risk levels, and timeframes for attainment of goals for each of the BCV watershed end uses (Table 4.3).

Figure 4.3. DARA SSF.

4.3.1.2 Evaluation of performance monitoring data

This section presents the monitoring data that evaluates progress toward meeting the goals of the BCV Phase I ROD. The BCV RAR CMP provides the monitoring requirements for groundwater, surface water, and biological media (e.g., fish and biota surveys) for both CERCLA performance and baseline assessments of trends, regulatory compliance, future actions, and in support of the CERCLA FYR of remedy protectiveness. Performance monitoring locations, parameters, and metrics are outlined in Table 4.4 and are summarized below, as well as other baseline and trend monitoring results.

4.3.1.2.1 Surface water

4.3.1.2.1.1 Surface water quality goals and monitoring requirements

The expected outcomes of the BCV Phase I ROD include AWQC compliance and annual mass (flux) reductions for nitrate and uranium from primary sources of these contaminants throughout the watershed. Surface water sampling for compliance with AWQC is primarily conducted in the year prior to each CERCLA FYR. The most recent evaluation of progress toward meeting AWQC in BCV was reported in the 2016 FYR.

As noted previously, the S-3 Ponds Site is the primary source of nitrate, whereas there are multiple major sources of uranium, including the S-3 Ponds Site, the former BYBY, and the BCBG (primarily via NT-8 inflow into Bear Creek). Reducing the flux from the primary sources of nitrate and uranium will decrease the flux of these contaminants leaving the valley via Bear Creek and will improve surface water and groundwater quality in the BCV watershed. To monitor remedial performance, the Phase I ROD establishes watershed-scale performance criteria (Table 4.1), as well as site-specific flux goals (Table 4.2) for the S-3 Ponds Site and BYBY (flux goals for BCBG are not specified). The Phase I ROD also defines water quality goals for groundwater and surface water in terms of AWQC and MCLs (see Table 4.3) for the various zones, as well as remediated sites.

Monitoring is keyed to the boundaries between the three zones defined in the ROD (Table 4.4). Key surface water monitoring locations include BCK 7.87, BCK 9.2, and BCK 12.34 (Figure 4.2). BCK 7.87 is the monitoring location at the boundary between Zones 1 and 2, and BCK 9.2 is the IP near the border of Zones 2 and 3. BCK 12.34 is located near the Bear Creek headwater and serves as an IP for surface water contaminant discharges from the S-3 Ponds area. Other significant monitoring locations within the watershed include NT-3 and NT-8 (Figure 4.2). NT-3 was historically heavily impacted by contaminant discharges from BYBY which has been remediated, and NT-8 carries runoff and contaminants from the western end of the BCBGs to Bear Creek just a short distance from the western end of Zone 3 and above the IP at BCK 9.2.

Table 4.3. Expected outcome of the selected remedy, BCV watershed[a]

	Zone 1	***Zone 2***	***Zone 3***		
			S-3 Site/Pathway 3	***BYBY/OLF Area***	***BCBGs***
Available land use and time frame	*Unrestricted use (compatible with residential use), available immediately*[b]	*Presently restricted use (compatible with recreational use); compatible with unrestricted use in 50 years*	*Restricted use, long-term waste management area/controlled industrial use*	*Restricted use; long-term waste management area/controlled industrial use*	*N/A*
Available groundwater use and time frame	*Unrestricted use (compatible with residential use) available immediately (MCLs met)*	*Presently restricted use (MCLs not met for nitrates, compatible with recreational use); unrestricted use in 50 years*	*Restricted use*	*Restricted use*	*N/A*
Available surface water use and time frame	*Unrestricted use (compatible with residential use) available immediately (AWQC met)*	*Unrestricted use (compatible with recreational use); available immediately (AWQC met)*	*Recreational use, AWQC met in 5 years following implementation*	*Recreational use, AWQC met in 5 years following implementation*	*N/A*
Cleanup levels, residual risk	- *MCLs in groundwater* - *AWQC in surface water* - *risk to residential receptor below RAO of 1 x* 10^{-5}	- *TBD for groundwater* - *AWQC in surface water* - *risk to residential receptor below RAO of 1 x* 10^{-5}	- *TBD for groundwater* - *AWQC in surface water* - *direct exposure risk to industrial/terrestrial receptors eliminated* - *risk to industrial receptor below RAO of 1 x* 10^{-5} - *Reduce seasonal nitrate flux at the NT-1/Bear Creek confluence by 40%*	- *TBD for groundwater* - *AWQC in surface water* - *risk to industrial receptor below RAO of 1 x* 10^{-5}	*N/A*
Anticipated socioeconomic and community revitalization impacts	*Property will meet conditions for residential/recreational/ industrial use*	*Property will meet conditions compatible with recreational/industrial use*	*Waste area is capped and used as a parking lot to support Y-12 activities; surrounding area available for additional controlled industrial use*	*Area devoted to waste management; proposed on-site disposal facility provides potential to create new jobs*	*N/A*
Anticipated environmental and ecological benefits	*Media not impacted*	*Slightly impacted groundwater will be restored*	*Impacted surface water will be restored*	*Impacted surface water will be restored, capping will protect terrestrial species*	*N/A*

[a]Source: *Record of Decision for the Phase 1 Activities in Bear Creek Valley, Oak Ridge, Tennessee* ([DOE/OR/01-1750&D4] Table 2.22).
[b]*Although the selected remedy will allow unrestricted land use for this zone, there are no plans to transfer ownership of this property.*

Table 4.3. Expected outcome of the selected remedy, BCV watershed[a] (cont.)

AWQC = ambient water quality criteria
BCBG = Bear Creek Burial Ground
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
MCL = maximum contaminant level
N/A = not applicable
NT = North Tributary
OLF = Oil Landfarm
RAO = remedial action objective
TBD = to be determined
Y-12 = Y-12 National Security Complex

Table 4.4. BCV watershed CERCLA performance monitoring[a]

Area/site	Media	Monitoring location	Schedule	Parameters	Performance standard
Zone 1	Biota	BCK 3.3	Semiannual survey and bioaccumulation monitoring	Fish and benthic macroinvertebrate species richness and density; bioaccumulation of mercury, metals (including uranium), and PCBs in stoneroller minnows; bioaccumulation of mercury and PCBs in rock bass	Measure changes in quality of aquatic habitat as compared to reference sites
	Surface water	BCK 4.55	Quarterly grab sample (in year prior to FYR)	Metals, including total and isotopic uranium, and mercury; VOCs; and nitrate[a]	AWQC, risk-based[b]
Zone 1/Zone 2 Boundary (Performance measurement for Zone 1)	Surface water	BCK-07.87	Quarterly grab samples (in year prior to FYR)	Metals, including total and isotopic uranium, and mercury; VOCs; and nitrate[a]	AWQC, risk-based[b]
	Groundwater	GW-712, GW-713, GW-714 (Picket W) SS-6 (spring)	Annual grab samples	Nitrate; metals, including uranium; and VOCs	MCLs, trend monitoring
Zone 2/Zone 3 Boundary – Integration Plane (Performance measurement for Zone 2)	Surface water	IP (BCK 9.2)	Quarterly grab samples (in year prior to FYR)	Metals, including total uranium and mercury; VOCs[a]	AWQC, risk-based[b]
			Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux ≤34 kg/year
			Monthly grab samples	Nitrate	Trend, risk-based[b]
		SS-5 (spring)	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux trend
	Groundwater	GW-683, GW-684 (Picket A)	Semiannual grab samples	Metals (including mercury, cadmium, and total uranium); VOCs, nitrate, isotopic uranium, and gross alpha and beta activity	TBD[c] trend monitoring
		GW-077, GW-078, GW-079, GW-080 (Exit pathway along strike from BCBGs)	Semiannual grab samples	Metals, VOCs, and isotopic uranium	MCLs for screening only
	Biota	BCK 9.9	Semiannual survey and bioaccumulation monitoring	Fish and benthic macroinvertebrate species richness and density; bioaccumulation of mercury, metals (including uranium), and PCBs in stoneroller minnows (whole body)	Measure changes in quality of aquatic habitat as compared to reference sites
			Semiannual monitoring	Toxicity testing	Trend
			Third quarter bioaccumulation monitoring in year prior to FYR	Bioaccumulation of metals, including mercury, and PCBs in invertebrates (preferably caddisflies), and metals and PCBs only in rock bass (fillets)	Measure changes in quality of aquatic habitat as compared to references sites

Table 4.4. BCV watershed CERCLA performance monitoring[a] (cont.)

Area/site	Media	Monitoring location	Schedule	Parameters	Performance standard
Zone 3	Groundwater	GW-704, GW-706 (Picket B)	Semiannual grab samples	Metals, nitrates, VOCs, gross alpha and beta activity, and isotopic uranium	MCLs for screening only
	Surface water	NT-5 (NT-5 H Flume)	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux trend
		NT-7	Monthly grab samples	Uranium (isotopic)	Uranium flux trend
		NT-8	Weekly flow-proportional composite samples	Uranium (isotopic)	Determine relative contribution of the BCBGs to uranium flux at BCK 9.2
			Quarterly grab samples (in year prior to FYR)	Metals, including total uranium and mercury; nitrate; and VOCs	AWQC
S-3 Ponds Site RA	Surface water	BCK 12.34	Quarterly grab samples (in year prior to FYR)	Mercury and VOCs[a] (see S-3 Ponds Pathway monitoring in this table for monthly grab for metals, including total uranium and cadmium, and weekly flow-proportionate monitoring for nitrate and isotopic uranium)	AWQC, risk-based[b] – within five years
		NT-1	Quarterly grab samples (in year prior to FYR)	Isotopic uranium; VOCs, and nitrate[a]	AWQC, risk-based[b]
	Biota	BCK 12.4	Semiannual survey and bioaccumulation monitoring	Fish and benthic macroinvertebrate species richness and density; bioaccumulation of mercury, metals, including uranium, in stoneroller minnows (whole body)	Measure changes in quality of aquatic habitat as compared to references sites
			Semiannual monitoring	Toxicity testing	Trend
		NT-1	Semiannual monitoring	Toxicity testing	Trend
BYBY	Surface water	NT-3	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux ≤4.3 kg/year
		NT-3	Quarterly grab samples (in year prior to FYR)	Metals, including total uranium and mercury; and nitrate[a]	AWQC, risk-based[b] – within five years; mercury ≤51 ng/L
		BCK 10.15	Weekly flow-proportional composite samples	Uranium (isotopic)	Uranium flux trend

Table 4.4. BCV watershed CERCLA performance monitoring[a] (cont.)

Area/site	Media	Monitoring location	Schedule	Parameters	Performance standard
BYBY (cont.)		BCK 11.54	Weekly flow-proportional composite samples	Uranium (isotopic)	BCK 11.54 is upgradient IP for BCBGs; measure uranium flux below BYBY
	Biota	NT-3	Semiannual survey (until recovery complete)	Fish and benthic macroinvertebrate species richness and density	Aquatic community data compared to data available for similar reference streams on the ORR
			Riparian vegetation recovery complete. Annual survey discontinued in FY 2012	Riparian vegetation recovery monitoring (percent plant recovery, species diversity, stream vegetation overhang, percent shading, growth and survival of planted species)	Compared to results of networks of similar riparian restoration sites monitored
Mercury Concentrations – Longitudinal Transect	Surface water	BCK 9.2, NT-8, SS-5 (spring), SS-4 (spring), BCK 11.54, BCK 12.34	Semiannual grab samples	Mercury and methylmercury	Trend
S-3 Ponds Pathway 3[d]	Surface water	BCK 12.34	Weekly flow-proportional composite samples	Isotopic uranium and nitrate	Uranium flux ≤27.2 kg/year; nitrate – 40% seasonal reduction, trend
			Monthly grab sample	Metals, including cadmium	Cadmium ≤0.25 µg/L; AWQC – within five years
		NT-1	Quarterly grab samples	Metals, including cadmium	Cadmium ≤0.25 µg/L
		NT-2	Weekly flow-proportional composite samples	Nitrate (flux)	Nitrate – 40% seasonal reduction in flux
S-3 Pathways 1 and 2[e]	Monitoring to evaluate the effectiveness of the S-3 Pathways 1 and 2 treatment system is discontinued[f]				
Downgradient Site Performance Wells[g]	Groundwater	GW-008, GW-046, GW-276	Annually in year prior to FYR	VOCs, metals, gross alpha and beta activity, and other COCs, as applicable	Gauge changes in contaminant trends downgradient of respective former RCRA units

Table 4.4. BCV watershed CERCLA performance monitoring[a] (cont.)

Area/site	Media	Monitoring location	Schedule	Parameters	Performance standard
Reference Locations	Biota	GHK 1.6, GHK 2.9	Semiannual survey	Benthic macroinvertebrate species richness and density	Provide quantifiable measures of stream ecological health and contaminant bioaccumulation by which ORR impacted sites are compared
		MBK 1.6	Semiannual survey	Fish and benthic macroinvertebrate species richness and density	
		PHK 1.6	Semiannual survey	Fish species richness and density	
		HCK 20.6	Semiannual bioaccumulation monitoring	Bioaccumulation of mercury, metals (including uranium) and PCBs in fish [two species: stoneroller minnows (whole body) and rock bass (fillets – mercury and PCBs only)	

NOTE: All sample collection and shipping is subject to schedule deviations due to abnormal demands on resources, adverse weather conditions, access restrictions (due to security restraints, etc.), or other emergency conditions, etc.

[a]Sampling will be conducted for COCs identified from the BCV RI for risk-based comparisons.
[b]RBCs of 1E-5 and HI of 1 for residential receptor for Zones 1 and 2 (surface water and groundwater) and industrial for Zone 3 (waste and associated soils and sediments).
[c]Cleanup levels for groundwater are to be determined under future decisions for the BCV watershed.
[d]RAs for the S-3 Pathway 3 have not been implemented; data are collected to establish a baseline against which performance of the action will be gauged.
[e]Correspondence from the regulators granting permission to shut down the treatment system at S-3 Pathways 1 & 2 inadvertently included uranium as the parameter analyzed for the biota; however, the correct parameters should have included mercury and PCBs. The correct parameters were approved in an earlier version of the CMP (*Water Resources Restoration Program Sampling and Analysis Plan for the Bear Creek Valley Watershed, Oak Ridge Reservation, Oak Ridge, Tennessee* [DOE/OR/01-2457&D2/A1]).
[f]Correspondence from regulators (DOE/OR/01-1836&D1/A1) granting permission to shut down treatment system at S-3 Pathways 1 & 2 requires continuation of monitoring at BCK 12.34, BCK 9.2, BCK 3.3, BCK 9.9, BCK 12.4, as indicated.
[g]Former RCRA post-closure permit point-of-compliance monitoring wells.

AWQC = ambient water quality criteria
BCBG = Bear Creek Burial Ground
BCK = Bear Creek kilometer
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
COC = contaminant of concern
FY = Fiscal Year
FYR = Five-Year Review
GHK = Gum Hollow Branch kilometer
GW = groundwater
HCK = Hinds Creek kilometer
HI = hazard index
IP = integration point
MBK = Mill Branch kilometer
MCL = maximum contaminant level
NT = North Tributary
ORR = Oak Ridge Reservation
PCB = polychlorinated biphenyl
PHK = Pinhook Branch kilometer
RA = remedial action
RBC = risk-based concentration
RCRA = Resource Conservation and Recovery Act of 1976
RI = Remedial Investigation
SS = surface spring
TBD = to be determined
VOC = volatile organic compound

Zone 1

Zone 1 of BCV watershed constitutes the valley area west of BCK 7.87 (Figure 4.2). Surface water quality is monitored at BCK 7.87 (Table 4.4). The surface water quality goal for Zone 1 is to meet risk levels consistent with unrestricted use (residential) and to meet AWQC (Table 4.3). Zone 1 surface water monitoring results are compared to AWQC and risk-based concentrations (RBCs) for residential exposure in each CERCLA FYR. RBCs are concentrations in a given medium for a specific receptor that are calculated at a risk level, defined as ELCR, of 1×10^{-5} or a HI of 1. They define levels of constituents that are considered protective of human health under the exposure conditions considered. The AWQC comparison includes quarterly grab samples for metals and anions (i.e., nitrate) during the year prior to each FYR. Quarterly samples are also obtained at BCK 4.55 at the point where Bear Creek turns northward. Analytical results for metals, mercury, and nitrate are compared to AWQC and RBCs for residential exposure in each FYR.

Semiannual fish and benthic macroinvertebrate species richness and density surveys are conducted at BCK 3.3 (Figure 4.2), as well as bioaccumulation monitoring of metals and PCB in stoneroller minnows and in rock bass (Table 4.4). Results are used to measure changes in the quality of aquatic habitat as compared to reference sites (e.g., Pinhook Branch kilometer [PHK] 1.6, Hinds Creek kilometer [HCK] 20.6).

Groundwater is monitored semiannually in Picket W wells GW-712, GW-713, and GW-714, as well as a nearby spring SS-6 (Figure 4.2) to determine whether contaminants have migrated through the exit pathway to the western portion of the valley. Samples are analyzed for nitrates, metals (including uranium), and VOCs and are compared to MCLs (Table 4.4).

Zone 2

Zone 2 of BCV watershed constitutes the section of the valley located between BCK 7.87 and BCK 9.2 (Figure 4.2) and functions as a buffer zone between Zones 1 and 3. The long-term goal for Zone 2 is to improve surface water quality consistent with eventually achieving unrestricted use within 50 years after all Phase 1 ROD remedies have been implemented. Monitoring station BCK 9.2 is located approximately at the boundary between Zone 2 (downstream) and Zone 3 (upstream). At BCK 9.2, weekly surface water flow-proportional samples are collected for isotopic uranium analysis and monthly grab samples are collected for nitrate analysis. Uranium and nitrate monitoring at BCK 9.2 represents the contribution in surface water from all sources within the Bear Creek watershed migrating from Zone 3 into Zone 2. In addition, quarterly samples for metals and VOCs are collected in the year prior to each CERCLA FYR. Zone 2 surface water results at BCK 9.2 are compared to the uranium flux goal of ≤34 kg/yr from the BCV Phase I ROD annually and to AWQC during the FYR (Table 4.4). In addition, results for uranium and nitrate at BCK 9.2 are compared to RBCs for residential exposure. To gauge the uranium flux trend upgradient of BCK 9.2, a weekly flow-proportional composite sample for isotopic uranium is obtained at monitoring location SS-5.

Along the Zone 2/Zone 3 boundary, groundwater quality is sampled semiannually along the transect of Picket A wells GW-683, GW-684, GW-077, GW-078, GW-079, and GW-080. Wells GW-683 and GW-684 are located along Bear Creek (Figure 4.2) and samples are analyzed for metals, VOCs, nitrate, isotopic uranium, and gross alpha and beta activity. These data are evaluated by observing the trend of results (Table 4.4). The remaining wells are located to the north along strike of the western edge of the BCBGs (Figure 4.2) and are sampled for metals, VOCs, and isotopic uranium. Results are compared to MCLs for screening purposes only (Table 4.4).

Semiannual fish and benthic macroinvertebrate species richness and density surveys are conducted at BCK 9.9 (Table 4.4), as well as bioaccumulation monitoring of mercury, metals (including uranium), and PCBs in stoneroller minnows (whole body) to gauge the effects of upgradient sources (i.e., S-3 Ponds Site, BYBY, and the BCBGs). Results are compared to reference sites to measure changes in the quality of aquatic habitat. For the FYR, an annual bioaccumulation study is conducted for metals (including mercury and PCBs) in invertebrates (preferably caddisflies) and metals and PCBs only in rock bass (fillets). These results are used to evaluate ecological and human health risk.

Zone 3 and Site-Specific Monitoring

Zone 3 of Bear Creek watershed is the section of the valley located east of BCK 9.2 (Figure 4.2) that contains a currently operating CERCLA waste disposal facility (EMWMF) and former waste disposal sites. The remedial goals for Zone 3 are to attain AWQC in all surface water (short-term), and reduce risks from direct contact to achieve conditions compatible with a long-term, controlled industrial end use. Surface water is monitored at a number of locations within Zone 3, including monitoring required specifically for the S-3 Ponds Pathway 3 and the BYBY (Figure 4.2; Table 4.4).

Cleanup levels for groundwater in Zone 3 were not specified in the Phase I ROD and no specific groundwater actions were included in the decision. The ROD indicates source area actions are intended to improve conditions in groundwater for protection of water quality in Zones 1 and 2. Groundwater within Zone 3 is monitored in Picket B wells GW-704 and GW-706, which sample groundwater in the S-3 plume (Figure 4.2). Groundwater samples from these wells are analyzed for metals, nitrates, VOCs, gross alpha and beta activity, and isotopic uranium (Table 4.4).

Monitoring for the S-3 Ponds Pathway 3 is conducted at surface water locations BCK 12.34, NT-1, and NT-2 (Figure 4.2) to provide sufficient information to develop a future response action. BCK 12.34 has continuous flow monitoring, and weekly flow-proportional composite samples are analyzed for nitrate, U-234, U-235, and U-238 to measure performance compared to the ROD goal of 27.2 kg/yr total uranium discharge into Bear Creek (Table 4.4). In addition, monthly grab samples are collected at BCK 12.34 for metals, including cadmium to measure remedy protectiveness compared to the AWQC. Quarterly grab samples for metals, including cadmium, are collected at NT-1 to measure performance compared to the ROD goal of ≤0.25 μg/L. Weekly flow-proportional composite samples are obtained at NT-2 to measure nitrate flux.

Biota monitoring associated with the S-3 Ponds Site (Table 4.4) includes semiannual surveys of fish and benthic macroinvertebrate species richness and density at BCK 12.4, as well as bioaccumulation of metals (including mercury and uranium) in stoneroller minnows (whole body). Results are compared to reference sites to measure changes in the quality of aquatic habitat.

Effectiveness of remediation at the BYBY is measured by water quality in the NT-3 stream (Figure 4.2). NT-3 has continuous flow measurements and weekly flow-proportional composite samples are analyzed for U-234, U-235, and U-238 to determine the annual uranium flux against the goal of ≤4.3 kg/year (Table 4.4). In addition, for the CERCLA FYR, a monthly grab sample is collected at NT-3 to meet AWQC for mercury, and, as stated in Table 4.4, surface water must be below RBCs for an industrial receptor (1E-5 ELCR). Weekly flow proportional composite samples are obtained at BCK 10.15 to provide a trend in uranium flux. BCK 11.54, a Bear Creek main stream station, is located downstream of NT-3 (Figure 4.2) and functions as an upstream IP for the BCBGs. Uranium flux is measured weekly at BCK 11.54.

Biota monitoring for the BYBY RA includes semiannual fish and benthic macroinvertebrate species richness and density surveys in NT-3 (Table 4.4). Results are compared to reference sites to measure changes to the quality of aquatic habitat.

Not associated with any specific action, surface water samples are collected monthly at NT-7 for isotopic uranium (Table 4.4) and a weekly flow-proportional composite sample is collected for isotopic uranium at NT-5 and NT-8. The monitoring at NT-8 is instrumental in determining the relative contribution of the BCBGs to uranium at BCK 9.2 (Figure 4.2). Additional monitoring is conducted in Zone 3 for the FYR and is detailed in Table 4.4.

Other Monitoring in BCV

Semiannual grab samples are obtained at several surface water locations throughout the BCV watershed (Figure 4.2) and analyzed for mercury and methylmercury (Table 4.4). These locations include BCK 9.2, NT-8, SS-5, SS-4, BCK 11.54, and BCK 12.34. These results will be observed over time to determine whether a trend is discernable.

In the year prior to the CERCLA FYR, an annual sample from the former RCRA POC wells is scheduled. These wells include GW-008, GW-046, and GW-276 and groundwater is analyzed for VOCs, metals, gross alpha and beta activity, and other COCs, as applicable. Results are used to gauge changes in contaminant trends downgradient of respective former RCRA units.

Biological monitoring reference locations for fish and benthic macroinvertebrate species richness and density surveys, as well as bioaccumulation studies, are monitored semiannually. These locations include Gum Hollow Branch kilometer (GHK) 1.6, GHK 2.9, MBK 1.6, PHK 1.6, and HCK 20.6 (Figure 4.2 and Table 4.4). These sites provide quantifiable measures of stream ecological health and contaminant bioaccumulation by which the ORR impacted sites are compared.

4.3.1.2.1.2 Surface water monitoring results

The discussion of surface water results is presented in this section in sequence of end use zone. The monitoring emphasis is on measuring remediation related reductions of COCs that are indicative of potential exposure risk for future land users.

Zone 1

Surface water in Zone 1 is sampled for radionuclides, metals, and VOCs at locations BCK 4.55 and BCK 7.87 (at the Zone 1/Zone 2 boundary) and mercury and methylmercury are sampled at BCK 4.6. Surface water monitoring results are compared to AWQC, and evaluated against the RBCs for residential exposure to surface water (1E-5) consistent with the unrestricted land use goals. Surface water monitoring was conducted in FY 2015 for the purposes of AWQC screening for the 2016 FYR. An evaluation of results is presented in the 2016 FYR document.

During FY 2018, uranium concentrations were greater than the 0.030 mg/L MCL in both semiannual samples collected at BCK 7.87 (Note: MCLs are used for screening purposes but are not ARARs for surface water). Total uranium concentrations were 0.052 and 0.044 mg/L in January and September samples, respectively. The uranium isotope signature at BCK 7.87 showed a predominance of U-238 (U-238/U-234 ratios were 2.4 and 2.0), which suggests an influence from NT-8 where uranium discharges are dominated by U-238. At BCK 4.55, total uranium concentrations were 0.02 and 0.011 mg/L in January and September, respectively, both of which are less than the uranium MCL. As was the case at BCK 7.87, U-238 dominated the uranium isotope ratio at BCK 4.55 with U-238/U-234 ratios of 1.4 and 2.0 in January and September, respectively. These isotope ratios greater than 1 indicate influence from the NT-8 source.

At BCK 7.87, Tc-99 was detected at 27.6 and 14.8 pCi/L in the January and September samples, respectively. At BCK 4.55, Tc-99 was detected at 7.93 pCi/L in January, but was not detected in the

September sample. Detected Tc-99 concentrations in Zone 1 surface water were approximately 1% of its 900 pCi/L MCL-DC. Nitrate was detected in Zone 1 surface water at a maximum concentration of 5.5 mg/L measured in the January sample collected at BCK 7.87. At BCK 4.6, mercury was detected at 5.68 and 1.09 ng/L in October and June, respectively, and methylmercury was detected at 0.059 and 0.241 ng/L in the same sampling events.

Figure 4.4 shows concentration histories for nitrate, total uranium, Tc-99, U-233/234, and U-238 for the time period 2001 through 2018 at BCK 7.87. Concentrations of all these contaminants have generally decreased since 2001. In one sample event in summer of 2006, concentration spikes for nitrate and Tc-99 were observed. Since 2002, nitrate concentrations have been below the 10 mg/L MCL, with the exception of the one observed spike. Since 2002, total uranium has generally fluctuated from the 0.03 mg/L MCL to twice the MCL.

Zone 2

Surface water monitoring was conducted at BCK 9.2, where upstream flow from Zone 3 source areas enters Zone 2. The BCK 9.2 sample location serves a dual function. It is used to assess both the water quality in Zone 2 because this location measures water quality of the inflowing stream, and it serves as the IP for surface water being discharged from sources in Zone 3.

Uranium isotopes are measured at BCK 9.2 to enable comparison with the 1E-5 risk-based residential exposure concentrations. The uranium isotopic data is also used to calculate the mass of uranium present.

As stated in Section 4.3.1.2.1.1, the watershed ROD goals for surface water at the Zone 3/Zone 2 boundary (BCK 9.2) include both an annual total uranium flux and a calculated risk level of 1E-5 ELCR. Risk levels are determined based on calculated uptake factors to humans and carcinogenic characteristics of specific radionuclides. Periodically, the uptake and risk factors are updated. Consequently, the calculated concentrations of each uranium isotope that are equivalent to the 1E-5 ELCR goal may change from year to year.

A change occurred between the FY 2016 and FY 2018 risk factors that caused a reduction in uranium isotope concentration goals of approximately 1 pCi/L for each isotope. Current year risk based activities for each uranium isotope (1E-5 risk level) are shown in the top row of Table 4.5. These risk-based values are updated annually based on current risk assessment criteria. Risk level goal attainment indicated in Table 4.5 is based on the RBCs applicable for the assessed year and changes in RBCs over time are not applied retroactively.

The FY 2018 average activities of U-234, U-235, and U-238 were 6.2, 0.5, and 14.4 pCi/L, respectively. The value for U-234 was slightly less than its risk-based activity level of 6.22 pCi/L while the U-238 average concentration exceeded its risk-based activity of 6.87 pCi/L. Uranium isotopic RBCs in prior years were higher than current year levels. These risk-based goals are equivalent to the hypothetical residential exposure goal of a 1E-5 ELCR attributable to the uranium isotopes in the BCV Phase I ROD.

Table 4.5 and Figure 4.5 present the historic annual average activity of isotopes of uranium and concentration of nitrate and annual average rainfall since the BCV Phase I ROD was implemented. Over the period of monitoring, U-235 has been less than the risk-based activity in Zone 2. During FY 2018, the RBC goal for U-234 and U-235 were met although the U-238 goal was not met at BCK 9.2. There has been a decrease of approximately 50% in the activity levels for U-234 and U-238 in the 18 years of data summarized in Table 4.5. An early decrease is apparent in Figure 4.5 following completion of BYBY remediation. A gradual decrease in the uranium isotope concentrations has been ongoing since 2006. Additional discussion of contaminant transport from Zone 3 into Zone 2 is presented below.

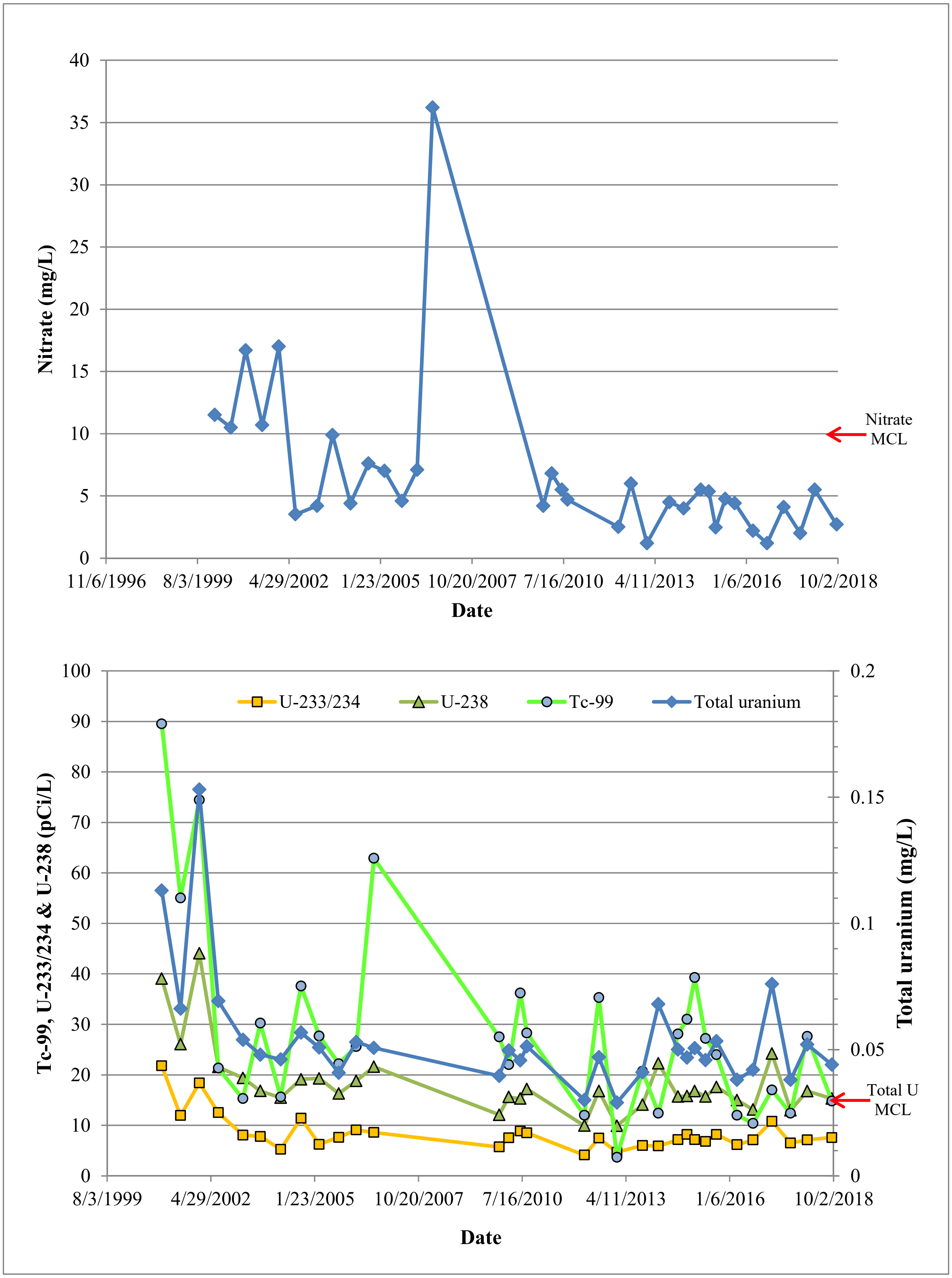

Figure 4.4. Concentration histories for nitrate, total uranium, Tc-99, U-233/234 and U-238 at BCK 7.87.

Table 4.5. Historic average activity of uranium isotopes and concentration of nitrate at the IP (BCK 9.2)

FY	U-234 pCi/L	U-235 pCi/L	U-238 pCi/L	Nitrate mg/L	Average ORR rainfall[a]
RBC[b]	6.22	6.32	6.87	32	--
2001	**13.7**	0.7	**28.5**	9.9	45.9
2002	**12.4**	0.8	**24.8**	12.9	52.7
2003	**9.4**	1.2	**18.4**	11.1	73.7
2004	**8.5**	1.1	**17.7**	8.4	56.4
2005	7.3	0.7	**15.9**	6.6	58.9
2006	**9.9**	0.9	**21.3**	9.8	46.4
2007	**8.8**	0.9	**18.8**	--	36.8
2008	**9.1**	0.9	**21.0**	--	49.3
2009	**8.8**	0.8	**21.6**	4.8	62.5
2010	**7.9**	0.8	**17.0**	5.9	55.8
2011	**7.6**	0.7	**17.6**	6.1	59.2
2012	6.3	0.6	**16.1**	4.8	61.8
2013	7.4	0.7	**17.0**	5.7	63.7
2014	7.0	0.7	**17.5**	4.6	48.8
2015	7.0	0.7	**16.8**	3.9	55.9
2016	6.7	0.5	**15.4**	4.5	50.23
2017	**7.8**	0.6	**18.1**	3.4	57.94
2018	6.2	0.5	**14.4**	4.5	58.89

Bold values indicate the yearly applicable RBC is exceeded. RBC values are reviewed annually and adjusted periodically as EPA risk factors are updated.

[a]Average annual rainfall in inches for rain gauges at Y-12, ETTP, ORNL, and DOE town site.
[b]FY 2018 RBCs (residential 1E-5 for radionuclides and HQ=1 for nitrate).

-- = data unavailable
BCK = Bear Creek kilometer
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park
FY = fiscal year
HQ = Hazard Quotient
IP = integration point
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation
RBC = risk-based concentration
Y-12 = Y-12 National Security Complex

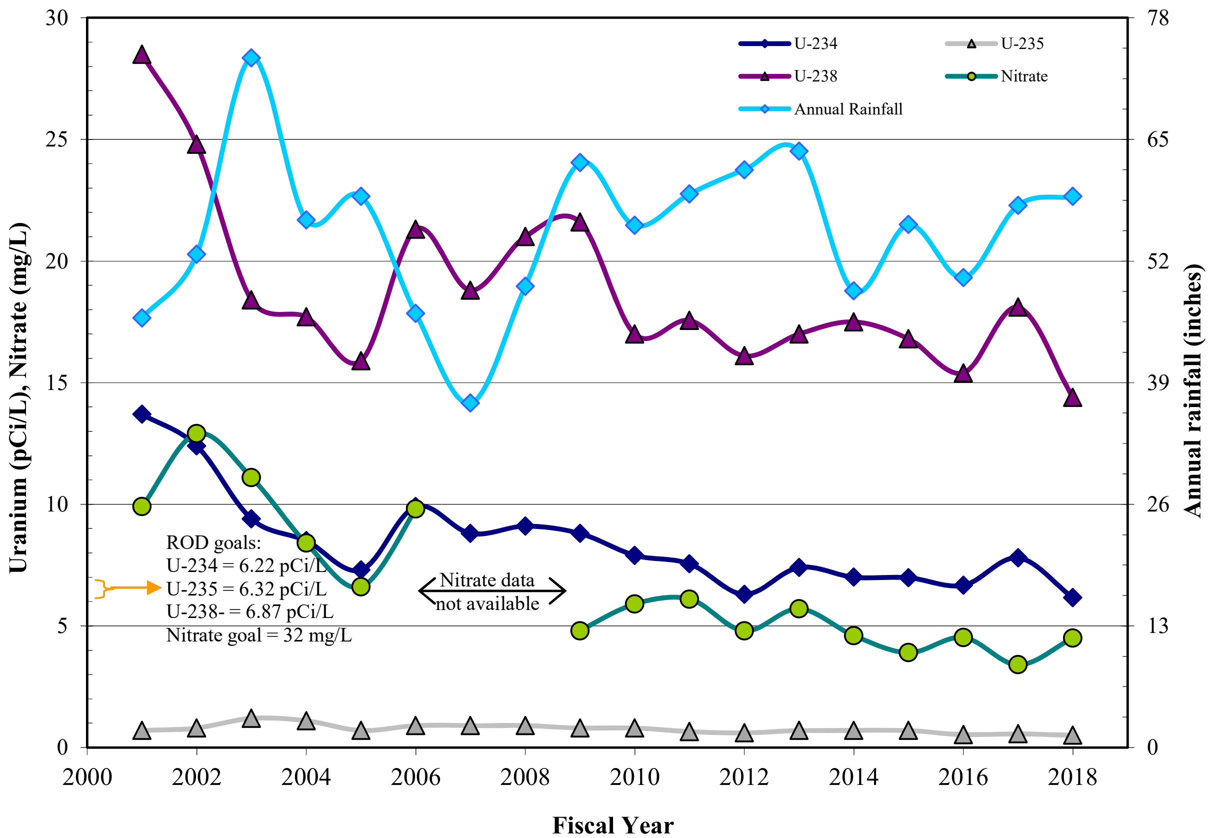

Figure 4.5. Average annual uranium isotope activity, nitrate concentration at BCK 9.2, and annual rainfall.

Nitrate concentrations measured at BCK 9.2 since approval of the BCV Phase I ROD are compared to the RBCs. Since FY 2000, the average annual nitrate concentrations in surface water at the IP (BCK 9.47 prior to FY 2006 and BCK 9.2 thereafter) have not exceeded the risk-based (HQ of 1) residential exposure concentration. During FY 2004 – 2018, the average nitrate concentrations measured at BCK 9.2 have been below the 10 mg/L MCL. The principal source of nitrate contamination is legacy disposal of nitric acid liquids in the S-3 Ponds in the headwaters of Bear Creek. Nitrate has been monitored historically at a number of locations in BCV. Concentrations are highest near the S-3 source and decrease with distance downstream to the west. BCK 9.2 flux measurements are discussed below for comparative purposes to Zone 3 sampling locations.

In Zone 2, samples were collected quarterly during FY 2015 at BCK 9.2 for the purposes of AWQC screening for the 2016 FYR. An evaluation of results is presented in the 2016 FYR document. During FY 2018, mercury was detected in both grab samples collected at BCK 9.2; with the maximum detected mercury concentration of 5.48 ng/L, which is less than the 51 ng/L recreation organisms only criteria. Cadmium and lead are analyzed in monthly grab samples collected at BCK 9.2. Cadmium was not detected in any of the monthly grab samples collected during FY 2018 and lead was detected at 0.97 J µg/L in the July 2018 sample. The State of Tennessee Ambient Water Quality Criterion Continuous Concentration for lead is 2.5 µg/L.

Zone 3

During FY 2018, surface water monitoring in Zone 3 included the ongoing monitoring of uranium flux at several locations, and nitrate concentration monitoring near the S-3 Ponds area and at the BCK 9.2 IP.

Surface water monitoring also includes intermediate monitoring stations, including tributary monitoring of specific RA areas. Two key metrics were identified in the ROD for effectiveness of remediation in Zone 3—reduction of risk levels and uranium flux at the IP (BCK 9.2) to 34 kg/yr, and reduction of the uranium flux at BCK 12.34 to 27.2 kg/yr. As previously discussed, U-238 activities at BCK 9.2 consistently exceed the RBC and, in all years prior to FY 2012 except FY 2005, U-234 activities exceeded the RBC. During FY 2017, the U-234 activity at BCK 9.2 exceeded its RBC although the goal was attained during FY 2018.

The post-BCV Phase I ROD history of measured uranium fluxes at BCK 9.2 and BCK 12.34, along with annual rainfall, are summarized in Table 4.6 and Figure 4.6. The watershed flux goal (≤34 kg/yr) for the Zone 3 IP was not met in FY 2018, based on the approximately 92 kg of uranium discharge measured at BCK 9.2. The FY 2018 uranium flux at BCK 12.34 was approximately 25.7 kg, which is less than the flux goal of 27.2 kg/yr. Continuous flow-paced sampling to measure the uranium flux at NT-3 was resumed in FY 2010 in response to the observation of increasing uranium concentrations in the NT-3 grab samples. During FY 2018, a uranium flux of approximately 2.8 kg was measured at the mouth of NT-3. This uranium discharge achieved the 4.3 kg/yr flux goal for the stream following remediation of the BYBY. Additional discussion of the NT-3 uranium discharge is provided in discussion of the BYBY remedy effectiveness evaluation later in this section.

Table 4.6. Uranium flux[a] at flow-paced monitoring locations in BCV watershed

FY	BCK 9.2	SS-5	NT-8	BCK 11.54	NT-3	BCK 12.34	Average rainfall[b]
ROD goal	**34**	--	--	--	**4.3**	**27.2**	--
2001	**88.7**	17.2	--	--	**79.9**	24.5	45.9
2002	**120.2**	13.1	--	158.2	**62.8**	25.4	52.7
2003	**165.4**	12.3	--	87.0	**4.6**	**44.3**	73.7
2004	**115.0**	9.5	--	45.8	1.2	**27.3**	56.4
2005	**115.4**	11.1	--	39.8	4.1	**40.3**	58.9
2006	**68.5**	--	--	25.2	1.7	21.3	46.4
2007	**59.5**	--	--	12.6	--[c]	15.8	36.8
2008	**73.2**	--	27.9	15.9	--[c]	23.0	49.3
2009	**147.7**	11.6	43.3[d]	27.2	--[c]	**32.9**	62.5
2010	**118.9**	9.9	61.0	32.5	**14.5**	**33.9**	55.8
2011	**108.7**	9.1	40	36.7	**16.3**	**37.8**	59.2
2012	**114.9**	9.2	43.3	45.4	**13.6**	**32.9**	61.75
2013	**122.3**	9.5	64.0	47.6	**22.3**	**40.3**	63.73
2014	**95.6**	7.7	72.4	38.6	1.87	24.0	48.8
2015	**88.8**	7.3	51.2	45.1	2.3	26.0	55.9
2016	**100.6**	9.3	47.6	32.0	1.5	**31.1**	50.23
2017	**125.0**	9.4	50.6	52.4	1.9	**32.8**	57.94
2018	**91.7**	9.3	48.0	37.3	2.8	25.7	58.89

[a]All flux values are kg of uranium/yr.
[b]Average annual rainfall in inches for rain gauges at Y-12, ETTP, ORNL, and DOE town site.
[c]Goal attained; flux monitoring discontinued FY 2007. Reinstituted in FY 2010.
[d]Uranium isotope mass balancing at BCK 9.2 suggests NT-8 contributed about 60 kg in FY 2009. Approximately 17 kg infiltrated into karst seepage pathways upstream of the NT-8 flume.

Table 4.6. Uranium flux[a] at flow-paced monitoring locations in BCV watershed (cont.)

Bold values indicate the *Record of Decision for the Phase 1 Activities in Bear Creek Valley, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4) goal for uranium flux has not been met.

-- = data unavailable
BCK = Bear Creek kilometer
BCV = Bear Creek Valley
DOE = U.S. Department of Energy
ETTP = East Tennessee Technology Park
FY = fiscal year
NT = North Tributary
ORNL = Oak Ridge National Laboratory
ROD = Record of Decision
SS = surface spring
Y-12 = Y-12 National Security Complex

Review of Figure 4.6 shows the relationship between annual total rainfall and total uranium flux at BCK 9.2 and BCK 12.34. The amount of uranium that is mobilized from buried waste sources and residual groundwater contamination in the S-3 Pond area depends on the amount of rainfall that occurs. Increased rainfall causes increased groundwater recharge, more leachate formation, higher groundwater levels, and more contaminant transport from incompletely contained buried/below-grade contaminant sources to the streams. The relationship between annual rainfall and annual uranium fluxes measured at BCK 9.2 and BCK 12.34 is strongly linear during the post-BCV Phase I ROD monitoring period, as demonstrated by the relatively high correlations between rainfall and uranium discharge flux shown in Figure 4.7. The higher mass flux and the greater positive slope of the trend at BCK 9.2 than at BCK 12.34 reflect the presence of a significant uranium source that enters Bear Creek between the two stations.

During FY 2007, data collection and refinement of the conceptual site model indicated that NT-8 was a significant contributor of uranium to Bear Creek and continuous flow-paced monitoring of NT-8 started in FY 2008. During FY 2018, monitoring of NT-8 documented that approximately 48 kg of uranium (approximately 52% of the total BCV uranium discharge of 91.7 kg as shown in Table 4.6) was discharged directly to Bear Creek (Table 4.6). The surface water goals not being met in NT-8 is an RER issue carried forward in Table 4.14. This issue will continue to exist until a future source control ROD for BCBGs and implementation of a remedy address the contamination source.

Estimates were made of the uranium contributions from NT-5 and NT-7. These estimates suggest that NT-5 contributed approximately 0.6 kg of uranium and NT-7 may have contributed approximately 1.7 kg of uranium during FY 2018.

Including all directly measured and estimated uranium sources contributing to the stream (BCK 12.34, NT-3, NT-5, NT-7, NT-8, and SS-5), the mass balance of uranium in the Bear Creek system during FY 2018 shows that about 88 kg of uranium were measured or estimated to enter Bear Creek from gauged stream locations in Zone 3 and 91.7 kg of uranium were measured discharging from Zone 3 at BCK 9.2. These data indicate a uranium mass balance difference of approximately 3 kg (approximately 3% error) for the BCV monitoring system, which is considered good considering the complex surface water and groundwater interactions in the karst environment.

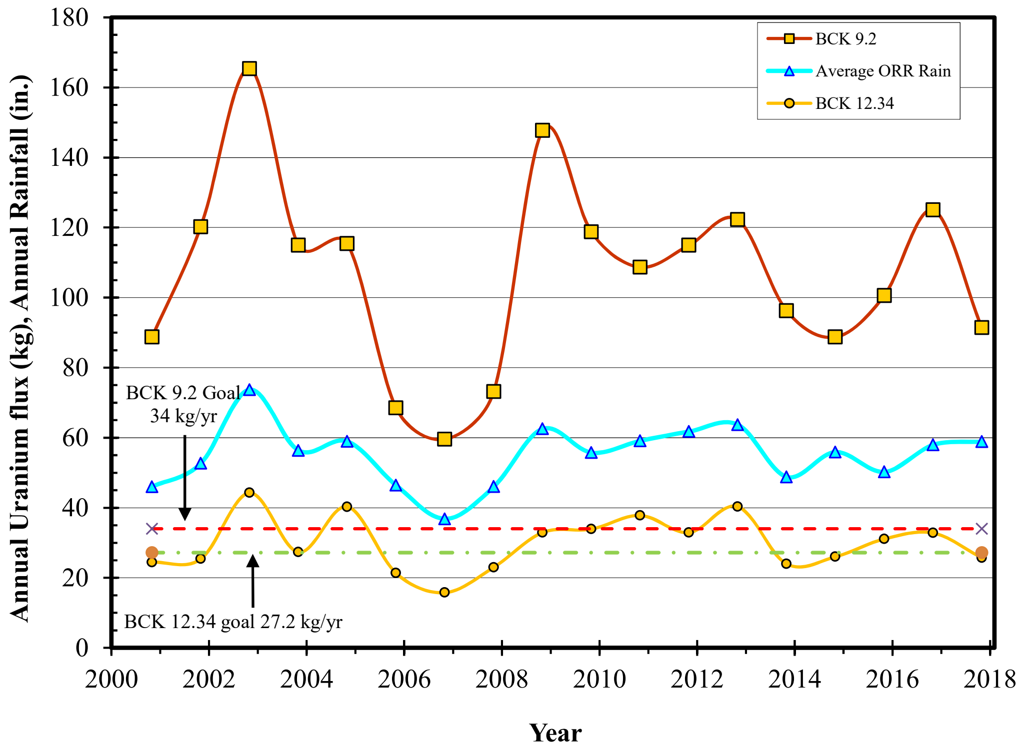

Figure 4.6. Post-ROD uranium flux at BCK 9.2 and BCK 12.34 and annual rainfall.

Dashed red and green lines indicate BCV Phase 1 ROD goals.

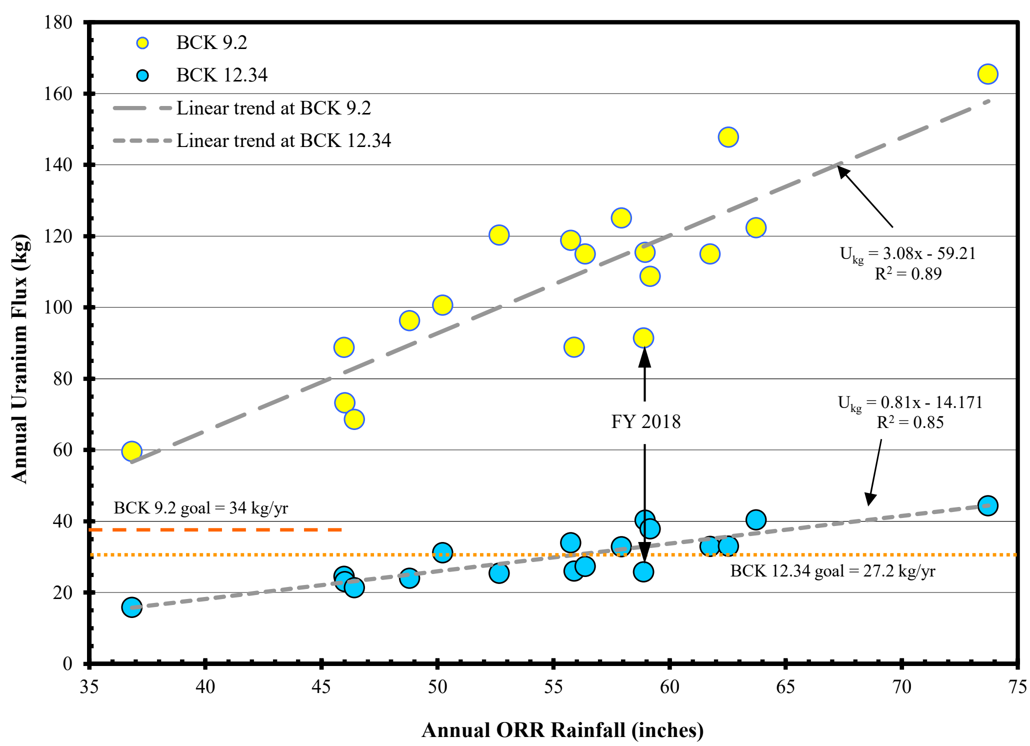

Figure 4.7. Average annual rainfall vs. annual uranium flux at BCK 9.2 and BCK 12.34.

Dashed red and orange lines indicate BCV Phase 1 ROD goals.

Nitrate and cadmium are also key COCs in surface water in BCV. The principal source of nitrate contamination is legacy disposal of nitric acid liquids in the S-3 Ponds, which created nitrate plumes in groundwater that discharge in the headwaters of Bear Creek. The S-3 Ponds site was capped and closed under RCRA requirements in 1988. The BCV Phase I ROD RA to address S-3 Ponds Pathway 3 groundwater has not yet been implemented.

Nitrate has been monitored historically at a number of locations in BCV. Concentrations are highest near the S-3 source and decrease with distance to the west and downstream. Figure 4.8 shows the average nitrate concentration in surface water at BCK 12.34, along with the annual average rainfall. The tendency for dilution of the nitrate concentrations during years of elevated rainfall is apparent in the graph with the mirror relationship between increased rainfall and decreased nitrate concentration. During FY 2018, the average nitrate concentration was 29.6 mg/L based on 49 weekly grab sample results. The maximum measured nitrate concentration during FY 2018 was 85 mg/L.

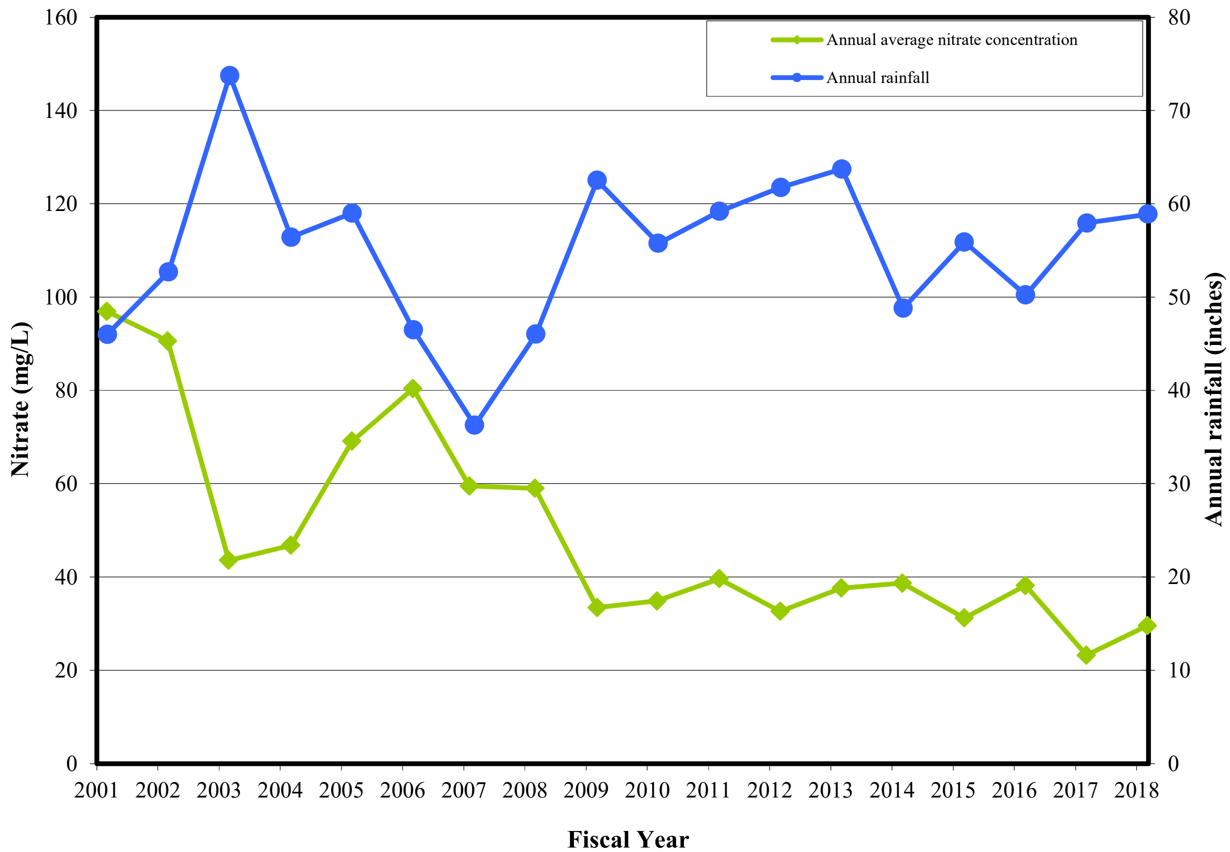

Figure 4.8. BCK 12.34 annual average nitrate concentration and annual rainfall.

The principal source of cadmium is also disposed liquids from the S-3 ponds. Figure 4.9 shows the cadmium concentrations over time since FY 2000 at NT-1 and BCK 12.34. Cadmium concentrations in the Bear Creek headwaters consistently exceed the 0.25 µg/L AWQC in samples from the NT-1 and BCK 12.34 sampling locations. Monthly samples obtained at BCK 12.34 during FY 2018 contained an average of 1.85 µg/L cadmium with a maximum measured concentration of 5.4 µg/L in December 2017. Monthly samples obtained at NT-1 contained an average of 9.7 µg/L cadmium with a maximum measured concentration of 16 µg/L in August 2017. The surface water goals not being met for cadmium near the S-3 Ponds is an RER issue carried forward (Table 4.14). Prioritizing and sequencing an RA for S-3 Ponds Pathway 3 as stipulated by the BCV Phase I ROD will address the issue.

Tc-99 is a known constituent in the S-3 Pond Plume Pathway 3 discharge area which affects NT-1. Similar to the behavior of the cadmium in NT-1, Tc-99 concentrations in the stream increase during summer and autumn low flow seasons and decrease during the higher flows of winter and spring. Tc-99 concentrations periodically exceed the 900 pCi/L MCL-DC screening concentration during periods of low surface water flow. During FY 2018 the regular and duplicate samples collected at NT-1 in August exceeded the 900 pCi/L MCL-DC screening level with a maximum measured result of 1,080 pCi/L.

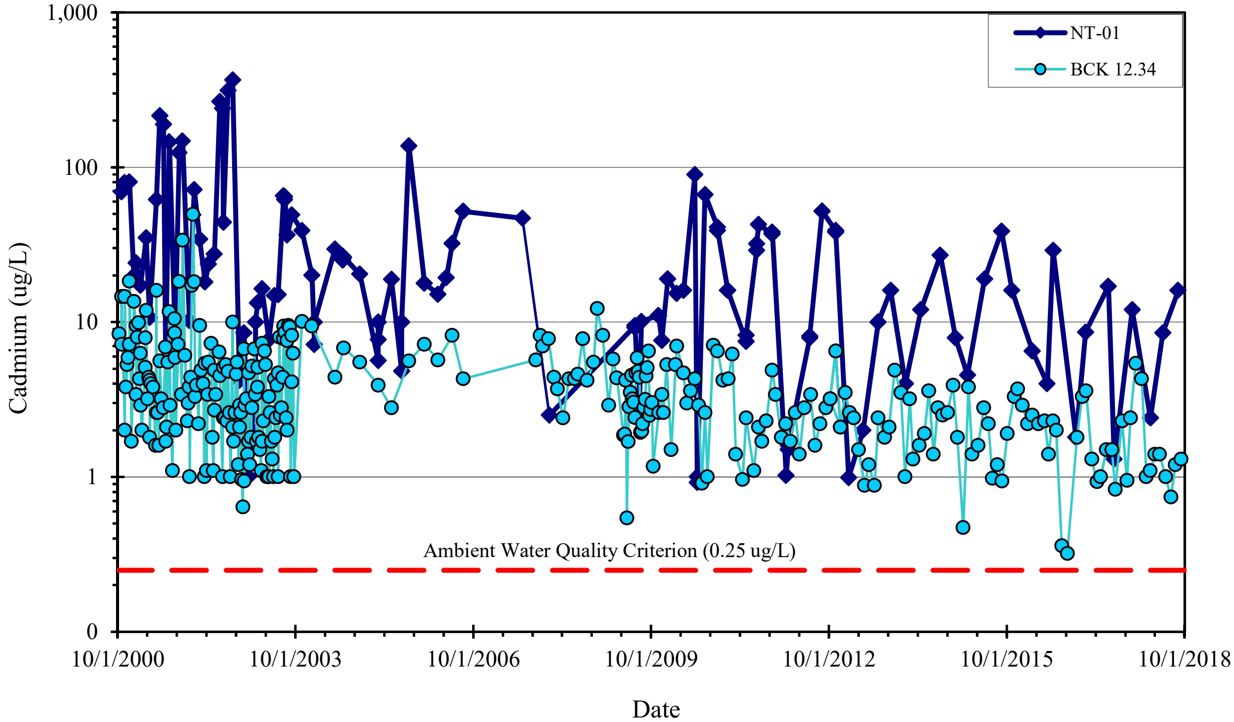

Figure 4.9. Cadmium concentrations at NT-1 and BCK 12.34.

In Zone 3, grab samples for the purposes of AWQC screening for the 2016 FYR were collected quarterly during FY 2015 at locations NT-1, BCK 12.34, NT-3, and NT-8. An evaluation of results is presented in the 2016 FYR document.

BYBY

Effectiveness of remediation at the BYBY is measured by water quality in the NT-3 stream (Figure 4.2). In addition to surface water monitoring at the BYBY, the *Phased Construction Completion Report for the Bear Creek Valley Boneyard/Burnyard Remediation Project at the Y-12 National Security Complex, Oak Ridge, Tennessee* (BCV BYBY PCCR; DOE/OR/01-2077&D2) specifies monitoring of benthic macroinvertebrate and fish communities in NT-3. Benthic macroinvertebrate and fish community monitoring results are presented in Section 4.3.1.2.3.

The remediation goal for the BYBY excavation is to attain a flux of less than 4.3 kg/yr uranium from NT-3. Immediately following BYBY remediation in the summer of 2002, uranium activities in NT-3 decreased significantly and uranium isotope ratios also changed. Historically, the flux reduction goal was met and confirmed with sustained flux reduction in post-remediation years until 2007. Regulatory approval to discontinue flow paced composite sampling at NT-3 and to replace it with monthly grab samples for uranium was granted in April 2007. Collection of grab samples on a monthly frequency continued except during prolonged dry weather when the stream is dry at the sampling station. Uranium activity levels gradually increased in FY 2007 through FY 2009 and flow-paced sampling was restarted at the beginning of FY 2010 to obtain reliable uranium flux data. The uranium flux goal of 4.3 kg/yr was exceeded from the restart in FY 2010 through FY 2013, but the goal has been attained since FY 2014. Table 4.7 is a tabulation of annual uranium flux, average activities of U-238 and U-234, and the U-238/U-234 ratios measured in NT-3.

Table 4.7. Annual uranium flux and average U-234 and U-238 activities at NT-3

FY	Uranium flux (kg/yr) (Goal = 4.3 kg/yr)	Average U-234 (pCi/L)	Average U-238 (pCi/L)	Average U-238/U-234 ratio	Comments
1999	161	208	450	2.16	
2000	120	230	514	2.24	
2001	79	196	476	2.43	
2002	64	135	292	2.15	BYBY remediation completed
2003	**5.2**	14	14	1.02	Continuous sampling
2004	1.5	7	6	0.85	Continuous sampling
2005	4.1	13	14	1.06	Continuous sampling
2006	1.7	17	16	0.93	Continuous sampling
2007	--	46	42	0.91	Continuous sampling
2008	--	41	39	0.94	Monthly grab sampling
2009	--	42	40	0.94	Monthly grab sampling
2010	**15**	24	22	0.96	Continuous sampling resumed
2011	**16**	32	30	0.94	Continuous sampling
2012	**14**	20	19	0.93	Continuous sampling
2013	**22**	16	15	0.95	Continuous sampling
2014	1.9	7.2	7.1	0.99	Continuous sampling
2015	2.3	11.6	10.6	0.90	Continuous sampling
2016	1.5	8.2	7.3	0.87	Continuous sampling
2017	1.9	8.8	7.8	0.87	Continuous sampling
2018	2.8	10.5	9.5	0.91	Continuous sampling

Bold values indicate the *Record of Decision for the Phase 1 Activities in Bear Creek Valley, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4) goal for uranium flux at NT-3 (4.3 kg/yr) has not been met.

-- = not applicable, not available, or insufficient data to calculate the statistic
BYBY = Boneyard/Burnyard
FY = fiscal year
NT = North Tributary

Variations in the NT-3 surface water uranium isotope ratios over time provide an indication of a change in the uranium source characteristic prior to, and following the BYBY RA. The data summary in Table 4.7 shows that, along with the reduction in total uranium activity and discharge flux in NT-3 following remediation, there was also a shift in the U-238/U-234 ratio. The U-238/U-234 decreased from average values of two to three (indicative of a depleted uranium source having a high fraction of U-238) downward to average values near one. The U-238/U-234 ratios observed post-remediation suggest that the recurrent uranium discharge originated from a depleted uranium source having a different isotopic signature than the remediated BYBY source. These isotopic shifts in the NT-3 surface water suggest that the BYBY source contained isotopically depleted uranium and the increases in uranium activity observed starting in FY 2007 were related to a different contaminant source. As shown on Figure 4.10, two other waste disposal units remain in the NT-3 watershed – the Hazardous Chemical Disposal Area (HCDA) and the Unit 6 Landfill (Figure 4.2 and Figure 4.10). The *2011 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2505&D2) contained a summary of sampling results from grab samples collected at several locations in NT-3. Those results showed that uranium was entering the NT-3 stream downslope from the western side of the Unit 6 Landfill. Those samples did not contain nitrate or Tc-99 which would be indicators of breakthrough of the S-3 Ponds contaminant plume into NT-3. An investigation of soil and groundwater contaminant distributions in the vicinity of the Unit 6 Landfill and NT-3 would be required to better understand the source of uranium entering NT-3. Such an investigation is one of the future potential projects listed in the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (ORR Groundwater Strategy; DOE/OR/01-2628&D2).

In addition to being a significant source of uranium to Bear Creek, the BYBY was also a historic source of mercury contamination. Surface water samples collected from the NT-3 monitoring station prior to the BYBY RA contained high concentrations of total mercury with concentrations in the 200 – 500 ng/L range in 1994 to 1999. In 2001, a value of nearly 660 ng/L was measured. Following completion of the BYBY RA in 2002, the mercury concentrations decreased rapidly with several detected spikes which have subsided to concentrations that are generally less than the AWQC level of 51 ng/L. The most recent criterion exceedance recorded in available data was measured in December 2006. Samples from NT-3 were analyzed for mercury in October 2017 (8.95 ng/L) and June 2018 (18.7 ng/L) and both results were less than the AWQC level, which met the ROD goal.

Methylmercury data are available for NT-3 from samples collected since winter 2010. The methylmercury concentrations measured in NT-3 are relatively high as a fraction of the total mercury and in an absolute sense when compared to those measured elsewhere on the ORR. During FY 2018, two samples were analyzed for methylmercury with concentrations of 0.134 ng/L in October 2017 and 0.173 ng/L measured in June 2018. The restored stream habitat in NT-3 constructed following the BYBY excavation has marshy vegetation along the channel edges. It is thought that the high organic carbon and microbial communities in these marshy areas is conducive to the methylation of mercury giving rise to the relatively high methylmercury concentrations in proportion to the low total mercury levels.

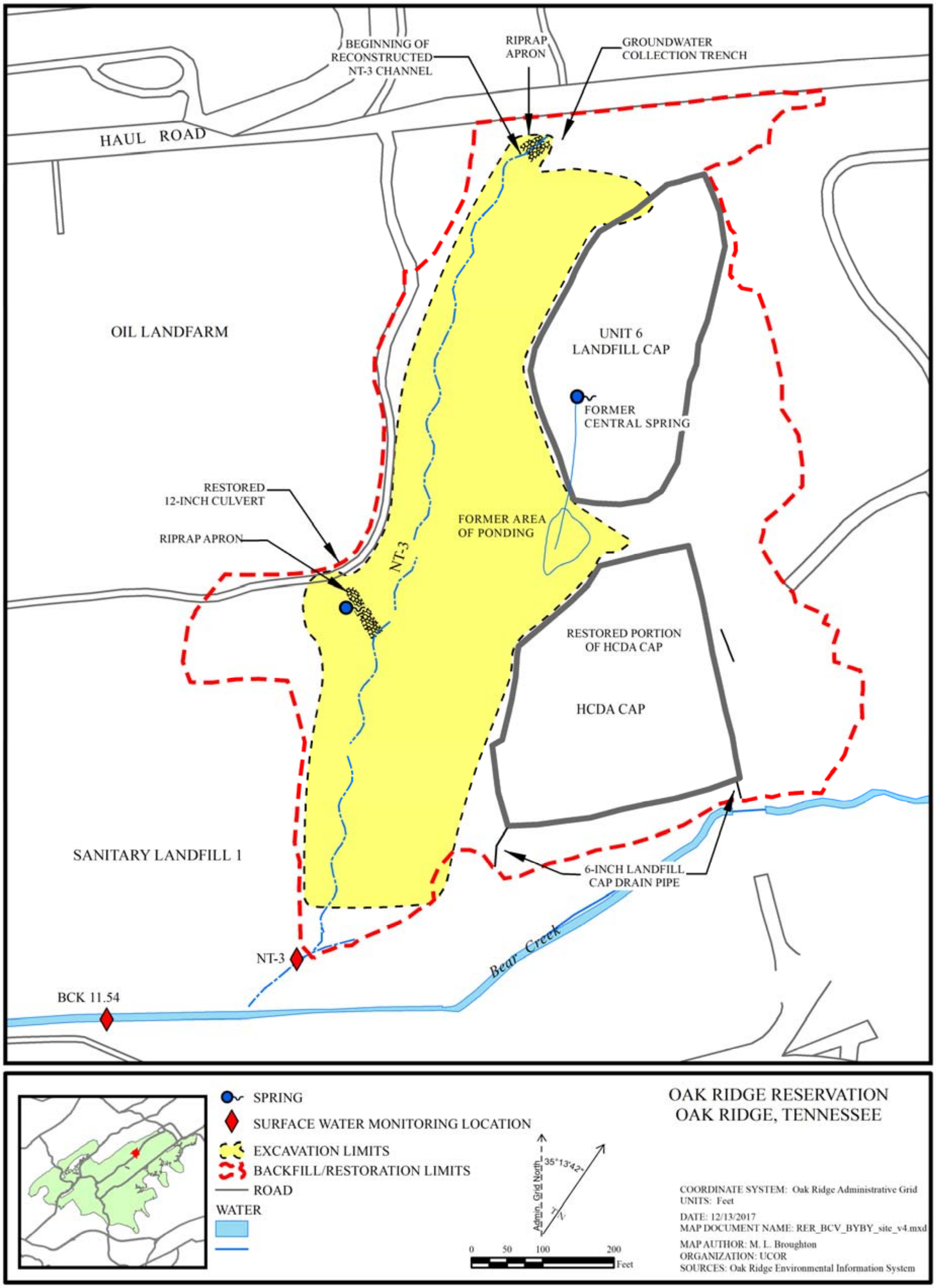

Figure 4.10. Location of BYBY site and monitoring locations.

4.3.1.2.2 Groundwater

The BCV Phase I ROD goals for groundwater are included in Table 4.1. Generalized areas of groundwater contamination are shown on Figure 4.2. The ROD had a goal to conduct source control actions to 'improve conditions in groundwater in Zone 3 to allow Zones 1 and 2 to achieve the intended goals' (Zone 1 and 2 groundwater goals were to maintain clean groundwater for unrestricted use and improve groundwater to achieve unrestricted use, respectively). The BCV RI identified the groundwater COCs that are listed in Table 4.8. Data are discussed in this section for the predominant COCs, focusing on those constituents that exceed MCLs (used solely as screening levels in Zones 2 and 3), or those COCs that occur at high concentrations in Zone 3 source areas and are detected in groundwater downgradient in Zones 2 and 1. The most significant impacts to groundwater in BCV occur within Zone 3 beneath and downgradient from the liquid and solid waste disposal areas. Some groundwater contamination is known to extend from Zone 3 westward into Zones 2 and 1 in the Maynardville Limestone.

Table 4.8. BCV groundwater COCs

Organics	Metals	Radionuclides	Anions
1,1,1-trichloroethane	Barium	Am-241	Fluoride
1,1,2- trichloroethane	Beryllium	Cs-137	Nitrate
1,1-dichloroethane	Boron	H-3	Nitrite
1,1-dichloroethene	Cadmium	K-40	
1,2-dichloroethane	Chromium	Np-237	
1,2-dichloroethene	Manganese	Pb-212	
2, 4-Dinitrophenol	Mercury	Ra-alpha	
Benzene	Nickel	Sr-90	
Bis(2-ethylhexyl)phthalate	Strontium	Tc-99	
Carbon tetrachloride	Uranium	Th-228	
Chloroform		Th-230	
Di-n-octylphthalate		U-234	
Methylene Chloride		U-235	
PCB-1254		U-238	
Perchloroethene			
Trichloroethene			
Trans-1,2-dichloroethene			
Trichlorofluoromethane			
Vinyl chloride			

Source: Table 5.4 in the *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/01-1455/D2&V1).

BCV = Bear Creek Valley
COC = contaminant of concern
PCB = polychlorinated biphenyl

Geologic and hydrogeologic conditions in BCV are complex. The bedrock formations that underlie the principal contaminant source areas include about 1,200 ft of stratigraphic thickness of thin- to medium-bedded, mixed clastic and carbonate rock types (from oldest to youngest by depositional age consisting of the Pumpkin Valley Shale, Rutledge Limestone, Rogersville Shale, Maryville Limestone, and Nolichucky Shale). Some of the limestone beds within these predominantly clastic bedrock units are important to groundwater contaminant transport through fractures and larger openings caused by chemical weathering.

The youngest depositional geologic unit in the Conasauga Group is the Maynardville Limestone, which is comprised of about 400 ft (stratigraphic thickness) of relatively pure carbonate bedrock. The Maynardville Limestone has been informally subdivided into as many as six distinct lithostratigraphic facies. These lithofacies represent slightly different depositional settings and/or zones that have experienced different post-depositional changes to their primary porosity. These differences in primary bedrock porosity make the zones susceptible to differential chemical weathering and formation of cavities and connected conduits that conduct groundwater flow. Of note is that the lithostratigraphic zone at the top of the Maynardville Limestone has the highest primary porosity and is coincident with a prominent zone of karst development that is a primary contaminant plume pathway. The Maynardville Limestone occupies the lowest topographic position in BCV and lies beneath Bear Creek. These lithostratigraphic facies tend to be laterally discontinuous and vary in thickness along geologic strike. In addition to the bedrock depositional heterogeneities, geologic structural features such as joints and fractures, intraformational thrust faulting, and cross-strike faulting further complicate groundwater migration through bedrock.

The role of local faults on groundwater transport may vary by the bedrock lithologies involved. For instance, cross faults that offset the thin- to medium-bedded clastic dominated formations may actually interrupt strike-parallel groundwater movement by abutting clastic beds against carbonate beds effectively forming local barriers to strike-parallel flow. On the other hand, cross faults in massive carbonate bedrock may facilitate flow through the associated fractures with enhancement by chemical weathering processes, thus increasing cross-strike flow. The karst conditions in the Maynardville Limestone facilitate contaminant movement via conduit flow. Such contaminant transport has both continuous and episodic aspects. Interconnections in conduit systems can produce conditions under which flow paths can shift both spatially and vertically depending on groundwater levels and total surface water and groundwater system flow volumes.

The following sections present summary data evaluations of the principal groundwater contaminants in BCV. ROD-based groundwater quality goals for each zone are listed in Table 4.1. Table 4.4 includes the BCV watershed CERCLA performance monitoring requirements that are used to evaluate attainment of these goals. Groundwater sampling locations are shown on Figure 4.2.

Zone 1

As noted in Table 4.1, the BCV Phase I ROD goal is to “maintain clean groundwater and surface water so that the area continues to be acceptable for unrestricted use.” MCLs are an ‘expected outcome’ (Table 4.3) in Zone 1. With this goal in mind, during FY 2018 groundwater monitoring in Zone 1 included sampling of three springs (SS-6, SS-7, and SS-8) and six monitoring wells (GW-710 through GW-715) that sample groundwater from the Maynardville Limestone near the Zone 1/Zone 2 boundary. This line of wells is referred to as Picket W. Well construction information for Picket W wells is summarized in Table 4.9. The wells are completed at a wide range of depths and elevations and open or screened intervals provide broad coverage of the several locally defined stratigraphic members of the Maynardville Limestone. Currently the wells are monitored semiannually for nitrate; metals, including uranium; VOCs, and radiological constituents.

The analytical data for groundwater contaminants in the transect are compiled to evaluate contaminant concentrations with respect to EPA’s National Primary Drinking Water Regulations MCLs or MCL-DCs for radionuclides and to determine if statistically significant trends are occurring. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants that may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations. Table 4.10 includes the data screening concentration summaries and M-K trend directions for constituents that have been detected at concentrations of 80% or more of their respective MCLs within the past decade.

Table 4.9. Well construction information for Picket W wells at the Zone 1/Zone 2 boundary

Well ID	Well type	Ground surface elevation	Sample zone top depth	Sample zone bottom depth	Sample zone top elevation	Sample zone mid-point elevation	Sample zone bottom elevation
GW-710	Open	906.83	539.7	744.5	367.13	264.73	162.33
GW-711	Open	901.96	616	666.2	285.96	260.86	235.76
GW-712	Open	873.61	441.5	457.5	432.11	424.11	416.11
GW-713	Open	877.83	305	315.2	572.83	567.73	562.63
GW-714	Open	872.3	115.1	145	757.2	742.25	727.3
GW-715	Screen	872.17	33.1	43.1	839.07	834.07	829.07

Depth data are ft bgs and elevation data are in ft aMSL.

aMSL = above Mean Sea Level
bgs = below ground surface
GW = groundwater
ID = identification

Wells GW-710 and GW-711 are very deep wells (about 745 ft and 666 ft, respectively) and their water chemistry is dominated by sulfate, chloride, calcium, and sodium. Drilling records indicate that bedrock penetrated in well GW-710 between depths of 350 ft and 699.5 ft bgs contained no water producing fractures. The well depth was extended an additional 45 ft at which point a yield of five to 10 gal/hr was obtained. In GW-711, groundwater bearing zones were not present in the depth range of 421 to 650 ft bgs, but sufficient water to provide samples was encountered between 650 and 666 ft depth. Development water from both wells GW-710 and GW-711 were described as greenish in color attributed to dissolved ferrous iron that became an orange precipitate after contact with the air. The development water from both wells had a petroliferous odor that was attributed to naturally-occurring organic compounds in the bedrock. As shown in Table 4.9, the open interval in GW-710 is about 205 ft in vertical length and its top elevation is approximately 80 ft higher than the top of the open zone in GW-711. The groundwater at the sampled depths contains approximately 4,000 mg/L total dissolved solids. During FY 2018, specific conductance values in GW-710 fluctuated in the range of about 3,900 to 4,300 µmho/cm, while those in GW-711 were about 4,100 – 4,300 µmho/cm. Dissolved oxygen is low (FY 2018 values ranged from 0.68 – 0.87 ppm in GW-710 and GW-711) in this deep groundwater and redox values are fairly strongly reducing at levels below -100 mV. These are indications that the groundwater in these zones has limited interaction with fresh recharging waters at the top of the aquifer.

Well GW-712 is nearly 460 ft deep and has a 16 ft long open interval in bedrock from which groundwater samples are obtained. Well GW-712 samples fresher groundwater than the deeper wells with specific conductance in the 267 – 369 µmho/cm range. During FY 2018, dissolved oxygen levels were 0.72 ppm or less and the redox values were -28 and -98 mV.

Well GW-713 is about 315 ft deep and samples groundwater from a 10 ft long open interval in bedrock. During FY 2018, the specific conductance of the groundwater in this well was measured to be 285 and 231 µmho/cm, although in the early 2000s, levels were in the 700 – 1,000 µmho/cm range. Dissolved oxygen levels measured in the well water during FY 2018 were 0.71 and 0.72 ppm, which are very low. Redox was measured at -156 and 27 mV in January and July, respectively.

Well GW-714 is about 145 ft deep and has a 30 ft long open interval in bedrock from which samples are drawn. During FY 2018, specific conductance was measured to be 364 and 483 µmho/cm, although in the early 2000s levels fluctuated in the 400 – 800 or higher µmho/cm range. Dissolved oxygen was measured to be 0.63 and 0.76 ppm in January and July 2018. Several higher values were reported in past years. In previous years, redox in well GW-714 has typically fluctuated in the range of about 50 – 200 mV, although, during FY 2018, the redox values were 75 and -74 mV.

Well GW-715 is about 43 ft deep and has a 10 ft long screen in the monitoring interval. This well was not actively monitored from 2004 through 2013 because it was removed from the required RCRA groundwater monitoring regime in BCV. Sampling of well GW-715 was resumed in FY 2014 to provide a more complete understanding of groundwater conditions in this portion of Zone 1 and to support DOE's ORR Groundwater Program. FY 2018 specific conductance values were 288 and 407 µmho/cm in February and August, respectively. In the early 2000s, conductivity values ranged from a low of <200 µmho/cm to several values in the 500 – 700 µmho/cm range. Dissolved oxygen levels in GW-715 are typical of the very shallow groundwater zone it samples with values of 8.56 and 3.91 ppm in FY 2018. Since this well is fairly shallow, it samples the most oxygen-rich groundwater of all the wells in Picket W. Redox levels in GW-715 lie in the range of 100 – 200 mV, with FY 2018 values of 176 and 145 mV.

Three springs (S-6.6, SS-7, and SS-8) were monitored in Zone 1 in FY 2018 (Figure 4.2). Sampling of these springs was conducted semiannually during the high-flow wet season (typically during winter) and during the low-flow dry season (during summer months). Figure 4.11 shows nitrate concentrations in the Zone 1 springs and wells where nitrate was consistently detectable from 2000 through FY 2018. Nitrate is commonly detected at BCV Zone 1 springs and in wells GW-714 and GW-715 at concentrations less than 50% of the MCL (10 mg/L).

Table 4.10. Summary of Picket W groundwater contaminant screening and trend evaluation (FY 2009 – FY 2018)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Alpha activity	GW-710	pCi/L	5 / 12	5 / 10	16.3	**21.3**	**21.3**	14	15	1 / 12	1 / 10	3 / 12	3 / 10	No trend	No trend
	GW-711	pCi/L	4 / 12	3 / 10	16.7	12.3	9.39	6.82	15	0 / 12	0 / 10	1 / 12	0 / 10	No trend	No trend
Arsenic	GW-710	mg/L	4 / 12	3 / 10	0.005	0.008	0.007	0.00067	0.01	0 / 12	0 / 10	1 / 12	0 / 10	Stable	Stable
	GW-710(F)	mg/L	2 / 12	2 / 10	0.005	0.006	0.006	ND	0.01	0 / 12	0 / 10	0 / 12	0 / 10	Stable	Stable
	GW-715	mg/L	1 / 10	1 / 10	0.005	0.009	0.009	ND	0.01	0 / 10	0 / 10	1 / 10	1 / 10	Stable	Stable
	GW-715(F)	mg/L	0 / 10	0 / 10	0.005	ND	ND	ND	0.01	0 / 10	0 / 10	0 / 10	0 / 10	--	--
Chromium	GW-715	mg/L	10 / 10	10 / 10	--	**0.13**	**0.13**	0.028	0.1	1 / 10	1 / 10	1 / 10	1 / 10	Stable	Stable
	GW-715(F)	mg/L	5 / 10	5 / 10	0.005	0.004	0.004	0.002	0.1	0 / 10	0 / 10	0 / 10	0 / 10	Stable	Stable
Total Radium Alpha	GW-710	pCi/L	11 / 11	9 / 9	--	**5.46**	**5.46**	**5.38**	5	2 / 11	2 / 9	7 / 11	6 / 9	No trend	Stable
Uranium	GW-715	mg/L	9 / 10	9 / 10	0.004	**0.032**	**0.032**	0.022	0.03	1 / 10	1 / 10	1 / 10	1 / 10	No trend	No trend
	GW-715(F)	mg/L	9 / 10	9 / 10	0.004	**0.033**	**0.033**	0.023	0.03	1 / 10	1 / 10	1 / 10	1 / 10	No trend	No trend

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Detection limits assigned to non-detects were used in evaluation of the M-K trends.
[b]MCL or MCL-DC as of May 2018.
[c]Significant linear trend from the M-K test at the 0.10 significance level.

Bold table entries indicate results that exceed MCL or MCL-DC values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

CV = coefficient of variation
Freq. = frequency
FY = fiscal year
GW = groundwater
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
M-K = Mann-Kendall
ND = not detected

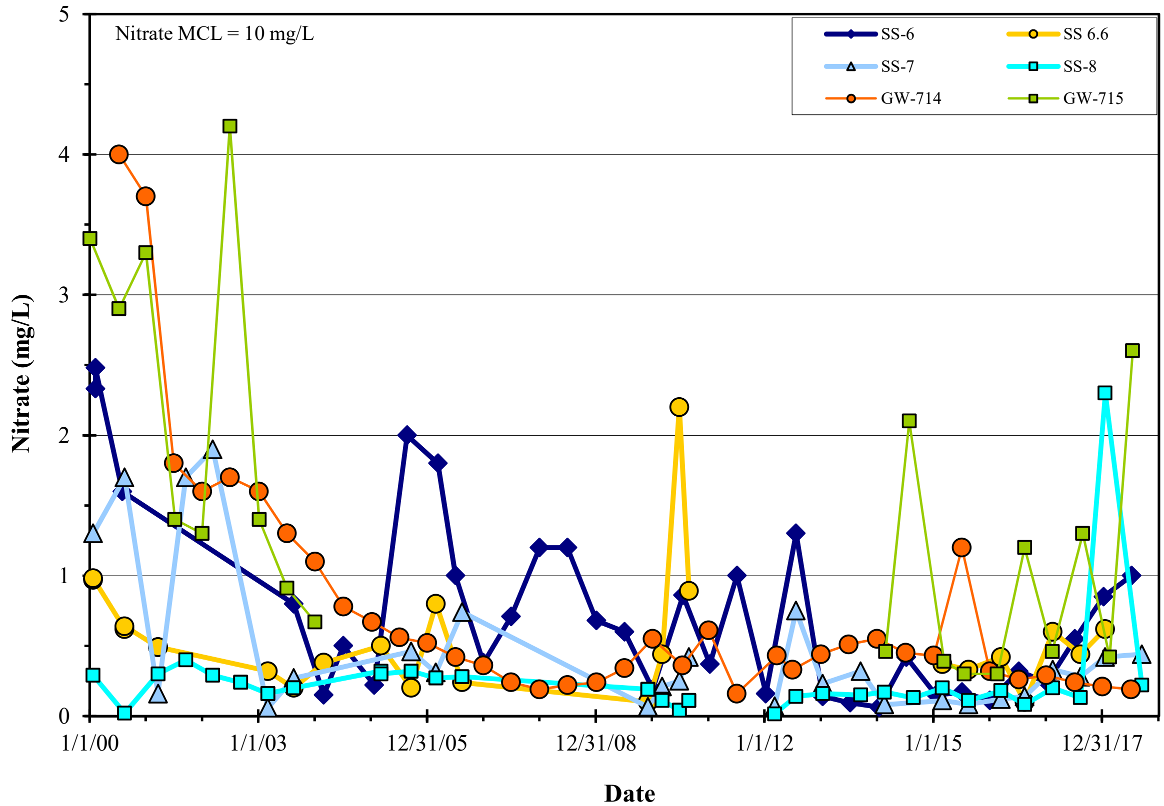

Figure 4.11. Nitrate concentrations in Zone 1 springs and wells GW-714 and GW-715.

Springs in BCV discharge groundwater from shallow epikarst pathways that discharge into Bear Creek. The springs act as IPs for groundwater in the karst groundwater flow system in the Maynardville Limestone. This bedrock flow system is very complex. The system contains both components of deep, long-distance flow originating at the S-3 Ponds area in the Bear Creek headwaters as well as shallow components where Bear Creek surface water and groundwater commingle. This commingling occurs as seasonal flow volume and groundwater level variation allow surface water to sink into the bedrock karst with resurgences to the surface via springs further downgradient. The Zone 1 springs are resurgence points for groundwater originating from within BCV and groundwater inputs from the northern slopes of Chestnut Ridge. Analyses are performed for a broad suite of parameters, such as metals (including uranium as a metal), VOCs, anions (including nitrate), and radionuclides (including uranium isotopes and Tc-99). Nitrate, uranium isotopes, and Tc-99 are signature contaminants that originate in the S-3 Ponds plume and are focal points in the following discussion.

Figure 4.12 shows the uranium concentrations in the Zone 1 spring samples from FY 2000 through FY 2018. Two sets of results are included for each location. One result is based on conversion of the uranium isotopic concentrations for the individual isotopes (U-234, U-235, and U-238) to an equivalent uranium metal concentration, while the other result is from the direct lab analysis for total uranium. The results for the two analytical methods are fairly comparable, although the sensitivity of the isotopic analysis sometimes provides a lower calculated uranium concentration than the lab method used for the total uranium analysis. In most cases, the data show that the uranium concentrations in the Zone 1 springs are less than the 30 µg/L MCL. During 2009 – 2013, a sample location error at Spring SS-6.6 resulted in samples from Bear Creek affecting the result from the spring, which accounts for the elevated uranium concentration at that location during that time period. During January 2018 an unusual spike of uranium was measured at Spring SS-8. The cause of this result is not well understood since the other, upstream springs in Zone 1 did not show a similar response.

Uranium isotopic ratios in the spring water discharges have been compared to those from other key source areas in BCV including the S-3 Ponds, discharge at BCK 12.34, NT-3 water, NT-8 water, and the combined discharge monitored at BCK 9.2. The uranium isotope ratios for other springs in Zone 1 all indicate that they are resurgence points for groundwater that entered the system from sinking groundwater downstream of the NT-8 sinking reach.

Analyses conducted since FY 2000 show the occasional presence of very low levels of Tc-99 in the springs, although Tc-99 was not detected in Zone 1 groundwater during FY 2018. Like nitrate, Tc-99 is a signature contaminant that originates from the S-3 Ponds releases. The levels of Tc-99 detected in the Zone 1 springs are in the range of 10 – 30 pCi/L, which are approximately 1% of the MCL-DC activity of 900 pCi/L. The majority of Tc-99 results are non-detect and nearly all the results indicate the presence of Tc-99 as estimated (J qualified). A Tc-99 result of 12.1 pCi/L was detected in the Spring SS-8 sample collected in January 2018 which was coincident with the elevated uranium result in that sample.

During the 1990s, low to trace concentrations of PCE, TCE, and 1,2-DCE were detected in SS-6 springwater. Chlorinated VOCs have not been detected at SS-6 since FY 1998. VOCs were not detected in any of the three springs accessible for sampling (SS-6.6, SS-7, and SS-8) in Zone 1 during FY 2018.

Groundwater monitoring of available wells and springs in Zone 1 shows that in recent years, including FY 2018, the ROD goal of protecting groundwater at MCLs has been attained. Ongoing groundwater monitoring does show the presence of below-MCL concentrations of some site-related contaminants. Because of the intermittent nature of contaminant detection at low levels in the Zone 1 groundwater, an area of intermittent plume extension in the Maynardville Limestone is shown on Figure 4.2. Contaminant concentrations continue to remain low, and per the approved BCV RAR CMP, will continue to be monitored and reported annually in the RER. The uncertainties about groundwater contaminant levels and flow paths in BCV Zones 1 and 2 have been identified as issues in the ORR Groundwater Strategy. Evaluation of potential pathways and installation of additional wells, as necessary, will be included in investigations during groundwater strategy implementation and will be sequenced according to ORR-wide groundwater issues prioritization.

Collectively, the data from groundwater monitoring in Picket W wells and Zone 1 springs indicates that the impacts to Zone 1 groundwater in this well transect are observed predominantly in the shallow groundwater. Shallow groundwater is most interactive with epikarst groundwater contaminant transport, which is spatially and temporally interactive with the surface water contaminant transport in Bear Creek.

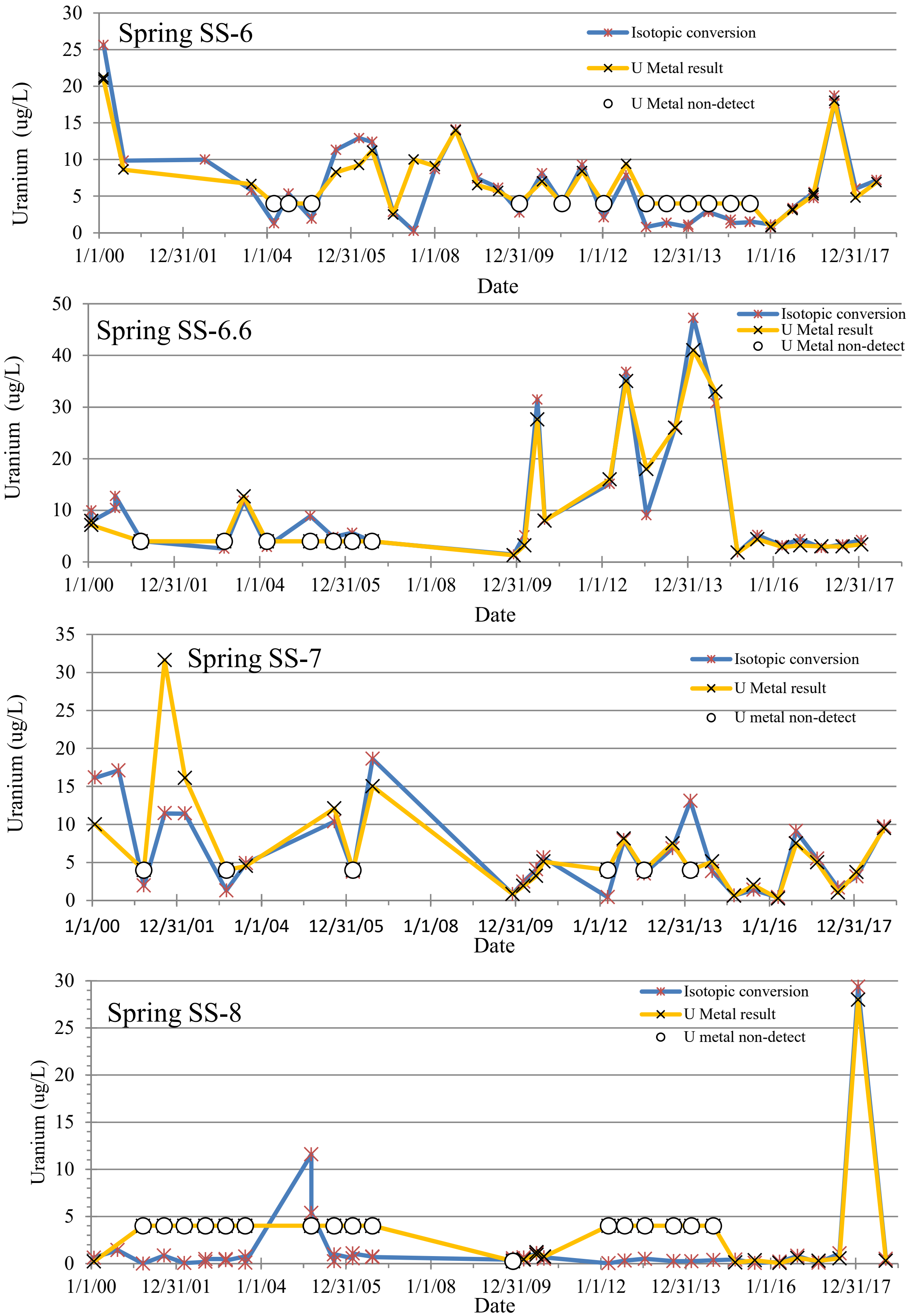

Figure 4.12. Zone 1 springs uranium concentrations, FY 2000 – FY 2018.

Zone 2

The groundwater quality goal for Zone 2 is to eventually achieve unrestricted use. The ROD did not include remediation levels for groundwater in Zone 2. MCL contaminant concentrations are used for data screening comparison levels.

Groundwater monitoring used to evaluate conditions in the eastern end of Zone 2 consists of sampling six wells along the boundary with Zone 3 near the western end of the BCBGs. Well locations are shown on Figure 4.2. Four of these wells (GW-077 through GW-080) are located west of NT-8 and north of Bear Creek Road in the Conasauga Group clastic bedrock formations and the other two wells (GW-683 and GW-684) are constructed in the Maynardville Limestone to the south of Bear Creek Road along the transect designated as Picket A (Figure 4.2).

Wells GW-077 (100 ft deep, screened between 814.4 and 827.3 ft aMSL) and GW-078 (21 ft deep, screened between 893.4 and 902.8 ft aMSL) sample groundwater in the Nolichucky Shale. Wells GW-079 (65 ft deep, screened between 912.3 and 927.3 ft aMSL) and GW-080 (30 ft deep, screened between 947.4 and 956.3 ft aMSL) sample groundwater from the Rogersville Shale Formation. All four of these wells are sampled for anions, metals, radionuclides, including uranium isotopes and total Ra-alpha activity, and VOCs. No VOCs were detected in any of the wells during FY 2018. All of the uranium metal results were lower than the 30 µg/L uranium metal MCL with a maximum measured concentration of 0.21 µg/L.

Several heavy metals are detected in the Zone 2 wells. The analytical data for groundwater contaminants in the transect are compiled to evaluate contaminant concentrations with respect to EPA's National Primary Drinking Water Regulations MCLs or MCL-DCs for radionuclides and to determine if statistically significant trends are occurring. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants that may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations.

Two of the six wells have exhibited metals concentrations that have exceeded MCL concentrations within the past 10 years – lead in GW-080 and nickel in GW-683. Table 4.11 summarizes the results for those metals. The frequency of detection of lead at GW-080 over the past 10 years is approximately 50% and only one sample has exceeded the MCL action level for lead (0.015 mg/L) within the past 10 years. The maximum detected lead concentration during FY 2018 was 0.003 mg/L. The variability of lead concentrations in samples from GW-080 is sufficiently high to prevent assignment of a trend direction with statistical confidence. The frequency of detection of nickel at GW-683 is also approximately 50% over the past 10 years but rose to 90% over the past five years probably because of more stringent detection limits in the laboratory analyses. The maximum measured nickel concentration of 0.11 mg/L within the past five years was just slightly greater than the 0.1 mg/L MCL. Nickel concentrations exhibited an increase in the full 10-year evaluation although concentration variability within the past five years has been sufficiently high to prevent assignment of a trend direction with statistical confidence. The maximum FY 2018 nickel concentration was 0.052 mg/L which is approximately 50% of the 0.1 mg/L MCL. These are the only six wells available to sample along the Zone 2/Zone 3 boundary at the western edge of the BCBGs. The possibility of deeper groundwater contamination migration from the DNAPL area beneath the BCBGs cannot be evaluated with the existing well network. This scarcity of groundwater monitoring opportunities in this area west of the BCBGs was identified in previous RERs and in the ORR Groundwater Strategy.

Table 4.11. Summary of heavy metals detection in Zone 2 and 3 wells (FY 2009 – FY 2018)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Lead	GW-080	mg/L	4 / 10	4 / 8	0.003	**0.028**	**0.028**	0.003	0.015	1 / 10	1 / 8	1 / 10	1 / 8	No trend	No trend
Nickel	GW-683	mg/L	12 / 20	9 / 10	0.01	**0.11**	**0.11**	0.052	0.1	1 / 20	1 / 10	4 / 20	4 / 10	Up	No trend

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Detection limits assigned to non-detects were used in evaluation of the M-K trends.
[b]MCL or MCL-DC as of May 2018.
[c]Significant linear trend from the M-K test at the 0.10 significance level.

Bold table entries indicate results that exceed MCL or MCL-DC values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

CV = coefficient of variation
Freq. = frequency
FY = fiscal year
GW = groundwater
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
M-K = Mann-Kendall

Wells GW-683 and GW-684 sample bedrock groundwater from the Maynardville Limestone upgradient of spring SS-5 and are monitored semiannually for metals, including uranium; nitrate; VOCs; and radiological constituents. Well GW-683 is 197.5 ft deep (screened interval elevation 772.65 to 835.55 ft aMSL) and well GW-684 is 129.6 ft deep (screened interval elevation 765.93 to 789.13 ft aMSL). The principal contaminants detected in these wells that presently or have historically exceeded the screening criteria are nitrate and uranium isotopes (Figure 4.13). Nitrate is compared to the MCL of 10 mg/L. Nitrate has been detected in wells GW-683 and GW-684 at concentrations less than half of the MCL since 2002. During the time period between 2009 and August 2018, the measured U-238 concentrations have been less than the Phase 1 ROD Zone 3 IP RBC of 6.87 pCi/L in wells GW-683 and GW-684.

Tc-99 was detected at a very low concentration of 3.2 J pCi/L in well GW-683 during February 2018 and was not detected in the August sample. Tc-99 was detected in both FY 2018 samples collected from well GW-684 at concentrations of 5.38 J and 7.99 pCi/L in February and July, respectively. Alpha activity was less than 5 pCi/L in well GW-683 during FY 2018 and was less than 7.4 pCi/L in samples collected from GW-684. Beta activity levels were 4.95 and 5.13 pCi/L in well GW-683 and were 8.86 and 12.9 pCi/L in the February and July sampling events at GW-684. Chlorinated VOCs including TCE and methylene chloride were detected at concentrations less than 0.5 µg/L in the February sample from well GW-683. At well GW-684, chloroform was detected at very low concentrations (0.36 J and 0.63 J µg/L) in February and July while TCE and cis-1,2-DCE were detected at 0.34 J and 0.38 J µg/L in the February sample.

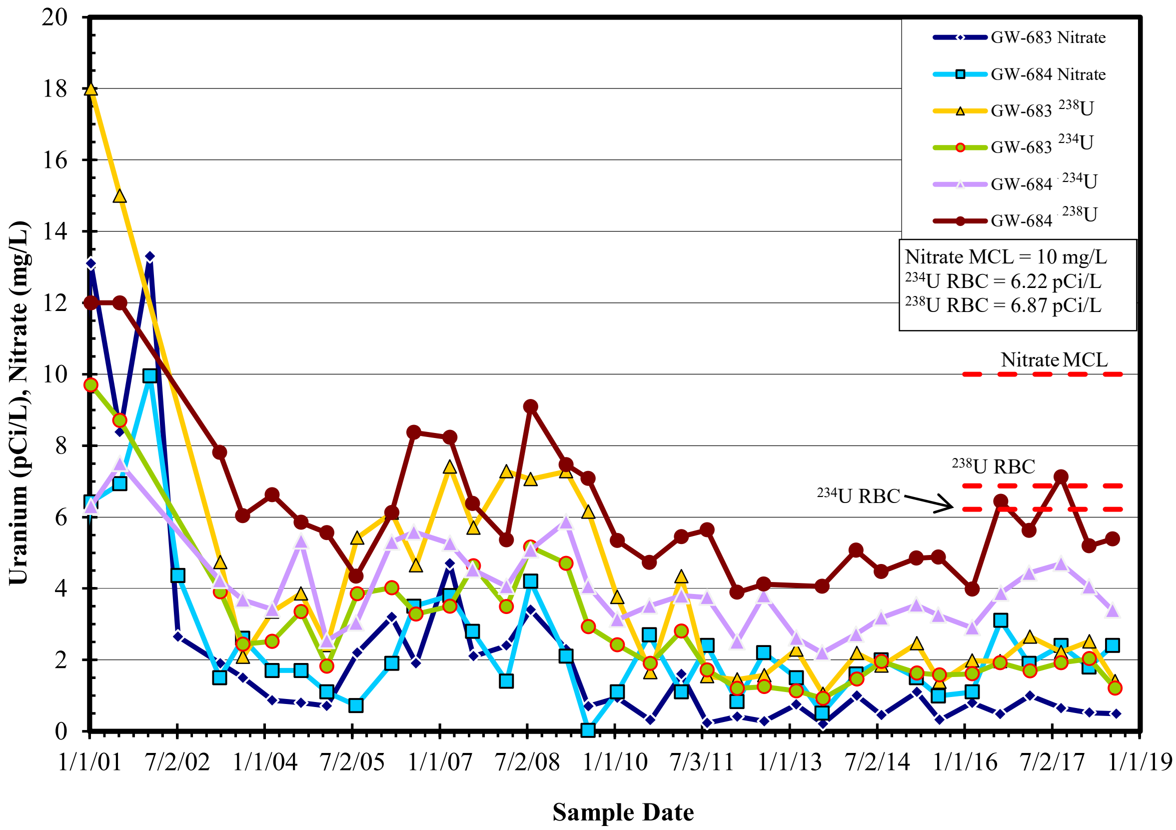

Figure 4.13. Constituents detected above RBC or MCL at wells GW-683 and GW-684.

Wells GW-683 and GW-684 sample groundwater contamination that originates from upgradient sources, including the S-3 Ponds and portions of the BCBGs, and flows through karst conduits in the Maynardville Limestone prior to rising to discharge into Bear Creek at spring SS-5 (Figure 4.2). Although a portion of the groundwater contaminant plume shown on Figure 4.2 terminates at the known plume discharge point at SS-5, detection of contaminants linked in springs further downgradient in Zone 1 to the S-3 Ponds plume from upstream of the BCBGs indicates the presence of some discrete conduit flow connecting Zones 1 and 3. Wells do not exist in the Maynardville Limestone in Zone 2 that could help delineate the contaminant transport characteristics in that area. Groundwater sampling further to the west at the Picket W wells (Figure 4.2) shows the presence of nitrate and uranium at concentrations less than MCL-based screening levels as discussed previously in the Zone 1 groundwater section. Transient episodes of groundwater contaminant migration occur through bedrock groundwater flow pathways through Zone 2 and into Zone 1. A scarcity of groundwater monitoring wells in appropriate locations and depths in Zone 2 makes it impossible to precisely map and track groundwater contaminant transport pathways that may emanate from DNAPL at depth beneath the BCBGs. This scarcity of wells in Zone 2 near the Zone 3 boundary capable of detecting contaminant migration in key geologic positions was identified in previous RERs and in the ORR Groundwater Strategy.

Zone 3

As summarized in Table 4.3, cleanup levels for groundwater in Zone 3 were not specified in the Phase I ROD and no specific groundwater actions were included in the decision. The ROD indicates source area RAs are intended to improve conditions in groundwater for protection of water quality in Zones 1 and 2. Groundwater monitoring in Zone 3 includes monitoring of wells GW-704 and GW-706, which sample groundwater in the S-3 plume, and former RCRA PCP sampling of wells GW-008 near the Oil Landfarm, GW-046 in the BCBGs, and well GW-276 near the S-3 Ponds Site (Figure 4.2). Contaminant plumes in BCV (courtesy of Y-12 GWPP) are shown in Figure 4.2.

The analytical data for groundwater contaminants in Zone 3 are compiled to evaluate contaminant concentrations with respect to EPA's National Primary Drinking Water Regulations MCLs or MCL-DCs for radionuclides and to determine if statistically significant trends are occurring. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants that may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations using an application of Kendall's tau-b correlation of concentrations with time (Helsel 2005) were also conducted. Data were compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification. For non-detect results, the detection limit is used in the M-K trend evaluations.

Table 4.12 summarizes the Zone 3 groundwater contaminant screening comparisons to 80% of the MCL and MCL-DC and the full MCL concentration for the past 10 years of monitoring. Groundwater contaminants in Zone 3 groundwater that exceed MCLs include meals, volatile organic compounds, nitrate, and uranium. Review of Table 4.12 shows that through the last 10 years of groundwater monitoring the contaminant concentrations have generally deceased based on successively decreasing maximum measured contaminant concentrations for the full 10-year, the 5-year, and the FY 2018 data summaries. Where contaminant concentration variability allows statistically significant trend assignments, the M-K trends for the 10-year evaluation period have been decreasing or stable. No increasing trends are assigned in the 10-year trend evaluation. In the 5-year evaluation period the majority of trends are assigned as stable conditions. Although many of the contaminants that have exceeded their respective MCL/MCL-DC concentrations in the 10-year evaluation continue to exceed the MCLs/MCL-DCs in the FY 2018 maximum values, the groundwater conditions have shown gradual improvement over the past decade.

Table 4.12. Summary of BCV Zone 3 groundwater contaminant screening and trend evaluation (FY 2009 – FY 2018)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,1-Dichloroethene	GW-008	mg/L	19 / 19	9 / 9	--	**0.008**	0.006	0.005	0.007	2 / 19	0 / 9	6 / 19	1 / 9	Down	Stable
	GW-046	mg/L	18 / 19	9 / 9	0.2	**0.13**	**0.067**	**0.022**	0.007	18 / 19	9 / 9	18 / 19	9 / 9	Stable	No trend
1,2-Dichloroethane	GW-046	mg/L	13 / 19	8 / 9	0.2	**0.007**	**0.007**	ND	0.005	5 / 19	1 / 9	5 / 19	1 / 9	No trend	Stable
Alpha activity	GW-276	pCi/L	19 / 19	9 / 9	--	**163**	**151**	**89.1**	15	19 / 19	9 / 9	19 / 19	9 / 9	Stable	Down
	GW-706	pCi/L	19 / 20	10 / 10	3.27	**24.8**	**24.8**	**17.8**	15	14 / 20	7 / 10	17 / 20	9 / 10	Stable	No trend
Benzene	GW-046	mg/L	18 / 19	9 / 9	0.2	**0.29**	**0.29**	**0.053**	0.005	18 / 19	9 / 9	18 / 19	9 / 9	No trend	No trend
Beryllium	GW-276	mg/L	19 / 19	9 / 9	--	**0.006**	**0.005**	0.003	0.004	5 / 19	1 / 9	12 / 19	7 / 9	No trend	Stable
Cadmium	GW-276	mg/L	19 / 19	9 / 9	--	**0.024**	**0.02**	**0.012**	0.005	19 / 19	9 / 9	19 / 19	9 / 9	No trend	Stable
cis-1,2-Dichloroethene	GW-046	mg/L	19 / 19	9 / 9	--	**6.9**	**5.5**	**1.2**	0.07	19 / 19	9 / 9	19 / 19	9 / 9	Stable	Stable
Methylene chloride	GW-046	mg/L	10 / 19	5 / 9	0.02	**0.32**	0.004	ND	0.005	5 / 19	0 / 9	6 / 19	1 / 9	No trend	No trend
Nickel	GW-276	mg/L	19 / 19	9 / 9	--	**0.3**	**0.26**	**0.15**	0.1	16 / 19	9 / 9	19 / 19	9 / 9	No trend	Down
Nitrate/Nitrite as Nitrogen	GW-276	mg/L	18 / 18	9 / 9	--	**13**	9.6	7.5	10	4 / 18	0 / 9	14 / 18	5 / 9	Down	Stable
	GW-704	mg/L	18 / 18	10 / 10	--	**13**	**11**	9.5	10	5 / 18	2 / 10	11 / 18	6 / 10	Stable	Stable
	GW-706	mg/L	18 / 18	10 / 10	--	**19**	**14**	**14**	10	11 / 18	4 / 10	16 / 18	8 / 10	Down	No trend
Nitrate-Nitrite	GW-276	mg/L	1 / 1	--	--	**12.2**	ND	ND	10	1 / 1	--	1 / 1	--	--	--
	GW-704	mg/L	2 / 2	--	--	**12.6**	ND	ND	10	1 / 2	--	1 / 2	--	Stable	--
	GW-706	mg/L	2 / 2	--	--	**21.4**	ND	ND	10	1 / 2	--	2 / 2	--	Stable	--
Tetrachloroethene	GW-008	mg/L	19 / 19	9 / 9	--	**0.051**	**0.036**	**0.027**	0.005	19 / 19	9 / 9	19 / 19	9 / 9	Down	No trend
	GW-046	mg/L	19 / 19	9 / 9	--	**1.6**	**0.86**	**0.29**	0.005	19 / 19	9 / 9	19 / 19	9 / 9	Down	Stable
	GW-276	mg/L	19 / 19	9 / 9	--	**0.006**	**0.005**	0.002	0.005	5 / 19	0 / 9	11 / 19	2 / 9	Down	Stable

Table 4.12. Summary of BCV Zone 3 groundwater contaminant screening and trend evaluation (FY 2009 – FY 2018) (cont.)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Trichloroethene	GW-008	mg/L	19 / 19	9 / 9	--	**0.013**	**0.011**	**0.007**	0.005	18 / 19	8 / 9	18 / 19	8 / 9	Down	Stable
	GW-046	mg/L	19 / 19	9 / 9	--	**1.6**	**1.5**	**0.33**	0.005	19 / 19	9 / 9	19 / 19	9 / 9	Down	Stable
	GW-704	mg/L	20 / 20	10 / 10	--	**0.04**	**0.033**	**0.021**	0.005	19 / 20	9 / 10	19 / 20	9 / 10	Down	Stable
	GW-706	mg/L	20 / 20	10 / 10	--	**0.016**	**0.011**	**0.006**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	Stable
Uranium	GW-276	mg/L	19 / 19	9 / 9	--	**0.6**	**0.53**	**0.27**	0.03	19 / 19	9 / 9	19 / 19	9 / 9	No trend	Stable
	GW-706	mg/L	20 / 20	10 / 10	--	**0.066**	**0.061**	**0.051**	0.03	20 / 20	10 / 10	20 / 20	10 / 10	Down	Stable
Vinyl chloride	GW-046	mg/L	19 / 19	9 / 9	--	**0.66**	**0.42**	**0.1**	0.002	19 / 19	9 / 9	19 / 19	9 / 9	Stable	Stable

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[b]MCL or MCL-DC as of May 2018.

[c]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data. M-K Tests are conducted in accordance with *Nondetects and Data Analysis: Statistics for Censored Environmental Data* (Helsel 2005).

-- = not applicable
BCV = Bear Creek Valley
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
GW = groundwater
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
M-K = Mann-Kendall M-K = Mann-Kendall
ND = not detected

Wells GW-704 and GW-706 are in Picket B and sample groundwater from bedrock in the Maynardville Limestone exit pathway downgradient from the former S-3 Ponds and other source areas. Well GW-704 samples groundwater from a depth of 256 ft (screened between 685.99 and 697.49 ft aMSL) and well GW-706 samples groundwater from a depth of 182 ft (screened between 743.28 and 769.68 ft aMSL). The wells are located midway between BCK 11.54 and SS-5. Samples from these wells contain uranium, nitrate, Tc-99, and VOCs (only TCE exceeds a 5 µg/L MCL screening level; while 1,1,1-trichloroethane [TCA], 1,1-DCA, carbon tetrachloride, PCE [<1 µg/L]; 1,1-DCE [<5 µg/L], chloroform [<3 µg/L], and cis-1,2-DCE [<40 µg/L], are detected at levels below their respective MCLs). Contaminant levels in both wells have exhibited decreasing or stable contaminant signatures over the past several years. Principal contaminant concentration graphs for wells GW-704 and GW-706 are shown in Figure 4.14. During FY 2018, contaminant levels continued their seasonal fluctuations and were consistent with previous years showing gradual long-term decreasing or stable trends over the past 15 years of monitoring.

Both shallow and deep sources of VOC contamination are present at the BCBGs. VOC liquids were disposed in some shallow waste burial trenches in Burial Ground A-South with resultant shallow and deep contamination. As shown on Figure 4.2, well GW-008 is located near the Oil Landfarm and GW-046 is located to the east of NT-7 near the southwest corner of Burial Ground A-South. Both of these relatively shallow wells are in areas that are impacted by past disposal of VOCs. Well GW-008 samples groundwater from a depth of about 25 ft (screened between 936.61 and 949.11 ft aMSL) and GW-046 samples groundwater from a depth of about 20 ft (screened between 897.83 and 913.13 ft aMSL). Concentration trends for the principal COCs in these wells are shown in Figure 4.15. While these wells were sampled in FY 2018 prior to the termination of RCRA permit monitoring, the groundwater sampling frequency at these wells has been decreased from semi-annual to annual sampling in the year prior to the FYR. The relatively low VOC concentrations in GW-008 continued during FY 2018 with a concentration rebound evident in the January 2018 sample compared to the July 2017 sample. Well GW-046, which is located downgradient from an area where large quantities of liquid wastes were disposed by percolation into shallow waste burial trenches, contains much higher VOC concentrations. In the January 2018 sample from well GW-046, VOC concentrations measured in GW-046 generally decreased significantly compared to previous levels. The decrease is suspected to be a response to precipitation recharge in the area that causes dilution of the shallow groundwater contaminant concentrations.

Groundwater surveillance monitoring of the BCBGs conducted by the Y-12 GWPP documents increasing VOC concentrations in the noncarbonate, fractured bedrock underlying the area. In a sample collected at a depth of 270 ft (elevation 637 ft aMSL) in well GW-629 (shown in Figure 4.2) by the Y-12 GWPP in 2009, PCE, TCE, and 1,1-DCA were measured at concentrations of 180 ppm, 24 ppm, and 11 ppm, respectively. PCE, TCE, and cis-1,2-DCE are detected in surface water in NT-8. These contaminants are not detected to date in wells GW-077 (100.5 ft deep [elevation 821 ft aMSL]) and GW-078 (21.1 ft deep [elevation 898 ft aMSL]) that lie farther west of the burial grounds and Bear Creek tributary NT-8, perhaps because the wells are located too far south to detect possible plume migration beneath NT-8.

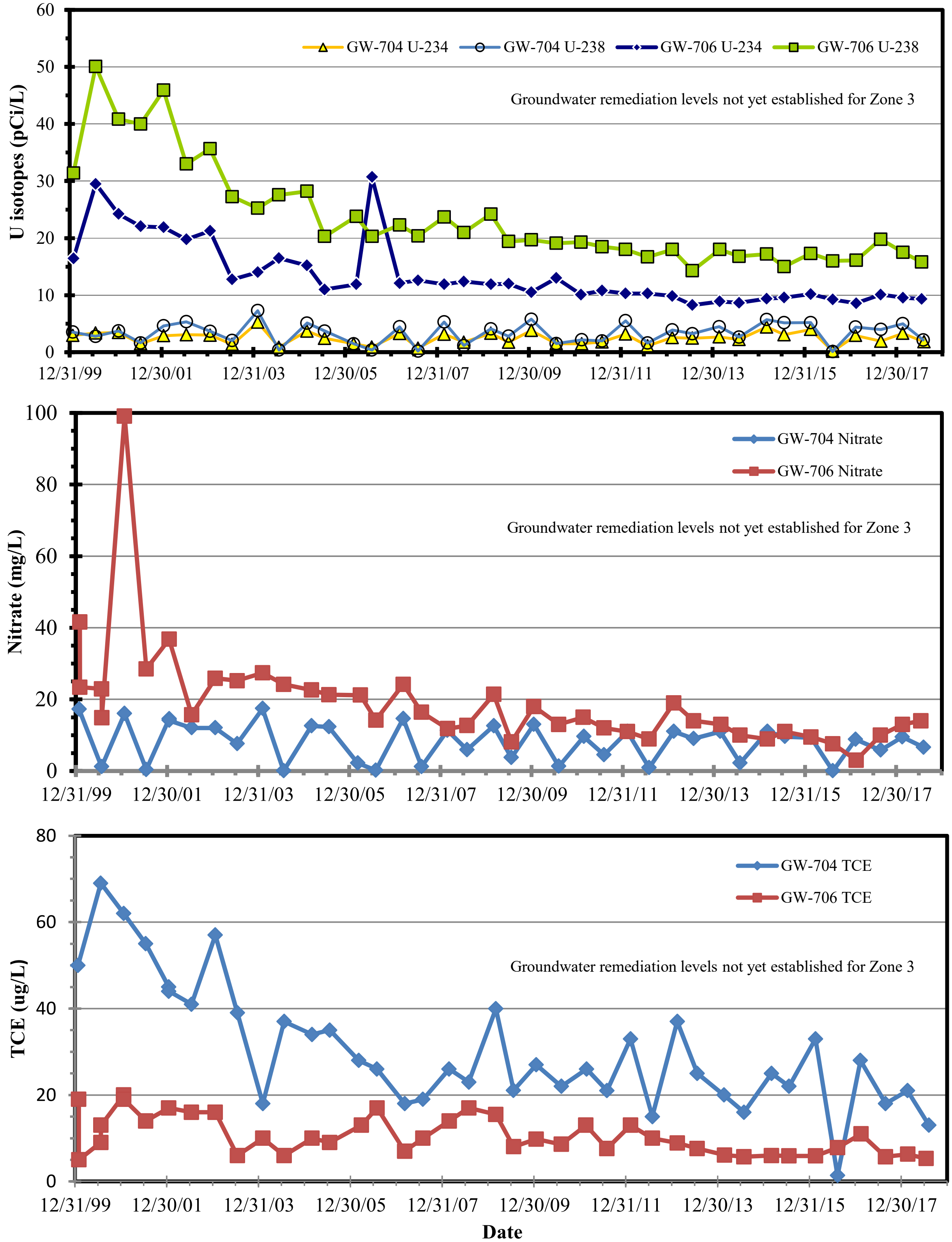

Figure 4.14. Principal contaminant trends in wells GW-704 and GW-706.

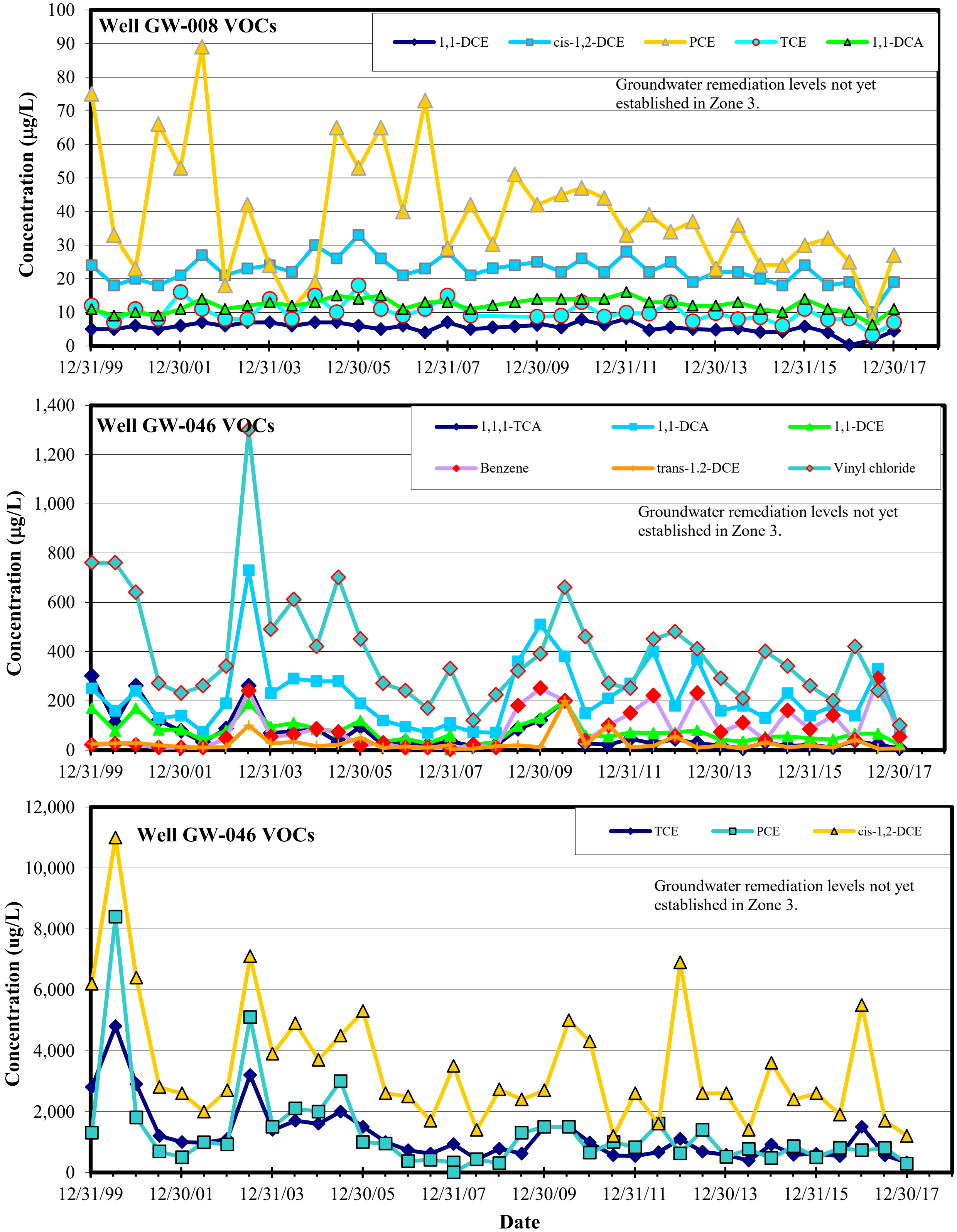

Figure 4.15. VOC concentration trends in wells GW-008 and GW-046.

4.3.1.2.3 Aquatic biological monitoring

4.3.1.2.3.1 Watershed biological monitoring

Aquatic biological monitoring of stream sites in BCV watershed (Figure 4.2) is used to evaluate stream ecological conditions over time, providing an important measure of the effectiveness of both past and potential future remedial and abatement actions in the watershed. Biological monitoring data for streams in BCV include results on (1) contaminant accumulation in fish, (2) fish community surveys, and (3) benthic macroinvertebrate community surveys.

To evaluate instream contaminant conditions and potential human and ecological risks in the BCV watershed, fish are collected twice a year and analyzed for a suite of metals and PCBs at sampling locations BCK 3.3, BCK 9.9, and BCK 12.4 (Figure 4.2). Also, an evaluation of overall ecological health of the streams is conducted by monitoring fish and benthic macroinvertebrate communities at BCK 3.3, BCK 9.9, BCK 12.4, and NT-3 (a tributary to Bear Creek). Mean mercury concentrations in rock bass from lower Bear Creek (BCK 3.3) averaged 0.69 µg/g in fall 2017 and 0.59 µg/g in spring 2018 (Figure 4.16). These concentrations are higher than concentrations seen in FY 2017 and remain above the EPA-recommended fish-based AWQC of 0.3 µg/g, and are elevated with respect to concentrations in fish collected from the reference site (HCK 20.6; Figure 4.2). The EPA-recommended fish-based AWQC of 0.3 µg/g is not a ROD-specified goal and is used for comparison purposes only. The overall temporal pattern of mercury concentrations in BCK 3.3 fish suggests seasonally variable levels in the general range of approximately 0.5 – 0.8 ppm, with a temporary increase in fish mercury concentrations over the 2011 – 2013 time period (during which time fish concentrations ranged from approximately 0.8 − 1 ppm on multiple occasions).

Over recent decades beavers have expanded their range in the Oak Ridge area and as a result lower Bear Creek has multiple large beaver dams that have extensively flooded riparian zones. The dams have created deeper stream pools suitable for rock bass, which has expanded its range in the last couple years to the middle sections of Bear Creek nearer BCK 9.9. In FY 2018, a full collection of six rock bass were collected from BCK 9.9 in both the spring and fall. Their mercury concentrations are similar to recent concentrations in lower Bear Creek (0.54 µg/g in fall 2017 and 0.76 µg/g in spring 2018; Figure 4.16). Rock bass are a higher trophic level fish and typically have between 15 – 40% higher mercury concentrations than redbreast sunfish, which are also found in Bear Creek. Average mercury concentrations in redbreast sunfish collected in fall 2017 were slightly below the AWQC (0.28 µg/g; Figure 4.16).

As seen at many other monitoring sites, mean PCB concentrations in sunfish collected from Bear Creek have fluctuated significantly over time, presumably due to annual differences in the type of prey and their relative PCB concentrations. In 2018, the mean PCB concentrations in rock bass fillet at the lowermost site (BCK 3.3) was 0.29 – 0.44 µg/g, while PCB levels in redbreast and rock bass at the site further upstream (BCK 9.9) were significantly higher (approximately 0.4 – 1.26 µg/g; Figure 4.17). While regulatory guidance and human health risk levels have varied widely for PCBs over the years, recently in the state of Tennessee, the water quality criterion (0.00064 µg/L for total PCBs; TDEC 2015) under the recreation designated use classification has been used by TDEC to calculate the fish tissue concentration triggering impairment and a TMDL, which is 0.02 µg/g in fish fillet (TDEC 2010a,b,c). TMDLs are used to develop controls for reducing pollution from both point and non-point sources in order to restore or maintain the quality of a water body and ensure it meets the applicable water quality standards. The fish PCB concentrations in Bear Creek are still well above the calculated TMDL concentration, which is not a ROD-specified goal and is used for comparison purposes only.

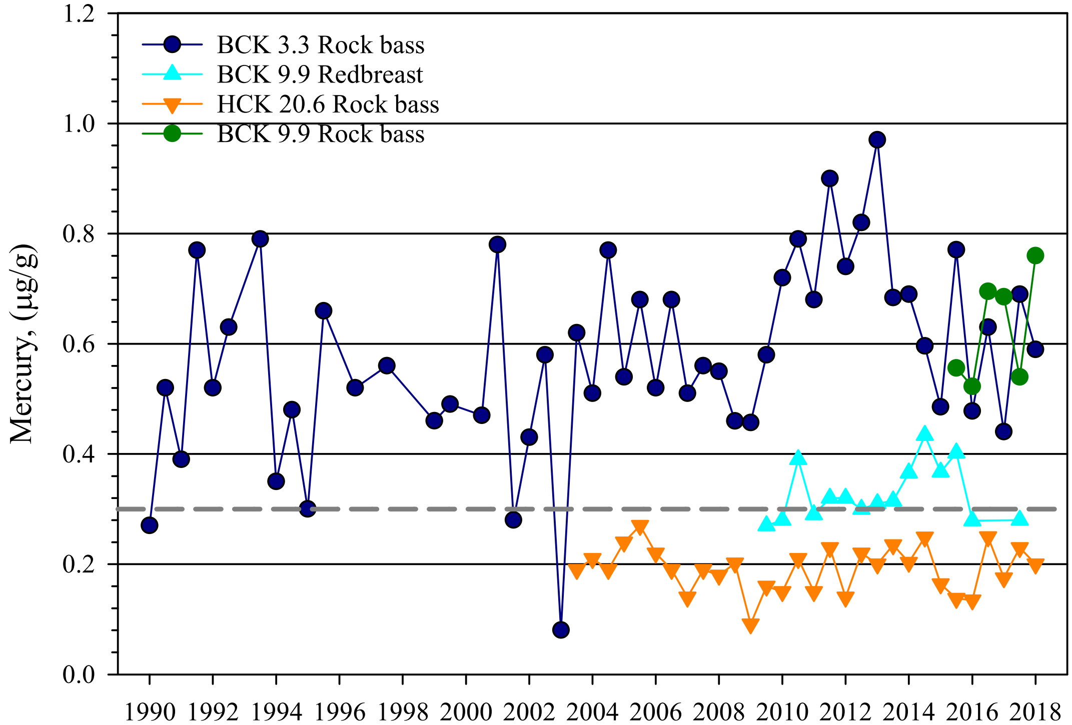

Figure 4.16. Mean concentrations of mercury in rock bass from BCK 3.3, redbreast sunfish from BCK 9.9, rock bass from BCK 9.9, and rock bass from the Hinds Creek reference site (HCK 20.6), 1990 – 2018.

Dashed line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

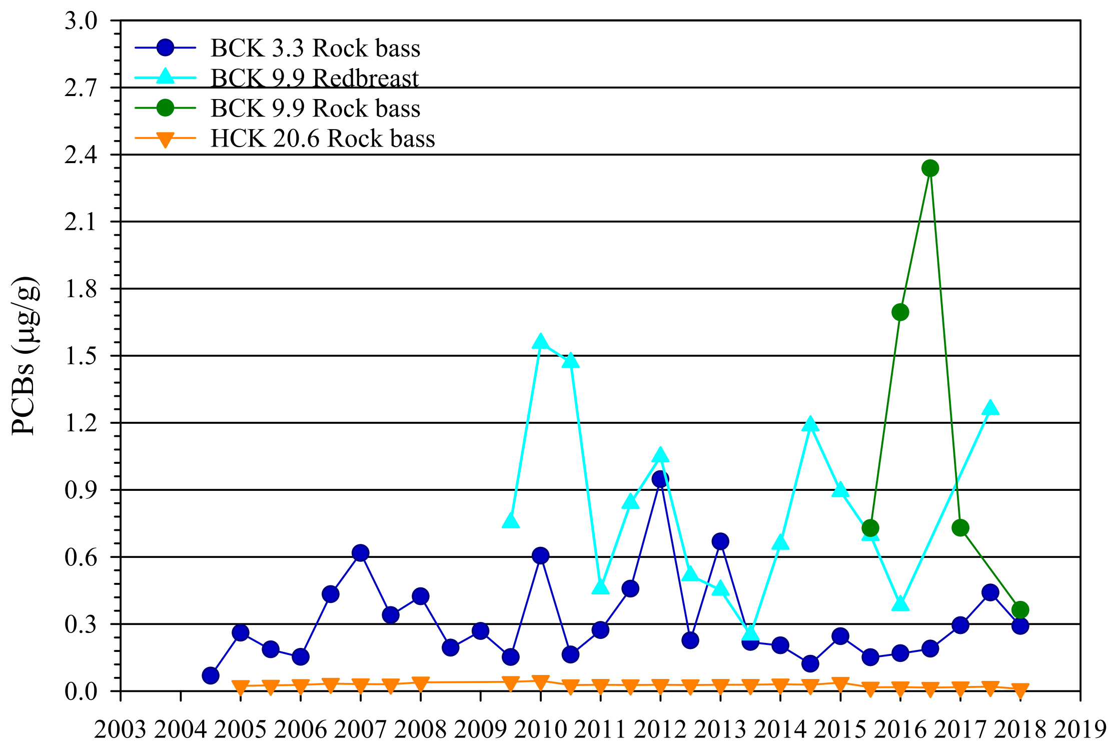

Figure 4.17. Mean concentrations of PCBs in rock bass from BCK 3.3, redbreast sunfish from BCK 9.9, rock bass from BCK 9.9, and rock bass from the Hinds Creek reference site (HCK 20.6), 2004 – 2018.

Though there has been much variability over the years, concentrations of nickel, cadmium, and uranium in large-scale stonerollers have historically been highest in upper Bear Creek and have decreased with distance downstream (Figure 4.18, Figure 4.19, and Figure 4.20, respectively). In recent years, concentrations of these metals in fish collected at BCK 12.4 have been decreasing such that concentrations were comparable in fish throughout the creek (and, in the case of nickel, were comparable to the reference site concentrations). However, in 2018, concentrations of these three metals increased in fish collected at BCK 12.4, such that a spatial gradient was once more apparent, with highest concentrations seen at upstream locations and decreasing with distance downstream. In the case of cadmium and nickel, concentrations at the BCK 3.3 site were comparable to those at the reference site (Figure 4.18 and Figure 4.19).

PCB concentrations in large-scale stonerollers in FY 2018 averaged between 0.82 – 3.3 µg/g, depending on the site, continuing the long-term trend of elevated levels in fish (Figure 4.21). PCB levels in minnows collected from the uppermost site in Bear Creek (BCK 12.4) were historically measured, but since concentrations were relatively low, and the primary source of PCBs to the watershed was thought to originate from NT-7 near BCK 9.9, this sampling was discontinued in 2003. PCB concentrations in minnows collected from upper Bear Creek (BCK 9.9) have historically been highest in the 1994 – 2008 time period. Since 2009, PCB concentrations in fish at BCK 9.9 have varied around 2 – 4 ppm. In contrast, PCB concentrations in fish at BCK 3.3 were relatively low over the 1994 – 2004 time period, spiked higher in 2005, and then have been on a gradual decline until the present day. A possible explanation for the contrasting trends between BCK 9.9 and BCK 3.3 is that the BCK 4.6 weir bypass in 2006 drastically changed the downstream environment, and potentially PCB exposure. Sediment retention behind the weir is no longer a potential source of PCBs to fish from BCK 3.3.

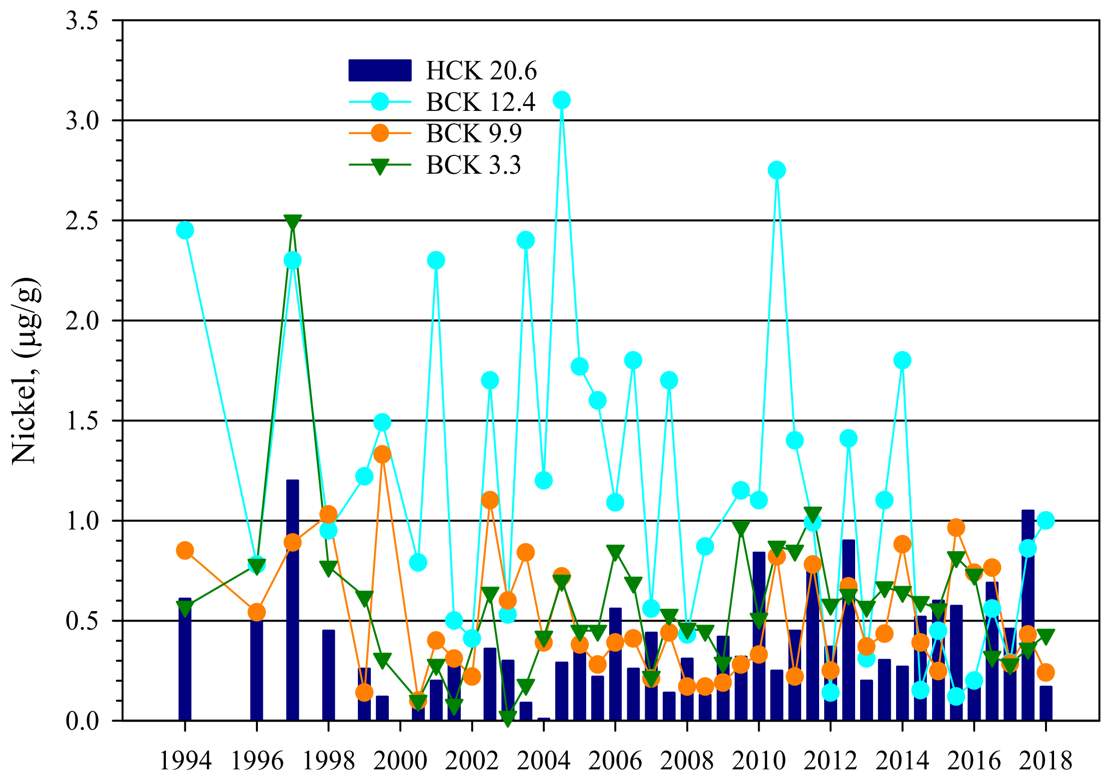

Figure 4.18. Mean nickel concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (HCK 20.6), 1994 – 2018.

On occasion over the years other minnow species have been substituted for stonerollers at the uppermost site, BCK 12.4.

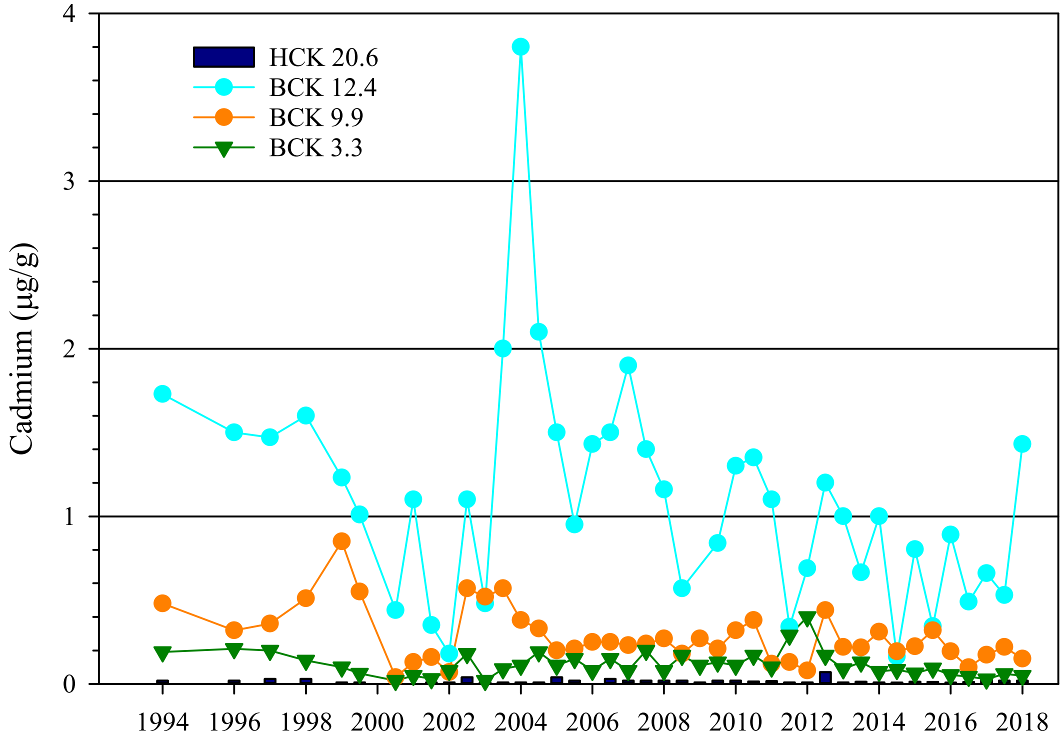

Figure 4.19. Mean cadmium concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (HCK 20.6), 1994 – 2018.

On occasion over the years other minnow species have been substituted for stonerollers at the uppermost site, BCK 12.4.

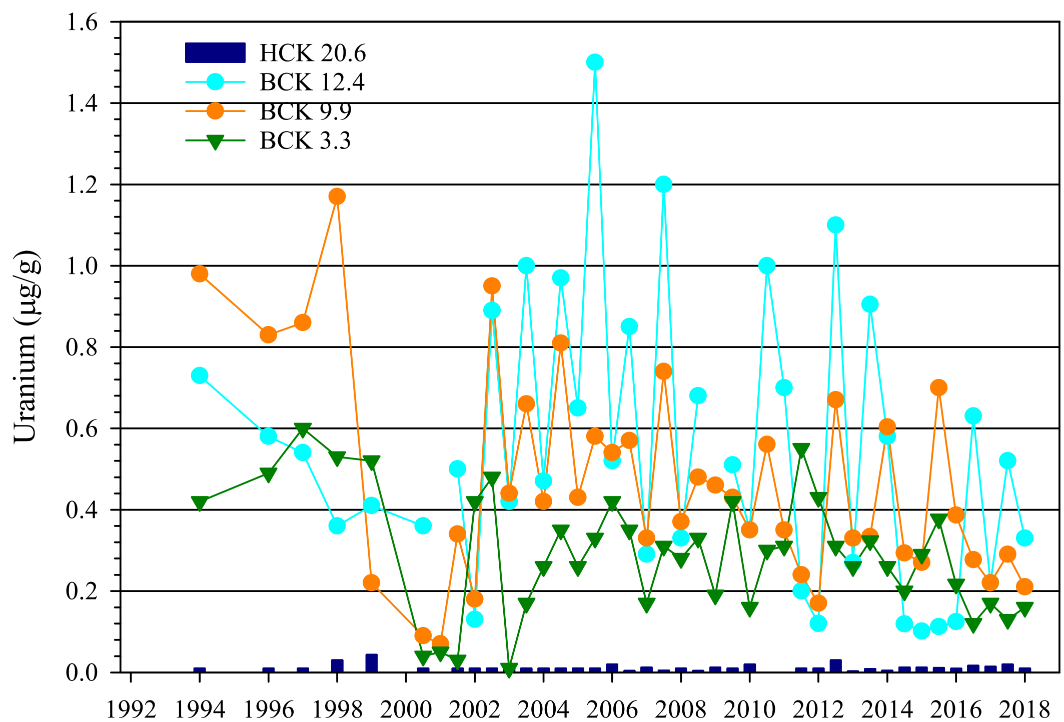

Figure 4.20. Mean uranium concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (HCK 20.6), 1994 – 2018.

On occasion over the years other minnow species have been substituted for stonerollers at the uppermost site, BCK 12.4.

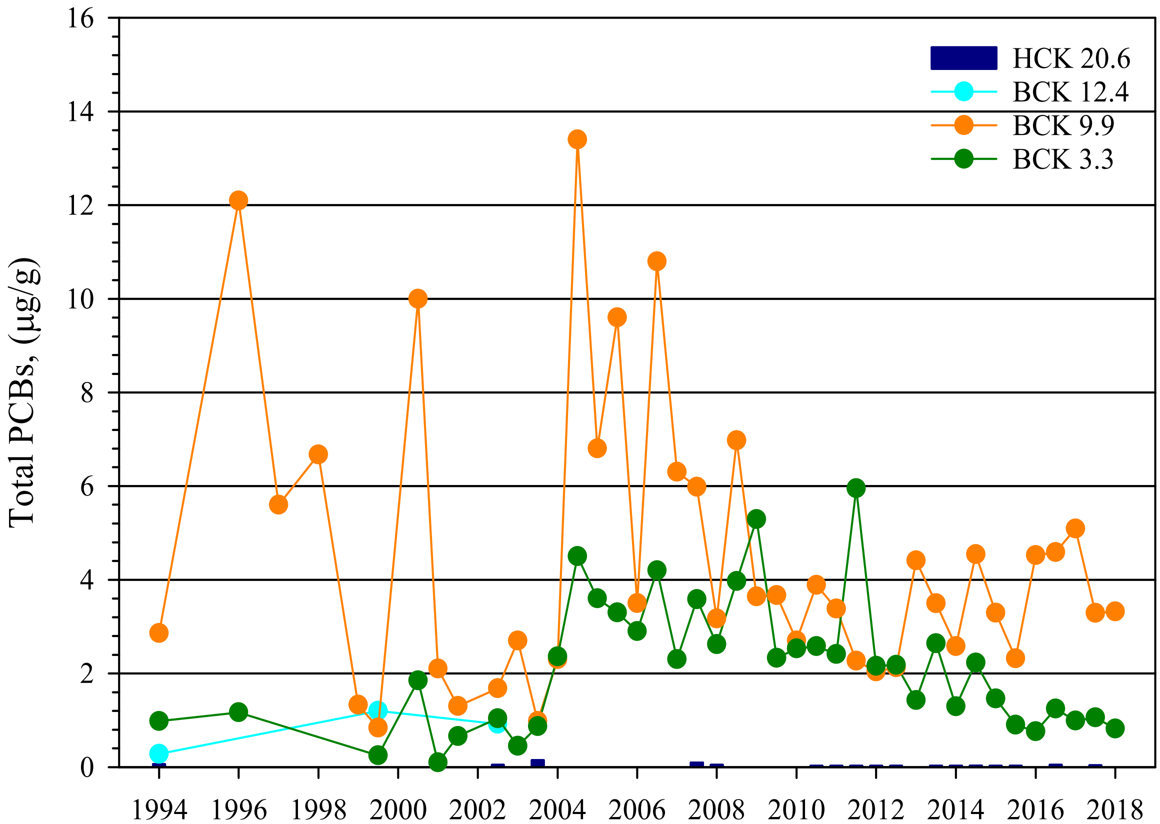

Figure 4.21. Mean PCB concentrations in stoneroller minnows at three sites in Bear Creek and a reference site (HCK 20.6), 1994 – 2018.

On occasion over the years other minnow species have been substituted for stonerollers at the uppermost site, BCK 12.4.

The fish communities in Bear Creek have generally been stable with some annual variation in terms of species richness. The downstream sites (BCK 3.3 and BCK 9.9) continue to have a lower number of species relative to a larger reference stream (BFK 7.6), but slightly higher than a smaller reference stream (MBK 1.6; Figure 4.22). However, both lower Bear Creek sites continued to be limited in sensitive species abundance in 2017 samples and continue to be dominated by more tolerant fish species. There was a substantially drop in species richness in 2018 at BCK 3.3; for the first time species richness was the same at BCK 3.3 and BCK 9.9. This result is at least partially due to increasing species diversity at BCK 9.9 since the weir removal efforts were completed in 2006, indicating that this effort has increased the opportunity for new fish species to colonize further up in the watershed.

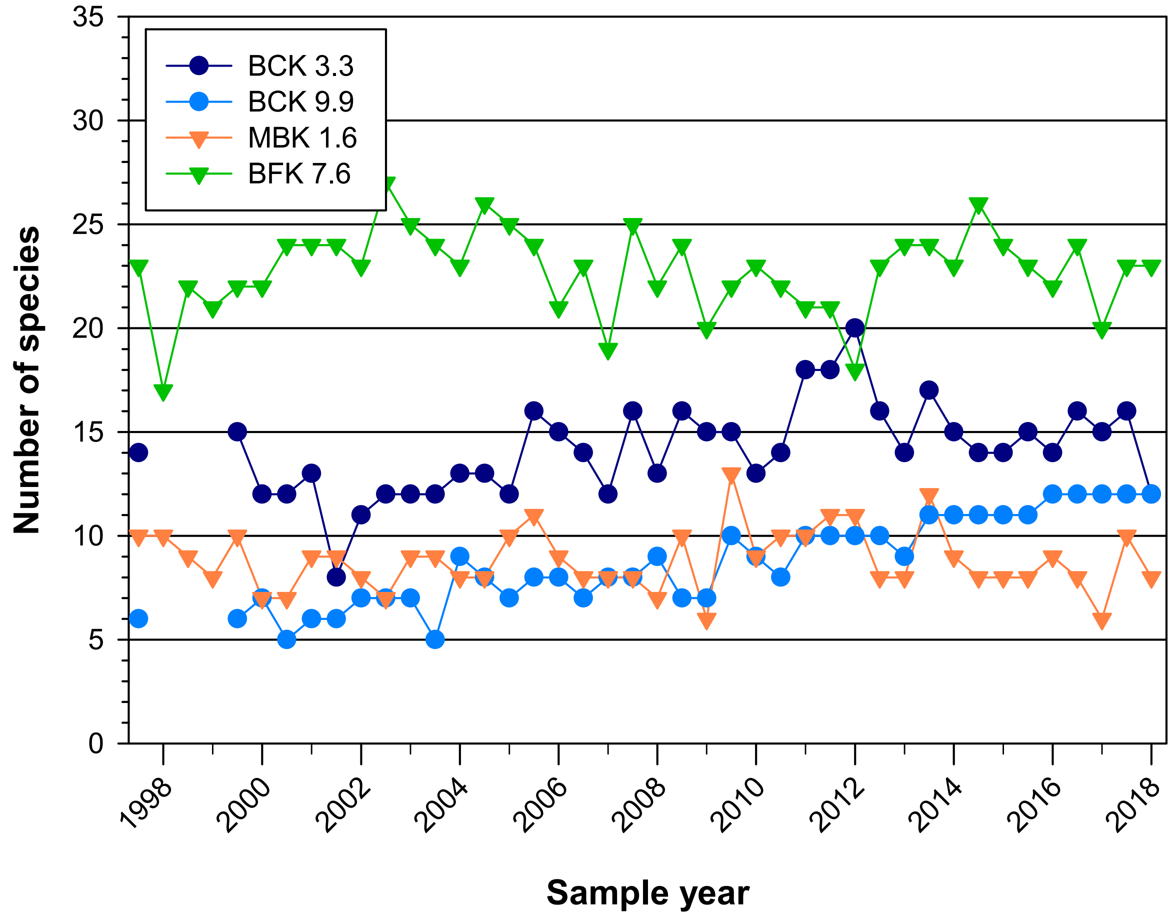

Figure 4.22. Species richness (number of species) in samples of the fish community in lower Bear Creek (BCK), and reference streams, Brushy Fork (BFK) and Mill Branch (MBK), 1997 – 2018.[a]

[a]Interruptions in data lines for BCK sites indicate no results available for those periods.

BCK 12.4 and NT-3 fish communities were equal to or below total richness values of both reference sites (MBK 1.6 and PHK 1.6) in 2017 – 2018 (Figure 4.23). The two sites remain lower in sensitive species, which is one indication of stream impairment. Previous studies have shown that during low rainfall months in late summer and fall, the upper Bear Creek sites receive a greater percentage of stream flow from contaminated groundwater, which likely contributes to measured stream toxicity (Peterson et al., 2000) and biota impairment. Both sites may also be affected by habitat limitations, especially a lack of pool depth during low flow periods (note the absence of fish after drought at BCK 12.4 in spring 2017 [Figure 4.23]). Stream mitigation efforts at BCK 12.4 have the potential to enhance these habitat limitations by creating a more balanced pool to riffle ratio and increasing the amount of available habitat by means of narrowing a previously channelized section of stream and restoring it to its original channel.

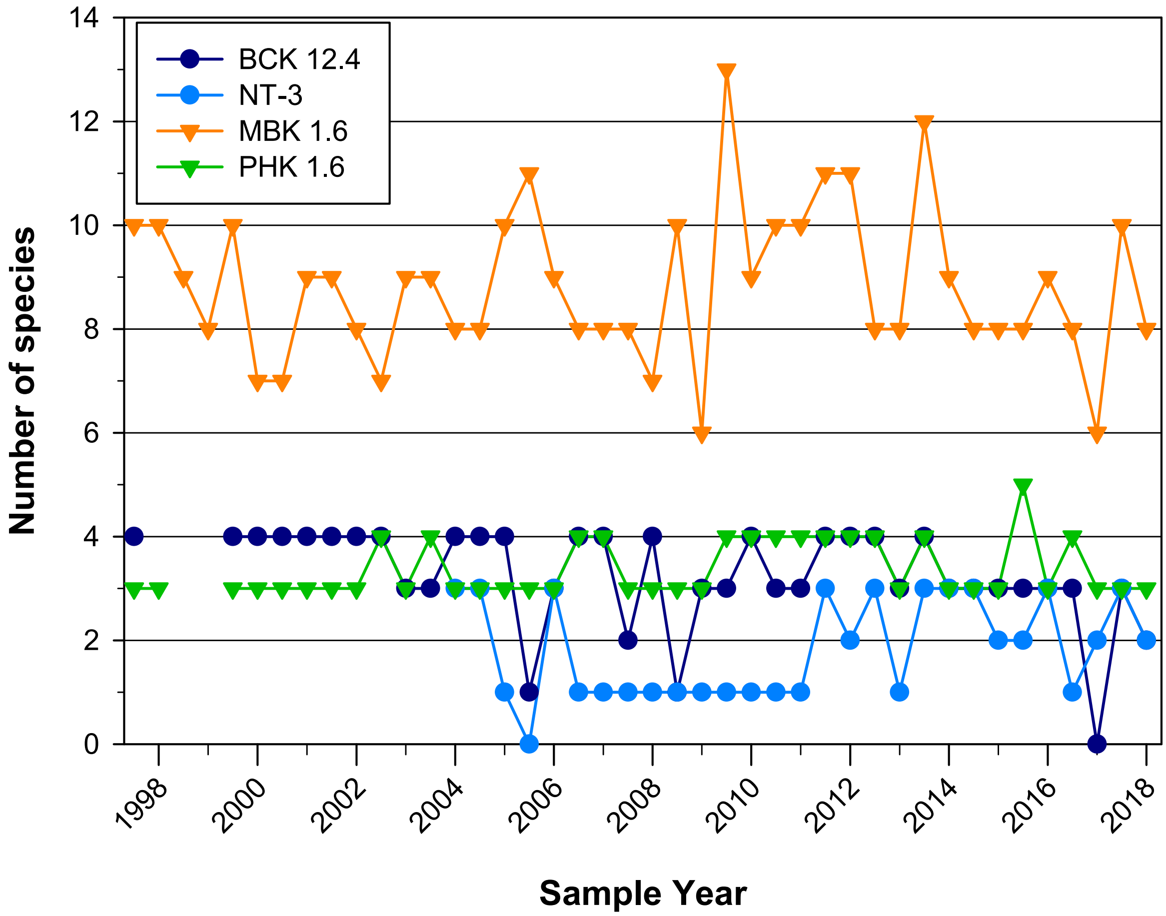

Figure 4.23. Species richness (number of species) in samples of the fish community in upper Bear Creek (BCK), NT-3, and two reference streams, Mill Branch (MBK) and Pinhook Branch (PHK), 1997 – 2018.[a]

[a]Interruptions in data lines for BCK sites indicate no results available for those periods.

Upper Bear Creek (BCK 12.4) and NT-3 continue to support notably fewer pollution-intolerant benthic macroinvertebrate taxa than nearby reference streams, with the differences between these and the reference sites generally most pronounced during October sampling periods (Figure 4.24). The impacts of significant drought conditions, including dry stream channels at one site (BCK 12.4) in the fall of 2016, are still apparent at all Bear Creek sites and reference sites. From 2012 to spring 2016, a trend of moderate increase in the number of pollution intolerant taxa EPT was apparent at NT-3; however, drought conditions in fall of 2016 induced large declines in EPT richness (Figure 4.23). Likewise, results for BCK 9.9 suggested a modest increase in the number of pollution intolerant taxa during the same time frame but also experience large declines in EPT taxa in fall 2016. The condition of the macroinvertebrate community at the most downstream site on Bear Creek (BCK 3.3) continues to be comparable to reference conditions.

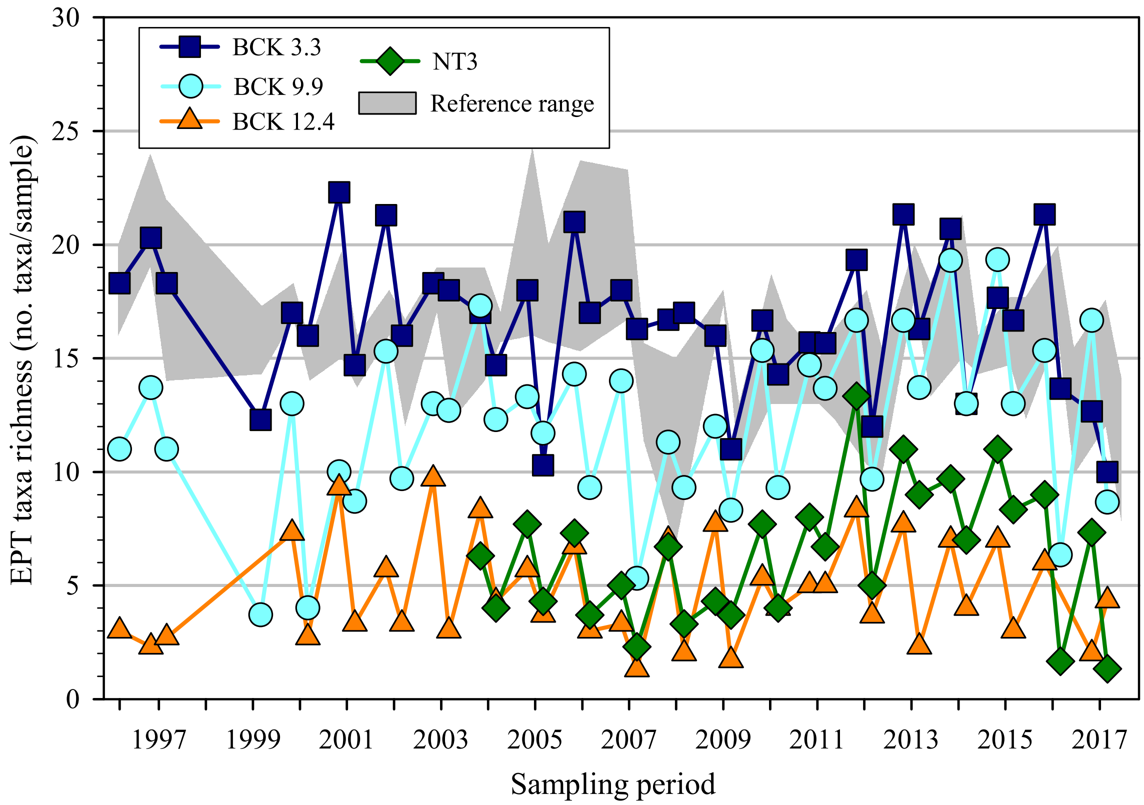

Figure 4.24. Mean (n = 3) taxonomic richness of the pollution-intolerant taxa for the benthic macroinvertebrate community at sites in Bear Creek, NT-3, and range of mean values among reference streams (two sites in Gum Hollow Branch and one site in Mill Branch), for October and April sampling periods from October 1996 – October 2017 (FY 2018).

Tick marks centered between April and October sampling periods for years after 1996.

NT-3 = North Tributary 3 to Bear Creek
EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies

4.3.2 LUCs

Watershed-scale remedy integrity and LUCs

LUC objectives outlined in the BCV Phase I ROD include restricting groundwater and surface water use consistent with designated end use for each zone (Figure 4.1). Objectives of these LUCs include preventing unauthorized contact, removal, or excavation of buried waste in the BCV watershed; precluding residential or recreational use of Zone 3; and preventing unauthorized access to contaminated groundwater in the BCV watershed. The BCV Phase I ROD also states that DOE will maintain the BCV Phase I sites as controlled industrial areas and limit public access by posting signs and conducting security patrols. Table 4.13 lists the LUCs for the BCV watershed as written in the BCV Phase I ROD.

Additionally, the engineered remedies are discussed below and included in Table 4.13 to be all inclusive of necessary verifications.

- S-3 Ponds Pathway 3—Access will be controlled and restricted. Once action is complete, inspection and maintenance of the passive *in situ* treatment system will be required.

- DARA SSF—Access will be controlled and restricted.

BYBY remedy integrity and LUCs

The following excerpts (italicized) from the BCV BYBY PCCR provide the operations and maintenance activities for the BYBY:

- *As part of the Y-12 Project Surveillance and Maintenance Program, the site will be inspected quarterly until the site is stabilized, then on a semiannual basis. Surveillance activities include inspection of capped areas for unwanted vegetation and erosion and inspection of access controls to site. Routine maintenance includes mowing of the capped areas. Non-routine maintenance will be performed as necessary.*

BCBGs (A-North, A-South, C-West)/Walk-In-Pits remedy integrity

BCBGs (A-North, A-South, C-West)/Walk-In-Pits remedy integrity components are listed in Table 4.13 and described below.

The RAR CMP requires semiannual inspections of site controls including access controls, cap/cover/surface drainage, signage, and benchmarks. In addition, the cap must be inspected for erosion damage following any 25-yr/24-hr intensity rainfall event. Also, monitoring wells require an annual comprehensive inspection including evaluation of well integrity (e.g. condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate).

S-3 Ponds Site remedy integrity

S-3 Ponds Site remedy integrity components are listed in Table 4.13 and described below.

The RAR CMP requires semiannual inspections of site access and integrity controls the S-3 Pond Site. In addition, the cap must be inspected for erosion damage following any 25-yr/24-hr intensity rainfall event. Also, monitoring wells require an annual comprehensive inspection including evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate).

Oil Landfarm remedy integrity

Oil Landfarm remedy integrity components are listed in Table 4.13 and described below.

While the Oil Landfarm Soil Containment Pad is part of the BCV BYBY PCCR, there are no LUCs specified. However, the RAR CMP requires semiannual inspections of site access and integrity controls. In addition, the cap must be inspected for erosion damage following any 25-yr/24-hr intensity rainfall event. Also, monitoring wells require an annual comprehensive inspection including evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate).

Table 4.13. LUCs for BCV

Areas	Project documents	LUCs	Frequency/implementation
LUCs – watershed-scale requirements			
Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee **(DOE/OR/01-1750&D4)**			
BCV Watershed	Phase I ROD (DOE/OR/01-1750&D4)	**Remedy integrity:** • S&M activities in BCV will be continued • Maintain existing cap (BYBY and Hazardous Chemicals Disposal Area, Oil Landfarm, Sanitary Landfill-1) • Continued S&M of access controls and surface cover (Spoil Area 1 landfill, SY-200 Yard) • Continue compliant storage of DARA mixed waste until it can be disposed **LUCs:** • Controlled industrial land use in Zone 3 and access restrictions in Zones 1 and 2 will be maintained • Prevent unauthorized contact, removal, or excavation of buried waste in the BCV • Preclude residential use in Zones 2 and 3 • Prevent unauthorized access to contaminated groundwater in BCV • Continue access restrictions for the S-3 disposal area • Posted signs and security patrols of the areas outside the fenced Y-12 Plant boundaries (most areas under the ROD except S-3 site) • DOE will limit public access • Institutional controls in place at the BCBGs will be maintained until remediation decisions for the BCBGs are addressed in future CERCLA decisions	• Following implementation of RAs, S&M of the site will be conducted under the Y-12 Plant sitewide S&M Program • Monitoring and enforcement of use restrictions on groundwater and surface water will be conducted as part of the Y-12 Plant sitewide S&M and water quality programs pending the completion of future CERCLA decisions • A review will be conducted within five years after initiation of the RA to ensure that the remedy continues to provide adequate protection of human health and the environment
BCBGs (A-North, A-South, C-West)/Walk-In-Pits	RAR CMP (DOE/OR/01-2457&D4)[a]	**Remedy integrity:** • Site inspections - access controls, cap/cover/surface draining, signage, 25-yr/24-hr rain event inspections, and benchmarks • Monitoring wells – comprehensive evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate)	• Inspect site semiannually • Inspect wells annually
S-3 Ponds Site	RAR CMP (DOE/OR/01-2457&D4)[a]	**Remedy integrity:** • Site inspections - access controls, cap/cover/surface draining, signage, 25-yr/24-hr rain event inspections, and benchmarks	• Inspect site semiannually • Inspect wells annually

Table 4.13. LUCs for BCV (cont.)

Areas	Project documents	LUCs	Frequency/implementation
		• Monitoring wells – comprehensive evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate)	
Oil Landfarm	RAR CMP (DOE/OR/01-2457&D4)[a]	**Remedy integrity:** • Site inspections - access controls, cap/cover/surface draining, signage, 25-yr/24-hr rain event inspections, and benchmarks • Monitoring wells – comprehensive evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate)	• Inspect site semiannually • Inspect wells annually
LUCs for specific areas			
Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee **(DOE/OR/01-1750&D4)**			
BYBY	PCCR (DOE/OR/01-2077&D2)	**Remedy integrity:** • Surveillance activities include inspection of capped areas for unwanted vegetation and erosion and inspection of access controls to site • Routine maintenance includes mowing of capped areas • Non-routine maintenance performed as necessary • After vegetation has been established and the site has been stabilized, the metal cap will be removed from the culvert north of the Haul Road	• Inspect site quarterly until site is stabilized • Inspect site on semiannual basis once stabilized
LUCs for specific areas			
Areas	**Project documents**	**LUCs**	**Frequency/implementation**
Record of Decision for Bear Creek Valley Operable Unit 2 (Spoil Area 1 and SY-200 Yard) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee **(DOE/OR/02-1435&D2)**			
Spoil Area 1 and SY-200 Yard	BCV OU 2 ROD (DOE/OR/02-1435&D2)	**LUCs:** • Institutional controls must be maintained indefinitely • Physical barriers (fences, gates, and signs) to limit access to the site • Deed restrictions to restrict construction at the sites and prohibit waste intrusion to mitigate direct exposure (primarily external exposure and inhalation of Ra-226) • Restrictions will also require the incorporation of indoor radon mitigation measures in accordance with EPA guidelines for any future structure built on site	• Periodic physical surveillance of the soil cover and other features of the site and maintenance or repair, as required • A FYR will be conducted after completion of RA to ensure remedy continues to protect human health and the environment

[a]The addition of post-RCRA LUC requirements to the RAR CMP is in preparation. This table will be updated upon approval of the BCV RAR CMP.

BCBG = Bear Creek Burial Ground
BCV = Bear Creek Valley

Table 4.13. LUCs for BCV (cont.)

BYBY = Boneyard/Burnyard
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
DARA = Disposal Area Remedial Action
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
FYR = Five-Year Review
LUC = land use control
OU = operable unit
PCCR = Phased Construction Completion Report
RA = remedial action
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976
ROD = Record of Decision
S&M = surveillance and maintenance
Y-12 = Y-12 National Security Complex

4.3.3 Status of LUCs

Status of watershed-scale remedy integrity and LUCs

LUCs in place in the BCV watershed were maintained throughout FY 2018 as part of the Y-12 S&M Program and in conjunction with CNS, NNSA's operating contractor for Y-12. Individual RAs under the BCV Phase I ROD underwent routine site inspections conducted by the Y-12 S&M Program as follows:

Status of S-3 Ponds Pathway 3 and DARA SSF remedy integrity and LUCs

These RAs have not yet been implemented. Access control was maintained in FY 2018 as part of general Y-12 plant controls and will be maintained until the actions are complete. These sites are not accessible to the public. Signs restricting access are in place and the areas are routinely patrolled by Y-12 security personnel.

Status of BYBY remedy integrity and LUCs

All components of the BYBY were inspected semiannually in FY 2018, including assessing the vegetative covers for erosion or subsidence; checking for blockage or erosion of the drainage control system; ensuring there are no construction activities and unauthorized materials within the area; evaluating that signs are not missing or damaged and contain correct contact information; ensuring access controls are in place and gates are locked; and ensuring the stability of the channel and banks of NT-3 from the Haul Road to the confluence with Bear Creek. Maintenance in FY 2018 included removing vegetation from a sign, replacing corrugated pipe on a cap drain, and evaluating soil subsidence above cap drain on west end of cap. Work is underway in the area of subsidence to re-contour and re-seed.

Status of BCBGs (A-North, A-South, C-West)/Walk-In-Pits remedy integrity

All components of the BCBGs (A-North, A-South, C-West)/Walk-In-Pits were inspected semiannually in FY 2018 by the Y-12 S&M Program, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. Routine mowing was conducted in FY 2018. Maintenance of the remedy integrity in FY 2018 included fixing burrow holes and replacing cap drain screens at A-North; cleaning out cap drains, replacing screens, and fixing or replacing several signs at A-South. C-West also required several screens on cap drains to be replaced, and maintenance at the Walk-In-Pits included removing unwanted vegetation on the protective cover mat.

Additionally, at A-South ponding was noted on the cap and an evaluation was conducted. Results of the evaluation were that it is not anticipated that either the PVC membrane or the clay liner are compromised by the observed depression. The area was re-contoured to a convex surface topography, re-seeded and re-surveyed.

Status of S-3 Ponds Site remedy integrity

All components of the S-3 Ponds Site were inspected semiannually in FY 2018 by the Y-12 S&M Program, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. Maintenance of the remedy integrity in FY 2018 included updating signs with correct contact information and replacing cap drain screens. Maintenance at the S-3 Ponds Pavement included removing unwanted vegetation.

<u>Status of Oil Landfarm remedy integrity</u>

All components of the Oil Landfarm were inspected semiannually in FY 2018 by the Y-12 S&M Program, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. Maintenance of the remedy integrity in FY 2018 included replacing cap drain screens.

4.4 SINGLE-PROJECT ACTIONS IN BCV

4.4.1 BCV Operable Unit 2 – Spoil Area 1 and SY-200 Yard

Locations of the Spoil Area 1 and SY-200 Yard (DOE/OR/02-1435&D2) RA are shown on Figure 4.1. The primary objective of this action was to mitigate exposure to contaminated soil and waste left in place. The scope of the remedy was to address the principal threats at the sites by maintaining the existing waste covers and implementing specific access and use restrictions.

4.4.1.1 LUCs

LUCs specified in the *Record of Decision for Bear Creek Valley Operable Unit 2 (Spoil Area 1 and SY-200 Yard) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (BCV OU 2 ROD; DOE/OR/02-1435&D2) include physical barriers (fences, gates, and signs) to limit access to the site, property record restrictions to restrict construction at the sites and prohibit waste intrusion to mitigate direct exposure, and periodic physical surveillance of the soil cover and other features of the site and maintenance or repair, as required. Restrictions also require incorporation of indoor radon mitigative measures in accordance with EPA guidelines for any future structure built onsite. These sites are designated as restricted industrial use areas in the BCV Phase I ROD.

4.4.1.2 Status of LUCs

The Spoil Area 1 and the SY-200 Yard sites of BCV OU 2 were inspected quarterly by the Y-12 S&M Program in FY 2018 for erosion of the cover, integrity of surface drainage, evidence of rodent damage, property signs, unlocked gates, and presence of unauthorized material in the area. Maintenance included updating the contact information on signs at Spoil Area 1 and SY-200 Yard. Both sites received routine mowing. For FY 2018, the property record notices for both areas were verified to be properly filed electronically at the Anderson County Register of Deeds office via http://www.andersondeeds.com.

4.5 BCV ISSUES AND RECOMMENDATIONS

The issues and recommendations for BCV are in Table 4.14.

Table 4.14. BCV issues and recommendations

Issue[a]	Action/recommendation	Responsible parties Primary/support	Target response date
New issue			
None			
Issue carried forward			
1. Surface water goals are not met for cadmium near S-3 Ponds. (2016 RER)	1. Prioritize/Sequence RA as stipulated by BCV Phase I ROD.	FFA parties	Sequencing is discussed yearly by the FFA parties.
2. Surface water goals are not met for uranium in NT-8 and consequently at BCK 9.2. (2016 RER)	2. Approve source control ROD for BCBGs and implement a remedy.	FFA parties	Sequencing is discussed yearly by the FFA parties.
Completed/resolved issues[b]			
None			

[a]A "New Issue" is an issue identified during evaluation of FY 2018 data for inclusion in the 2019 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution.
[b]The year in which the issue originated is provided in parentheses, e.g., (2013 RER).

BCBG = Bear Creek Burial Ground
BCK = Bear Creek kilometer
BCV = Bear Creek Valley
FFA = Federal Facility Agreement
FY = fiscal year
NT = North Tributary
RA = remedial action
RER = Remediation Effectiveness Report
ROD = Record of Decision

4.6 REFERENCES

DOE/OR/01-1455/D2&V1. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Management.

DOE/OR/01-1750&D4. *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1836&D1/A1. *Removal Action Report for the Bear Creek Valley Interception Trenches for the S-3 Uranium Plume, Pathways 1 and 2 at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1993, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2077&D2. *Phased Construction Completion Report for the Bear Creek Valley Boneyard/Burnyard Remediation Project at the Y-12 National Security Complex, Oak Ridge, Tennessee*, 2003, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2457&D2/A1. *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2457&D3. *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2505&D2. *2011 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2628&D2. *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee, Volumes 1 and Volume 2*, 2014, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1435&D2. *Record of Decision for Bear Creek Valley Operable Unit 2 (Spoil Area 1 and SY-200 Yard) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1996, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Helsel, D.R. 2005, *Nondetects and Data Analysis: Statistics for Censored Environmental Data,* John Wiley & Sons, New York, 250 p.

Peterson, M.J., J.M. Loar, L.A., Kszos, M.G. Ryon, J.G. Smith. 2000. *Biomonitoring for environmental compliance at select DOE facilities: fifteen years of the Biomonitoring and Abatement Program*. Proceedings of the 25th Annual Conference of the National Association of Environmental Professionals. Overcoming Barriers to Environmental Improvement. National Association of Environmental Professionals publication.

TDEC 2010a. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee.

TDEC 2010b. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, μμ, Morgan, Rhea, and Roane Counties, Tennessee.

TDEC 2010c. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Fort Loudon Reservoir: Fort Loudon Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee.

TDEC 2015. State of Tennessee Water Quality Standards, Chapter 0400-40-03, General Water Quality Criteria, April 2015. Tennessee Department of Environment and Conservation, Division of Water Pollution Control.
URL: http://sharetngov.tnsosfiles.com/sos/rules/0400/0400-40/0400-40-03.20150406.pdf.

TNHW-116. *RCRA Post-Closure Permit for the Bear Creek Hydrogeologic Regime*, 2003, Y-12 National Nuclear Security Complex, Oak Ridge, Tennessee, EPA I.D. No. TN3 89 009 0001, September 2003, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

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5. Y-12 – CHESTNUT RIDGE

5.1 INTRODUCTION AND STATUS

5.1.1 Introduction

Chestnut Ridge is not physically situated within one of the areas with existing watershed-scale RODs, but is located south of Y-12 on the ORR (Figure 5.1). Chestnut Ridge is the site of several active, industrial landfills and former waste disposal areas. A Final ROD will be prepared for the Chestnut Ridge area to address any remaining non-operation areas, along with groundwater and ecological concerns. The CERCLA decisions to date for Chestnut Ridge have been single-action, legacy project decisions. Figure 5.1 shows the locations of CERCLA actions on Chestnut Ridge that have required monitoring or LUCs. In subsequent sections, the effectiveness of each completed action is assessed by reviewing performance monitoring objectives and results and verifying LUCs. Table 5.1 lists the CERCLA action performance monitoring requirements for actions on Chestnut Ridge.

Table H.4 in Appendix H lists all completed CERCLA actions on Chestnut Ridge and the corresponding completion documents, and identifies whether monitoring or LUCs are required. Figure H.4 in Appendix H is a location map of the actions. For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions on Chestnut Ridge is provided in Chapter 9 of Volume 1 of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

5.1.2 Status Update

In May of 2017, DOE requested from TDEC-DSWM that the re-application of the *RCRA Post-closure Permit for the Chestnut Ridge Hydrogeologic Regime* (2006 Chestnut Ridge PCP; TNHW-128) be denied and the applicable substantive requirements for post-closure care, monitoring, and reporting for the relevant units be integrated into the CERCLA process. The relevant units associated with the Chestnut Ridge Hydrogeologic Regime include: 1) KHQ, 2) Chestnut Ridge Security Pits (CRSPs), 3) East Chestnut Ridge Waste Pile (ECRWP), and 4) Chestnut Ridge Sediment Disposal Basin (CRSDB). The TDEC-DSWM granted the request on February 23, 2018. Substantive requirements for post-closure care and monitoring are managed in the *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (EFPC/CR RAR CMP; DOE/OR/01-2466&D4). Reporting of post-closure care and monitoring are integrated into this 2019 RER and will be captured in the CERCLA FYR, as appropriate.

No additional CERCLA actions were implemented or completed during FY 2018, nor were any associated FFA documents submitted or approved for CERCLA actions located on Chestnut Ridge. Monitoring in support of performance assessments and evaluations continued.

5.2 ASSESSMENT SUMMARY

A summary of the Chestnut Ridge assessment for FY 2018 is provided below, followed by more detailed evaluations.

5.2.1 Performance Summary

5.2.1.1 United Nuclear Corporation Disposal Site

Low concentrations of nitrate and gross beta activity continue to be detected in two downgradient monitoring wells, however, the levels remain well below screening criteria based on drinking water standards and much less than levels estimated to be possible in the feasibility study (FS) for the site. The only FY 2018 Sr-90 detection at the United Nuclear Corporation (UNC) site occurred in August at downgradient surface water sampling location UNC SW-1 at a concentration of 0.601 J pCi/L.

5.2.1.2 KHQ

During FY 2018, carbon tetrachloride was detected in GW-144 at an estimated concentration (0.7 J µg/L) substantially below the drinking water MCL (5 µg/L). Other VOCs were not detected in the sample.

5.2.1.3 FCAP/Upper McCoy Branch

The FCAP wetland continues to reduce arsenic concentrations in effluent surface water when compared to pre-remediation conditions; however, there is decreasing arsenic removal effectiveness over time. The arsenic concentrations in wetland effluent exceed the AWQC screening concentration of 0.01 mg/L.

Biota monitoring indicates arsenic levels in Rogers Quarry fish are near background. However, selenium and mercury concentrations remain higher in fish relative to typical background concentrations for selenium and relative to federal AWQC guidelines for mercury, suggesting continuing low-level inputs from either the FCAP, stream and/or quarry ash deposits downstream, or ash deposits historically deposited in Rogers Quarry.

The 2016 FYR identified the performance of FCAP wetland and health of the Rogers Quarry fish population as an issue. Because of this issue, the FYR deferred the protectiveness statement for the FCAP ROD, stating that, "a protectiveness statement for aquatic life cannot be made at this time." To address this issue, DOE initiated investigations in FY 2017 that concluded during FY 2018, including evaluations of wetland conditions and the sedimentation basin. A report of the result of those investigations is included as Appendix C.1 of this RER. Key elements and findings of the investigation included:

- A physical survey of the wetland confirmed excessive accumulation of material in the center of the wetland that causes channelization of flow around the area perimeter,
- Installation of flow measurement flumes (MCK 2.0 and MCK 2.05) upstream and downstream of the wetland allowed for measurement of flow volumes and supported composite sampling to evaluate dissolved and particulate fluxes passing through the wetland,
- A dye tracer test documented the relatively short residence time of water in the wetland under current conditions (90th percentile of tracer mass passed out of the wetland at about 4.6 hours elapsed time),
- Collection of wet season and dry season baseflow and storm event composite samples allowed for the determination of time and flow averaged metals concentrations under varying seasonal and flow conditions. Flux calculations determined that arsenic reduction in the wetland was variable and that the wetland at times served as a source of arsenic in both wet and dry seasons,

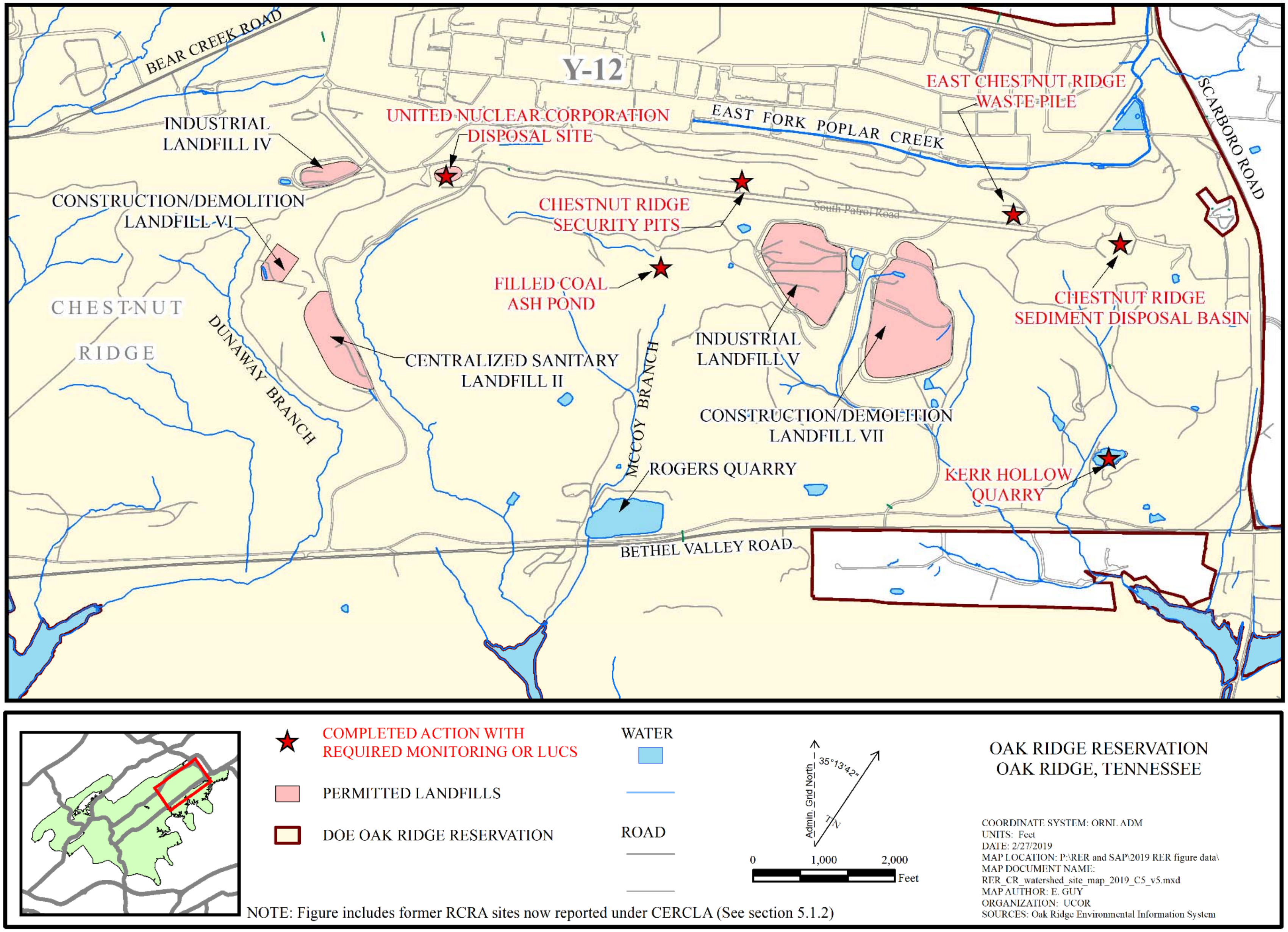

Figure 5.1. Completed CERCLA actions on Chestnut Ridge with required monitoring or LUCs.

Table 5.1. CERCLA actions performance monitoring for sites on Chestnut Ridge

Media	Monitoring location	Schedule and type of sample	Parameters	Performance standard
		UNC Disposal Site		
Groundwater	1090 GW-203 GW-221	Semiannual grab samples	Ions including nitrates; metals; gross alpha and beta, Sr-90, isotopic uranium; field parameters including solids	Nitrate concentrations remain below 10 mg/L and are "not expected to exceed 8 mg/L." Sr-90 levels remain below 2 pCi/L.
	GW-205		In addition to those above, gamma and Tc-99.	
Surface water	UNC SW-1		Ions including nitrates; metals; gross alpha and beta, Sr-90; field parameters, including solids.	
		KHQ[a]		
Groundwater	GW-144	Annual grab samples, alternating between wet (Q2) and dry (Q4) seasons every other year	Field parameters and VOCs (including carbon tetrachloride).	Carbon tetrachloride concentrations are not detected above practical quantitation limits (or the laboratory's method detection limit).
		FCAP		
Surface water	MCK 2.05[b] MCK 2.0	*Specific sampling locations and frequencies will be presented in the annual sampling and analysis plan prepared by the* [WRRP]. *Results of monitoring conducted will be published annually in the ORR Remediation Effectiveness Report*[c]	*Surface water samples will be collected and analyzed for the primary contaminants of concern (aluminum, arsenic, iron, manganese, and zinc) and other constituents of relevance to evaluating wetland performance at the site.*[c]	*Surface water monitoring will be used to verify the effectiveness of the remedial action and to provide the basis of the CERCLA five-year review. These monitoring results will be analyzed to verify that the passive treatment system reduces contaminant levels in Upper McCoy Branch at least as well as the original wetlands and trends will be evaluated to determine whether the new passive treatment system requires maintenance.*[c]
		Semiannual grab samples	Metals, ions, gross alpha and beta, and water quality parameters.	

Table 5.1. CERCLA actions performance monitoring for sites on Chestnut Ridge (cont.)

Media	Monitoring location	Schedule and type of sample	Parameters	Performance standard
CRSPs[a]				
Groundwater	GW-322	Biennial grab samples alternating between wet and dry seasons	Field parameters and VOCs	Trend analysis
	GW-798	Semiannual grab sample		
ECRWP[a]				
Groundwater	GW-161 GW-294 GW-296 GW-298	Semiannual grab sample	Field parameters, ions (including nitrate), metals (including mercury), VOCs, and gross alpha activity	Comparison with fixed calculated UTL for Chestnut Ridge
Leachate	Leachate sump	Annual grab sample	Metals, ions, VOCs, SVOCs, pesticides, pH, and gross alpha and beta activity	Compliance with treatment system WAC
CRSDB[a]				
Groundwater	GW-159 GW-731 GW-732 GW-156	Grab samples alternating between wet and dry seasons (in year prior to FYR)	Field parameters, metals (including mercury), TDS, and TSS	Comparison with fixed calculated UTL for Chestnut Ridge

[a]The TDEC-DSWM granted the DOE's request to deny the RCRA 2006 Chestnut Ridge PCP re-applications for Bear Creek, EFPC, and the Chestnut Ridge watersheds on February 23, 2018. The applicable substantive requirements for post-closure care, monitoring, and reporting for the relevant units have now been integrated into the CERCLA process.

[b]The two locations chosen by the WRRP for semiannual monitoring downstream from the contaminant source. MCK 2.05 is at the influent to the wetland and the one below the wetland is MCK 2.0.

[c]From the *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and vicinity) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/01-1596&D1).

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CRSBD = Chestnut Ridge Sediment Disposal Basin
CRSP = Chestnut Ridge Security Pits
DOE = U.S. Department of Energy
DSWM = Division of Solid Waste Management
ECRWP = East Chestnut Ridge Waste Pile
EFPC = East Fork Poplar Creek
FCAP = Filled Coal Ash Pond
FYR = Five-Year Review
GW = groundwater
KHQ = Kerr Hollow Quarry
MCK = McCoy Branch kilometer
ORR = Oak Ridge Reservation
PCP = Post-Closure Permit
Q2 = quarter two
Q4 = quarter four
RCRA = Resource Conservation and Recovery Act of 1976

Table 5.1. CERCLA actions performance monitoring for sites on Chestnut Ridge (cont.)

SVOC = semivolatile organic compound
SW = surface water
TDEC = Tennessee Department of Environment and Conservation
TDS = total dissolved solids
TSS = total suspended solids
UNC = United Nuclear Corporation
UTL = upper tolerance limit
VOC = volatile organic compound
WAC = waste acceptance criteria
WRRP = Water Resources Restoration Program

- Collection of bulk water samples during a stormflow event showed a "first flush" behavior of ash erosion from the FCAP top surface, no ash movement through the wetland, and a small percentage of ash in sediment transported into Rogers Quarry.

- Fish from McCoy Branch and Rogers Quarry were collected for metals analysis (fillets and ovaries) and a closer examination of fish health parameters. FY 2018 fish sampling in Rogers Quarry found no deformed fish and only one emaciated fish, suggesting that detrimental exposures to selenium are transitory (only older fish were negatively affected) and there is an overall positive trend, and

- An investigation of other regional quarries without coal ash impacts was conducted in an effort to evaluate if quarries in general resulted in food limitation and poor largemouth bass condition. Based on the investigation, there is no evidence that the general conditions of quarries are a cause of deformities or highly emaciated conditions in fish.

Appendix C.1 of this report provides additional details on the FCAP investigations.

5.2.1.4 CRSP

Four VOCs were detected in the groundwater sample collected from CRSP well GW-322 in July 2018: 1,1,1-TCA (3.3 J µg/L), PCE (4 J µg/L), 1,1 DCE (20 µg/L), and 1,1-DCA (39 µg/L). Only the 1,1 DCE concentration exceeds the 7 µg/L MCL screening level.

Historical results show PCE at CRSP well GW-798 detected at concentrations either slightly above or below the drinking water MCL (5 µ/L), with the concentration for the sample collected in July 2018 (2.7 µ/L) being the lowest evident since January 2001 (2 µ/L).

5.2.1.5 ECRWP

Several analytes (barium, chloride, iron, nitrate, sulfate, and gross beta) were detected in POC wells GW-161, GW-296, and GW-298 during FY 2018. Statistical analysis of the respective semiannual groundwater sampling/analysis results does not indicate any statistically significant differences between the concentrations of the analytes detected in the POC wells and upgradient/background well GW-294. Accordingly, the FY 2018 groundwater monitoring results do not provide evidence potentially indicating the release of contaminants derived from wastes in the ECRWP.

Leachate sample results collected from the ECRWP during FY 2018 are consistent with previous annual leachate sampling/analysis data. These results do not indicate any significant change in the chemical characteristics of the leachate or the need to add any parameters/constituents to the analytes the EFPC/CR RAR CMP specifies for groundwater monitoring at the ECRWP.

5.2.2 LUC Protectiveness

All LUCs determined necessary for protection of the environment and/or human health are in place and have been maintained.

5.3 UNC DISPOSAL SITE

5.3.1 Performance Monitoring

5.3.1.1 Performance monitoring goals and objectives

The UNC Disposal Site is a 1.3 acre landfill located near the crest of Chestnut Ridge south of Y-12 (Figure 5.1 and Figure 5.2). The *Record of Decision United Nuclear Corporation Disposal Site Declaration, Y-12 Plant, Oak Ridge, Tennessee* (UNC Disposal Site ROD; DOE 1991) was approved in June 1991. Field activities began in May 1992 and were completed in August 1992. Remedial activities included a multilayer cover system, access controls, and groundwater monitoring using existing wells.

This waste disposal facility utilized an unlined excavation in the thick soils near the crest of Chestnut Ridge for retention of approximately 11,000 55-gal drums of cement-fixed sludge, 18,000 drums of contaminated soil, and 288 wooden boxes of contaminated building and process equipment demolition debris from the UNC Disposal Site uranium recovery facility in Wood River Junction, Rhode Island. In addition, Formerly Utilized Sites RA Program waste from the Elza Gate site in Oak Ridge was placed in the site before the final multilayer cap was constructed to limit percolation of rainwater into the waste.

The major goal of the RA in the UNC Disposal Site ROD is to "ensure that mobile contaminants in the UNC waste, principally nitrate and Sr-90, are not leached to groundwater at a rate that would result in concentrations of these contaminants above safe drinking water standards." The *Feasibility Study for the United Nuclear Corporation Disposal Site at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (ES/ER-15&D1) included results of contaminant transport modeling that indicated possible impacts to groundwater including potential nitrate concentrations of as much as 193 mg/L and Sr-90 concentrations as great as about 50 pCi/L. The expected performance of the remedy in the UNC Disposal Site ROD is to control contaminant migration so that nitrate is less than the MCL of 10 mg/L and no more than 2 pCi/L of Sr-90 will occur in groundwater, which is within the CERCLA ELCR risk range of 10^{-4} to 10^{-6}. Further, the groundwater concentration "is not expected to exceed 8 mg/L for nitrate." The *Post-Construction Report for the United Nuclear Corporation Disposal Site at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (UNC PCR; DOE/OR/01-1128&D1) specifies implementation of a groundwater monitoring program. Although specific frequencies, locations, and analytes are not mandated by the report, groundwater is monitored for COCs (nitrate and Sr-90) for input into the performance assessment.

5.3.1.2 Evaluation of performance monitoring data

Monitoring at the UNC site consists of semiannual sampling at one upgradient well (well 1090), three downgradient wells (GW-203, GW-205, and GW-221), and one downgradient surface water location (UNC SW-1) shown on Figure 5.2. The FY 2018 average groundwater elevations (based on two measurements at the time of sampling) at each sampled well are also shown on the figure below the well number. Although well 1090 is designated as an upgradient monitoring location based on groundwater elevations in the area, the fact that the elevation of the base of the buried waste within the unlined UNC waste disposal unit is much higher than the groundwater elevations indicates that percolating groundwater beneath the waste could affect any of the nearby wells. Samples were analyzed for field parameters, metals, nitrate, gross alpha and beta activity, and Sr-90. Additional isotopic analyses were conducted on samples collected from well GW-205 as noted below. Data for electrical conductivity, pH, nitrate, gross alpha and beta activity, and Sr-90 analyses for all wells are provided in Table 5.2. K-40 was analyzed in well GW-205 and the UNC SW-1 (Table 5.2).

Field measurements of groundwater electrical conductivity show that well 1090 had higher electrical conductivity than the other sampled locations, which was caused by higher concentrations of calcium, magnesium, bicarbonate, and chloride than levels measured in the other monitoring locations. The pH levels measured at the UNC site are typical of shallow groundwater at the ORR. Well GW-205 stands out somewhat because of slightly elevated pH compared to the other monitored locations. The history of monitoring at well GW-205 started in 1987. In 1998, the well purge method was changed from a standard three-well-volume method to low-flow purging. Contemporaneous with that change, pH, conductivity, beta activity, and potassium (which has natural K-40 beta radiation) concentrations increased, possibly an indication of grout or other alkaline material influence on local groundwater. Prior to the sampling method change, the pH ranged between 7.5 and 8.5 and, following the method change, the pH ranged between 9.5 and 10.5. The well was aggressively redeveloped in autumn 2010, after which pH levels in the well decreased. The pH levels at well GW-205 during FY 2018, 8.08 in February (Quarter 2) and 7.67 in July (Quarter 4), are within the observed range of fluctuation since well redevelopment.

In FY 2018, nitrate concentrations downgradient of the site have remained well below the 10 mg/L SDWA MCL and the "not expected to exceed range" of 8 mg/L. Nitrate concentration was slightly higher in the upgradient well (1090) than in any other location although both measured results were <1 mg/L. In FY 2018, Sr-90 was not detected in any of the monitoring well samples but was detected at 0.601 J pCi/L in the Quarter 4 sample from the downgradient surface water location (UNC-SW1).

Alpha activity was detected in well 1090 in February 2018 at an estimated result of 1.76 J pCi/L. In July 2018, alpha activity was detected in wells GW-203 and GW-221 with estimated results of 2.14 J pCi/L and 2.8 J pCi/L, respectively. All detected alpha activity results at the UNC Disposal Site are less than 20% of the 15 pCi/L MCL.

Table 5.3 summarizes the Sr-90 analytical results for the monitoring locations at the UNC Disposal Site from February 1999 to September 2018. Sr-90 has been detected sporadically at low concentrations in groundwater adjacent to the UNC Disposal Site. The FY 2006 17.8 pCi/L result from well GW-205 exceeded the SDWA MCL-DC of 8 pCi/L but was below the *Feasibility Study for the United Nuclear Corporation Disposal Site at the Y-12 Plant, Oak Ridge, Tennessee* (ES/ER-15&D1) estimate of a maximum groundwater Sr-90 concentration of 50 pCi/L.

During FY 2018, surface water was sampled at the nearest downgradient spring location (UNC SW-1) in late February and July to determine if site related contaminants affect surface water (Table 5.2). Analytical results indicate that nitrate levels are below drinking water criteria and are lower than, or comparable to, results from site monitoring wells. Sr-90 was detected at 0.601 J pCi/L in the August 2018 sample.

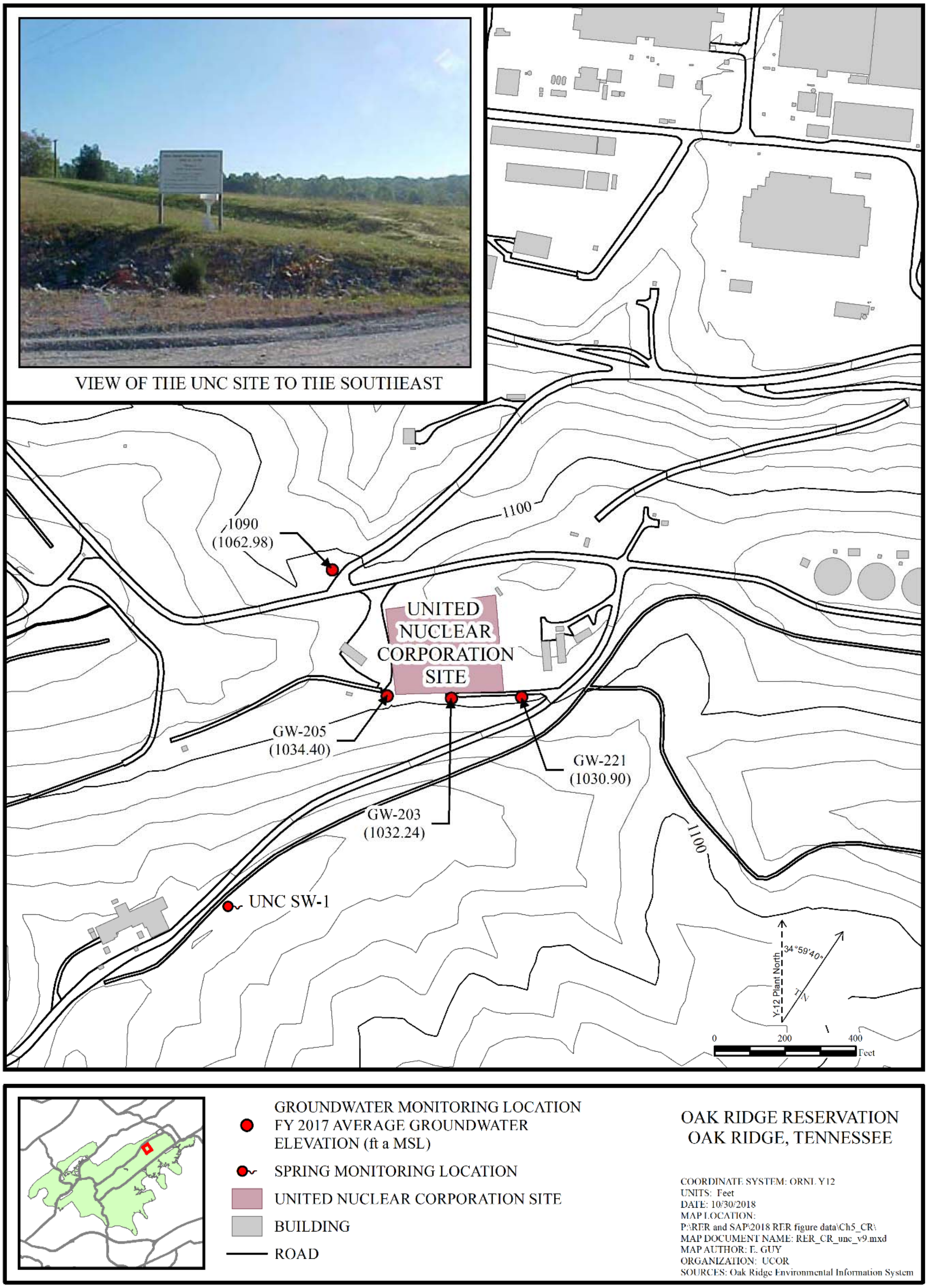

Figure 5.2. Location map of UNC Disposal Site.

Table 5.2. Analytical results for field parameters and performance indicator constituents at the UNC Disposal Site, FY 2018

Date	Upgradient well	Downgradient wells			Downgradient spring
	1090	GW-203	GW-205	GW-221	UNC SW-1
Conductivity (µmhos/cm)					
Q2-FY18	432	286	279	243	103
Q4-FY18	499	237	306	269	155
pH (units)					
Q2-FY18	7.2	7.54	8.08	7.57	7.37
Q4-FY18	7.08	7.77	7.67	7.58	6.64
Nitrate (mg/L)					
Q2-FY18	0.82	0.56	0.31	0.57	0.23
Q4-FY18	0.95	0.97	0.37	0.66	0.28
Gross alpha (pCi/L)					
Q2-FY18	1.76 J	0.278 U	1.17 U	1.23 U	0.843 U
Q4-FY18	0.0622 U	2.14 J	0.0288 U	2.8 J	-0.0612 U
Gross beta (pCi/L)					
Q2-FY18	2.12 J	2.07 J	7.43	1.49 U	0.879 U
Q4-FY18	1.89 J	-0.204 U	7.81	3.8	1.14 U
Sr-90 (pCi/L)					
Q2-FY18	0.0514 U	-0.0897 U	-0.165 U	-0.249 U	-0.00547 U
Q4-FY18	0.169 U	0.192 U	0.325 U	0.0554 U	0.601 J
K-40 (pCi/L)					
Q2-FY18	--	--	49.2 U	--	7.31 U
Q4-FY18	--	--	-141 U	--	-38.1 U

-- = not applicable, not available, or insufficient data to calculate the statistic
FY = fiscal year
GW = groundwater well
J = estimated value
Q2 = Quarter 2
Q4 = Quarter 4
SW = surface water
U = not detected
UNC = United Nuclear Corporation

Table 5.3. UNC Disposal Site groundwater Sr-90 detection summary, February 1999 – September 2018

Sample location	Number of results	Number of detects	Maximum concentration (pCi/L)	Date of maximum
1090	42	10	2.22 J	Aug-00
GW-203	41	5	1.34 J	Jul-06
GW-205	41	6	**17.8**	Jul-06
GW-221	41	11	2.83	Jul-06
UNC SW-1	9	2	0.601 J	Aug-18

Bold value indicates Sr-90 result exceeds the 8 pCi/L MCL-DC.

GW = groundwater well
J = estimated value
UNC = United Nuclear Corporation

5.3.2 Remedy Integrity

UNC Disposal Site remedy integrity components are listed in Table 5.4 and described below.

The UNC PCR requires that surveillance activities continue for 30 years from completion of remediation to ensure that the cap adequately contains the waste in the site. Specific requirements include a visual inspection of the cap be conducted quarterly for the first two years after construction, and semiannually thereafter. If necessary, restorative measures will be implemented. Minor deficiencies such as damaged drains or signs will be noted on the inspection forms and corrected. However, major deficiencies such as the collapse of the cap or major erosion problems will be reported. Required routine maintenance includes mowing and replacement of any topsoil and vegetation, as required.

5.3.2.1 Status of remedy integrity

All components of the UNC Disposal Site were inspected semiannually in FY 2018 by the Y-12 S&M Program and are in place, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. Routine mowing was conducted in FY 2018. Additionally, the UNC Disposal Site is located within the Y-12 property protection area and, as such, is not accessible to the public. The area is routinely patrolled by Y-12 security personnel.

Table 5.4. LUCs for Chestnut Ridge

LUCs for completed actions in Chestnut Ridge[a]			
Specific areas	**Project documents**	**LUCs**	**Frequency/implementation**
UNC Disposal Site	PCR (DOE/OR/01-1128&D1)	**Remedy integrity:** • Site inspections will continue for a period of 30 years following this RA to ensure that the cap is adequately containing the wastes in the site • Routine maintenance will include mowing of the site and the replacement of any topsoil and vegetation that may have been washed from the site	• Inspect site quarterly during the first two years • Inspect site on semiannual basis after first two years
KHQ	ROD (DOE/OR/02-1398&D2)[b] EFPC/CR RAR CMP (DOE/OR/01-2466&D4)[c]	**Remedy integrity:** • Regular inspection and maintenance include the site-security fence, survey benchmarks, and the groundwater monitoring wells **LUCs:** • Submit notice to local zoning authority with record of the type, location, and quantity of hazardous wastes disposed • Record a notice in the deed/survey plat	• Inspect site quarterly • The status of the site under CERCLA will be reviewed every five years
FCAP	RAR (DOE/OR/01-1596&D1)	**Remedy integrity:** • Routine inspections will verify the establishment and health of the wetland plants • Adequate inspections and maintenance of the dam, spillway channel, adjacent slopes, settling basin, and wetlands • Inspector will look for evidence of erosion, such as rill or gully development, and slope instability at the dam and adjacent areas. Also check general condition of the vegetative cover on the dam, looking for dead spots, excessive weed growth, or invasion of unwanted species. • The emergency spillway and any drainage control structures will be inspected as part of the general facility inspection. The spillway inlet and outlet, as well as the main channel, will be inspected for blockage, settlement, ponding, unwanted vegetation, erosion, damage to the revetment mattress, and other visible factors that could affect performance. The underdrain and settling basin located at the toe of the dam will be inspected for any blockage or impediment to flow. In addition, the settling basin will be inspected for excessive sediment accumulation. The wetlands located down gradient of the settling basin will be monitored for viability of vegetation, and plants will be checked for stability and growth. • The permanent benchmarks will be inspected to determine if they have been damaged. Also, to prevent unauthorized access to the site, the inspector will ensure that the gate at the entrance to the facility is locked and in good condition and that signs restricting unauthorized access are legible and in good condition. During each quarterly inspection, the	• Inspections conducted quarterly throughout post-remediation care period • Dam and spillway will also be inspected following any rainfall event equivalent to a 25-yr, 24-hr intensity

Table 5.4. LUCs for Chestnut Ridge (cont.)

LUCs for completed actions in Chestnut Ridge[a]			
Specific areas	**Project documents**	**LUCs**	**Frequency/implementation**
		inspector will also note any evidence of unauthorized access and the need for additional security measures. • Site maintenance will include repair of any damage observed during the site inspection. Any erosion damage will be repaired by restoring the area to its original grade and replacing cover material. Excessive sediment accumulation in the settling basin will be removed, characterized for potential COCs, and disposed of accordingly. Any blockage or impediment to proper drainage will be removed or repaired. Wetland vegetation will be replaced or replenished, and, if feasible, hydraulic characteristics will be adjusted as necessary to maintain the viability of the wetlands. **LUCs:** • Deed restrictions per the ROD filed at the Anderson County courthouse • Ash pond and dam are isolated from the public through ORR institutional controls. The site is restricted by fencing and bar gates. • Site is located in the "No Hunting Safety/Security Zone" between the Y-12 Plant and BV Road • Signs placed at bar gate and around pond indicate that this area is restricted and that permission is required before beginning any excavation or construction activities at the site	
CRSP	EFPC/CR RAR CMP (DOE/OR/01-2466&D4)[c]	**Remedy integrity:** • Site inspections - access controls, cap/cover/surface draining, signage, 25-yr/24-hr rain event inspections, and benchmarks • Monitoring wells – comprehensive evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate)	• Inspect site semiannually • Inspect wells annually
ECRWP	EFPC/CR RAR CMP (DOE/OR/01-2466&D4)[c]	**Remedy integrity:** • Leachate system inspection • Site inspections - access controls, cap/cover/surface draining, signage, 25-yr/24-hr rain event inspections, and benchmarks • Monitoring wells – comprehensive evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate)	• Inspect leachate weekly • Inspect site semiannually • Inspect wells annually

Table 5.4. LUCs for Chestnut Ridge (cont.)

LUCs for completed actions in Chestnut Ridge[a]			
Specific areas	**Project documents**	**LUCs**	**Frequency/implementation**
CRSDB	EFPC/CR RAR CMP (DOE/OR/01-2466&D4)[c]	**Remedy integrity:** • Site inspections - access controls, cap/cover/surface draining, signage, 25-yr/24-hr rain event inspections, and benchmarks • Monitoring wells – comprehensive evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate)	• Inspect site semiannually • Inspect wells annually

[a]Remedy integrity/LUCs for specific areas are determined by each remediation project and listed in the project-specific completion report.

[b]*Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/02-1398&D2) defers all LUC requirements to the RCRA PCPs.

[c]Site controls for former RCRA post-closure permitted facilities in Chestnut Ridge watersheds added to the *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2466&D4**)** in an errata dated February 23, 2018.

BV = Bethel Valley
CERCLA = Comprehensive Environmental Response, Compensation and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
COC = contaminant of concern
CR = Chestnut Ridge
CRSDB = Chestnut Ridge Sediment Disposal Basin
CRSP = Chestnut Ridge Security Pits
ECRWP = East Chestnut Ridge Waste Pile
EFPC = East Fork Poplar Creek
FCAP = Filled Coal Ash Pond
KHQ = Kerr Hollow Quarry
LUC = land use control
ORR = Oak Ridge Reservation
PCP = Post-Closure Permit
PCR = Post-Completion Report
RA = remedial action
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976
ROD = Record of Decision
UNC = United Nuclear Corporation
Y-12 = Y-12 National Security Complex

5.4 KHQ

5.4.1 Performance Monitoring

5.4.1.1 Performance monitoring goals and objectives

The *Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (KHQ ROD; DOE/OR/02-1398&D2) presents the decision for No Further Action (NFA) at the KHQ site (Figure 5.1 and Figure 5.3). The RCRA closure of KHQ, which was intended to prevent physical exposure to contaminants within the quarry and mitigate migration of contaminants to groundwater or surface water runoff, was deemed protective of human health and the environment under CERCLA, resulting in the NFA decision. The NFA decision deferred all inspection/maintenance (including security), monitoring, and reporting requirements for KHQ to the 1996 *RCRA Post-Closure Permit for the Chestnut Ridge Hydrogeologic Regime, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (1996 Chestnut Ridge PCP; TNHW-088) and the renewed 2006 Chestnut Ridge PCP. In February 2018, the substantive RCRA requirements for post-closure care, monitoring, and reporting for KHQ transitioned to CERCLA and were incorporated into the EFPC/CR RAR CMP. Based on the extensive results/findings of RCRA post-closure detection monitoring for KHQ, the substantive monitoring requirements include sampling/analysis of groundwater from POC well GW-144, biennial sampling frequency (performed during alternating wet/dry seasonal weather/flow conditions), and laboratory analyses for VOCs for trend analysis. Also, with the transition to CERCLA, the RER and CERCLA FYR serves as the forum to present the groundwater sampling/analysis results and an evaluation of the results.

The KHQ ROD states that monitoring of the surface water discharge point (Outfall 301) from the quarry will be performed as a best management practice. Because the outfall was typically dry, the DOE obtained approval to discontinue monitoring of Outfall 301 at the quarry in 2002.

5.4.1.2 Evaluation of performance monitoring data

In accordance with the EFPC/CR RAR CMP, the initial biennial sampling of groundwater from POC well GW-144 at KHQ was performed in July 2018. Analytical results for the sample show that the only detected VOC was carbon tetrachloride which was detected at a very low (estimated) concentration (0.7 J µg/L). The detected carbon tetrachloride concentration was much less than the 5 µg/L MCL. Previous groundwater sampling and analysis results show that carbon tetrachloride was detected in 23 of 93 groundwater samples collected from well GW-144 before July 2018, most recently in July 2015 (1.1 µg/L). Many of the detected carbon tetrachloride results were reported for groundwater samples collected when wastes in the KHQ were removed/disturbed during the early and mid-1990s. Sporadic detections of carbon tetrachloride in the groundwater collected from well GW-144 over such an extended time period suggests a continued low-level source at KHQ, presumably the dissolution of carbon tetrachloride present in the wastes that remain in the quarry and/or residual in the fractured bedrock or sediment on the quarry floor. The persistent long-term presence of carbon tetrachloride suggests minimal biodegradation in the groundwater, and reflects the very slow advective groundwater transport possible under the nearly flat horizontal hydraulic gradient at KHQ.

5.4.2 Remedy Integrity and LUCs

Remedy integrity components and LUCs for KHQ are listed in Table 5.4 and described below.

The KHQ ROD does not specify any requirements; however, the 2006 Chestnut Ridge PCP required that all security components, signage, survey benchmarks, and monitoring systems at KHQ be inspected quarterly throughout the post-closure care period of 30 years. Final closure certification for the site was February 22, 1995. As a RCRA closure, deed restrictions were required to be filed at the County Register of Deeds Office.

5.4.2.1 Status of remedy integrity and LUCs

KHQ was inspected quarterly in FY 2018 by the Y-12 S&M Program for proper signage, integrity of benchmarks and monitoring wells, including downhole condition, condition of the fences, gates, and locks, and condition of the access road. Maintenance of the remedy integrity in FY 2018 included routine mowing, removing several downed trees, repairing fencing, and replacing posts and signs.

Additionally, the KHQ is located outside the Y-12 property protection area; therefore, separate security fencing and signs exist at the site. The KHQ deed restrictions were filed on April 28, 1994, at the Anderson County Register of Deeds Office and remain in place.

5.5 FCAP/UPPER MCCOY BRANCH

5.5.1 Performance Monitoring

5.5.1.1 Performance monitoring goals and objectives

The FCAP is situated south of Y-12 along the southern slope of Chestnut Ridge (Figure 5.1 and Figure 5.4). The scope of the *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee* (Chestnut Ridge OU 2 ROD; DOE/OR/02-1410&D3) was to remediate the FCAP and vicinity. The *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity)* (Chestnut Ridge OU 2 RAR; DOE/OR/01-1596&D1) documents the following actions: the crest of the dam was raised, the face of the dam was reinforced, a subsurface drain was installed, large trees were removed from the face of the dam, the emergency spillway was repaired (including removal of the steep slope to the east of the spillway), a settling basin and oxygenation weir were constructed at the foot of the dam, and a small wetland was revitalized downstream of the settling basin. The RA also includes long-term monitoring of the dam and controls to limit access.

The goal of the RA specified in the Chestnut Ridge OU 2 ROD is to reduce risk posed by the site to "plants, animals and humans by: (1) upgrading containment of the coal ash with dam improvements and stabilization, (2) reducing contaminant migration into Upper McCoy Branch with a passive treatment system (existing wetland), and (3) restricting human access to the contamination by implementing institutional controls." The functional goals are to:

- *minimize the migration of contaminants into surface water,*
- *minimize direct contact of humans and animals with the ash,*
- *reduce the potential for future failure of the dam, and*
- *preserve the local habitat in the long term.*

Page 2-21 of the Chestnut Ridge OU 2 ROD requires that surface water be periodically sampled "and analyzed to verify that the passive treatment system reduces contaminant levels in water entering Upper McCoy Branch at least as well as the existing wetland and to evaluate whether the passive treatment system requires maintenance." The Chestnut Ridge OU 2 RAR specifies that surface water samples "be collected and analyzed for the primary COCs (aluminum, arsenic, iron, manganese, and zinc) and other constituents of relevance to evaluating wetland performance at the site." Two locations, one at the influent to the wetland

(McCoy Branch kilometer [MCK] 2.05) and one below the wetland (MCK 2.0), are monitored for metals, anions, radionuclides, and other water quality parameters on a semiannual basis. Both monitoring locations are downstream of the contaminant source.

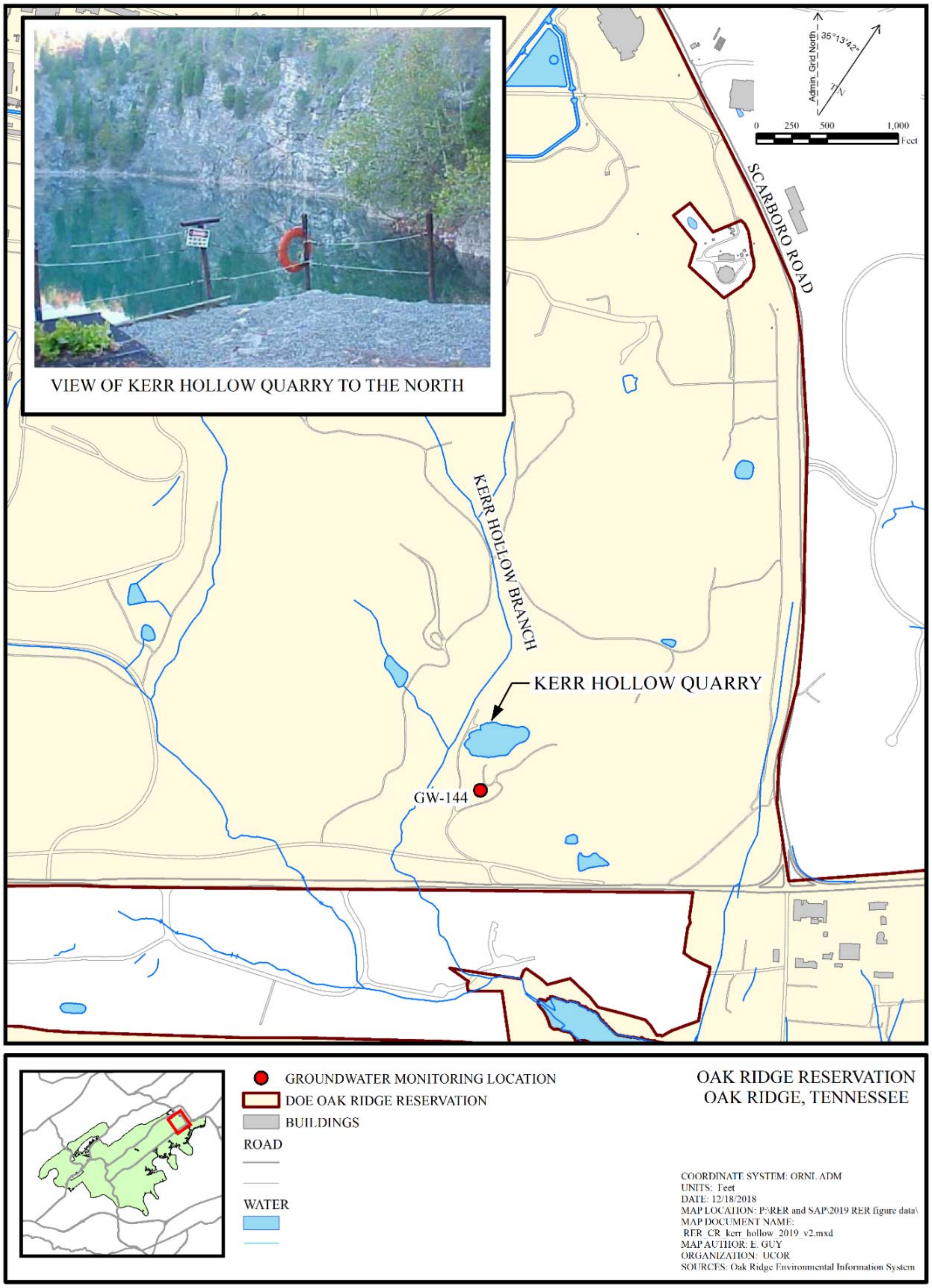

Figure 5.3. Location map of KHQ.

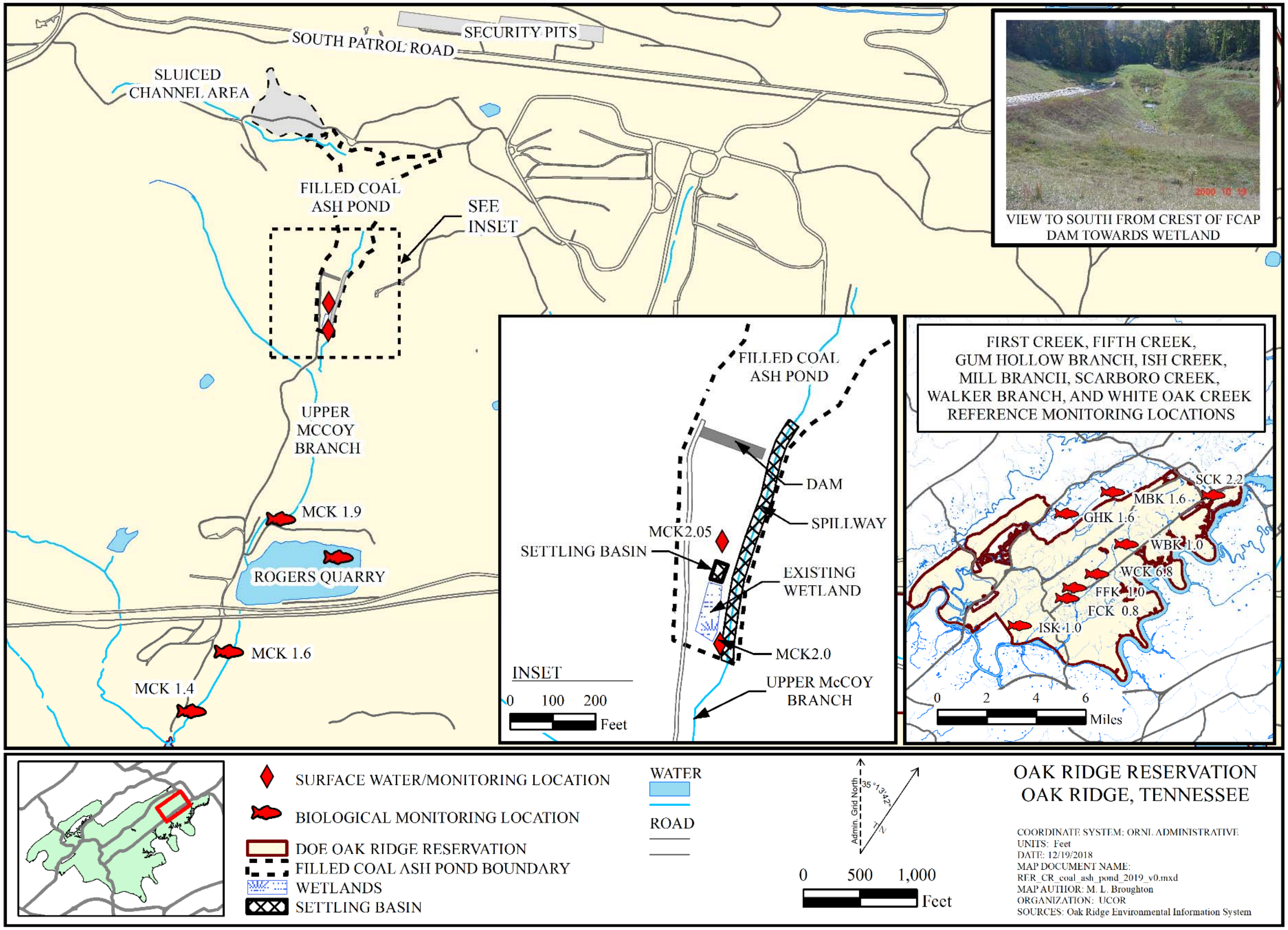

Figure 5.4. Location map of FCAP and associated reference locations.

Monitoring of biological communities is conducted to evaluate protection of the ecosystem in the FCAP vicinity as specified in the Chestnut Ridge OU 2 ROD. The ROD does not specify compliance with AWQC; however, AWQC are used only as comparative criteria to track reduction in "contaminant migration to surface water" and "risk to ecological receptors." Biological communities are monitored downstream of the wetland effluent (MCK 1.9) and also below the Rogers Quarry dam (MCK 1.4 and MCK 1.6). Fish are collected from Rogers Quarry for contaminant analysis on an annual basis.

The 2016 FYR deferred the protectiveness of FCAP for aquatic life. The FYR additionally noted that the performance of the wetland system may be diminishing over time; that water flow across the wetlands is channelized along the outer edges, rather than flowing across the entire wetland due to buildup of sediment or organic matter, and an invasive plant species is displacing the indigenous cattail community. In response to this issue, DOE completed an investigative Action Plan of the wetlands to determine if improvements to the physical conditions are necessary to increase efficiency. The plan also included an evaluation of the fish population and health in Rogers Quarry. Results of that investigation are summarized in this section of the RER and Appendix C contains a report of the investigation and its results.

5.5.1.2 Evaluation of performance monitoring data

5.5.1.2.1 Surface water

To fulfill the performance monitoring goals and objectives, the monitoring data evaluation for the FCAP RA focuses on comparison of metals contaminant concentrations to pre-action levels and overall reduction of metals between the inlet and outlet sampling locations at the wetland. Water quality monitoring at the site includes anions, metals, and gross alpha/beta activity. DOE monitors a broad suite of metals in the wetland influent and effluent to evaluate the metals attenuation effectiveness of the action.

Past monitoring results show that arsenic is the most significant metal present in the site discharge. Elevated concentrations of arsenic are above AWQC screening criteria at FCAP. During FY 2018, lead, cadmium, chromium, and copper were not detected in surface water samples at FCAP. Mercury and antimony, when detected, are present at concentrations far lower than their respective screening AWQC levels. In recent years, selenium has been detected in FCAP wetland influent and effluent samples at concentrations that approach the screening AWQC for protection of fish and aquatic life (5 µg/L). Iron and manganese are common and abundant metals present in coal ash leachate. These elements form solid metal oxide precipitates when the leachate water comes in contact with free oxygen, such as when leachate contacts air or other water rich in dissolved oxygen. The AWQC values are used for comparison purposes only and are not a ROD-specified goal.

Table 5.5 summarizes monitoring data from FY 1996 prior to the RA, while Table 5.6 summarizes the FY 2018 monitoring results. The upstream (before flow through the wetland) sampling location is MCK 2.05 and the downstream (after flow through the wetland) is MCK 2.0. For the baseline event, the data summary is based on both filtered and unfiltered sample results for which four replicate samples were collected on the same date. Percent reduction of metals concentrations for average dissolved (filtered sample results) and average total (unfiltered sample results) shows that for arsenic, concentrations in the wetland effluent water were higher than in the influent water. Because filtered results were non-detects for iron and zinc in the 1996 dataset, no reduction factor is calculated. The total iron concentration was reduced about 17% in the 1996 dataset. Dissolved manganese was reduced by about 11%, although the total manganese concentration in the wetland effluent was over six times the level measured in the influent. The total zinc concentration in wetland effluent was slightly greater than twice the influent concentration.

Table 5.5. Summary of FCAP pre-remediation monitoring results, FY 1996

Analyte	Units	MCK 2.05[a] (filtered)			MCK 2.05[a] (unfiltered)			MCK 2.0[b] (filtered)			MCK 2.0[b] (unfiltered)			Percent reduction[c]	
		Avg	Max	Stdev	Avg	Max	Stdev	Avg	Max	Stdev	Avg	Max	Stdev	Filtered	Unfiltered
Arsenic[d]	mg/L	0.007	**0.011**	0.004	**0.484**	**1.4**	0.623	**0.014**	**0.017**	0.003	**0.572**	**1.2**	0.606	-100	-18
Iron	mg/L	--[e]	0.014	--[e]	20.1	48	23.1	0.091	0.26	0.114	16.7	43	17.7	--	17
Manganese	mg/L	0.089	0.17	0.087	1.94	3.8	1.48	0.079	0.15	0.077	13.8	39	17.9	11	-611
Zinc[f]	mg/L	0.022	0.052	0.022	0.035	0.056	0.023	--[e]	0.009	--[e]	0.072	0.2	0.091	--	-106

[a]Dam effluent/wetland influent.
[b]Wetland effluent.
[c]Percent reduction is difference between average upstream and downstream samples in proportion to the upstream concentration.
[d]AWQC screening criterion for arsenic is 0.01 mg/L. Source: TDEC 0400-40-03-.03(4) recreational criteria – organisms only.
[e]Value not determined because only one valid result was available.
[f]AWQC screening criterion for zinc is 0.12 mg/L. Source: TDEC 0400-40-03-.03(3) criteria continuous concentration for protection of fish and aquatic life. AWQC for zinc are hardness dependent. The 0.12 mg/L ambient water quality criterion for zinc is based on the most conservative criterion for hardness.

Bold value indicates sample concentration exceeds AWQC.

-- = not applicable, not available, or insufficient data to calculate the statistic
Avg = average
AWQC = ambient water quality criteria
FCAP = Filled Coal Ash Pond
FY = fiscal year
Max = maximum
MCK = McCoy Branch kilometer
Stdev = standard deviation
TDEC = Tennessee Department of Environment and Conservation

Table 5.6. Summary of FY 2018 post-remediation data from MCK 2.05 and 2.0

Analyte	Units	Wet-season sample		Percent reduction[a]		Dry-season sample		Percent reduction[a]		AWQC
		MCK 2.05[b] March 2018 Unfiltered/filtered	**MCK 2.0[c] March 2018 Unfiltered/filtered**	**Unfiltered**	**Filtered**	**MCK 2.05[b] August 2018 Unfiltered/filtered**	**MCK 2.0[c] September 2018 Unfiltered/filtered**	**Unfiltered**	**Filtered**	
Arsenic[d]	mg/L	Reg **0.035**/ **0.031**	**0.034 / 0.015**	-1	50	Reg **0.036 / 0.025**	**0.021** / 0.0097	35	60	0.01
		Dup **0.032** / **0.029**				Dup **0.029 / 0.023**				
Iron	mg/L	Reg 0.46 / 0.3	0.63 / 0.017 U	-35	>94-	Reg 0.77 / 0.25	0.49 / 0.048	34	82	NA
		Dup 0.47 / 0.31				Dup 0.71 / 0.27				
Manganese	mg/L	Reg 0.74 / 0.75	0.3 / 0.012	60	98	Reg 0.88 / 0.89	0.28 / 0.021	68	98	NA
		Dup 0.75 / 0.75				Dup 0.87 / 0.9				
Zinc[e]	mg/L	Reg 0.0032 J / 0.0091 J	0.0043 J / 0.0028 U	59	>55	Reg 0.00099 J / 0.0016 J	0.00062 U / 0.00062 U	>32	>64	0.12
		Dup 0.018 / 0.0033 J				Dup 0.00083 J / 0.0018 J				

[a]Percent reduction is difference between upstream average of regular and duplicate sample results and downstream samples in proportion to the upstream concentration.
[b]Dam effluent/wetland influent.
[c]Wetland effluent.
[d]AWQC screening criterion for arsenic is 0.01 mg/L. Source: TDEC 0400-40-03-.03(4) recreational criteria – organisms only.
[e]AWQC screening criterion for zinc is 0.12 mg/L. Source: TDEC 0400-40-03-.03(3) criteria continuous concentration for protection of fish and aquatic life. AWQC for zinc are hardness dependent. The 0.12 mg/L ambient water quality criterion for zinc is based on the most conservative criterion for hardness.

Bold value indicates sample concentration exceeds AWQC.

AWQC = ambient water quality criteria
Dup = duplicate sample
FY = fiscal year
J = estimated value
MCK = McCoy Branch kilometer
NA = not applicable
Reg = regular sample
TDEC = Tennessee Department of Environment and Conservation
U = not detected

Table 5.6 summarizes FY 2018 results from regular unfiltered and field-filtered samples collected at the downstream site (MCK 2.0) under wet season (March) and dry season (August) conditions and regular plus duplicate samples collected at the upstream location (MCK 2.05). During FY 2018, the only sample that met the arsenic AWQC screening level (0.01 mg/L for recreation organisms only) was the dry season (August) filtered sample from the downstream sample location. As shown in Table 5.6, during FY 2018, a very small increase in arsenic was noted in the wet season (March) downstream unfiltered sample compared to the upstream samples although the filtered sample from downstream showed a 50% arsenic reduction. During the dry (August) sampling event, the total arsenic concentration was reduced by 35% during water flow through the wetland and the filtered arsenic concentration was reduced by 60%.

Figure 5.5 shows the history of downstream (MCK 2.0, wetland effluent) total arsenic and filtered arsenic concentration results. All the measured arsenic concentrations are much lower than the screening AWQC for protection of fish and aquatic life of 0.15 mg/L. None of the FY 2018 samples contained selenium at levels greater than the EPA's 3.1 µg/L freshwater AWQC for protection of aquatic life (EPA 2016). The maximum measured selenium concentration in the routine FCAP wetland sampling program was 2.9 µg/L and the average was 2.2 µg/L.

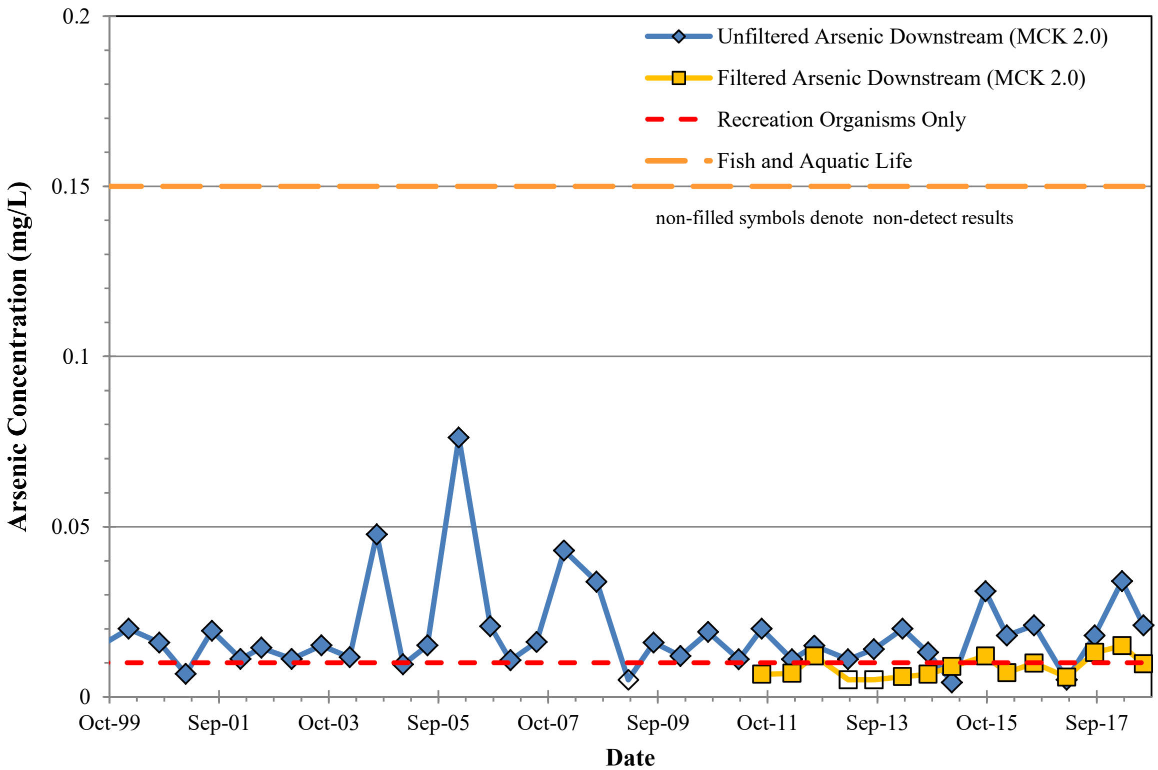

Figure 5.5. History of arsenic concentration in FCAP wetland effluent (MCK 2.0).

The goal of FCAP remediation is to reduce metals discharges from the coal ash to surface water in McCoy Branch. The remedy included two elements – replacement of the dam which held the coal ash with a new structure to prevent erosion and transport of the ash downstream, and enhancement of an existing wetland to passively reduce metals concentrations downstream. Arsenic has been identified above as the principal COC. Two metrics are used to evaluate the overall performance of the FCAP remedy.

The first metric of interest is the percentage reduction of total arsenic concentrations over time for both the upstream (MCK 2.05) and downstream (MCK 2.0) monitoring locations. Figure 5.6 shows the percent reductions in total arsenic concentrations for the period 1998 through 2018. This graph provides the "running percent decrease" factor that has been observed since the dam stabilization. The pre-remediation values are those presented in Table 5.5. At the upstream monitoring location, the percent reduction attributable to the FCAP dam improvements is typically greater than 75%, although two samples experienced very poor reduction factors that actually plot in the negative reduction range indicating increased concentrations downstream compared to upstream. Increases in total metals concentration downstream are typically associated with suspended particulates.

The second and more important metric of interest is the percent reduction in arsenic concentration between water entering the wetland at MCK 2.05 and water leaving the downstream end of the wetland at MCK 2.0. Figure 5.7 shows the percent of total arsenic at MCK 2.0 compared to average of arsenic concentrations measured in both the unfiltered regular sample and a field duplicate sample collected at MCK 2.05. The percent reduction of arsenic during flow through the wetland is typically greater than 20% although the reduction factors are highly variable. As shown on Figure 5.7, there appears to be some decreasing arsenic removal effectiveness over time. The sample events with lower arsenic reduction factors are not seasonally dependent.

The post-action wetland is more effectively reducing metals effluent from the site than under the pre-existing condition. Although AWQC were not specified as performance criteria for the action, the post-action concentration comparisons for arsenic to the criteria show that the levels of exceedance are much smaller subsequent to completion of the remedy than prior to remedy completion and exceedances are less frequent.

During FY 2017 and 2018, DOE conducted investigations in response to the 2016 FYR issue concerning the FCAP wetland performance. A report of the result of those investigations is included as Appendix C of this RER. Key elements and conclusions of the investigations included (also see Section 5.5.1.2.2):

- A physical survey of the wetland confirmed excessive accumulation of material in the center of the wetland that causes channelization of flow around the area perimeter,
- Installation of flow measurement flumes (MCK 2.0 and MCK 2.05) upstream and downstream of the wetland allowed for measurement of flow volumes and supported composite sampling to evaluate dissolved and particulate fluxes passing through the wetland,
- A dye tracer test documented the relatively short residence time of water in the wetland under current conditions (90^{th} percentile of tracer mass passed out of the wetland at about 4.6 hours elapsed time),
- Collection of wet season and dry season baseflow and storm event composite samples allowed for the determination of time and flow averaged metals concentrations under varying seasonal and flow conditions. Flux calculations determined that arsenic reduction in the wetland was variable and that the wetland at times served as a source of arsenic in both wet and dry seasons.
- Collection of bulk water samples during a stormflow event helped to determine the nature of sediment in the wetland influent and effluent as well as in the FCAP spillway and at a location immediately upstream of Rogers Quarry. Sheet erosion and limited erosion of surface channels in the ash upstream of the revetment spillway associated with high intensity precipitation are primary contributors to transport of ash-containing sediments. In addition, surface sediments are subject to displacement associated with frost heave.

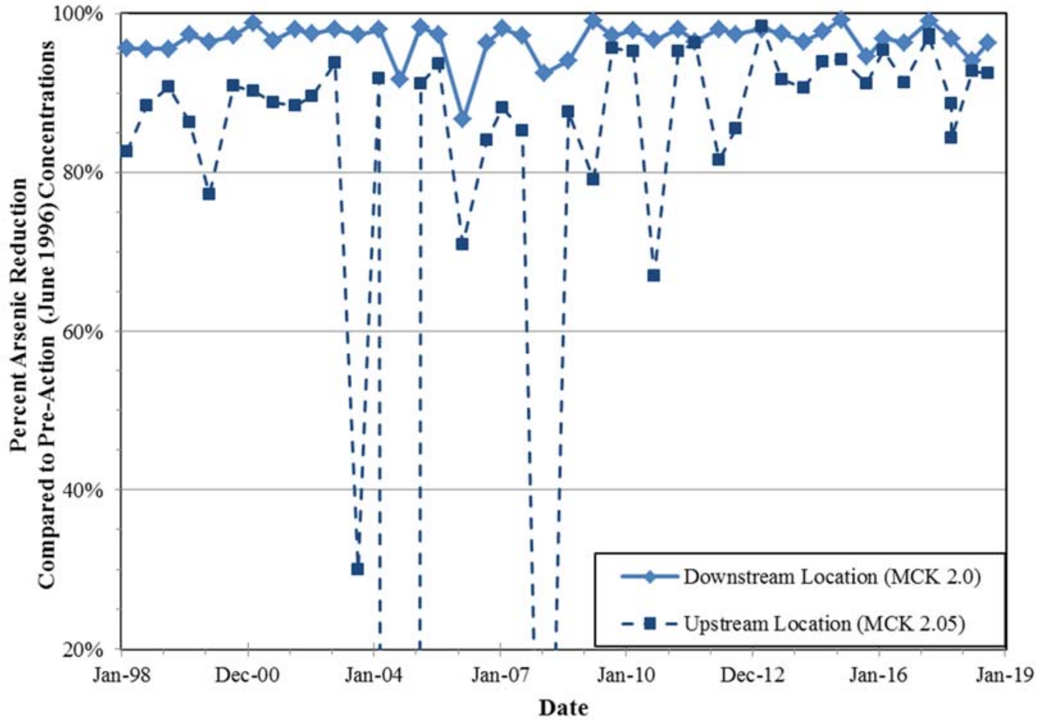

Figure 5.6. Post-remediation percent reduction of total arsenic concentrations in McCoy Branch compared to pre-remediation levels.

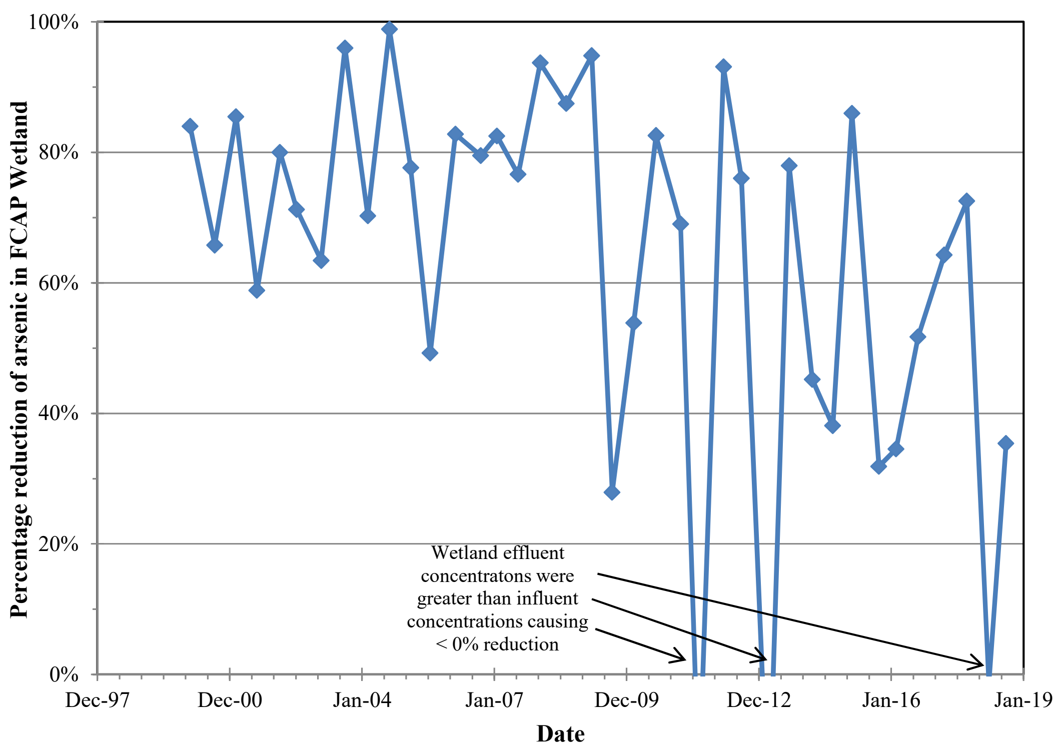

Figure 5.7. Percentage reduction of total arsenic concentration in flow through the FCAP wetland.

5.5.1.2.2 Biota

Fly-ash disposal from Y-12 into the FCAP, as well as direct disposals of ash into Rogers Quarry (Figure 5.4), affected water quality in the lower reaches of McCoy Branch and the quarry. Biological monitoring studies have documented contaminants in fish and impacts to biota in the lower reaches of the McCoy Branch watershed and Rogers Quarry. To evaluate in-stream exposure and potential human health risks in the McCoy Branch watershed, adult largemouth bass were collected from Rogers Quarry and analyzed for concentrations of key COCs, including selenium, mercury, and arsenic. An evaluation of overall ecological health in the stream was conducted by monitoring the fish and benthic macroinvertebrate communities. Fish sampling of Rogers Quarry in FY 2016 and FY 2017 resulted in the observation of physiological abnormalities in largemouth bass. The need for further investigation was identified as part of the 2016 FYR. Results of investigations in 2018 to examine the potential causes of the fish observations are briefly summarized here and reported in Appendix C.1.

Average wet weight selenium concentrations in largemouth bass collected from Rogers Quarry decreased substantially in 2018 (1.08 µg/g, but remain above typical background concentrations [approximately 0.5 µg/g]). Using the percentage of moisture for fish fillets, this concentration would be 5.4 µg/g on a dry weight basis, which is below the EPA-recommended 11.3 µg/g dry weight tissue criterion for selenium in fillets. Average wet weight mercury concentrations in largemouth bass fillets in 2018 (0.55 µg/g) were slightly lower than in 2017 continuing a steady decline since 2014, but remained above the 0.3 µg/g fish tissue criterion. Arsenic concentrations continued to be near background levels since 2007 (Figure 5.8). The elevated selenium and mercury concentrations in fish from Rogers Quarry suggest continuing low-level inputs from the FCAP (Figure 5.8). The ROD does not specify AWQC values are performance goals. The AWQC are used as screening values for comparative purposes.

The species richness (number of species) of the fish community at MCK 1.6 in McCoy Branch has shown a wide range of variation since sampling began in the late 1980s (Figure 5.9). The wide variation at MCK 1.6 is likely related to the proximity of the site to Melton Hill Reservoir which serves as a source for many species in some years, including those not generally expected in a smaller stream (i.e. non-resident species such as smallmouth bass *Micropterus dolomieu*). Low numbers of species in general at this site, and especially in some years, may be due to influences from Rogers Quarry upstream. The quarry undoubtedly changes water quality and chemistry characteristics downstream including temperature. In addition, natural impacts such as beaver activity and the drought conditions experienced in late summer 2016 can negatively impact stream fish communities by altering available habitat. The species richness at MCK 1.9 remained stable at three species (western blacknose dace *Rhinichthys atratulus*, banded sculpin *Cottus carolinae*, and creek chub *Semotilus atromaculatus*) again in 2018 (Figure 5.9). There is a sizeable population of all three species, including multiple age classes, indicating these species will continue to maintain a presence in the stream despite poor stream substrate in some places and various impacts including a long history of ash deposition and beaver activity. Both McCoy Branch sites had far fewer sensitive species, such as darters, when compared with the mean of fish communities in the reference streams and were dominated by tolerant species in 2018.

Although variation in the benthic macroinvertebrate community through time continues to be strong at both sites on McCoy Branch, seasonal and annual fluctuations have dampened since 2009. The number of pollution-intolerant benthic macroinvertebrate taxa (EPT taxa richness) continued to show a strong seasonal trend at MCK 1.4, with the highest values consistently occurring in April (Figure 5.10). There continues, however, to be no such strong seasonal trend at MCK 1.9. Variation between years also continues to be notable, but since 2009, no major changes have occurred in overall trends; thus, conditions at both sites appear to have stabilized. EPT richness continues to be lower than the reference range at both McCoy Branch sites. Periodic droughts may be influencing invertebrate communities within McCoy Branch. The effects of intense drought conditions in the fall of 2016 were evident by declines in EPT richness in both reference sites and

McCoy Branch sites – the effects of the 2016 drought are still noticeable among many impacted and reference sites across the ORR. The magnitude and duration of the impacts of 2016 drought conditions will likely require more years of sampling to fully capture. The form of the stream channel and characteristics of the substrate at MCK 1.9 continue to show strong evidence of significant scouring, down-cutting, and erosion since 2008, and fly ash-containing sediments persist in the flood plain in the upper reaches of the stream. More detailed causal investigations have not been conducted, but potential stressors to instream invertebrate communities include chemical exposure from fly ash, flashy stream flows, and lower-quality habitat (e.g., sedimentation, propensity to scour, and increased pool habitat created by beavers). Even with a reduction in the number of pollution-intolerant taxa at MCK 1.9, the site still supports some taxa that are generally intolerant of poor water quality and are typically found predominantly at reference sites (e.g., the stoneflies *Leuctra* and *Tallaperla*; the beetle *Anchytarsus bicolor*). MCK 1.4, on the other hand, generally has higher densities of taxa that typically dominate sites with mildly to moderately poor water quality (e.g., filter-feeding caddisflies and Orthocladiinae midges).

DOE conducted investigations in response to the 2016 FYR issue; for fish there was an observation of fish morphological abnormalities in 2016 which prompted a more detailed investigation of the Rogers Quarry fish population (FY 2017 and FY 2018). Results of those investigations are included as Appendix C of this RER. Key elements and conclusions of the investigations included:

- Fish from McCoy Branch and Rogers Quarry were collected for metals analysis (fillets and ovaries) and a closer examination of fish health parameters. FY 2018 fish sampling in RQ found no deformed fish and only one emaciated fish, suggesting that detrimental exposures to selenium are transitory (only older fish were negatively affected) and there is an overall positive trend.
- An investigation of other regional quarries without coal ash impacts was conducted in an effort to evaluate if quarries in general resulted in food limitation and poor largemouth bass condition. Based on the investigation, there is no evidence that the general conditions of quarries are a cause of deformities or highly emaciated conditions in fish.

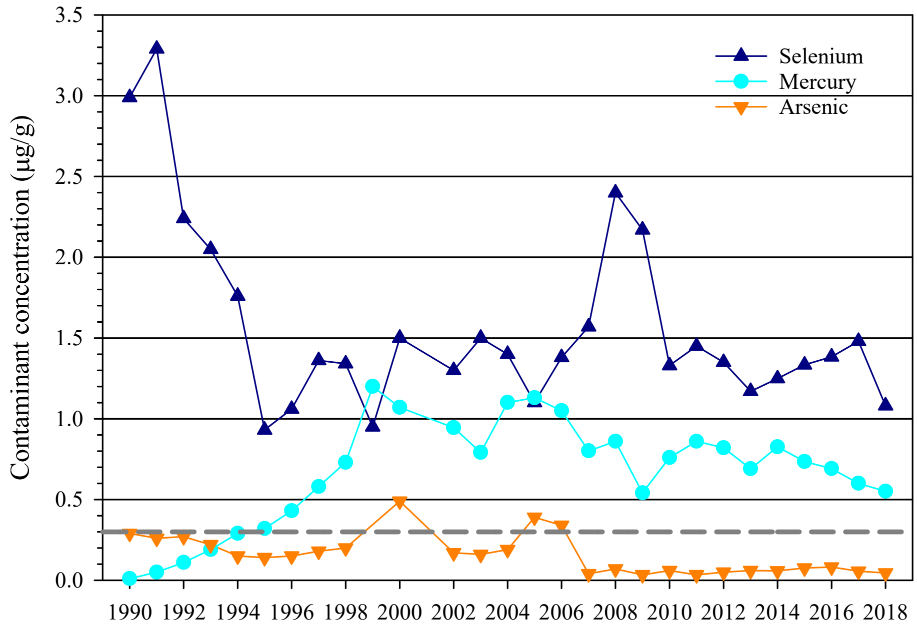

Figure 5.8. Mean concentrations of selenium, mercury, and arsenic in fillets of largemouth bass from Rogers Quarry, 1990 – 2018 (n=6 fish/yr).

Dashed gray line indicates federal recommended AWQC for mercury in fish fillets (0.3 µg/g). Note these are screening criteria.

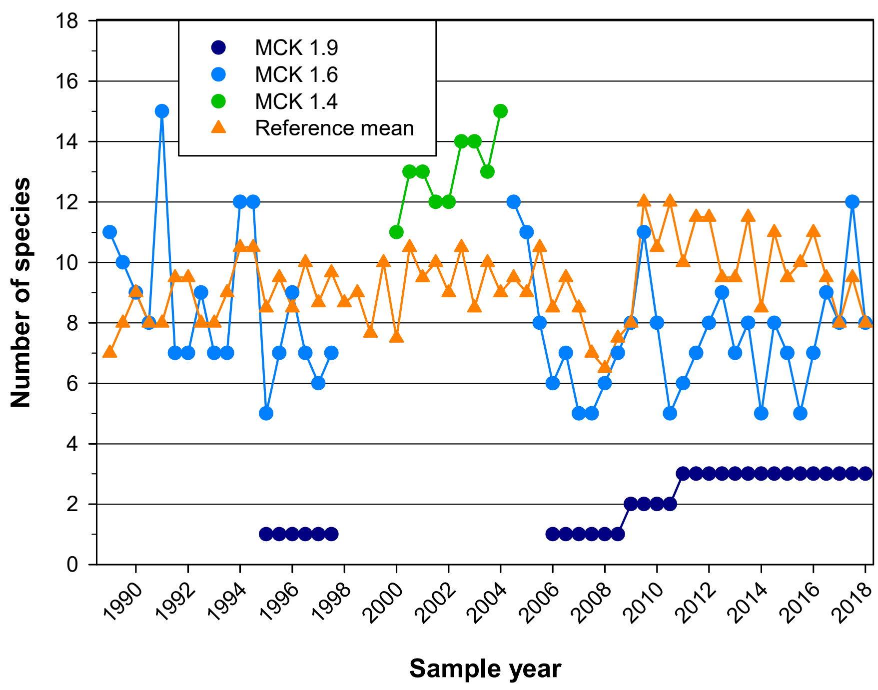

Figure 5.9. Species richness (number of species) in samples of the fish community in McCoy Branch (MCK) and the mean value of two-three reference streams, Scarboro Creek, Mill Branch, and Ish Creek, 1989 − 2018.

See Figure 5.4 for locations of reference sampling sites. Interruptions in data lines for MCK sites indicate no results available for those periods.

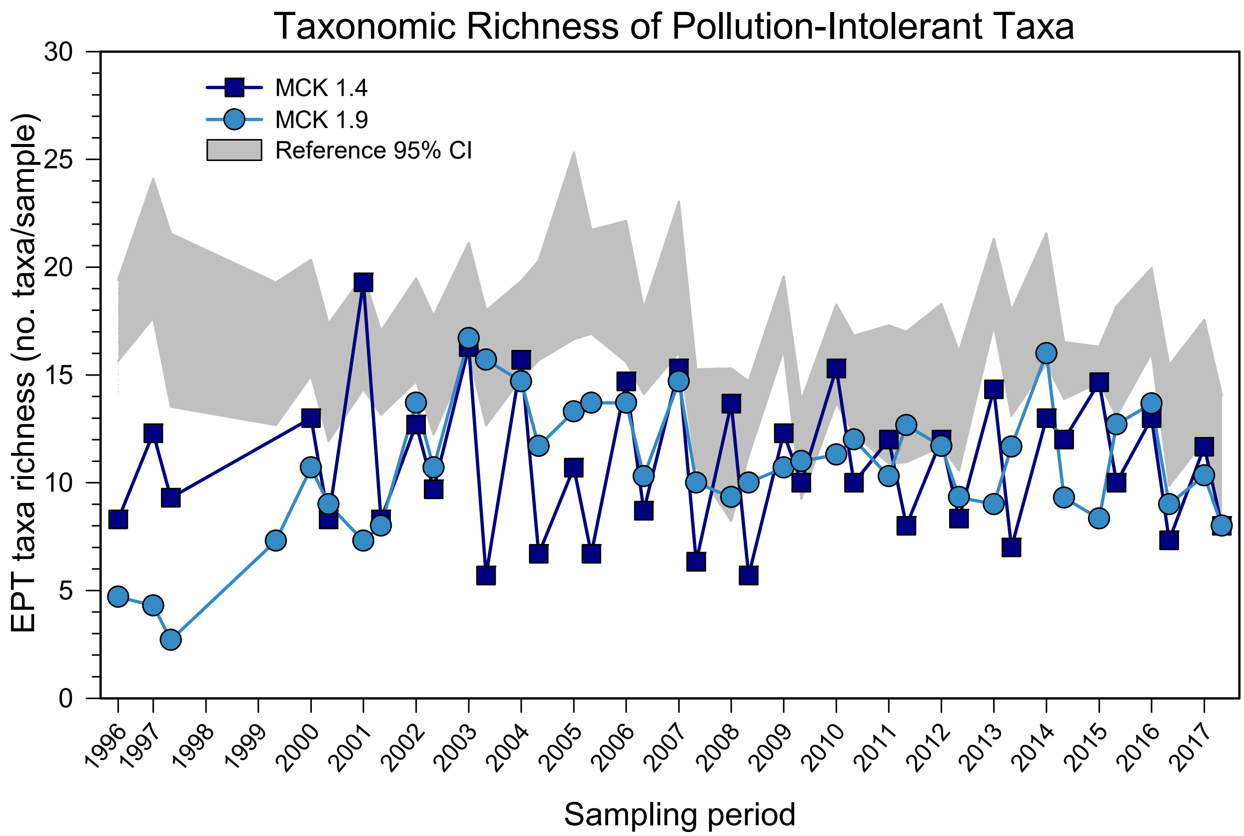

Figure 5.10. Taxonomic richness of pollution-intolerant taxa (EPT taxa richness) in the benthic macroinvertebrate community at sites in McCoy Branch, and the range of mean values at reference streams (First Creek, Fifth Creek, Gum Hollow Branch, Mill Branch, Walker Branch, and WOC), 1996 – 2018.

Each symbol represents the mean of three samples for April and October sampling periods beginning with October 1996. Tick marks for the x-axis are centered on April samples whereas October sampling falls between two given years.

The gray shading is the range of mean values for reference sites.

5.5.2 Remedy Integrity and LUCs

Remedy integrity components and LUCs for FCAP are listed in Table 5.4 and described below.

The Chestnut Ridge OU 2 RAR requires that inspections of the site be conducted quarterly throughout the post-remediation care period, and any required maintenance be conducted based on inspection findings. Post-remediation performance of FCAP is dependent on adequate inspection and maintenance of the dam, spillway channel, adjacent slopes, settling basin, and wetlands. Because erosion damage is of great concern, the dam and spillway will also be inspected following any rainfall event equivalent to a 25-yr, 24-hr intensity.

5.5.2.1 Status of remedy integrity and LUCs

All remedy components of the FCAP were inspected quarterly in FY 2018 by the Y-12 S&M Program including dam and slope stability, vegetative cover of dam and adjacent slopes, settling basin, spillway, underdrain discharge pipe, wetland area, benchmarks, and site security and access controls. Maintenance of the remedy integrity in FY 2018 included removing vegetation growing in the revetment mat and updating signs with correct contact information.

Multiple actions were performed in FY 2017 and FY 2018 to address the wetland area issues (a FYR issue) discussed above. Topographic surveys and walk-downs of the wetland confirmed the erosional downcutting and channelization observed along the wetland boundaries, and visual characterization of the wetland vegetation over the last two growing seasons identified tall fescue as the encroaching species. Flow-paced monitoring at surface water locations (flumes) installed at the head and mouth of the wetland is ongoing to characterize the volume, residence time, and chemical constituents of leachate transported through the site.

5.6 CRSP

5.6.1 Performance Monitoring

5.6.1.1 Performance monitoring goals and objectives

The TDEC accepted the certification of RCRA final closure of the CRSP on December 15, 1989, which included construction of a low-permeability cap over the waste disposal trenches at the site. Site-specific RCRA post-closure care, monitoring, and reporting requirements for the CRSP were included in the 1996 Chestnut Ridge PCP and the renewed 2006 Chestnut Ridge PCP. After the substantive RCRA requirements for post-closure care of the CRSP transitioned to CERCLA in February 2018, functionally equivalent groundwater monitoring objectives for the CRSP were addressed in the EFPC/CR RAR CMP, which specifies biennial sampling/analysis for VOCs in a POC well (GW-322) at the site (Figure 5.11). Based on the extended groundwater sampling/analysis history for the POC wells at the site, the biennial VOC sampling/analysis frequency will provide data adequate for the concentration trend analysis on which the performance of the low-permeability cap is to be evaluated. Also, ongoing detection monitoring at Construction/Demolition Landfill VII (Figure 5.11) involves semiannual sampling/analysis of an upgradient/background well (GW-798) that is known to yield groundwater containing PCE from the CRSP and, therefore, provides data relevant to downgradient transport of groundwater contaminants from the site.

5.6.1.2 Evaluation of performance monitoring data

Four VOCs were detected in the groundwater sample collected from CRSP well GW-322 in July 2018: 1,1,1-TCA (3.3 J µg/L), PCE (4 J µg/L), 1,1-DCE (20 µg/L), and 1,1-DCA (39 µg/L). The 1,1,1-TCA and PCE concentrations are below respective drinking water MCLs of 200 µg/L and 5 µg/L, whereas the 1,1-DCE concentration exceeds the 7 µg/L MCL. An MCL for 1,1-DCA has not been established. The MCL values are used as screening criteria for the water quality evaluation and are not a specified goal.

Based on comparison to the maximum summed VOC concentrations observed before RCRA closure of the CRSP (1,022 µg/L in August 1988), the VOC levels in the groundwater from well GW-322 have decreased by 90% within 30 years (66.3 µg/L in July 2018). Also, the data delineate somewhat divergent long term trends for individual compounds. As shown on Figure 5.12, concentrations of PCE are only slightly lower than evident before closure of the CRSP, whereas 1,1,1-TCA concentrations decreased substantially, potentially as a result of chemical degradation processes that do not effect PCE. Conversely, following closure of the CRSP, the respective concentrations of 1,1-DCE and 1,1-DCA generally increased through the late 1990s and subsequently decreased, although the concentrations of 1,1-DCA have decreased more slowly than the concentrations of 1,1-DCE. The variably decreasing long-term concentrations trends for these VOCs reflect the combined influence of natural attenuation processes and indicate that the low-permeability cap at the CRSP continues to hydraulically isolate the buried wastes and to minimize downward vertical migration/recharge of VOCs derived from the buried wastes and the contaminated soils in the unsaturated subsurface beneath the site.

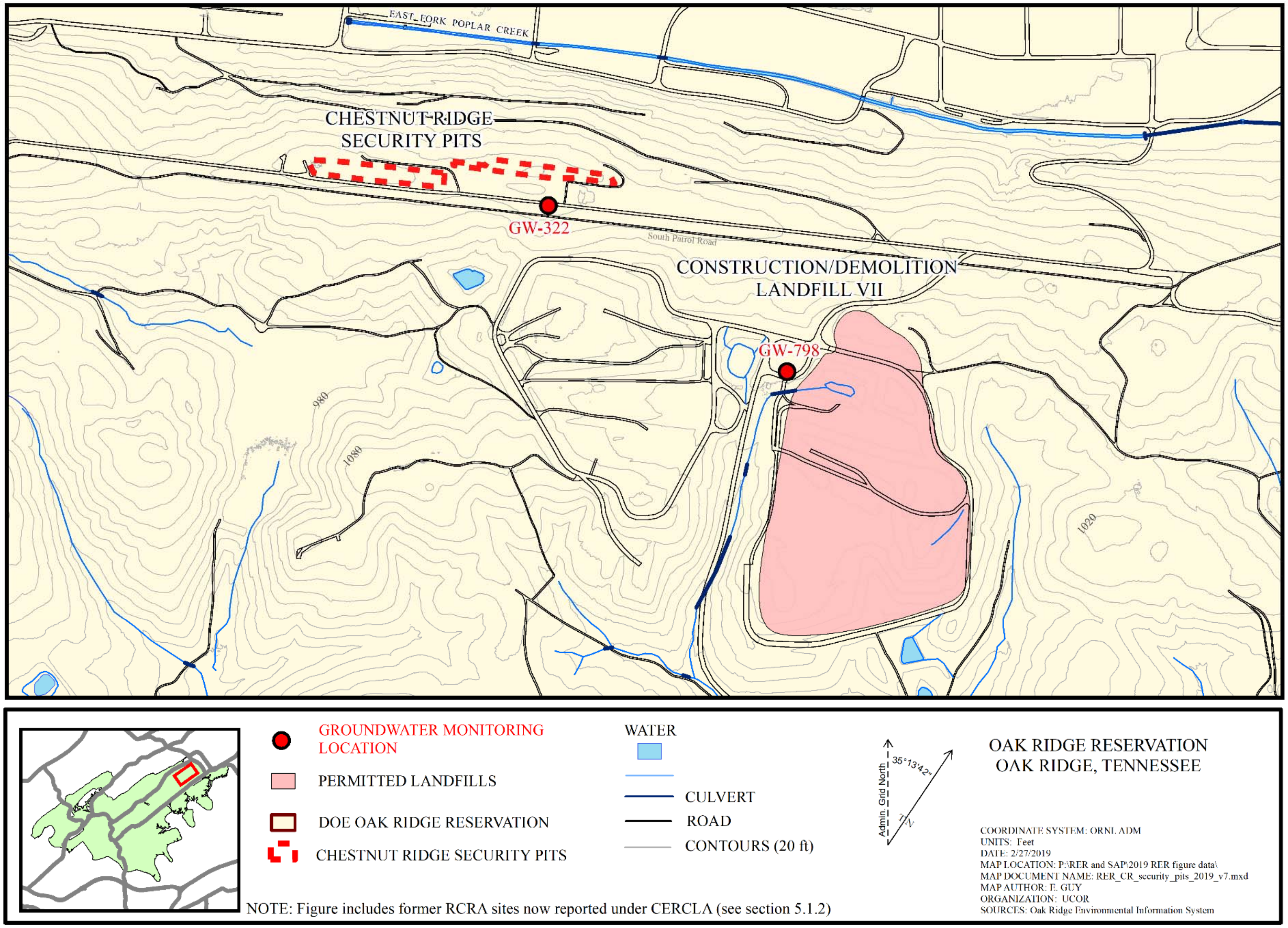

Figure 5.11. Location map of CRSP.

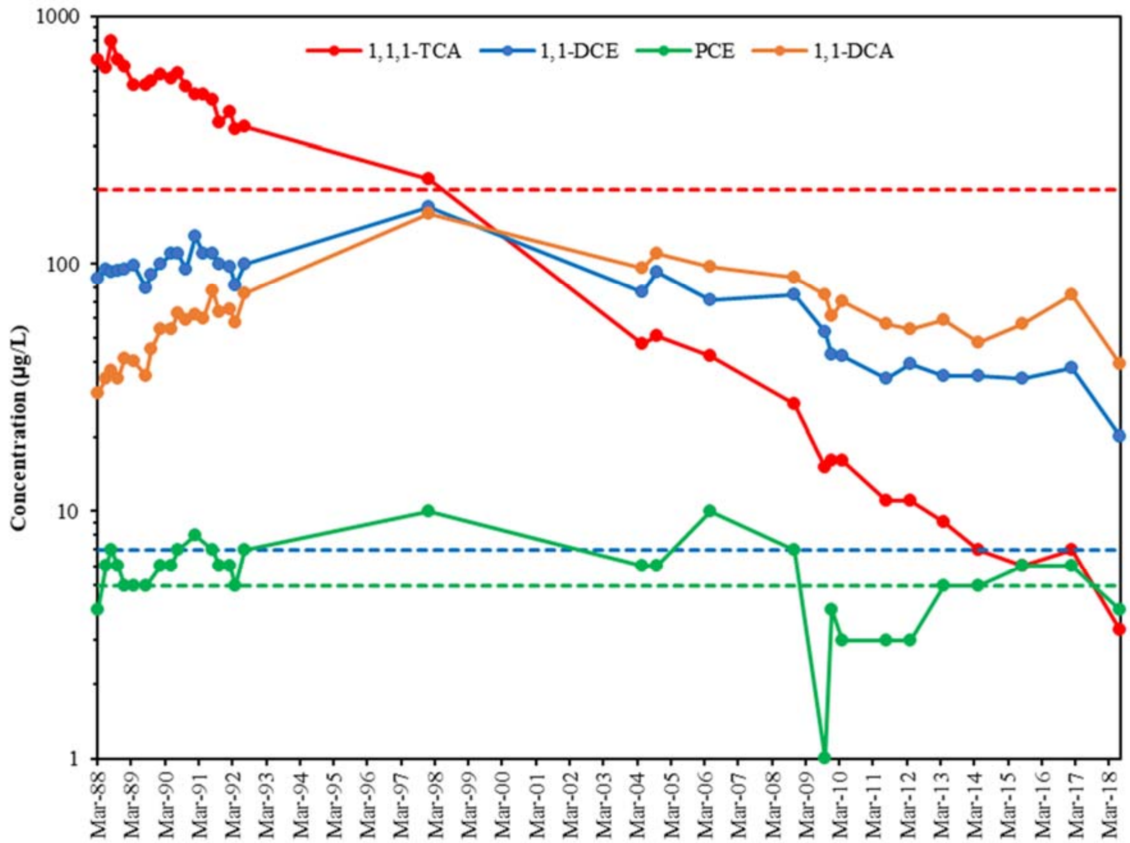

Figure 5.12. Concentration of 1,1,1-TCA, PCE, 1,1-DCE and 1,1-DCA in groundwater from well GW-322.

Well GW-798 is located at Construction/Demolition Landfill VII approximately 1500 ft directly east-southeast (downhill) of the CRSP (Figure 5.11), with static water levels in the well indicating groundwater elevations approximately 60 to 65 ft lower than evident at the CRSP. Concentrations of PCE slightly above and below the drinking water MCL (5 µg/L) were detected in the groundwater samples collected from the well in January and July 2018 (6.04 µg/L and 2.73 µg/L, respectively). MCL values are used for the water quality evaluation as a screening criteria and are not a specified goal. These PCE results continue a variable long-term concentration trend (Figure 5.13), which is dominated by temporal peak levels evident in January 2003 (11 µg/L), February 2009 (15 µg/L, the historical maximum concentration), and February 2012 (11.7 µg/L); however, concentrations have been decreasing in the last 10 years. The fluctuating to decreasing long-term trend concentration does not indicate any significant change (increasing or decreasing) in the flux of PCE from the groundwater contaminant plume associated with the CRSP.

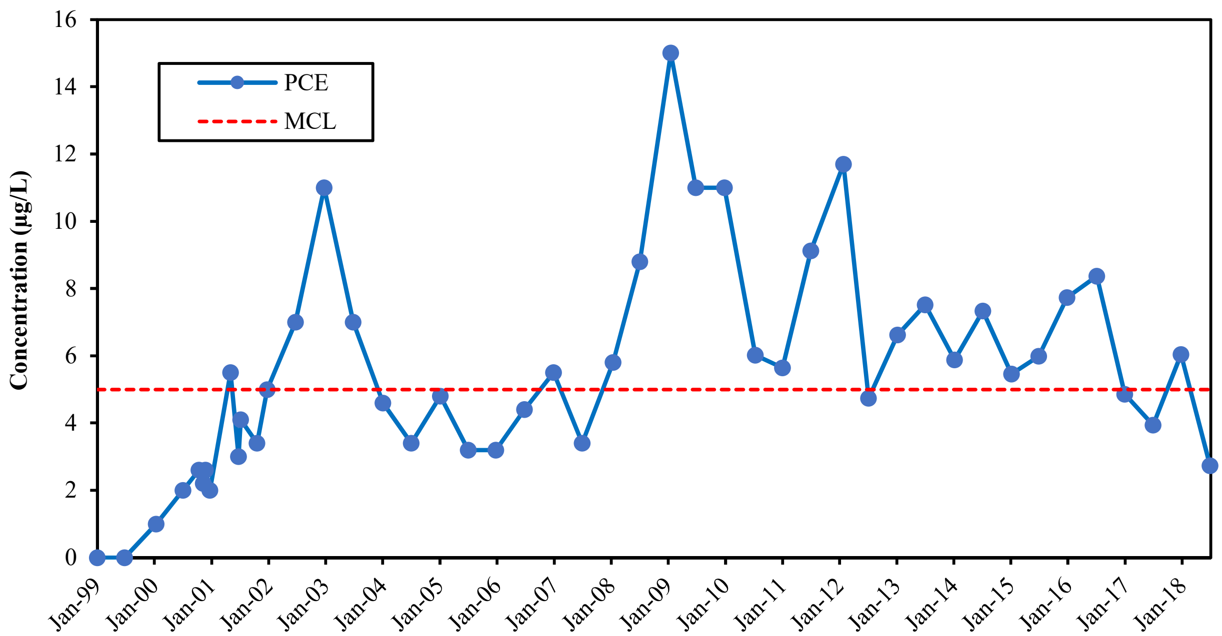

Figure 5.13. Concentrations of PCE in groundwater from well GW-798.

5.6.2 Remedy Integrity

CRSP remedy integrity components are listed in Table 5.4 and described below.

The EFPC/CR RAR CMP requires semiannual inspections of site controls including access controls, cap/cover/surface drainage, signage, and benchmarks. In addition, the cap must be inspected for erosion damage following any 25-yr/24-hr intensity rainfall event. Also, monitoring wells require an annual comprehensive inspection including evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate).

5.6.2.1 Status of remedy integrity

All components of the CRSP were inspected semiannually in FY 2018 by the Y-12 S&M Program, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. Routine mowing was conducted in FY 2018. Additionally, the CRSP site is located within the Y-12 property protection area and, as such, is not accessible to the public. The area is routinely patrolled by Y-12 security personnel. Maintenance of the remedy integrity in FY 2018 included updating signs with correct contact information.

5.7 ECRWP

5.7.1 Performance Monitoring

5.7.1.1 Performance monitoring goals and objectives

The TDEC-DSWM accepted the certification of RCRA final closure of the ECRWP (Figures 5.1 and 5.14) on January 5, 2006, and the site was included in the 2006 Chestnut Ridge PCP issued by the TDEC-DSWM later that year. When the substantive RCRA requirements for post-closure care of the ECRWP transitioned to CERCLA in February 2018, the site was in the 12th year of the RCRA 30-year post-closure care period specified in the 2006 Chestnut Ridge PCP, and continued implementation of the same or functionally equivalent inspection, maintenance, and monitoring will ensure continued protection of human health and the environment. Accordingly, groundwater monitoring requirements specified for the ECRWP in the EFPC/CR RAR CMP include the same well network (GW-161, GW-294, GW-296, and GW-298), semiannual groundwater sampling/analysis frequency, and laboratory analyses for the same suite of metals, VOCs, and gross alpha/gross beta. The EFPC/CR RAR CMP also specifies annual sampling/analysis of leachate from the ECRWP. The FY 2018 groundwater monitoring data and leachate sampling/analysis results are described in the following section. Groundwater sample locations are provided on Figure 5.14.

5.7.1.2 Evaluation of performance monitoring data

Semiannual groundwater monitoring at the ECRWP during FY 2018 was performed in January 2018 in accordance with the general and site-specific requirements of the 2006 Chestnut Ridge PCP and in July 2018 per the equivalent requirements transitioned to the CERCLA process and specified in the EFPC/CR RAR CMP. The associated field and laboratory data are summarized in Appendix E.

Respective FY 2018 groundwater sampling/analysis results for POC wells GW-161, GW-296, and GW-298 show detections of barium, chloride, and nitrate (as N) in each sample from all three wells. Iron and sulfate are also detected in the samples from POC well GW-161 (see data in Appendix E). With the exception of iron, each of these analytes was detected in the groundwater samples from upgradient/background well 7GW-294. Gross alpha and VOCs were not detected in the groundwater samples from any of the wells, but a low-level of gross beta activity (3.35 pCi/L) was reported for the sample collected from POC well GW-161 in July 2018.

Concentrations of the analytes detected in the groundwater samples from the POC wells are below respective background levels in uncontaminated groundwater at the ECRWP (the background values are included with the groundwater monitoring data in Appendix E). Based on these findings, the FY 2018 groundwater monitoring data for the POC wells do not indicate the release of contaminants potentially derived from wastes in the ECRWP.

A sample of the leachate from the above-ground storage tank at the ECRWP was collected during FY 2018 and analyzed for inorganic analytes, VOCs, gross alpha, and gross beta in accordance requirements specified in the EFPC/CR RAR CMP. Approximately half of the analytes reported from groundwater monitoring were detected in the leachate sample (see data summary in Appendix E). The highest concentrations of the detected inorganic analytes were reported for chloride (14 mg/L), sulfate (7.7 mg/L), and potassium (6.9 mg/L), and the highest concentrations of the detected VOCs were reported for 1,1-DCA (44 µg/L) and cis-1,2-DCE (27 µg/L). These analytical results are consistent with historical ECRWP leachate data and do not suggest any significant change in the chemical characteristics of the leachate.

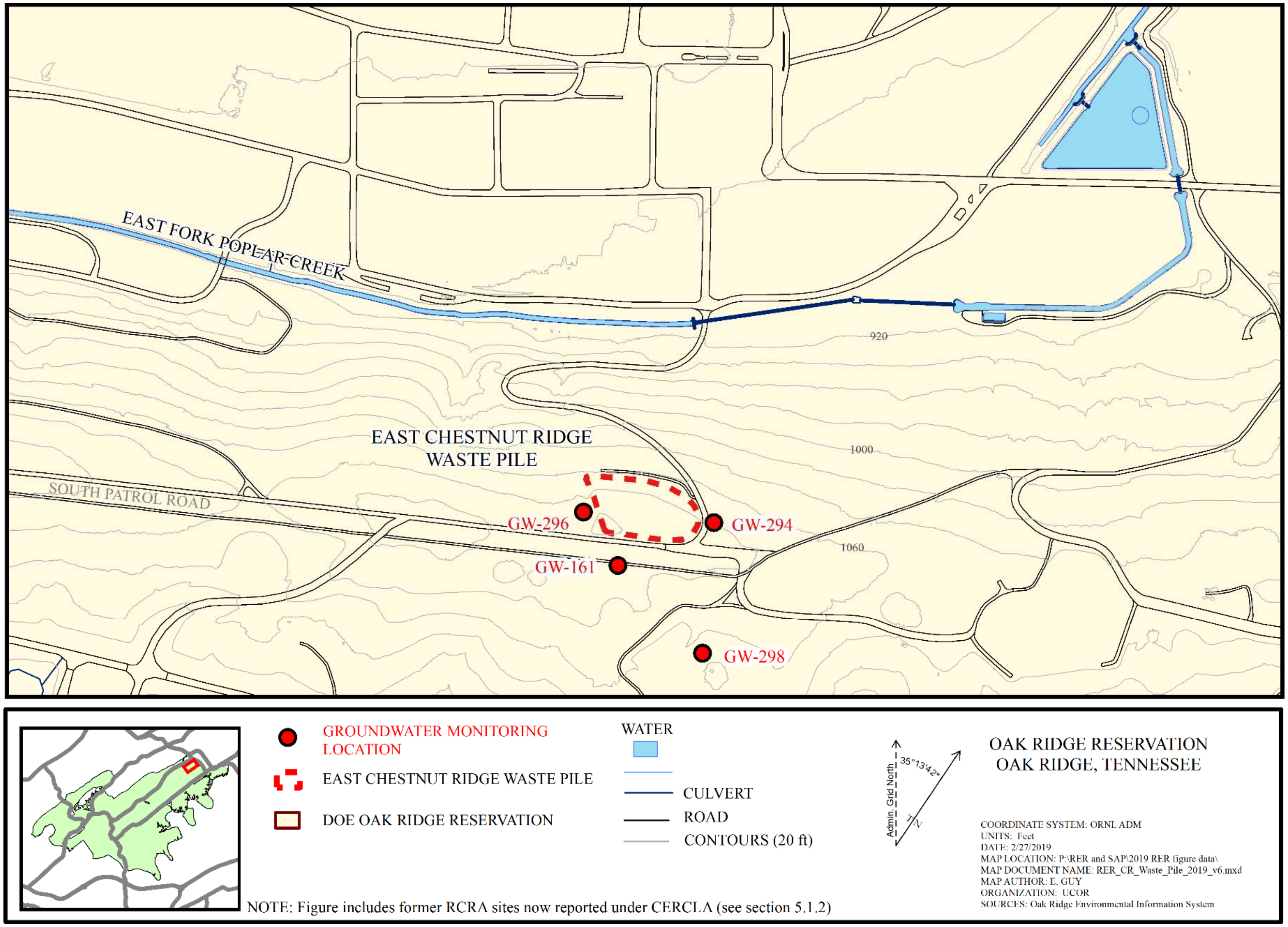

Figure 5.14. Location map of ECRWP.

5.7.2 Remedy Integrity

ECRWP remedy integrity components are listed in Table 5.4 and described below.

The EFPC/CR RAR CMP requires semiannual inspections of site controls including access controls, cap/cover/surface drainage, signage, and benchmarks. In addition, the cap must be inspected for erosion damage following any 25-yr/24-hr intensity rainfall event. Also, monitoring wells require an annual comprehensive inspection including evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate).

The ECRWP leachate collection system is inspected weekly for blockage, leaks, or overflow at the sump and for fluid in the concrete valve pit. The sump cover also is inspected for damage and proper placement. Sump volume is monitored weekly and the facility manager is notified when pumping is needed. Fluid flowing into the sump from the leachate collection pipe has been characterized as RCRA-listed F039 leachate. When liquid from the collection sump is transferred to poly-tanks, the portable tanks are stored in a CERCLA Waste Management Area. The leachate is treated at the Y-12 Groundwater Treatment Facility.

5.7.2.1 Status of remedy integrity

All components of the ECRWP were inspected semiannually in FY 2018 by the Y-12 S&M Program, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. Routine mowing was conducted in FY 2018. Additionally, the CRSPs site is located within the Y-12 property protection area and, as such, is not accessible to the public. The area is routinely patrolled by Y-12 security personnel. Maintenance of the remedy integrity in FY 2018 included updating signs with correct contact information. The leachate collection system was inspected every seven days and the Waste Management Area maintained.

5.8 CRSDB

The CRSDB was used between 1973 and 1987 for the disposal of contaminated soils and sediments removed from various areas within Y-12 (Figure 5.1 and Figure 5.15). Closure of the site was completed in 1989 and involved installation of a multi-layer, low-permeability cap (including associated cap drains and storm water drainage system) designed to achieve RCRA final closure performance standards required for hazardous waste landfills. The TDEC accepted the certification of RCRA final closure of the CRSDB on December 15, 1989, and RCRA post-closure care, monitoring, and reporting requirements for the CRSDB were included in the 1996 Chestnut Ridge PCP issued by the TDEC-DSWM. Most of the same general and site-specific RCRA post-closure maintenance, monitoring, and reporting requirements for the CRSDB were retained in the renewed 2006 Chestnut Ridge PCP, although the renewed PCP specified annual groundwater monitoring instead of the semiannual monitoring required under the expired PCP.

With the TDEC-DSWM decision to deny the permit renewal application for the 2006 Chestnut Ridge PCP in February 2018, the requirements related to post-closure site security and inspection/maintenance of the low-permeability cap at the CRSDB transitioned to the CERCLA process. While groundwater sampling/analysis results from RCRA interim status detection monitoring (1986 − 1995) and RCRA post-closure detection monitoring (1996 – 2016) demonstrate that the CRSDB has not been a source of groundwater contamination and is unlikely to ever become so, monitoring of GW-159, GW-731, GW-732, and GW156 will continue the year prior to the CERCLA FYR (Figure 5.15) and will be reported in the FYR.

5.8.1 Remedy Integrity

CRSDB remedy integrity components are listed in Table 5.4 and described below.

The EFPC/CR RAR CMP requires semiannual inspections of site controls including access controls, cap/cover/surface drainage, signage, and benchmarks. In addition, the cap must be inspected for erosion damage following any 25-yr/24-hr intensity rainfall event. Also, monitoring wells require an annual comprehensive inspection including evaluation of well integrity (e.g., condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate).

5.8.1.1 Status of remedy integrity

All components of the CRSDB were inspected semiannually in FY 2018 by the Y-12 S&M Program, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. Routine mowing was conducted in FY 2018. Additionally, the CRSDB site is located within the Y-12 property protection area and, as such, is not accessible to the public. The area is routinely patrolled by Y-12 security personnel. Maintenance of the remedy integrity in FY 2018 included updating signs with correct contact information.

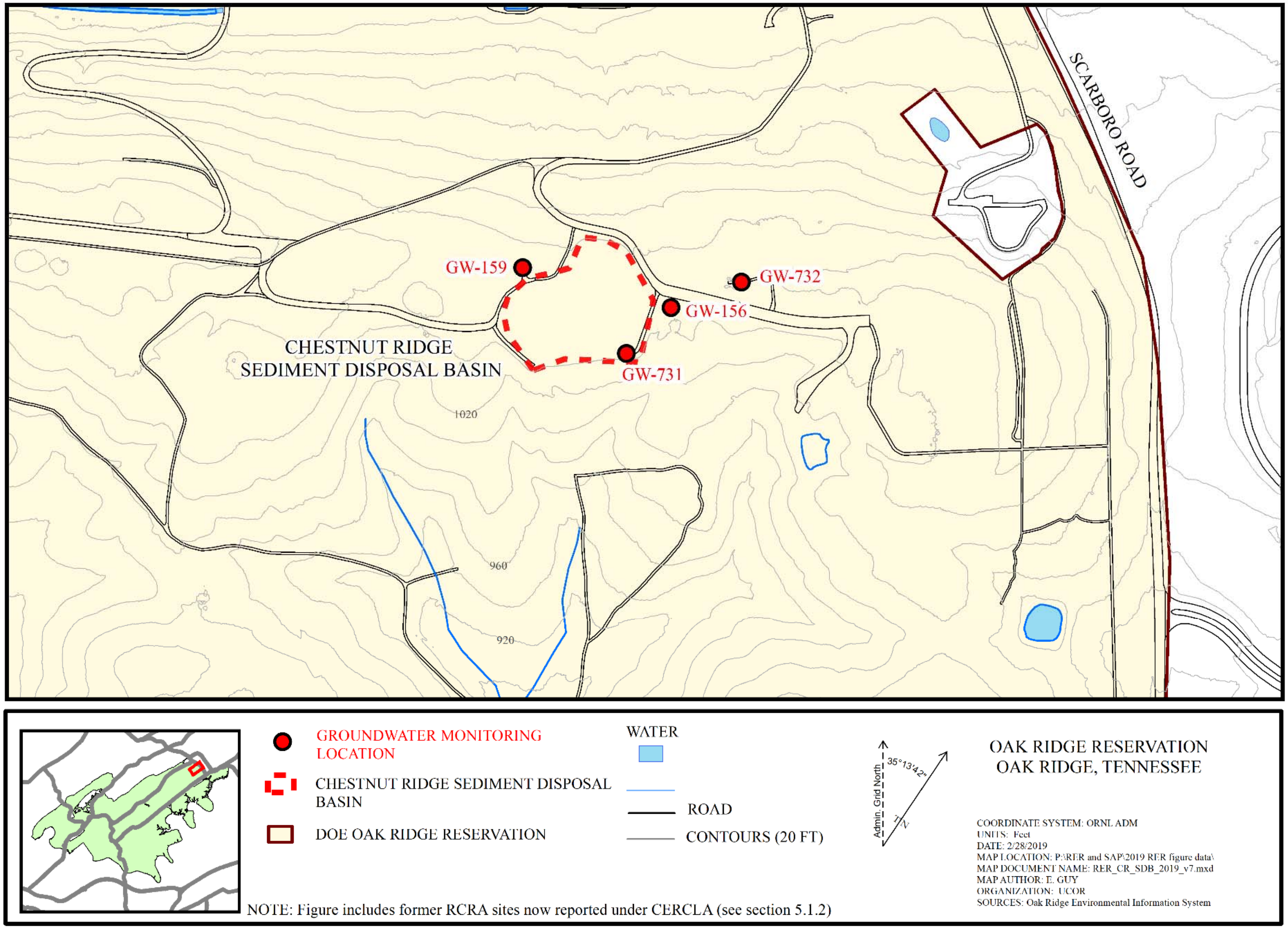

Figure 5.15. Location map of CRSDB.

5.9 CHESTNUT RIDGE ISSUES AND RECOMMENDATIONS

There are no RER issues and recommendations for Chestnut Ridge (Table 5.7).

The 2016 FYR identified the effectiveness of the passive wetland system as an issue at the FCAP and recommended that the wetland be re-examined to determine if improvements to the physical conditions are necessary to increase efficiency. Further investigation of the Rogers Quarry fish population and health was also recommended. These investigations (Appendix C.1) were completed in FY 2017 and FY 2018. This closes the 2016 FYR issues regarding the FCAP investigations (Table 1.4).

Table 5.7. Chestnut Ridge issues and recommendations

Issue[a]	Action/recommendations	Responsible parties	Target response date
		Primary/support	
New issue			
None			
Issue carried forward			
None			
Completed/resolved issues[b]			
None			

[a]A "New Issue" is an issue identified during evaluation of FY 2018 data for inclusion in the 2019 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution.
[b]The year in which the issue originated is provided in parentheses, e.g., (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report

5.10 REFERENCES

DOE 1991. *Record of Decision United Nuclear Corporation Disposal Site Declaration, Y-12 Plant, Oak Ridge, Tennessee*, U.S. Department of Energy, Oak Ridge Field Office, Oak Ridge, TN.

DOE/OR/01-1128&D1. *Post-Construction Report for the United Nuclear Corporation Disposal Site at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1993, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1596&D1. *Remedial Action Report on Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2466&D4. *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee,* 2018, U.S. Department of energy, Office of Environmental Management, Oak Ridge, TN

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1398&D2. *Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/02-1410&D3. *Record of Decision for Chestnut Ridge Operable Unit 2 (Filled Coal Ash Pond and Vicinity), Oak Ridge, Tennessee*, 1996, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

EPA 2016. *Aquatic Life ambient Water Quality Criterion for Selenium – Freshwater 2016*, EPA 822-R-16-006, U.S. Environmental Protection Agency, Washington, D.C.

ES/ER-15&D1. *Feasibility Study for the United Nuclear Corporation Disposal Site at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* 1991, Y/ER/Sub-90/VK168/3&D1, U.S. Department of Energy, Environmental Restoration Division, Oak Ridge, TN.

TNHW-088. *Post-Closure Permit for the Chestnut Ridge Hydrogeologic Regime*, *Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* EPA I.D. No. TN 3 89 009 0001, June 1996, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

TNHW-128. *RCRA Post-Closure Permit for Chestnut Ridge Hydrogeologic Regime, Y-12 National Security Complex, Oak Ridge, Tennessee*, EPA I.D. No. TN3 89 009 0001, September 2006, Tennessee Department of Environment and Conservation-Division of Solid Waste Management, Nashville, TN.

6. Y-12 – UEFPC

6.1 INTRODUCTION AND STATUS

6.1.1 Introduction

The UEFPC watershed, located in the eastern portion of the ORR, is the site of the main plant area of Y-12. Figure 6.1 shows the locations of CERCLA actions in UEFPC that have required monitoring or LUCs and illustrates ROD-designated end uses. In subsequent sections, the effectiveness of each completed action is assessed by reviewing performance monitoring objectives and results and verifying LUCs.

Completed CERCLA actions in the UEFPC watershed are gauged against their respective action-specific goals. However, because all planned CERCLA actions have not been completed, monitoring of baseline conditions is conducted against which the effectiveness of the actions can be evaluated in the future. The collected data provides a preliminary evaluation of the early indicators of effectiveness at the watershed-scale.

Table H.5 in Appendix H lists all completed CERCLA actions in UEFPC and the corresponding completion documents, and identifies whether monitoring or LUCs are required. Figure H.5 in Appendix H is a location map of the actions and illustrates ROD-designated end uses in UEFPC. For a complete description of background information and performance metrics for each remedy, a compendium of all CERCLA decisions in the watershed within the context of a contaminant release conceptual model is provided in Chapter 7 of Volume 1 of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

6.1.2 Status Update

New Hope Pond and Eastern S-3 Groundwater Plume. In May of 2017, DOE requested from TDEC-DSWM that the re-application of the *RCRA Post-Closure Permit for the Upper East Fork Poplar Creek Hydrogeologic Regime* (UEFPC PCP; TNHW-113) be denied and the applicable substantive requirements for post-closure care, monitoring, and reporting for the relevant units be integrated into the CERCLA process. The relevant units associated with the UEFPC Hydrogeologic Regime include: 1) New Hope Pond and 2) the Eastern S-3 Groundwater Plume. The TDEC-DSWM granted the request on February 23, 2018. Substantive requirements for post-closure care and monitoring are managed in the *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (EFPC/CR RAR CMP; DOE/OR/01-2466&D4). Reporting of post-closure care and monitoring are integrated into this 2019 RER and will be captured in the CERCLA FYR, as appropriate.

<u>Watershed-scale actions</u>

Outfall 200 Water Treatment Facility. A new water treatment facility is being constructed to reduce the mercury concentration in water exiting the Y-12 site at Station 17. The contract to build this treatment facility was awarded in November 2018. Outfall 200 is the point at which the west end Y-12 storm drain system discharges to UEFPC (Figure 6.2). Mercury from historical operations at Y-12 is present in the Outfall 200 storm water and to a lesser amount in other storm drains east of Outfall 200 entering EFPC. In FY 2018, a *Remedial Design Report/Remedial Action Work Plan for Water Treatment at Outfall 200 in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (RDR/RAWP;

DOE/OR/01-2735&D2) for the facility was finalized and early site preparation including the construction of the necessary utilities and the demolition of existing structures was started. The scope of the RA includes the construction and operation of the facility with a treatment capacity for 3000 gpm of influent surface water. The facility will also store up to 2 million gal of additional storm water collected during higher storm flow conditions. The goal of the treatment operation is to reduce mercury concentrations in the treated effluent to 51 ng/L, which will be discharged back into UEFPC. The *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (UEFPC Phase I ROD; DOE/OR/01-1951&D3) goal for mercury in surface water at Station 17 is 200 ng/L.

Refer to Appendix G for an update on building D&D activities at Y-12.

6.2 ASSESSMENT SUMMARY

A summary of the UEFPC assessment for FY 2018 is provided below, followed by more detailed evaluations.

6.2.1 Performance Summary

6.2.1.1 UEFPC Phase I ROD

The CERCLA actions completed to date in UEFPC include the Big Springs Water Treatment System (BSWTS) and West End Mercury Area (WEMA) storm drain projects under the UEFPC Phase I ROD. Implementation of additional actions under the UEFPC Phase I ROD and the *Strategic Plan for Mercury Remediation at the Y-12 National Security Complex, Oak Ridge, Tennessee* (DOE/OR/01-2605&D2), is planned, including a new Outfall 200 Water Treatment Facility to reduce the mercury concentration in water exiting the Y-12 site.

- The mercury discharge measured at Station 17 (the surface water IP for the UEFPC watershed) was approximately 12.4 kg for FY 2018. The average total mercury concentration at Station 17 was 1,858 ng/L compared to the UEFPC Phase I ROD goal of 200 ng/L. The FY 2018 results show an increase compared to FY 2017 that is attributed to mercury discharges in the Outfall 163 storm drain network related to D&D activities at the COLEX facility.
- The FY 2018 mercury discharge measured at Outfall 200A6 was approximately 10.2 kg, with an average total mercury concentration of 5,378 ng/L. Outfall 200A6 serves as an IP for contamination leaving the WEMA. At Outfall 200A6, approximately 76% of the mercury was dissolved (largely because chlorinated water discharges into the upstream storm drains facilitate dissolution and transport of mercury), while at Station 17, only approximately 9% of the mercury was dissolved. Downstream of storm drain dechlorinators, dissolved mercury is subject to sorption on stream sediment and materials in the channel. Stormflow suspension and transport of contaminated sediment account for much of the mercury flux measured at Station 17.
- BSWTS operated throughout FY 2018 with a mercury removal effectiveness of approximately 99%. All of the FY 2018 weekly composite samples of BSWTS effluent had mercury concentrations less than the performance standard of 200 ppt (200 ng/L). The average mercury concentration in effluent from the Central Mercury Treatment System (CMTS) met the NPDES Permit discharge limit of 2 µg/L.

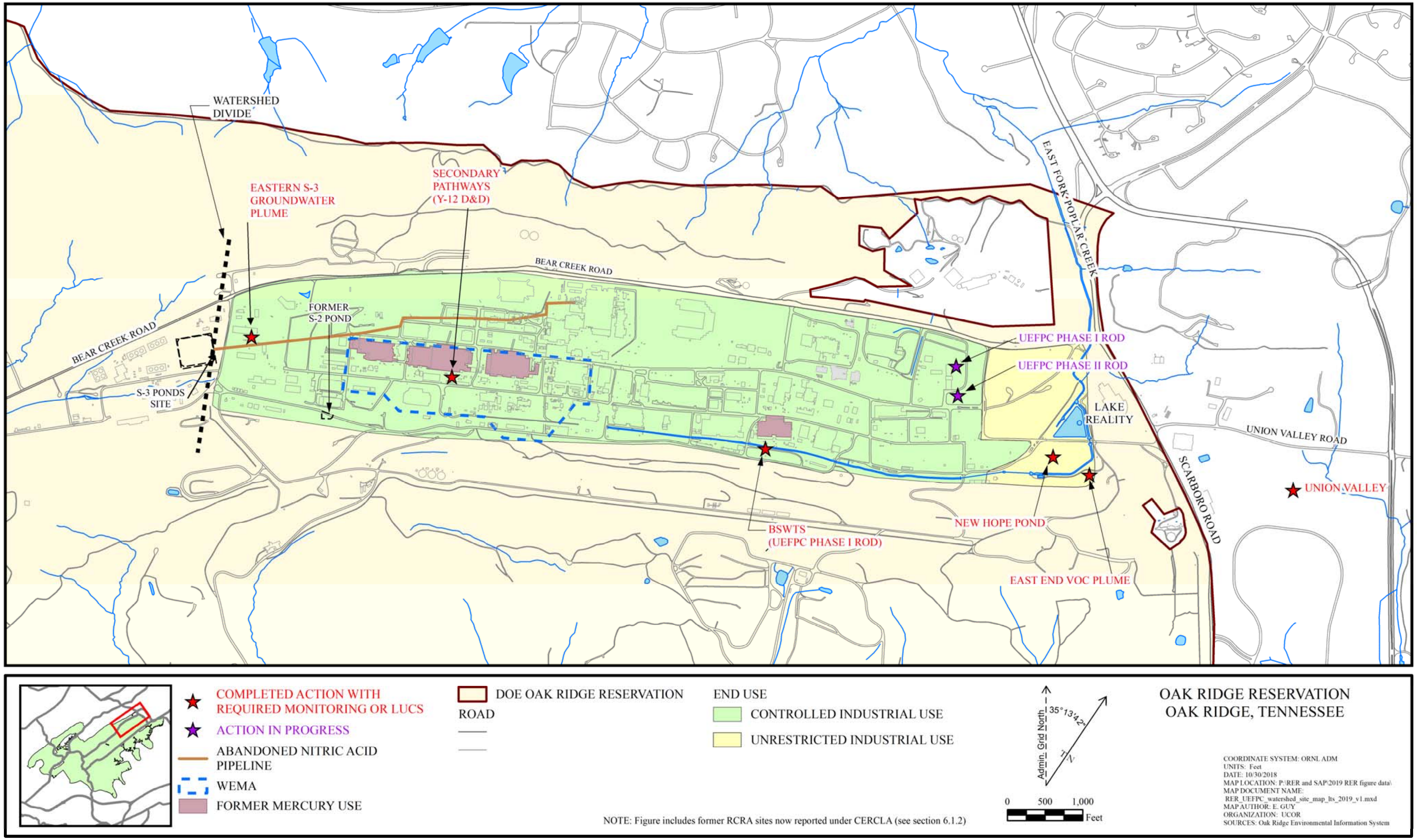

Figure 6.1. Completed CERCLA actions with required monitoring or LUCs in UEFPC and end uses in UEFPC.

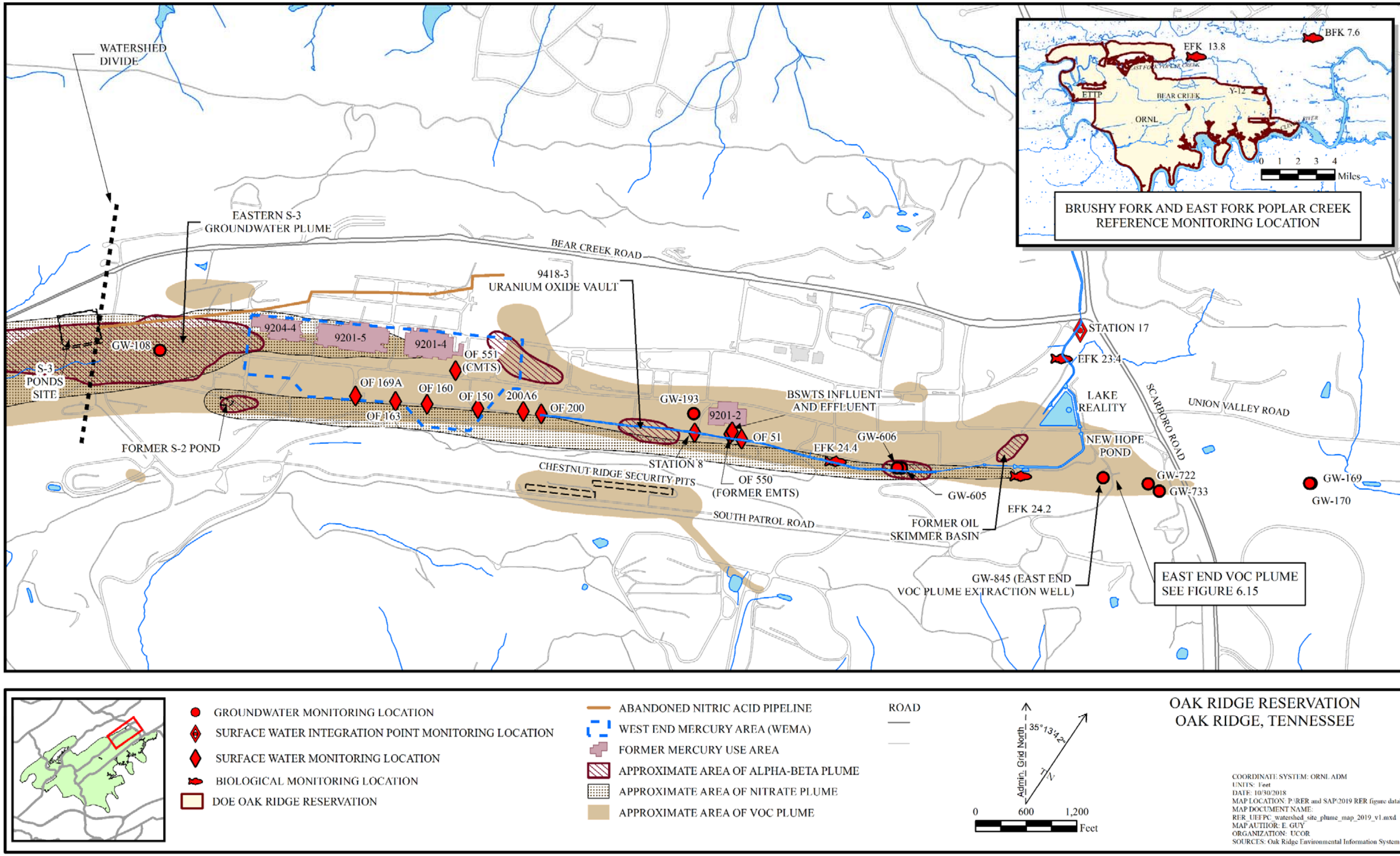

Figure 6.2. Monitoring locations in UEFPC and associated reference locations.

- The CMTS met its NPDES discharge limit requirements in all FY 2018 samples.
- The performance standard for uranium at Station 17 is to monitor the trend. The uranium flux measured at Station 17 during FY 2018 (134 kg) decreased somewhat in comparison to FY 2016 and FY 2017 levels (141 and 147 kg), respectively.
- Groundwater monitoring in the Eastern S-3 Groundwater Plume shows that nitrate and Tc-99 concentrations are gradually decreasing near the source area as indicated by data from well GW-108. Tc-99 has not migrated as far east as well GW-193. The numerous groundwater contaminant sources in UEFPC contribute to a complex groundwater contaminant plume.
- Aquatic biological monitoring shows that mercury concentrations in rock bass at Station 17 over the 2017 – 2018 time period were lower than they have been in recent years but remain approximately two to three times higher than screening levels from EPA's fish-based criteria. Mercury concentrations in fish at the uppermost site in EFPC remain higher than prior to the storm drain cleanout. Overall, mercury and PCBs concentrations in fish remain well above reference stream values.
- Fish and invertebrate communities are much improved over the last 20 years in the lower part of the creek (Peterson et al., 2011), but stream communities remain impacted at upstream sites. Notable since flow augmentation ended is that there have been declines in fish abundance in the upstream part of the creek, despite similar numbers of species over the years (Peterson, personal communication). This is not unexpected given the lower water volumes in the creek after the end of flow augmentation in the spring of 2014. A fish kill was observed in UEFPC in July and August of 2018, failed toxicity tests were provided to TDEC as part of Y-12 NPDES Permit requirements. An NPDES-required Toxicity Identification Evaluation/Toxicity Reduction Evaluation (TIE/TRE) was initiated, with studies conducted in the field and laboratory through fall-winter of 2018 – 2019 to identify the causes of toxicity. Results of these studies will be provided in Y-12 FY 2019 TIE/TRE reporting and in future RERs.

6.2.1.2 EEVOC Plume

The EEVOC air stripper demonstrated a high effectiveness for VOC removal during FY 2018. Only short term shutdowns occurred for maintenance of system components or electrical power outages. The offsite groundwater VOC concentrations continued to show that offsite migration of the plume is largely contained by the EEVOC system.

6.2.2 LUC Protectiveness

All LUCs determined necessary for protection of the environment and/or human health are in place and have been maintained.

6.3 PHASE I INTERIM SOURCE CONTROL ACTIONS IN THE UEFPC CHARACTERIZATION AREA

Remediation of the environmental contamination in the UEFPC watershed is being conducted in stages using a phased approach. The UEFPC Phase I ROD addresses principal threat source material control remedies designed to reduce mercury loading within UEFPC. The RAO for the selected remedy is to restore surface water to human health recreational risk-based values at Station 17. Principal components of the decision include[1]:

- removal of contaminated sediments in storm sewers, UEFPC, and Lake Reality;
- treatment of discharge from Outfall 51 (including a large-volume spring) and Building 9201-2 sumps;
- temporary water treatment using existing facilities East End Mercury Treatment System and the CMTS;
- LUCs to prevent consumption of fish from UEFPC and to control/monitor access by workers and the public; and
- monitoring of surface water (Station 17).

Over the past several years, DOE has identified the need for changes to some of the actions selected in the UEFPC Phase I ROD. An Explanation of Significant Differences [ESD] for the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-2539&D2) was approved in August 2012. The ESD made changes that were designed to be consistent with the remediation strategy to conduct RAs in the watershed generally in an upgradient to downgradient sequence to reduce the potential for recontamination, a sequence consistent with the approach outlined in the UEFPC Phase II ROD (DOE/OR/01-2229&D3). These changes included elimination of the asphalt capping of unpaved areas (see footnote 1) because of the accelerated pace of demolition of buildings in the WEMA, revision of the schedule for removal of contaminated sediments and soils from UEFPC and Lake Reality, and elimination of the planned treatability study to evaluate the technical feasibility of using horizontal groundwater capture as part of hydraulic isolation in WEMA, as well as the elimination of the treatability study of the Building 81-10 soils.

The BSWTS was constructed to treat discharge from Outfall 51 (including the large-volume spring) and to treat water from the Building 9201-2 sumps. Mercury contaminated water was rerouted from Building 9201-2 sumps and the East End Mercury Treatment System to the BSWTS in December 2006. The East End Mercury Treatment System and Outfall 550 are no longer in operation.

An *Amendment to the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee – Water Treatment at Outfall 200* (DOE/OR/01-2697&D2) was approved in May 2016. This modification to the selected remedy includes the construction and operation of a new water treatment facility to further reduce mercury concentrations in the discharges adjacent to the former mercury-use buildings in the WEMA. The IP for the WEMA storm sewer network is Outfall 200. Surface water quality metrics utilized to evaluate progress toward attainment of the Phase I Interim RAO include 200 ppt (200 ng/L) performance metric for mercury in surface water at Station 17. Construction of the water treatment system began in 2018.

In May of 2017, DOE requested from TDEC DSWM that the re-applications of the UEFPC PCP be denied and the applicable substantive requirements for post-closure care, monitoring, and reporting for the relevant units be integrated into the CERCLA process. TDEC-DSWM granted the request in February 2018. The post-closure monitoring requirements for the Eastern S-3 Groundwater Plume (Table 6.1) have been integrated into the EFPC/CR RAR CMP and results are reported in the annual RER.

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[1]Capping of contaminated soils in the West End Mercury Area (WEMA) was never implemented. An *Explanation of Significant Differences for the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-2539&D2) was approved in August 2012 to remove the action from the selected remedy in the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-1951&D3).

6.3.1 Performance Monitoring

6.3.1.1 Performance monitoring goals and objectives

Performance measures and monitoring requirements for watershed-scale and single-project actions in UEFPC are summarized in Table 6.1, and monitoring locations are shown in Figure 6.2.

6.3.1.2 Evaluation of performance monitoring data

6.3.1.2.1 Surface water

6.3.1.2.1.1 Surface water quality goals and monitoring requirements

The UEFPC Phase I ROD includes a 200 ppt performance metric for mercury in surface water at the UEFPC IP (Station 17) based on an adult recreator consuming only fish. Surface water monitoring at Station 17, including analysis for uranium and zinc, is conducted to gauge the cumulative effects of the various upstream actions as they are completed. In addition, biological monitoring is performed to assess reductions of mercury in fish tissue at EFPC kilometer (EFK) 23.4. To achieve the watershed-wide mercury reduction objectives, individual components of the Phase I remedy have action-specific performance standards. The BSWTS effluent must meet the 200 ppt (0.2 µg/L) interim performance goal for mercury. The effluent from CMTS, constructed with older technology, must meet an NPDES Permit discharge limit at Outfall 551 of 2 µg/L (2000 ppt), although the Phase I ROD still requires a 200 ppt at Station 17.

In November 2011, the TDEC issued a new NPDES Permit applicable to the Y-12 site. In that permit the state of Tennessee included a target average mercury concentration of 87.5 ng/L and a median annual daily mercury load of 2.42 g/d in water at Station 17 that was expected to allow mercury in fish tissue to decrease to the EPA-recommended AWQC (0.3 µg/g mercury in fish). This target mercury concentration in surface water at Station 17 is significantly less than the 200 ppt goal set in the approved UEFPC Phase I ROD. The 2011 Permit also included requirements for the DOE to perform several activities that were deemed appropriate to reduce the site mercury discharges to the permit-specified level. Some of the activities required by the permit were consistent with modification of actions required in previous permits (e.g., modification of location and amount of supplemental flows to the creek), while others were enforcement of CERCLA actions to address mercury reduction. In November 2011, the DOE filed an appeal to remove the performance of CERCLA actions from the permit, most of which were already subject to implementation by DOE OREM under the *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014). In 2014, the NPDES Permit was modified to remove the required mercury monitoring at Station 17. The Y-12 NPDES Permit expired in November 2016; a permit re-application was prepared and submitted in May 2016. The new permit was issued for public comment in November 2017 and a public hearing was held in February 2018; however, the final permit has not yet been issued. The draft permit establishes requirements necessary for DOE to attain compliance with Tennessee water quality criteria through a combined effort of CERCLA (administered by DOE OREM) and the Clean Water Act of 1972 (CWA) actions (administered by the NNSA).

Table 6.1. Performance measures for UEFPC watershed

Site	ROD goal	Performance standard	Monitoring location	Schedule and parameters
Watershed-scale actions (Section 6.3)				
Station 17	Reduce mercury levels to a level protective of a recreational receptor based on fish consumption.	0.2 μg/L (200 ppt) total mercury Specific numeric standards not defined for uranium or zinc monitoring; Performance determined from trend evaluation.	Station 17	Continuous flow-paced monitoring for mercury and uranium (weekly collection); weekly grab sample for zinc.
Building 9201-2 Water Treatment System (BSWTS)	Reduce mercury levels to a level protective of a recreational receptor based on fish consumption.	200 ppt mercury	Water Treatment System effluent discharge point	Quarterly grab samples for VOCs and semiannual monitoring for mercury and uranium.
CMTS	Ongoing treatment of effluents from WEMA pending demonstration of effectiveness of remedy (hydraulic controls, capping).	200 ppt mercury at Station 17[a]	Outfall 551[a]	Continuous flow-paced monitoring for mercury (minimum weekly collection frequency); continue current system performance monitoring as required by operations and maintenance specifications.
East End Mercury Treatment System no longer operational	Treatment of effluents from Building 9201-2 sumps was tied-in to BSWTS December 2006.	200 ppt mercury	Outfall 550 flow piped to the BSWTS in December 2006	Discontinued
WEMA	Protect recreational surface water users.	Reduction by approximately 50% of mercury flux in WEMA outfalls. Reduction will be monitored in outfalls and is anticipated within one year of remediation.[b]	Outfalls 150, 160, 163, and 169A	Continuous flow-paced monitoring for mercury (minimum weekly collection frequency) prior to remediation.
UEFPC and Lake Reality	Protect recreational surface water users.	Reduction of 70% of Station 8 area ungauged mercury flux and up to 100% of ungauged mercury flux between Stations 8 and 17. Reduction will be monitored at Station 8 and Station 17 and is anticipated within one year of remediation.	Station 8 and Station 17	Grab samples at Station 8 weekly. Weekly monitoring at Station 17 for mercury.
Eastern S-3 Ponds Plume	Monitor exit pathway to determine extent of S-3 Ponds plume	No specific numeric performance standard established. Trend Tc-99 as the signature contaminant of source.	GW-193 GW-733 GW-605 GW-606	Annual grab sample for Tc-99.
	Monitor downgradient eastern point-of-compliance well of former S-3 Ponds Site	No specific numeric performance standard established. Trend contaminant concentrations.	GW-108	Annual grab sample obtained in the year before the FYR, alternating between wet (Q2)/dry (Q4) seasons each sampling event.

Table 6.1. Performance measures for UEFPC watershed (cont.)

Site	ROD goal	Performance standard	Monitoring location	Schedule and parameters
Single – Project actions (Section 6.5)				
EEVOC Plume	Reduce risk from exposure in offsite areas and mitigate offsite migration of contamination.	No specific numeric performance standards established. System performance: trend VOC concentrations downgradient of extraction well. Treatment system discharge at downstream POC (LRBP-1) must not exceed AWQC recreational (for organism only) 16 µg/L carbon tetrachloride.	Treatment system influent and effluent and LRBP-1 GW-722, GW-169 and GW-170	Quarterly grab samples of system influent/effluent for metals, VOCs, nitrate, and uranium. Quarterly grab samples at LRBP-1 for VOCs. Semiannual grab samples of downgradient wells for VOCs.

[a]The NPDES Permit discharge limit at Outfall 551 (CMTS) for mercury is a monthly average of 2,000 ppt (2 µg/L), and daily maximum of 4,000 ppt (4 µg/L).

[b]Baseline monitoring re-instated FY 2010.

AWQC = ambient water quality criteria
BSWTS = Big Spring Water Treatment System
CMTS = Central Mercury Treatment System
EEVOC = East End Volatile Organic Compound
FY = fiscal year
FYR = Five-Year Review
GW = groundwater well
LRBP = Lake Reality By-Pass
NPDES = National Pollutant Discharge Elimination System
POC = point-of-compliance
Q2 = quarter 2
Q4 = quarter 4
ROD = Record of Decision
UEFPC = Upper East Fork Poplar Creek
VOCs = volatile organic compound
WEMA = West End Mercury Area

6.3.1.2.1.2 Surface water monitoring results

Mercury treatment and capture systems performance

DOE operates two mercury wastewater treatment systems in the UEFPC watershed (CMTS or Outfall 551) and BSWTS. Locations of these systems are shown on Figure 6.2.

Continued monitoring of effluent from the CMTS, which treats building sump discharges from the WEMA, is specified in the UEFPC Phase I ROD pending demonstration of the effectiveness of actions.

The UEFPC Phase I ROD states that the CMTS, "Meet NPDES requirement of 200 ppt mercury at Station 17" which represents the ROD intent that the treatment system effluent be controlled as one component of the multiple actions required to attain the water quality goal at Station 17. Additionally, there are NPDES permit limits of 2,000 ppt monthly average and 4,000 ppt daily maximum mercury concentrations. Effluent samples were collected from weekly 24-hr composites at Outfall 551 and analyzed for mercury. In 2018, all of the weekly sample results from the CMTS effluent were less than the 2 µg/L (2,000 ng/L or 2,000 ppt) NPDES Permit limit for total mercury. Because of a 2005 accidental introduction of methanol from a leaking Alpha 5 cooling (brine) system that interfered with mercury treatment, a *Non-Significant Change to the Record of Decision for Phase 1 Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-1951&D3/R2) was approved in May 2007 so that the CMTS no longer receives water from sump pumps located in the basement of Building 9201-5. The CMTS continues treatment of Building 9201-4 sump water (a much larger source of mercury).

Extensive mercury contamination exists in the WEMA as a result of historic process leaks and spills. Some of the mercury remains in the soil as elemental mercury metal. Movement of elemental mercury in the soil can occur as a result of pore pressure changes related to groundwater level fluctuations and rainfall percolation processes. As the mercury moves downward and laterally, it seeps into the subsurface storm drains through cracks and open joints. Once in the storm drains, the mercury accumulates in low points and moves with the storm water current.

The UEFPC Phase 1 ROD states that approximately 25% of the mercury discharged from the site via the UEFPC originated from Outfall 51. The ROD further stipulated construction of a mercury water treatment system with a 300 gpm capacity and an effluent mercury concentration limit of 200 ppt. The main source of flow at Outfall 51 was Big Spring, located near the southeast corner of Building 9201-2. Mercury contamination within shallow groundwater beneath and adjacent to Building 9201-2 discharges at this spring. The source area extent that feeds Big Spring is not well understood and much of the flow and contamination is thought to originate from source areas to the west in the WEMA. At the time of Building 9201-2 construction in 1943, the spring discharge was captured within a brick enclosure (spring box) and directed to UEFPC via a drainpipe. In the latter part of FY 2005, Big Spring flow was routed to the new BSWTS during test and start-up operations. As a result, the flow at Outfall 51 decreased significantly. While it was anticipated that construction and operation of BSWTS would cut off flow to Outfall 51, during BSWTS construction it was discovered that, in addition to flow from the spring box, Outfall 51 also provides a minimal pathway for drainage of the BSWTS area shallow subsurface flow.

The UEFPC Phase 1 ROD specifies a 0.2 µg/L (200 ppt) goal for mercury in BSWTS effluent. Outfall 51 and BSWTS effluent are separate monitoring locations. The BSWTS influent is grab sampled on a monthly frequency inside the treatment facility upstream of any treatment processes. BSWTS effluent is sampled using a continuous, flow-paced autosampler to obtain representative samples of the total effluent on a seven-day integration basis. At Outfall 51, flow rate is monitored continuously and, under baseflow conditions, grab samples are collected monthly from the end of pipe. During prolonged rainy periods, often observed in winter when the Outfall 51 flow rate is greater than 60 gpm, grab samples are collected on a weekly frequency from end of pipe to provide more data for mercury mass discharge from this area.

Figure 6.3 provides a comparison of mercury concentrations at Outfall 51 and the BSWTS effluent. During FY 2018, the average BSWTS influent concentration was about 2.7 µg/L. In FY 2018, the BSWTS treated more than 101 million gal of contaminated water. Since July 2008, the BSWTS effluent is sampled continuously and weekly composite samples are analyzed for total mercury. The average mercury concentration in BSWTS effluent during FY 2018 was 0.033 µg/L, which is nearly an order of magnitude less than the 0.2 µg/L goal specified in the UEFPC Phase I ROD. None of the weekly composite samples collected during FY 2018 exceeded the 0.2 µg/L effluent goal. The FY 2018 total mercury flux discharged in the treated BSWTS effluent was approximately 12.4 g. Based on comparison of the average influent and effluent mercury concentrations for FY 2018, the treatment effectiveness was 99%. The granular activated carbon treatment media in the BSWTS is typically changed annually during autumn. The effluent mercury concentration decreases following media change out and gradually increases through the operating year prior to the subsequent change out.

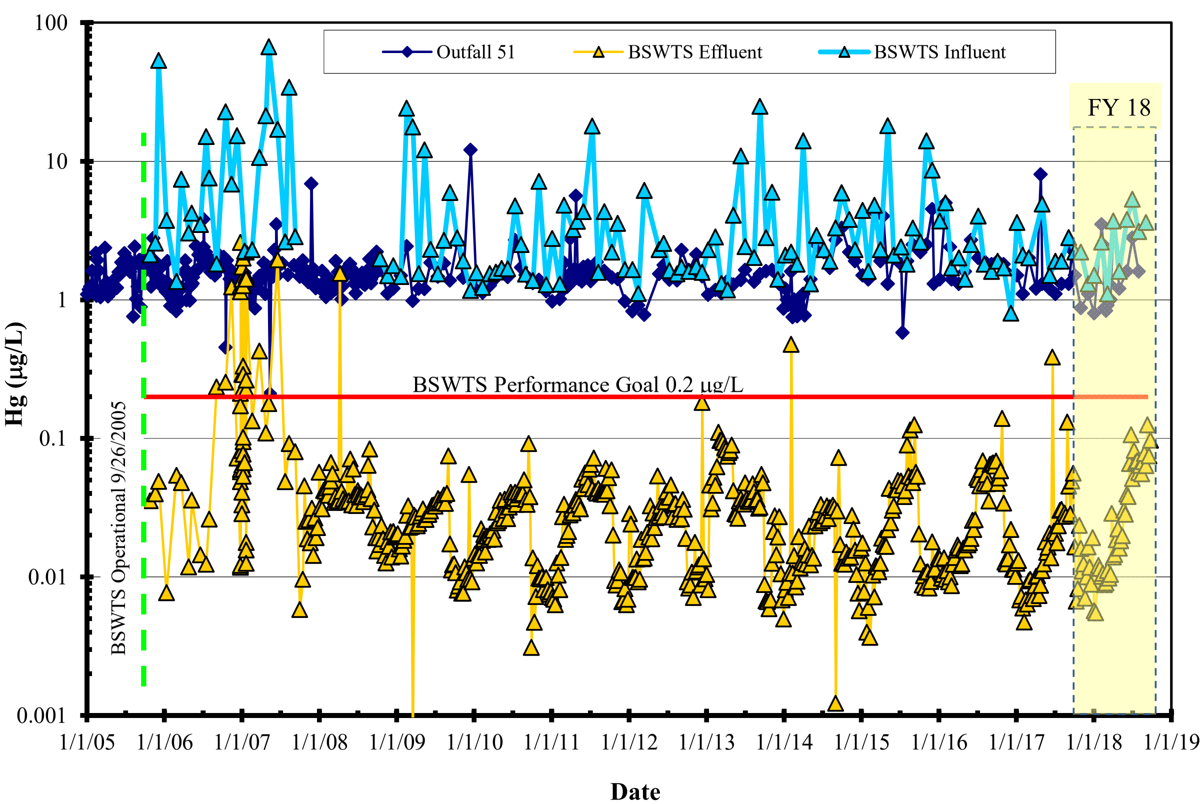


Figure 6.3. Mercury concentrations at Outfall 51 and BSWTS.

Since the BSWTS was designed to operate at a maximum capacity of 300 gpm, there are times during prolonged rainy periods when the system receives more inflow volume than can be treated. At those times there is treatment system bypass flow. Although such conditions can occur in any season, the majority of bypass flows occur during the winter and spring months when groundwater recharge amounts are greatest. During FY 2018, the annual rainfall total was slightly greater than the long-term average in Oak Ridge. The amount of inflow exceeded the system design treatment capacity during portions of FY 2018, which necessitated allowing bypass flows to occur during 12 weeks out of the year. The majority by volume (86%) of bypass flows occurred during four weeks (ending February 14 [30%], February 21 [20%], February 28 [11%], and March 7 [25%]). The total bypass discharge volume was approximately 1.4 million gal which equates to an approximate mercury discharge of about 33 g for the year.

During FY 2018, flow monitoring continued at Outfall 51 to measure wet season flows discharging from the outfall. Instantaneous flow measurements observed during monthly sampling episodes at Outfall 51 ranged from about 24 gpm in October 2017 to about 91 gpm during February 2018. The total estimated mercury discharge from Outfall 51 during FY 2018 is estimated to be approximately 160 g. The average mercury concentration from Outfall 51 was 1.6 µg/L during FY 2018.

UEFPC mercury mass balance

DOE operates continuous mercury monitoring systems at multiple locations in the UEFPC watershed including mercury treatment facility discharges, several manhole locations within the WEMA, and at instream locations in UEFPC (Figure 6.2). High level summary results of the mercury monitoring are provided in Table 6.2 which includes daily total mercury flux and total annual flux summaries.

Table 6.2. Summary statistics for daily mercury discharge from monitored locations in UEFPC watershed, FY 2018

Outfall	Median[a]	Mean[a]	Maximum[a]	Mercury flux[b]
169A[c] (main stem)	1.3	2.8	112	1,001
163 (lateral branch)	0.81	7.6	259	2,758
160 (lateral branch)	0.12	0.20	1.8	74
150 (lateral branch)	0.87	1.7	13.4	630
Sum of WEMA outfalls				4,463
200A6 (main stem entering UEFPC)	9.6	28	535	10,234
51 (side stem)	0.4	0.5	1.3	160
BSWTS	0.02	0.034	0.13	12.4
BSWTS bypass flow (intermittent)	--	--	--	33
Station 8 (instream)	16.2	31.5	498	11,458
Station 17[d] (instream)	14.7	34.0	1,291	12,377

[a]Values are g/d.
[b]Mercury flux is total g measured/estimated for FY 2018.
[c]Outfall 169 sampling location was replaced by Outfall 169A located approximately 120 ft downstream in the storm drain pipe.
[d]OREM operates continuous flow-paced sampling at a mid-channel location at Station 17.

-- = not applicable, not available, or insufficient data to calculate the statistic
BSWTS = Big Spring Water Treatment System
FY = fiscal year
OREM = Oak Ridge Environmental Management
UEFPC = Upper East Fork Poplar Creek
WEMA = West End Mercury Area

Since January 2010, flow-paced continuous sampling has been operated at five locations in the WEMA. In early January 2010, flow-paced continuous sampling devices became operational at Outfalls 150, 160, 163, and 169A. These outfalls carry the principal WEMA drainages into the main storm drain pipes that discharge at Outfall 200 and make up the headwater of UEFPC. Continuous flow-paced monitoring at Outfall 200A6 has been implemented since the beginning of FY 2007. Outfall 200A6 is located in the main storm drain that carries discharge from the WEMA to the headwater of the UEFPC and the other outfalls are located to the west and upstream in the storm drain network (Figure 6.2). Outfall 200A6 serves as an IP for contamination leaving the WEMA.

During FY 2011, a major storm drain sediment removal and drain pipe repair project was conducted to remove accumulated sediment and repair deteriorated pipe sections in portions of the WEMA. The project field work occurred between late February and the end of September 2011. Coincident with work in the storm drains there were increases in mercury concentration and flux at the WEMA manholes (Outfalls 150, 160, 163, and 169A), at Outfall 200A6, and at Station 17, flux has decreased since the repair work has been completed. Monitoring conducted during FY 2018 shows that activities related to demolition of the COLEX facility in the Outfall 163 storm drain area caused a sharp increase in the mercury discharge flux from that area. During the period between late April and late August mercury concentrations in Outfall 163 were very elevated with a maximum measured concentration of 210,000 ng/L in the July 18 7-day composite sample. Mercury discharge concentrations and fluxes downstream of Outfall 163 at Outfall 200A6, Station 8, and Station 17 increased sharply in FY 2018 compared to FY 2017. Table 6.3 tabulates the median daily mercury load measured at Outfall 200A6 for the time period FY 2007 through FY 2018. There is a significant mass imbalance in the FY 2018 data for the sum of WEMA monitoring locations. The total mercury discharge measured at Outfall 200A6 was approximately 10.2 kg while the sum of mercury measured at the four upstream sites was only 4.2 kg. The probable cause of this imbalance is an underestimate of the Outfall 163 contributions to the storm drain system. During the several months of elevated mercury concentrations at Outfall 163 it is likely that the collected samples under-represented the total amount of mercury that passed through that location.

Figure 6.4 shows the relative FY 2018 contributions of mercury from WEMA Outfalls 150, 160, 163, and 169A to the sum of their measured mercury discharges.

Table 6.3. Median daily mercury flux measured at Outfall 200A6

FY	Median daily mercury discharge (g/d)
2007	4.7
2008	6.2
2009	7.3
2010	6.9
2011	13.8
2012	5.4
2013	5.9
2014	4.5
2015	3.7
2016	4.7
2017	3.7
2018	9.6

FY = fiscal year

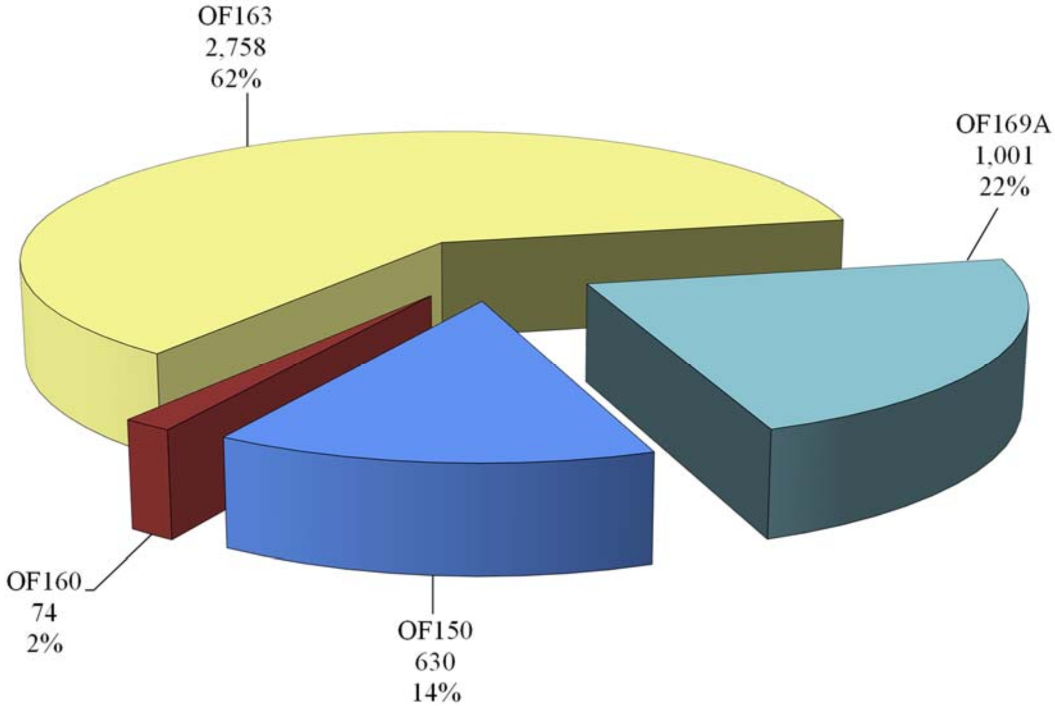


Figure 6.4. FY 2018 relative contributions of mercury from WEMA storm drain outfalls (total grams mercury and percent of sum).

Table 6.2 includes summary statistical data for the amount of mercury measured at the four WEMA outfalls, Station 200A6, Outfall 51, Station 8, and Station 17. Median, mean, and maximum calculated daily mercury discharge masses are included as is the measured total mercury flux measured at each location during FY 2018. There is an obvious increase in the mercury flux from upstream to downstream from Outfall 200A6 through the Station 8 site to Station 17. As surface water flows down the channel of UEFPC from Outfall 200 to Station 17, two significant processes affect the forms of mercury in the water column. The first of these processes is the adsorption of dissolved mercury onto sediment, both that suspended in the water column and channel bottom and side sediment. The second process is scour of contaminated stream channel sediment with transport downstream and past Station 17. The results of these processes are exemplified in the data shown in Table 6.4. The frequency of detection of suspended sediment in the weekly composite samples at each location shows that sediment transport out of the storm drains is less frequent than the transport at the downstream locations. The average and maximum measured suspended sediment concentrations are variable among the sampling locations and the highest frequency of measurable suspended solids occurred at Station 17.

During FY 2018 the pattern of mercury concentration differed from recent years because of the Outfall 163 mercury discharges. In recent years total mercury concentrations and flux have progressively increased from Outfall 200A6 to Station 8 and Station 17 while the dissolved mercury concentrations have decreased in the downstream flow direction. As shown in Table 6.4, during FY 2018 the total mercury concentrations have decreased while the mercury fluxes increased downstream and the dissolved mercury concentrations decreased. Just as there is an increasing particle association of mercury from Outfall 200 downstream to Station 17, there is an increase in flow volume attributable to both facility discharges and groundwater influx to the stream. The combined effects of the increased flow volume along with greater particle association of mercury and generally higher suspended solids load downstream are an increasing total mercury load in UEFPC at Station 17 than at upstream monitoring locations. Inspection of the annual mercury flux column in Table 6.2 clearly shows this.

Table 6.4. Summary of suspended solids and mercury data at Outfall 200A6, Station 8, and Station 17

Location	TSS No. detects/ No. of samples	Average detected TSS (mg/L)[a]	Average of all TSS results (mg/L)[b]	Maximum TSS (mg/L)	Average total mercury (ng/L)	Average dissolved mercury (ng/L)	Percent dissolved mercury
Outfall 200A6	22 / 51	12	7.6	85	5,378	4,226	76%
Station 8	48 / 52	23	21	140	3,521	814	23%
Station 17	51 / 52	35	34	200	1,858	155	9%

[a]Average of all detected TSS results that were greater than the detection limit.
[b]Average of all TSS results including non-detected results assumed to be equal to the detection limit concentration (4 mg/L).

No. = number
TSS = total suspended solids

Figure 6.5 shows the FY 2018 weekly mercury concentration, daily rainfall and average flow rate, along with the calculated daily mercury discharge at Outfall 200A6. Total mercury concentration hovered in the range of 800 – 1,000 ppt from October through March followed by a large increase in concentration in April through much of August during the COLEX facility demolition. The maximum weekly composite sample concentration occurred on July 18, 2018 with a total mercury concentration of 33,600 ng/L.

IP monitoring results at Station 17

Station 17 is the IP where the stream leaves Y-12 and DOE property. The UEFPC watershed remediation goals focus on reduction of mercury in surface water in and downstream of Y-12. Uranium and zinc are also COCs in the UEFPC surface water.

Prior to FY 2014, the continuous monitoring of mercury discharges at Station 17 was conducted by the Y-12 GWPP (Y-12 operating contractor) in support of the NPDES Permit requirements. During FY 2011, the WRRP (OREM contractor) installed a supplemental surface water sampling system in response to elevated mercury discharges that accompanied a storm drain sediment removal project in the WEMA. In 2014, the NPDES Permit was modified and Y-12 GWPP discontinued continuous monitoring of mercury discharges at Station 17. WRRP continues to monitor mercury at Station 17 through FY 2018.

Figure 6.6 shows the Station 17, daily average flow and mercury flux calculated as the flow-weighted fraction of the weekly total mercury concentration (top graph), weekly total mercury concentration (middle graph), and daily rainfall (bottom graph) for FY 2018. Also noted on the center graph panel is the 200 ppt ROD goal for total mercury concentration at this location. The annual average concentration from the composite samples was 1,858 ppt. Total mercury concentrations and calculated daily fluxes during FY 2018 showed an increase compared to previous years as a result of the Outfall 163 mercury discharges related to the COLEX demolition.

Annual fluxes and average concentrations of uranium and mercury at Station 17 from FY 2000 through FY 2018 are listed in Table 6.5.

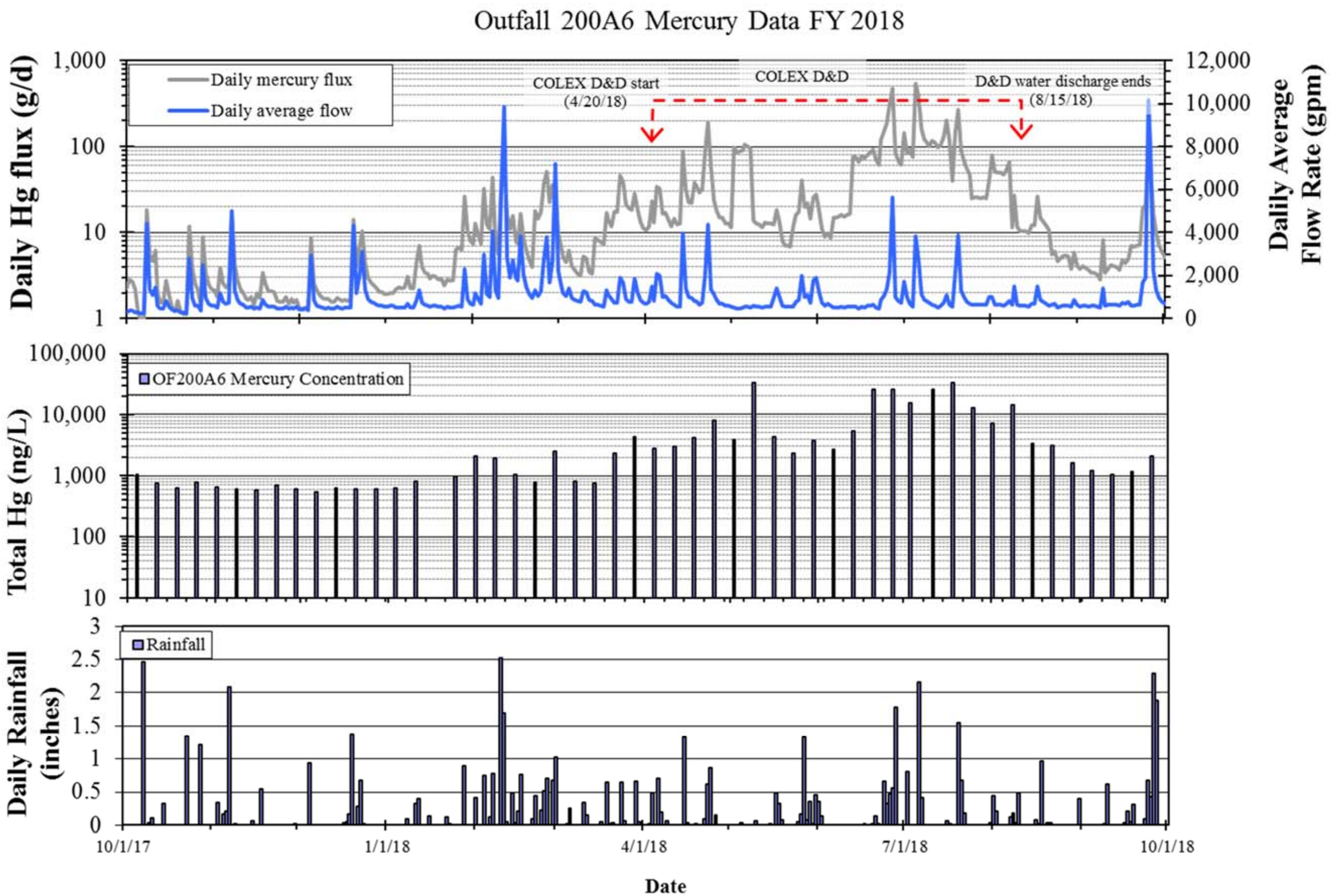


Figure 6.5. Outfall 200A6 mercury discharges during FY 2018.

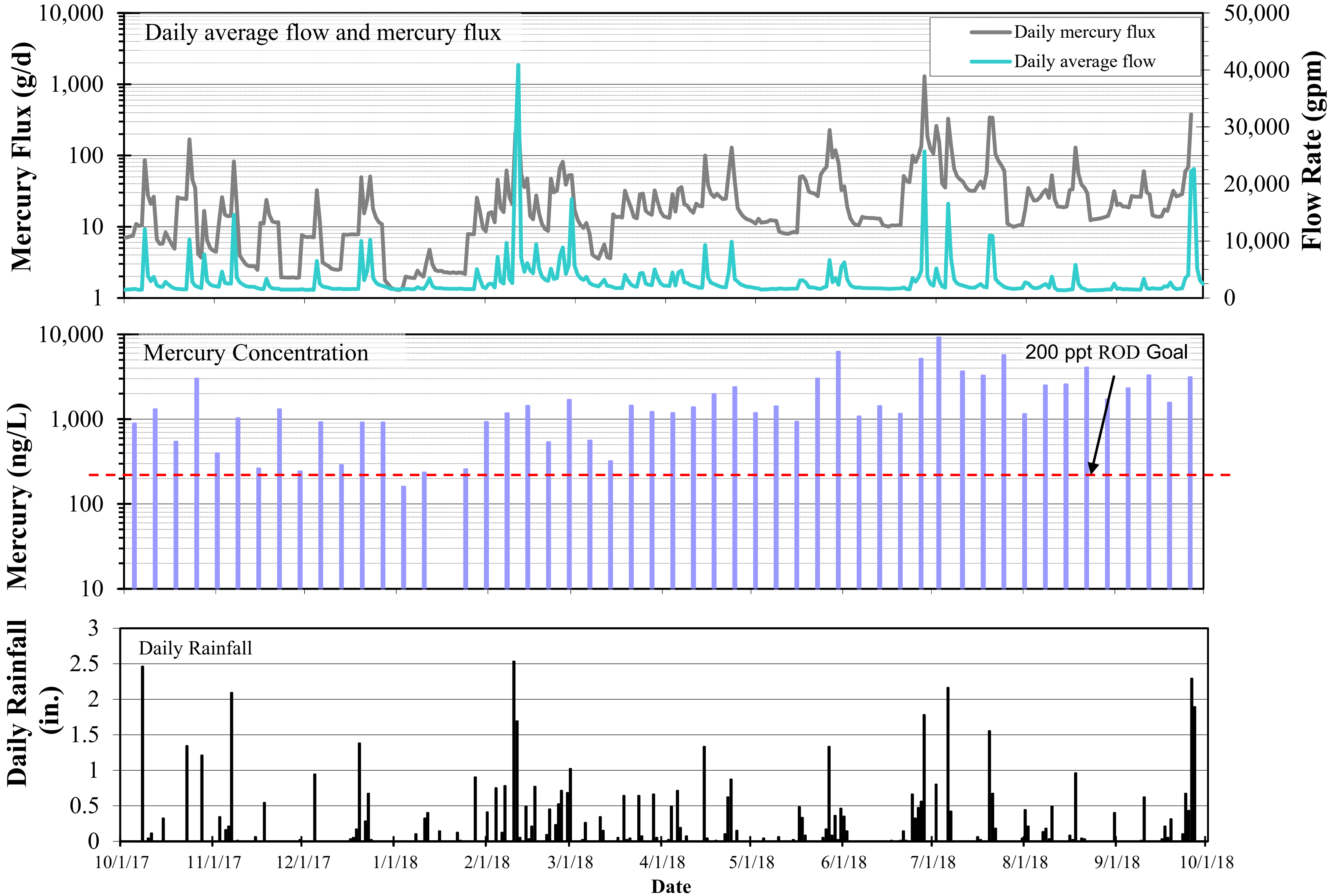


Figure 6.6. Summary of FY 2018 mercury discharge data for Station 17.

Table 6.5. Annual uranium and mercury fluxes[a] and average concentrations at Station 17

Date	Mercury flux (kg)[b]	Average mercury (µg/L)[b,c]	Uranium flux (kg)[b]	Average uranium (µg/L)[b]	Annual rainfall (in.)[d]
2000	12.0	**0.746**	143	12	52
2001	9.4	**0.638**	85	7	45.98
2002	7.3	**0.536**	172	14	52.67
2003	8.8	**0.597**	148	11	73.73
2004	8.2	**0.524**	119	10	56.38
2005	14.6	**0.742**	157	12	58.96
2006	4.0	**0.328**	89	8	46.42
2007	4.0	0.198	86	7	36.26
2008	2.7	**0.221**	98	9	46.02
2009	3.9	**0.273**	177	14	62.5
2010	7.0	**0.476**	198	16	55.8
2011	24	**1.66**	173	13	60.4
2012	21.5	**1.78**	161	14	61.8
2013	20	**1.71**	181	15	63.7
2014	14.4	**1.49**	120	12	48.8
2015	8.1	**1.03**	178	25	55.9
2016	5.3	**0.743**	141	21	50.23
2017	8.3	**0.856**	147	21	57.94
2018	12.4	**1.86**	134	21	58.89

[a]*Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-1951&D3) flux goals for uranium and mercury at Station 17 do not exist.

[b]2000 through 2010 value is the NPDES reported seven-day continuous flow-paced sample, after 2011, weekly composite samples were collected and analyzed by OREM.

[c]**Bold** values exceed *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-1951&D3) mercury concentration goal of 200 ppt (0.2 µg/L) for Station 17.

[d]Average annual rainfall = 54 in.

NPDES = National Pollutant Discharge Elimination System
OREM = Oak Ridge Environmental Management

COCs identified in the UEFPC watershed ROD also include zinc and uranium. Areas of radiologically contaminated groundwater in the UEFPC Watershed are shown on Figure 6.2. Areas of radiological groundwater plumes (uranium and/or Tc-99 contamination) are shown as alpha−beta activity plumes. Uranium contamination in the UEFPC originates from groundwater seepage and storm water transport of surface contamination in Y-12. Groundwater contamination in the WEMA is a source of uranium flux at Outfall 200A6. Other sources of uranium located in the eastern end of Y-12 that may enter UEFPC are the former Oil Skimmer Basin located adjacent to the original UEFPC channel in the eastern end of the plant area, an unknown source adjacent to wells GW-605/GW-606, and the Uranium Oxide Vault/Building 9418-3 (Figure 6.2). As shown in Table 6.5, the uranium flux measured at Station 17 during FY 2018 decreased somewhat in comparison to FY 2017. The annual uranium flux is generally proportional to annual rainfall, with higher uranium fluxes occurring during years of higher rainfall. The average uranium concentration measured at Station 17 in FY 2018 was about 21 µg/L, which is essentially the same as the FY 2017 average concentration. During FY 2018, seven of the uranium concentrations in the weekly composite samples equaled or exceeded the 30 µg/L MCL (for UEFPC surface water, the uranium MCL is used only as a screening level). The maximum detected uranium concentration was 47 µg/L, which was measured in a 7-day composite sample collected on March 7, 2018.

Zinc was analyzed in weekly unfiltered grab samples collected at Station 17 during FY 2018 for comparison to the AWQC (120 µg/L). Zinc was detected in all of the 52 weekly samples. The average detected zinc concentration during FY 2018 was 25 µg/L, and the maximum detected zinc concentration was 250 µg/L, which was measured in the August 22, 2018 sample collected at the end of a period of deep drought. The August 22 sample was the only sample that exceeded the AWQC.

6.3.1.2.2 Groundwater

Remediation of contaminated groundwater within the UEFPC watershed is deferred to future CERCLA decision documents. The associated performance monitoring goals, objectives, and requirements at the watershed-scale for UEFPC groundwater have not yet been determined. The EEVOC Plume performance monitoring objectives are discussed in Section 6.5.1.1.1.

The *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (UEFPC RI; DOE/OR/01-1641/V1-V4&D1) estimated that groundwater contamination underlies about half of the industrial portion of the UEFPC watershed, and VOCs, radionuclides, nitrate, and metals are the prevalent groundwater contaminants. Figure 6.2 shows that the UEFPC groundwater contamination forms a complex of overlapping plumes of different chemical compounds originating from different sources as provided by the Y-12 GWPP. The predominant groundwater contaminants in the UEFPC watershed include nitrate, chlorinated VOCs, and radiological contamination including uranium and Tc-99. Groundwater monitoring locations are also shown on Figure 6.2. The UEFPC Phase I ROD identified groundwater COCs for industrial site use and baseline residential scenarios as shown in Table 6.6. Sampling at various locations has been tailored to key contaminants in the respective areas and is in accordance with the approved EFPC/CR RAR CMP.

Groundwater contamination that originates from the former S-3 Ponds liquid waste disposal site enters the UEFPC watershed at its western end on the watershed divide between UEFPC within the plant area and Bear Creek to the west. The Eastern S-3 Groundwater Plume carries high concentrations of nitrate derived from nitric acid in the metal plating waste liquids disposed in the ponds as well as elevated Tc-99 along the axis of BCV. Groundwater monitoring related to contamination in the Eastern S-3 Groundwater Plume was previously conducted under RCRA authority. On February 23, 2018, TDEC granted the request from DOE to discontinue UEFPC PCP monitoring for groundwater in the UEFPC and to integrate substantive equivalent reporting in the annual RER. Wells formerly included in the UEFPC PCP monitoring program include wells GW-108, GW-193, GW-605, GW-606, and GW-733. As shown on Figure 6.2, these five wells are spread from west to east along the axis of the Upper East Fork valley. The wells were intended to monitor the migration of the Eastern S-3 Groundwater Plume although in the years following issuance of the RCRA permit knowledge has been gained that multiple sources contribute to the complex plume.

Well GW-108 is a 58 ft deep well located in the Nolichucky shale relatively close to the source of the Eastern S-3 Groundwater Plume as shown in Figure 6.2. Figure 6.7 shows analytical results for Tc-99 and nitrate in well GW-108. These contaminants, which far exceed their screening level drinking water MCL or MCL-DC (10 mg/L MCL for nitrate and 900 pCi/L MCL-DC for Tc-99), originate from the S-3 Ponds in a low pH plume finger that seeps eastward into the UEFPC watershed. The nitrate concentrations are undergoing a long-term decreasing trend with one obvious outlier data point in 2005. The Tc-99 activities are also showing a decreasing trend since the summer of 2010. Well GW-193 lies in the Maynardville Limestone approximately 6,400 ft east of well GW-108. Well GW-193 is monitored for Tc-99 which was not detected in the FY 2018 semi-annual samples collected in January and July.

Table 6.6. Groundwater COCs in the UEFPC watershed

COC	Industrial scenario	Residential scenario
Arsenic	X	X
Barium	X	X
Beryllium	X	X
Cadmium	X	X
Chromium	X	X
Fluoride	X	X
Manganese	X	X
Mercury	X	X
Nickel	X	X
Nitrate as nitrogen	X	X
Nitrite as nitrogen	X	X
Selenium	X	X
Strontium (metal)		X
Total uranium (metal)		X
Vanadium		X
Zinc		X
1,1-Dichloroethene	X	X
1,2-Dichloroethane	X	X
1,2-Dichloroethene	X	X
Benzene	X	X
Bis(2-ethylhexyl)phthalate	X	X
Bromoform		X
Carbon tetrachloride	X	X
Chloroform		X
Di-n-octylphthalate		X
Methylene chloride		X
Tetrachloroethene	X	X
Toluene		X
Trichloroethene	X	X
Vinyl chloride	X	X
cis-1,2-Dichloroethene	X	X
Cesium-137		X
Radium-226	X	X
Radium-228	X	X

Table 6.6. Groundwater COCs in the UEFPC watershed (cont.)

COC	Industrial scenario	Residential scenario
Technetium-99	X	X
Thorium-228	X	X
Uranium-234	X	X
Uranium-235		X
Uranium-238	X	X

Source: Table 2.7 of the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-1951&D3).

COC = contaminant of concern
UEFPC = Upper East Fork Poplar Creek

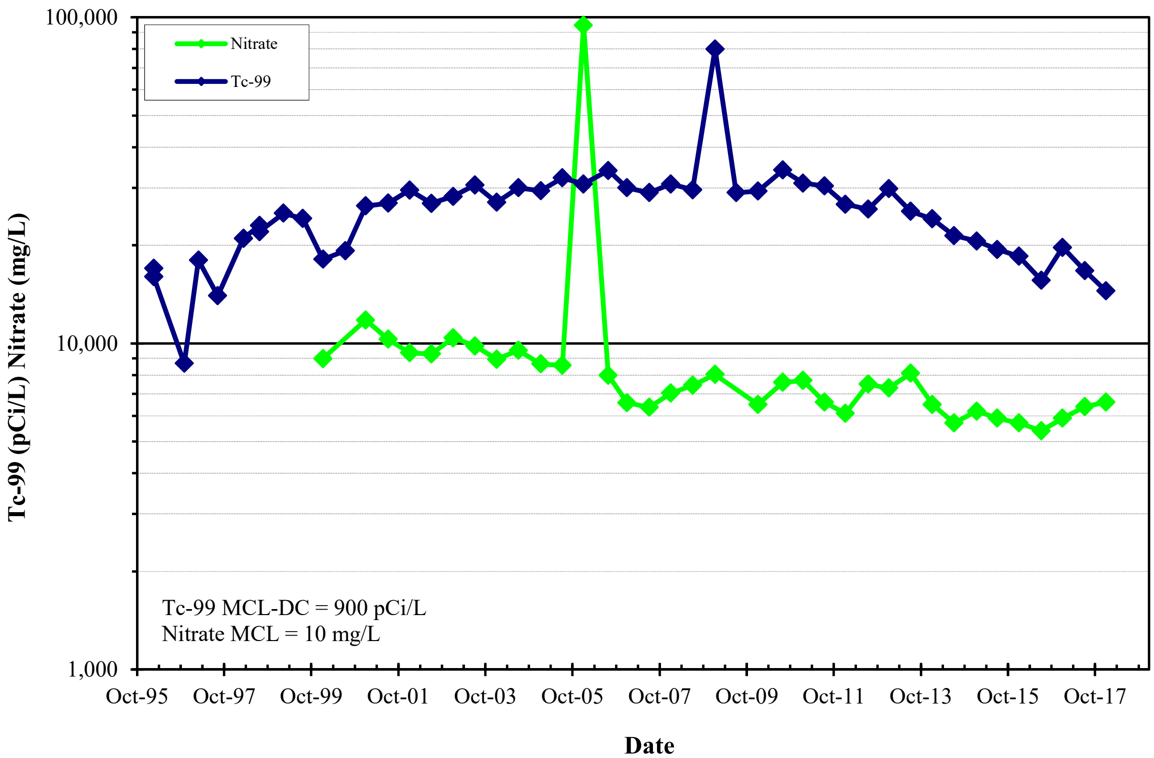
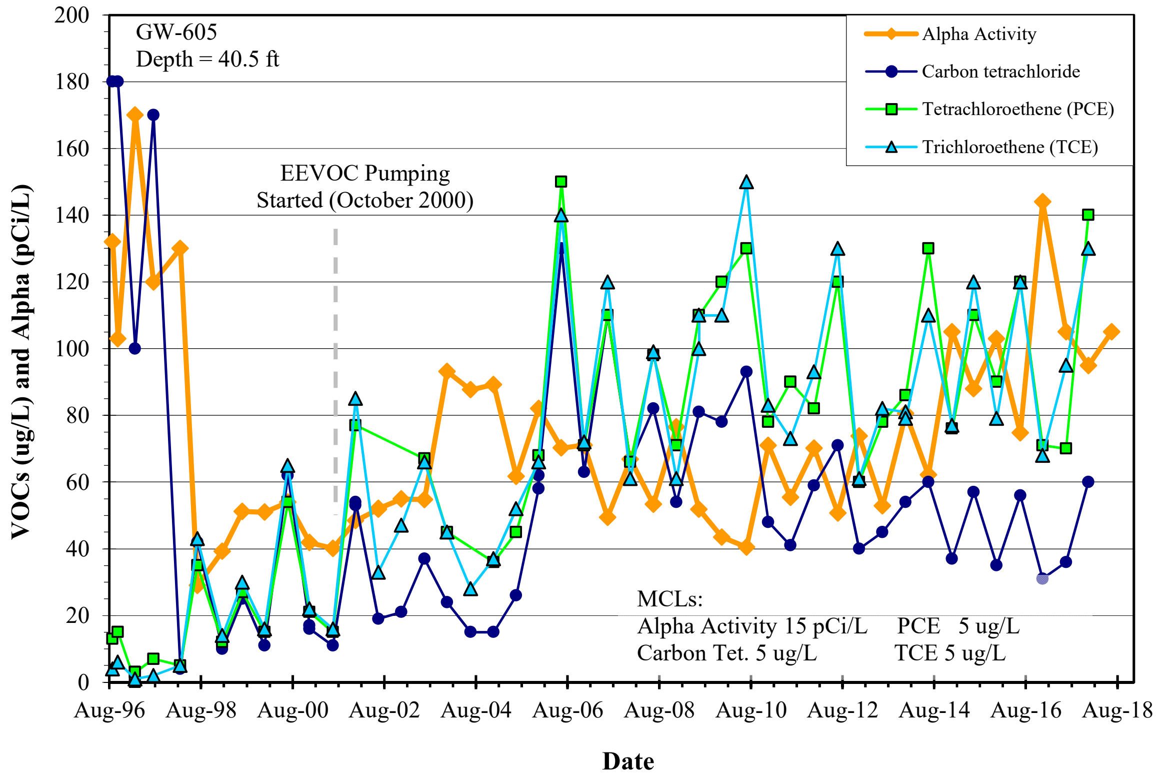


Figure 6.7. Well GW-108 nitrate concentration and Tc-99 activity.

Wells GW-605 and GW-606 lie approximately 9,000 ft to the east of well GW-108 and are located in the Maynardville Limestone exit pathway upgradient of the EEVOC Plume interception and treatment system (Figure 6.2). Well GW-605 is a relatively shallow well (40.5 ft deep), while GW-606 is deeper (175 ft deep). Figure 6.8 shows concentrations of signature contaminants in wells GW-605 and GW-606. These wells are located near the upgradient edge of the capture zone for the EEVOC pump and treat system that started in October 2000 (see Section 6.5.1). Although cause and effect of variations in contaminant levels in the wells are not positively confirmed, some of the contaminant signatures appear to be influenced by possible changes in groundwater flow paths associated with establishment of the pump and treat system capture zone.



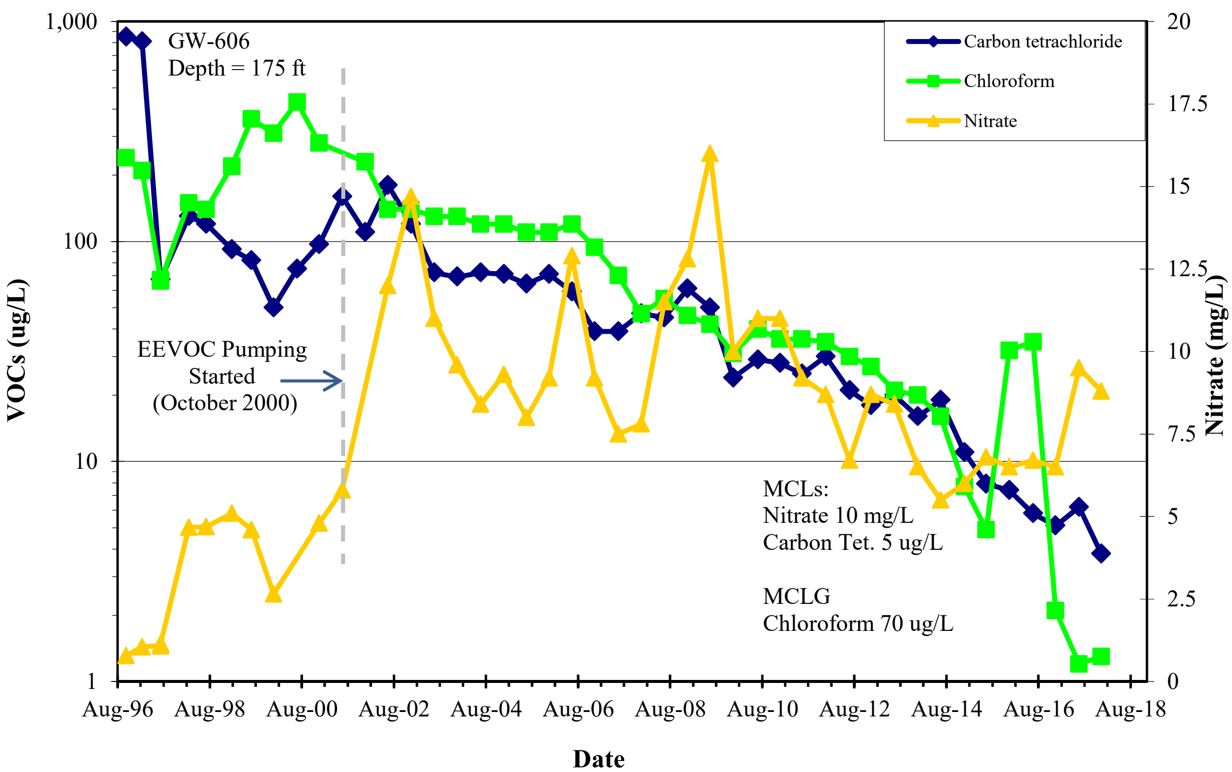


Figure 6.8. Wells GW-605 and GW-606 signature contaminant concentrations.

The alpha activity in well GW-605 is attributed to U-234 and U-238, which remained present in the well at concentrations of about 70 pCi/L in January and July 2018. The well GW-605 alpha activity has been increasing since 2010. The total uranium concentration in the January 2018 sample from well GW-605 was 0.21 mg/L. The concentration behavior of three chlorinated VOCs, carbon tetrachloride, PCE, and TCE in well GW-605 show that a significant increase occurred in the summer of 2006 followed by somewhat erratic concentration fluctuations. The cause of the significant increase in 2006 is not known, although deactivation and demolition of facilities in the area may be related to a change in groundwater conditions. Well GW-605 is sampled semiannually, with samples typically collected in January and July. Samples collected during the summer typically have higher VOC concentrations than those collected during the winter, while the alpha activity fluctuations follow an inverse pattern. Prominent July peaks of VOC concentration have been observed in 2006, 2007, 2010, 2012, 2014, 2015, 2016, and 2017. This pattern of higher versus lower concentrations suggests winter season dilution of VOCs in groundwater in the vicinity of this well. Since the alpha and VOC concentration fluctuation patterns are opposite one another in the seasonal sense, it is probable that the uranium, which causes the alpha signal, originates from shallower contamination that is mobilized during winter groundwater recharge events, while the VOCs originate from a different groundwater source that exhibits a dilutional response during the winter higher groundwater recharge season.

At well GW-606, concentrations of carbon tetrachloride and its degradation product chloroform have decreased since the EEVOC Plume collection and treatment started operation in October 2000. Nitrate was present in well GW-606 prior to initiation of groundwater withdrawal and treatment. As shown in Figure 6.8, the nitrate concentration increased after groundwater withdrawal started and has fluctuated in concentration between about 5 and 16 mg/L. Since January 2011, nitrate in GW-606 has been measured at concentrations less than the screening 10 mg/L MCL. During FY 2018, well GW-606 contained 4.5 µg/L of uranium and PCE was present at 4.6 µg/L in the January sample. Like the VOCs detected in well GW-605, the nitrate contamination represented by the GW-606 data is thought to be captured in the zone of influence of the EEVOC treatment system. Section 6.5.1 presents performance monitoring data relevant to the Y-12 EEVOC Plume removal action that includes annual nitrate and uranium data.

Well GW-733 is located near the DOE site boundary near Scarboro Road and is approximately 700 ft east of the EEVOC Plume extraction well (GW-845). Well GW-733 is monitored annually for Tc-99 and VOCs. Technetium was not detected in the January 2018 sample. Carbon tetrachloride was present at 2.8 µg/L (less than the 5 µg/L MCL) and chloroform was detected at 0.57 J µg/L (much less than the 70 µg/L MCL). No other VOCs were detected in the GW-733 FY 2018 sample.

The UEFPC Phase I ROD did not specify target groundwater contaminant levels or other ARAR-based performance criteria for groundwater; SDWA MCLs are used as screening criteria to evaluate performance.

6.3.1.2.3 Aquatic biology

Bioaccumulation of COCs in fish and stream ecological health have been monitored in UEFPC since 1985. Data collected on contaminant bioaccumulation and the composition and abundance of communities of aquatic organisms provide direct evaluation of the effectiveness of abatement and remedial measures in improving ecological conditions in the stream (Peterson et al., 2011).

Fish mercury concentrations in UEFPC have been compared to aqueous mercury concentrations over time to provide an assessment of fish responses to various Y-12 actions that can affect mercury. As noted in Section 6.3.1.2.1.2 focused on surface water monitoring results, mercury in water data has been collected by WRRP and Y-12 NPDES programs at Station 17 since 2011, using different collection techniques at slightly different instream locations. Although the WRRP data is generally higher in mercury and thought to be more representative of water concentrations at the site, Y-12 NPDES data trends similarly over time and is used for comparisons with fish because the Y-12 water data has been collected the same way since the early 1990s. Using the Y-12 compliance data, aqueous mercury concentrations at Station 17 have both decreased and increased in response to actions at Y-12 (Figure 6.9). During the 1990s, surface water mercury concentrations decreased steadily, eventually leveling off at approximately 0.4 µg/L by the early 2000s. After the implementation of the BSWTS in 2007, aqueous concentrations dropped again, reaching a new "baseline" of approximately 0.30 µg/L that lasted until 2010. Following WEMA storm drain clean-out activities beginning in 2010, average aqueous mercury concentrations increased sharply, peaking at approximately 0.93 µg/L in the spring of 2011. Mean concentrations in 2018 were approximately 0.77 µg/L, significantly higher than in 2017, but comparable to concentrations seen during storm drain clean out activities (Figure 6.9). These results are consistent with higher surface water mercury results in the summer of 2018 reported by the WRRP at multiple locations further upstream (Section 6.3.1.2.1.2).

While mercury concentrations in rock bass collected at EFK 23.4 (near Station 17) have remained relatively stable over the past few years in the face of significant fluctuations in aqueous mercury concentrations, mean concentrations in spring 2017 and 2018 were significantly lower than they have been in the past (Figure 6.9). Mercury concentrations in this species in the fall remain elevated (0.93 µg/g in fall 2017, but concentrations in this species collected in spring 2018 were significantly lower (mean concentration 0.56 µg/g). This apparent decrease could be due in part to the size of fish collected. The fish collected in spring 2018 were significantly smaller (mean weight 76.9 g) than in fall 2017 (mean weight 176.9 g) and in recent years. Although the monitoring program tries to collect similarly-sized fish during each sampling event, larger or smaller fish are sometimes sampled depending on availability of fish. Studies are underway in the latter half of calendar year 2018 to evaluate how fish respond to the elevated mercury concentrations in water observed in summer of 2018.

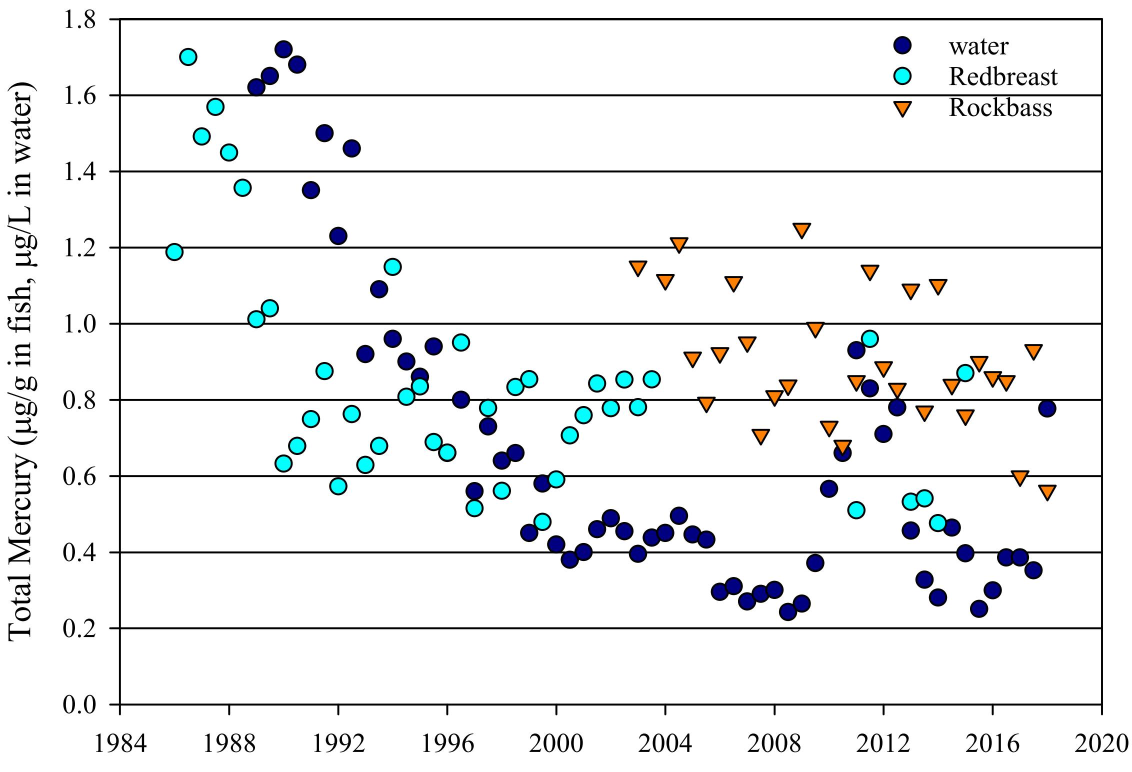


Figure 6.9. Mean concentration of mercury in redbreast sunfish and rock bass fillets at EFK 23.4 versus trailing 6 mo. mean concentration of mercury in water.

Mercury concentrations in redbreast collected at EFK 24.2 (approximately 1 km upstream from Station 17 and above Lake Reality) have also been responsive to temporal changes in water concentrations in the creek (Figure 6.10). Fish mercury concentrations at EFK 24.2 declined steadily during the 1990s as water concentrations declined, remained relatively stable at approximately 0.6 µg/g until the storm drain cleanout in 2011, and then increased to approximately 1 µg/g for a short time after surface water mercury concentrations spiked. Since the storm drain cleanout was completed and mercury concentrations in water again declined, fish concentrations at EFK 24.2 also decreased from peak concentrations in 2011 – 2012. However, current fish mercury concentrations remain slightly higher than the period prior to storm drain cleanout. The termination of flow management in spring 2014 is likely a factor affecting current mercury exposure and bioaccumulation in UEFPC.

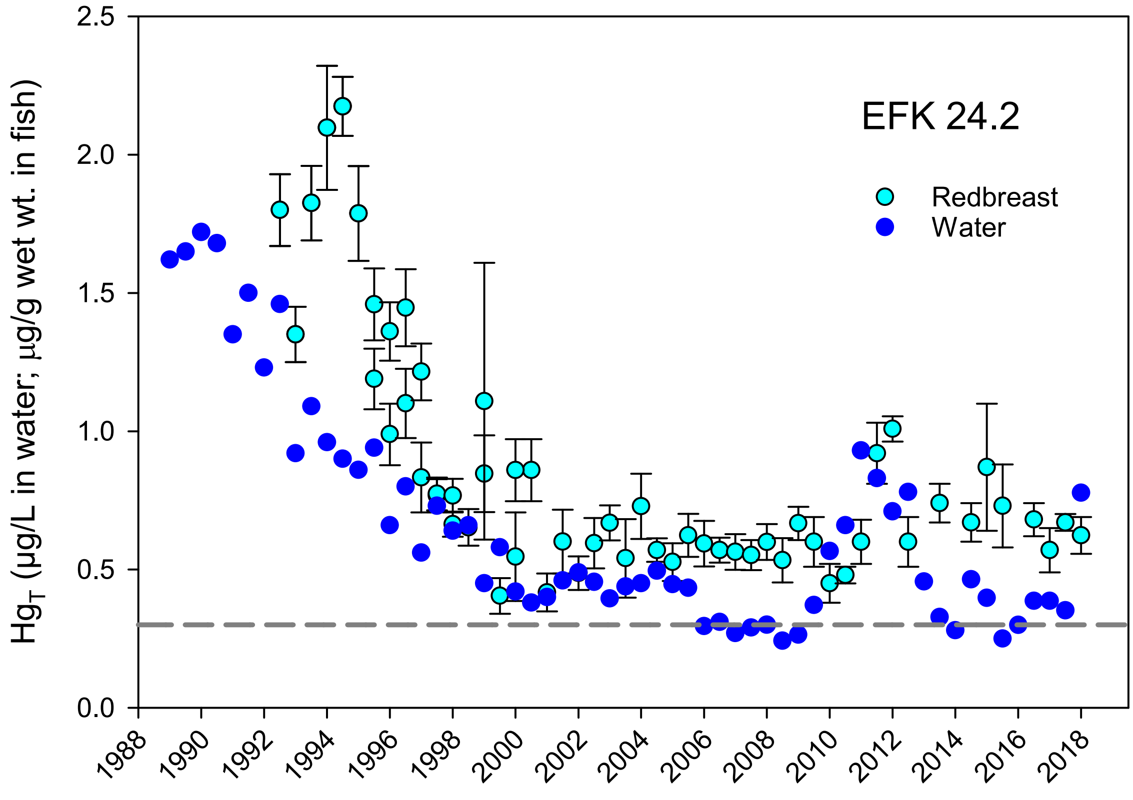


Figure 6.10. Mean concentration of mercury in redbreast sunfish fillets at EFK 24.2 versus trailing 6 mo. mean concentration of mercury in water at Station 17 (EFK 23.4).

Dashed line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

Because the consumption of contaminated fish represents the largest dose of many bioaccumulative contaminants to humans, fish fillet concentrations are relevant to assessing human health risks, while whole body fish are relevant to assessing ecological risks. In EFPC, whole body forage fish (largescale stonerollers) and fillets of sunfish were analyzed for PCBs. Mean PCB concentrations in whole body composites of stoneroller minnows at EFK 24.4 increased from 2.12 ± 0.15 µg/g in 2017 to 3.28 ± 0.32 in 2018, but remained comparable to concentrations seen in recent years. The concentrations seen in 2018 were above the whole body fish remediation goal of 2.3 µg/g agreed to by EPA and TDEC and established for ETTP's K-1007-P1 Holding Pond (there is no such performance goal for EFPC; this value is only used a screening level here for comparison purposes). Total PCB concentrations in sunfish fillets at EFK 23.4 (0.61 µg/g), remained comparable to 2017 and recent years, and much lower than the peak levels observed in the mid-1990s (Figure 6.11).

To put the PCB results from EFPC in perspective, various screening level regulatory and risk consumption limits for PCBs can be compared. Regulatory guidance and human health risk levels have varied widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criterion for total PCBs is 0.00064 µg/L under the recreation designated use classification and is the target for PCB-focused TMDLs, including for local reservoirs (Melton Hill, Watts Bar, and Fort Loudon; TDEC 2010a,b,c). In the state of Tennessee, assessments of impairment for water body segments as well as public fishing advisories are based on fish tissue concentrations. Historically, the FDA threshold limit of 2 µg/g PCBs in fish fillet was used for advisories, and then for many years an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as the fish species and size. The remediation goal for fish fillet at the ETTP K-1007-P1 Holding Pond is 1 µg/g PCBs (DOE/OR/01-2456&D1/R1). Most recently, the water quality criterion has been used to calculate the fish tissue concentration triggering impairment and a TMDL (TDEC 2015), and this concentration is 0.02 µg/g PCBs in fish fillet (TDEC 2010a,b,c). TMDLs are used by TDEC to develop controls for reducing pollution from both point and non-point sources in order to restore or maintain the quality of a water body and ensure it meets the applicable water quality standards. The fish PCB concentrations in UEFPC, at approximately 0.5 µg/g in fish fillet, are well above this TMDL-based impairment concentration.

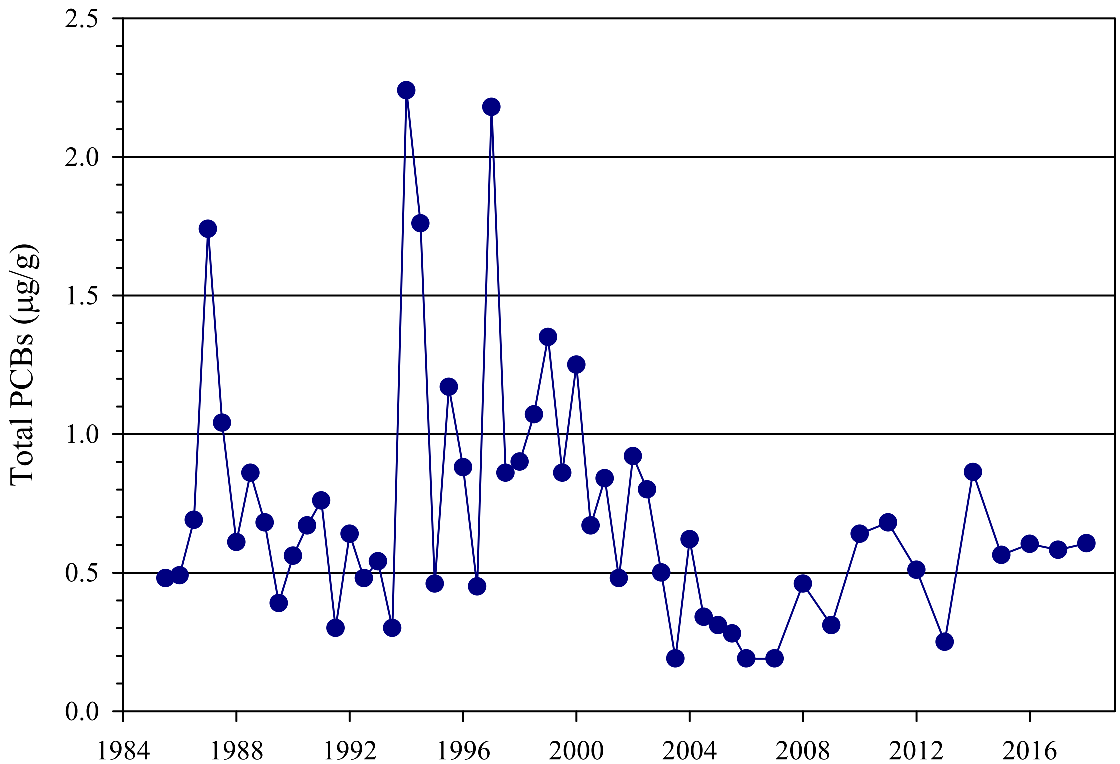


Figure 6.11. Mean concentrations of PCBs in redbreast sunfish and rock bass at EFK 23.4, 1985 – 2018.

There was a significant improvement in species richness (number of species) at EFK 23.4 from 1985 – 1991 when the number of fish species increased from six to 14. However, since the early 1990s species richness has varied but remained in the range of eight to 15 species with little to no improvement over time. The site is significantly below fish richness values for a comparable reference fish community such as Brushy Fork (BFK 7.6) which has ranged from 18 to 27 species over the last two decades (Figure 6.12). UEFPC has experienced occasional fish kills since 2011 including in the summer of 2018, and reduced flow since flow augmentation was ended in 2014 (in response to the 2018 fish kill an NPDES-required TIE/TRE was initiated, with studies conducted in the field and laboratory through fall-winter of 2018 – 2019 to identify the causes of toxicity. Results of these studies will be provided in the Y-12 FY 2019 TIE/TRE reporting and future RERs). These factors could be influencing the ability of new species to colonize this area. In contrast, the species richness of the fish community further downstream at EFK 13.8 has continued to improve since the late 1980s, and now routinely meets or exceeds richness at the reference site. The improvement at EFK 13.8 includes more sensitive species, such as darters and suckers, but the density of these sensitive species is still below reference values. Furthermore, the density of more tolerant species remains high at both sites. Fish community surveys of a site in UEFPC, EFK 24.4, have consistently found four fish species, ostensibly because there is weir barrier to fish movement near the downstream end of Lake Reality. Since flow augmentation ended in 2014, there is not a clear impact on fish community diversity values at either UEFPC monitoring sites, although density values (fish per meter) at UEFPC sites have decreased (results not shown; Peterson et al., 2018).

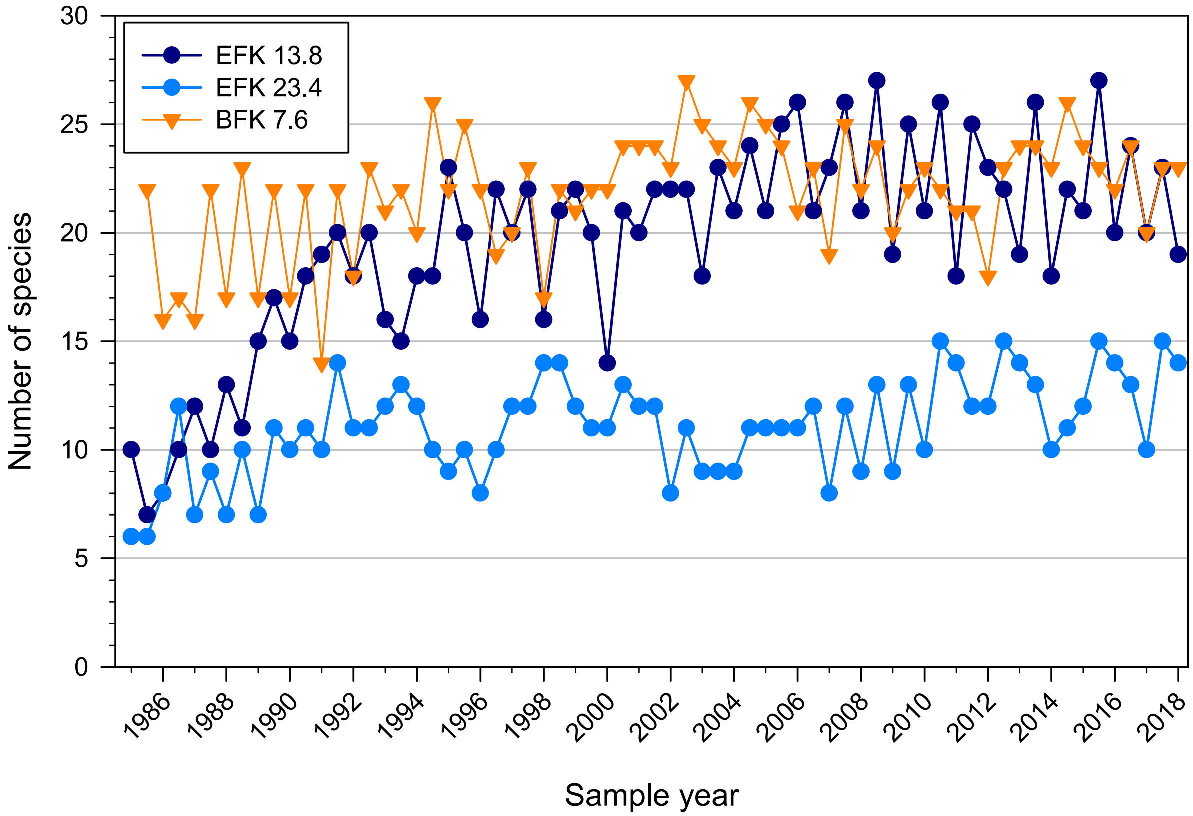


Figure 6.12. Species richness (number of species) in samples of the fish community at two sites in EFPC and a reference stream, Brushy Fork, 1985 – 2018.

From the late 1980s until the early 2000s, the number of pollution-intolerant benthic macroinvertebrates (i.e., EPT taxa richness) increased noticeably at EFK 23.4 and 24.4, after which EPT taxa richness reached a plateau. EPT taxa richness values at EFK 23.4 continues to be distinctly higher than at EFK 24.4, while fluctuating in and out of the 95% confidence band of the EFPC reference sites (Brushy Fork site BFK 7.6 and Hinds Creek site HCK 20.6; Figure 6.13). Since 2013, EPT taxa richness values at EFK 23.4 have remained higher or at the upper end of the range of values represented in reference sites. The number of pollution-intolerant taxa at EFK 24.4 in October 2017 (FY 2018) was similar to those found in recent years and continues to remain well below the 95% confidence band for the reference sites. Since monitoring began, the number of pollution intolerant taxa at EFK 13.8 has been similar or slightly higher than that of reference sites. Since 2013 prior to flow augmentation ending, the number of EPT taxa has decreased at all three EFPC sites. Future monitoring of the stream macroinvertebrate community will help elucidate whether this trend is a response to flow augmentation ending and continues.

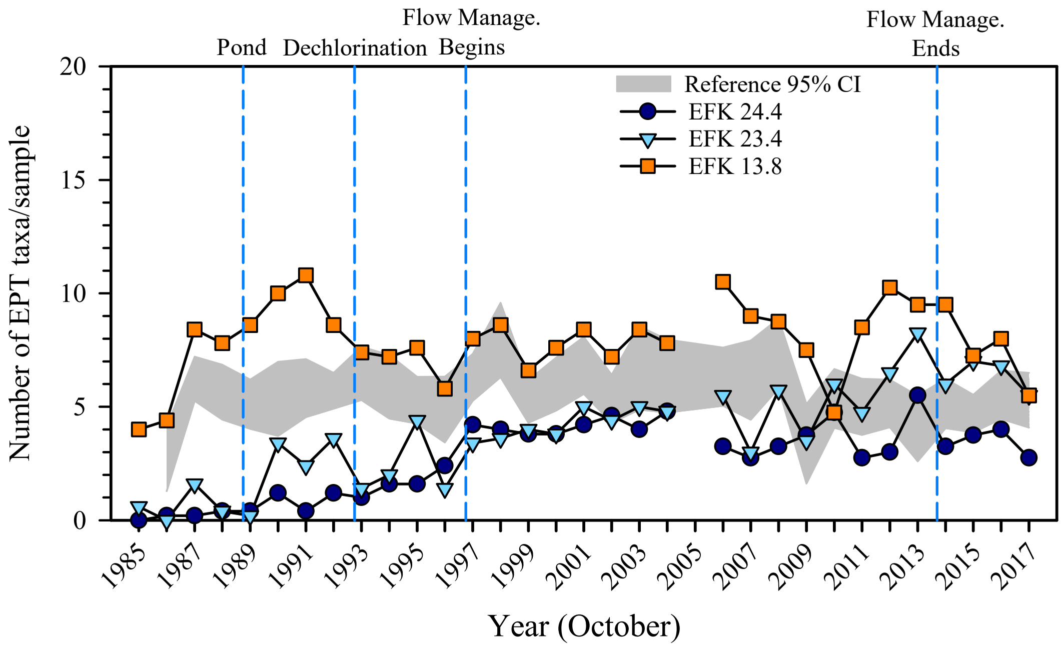


Figure 6.13. Mean (n = 5; n = 4 after 2006) taxonomic richness of the pollution-intolerant taxa (EPT taxa richness) for the benthic macroinvertebrate community at sites in UEFPC and the 95% confidence band for two reference sites (Brushy Fork and Hinds Creek) October sampling periods, 1985 – 2017.[a,b]

[a]Major events in the 1980s and 1990s include New Hope Pond replacement with Lake Reality, dechlorination of discharges, and the start-up of flow management (Flow Manage. Begins); flow management ended in late 2013.
[b]CI = confidence interval; EFK = EFPC kilometer; EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.

6.3.2 LUCs

LUCs for UEFPC Phase I ROD areas are listed in Table 6.7 and described below.

Watershed-scale remedy integrity and LUCs

The UEFPC Phase I ROD specifies remedy maintenance and LUCs to reduce the risk of human exposure to contaminants. The LUCs include an EPP program, property record restrictions, property record notices, zoning notices, signs, and surveillance patrols. Additionally, completed actions under this ROD require maintenance of water treatment systems integrity. The engineered remedies are included in Table 6.7 to be all inclusive of necessary verifications.

New Hope Pond remedy integrity

New Hope Pond remedy integrity components are listed in Table 6.7 and described below.

The RAR CMP requires semiannual inspections of site controls including access controls, cap/cover/surface drainage, signage, 24-yr/24-hr rain event inspections, and benchmarks. Also, monitoring wells require an annual comprehensive inspection including evaluation of well integrity (e.g. condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate).

Table 6.7. LUCs for the UEFPC watershed

LUCs[a] – Watershed-scale requirements					
Type of control	***Affected areas***	***Purposes of control***	***Duration***	***Implementation***	**Frequency/ implementation**
Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee **(DOE/OR/01-1951&D3) and** ***Explanation of Significant Differences for the Record of Decision for Phase I Interim Source Control Actions in Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*** **(DOE/OR/01-2539&D2)**					
1. Property Record Restrictions[b] *A. Land use* *B. Groundwater*	*WEMA mercury-contaminated areas*	*Restrict use of property by imposing limitations.* *Prohibit uses of groundwater*	*Indefinitely*	*Drafted and implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office*	DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)
2. Property Record Notices[c]	*WEMA mercury-contaminated areas*	*Provide notice to anyone searching records about the existence and location of contaminated areas*	*Indefinitely*	*Initial Notice recorded by DOE in accordance with state law at County Register of Deeds office: 1) as soon as practicable after signing of the ROD; 2) upon transfer of affected areas; 3) final Notice upon completion of all other remedial actions*	DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)
3. Zoning Notices[d]	*WEMA mercury-contaminated areas*	*Provide notice to City Planning Commission about the existence and location of waste disposal and/or contaminated areas and providing use limitations information for zoning/planning purposes if/when UEFPC areas are transferred out of DOE federal control.*	*Indefinitely*	*Zoning notice, use limitations information, and boundary survey plat will be filed with the City Planning Commission if/when areas are to be transferred out of DOE federal control.*	DOE official (or its contractors) will verify no less than annually that information is properly maintained with the City Planning Commission

Table 6.7. LUCs for the UEFPC watershed (cont.)

LUCs[a] – Watershed-scale requirements					
Type of control	***Affected areas***	***Purposes of control***	***Duration***	***Implementation***	**Frequency/ implementation**
4. Excavation/Penetration Permit Program[e]	*WEMA mercury-contaminated areas*	*Provide notice to worker/developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity*	*As long as property remains under DOE control*	• *Implemented by DOE and its contractors* • *Initiated by permit request*	DOE official (or its contractors) will verify no less than annually the functioning of permit program against existing procedures
5. Signs[f]	*UEFPC surface water*[g]	*Provide notice or warning to prevent unauthorized access*	*Indefinitely*	*Signage maintained by DOE*	DOE official (or its contractors) will conduct field survey no less than annually of all signs to assess condition (i.e., remain erect, intact, and legible)
6. Surveillance Patrols	*UEFPC surface water*[g]	*Control and monitor access by workers/public*	*Indefinitely*	• *Established and maintained by DOE* • *Necessity of patrols evaluated upon completion of remedial actions*	DOE official (or its contractors) will verify no less than annually against procedures/plans that routine patrols conducted
7. Engineered Remedy[h] (e.g., engineered caps, soil covers, treatment systems)	Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions: BSWTS, CMTS, Y-12 EEVOC Plume, Secondary Pathways, New Hope Pond, Eastern S-3 Groundwater Plume	Part of the cleanup or containment activity to help minimize the potential for exposure to contamination.	Until the concentration of hazardous substances are at such levels to allow for UU/UE; maintain integrity of the CERCLA remedy until final decision is made	• Remedy maintained by DOE through operations, surveillance, and maintenance	Verify annually that the remedies are being maintained

Table 6.7. LUCs for the UEFPC watershed (cont.)

Type of control	Affected areas	Purposes of control	Duration	Implementation	Frequency/ implementation
LUCs[a] – Watershed-scale requirements					
***Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek, Oak Ridge, Tennessee* (DOE/OR/01-2229&D3)**					
1. DOE land notation (Property record restrictions)[b]	*Throughout entire Y-12 industrial area*	*Restrict use of property consistent with LUC objectives*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure*	*Drafted and implemented by DOE upon completion of remediation activities per this ROD or transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office.*	DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)
2. Property record notices[c]	*Throughout entire Y-12 industrial area*	*Provide notice to anyone searching records about the existence and location of contaminated areas*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure*	*Notice provided by DOE EM to the public as soon as practicable, but no later than 90 days after approval of the LUCIP.*	DOE official (or its contractors) will verify no less than annually that information is properly recorded at County Register of Deeds office(s)
3. Zoning notices[d]	*Throughout entire Y-12 industrial area*	*Provide notice to city about the existence and location of waste disposal and residual contamination areas for zoning/planning purposes*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure*	*Initial Zoning Notice (same as Property Record Notice) filed with City Planning Commission as soon as practicable after approval of the LUCIP; final Zoning Notice and survey plat files with City Planning Commission upon completion of all remedial actions*	DOE official (or its contractors) will verify no less than annually that information is properly maintained with the City Planning Commission
4. Excavation/penetration permit program[e]	*Throughout entire Y-12 industrial area*	*Provide notice to worker/developer (i.e., permit requestor) on extent of contamination and prohibit or limit excavation/penetration activity*	*As long as property remains under DOE control, including transferred property remaining subject to the excavation/penetration permit program*	*Implemented by DOE and its contractors; initiated by permit request*	DOE official (or its contractors) will verify no less than annually the functioning of permit program against existing procedures

Table 6.7. LUCs for the UEFPC watershed (cont.)

LUCs [a] – Watershed-scale requirements					
Type of control	***Affected areas***	***Purposes of control***	***Duration***	***Implementation***	**Frequency/ implementation**
5. Security guards/surveillance patrols	*Patrol of selected areas throughout Y-12, as necessary*	*Control and monitor access by workers/public*	*Until the concentrations of hazardous substances are at such levels to allow for unrestricted use and exposure as well as established programmatic needs*	*Established and maintained by DOE; necessity of patrols evaluated upon completion of remedial actions. Existing routine patrols continued.*	DOE official (or its contractors) will verify no less than annually against procedures/plans that routine patrols conducted

LUCs for specific areas			
Areas	**Project documents**	**LUCs**	**Frequency/ implementation**
***Record of Decision for an Interim Action for Union Valley, Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/01-1641/V1-V4&D2)**			
Union Valley	Interim ROD (DOE/OR/02-1545&D2)	**LUCs:** • License agreements with property owners notifying them of the potential contamination and requiring them to notify DOE of any changes in use of groundwater or surface water in certain areas • Appropriate verification by DOE of compliance with the agreements and notification of state and local agencies • The DOE Real Estate Office and DOE's management and operations contractor's real estate office are responsible for (1) completing the annual title search by the anniversary date of this ROD to determine whether any affected property has changed hands; (2) notifying property owners, the Oak Ridge city manager, and the TDEC/DOE Oversight Division (now called the TDEC/DOE Oversight Office) of their obligations under the agreements and updating them on the status of the environmental investigations; (3) surveying owners by telephone to determine whether any new groundwater wells have been constructed or planned of there are any new uses for surface water; and (4) notifying licensed well drillers in Tennessee of the license agreements and their terms.	The DOE Real Estate Office shall report search results to the DOE Program Office annually

[a] Source for LUCs: *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-1951&D3), *Explanation of Significant Differences for the Record of Decision for Phase I Interim Source Control Actions in Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR01-2539&D2), and *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek, Oak Ridge, Tennessee* (DOE/OR/01-2229&D3).

[b] *Property Record Restrictions—Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of DOE and its predecessor agencies.*

[c] *Property Record Notices—Refers to any non-enforceable, purely informational document recorded along with the original property acquisition records of DOE and its predecessor agencies that alerts anyone searching property records to important information about residual contamination/waste disposal areas on the property.*

[d] *Zoning Notices—Includes information on the location of waste disposal areas and residual contamination depicted on a survey plat, which is provided to a zoning authority (i.e., City Planning Commission) for consideration in appropriate zoning decisions for non-DOE property.*

Table 6.7. LUCs for the UEFPC watershed (cont.)

[e] *Excavation/Penetration Permit Program—Refers to the internal DOE/DOE contractor administrative program(s) that requires permit requester to obtain authorization, usually in the form of a permit, before beginning any excavation/penetration activity (e.g., well drilling) for the purpose of ensuring that the proposed activity will not affect underground utilities/structures, or in the case of contaminated soil or groundwater, will not disturb the affected area without the appropriate precautions and safeguards.*

[f] *Signs—Posted command, warning, or direction*

[g] To prevent consumption of fish from UEFPC.

[h] Engineered Remedy is included in this table to be all inclusive of necessary verifications.

BSWTS = Big Spring Water Treatment System
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMTS = Central Mercury Treatment System
DOE = U.S. Department of Energy
EEVOC = East End Volatile Organic Compound
EM = Environmental Management or Oak Ridge Environmental Management
LUC = land use control
LUCIP = Land Use Control Implementation Plan
ROD = Record of Decision
TDEC = Tennessee Department of Environment and Conservation
UEFPC = Upper East Fork Poplar Creek
UU/UE = unlimited use/unrestricted exposure
WEMA = West End Mercury Area
Y-12 = Y-12 National Security Complex

Eastern S-3 Ponds Groundwater Plume remedy integrity

Eastern S-3 Groundwater Plume remedy integrity components are listed in Table 6.7 and described below.

Eastern S-3 Plume is a groundwater plume only and, therefore, the controls relevant to monitoring well inspections apply. The RAR CMP requires an annual comprehensive inspection including evaluation of well integrity (e.g. condition of cap and casing(s), presence of weep hole, well lock, well identification, concrete pad, guard posts, etc.), including below-grade components (as appropriate).

6.3.2.1 Status of LUCs

Status of Watershed-scale remedy integrity and LUCs

LUCs in UEFPC Phase I ROD areas were maintained, including signs to control access, surveillance patrols, and an ongoing EPP program. Maintenance of water treatment systems integrity (CMTS and BSWTS) are discussed in Section 6.3.1.2.1.2.

Property Record Restrictions have been recorded by DOE at the Anderson County Register of Deeds office for two parcels in the UEFPC that have been transferred for private sector operations/development. Information on these two parcels is contained in the 2016 FYR.

Status of New Hope Pond remedy integrity

All components of the New Hope Pond were inspected semiannually in FY 2018 by the Y-12 S&M Program, including erosion or settlement of the cover, integrity of surface drainage, evidence of rodent damage, proper signage, and integrity of benchmarks and monitoring wells. Maintenance of the remedy integrity in FY 2018 included replacing cap drain screens and unclogging cap drains, evaluating and filling several erosion areas, and replacing contact information on sign.

Status of Eastern S-3 Groundwater Plume remedy integrity

Monitoring wells associated with the Eastern S-3 Groundwater Plume were inspected annually in FY 2018 by the Y-12 S&M Program. No well maintenance was required in FY 2018.

6.4 PHASE II INTERIM RAs FOR CONTAMINATED SOILS AND SCRAPYARD IN UEFPC

The *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek, Oak Ridge, Tennessee* (DOE/OR/01-2229&D3), referred to as the UEFPC Phase II ROD, addresses contaminated soil, scrap, buried waste, and subsurface structures (including slabs) throughout the Y-12 industrial area, which is located in the UEFPC watershed. As stated on pages 1 – 3 of the ROD:

> *A primary objective of the remediation measures presented in this ROD is to protect industrial workers from exposure to hazardous substances at Y-12. The focus of efforts is aimed at eliminating or reducing existing contamination to below unacceptable risk-based levels for workers on-site. This is done through the remediation of areas of contamination and the application of LUCs, including institutional controls. Another objective in this ROD is to protect groundwater and surface water by removing contamination in soil, buried waste, or subsurface structures that could contribute to future contamination above unacceptable risk-based levels.*

The selected remedy includes the following principal actions (from pages 1 – 4 and 1 – 5 of the ROD):

- *Predesign characterization will be conducted to confirm and fully delineate areas of contamination and to identify sources of unacceptable releases to groundwater and surface water.*

- *Accessible unacceptably contaminated soils (defined as that not under buildings or critical active utilities or roads) exceeding the remediation level will be excavated to allow for controlled industrial[2] land use up to a depth of 2 ft. Accessible unacceptably contaminated soils in the easternmost areas of Y-12 will be excavated up to a depth of 10 ft to allow for more aggressive future DOE development. This remedy includes all Y-12 soils as, over time, currently inaccessible soil will become accessible and will be addressed. Removed soils that meet the waste acceptance criteria (WAC) at the Environmental Management Waste Management Facility (EMWMF) or another appropriate ORR disposal facility will be disposed at those facilities. If the soil does not meet the ORR WACs, the soil will be sent off-site for disposal.*

- *Accessible unacceptably contaminated soils exceeding the remediation levels for protection of groundwater and surface water will be excavated to the water table or bedrock to protect against unacceptable releases to underlying groundwater or surface water. Removed soils that meet the WAC at the EMWMF or another appropriate ORR disposal facility will be disposed at those facilities. If the soil does not meet the ORR WACs, the soil will be sent off-site for disposal.*

- *Scrap located in the Y-12 Salvage Yard will be removed. Scrap will be characterized and size-reduced as needed. Contaminated scrap that meets the WAC at the EMWMF or another appropriate ORR disposal facility will be disposed at those facilities. If the scrap does not meet the ORR WACs, it will be sent off-site for disposal.*

- *Limited groundwater monitoring near deep soil excavation areas will be conducted for a minimum of five years to assess the effectiveness of source removal to protect groundwater. Surface water monitoring is already being conducted under the Phase I ROD* (DOE/OR-01-1951&D3)*, and no additional surface water monitoring is included as part of this ROD.*

- *LUCs will be implemented to prohibit use of land for any non-industrial activity and to prevent unacceptable exposures to residual contamination in that area. The LUCs will extend to the entire Y-12 industrial area.*

Actions completed to date under the UEFPC Phase II ROD include the Y-12 Salvage Yard scrap removal, Y-12 Salvage Yard soil remediation and removal. An *Addendum to Phased Construction Completion Report for Y-12 Salvage Yard-Scrap Removal* (DOE/OR/01-2481&D1/A1) was approved in February 2014 for the disposal and removal of five tanks stored to the southwest of the West End Treatment Facility in order to reduce the potential for mercury releases and the potential for worker exposure to mercury vapor. There are no performance monitoring requirements or LUCs specified for any of these actions.

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[2]*Controlled industrial—defined by the Oak Ridge Reservation (ORR) End Use Working Group as industrial land use with excavation limited to 2 ft.*

6.4.1 LUCs

LUCs for UEFPC Phase II ROD areas are listed in Table 6.7 and described below.

Watershed-scale LUCs

The UEFPC Phase II ROD specifies LUCs will be implemented to prohibit use of land of any non-industrial activity and to prevent unacceptable exposures to residual contamination in that area. The LUCs include property record restrictions, property record notices, zoning notices, an EPP program, and continued existing surveillance patrols. There are no completed actions under this ROD that require additional LUCs.

6.4.1.1 Status of LUCs

Status of Watershed-scale LUCs

LUCs in UEFPC Phase II ROD areas were maintained in FY 2018. Protective controls to the workforce within the UEFPC area include surveillance patrols and an ongoing EPP program provided by the NNSA program at the site. While the EPP process was followed throughout Y-12 remediated areas, an incident was noted on October 8, 2018 at the Y-12 Biology Complex D&D Project during installation of a sanitary water line where the field team did not adequately implement the controls identified in the Job Hazard Analysis and a corrective action was implemented.

6.5 SINGLE-PROJECT ACTIONS IN THE UEFPC WATERSHED

6.5.1 EEVOC Plume

The EEVOC Plume (DOE/OR/01-1819&D2) extraction/treatment system began operation in 2000 to prevent further migration of the VOC-contaminated groundwater plume off the ORR. At the request of the regulators, the system operated for five years to evaluate performance before preparation and approval of the *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee* (EEVOC RmAR; DOE/OR/01-2297&D1). This EEVOC RmAR recommended continuation of the current plume interception system and specified evaluation of the system performance in the annual RER.

6.5.1.1 Performance monitoring

6.5.1.1.1 Performance monitoring goals and objectives

As specified in the *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee* (EEVOC AM; DOE/OR/01-1819&D2), the goals of the removal action are to reduce health and environmental risks associated with the migration of VOC-contaminated groundwater from the east end of Y-12, to reduce the potential risk from exposure to this contamination in offsite areas, and to mitigate offsite migration of contaminants. The remedy consists of continuous operation of a plume containment pumping well with air stripping of the pumped groundwater for VOC removal prior to discharge into UEFPC. No specific numeric performance standards were established. Existing human health or ecological risks specific to groundwater were evaluated during the UEFPC RI, and a *Union Valley Interim Study Remedial Site Evaluation* (Y/ER-206/R1) was incorporated into the removal action. The risk assessments presented in the Union Valley Interim Study addressed hypothetical risks related to groundwater use, as well as potential risk related to exposure to spring discharges in Union Valley.

System performance is measured by evaluating reductions in VOC concentrations downgradient of the extraction well (GW-845). The EEVOC RmAR identified changes to monitoring frequencies and analysis, which were implemented in FY 2007. As shown in Table 6.1, quarterly sampling is performed on extracted groundwater from GW-845 (system influent), with analysis including VOCs, metals, nitrate, and uranium. The same analysis is performed on the effluent from the treatment system discharging to UEFPC. The treatment system discharge measured at the downstream POC, monitoring location LRBP-1, must not exceed the applicable AWQC (16 µg/L carbon tetrachloride). Semiannual sampling is performed at the downgradient multiport well (GW-722) and downgradient well cluster (GW-169 and GW-170) for VOC analysis.

6.5.1.1.2 Evaluation of performance monitoring data

6.5.1.1.2.1 Groundwater

Figure 6.14 and Figure 6.15 show the EEVOC chlorinated hydrocarbon concentrations before pumping at well GW-845 was started in FY 2000, and in FY 2018 showing the region of maximum contaminant removal, respectively. Concentrations represent the sum of all detected VOCs. Although VOC contamination is widespread throughout the UEFPC watershed, two distinct local contaminant sources are evident near the EEVOC Plume containment pumping well – a carbon tetrachloride source near the southwestern portion of the plume and a strong source of PCE and TCE near the northwestern portion of the plume. Comparison of the two figures shows that the groundwater pump and treat system has decreased chlorinated VOC concentrations along the extent of the southern half of the plume, while concentrations along the northern edge have remained essentially constant. This contrast is attributed to the occurrence of less permeable bedrock at the base of the Maynardville Limestone near its contact with the Nolichucky Shale. The groundwater extraction system has effectively withdrawn contaminant mass from the more permeable limestone strata, but the contaminated groundwater is not as effectively withdrawn from the shale bedrock. PCE and TCE are detected at low concentrations in the extracted groundwater that is sent to the treatment system, suggesting that there is capture of that portion of the plume, although the mass removal is small.

Figure 6.16 shows the drawdown feature created by pumping of well GW-845 in plan view and in cross-sectional views. The asymmetrical drawdown feature is created because of the dipping attitude of bedrock and spatial variability of permeability. The screened interval of well GW-845 is 280 ft long, as shown in Figure 6.16, which allows the well to capture contaminants from a large vertical region in bedrock. This extensive vertical capture capability increases the likelihood that this system will intercept contaminants seeping eastward in the Maynardville Limestone from source areas to the west in the Y-12 industrial area.

As stated in the EEVOC AM, system performance is measured by evaluating reductions in VOC concentrations downgradient of the extraction well (GW-845). The EEVOC AM specified quarterly sampling and analysis at the extraction well; well GW-722, located approximately 180 m (600 ft) downgradient of the extraction well; and wells GW-169, GW-170, and GW-232, located about 730 m (2,400 ft) east along geologic strike in Union Valley. Additional analyses for uranium, mercury, and nitrate were specified to evaluate whether long-term pumping mobilizes metals, radiological contaminants, or nitrate from upgradient sources within Y-12, such as the former Oil Skimmer Basin located approximately 300 m (1,000 ft) west of well GW-845 (Figure 6.14 and Figure 6.15). Consistent with recommendations in the approved *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2289&D3) and EEVOC RmAR, sampling of well GW-232 in Union Valley has been discontinued and sampling frequency and target analytes at other wells specified in the AM have been modified.

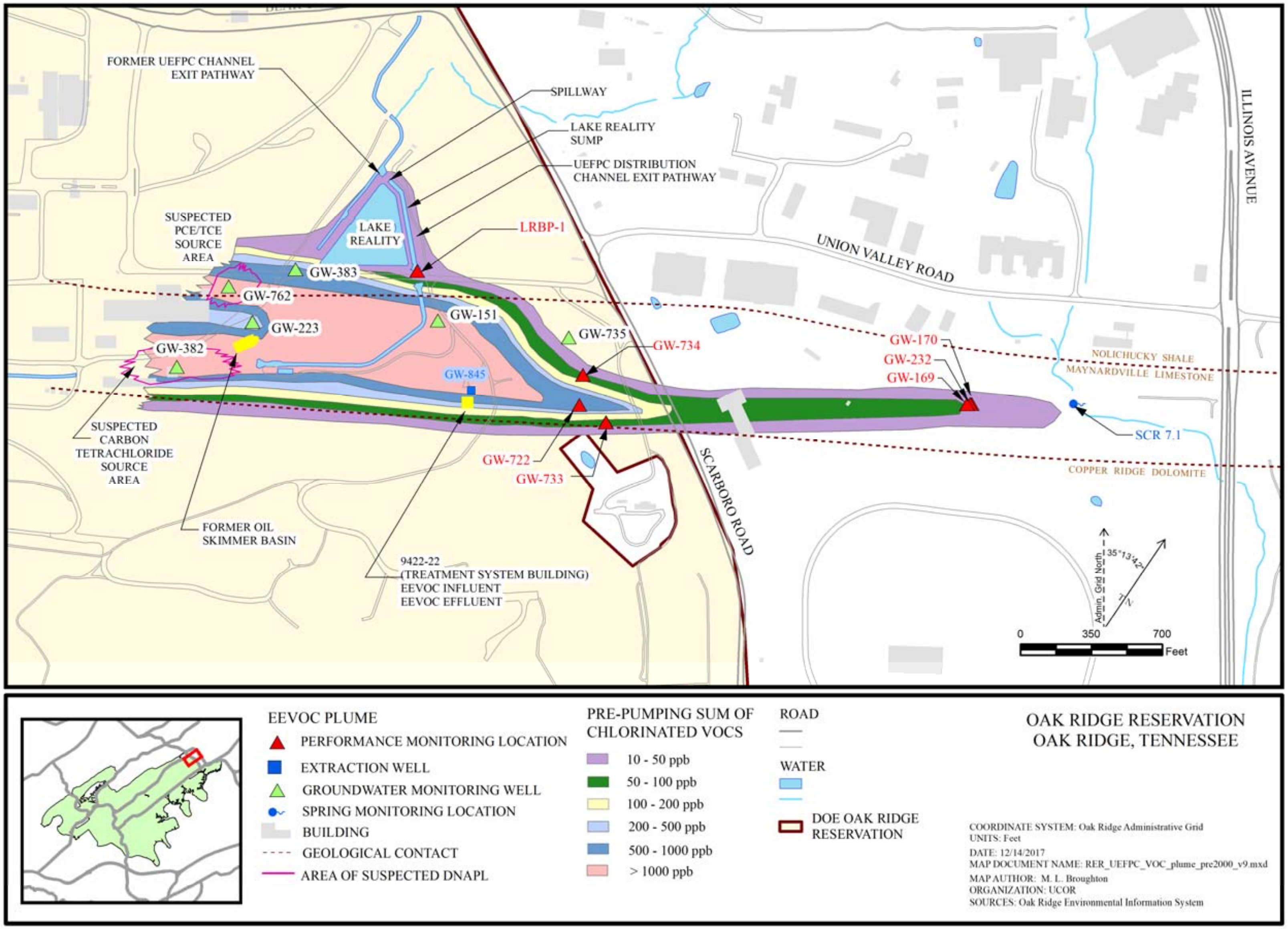

Figure 6.14. EEVOC Plume before pump and treatment system startup, 1998 – 2000.

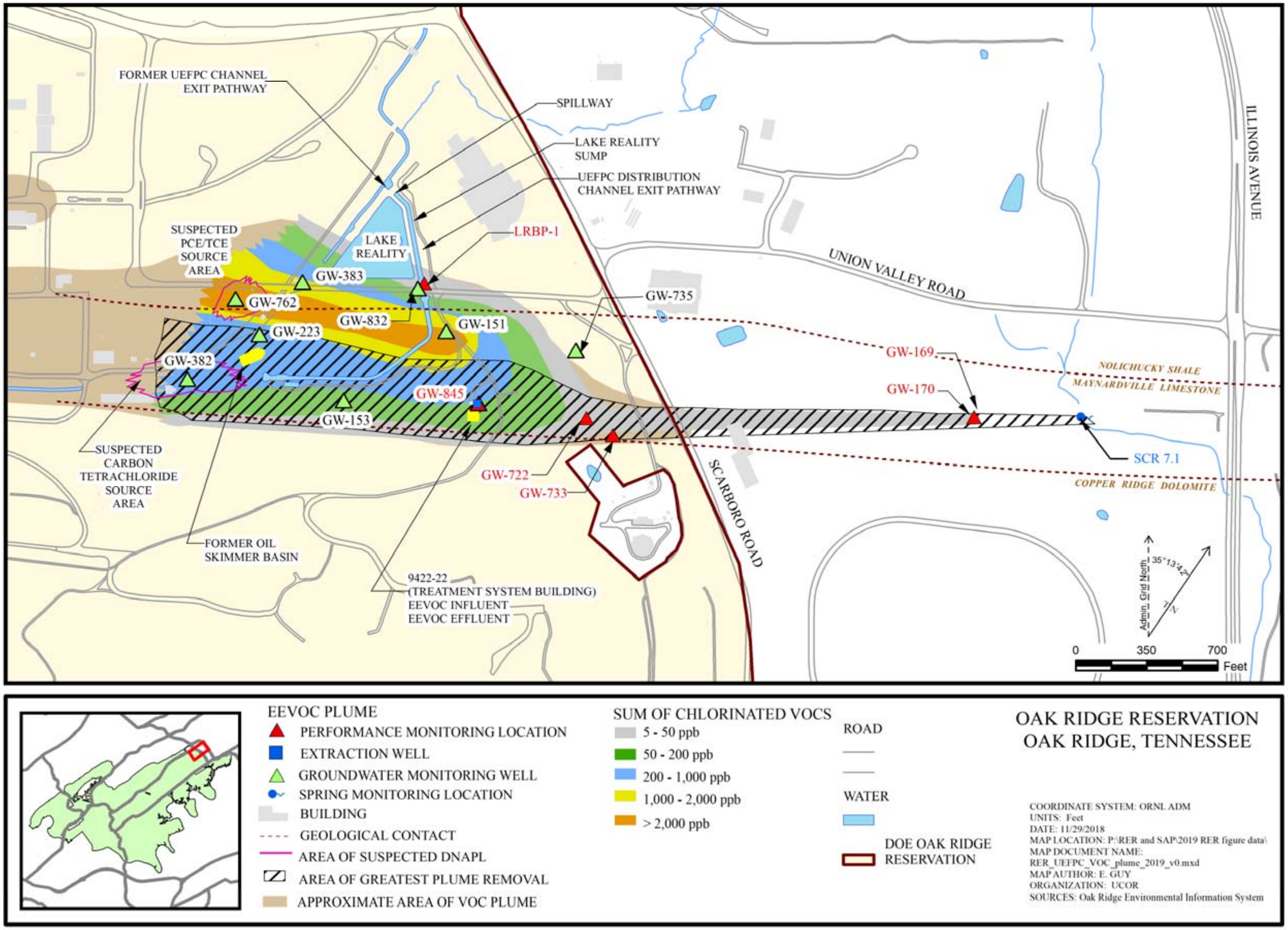

Figure 6.15. EEVOC Plume in FY 2018 showing region of maximum chlorinated VOC removal.

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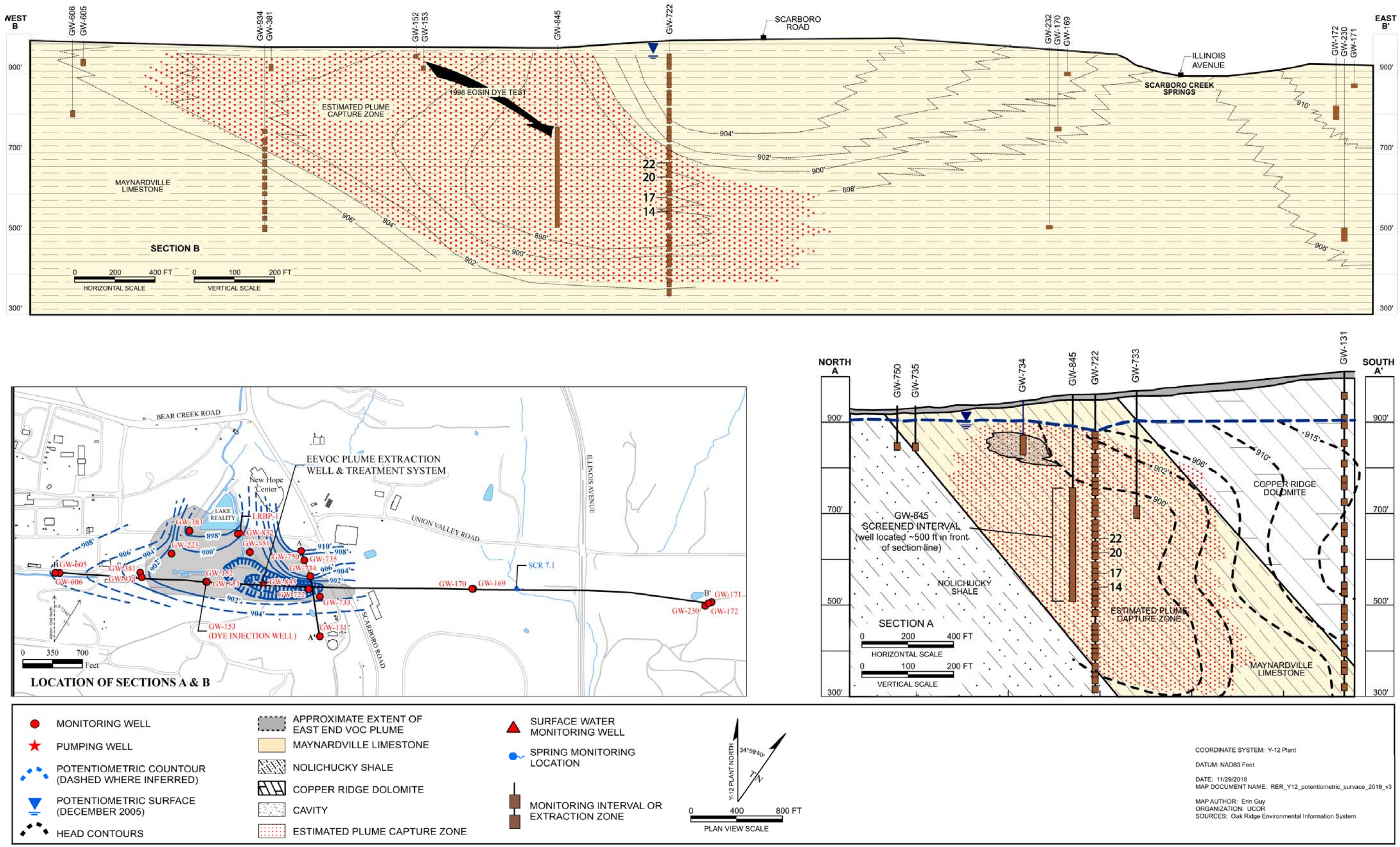

Figure 6.16. Potentiometric data and subsurface plume distribution for the EEVOC Plume at Y-12.

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Treated groundwater is continuously discharged into UEFPC. The EEVOC RmAR requires at least quarterly sampling and analysis of influent and effluent for VOCs, metal, nitrate, and uranium. The AWQC for carbon tetrachloride (currently 16 µg/L) is the ARAR for the treated discharge monitored at LRBP-1, the downstream POC.

6.5.1.1.2.1.1 Maynardville limestone exit pathway

The EEVOC influent station has a valved sample port that allows collection of water before treatment to represent groundwater concentrations from well GW-845 completed in the Maynardville Limestone exit pathway. Data obtained to date indicate that carbon tetrachloride concentrations in the pumping well have undergone a gradual decrease from concentrations greater than 200 µg/L to an average of 143 µg/L during FY 2018 with a range from 120 to 160 µg/L (Figure 6.17). Chloroform concentrations have stabilized at about 10 µg/L.

Signature VOCs within the intermediate and deep intervals of the Maynardville Limestone directly east of the pumping well (Figure 6.16) also decreased significantly relative to baseline data. This pathway is monitored via well GW-722 (Port 14 at 425 ft bgs, Port 17 at 385 ft bgs, Port 20 at 333 ft bgs, and Port 22 at 313 ft bgs). The ports discussed here contain the highest concentrations of contaminants. Other ports in well GW-722 are sampled by the Y-12 GWPP. That monitoring confirms that carbon tetrachloride, PCE, and TCE are generally not detected or occur at concentrations below MCLs in other ports since the pump and treatment operation started. The FY 2018 analytical results for several signature VOCs in well GW-722, Port 14 and Port 20, are in Table 6.8. Sample Port 20 has typically shown the highest VOC results; therefore, data from this sampling point are shown in Figure 6.17 to illustrate carbon tetrachloride and PCE trends over time. During the period of operation of the extraction system, carbon tetrachloride concentrations have decreased from the 200 – 1,000 µg/L range to less than 50 µg/L. PCE concentrations have decreased from levels of approximately 30 µg/L to recent levels (8.5 µg/L in February 2018) just slightly greater than the 5 µg/L MCL screening criteria. The other sampling zones in well GW-722 show similar decreases in VOC concentrations.

In Union Valley east of Scarboro Road (Figures 6.15 and 6.16), signature VOCs (Table 6.8) have historically been detected in wells GW-169 (water table interval screened between about 895 and 901 ft aMSL) and GW-170 (intermediate interval; open hole between about 800 and 827 ft aMSL), which are directly along strike to the east of Y-12. Well GW-170 has historically had the highest offsite levels of carbon tetrachloride and chloroform with highly variable concentrations, but with an overall decline since 1994. Since EEVOC operation started in 2000, carbon tetrachloride concentrations have stabilized at about 5 µg/L or less, and since about 2007, concentrations have further decreased to levels below 2 µg/L with some non-detect results. A sharp decrease of carbon tetrachloride concentrations occurred in well GW-170 prior to the EEVOC Plume treatment system start-up in October 2000, which correlated to an increase in pH. The available data suggest that water quality in the Union Valley area east of Illinois Avenue may have been affected by large-scale construction activities near Scarboro Road, resulting in elevated pH conditions and increased surface water dilution in the shallow and intermediate zones of the Maynardville Limestone in this area. Signature VOCs observed in well GW-169 have remained consistently low over time at between 1 and 4 µg/L. During FY 2018, carbon tetrachloride and chloroform were not detected in well GW-169, although PCE and TCE were detected at estimated concentrations less than 1 µg/L. No PCE or TCE degradation products, such as 1,2-DCE or VC, were detected.

Prior to implementation of the EEVOC remedy, carbon tetrachloride and TCE were regularly detected in water discharging at spring Scarboro Creek (SCR) 7.1. Subsequent to the EEVOC pumping and treatment, the detection of these signature contaminants at SCR 7.1 has been very infrequent and no VOCs were detected in the FY 2018 sample from the spring.

DOE samples three additional wells (GW-171, GW-172, and GW-230 shown on the inset map in Figure 6.16) in the Maynardville Limestone to the northeast of wells GW-169 and GW-170 and Illinois Avenue (approximately one mile from the EEVOC extraction well). These wells are located to the south of a former City of Oak Ridge sanitary landfill and a hardwood sawmill site. Sampling of these wells was initiated between 1990 – 1994 and each well has been sampled on 40 to 46 occasions. None of the samples have contained detectable carbon tetrachloride, chloroform, PCE, or TCE which are among the signature compounds in the Y-12 EEVOC Plume. The deepest well in the group (GW-230) samples water from an elevation range between 513 and 578 ft aMSL, which is consistent with the elevation of the EEVOC Plume where it is intercepted by the GW-845 extraction well and is detected in sampling zones in Westbay® well GW-722. However, low concentrations of benzene, chlorobenzene, toluene, cis-1,2-DCE, and VC are detected. None of these contaminants are present at concentrations greater than MCL screening criteria. The other two wells are shallow and do not exhibit detectable chlorinated VOCs. A complicating factor concerning interpreting data from these wells is their location in close proximity to the former sanitary landfill and sawmill sites.

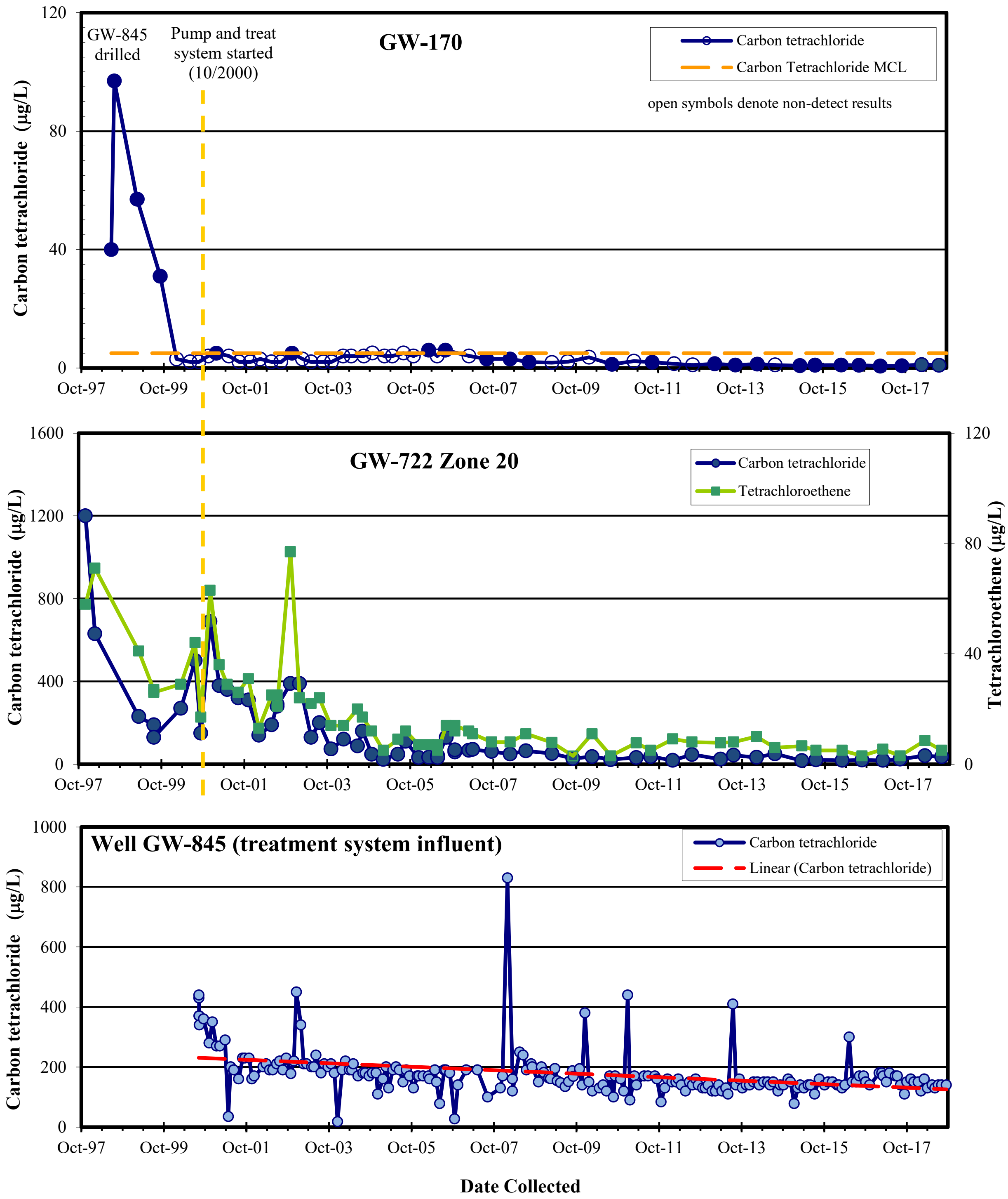

Figure 6.17. Selected VOC trends in the Maynardville Limestone exit pathway.

Table 6.8. Selected FY 2018 data for Y-12 EEVOC Plume performance

Chemical	Units	Sample name Sample date			
		GW-169 2/22/2018	GW-169 7/25/2018	GW-170 2/22/2018	GW-170 7/25/2018
Alpha activity (MCL = 15 pCi/L)	pCi/L	1.44 J	1.84 U	1.17 J	0.381 U
Chemical	**Units**	**Sample name Sample date**			
		GW-722-20 2/27/2017	**GW-722-20 7/24/2018**	**GW-722-14 2/27/2018**	**GW-722-14 7/18/2018**
Carbon tetrachloride (MCL = 5 µg/L)	µg/L	41	35	10	5
Chloroform (MCLG = 70 µg/L)	µg/L	6.2	6	1.8	5 U
PCE (MCL = 5 µg/L)	µg/L	8.5	5 J	1.7	5 U
TCE (MCL = 5 µg/L)	µg/L	2.4	2 J	0.93 J	5 U

EEVOC = East End Volatile Organic Compound
FY = fiscal year
GW = groundwater well
J = estimated value
MCL = maximum contaminant level
MCLG = maximum contaminant level goal
PCE = tetrachloroethene
TCE = trichloroethene
U = not detected
Y-12 = Y-12 National Security Complex

6.5.1.1.2.1.2 Treatment system performance

Treatment system performance monitoring began in November 2000, following startup. Figure 6.18 shows the cumulative actual EEVOC treated water volume in FY 2018. During FY 2018, the treatment system operated well with one 2+ day outage in November to replace an air stripper pump level sensor, a one day outage in January for maintenance of an air stripper sump pump, and a one day outage in April due to a power outage.

To evaluate the effectiveness of the treatment system, influent and corresponding effluent samples have been collected since operations began. In FY 2018, concentrations of carbon tetrachloride in treatment system influent (from well GW-845) ranged from 120 µg/L to 160 µg/L and averaged 143 µg/L for the year (Table 6.9). The concentration range for carbon tetrachloride in the effluent stream ranged from 0.32 U µg/L to 15 µg/L and averaged 5.2 µg/L. Removal efficiency for carbon tetrachloride ranged from about 92% to >99% and averaged about 96% in FY 2018, while removal efficiency for chloroform ranged from 68% to >97% and averaged about 82%. Table 6.10 summarizes total mass removals for the principal VOCs since operations began in 2000. Facility operators have increased maintenance activities on the air stripper, which results in improved VOC removal efficiency.

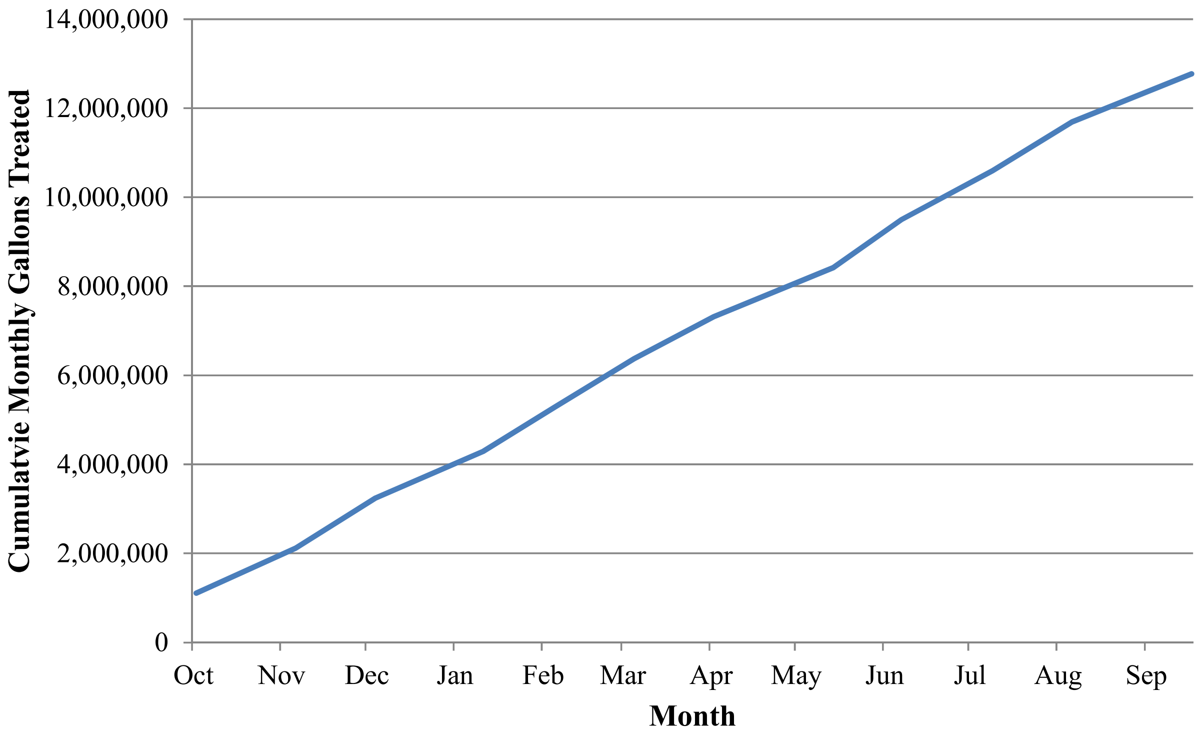

Figure 6.18. EEVOC treatment system cumulative monthly water volume treated during FY 2018.

Effluent concentration limits were not stipulated for the treatment system. However, to maintain protectiveness of the environment and to monitor the effectiveness of the treatment system, the EEVOC treatment system effluent is sampled and analyzed monthly for VOCs. At the LRBP-1 instream POC sample location, VOCs are analyzed monthly. All monthly EEVOC treatment system effluent samples collected during FY 2018 except the field duplicate October 2017 sample contained carbon tetrachloride at levels equal to or less than the AWQC value of 16 µg/L. The October 2017 regular sample carbon tetrachloride concentration was 0.96 J µg/L while the field duplicate sample contained 28 µg/L.

Maximum FY 2018 results of selected organic and radiological constituents in both influent and effluent samples are presented in Table 6.11. Reductions observed for other signature VOCs detected in the influent stream (Table 6.9 and Table 6.11) are consistent with the relative ranking of their volatility, as indicated by their respective Henry's Law constants (i.e., carbon tetrachloride >PCE >chloroform).

Table 6.9. EEVOC Plume treatment system performance data, FY 2018

Chemical	Date	Influent result (µg/L)	Effluent result (µg/L)	Percent reduction	Estimated net mass removal (kg)[a]
Carbon tetrachloride	10/2/2017	150	0.32 U	>99%	0.629
	11/6/2017	160	1.3	99%	0.607
	12/4/2017	150	12	92%	0.588
	1/11/2018	150	6.4	96%	0.568
	2/5/2018	120	0.82	99%	0.446
	3/5/2018	160	5.8	96%	0.639
	4/2/2018	130	1.6	99%	0.456

Table 6.9. EEVOC Plume treatment system performance data, FY 2018 (cont.)

Chemical	Date	Influent result (µg/L)	Effluent result (µg/L)	Percent reduction	Estimated net mass removal (kg)[a]
	5/14/2018	140	15	89%	0.523
	6/7/2018	130	2.7	98%	0.520
	7/9/2018	140	2.3	98%	0.571
	8/6/2018	140	2.7	98%	0.571
	9/17/2018	140	12	91%	0.522
FY 2018 annual average:		**143**	**5.2**	**96%**	
FY 2018 annual mass removal:					**6.6 kg**
Chloroform	10/2/2017	9.7	0.3 U	>97%	0.039
	11/6/2017	9.5	0.78 J	92%	0.033
	12/4/2017	11	2.9	74%	0.034
	1/11/2018	10	2.2	78%	0.031
	2/5/2018	7.5	0.64 J	91%	0.026
	3/5/2018	9.8	2	80%	0.032
	4/2/2018	9.2	0.99 J	89%	0.029
	5/14/2018	9.6	3.1	68%	0.027
	6/7/2018	9.7	1.4	86%	0.034
	7/9/2018	8.5	1.2	86%	0.030
	8/6/2018	8.5	1.3	85%	0.030
	9/17/2018	10	3	70%	0.029
FY 2018 annual average:		9.4	1.7	82%	
FY 2018 annual mass removal:					**0.4 kg**
PCE	10/2/2017	24	0.3 U	>99%	0.100
	11/6/2017	20	0.36 J	98%	0.075
	12/4/2017	23	2.6	89%	0.087
	1/11/2018	22	1.6	93%	0.081
	2/5/2018	19	0.3 U	>98%	0.070
	3/5/2018	20	1.3	94%	0.077
	4/2/2018	21	0.35 J	98%	0.073
	5/14/2018	23	3.3	86%	0.082
	6/7/2018	18	0.54 J	97%	0.071
	7/9/2018	21	0.63 J	97%	0.084
	8/6/2018	21	0.69 J	97%	0.084
	9/17/2018	18	2.3	87%	0.064
FY 2018 annual average:		**21**	**1.2**	**94%**	
FY 2018 annual mass removal:					**0.95 kg**

[a]Estimated net mass removal is based on treated volume for the sample month. Influent and effluent concentrations are assumed to be applicable to total treated volume.

Table 6.9. EEVOC Plume treatment system performance data, FY 2018 (cont.)

EEVOC = East End Volatile Organic Compound
FY = fiscal year
J = estimated value
PCE = tetrachloroethene
U = not detected

Table 6.10. Estimated mass removals for key EEVOC Plume constituents since inception of treatment operations

FY	Carbon tetrachloride (kg)	PCE (kg)	Chloroform (kg)
2001	9.2	0.74	0.81
2002	7.7	0.81	0.39
2003	9.9	1.03	0.44
2004	7.4	0.83	0.27
2005	6.3	0.86	0.29
2006	6.7	0.86	0.34
2007	5.7	0.63	0.22
2008	7.2	1.1	0.37
2009	6.8	0.88	0.20
2010	4.9	0.68	0.21
2011	2.7	0.31	0.04
2012	5.5	0.73	0.22
2013	3.9	0.64	0.19
2014	5.1	0.72	0.23
2015	5.1	0.77	0.26
2016	7.5	1.5	0.83
2017	6.0	0.74	0.3
2018	6.6	0.95	0.4
Totals	114	14.8	5.9

EEVOC = East End Volatile Organic Compound
FY = fiscal year
PCE = tetrachloroethene

Table 6.11. Summary of EEVOC Plume groundwater treatment system performance results, FY 2018

Analyte	Units	Maximum influent result (GW-845)	Maximum effluent result
2-Butanone	µg/L	15 U	3 U
Carbon tetrachloride	µg/L	160	15
Chloroform	µg/L	11	3.1
1,1-DCA	µg/L	0.39 J	0.3 U
1,1,1-TCA	µg/L	1.5 U	0.3 U
Cis-1,2-DCE	µg/L	4.6 J	1.1
Trans-1,2-DCE	µg/L	1.6 U	0.33 U
PCE	µg/L	24	3.3
TCE	µg/L	7.2	0.88 J
Nitrate[a]	mg/L	2.1	2.1
Total uranium[a]	mg/L	0.0042 J	0.004 J
U-234[a]	pCi/L	4.34 J	4.45 J
U-235[a]	pCi/L	0.367 J	0.313 J
U-238[a]	pCi/L	2.56	2.38

[a]Note system design and remedy is targeted for VOCs.

DCA = dichloroethane
DCE = dichloroethene
EEVOC = East End Volatile Organic Compound
FY = fiscal year
GW = groundwater well
J = estimated value
PCE = tetrachloroethene
TCA = trichloroethane
TCE = trichloroethene
U = not detected
VOC = volatile organic compound

During FY 2018, monitoring data for treatment system influent show that U-234 and U-238 reached their highest activities for the year in February. Figure 6.19 is a graph of the measured activities of U-234 and U-238 throughout the EEVOC treatment system operations through FY 2018. Table 6.11 includes the maximum EEVOC treatment system influent and effluent uranium isotopic activities. The uranium concentration calculated from the isotopic activities in influent and effluent ranged from about 1 to 5 µg/L and averaged 4 µg/L during FY 2018. These levels are much less than the 30 µg/L MCL reference concentration. Based on the monthly groundwater withdrawal rate throughout FY 2018, the estimated uranium mass discharged from the EEVOC system was approximately 0.20 kg for the year. This mass is a minor contribution to the yearly uranium mass measured at Station 17 (Section 6.3.1.2.1.2). During FY 2018, the strong seasonal fluctuations of uranium concentrations noted over the past several years continued, with higher activities measured during winter and spring than during summer and early autumn. This cyclic contaminant concentration signature is indicative of the role of dynamic groundwater plume transport in response to seasonal climatic drivers.

The EEVOC AM acknowledged the potential for other contaminants to increase in the EEVOC collected groundwater over time as a result of the groundwater withdrawals. The AM recognized the possibility that the treatment process can be modified to accommodate treatment of other contaminants, as warranted.

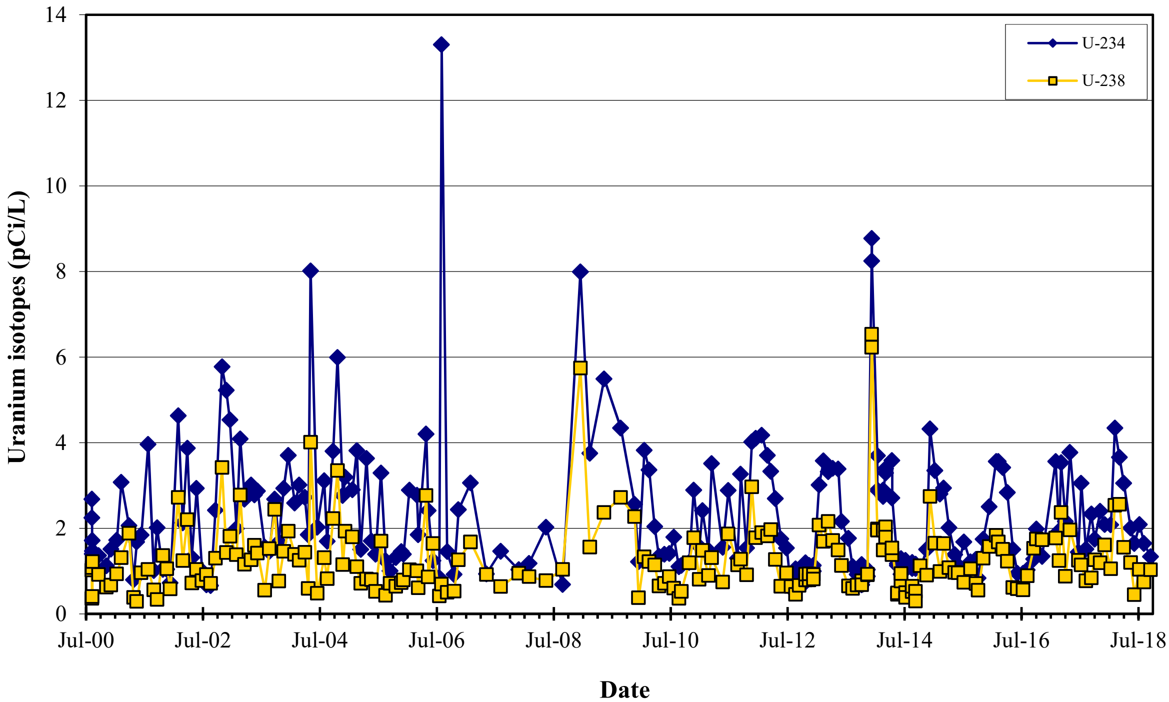

Figure 6.19. Activities of U-234 and U-238 in EEVOC treatment system influent.

6.5.1.2 Remedy integrity

The remedy integrity components for EEVOC Plume treatment system are listed in Table 6.7 and described below.

Other than maintenance of the EEVOC Plume treatment system discussed above in Section 6.5.1, no requirements were specified in the EEVOC AM.

6.5.1.3 Status of remedy integrity

Although no requirements are specified other than maintenance of the EEVOC Plume treatment system, the site remained protected by the DOE 229 Boundary access controls (this security boundary is designated pursuant to Section 229 of the Atomic Energy Act of 1954 which prohibits unauthorized entry) and was regularly patrolled by security personnel. In addition, groundwater use remained restricted within Y-12 and Union Valley.

6.5.2 Union Valley

Location of the *Record of Decision for an Interim Action for Union Valley, Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (Union Valley Interim Action; DOE/OR/02-1545&D2) is shown on Figure 6.1. The primary objective of this interim action was to protect human health from a contaminated plume originating from beneath Y-12 and detected in the groundwater below privately owned land in Union Valley.

6.5.2.1 Performance monitoring

Institutional controls were selected as the interim remedy to ensure that public health is protected while final actions are being developed and implemented and to identify and prohibit, if necessary, future activities with a potential to accelerate the rate of contaminant migration from the contaminated area or increase the extent of the contaminant plume.

No surface water or groundwater monitoring is required as part of this interim action. An associated action, the EEVOC Plume removal action, included construction of a groundwater treatment facility to prevent further migration of the VOC-contaminated groundwater plume off the ORR into Union Valley. The EEVOC Plume performance monitoring objectives are discussed in Section 6.5.1.1.1.

6.5.2.2 LUCs

LUCs for Union Valley are listed in Table 6.7 and described below.

The Union Valley Interim Action requires that DOE ensure that the required property title searches and appropriate notifications are made until a final ROD is issued for the UEFPC contaminated area. DOE is responsible for the following institutional controls:

- Complete an annual title search by the anniversary date of the ROD to determine whether any affected property has changed hands;
- Notify property owners, the Oak Ridge city manager, and the TDEC/DOE Oversight Office of their obligations under the agreements and update them on the status of the environmental investigations;
- Survey owners by telephone to determine whether any new groundwater wells have been constructed or planned or there are any new uses for surface water; and
- Notify licensed well drillers in Tennessee of the license agreements and their terms.

6.5.2.2.1 Status of LUCs

Compliance with all requirements was verified in FY 2018. The WRRP ensured that property owners, the Oak Ridge City Manager, and TDEC/DOE Oversight Office, now called TDEC, Division of Remediation Oak Ridge Office, had been notified of their respective obligations and that Tennessee licensed well drillers were notified of the license agreements and terms. Documentation that all required title searches were conducted and that property owners were surveyed by telephone, as required, was provided by the WRRP in conjunction with DOE Realty Office. A copy of the documentation is maintained by the WRRP for use in the annual RER, and verification by WRRP is tracked in LUM.

6.6 UEFPC WATERSHED ISSUES AND RECOMMENDATIONS

The are no issues and recommendations for the UEFPC watershed (Table 6.12).

Table 6.12. UEFPC watershed issues and recommendations

Issue[a]	Action/recommendation	Responsible parties Primary/support	Target response date
New issue			
None			
Issues carried forward[b]			
None			
Completed/resolved issues			
None			

[a]A "New Issue" is an issue identified during evaluation of FY 2018 data for inclusion in the 2019 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year of the RER in which the issue originated is provided in parentheses, e.g., (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report
UEFPC = Upper East Fork Poplar Creek

6.7 REFERENCES

DOE/OR/01-1641/V1-V4&D1. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1998, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1819&D2. *Action Memorandum for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, 1999, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1951&D3. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1951&D3/R2. *Non-Significant Change to the Record of Decision for Phase 1 Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2229&D3. *Record of Decision for Phase II Interim Remedial Actions for Contaminated Soils and Scrapyard in Upper East Fork Poplar Creek, Oak Ridge, Tennessee,* 2006, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2289&D3. *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2297&D1. *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee*, 2006, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2456&D1/R1. *Removal Action Report for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment, Oak Ridge, Tennessee*, 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2466&D4. *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2481&D1/A1. *Addendum to the Phased Construction Completion Report for Scrap Metal Removal at the Y-12 Old Salvage Yard, Y-12 National Security Complex, Oak Ridge, Tennessee,* 2013, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2539&D2. *Explanation of Significant Differences for the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2605&D2. *Strategic Plan for Mercury Remediation at the Y-12 National Security Complex, Oak Ridge, Tennessee*, 2014, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge TN.

DOE/OR/01-2697&D2. *Amendment to the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee, Water Treatment at Outfall 200*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee,* 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2735&D2. *Remedial Design Report/Remedial Action Work Plan for Water Treatment at Outfall 200 in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1545&D2. *Record of Decision for an Interim Action for Union Valley, Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR-1014. *Federal Facility Agreement for the Oak Ridge Reservation*, 1992, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.
URL: http://sharetngov.tnsosfiles.com/sos/rules/0400/0400-40/0400-40-03.20150406.pdf.

Peterson, M.J., R.A. Efroymson, and S.M. Adams. 2011. *Long-Term Biological Monitoring of an Impaired Stream; Synthesis and Environmental Management Implications*. Environmental Management 47:6: 1125-1140.

Peterson, M.J, T.J. Mathews, R.A. McManamay, R.T. Jett, N.J. Jones, M.W. Jones, A.M. Fortner, and G.W. Morris. 2018. Y-12 National Security Complex Biological Monitoring and Abatement Program—2017 Calendar Year Report. ORNL/SPR-2018/886. July 2018. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

TDEC 2010a. Proposed Total Maximum Daily Loads for Polychlorinated Biphenyls and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee.

TDEC 2010b. Proposed Total Maximum Daily Loads for Polychlorinated Biphenyls and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, Meigs, Morgan, Rhea, and Roane Counties, Tennessee.

TDEC 2010c. Proposed Total Maximum Daily Loads for Polychlorinated Biphenyls and Chlordane in Fort Loudon Reservoir: Fort Loudon Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee.

TDEC 2015. State of Tennessee Water Quality Standards, Chapter 0400-40-03, General Water Quality Criteria, April 2015. Tennessee Department of Environment and Conservation, Division of Water Pollution Control.

TNHW-113. *RCRA Post-Closure Permit for the Upper East Fork Poplar Creek Hydrogeologic Regime*, 2003, Y-12 National Nuclear Security Complex, Oak Ridge, Tennessee, EPA I.D. No. TN3 89 009 0001, September 2003, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

Y/ER-206/R1. *Union Valley Interim Study Remedial Site Evaluation, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge TN.

7. OFFSITE

7.1 INTRODUCTION AND STATUS

7.1.1 Introduction

The CERCLA actions evaluated in this chapter are located outside the ORR boundary, and therefore are referred to as "offsite" actions. These areas are included in the Oak Ridge NPL Site and are listed in the FFA Appendix C. Figure 7.1 shows locations of the offsite CERCLA actions that have required monitoring or LUCs. In subsequent sections, the effectiveness of each completed action is assessed by reviewing performance monitoring objectives and results and verifying LUCs.

Poplar Creek, the Clinch River, and LWBR comprise a single, hydrologically connected system through which contaminants originating on the ORR are transported. However, the CERCLA decisions and evaluations of effectiveness are discussed separately (Clinch River/Poplar Creek, Section 7.4 and LWBR, Section 7.5).

Table H.6 in Appendix H lists all completed offsite CERCLA actions and the corresponding completion documents, and identifies whether monitoring or LUCs are required. Figure H.6 in Appendix H is a location map of the actions. For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions for offsite actions is provided in Chapter 4 of Volume 1 of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

7.1.2 Status Update

During FY 2018, no additional CERCLA actions were implemented or completed, nor were any associated FFA documents submitted or approved for offsite CERCLA actions. Monitoring in support of performance assessments and evaluations continued.

7.2 ASSESSMENT SUMMARY

A summary of the offsite assessment for FY 2018 is provided below, followed by more detailed evaluations.

7.2.1 Performance Summary

LEFPC. Monitoring at Station 17 is conducted to measure the concentration and mass flux of mercury that is discharged from the UEFPC watershed into LEFPC. During FY 2018, the flow-paced continuous monitoring detected an average concentration of 1,860 ng/L, up from 856 ng/L in FY 2017, and a mass flux of 12.4 kg mercury, up from 8.3 kg in FY 2017 (Section 6.3.1). The levels of mercury in fish tissue in the LEFPC have remained elevated in comparison to fish from reference streams. In fall 2017 in LEFPC, fish concentrations were higher (up to approximately 50% higher at some sites, ranging from 1.2 – 1.4 µg/g depending on species) than they have been in recent years (approximately 0.8 – 1.0 µg/g).

Clinch River/Poplar Creek. Performance monitoring of the Clinch River and Poplar Creek continues to indicate an overall downward trend in fish PCB concentrations. The decreasing PCB trends in fish are some of the most dramatic observed by the long-running Oak Ridge biological monitoring programs. Large striped bass from the Clinch River appear to be the species of greatest concern relative to PCBs. Mercury concentrations in fish at monitored sites continue to indicate the influence of mercury sources from EFPC, with elevated levels in fish in Poplar Creek and lower levels downstream. The ROD goal of evaluating changes in fish contaminant levels and how those levels compare to fish advisory limits continues to be addressed with monitoring.

LWBR. Performance monitoring results from LWBR obtained during FY 2018 continue to indicate that PCB levels in fish are decreasing from historical levels.

7.2.2 LUC Protectiveness

All LUCs determined necessary for protection of the environment and/or human health are in place and have been maintained.

7.3 LEFPC

7.3.1 Performance Monitoring

7.3.1.1 Performance monitoring goals and objectives

The *Record of Decision for Lower East Fork Poplar Creek, Oak Ridge, Tennessee* (LEFPC ROD; DOE/OR/02-1370&D2) addressed the mercury contamination in the floodplain sediments of the creek that runs from Y-12 (in the UEFPC watershed) through the city of Oak Ridge to the confluence of the LEFPC with Poplar Creek at ETTP (Figure 7.2). The ROD identified two primary areas of the floodplain that required excavation of mercury-contaminated soils >400 ppm (mg/kg): an area located at the National Oceanic and Atmospheric Administration site, and another area located farther downstream known as the Bruner site (Figure 7.1). A revised version of the *Remedial Action Report on the Lower East Fork Poplar Creek Project, Oak Ridge, Tennessee* (LEFPC RAR; DOE/OR/01-1680&D5) action was approved in 2000.

A major component of the selected remedy for LEFPC was to perform appropriate monitoring to ensure effectiveness. The LEFPC RAR provides a description of all measures taken during the remedial activities to comply with ARARs and supplemental monitoring activities. During FY 2018, mercury inputs from UEFPC to LEFPC were monitored at Station 17 to meet the requirements defined by the *Record of Decision for Phase I Interim Source Controls Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (UEFPC Phase I ROD; DOE/OR/01-1951&D3). The LEFPC ROD or RAR do not stipulate monitoring beyond five years.

7.3.1.2 Evaluation of performance monitoring data

As a requirement of the LEFPC RAR, mercury releases from Y-12 have been, and continue to be, measured at Station 17, the point at which the government land transitions to city property along LEFPC (Figure 7.2). A full discussion of the historical and current trends in mercury releases at Station 17 is presented in Section 6.3.

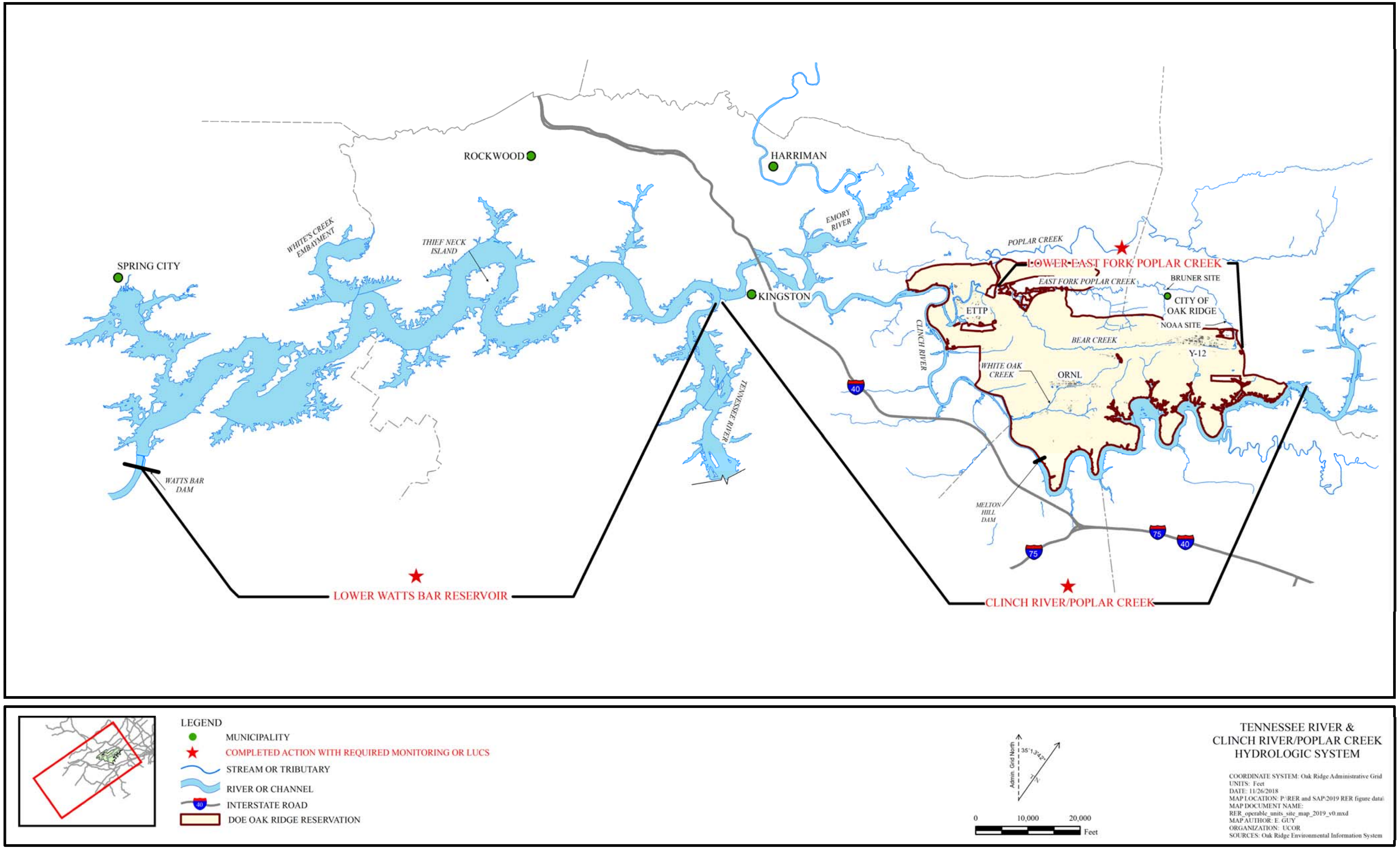

Figure 7.1. Completed CERCLA actions at offsite locations with required monitoring or LUCs.

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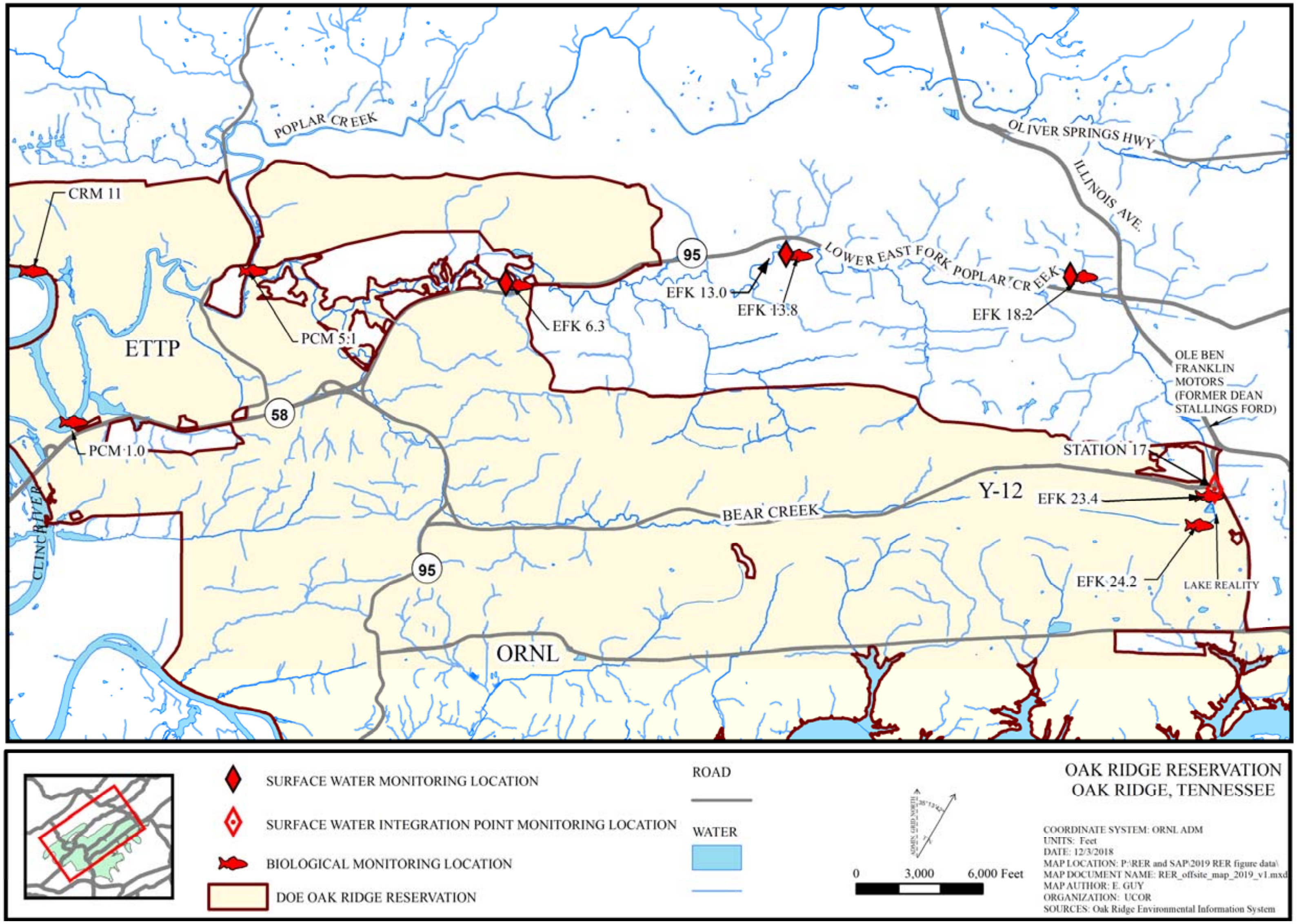

Figure 7.2. Monitoring locations in LEFPC.

The effect of the upstream mercury source on LEFPC and downstream spatial trends in mercury bioaccumulation in various sunfish species (rock bass, redbreast, and bluegill) are depicted in Figure 7.3. Although there is variability in mercury concentrations between sites and species of fish, mercury concentrations are highest in fish that feed at higher trophic levels such that concentrations in rock bass >redbreast >bluegill collected at the same site and season. In FY 2018, concentrations in redbreast (mean concentration 1.16 $\pm$ 0.12) and rock bass (mean concentration 1.46 $\pm$ 0.24) were highest at EFK 6.3, the lowermost site monitored on EFPC.

Mercury concentrations in sunfish in Poplar Creek (mean concentration 0.61 µg/g at Poplar Creek mile [PCM] 5.1) were lower in FY 2018 than in FY 2017, but still two-fold higher than the EPA's recommended mercury AWQC of 0.3 µg/g in fish fillets (the criterion here is used for comparison purposes, and is not a requirement of the ROD). Mean concentrations in bluegill collected in lower Poplar Creek (PCM 1) were higher in FY 2018 than in FY 2017, averaging 0.30 µg/g just at EPA's recommended criterion. Regardless of the sunfish species, it is evident that the mercury content in fillets of sunfish is above EPA's recommended AWQC of 0.3 µg/g mercury in fish throughout LEFPC and Poplar Creek but decreases below this threshold within a few kilometers downstream in the Clinch River.

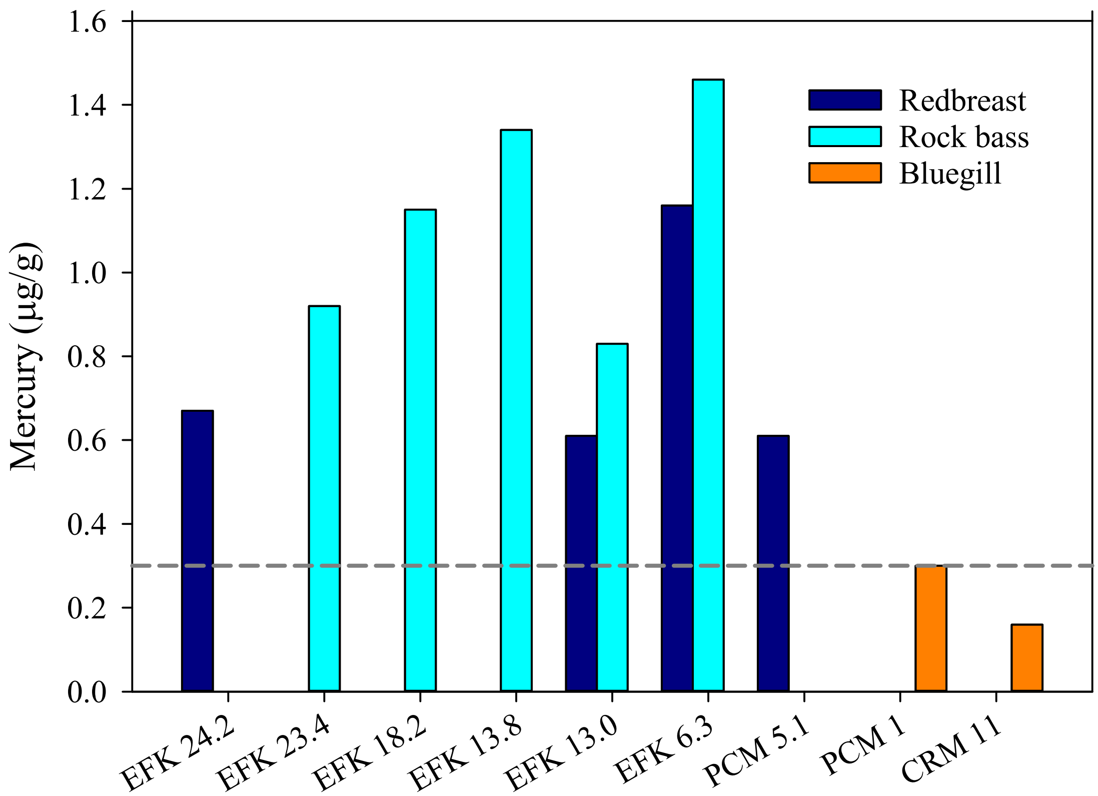

Figure 7.3. Spatial pattern of mercury bioaccumulation in various fish species in LEFPC (EFK), Poplar Creek (PCM) and the Clinch River (Clinch River mile) in FY 2018.

Dashed line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

At EFK 6.3, the long-term trend since the 1980s is of increasing mercury concentrations in fish (Southworth et al., 2011; Figure 7.4). However, trend analysis is again complicated by the change in fish species availability. If considering redbreast or rock bass temporal trends only, there is no clear evidence of an increasing or decreasing trend in recent years (especially over the 2003 – 2018 time period). Rock bass and redbreast mercury concentrations in fall 2017 (FY 2018) increased significantly over values reported in fish over the last three to four years (Figure 7.4). Rock bass fillet concentrations in fall 2017 in the lower stretches of the creek (EFK 13.8 and EFK 6.3) are among the highest on record (Figure 7.3 and Figure 7.4; Peterson et al., 2018). The reasons for the downstream increases in fish mercury concentrations are unknown but may be related to multiple factors including the cessation of flow augmentation in UEFPC which could have affected habitat and mercury dissolution and methylation dynamics. It will be interesting to see if the significant increases seen in aqueous mercury concentrations in 2018 in UEFPC (Chapter 6) affect mercury bioaccumulation in fish in LEFPC over the next one to two years.

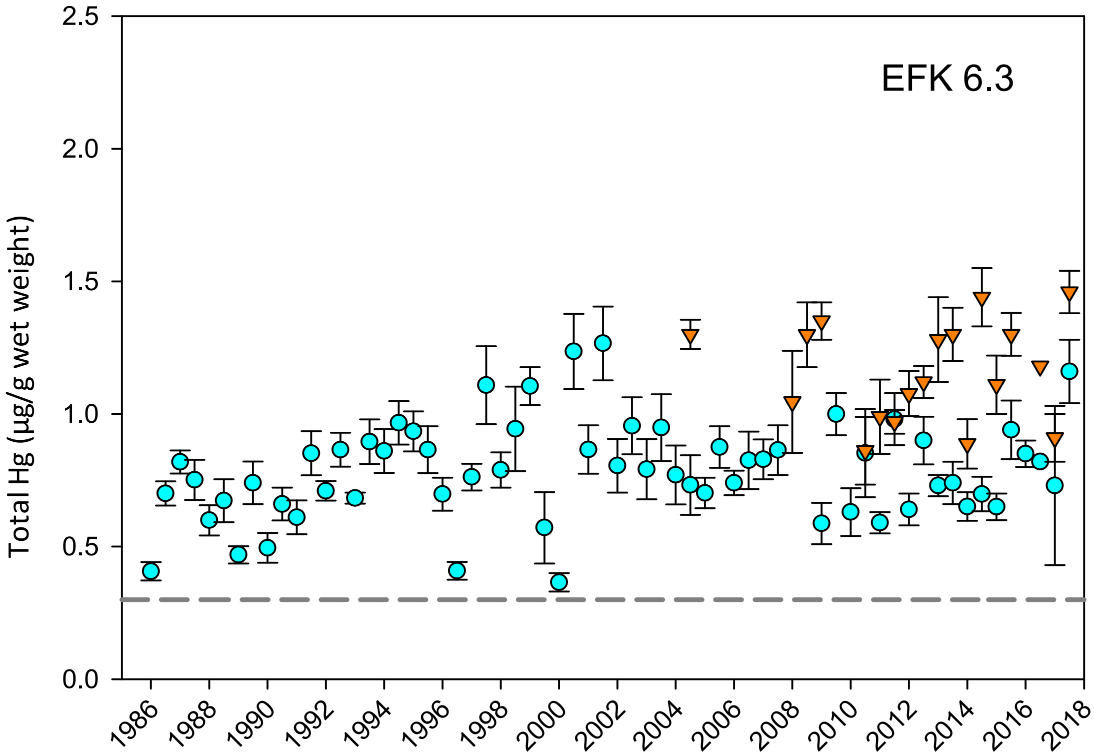

Figure 7.4. Mean mercury concentration (± standard error) in muscle tissue of redbreast sunfish (light blue circles) and rock bass (orange triangles) at EFK 6.3.[a]

[a]Dashed line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

7.3.2 LUCs

LUCs for LEFPC are listed in Table 7.1 and described below.

The LEFPC ROD states that although residential use of soil horizon (shallow) groundwater is not realistic, as a safeguard, DOE will monitor to detect any future residential use of shallow groundwater.

The LEFPC RAR requires an annual survey to verify land use in the area of the former Dean Stallings Ford (Figure 7.2) automobile dealership parking lot has not changed since the issuance of the ROD and exposure pathways remain protected. Additionally, the 2011 FYR identified that the property is for sale and that could result in a change in land use. It was stated that if changes occur DOE will evaluate the need for additional institutional controls and other response activities. However, Dean Stallings Ford is now closed and the property (Parcel No. 105D A 016.00) was leased to Ole Ben Franklin Motors, a used car dealership, in January 2014. The contamination remaining under the asphalt lot should not cause problems but would need to be disclosed in the event that the property is sold, and would need to be addressed in the event that the asphalt is removed.

The verification of this LUC is tracked in LUM.

7.3.2.1 Status of LUCs

To meet the requirement that DOE monitor to detect any residential use of shallow groundwater, a periodic survey to detect residential use of shallow groundwater was performed in FY 2018. There were no new wells identified for residential use along LEFPC.

Visual inspections in FY 2018 confirmed that land use of the property of the former Dean Stallings Ford automobile dealership has not changed. The area continues to be leased to Ole Ben Franklin Motors used car dealership that opened for business in January 2014.

7.4 CLINCH RIVER/POPLAR CREEK

7.4.1 Performance Monitoring

7.4.1.1 Performance monitoring goals and objectives

The Clinch River/Poplar Creek OU addresses the sediments and biota from the Clinch River mile (CRM) 0.0 at the confluence of the Clinch and Tennessee rivers, upstream past the Melton Hill Reservoir dam at CRM 23.1 to the upstream boundary of the ORR at CRM 43.7 near the Solway Bridge (Figure 7.5). The Clinch River/Poplar Creek OU also includes the Poplar Creek embayment from the creek mouth at CRM 12.0, upstream to its confluence with LEFPC at PCM 5.5 (Figure 7.2).

A major component of the *Record of Decision for the Clinch River/Poplar Creek Operable Unit, Oak Ridge, Tennessee* (Clinch River/Poplar Creek OU ROD; DOE/OR/02-1547&D3) is appropriate monitoring to ensure the institutional controls remain protective against the risk of potential exposure to COCs in sediments and fish tissue.

The original monitoring plans for the action are in the *Remedial Action Report for Clinch River/Poplar Creek in East Tennessee* (Clinch River/Poplar Creek RAR; DOE/OR/02-1627&D3). However, in September 1999, DOE recommended two broad changes to the monitoring plans. The first was to combine the monitoring requirements for two OUs, the Clinch River/Poplar Creek OU and the LWBR OU into a single entity for monitoring purposes because the two OUs are, in fact, part of the same hydrologic system. The second was to change the number and locations of monitoring stations and sampling techniques in both OUs. Based on these recommendations, which were based on the hydrological connection of Poplar Creek, Clinch River, and Watts Bar Reservoir, a *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1820&D2) was prepared.

Table 7.1. LUCs for Offsite

LUCs for completed actions Offsite[a]			
Specific areas	**Project documents**	**LUCs**	**Frequency/implementation**
LEFPC	ROD (DOE/OR/02-1370&D2) RAR (DOE/OR/01-1680&D5)	**LUCs:** • DOE will monitor to detect any future residential use of the shallow soil horizon groundwater • A survey to determine any changes in land use patterns along LEFPC • Annual survey to verify land use in the area of the Dean Stallings Ford automobile dealership parking lot shall be performed to verify that the land use has not changed since the issuance of the EFPC-Sewer Line Beltway Remedial Investigation Report	• A FYR will be required to evaluate whether the selected remedy remains protective • Before each FYR, land-use patterns will be re-evaluated along LEFPC to ensure that the land-use assumption used to develop the 400 ppm mercury cleanup level remains valid
Clinch River/Poplar Creek	RAR (DOE/OR/02-1627&D3) CMP (DOE/OR/01-1820&D3)	**LUCs:** • Survey of local fisherman to confirm the effectiveness of fish consumption advisories • Irrigation survey – identify and survey local irrigators using Clinch River or Poplar Creek as a water source for irrigating crops, fields, or gardens • Fish consumption advisories to reduce exposure to contaminants in fish tissue • Existing institutional controls to control potential sediment-disturbing activities	• Fish advisory survey conducted one time only in 2000. Results reported in 2001 RER. • Conduct irrigation survey before preparation of the decision document for the surface water OU • Fish consumption advisories are issued by the TDEC Division of Water Resources • DOE participates in the WBIWG to review permitting and use activities that could result in disturbance of sediments
LWBR	RAWP (DOE/OR/02-1376&D3) CMP (DOE/OR/01-1820&D3)	**LUCs:** • Fish consumption advisories to reduce exposure to contaminants in fish tissue • Existing institutional controls to control potential sediment-disturbing activities	• Fish consumption advisories are issued by the TDEC Division of Water Resources • DOE participates in the WBIWG to review permitting and use activities that could result in disturbance of sediments

[a]LUCs for specific areas are determined by each remediation project and listed in the project-specific completion report.

CMP = Comprehensive Monitoring Plan
DOE = U.S. Department of Energy
EFPC = East Fork Poplar Creek
FYR = Five-Year Review
LEFPC = Lower East Fork Poplar Creek
LUC = land use control
LWBR = Lower Watts Bar Reservoir
OU = operable unit
RAR = Remedial Action Report
RAWP = Remedial Action Work Plan
RER = Remediation Effectiveness Report
ROD = Record of Decision
TDEC = Tennessee Department of Environment and Conservation
WBIWG = Watts Bar Interagency Working Group

Based on sampling results from 1999 – 2004, the combined monitoring plan was revised in FY 2004. The combined monitoring plan consists of two components for the Clinch River/Poplar Creek – annual monitoring of major COCs in fish and additional monitoring for Clinch River/Poplar Creek (sediment, surface water, turtles) once every five years to support the CERCLA FYR (Table 7.2). In 2013, this monitoring plan was revised and is now referred to as the *Lower Watts Bar Reservoir and Clinch River/Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (LWBR RAR CMP; DOE/OR/01-1820&D3).

The combined monitoring program uses a scientifically rigorous sampling design supporting the identification and evaluation of changes in COC concentrations in fish. This evaluation is directly applicable to the ROD-specified requirements to detect changes in fish contaminant concentrations and to evaluate whether institutional controls, i.e., the fish consumption advisory, are effective (LWBR RAR CMP). If concentrations of contaminants in tissues of these species increase substantially, a study to determine the cause of the change may be warranted. Conversely, decreases in COC concentrations would support the evaluation of the need for continuing the fish advisory.

The ROD requirements for the Clinch River/Poplar Creek hydrologic unit are satisfied by conducting annual sampling of contaminant concentrations in fish. Sites sampled in FY 2018 include sites in the Clinch River between Melton Hill Dam and the confluence with the Tennessee River, a site in Poplar Creek, and a Clinch River reference site (upstream of Melton Hill Dam) that is sampled for comparison purposes (Figure 7.5). The sites sampled are based on their position below key DOE inputs and stream/river exit points, as well as their importance as long-term measures of change. Most of the designated sites have been monitored annually since the mid-1980s and are important sites for evaluating long-term change (DOE/OR/01-2058&D2). Target species are channel catfish, largemouth bass, and striped bass. Depending on the site and species, PCBs, mercury, and Cs-137 concentrations are determined in fish fillets. Historically, striped bass were monitored below the Bull Run and Kingston steam plants (CRM 48 and CRM 2.6, respectively), but since 2008 Tennessee Valley Authority (TVA) steam plant generators have not been running on regular schedules and so striped bass have rarely been available at Bull Run steam plant. In addition, striped bass are naturally anadromous, living most of their lives in the ocean and then migrating into large freshwater rivers along the Atlantic coast. They have been stocked extensively in freshwater reservoirs for sport fishermen. Locally, the Tennessee Wildlife Resources Agency (TWRA) currently maintains striped bass in the Watts Barr and Norris Reservoirs, but stocking Melton Hill was discontinued in an effort to promote a muskellunge fishery. Because striped bass do not reproduce locally, their populations have dwindled in Melton Hill to the point at which collection has become increasingly difficult to impossible. Since 2014, the range of the upstream reference site has therefore expanded from between CRM 48 into CRM 99 (Norris Reservoir).

Largemouth bass are now collected for mercury bioaccumulation on an annual cycle in the fall. Channel catfish will continue to be collected annually in the summer.

Fish consumption advisories are issued by the TDEC and posted at the TWRA website. The advisories are based on a calculation of fish concentration thresholds from the aqueous PCB AWQC, and TDEC interpretation of site-specific risks.

Signs are placed at main public access points and a press release is submitted to local newspapers when an advisory is issued or changed. The list of advisories is also published in TWRA's annual fishing regulations.

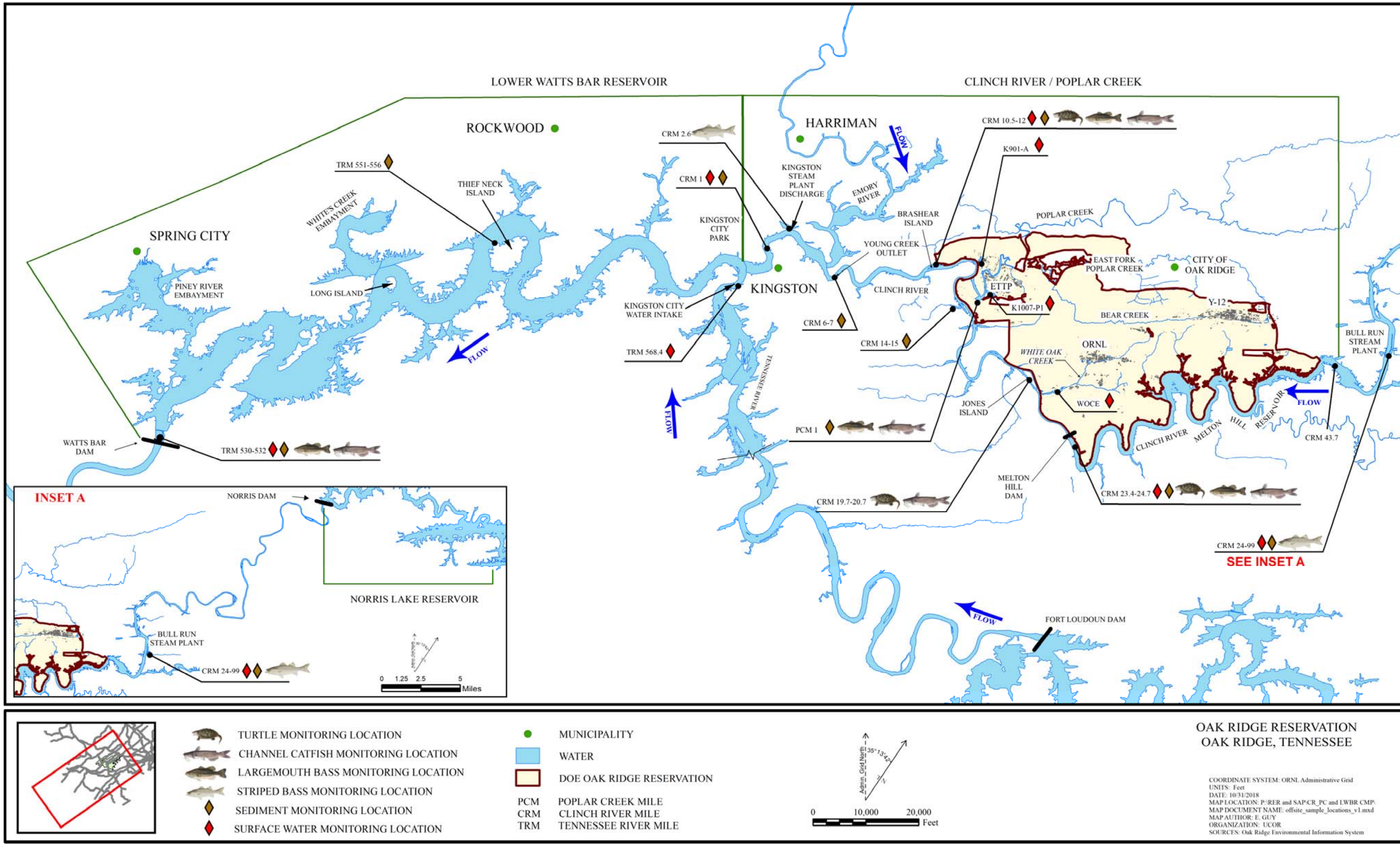

Figure 7.5. Monitoring locations in the Clinch River/Poplar Creek and LWBR OUs.

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Table 7.2. Monitoring locations in Clinch River/Poplar Creek

Monitoring stations	Analyses[a]
Surface water: CRM 48, CRM 23.4–24.7, WOCE, K-1007-P1 Holding Pond, K-901-A Pond, CRM 10.5–12, and CRM 1, once every five years	Surface water—isotopic uranium, total mercury, TAL metals, and hydrolab profile
Sediment: CRM 48, CRM 23.4–24.7, CRM 14–15, PCM 1, CRM 10.5–12, CRM 6–7, and CRM 1, once every five years	Total metals, total mercury, and Cs-137. Samples from Poplar Creek will also be analyzed for Tc-99, U-234/235/238, Co-60, and PCBs
Fish: CRM 23, PCM 1, and CRM 11 (catfish and largemouth bass) and CRM 20 (catfish only), annually. As of FY 2013, largemouth bass are collected in the fall and channel catfish in summer Downstream Clinch River (CRM 2.6, or as needed from downstream of DOE facilities), and upstream Clinch River (CRM 48, or Norris Lake reference site (NORRIS) (striped bass), winter only	Catfish: PCBs, total mercury, Cs-137 (CRM 20 only), and total lipid Largemouth bass: total mercury Striped Bass: PCBs and total lipid
Turtles: CRM 23, CRM 20, and CRM 11, once every five years in summer	PCBs, total mercury, Cs-137, and total lipid

[a]Analyses listed are those required to monitor action effectiveness.

CRM = Clinch River mile
DOE = U.S. Department of Energy
FY = fiscal year
PCB = polychlorinated biphenyl
PCM = Poplar Creek mile
TAL = target analyte list
WOCE = White Oak Creek Embayment

7.4.1.2 Evaluation of performance monitoring data

The selected remedy identified in the Clinch River/Poplar Creek OU ROD is still in place and effective. Institutional controls prevent exposure to contaminated sediment that could pose a risk to human health (via the Watts Bar Interagency Working Group [WBIWG]); fish consumption advisories are issued by TDEC; and annual monitoring is conducted to evaluate changes in contaminant levels. Performance monitoring for the Clinch River/Poplar Creek has primarily focused on contaminant trending in fish to address the requirement for annual monitoring to detect changes in contaminant levels or mobility.

Results of FY 2018 monitoring for Poplar Creek and the Clinch River arm of Watts Bar Reservoir are provided in Table 7.3. PCB concentrations in Clinch River channel catfish were similar in 2018 compared to the past few years and have been trending downward for more than a decade, although there has been substantial year-to-year variability (Figure 7.6). PCBs in channel catfish from Poplar Creek are similarly variable (Figure 7.6). The highest mean PCB concentrations in catfish have historically been found in Poplar Creek, but the concentrations at this site have been decreasing steadily such that concentrations in these fish have been approaching those in fish from the Clinch River. PCB concentrations in striped bass collected from CRM 2.6 were significantly higher than those seen at the Norris Lake reference site (Table 7.3). These concentrations were comparable to values seen in recent years, and within the range of normal inter-annual variation observed at these sites.

No criteria were set as goals in the ROD, but annual monitoring results in fish can be compared to various regulatory screening levels for comparison purposes. Evaluations of PCB concentrations in fish must carefully consider the species of fish sampled and the assumptions used in any risk analyses. Regulatory guidance and human health risk levels have varied widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. The Tennessee water quality criterion for total PCBs is 0.00064 µg/L under the recreation designated use classification and is the target for PCB-focused TMDLs, including for local reservoirs (Melton Hill, Watts Bar, and Fort Loudon; TDEC 2010a,b,c). In the State of Tennessee, assessments of impairment for water body segments as well as public fishing advisories are based on fish tissue concentrations. Historically, the FDA threshold limit of 2 µg/g in fish fillet was used for advisories, and then for many years an approximate range of 0.8 to 1 µg/g was used, depending on the data available and factors such as the fish species and size. Most recently, the water quality criterion (0.00064 µg/L for total PCBs; TDEC 2015) has been used by TDEC to calculate the fish tissue concentration triggering impairment and a TMDL, and this concentration is 0.02 µg/g in fish fillet (TDEC 2010a,b,c). TMDLs are used to develop controls for reducing pollution from both point and non-point sources in order to restore or maintain the quality of a water body and ensure it meets the applicable water quality standards. The fish PCB concentrations in the Clinch River and Watts Bar are still well above the calculated TMDL concentration.

Temporal trends in mean mercury concentrations in largemouth bass from Poplar Creek, the Clinch River, and Lower Watts Bar are shown in Figure 7.7. Although there is some inter-annual variability, mercury concentrations at CRM 20 (Figure 7.7) have remained fairly constant over the time period and with the exception of one year, are below the EPA fish tissue guidance value of 0.3 µg/g. In contrast, largemouth bass in Poplar Creek (PCM 1) and the Clinch River site downstream of Poplar Creek (CRM 11) have varied considerably from year to year. In 2018, mercury concentrations at the PCM 1 site (mean concentration 0.26 µg/g) were slightly higher than in 2017, but were significantly lower than in previous years and were again below the EPA threshold limit of 0.3 µg/g. In contrast, mercury concentrations in largemouth bass at the Tennessee River mile (TRM) 530 site were lower in 2018 (0.15 µg/g) than in 2017, dropping below EPA threshold limits for this species at this site. Mercury concentrations at CRM 11 were similar to those seen in 2017, and remained below the EPA threshold. In FY 2018, the highest mercury concentration in offsite largemouth bass was seen at PCM 1, but because of the substantial decreases in mercury in bass at this site since 2012 (Figure 7.7), the current mercury concentrations are only slightly higher than those found in the same species in the Clinch River.

Bluegill and redbreast sunfish have also been collected for mercury analysis from PCM 1 and PCM 5.1. The PCM 5.1 sampling location is centered at the confluence of EFPC and Poplar Creek and has been monitored since 2006 (Figure 7.2). Mercury concentrations at the PCM 5.1 site have consistently been higher than at PCM 1, consistent both with the pattern of downstream dilution of mercury within Poplar Creek and also with the difference in species collected at the two sites (Figure 7.8). Previous studies have shown that redbreast sunfish accumulate 25 – 50% more mercury than similarly sized bluegill sunfish collected from the same sites (Southworth et al., 1994). Regardless, mercury concentrations in sunfish at both of these sites had been slowly increasing since 2006, with a significant increase seen in redbreast collected at the upper site from 2012 – 2014. This time period is just after significant increases were observed in both aqueous mercury and sunfish mercury concentrations in UEFPC which have been attributed to storm drain cleanout activities from 2010 – 2011. Mean mercury concentrations in fish fillets at PCM 5.1 appear to be decreasing after a peak in 2014, suggesting that levels associated with the storm drain cleanout may have peaked, and now may be headed to more normal historical levels, but concentrations continue to exceed the fish-based AWQC. Mean mercury concentrations in bluegill collected from PCM 1 have been fluctuating around the AWQC, and were slightly below this limit in FY 2018.

Mercury concentrations in catfish were below the screening level EPA fish tissue criterion at all sites monitored in FY 2018 (Table 7.3). Levels of Cs-137 were below analytical detection limits in all fish collected from the Clinch River sample site immediately downstream of WOC (which flows from ORNL).

Table 7.3. Mean concentrations (n = 6 fish, ± standard error) of total PCBs (Aroclor-1248+1254+1260), total mercury, and Cs-137 in fish muscle fillet from offsite locations in FY 2018

Monitoring location		Total PCBs (mg/kg)		Mercury (mg/kg)		Cs-137 (pCi/g)
Site	**Description**	**Channel catfish**	**Striped bass**	**Largemouth bass**	**Channel catfish**	**Channel catfish**
Clinch River						
CRM 20	Jones Island downstream of WOC	0.152 ± 0.019		0.146 ± 0.021	0.066 ± 0.011	<0.01
CRM 11	Brashear Island downstream of Poplar Creek	0.155 ± 0.029		0.186 ± 0.037	0.122 ± 0.023	
CRM 2.6	Kingston Fossil Plant		0.229 ± 0.020			
Poplar Creek						
PCM 1	Near K-1007-P1 outlet	0.184 ± 0.040		0.261 ± 0.035	0.205 ± 0.045	
LWBR						
TRM 530	Watts Bar Reservoir forebay	0.044 ± 0.015		0.154 ± 0.019	0.073 ± 0.014	
Reference sites (upstream of Clinch River/Poplar Creek – LWBR)						
CRM 23	Melton Hill Reservoir forebay	0.071 ± 0.010		0.086 ± 0.014	0.064 ± 0.014	
CRM 95	Norris Lake		0.041 + 0.002			

CRM = Clinch River mile
FY = fiscal year
LWBR = Lower Watts Bar Reservoir
PCB = polychlorinated biphenyl
PCM = Poplar Creek mile
TRM = Tennessee River mile
WOC = White Oak Creek

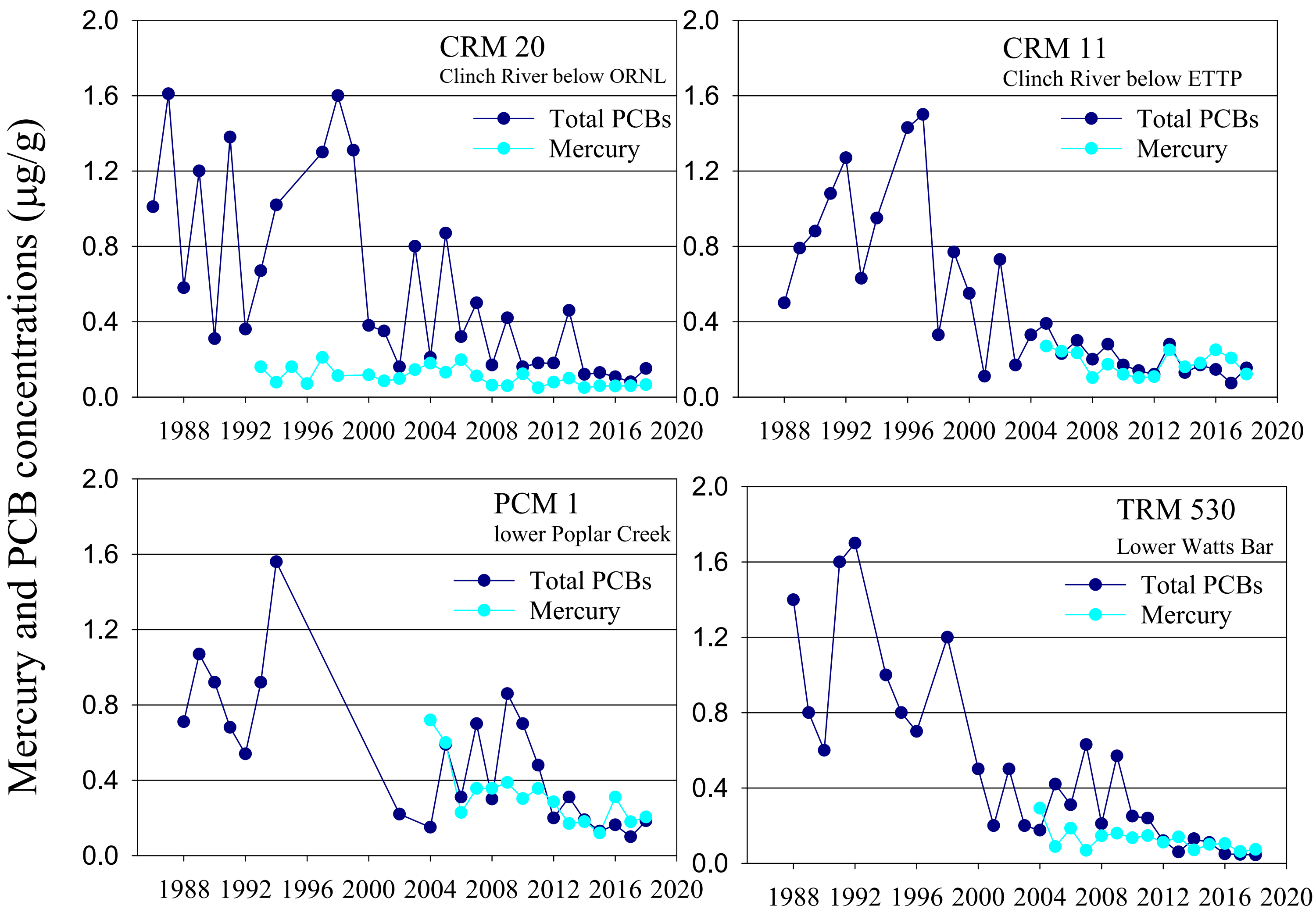

Figure 7.6. Average mercury and PCB concentrations in channel catfish from Clinch River/Poplar Creek and LWBR sites, 1986 – 2018.

(Courtesy of multiple programs in the early years, including Biological Monitoring and Abatement program, Annual Site Environmental Report, and TVA, 1986 – 2003).

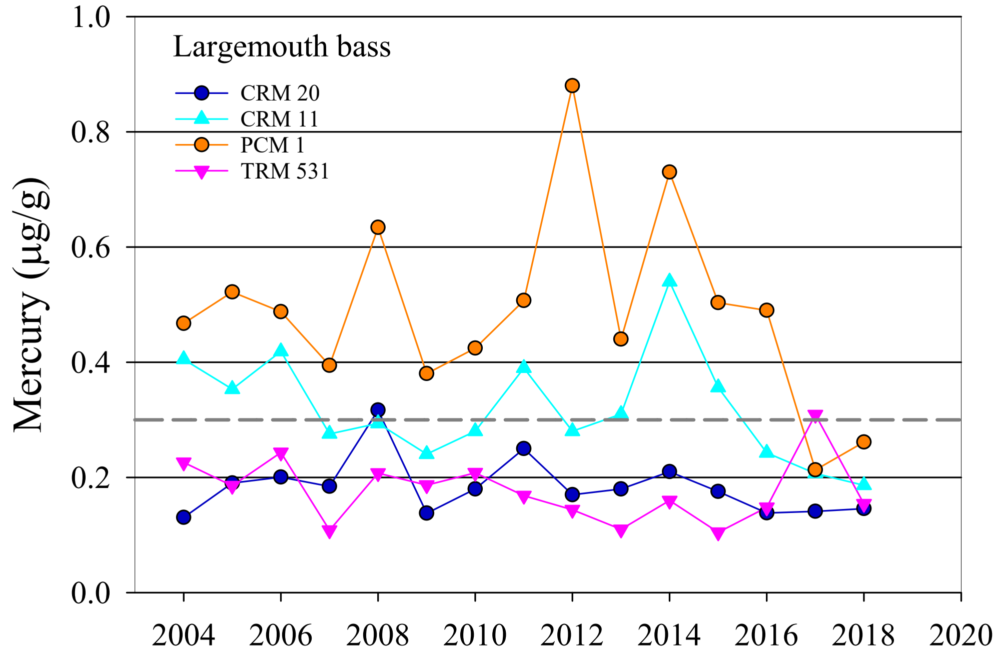

Figure 7.7. Mean mercury concentrations in largemouth bass from Clinch River/Poplar Creek and LWBR sites, 2004 – 2018.

Dashed gray line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

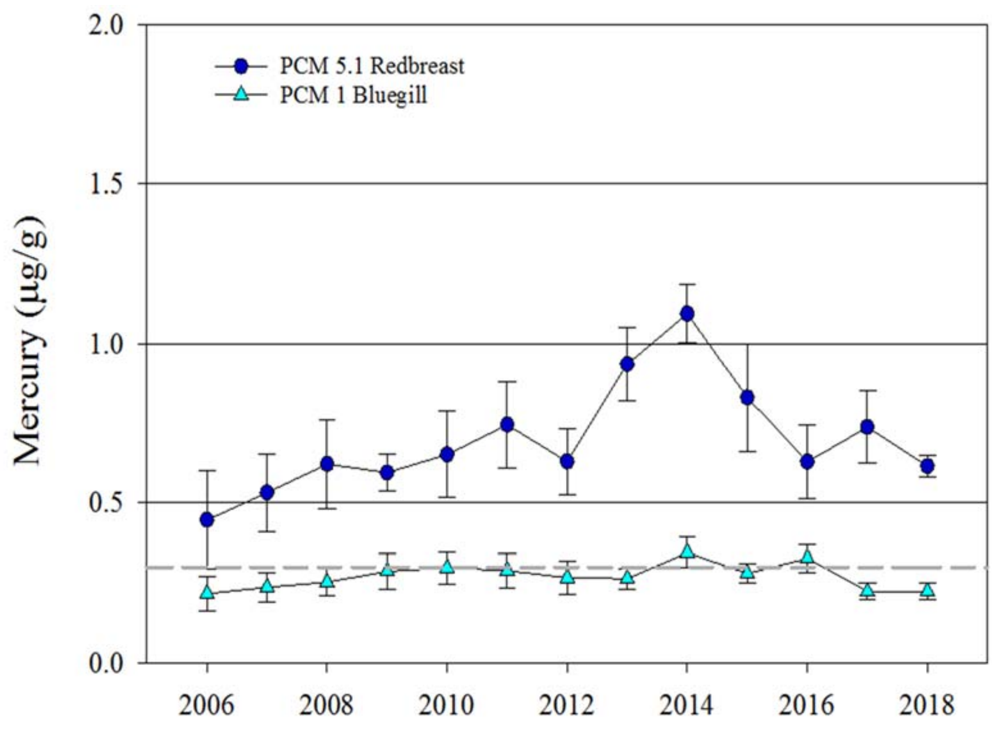

Figure 7.8. Mean mercury concentrations in sunfish from Poplar Creek, 2006 – 2018.

Dashed gray line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish).

7.4.2 LUCs

LUCs for Clinch River/Poplar Creek are listed in Table 7.1 and described below.

Requirements specified in the Clinch River/Poplar Creek RAR include institutional controls for the Clinch River/Poplar Creek:

- continued use of TDEC's fish consumption advisories to limit exposure to contaminated fish;
- continued scrutiny of sediment-disturbing activities in Clinch River/Poplar Creek by the WBIWG, comprised of TDEC, TVA, Army Corps of Engineers, and DOE, to prevent exposure to potentially contaminated dredged soil that could pose a risk to human health;
- conduct of a survey of irrigation practices before the preparation of the decision document for the surface water OU; and
- one-time survey of local fishermen to determine the effectiveness, i.e., awareness of fish consumption advisories.

7.4.2.1 Status of LUCs

TDEC, Division of Water Resources, maintains fish consumption advisories for the local area. The TWRA posts these advisories on their web site, and it was last updated in August 2018. These same advisories are included in the TWRA's 2018 – 2019 Tennessee Fishing Guide that is available online and where fishing licenses are sold.

The WBIWG provided continued controls on sediment disturbing activity in the deep-water channel. In FY 2018, only one dredging permit application was received and approved for Clinch River/Poplar Creek and LWBR. A survey of irrigation practices will be conducted when the RI for Clinch River/Poplar Creek surface water is performed, which is scheduled in the out-years of ORR cleanup.

The fish advisory survey was conducted in 2000 and results were reported in the 2001 RER.

A review of the efficacy of institutional controls preventing sediment exposure and the effectiveness of the fish consumption advisory was provided in the *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (2006 RER/FYR; DOE/OR/01-2289&D3) and referenced again in the 2016 FYR. The results of that review suggest that institutional controls in place are effective in limiting human exposure, although some areas of the reservoir are not well posted and there are some groups of fishermen who do not follow advisories. The State of Tennessee is responsible for issuing fish consumption advisories and communicating relevant health information to the public.

7.5 LWBR

7.5.1 Performance Monitoring

7.5.1.1 Performance monitoring goals and objectives

The LWBR OU extends 38 river miles from TRM 567.5, at the mouth of the Clinch River, downstream to the Watts Bar Reservoir dam at TRM 529.9 (Figure 7.5).

The original post-ROD monitoring plans for the action are in the *Remedial Action Work Plan for Lower Watts Bar Reservoir in Tennessee* (DOE/OR/02-1376&D3). As discussed in Section 7.4.1, monitoring requirements for the LWBR are included with requirements for Clinch River/Poplar Creek in the LWBR RAR CMP.

The overall goal of the remedy for LWBR is to protect human health and the environment by reducing exposure to contaminated sediment in the main river channel and contaminants in fish. The monitoring strategy is provided in the LWBR RAR CMP and summarized in Table 7.4.

Table 7.4. Monitoring locations in LWBR

Monitoring stations	Analyses[a]
Surface water: TRM 568.4 and TRM 530–532, once every five years[b]	Surface water—isotopic uranium, total mercury, TAL metals, and hydrolab profile
Sediment: TRM 551–556 and TRM 530–532, once every five years[b]	Total metals, total mercury, and Cs-137
Fish: TRM 530 (catfish and largemouth bass), annually. As of FY 2013, largemouth bass are collected in the fall and channel catfish in summer.	Catfish: PCBs, total mercury, and total lipid Largemouth bass: total mercury

[a]Analyses listed are those required to monitor effectiveness.
[b]Sampling takes place the year before the FYR, e.g., FY 2020 for the 2021 FYR.

FY = fiscal year
FYR = Five-Year Review
LWBR = Lower Watts Bar Reservoir
PCB = polychlorinated biphenyl
TAL = target analyte list
TRM = Tennessee River mile

Fish consumption advisories are maintained by the TDEC and posted at the TWRA website. The advisories are based on a calculation of fish concentration thresholds from the aqueous PCB AWQC, and TDEC interpretation of site-specific risks.

Signs are placed at main public access points and a press release is submitted to local newspapers when an advisory is issued or changed. The list of advisories is also published in TWRA's annual fishing regulations.

7.5.1.2 Evaluation of performance monitoring data

Performance monitoring in LWBR has primarily focused on the LWBR RAR CMP requirements to evaluate changes in fish contaminant levels. These trending results are directly related to the ROD requirement that monitoring of water, sediment, and biota be continued to determine if there is a change in the currently calculated risk that would pose a threat to human health and/or the environment. The ROD indicated that the response action (namely, monitoring of contaminant levels or mobility) was considered applicable to evaluation reduction in ecological risk.

Monitoring results indicate that PCB concentration at TRM 530 in FY 2018 averaged 0.044 µg/g in channel catfish (Table 7.3), which is comparable to the concentration observed at this site in FY 2017. As was previously discussed, regulatory guidance and human health risk levels have varied widely for PCBs, depending on the regulatory program and the assumptions used in the risk analysis. Although historically fish advisories were considered when fish fillets were in the 0.8 to 1 µg/g range, the current target concentration for Watts Bar Reservoir is 0.02 mg/kg in fish fillet (TDEC 2010a,b,c). The fish PCB concentrations in LWBR are still above this concentration, which is used as a screening level for comparison purposes only. The good news is that the current levels are substantially lower than the concentrations observed in the 1980s and 1990s when the advisories were first issued (Figure 7.6).

Mercury concentrations in fish from LWBR in 2018 dropped below the EPA recommended AWQC of 0.3 µg/g mercury in fish, suggesting that the apparent increase in concentrations seen in 2017 was, perhaps, due to the larger size of the fish collected in that year. The AWQC value is not a ROD goal and is used for comparison purposes only.

7.5.2 LUCs

LUCs for LWBR are listed in Table 7.1 and described below.

The Remedial Action Work Plan for Lower Watts Bar Reservoir in Tennessee (DOE/OR/02-1376&D3) stipulates institutional controls, including continued use of TDEC's fish consumption advisories to limit exposure to contaminated fish and continued scrutiny of sediment-disturbing activities in LWBR by the WBIWG to prevent exposure to potentially contaminated dredged soil that could pose a risk to human health.

7.5.2.1 Status of LUCs

TDEC, Division of Water Resources, maintains fish consumption advisories for the local area. The TWRA posts these advisories on their web site and it was last updated in August 2018. These same advisories are also published in the TWRA's 2018 – 2019 Tennessee Fishing Guide that are available online and where fishing licenses are sold.

The WBIWG provided continued controls on sediment-disturbing activity in the deep-water channel. In FY 2018, only one dredging permit application was received and approved for Clinch River/Poplar Creek and LWBR.

A review of the efficacy of institutional controls preventing sediment exposure and the effectiveness of the fish consumption advisory was provided in the 2006 RER/FYR and referenced again in the 2016 FYR. The results of that review suggest that institutional controls in place are effective in limiting human exposure, although some areas of the reservoir are not well posted and there are some groups of fisherman who do not follow advisories. The State of Tennessee is responsible for issuing fish consumption advisories and communicating relevant health information to the public.

7.6 OFFSITE ISSUES AND RECOMMENDATIONS

There are no issues and recommendations for the offsite areas (Table 7.5).

Table 7.5. Summary of technical issues and recommendations

Issue[a]	Action/recommendation	Responsible parties Primary/support	Target response date
New issue			
None			
Issue carried forward			
None			
Completed/resolved issues[b]			
None			

[a]A "New Issue" is an issue identified during evaluation of FY 2018 data for inclusion in the 2019 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year in which the issue originated is in parentheses, e.g. (2013 RER).

FY = fiscal year

RER = Remediation Effectiveness Report

7.7 REFERENCES

DOE/OR/01-1680&D5. *Remedial Action Report on the Lower East Fork Poplar Creek Project, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1820&D2. *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee*, 1999, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1820&D3. *Lower Watts Bar Reservoir and Clinch River Poplar Creek Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2004, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1951&D3. *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2058&D2. *2003 Remediation Effectiveness Report for the U.S. Department of Energy, Oak Ridge Reservation, Oak Ridge, Tennessee*, 2003, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2289&D3. *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1370&D2. *Record of Decision for Lower East Fork Poplar Creek, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/02-1376&D3. *Remedial Action Work Plan for Lower Watts Bar Reservoir in Tennessee*, 1996, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/02-1547&D3. *Record of Decision for the Clinch River/Poplar Creek Operable Unit, Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1627&D3. *Remedial Action Report for Clinch River/Poplar Creek in East Tennessee,* 1999, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Peterson, M.J, T.J. Mathews, R.A. McManamay, R.T. Jett, N.J. Jones, M.W. Jones, A.M. Fortner, and G.W. Morris. 2018. Y-12 National Security Complex Biological Monitoring and Abatement Program—2017 Calendar Year Report. ORNL/SPR-2018/886. July 2018. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Southworth, G.R., M.J. Peterson, S.M. Adams, and B.G. Blaylock 1994. "Estimation of appropriate background concentrations for assessing mercury contamination in fish," *Bulletin of Environmental Contamination and Toxicology*, 53: 211-218.

Southworth, G.R., M.J. Peterson, W.K. Roy, and T.J. Mathews 2011. Monitoring Fish Contaminant Responses to Abatement Actions: Factors that Affect Recovery, *Environmental Management* 47:6:1064-1076.

TDEC 2010a. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee.

TDEC 2010b. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, Meigs, Morgan, Rhea, and Roane Counties, Tennessee.

TDEC 2010c. Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Fort Loudon Reservoir: Fort Loudon Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee.

TDEC 2015. State of Tennessee Water Quality Standards, Chapter 0400-40-03, General Water Quality Criteria, April 2015. Tennessee Department of Environment and Conservation, Division of Water Pollution Control.
URL: http://sharetngov.tnsosfiles.com/sos/rules/0400/0400-40/0400-40-03.20150406.pdf.

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8. ETTP

8.1 INTRODUCTION AND STATUS

8.1.1 Introduction

The ETTP, located near the northwest corner of the ORR, contains contaminated facilities and media from past gaseous diffusion and centrifuge operations. Figure 8.1 shows the locations of CERCLA actions at ETTP that require monitoring or LUCs and ROD-designated end uses. Subsequent sections assess, the effectiveness of each completed action by reviewing performance monitoring objectives and results and verifying LUCs.

Completed CERCLA actions at ETTP are gauged against their respective action-specific goals. For CERCLA actions that are not complete, ongoing monitoring is conducted against which the effectiveness of the actions can be evaluated in the future. Monitoring required by approved CERCLA decision or post-decision documents and ongoing monitoring of actions in progress is included in the approved *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (ETTP RAR CMP; DOE/OR/01-2477&D3).

Table H.7 in Appendix H lists all completed CERCLA actions at ETTP and the corresponding completion documents and identifies whether monitoring or LUCs are required. Figure H.7 in Appendix H is a location map of the actions and illustrates ROD-designated end uses at ETTP. For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions at ETTP within the context of a contaminant release conceptual model is provided in Chapter 10 of Volume 1 of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy, Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2). This information is updated in the annual RER and republished every fifth year in the CERCLA FYR.

8.1.2 Status Update

Many of the early completed CERCLA actions at ETTP were single-project actions to address primary sources of contamination or primary release mechanisms. These early actions helped to reduce contaminant loading to groundwater and surface water. The strategy now implemented addresses the sources in a watershed approach that ensures consistent remediation approaches to reach the end use objectives. Concurrent with these remediation actions, demolition of buildings at ETTP has been occurring under CERCLA removal authority.

To complete the primary source RA work, ETTP was divided into two zones. Zone 1 comprises 1,425 acres outside the main plant area, and Zone 2 comprises 869 acres of the main plant area (Figure 8.1). Actions under two RODs have been on-going to address soil, buried waste, and subsurface structures for the protection of human health and to limit further contamination of groundwater through source reduction or removal (*Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* [Zone 1 Interim ROD; DOE/OR/01-1997&D2] and *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* [Zone 2 ROD; DOE/OR/01-2161&D2]).

The cleanup of the remaining environmental media at ETTP, e.g. groundwater, surface water/sediment, and remaining ecological receptors will be addressed under additional CERCLA final decision documents.

Planning continued in FY 2018 for the ETTP groundwater RODs. A groundwater treatability study was completed to determine the effectiveness of in situ groundwater treatment technologies. *The Design Characterization Completion Report for Sitewide Groundwater Treatability Study at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2768&D1) was submitted to EPA and TDEC for review. In addition, work began on the *K-31/K-33 Area Groundwater Remedial Site Evaluation Report for the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2765&D1).

8.1.3 Summary of Conditions

Sitewide-scale performance objective measures are not formally in place at ETTP, primarily because the Zone 1, Zone 2, and Sitewide environmental media efforts are not at a point to determine long-term performance assessment measures. However, monitoring of conditions and trends continues and are included in Section 8.5 and Appendix D and are summarized below. Results of the single-project actions are included in Section 8.4 and are summarized below.

Groundwater. The data screen and M-K trend assignments show that contaminant concentration trends are highly variable across the site as numerous remediation activities are underway.

- VOC concentrations in wells monitored downgradient of K-1070-C/D show that a broad area is affected by releases from the past disposal of liquid VOCs at G-Pit. While concentrations in wells UNW-114 and UNW-064 continue to decrease, very high VOC concentrations affect wells DPT-K1070-5 and DPT-K1070-6. The persistent, very high concentrations of these VOCs suggest an ongoing contaminant source release.

- Contaminant conditions in the groundwater exit pathway areas are generally stable and similar to conditions in recent years. In the K-31/K-33 area, chromium continues to be measured at levels near or slightly above screening level MCLs although during FY 2018 all chromium results were less than the 0.1 mg/L MCL. Nickel is present in groundwater samples from one well (UNW-043) at concentrations greater than the state of Tennessee screening criterion of 0.1 mg/L.

- In the K-1064 Peninsula, arsenic exceeded its screening level MCL in groundwater samples collected during FY 2018. TCE concentrations continued to decrease with a maximum detected concentration less than the screening level MCL in FY 2018.

- In the K-27/K-29 area, chromium continues to exceed its 0.1 mg/L MCL screening level in unfiltered samples from wells UNW-038 and UNW-096 although concentrations in filtered samples are less than the MCL screening level. Nickel exceeds the state of Tennessee water quality screening criterion in wells UNW-038 and UNW-096. TCE continues to gradually decrease in wells UNW-038 and UNW-096.

- Samples from spring PC-0, which discharges groundwater into Poplar Creek, had TCE concentrations greater than the 5 µg/L MCL during November 2017 and February 2018, but concentrations were less than the MCL in April 2018. At spring 10-895, TCE was detected at concentrations less than the MCL screening level during FY 2018.

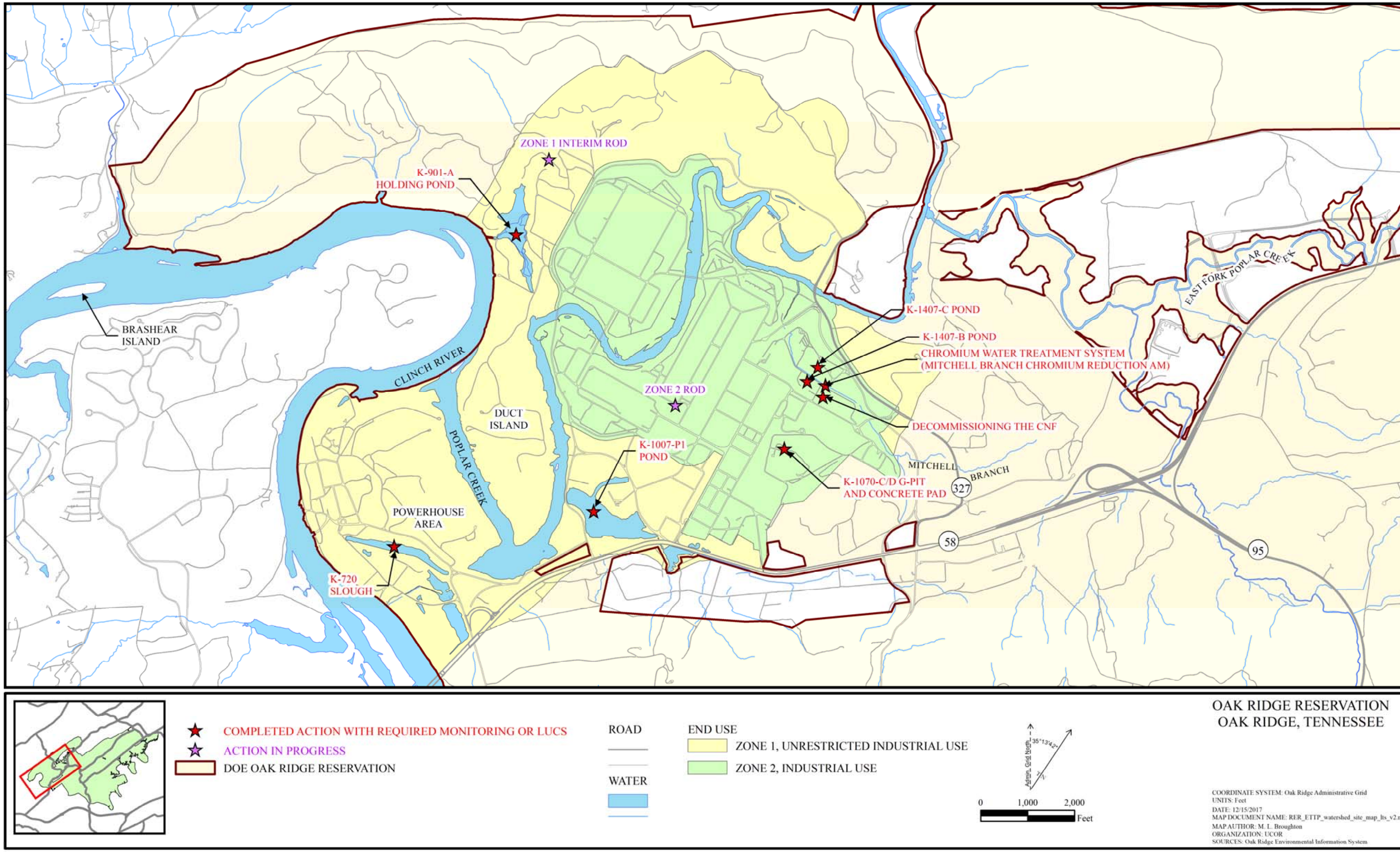

Figure 8.1. Completed CERCLA actions with required monitoring or LUCs at ETTP and end uses at ETTP.

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- In the K-770 area, alpha activity concentrations have decreased to levels less than the 15 pCi/L screening level.

- At wells near the K-1007-P1 Holding Pond, alpha activity was detected at a concentration less than the 15 pCi/L screening concentration in well UNW-108 and TCE was not detected although in previous years it was measured at concentrations greater than its 0.005 mg/L screening concentration.

- Monitoring results from wells in the K-1407-B/C ponds area are generally consistent with results from previous years and show several fold concentration fluctuations in seasonal and longer term periods. The detection of VOCs at concentrations well above 1,000 µg/L and the steady concentrations over recent years suggest the presence of DNAPL in the vicinity of well UNW-003.

Surface water. Contaminant levels are generally stable and consistent with levels in recent years. All surface water radiological data were well below the screening level of 4% of the sum of fraction of the DCS concentrations that results in an effective dose equivalent of 4 mrem as a general drinking water level comparison.

- VOC concentrations in Mitchell Branch in FY 2018 remained well below the applicable AWQC and the benchmark values for potential surface water toxicity.

- Collection and treatment of groundwater containing hexavalent chromium is ongoing and is protective of water quality in Mitchell Branch, as levels in Mitchell Branch are below AWQC.

- Surface water measurements for PCBs and mercury periodically continued to exceed the AWQC in some storm water outfalls and surface water locations. The long-term mercury trend at the K-1700 weir Mitchell Branch exit pathway location shows a continuing decline from peak levels in FY 2010.

Biological monitoring. Fish have not attained remediation goals at K-1007-P1 and K-901-A Holding Ponds. A FYR issue (Table 1.4) identified additional management actions for both ponds with annual reporting in the RER and the next FYR (2021). In FY 2018, PCB concentrations in caged clams increased in SD-100. Concentrations in fish collected from the K-720 Slough were comparable to concentrations in recent years.

8.1.4 LUC Protectiveness

All LUCs at ETTP specified in the ETTP RAR CMP for the protection of the environment and/or human health have been implemented.

8.2 ZONE 1 INTERIM ROD

The Zone 1 Interim ROD requires soil RAs for unrestricted industrial use to a depth of 10 ft and for sources of groundwater contamination. Zone 1 was divided into 80 exposure units (EUs) for RA determination evaluation purposes. Major components of the Zone 1 Interim ROD are:

- excavation of Blair quarry and associated contaminated soil,

- excavation of contaminated soil in the K-895 Cylinder Destruct Facility and the Powerhouse Area,

- removal of scrap metal and debris from the K-770 Area,

- removal of sludge and demolition of the K-710 sludge beds and Imhoff tanks,

- implementation of LUCs, and

- characterization and removal of soil up to 10 ft in depth that exceeds remediation levels set to protect a future industrial worker; removal of soil to bedrock, water table, or acceptable levels of contamination to protect underlying groundwater to meet drinking water MCLs.

The status of the Zone 1 Interim ROD is summarized in Figure 8.2. Recent activities in Zone 1 are discussed below:

- The *Explanation of Significant Differences Related to the Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/01-1997&D2) Addressing Identified Ecological Impacts at Duct Island, Oak Ridge, Tennessee* (DOE/OR/01-2781&D2) was approved that adds RAs at Duct Island that address ecological risks, specifically threats to terrestrial wildlife (Figure 8.3). Final delineation sampling for this RA was completed in FY 2018. Excavation and confirmation sampling also began in FY 2018. Final confirmation sampling and backfilling will be completed in FY 2019.

- The *Phased Construction Completion Report for Remediation of the Zone 1 Powerhouse Duct Bank, Oak Ridge, Tennessee* (DOE/OR/01-2736&D2) was submitted to the regulatory agencies to document the completed RA along the Zone 1 duct bank.

- EPA and TDEC approved the *Addendum 3 to the Phased Construction Completion Report for the Duct Island Area and K-901 Area in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2261&D2/A3) that covered the final work at EU Z1-50. The addendum recommended this area be approved for unrestricted industrial use to 10 ft bgs.

- The *Record of Decision for Final Soil Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (Zone 1 Final Soil ROD; DOE/OR/01-2711&D2) was submitted for approval in FY 2017. The EPA and TDEC suspended review of the document pending approval of several Zone 1 Interim ROD PCCRs and resolution of the ARARs associated with the K-720 Fly Ash Pile. Discussions continued among DOE, EPA, and TDEC in FY 2018.

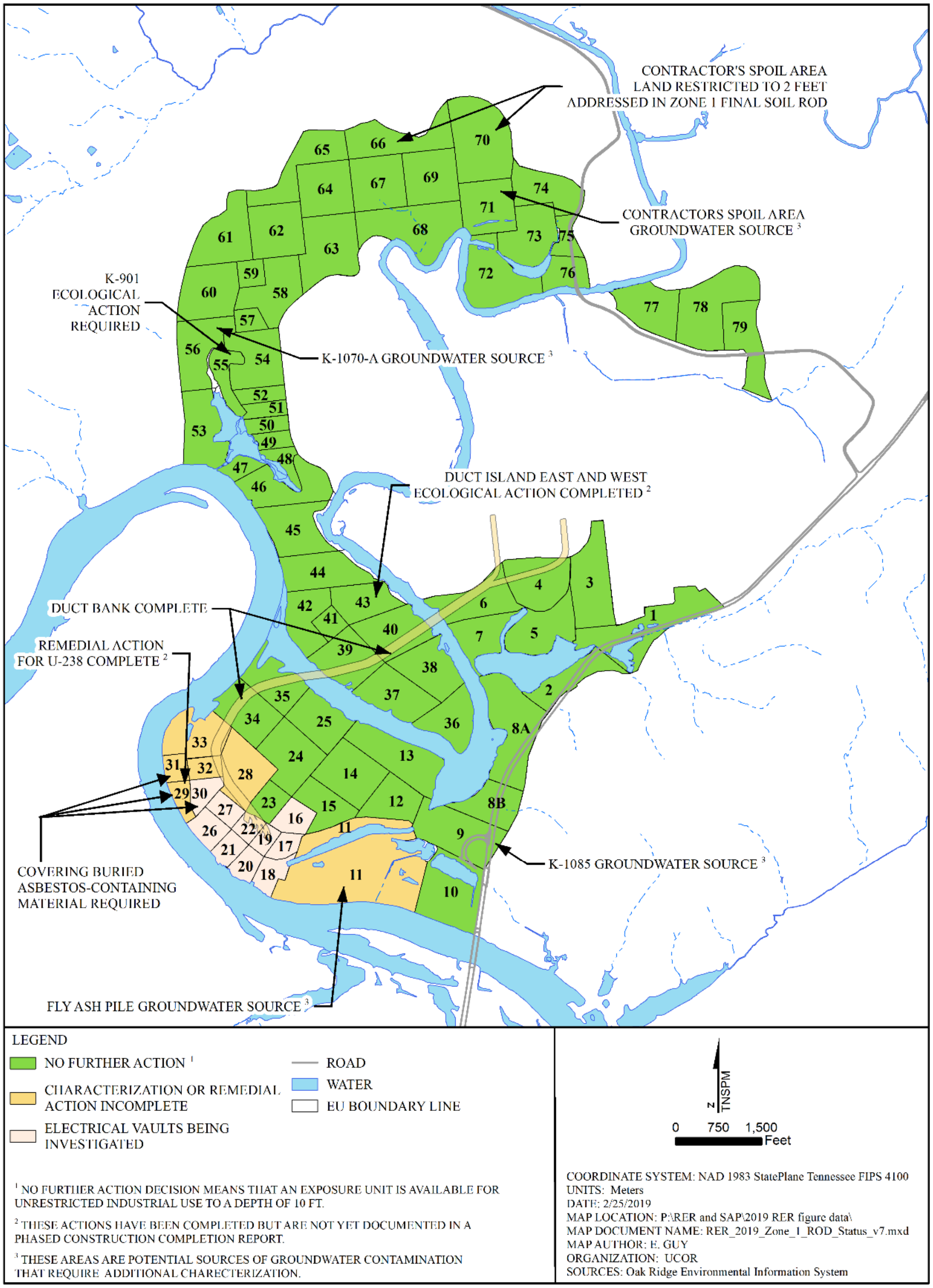

Figure 8.2. ETTP Zone 1 Interim ROD status.

Figure 8.3. Zone 1 Duct Island east and west ecological RA locations.

8.2.1 Performance Summary

The RAOs for Zone 1 are to:

- *Protect human health under an unrestricted industrial land use to a risk level not to exceed 1×10^{-4}, and*
- *Control leaching and migration from contaminated soil to help minimize further impacts to groundwater*

Completion of the Zone 1 Interim ROD is documented in PCCRs listed in Table H.7 in Appendix H. No performance monitoring is required under the Zone 1 Interim ROD at this time. Final performance monitoring may be identified in the Zone 1 Interim ROD RAR when all work is complete.

8.2.2 LUCs

LUCs for the Zone 1 Interim ROD will be finalized in a RAR. In the meantime, current Zone 1 LUCs are documented in the ETTP RAR CMP. These LUCs are listed in Table 8.1 and described below.

The Zone 1 Interim ROD establishes "unrestricted industrial" as the end use for Zone 1 and requires LUCs to prevent disturbance of soils below 10 ft in depth and to restrict future land use to industrial/commercial activities. Property restriction notices and restrictions in accordance with this land use and a penetration permitting process in this area have been implemented. There are no slabs in Zone 1 with provisional management.

Table 8.1. LUCs for the ETTP

LUCs – Sitewide requirements				
Type of control	**Duration**	**Implementation**	**Affected Areas[a]**	**Verification frequency**
1. Property Record Restrictions A. Land use B. Groundwater	*Until the concentrations of hazardous substances are at such levels to allow for UU/UE; CERCLA groundwater use prohibitions are in place until the final decision is made on groundwater*	*Implemented by DOE upon transfer of affected areas. Recorded by DOE in accordance with state law at County Register of Deeds office*	*All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions: A. ED-1, K-1330, K-1007, K-1580, K-1225, K-1400, K-1036, ED-5 East, K-1652, ED-7, K-1515, ED-5 West, K-1000, K-1501-H and L, ED-4, K-1008-F, ED-8, K-792/K-791-B/ K-796-A, ED-9, ED-10, ED-11, ED-12 B. ED-1, ED-5 East, ED-7, ED-5 West, ED-8, ED-9, ED-10, ED-11, ED-12*	*Five years*
2. Property Record Notices	*Until the concentrations of hazardous substances are at such levels to allow for UU/UE; CERCLA groundwater use prohibitions are in place until the final decision is made on groundwater*	*Notice recorded by DOE in accordance with state law at County Register of Deeds office and copied to the appropriate zoning office: A. as soon as practicable after signing of the ROD; or B. upon completion of RAs, when appropriate.*	*All waste management areas and other areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions: A. All ETTP B. K-1007-P1 Pond, K-901-A Pond, and K-720 Slough*	*Five years*
3. Excavation/ Penetration Permit Program	*Until the concentrations of hazardous substances are at such levels to allow for UU/UE; unauthorized groundwater use prohibitions are in place until the final decision is made on groundwater*	• *Implemented by DOE and its contractors* • *Initiated by permit request*	*Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions: All ETTP for groundwater, Zone 1 below 10 ft, all Zone 2*	*Monitor annually to ensure the permit program is functioning properly*
4. Access Controls (e.g., fences, gates, and portals)	*Until the concentrations of hazardous substances are at such levels to allow for UU/UE; CERCLA groundwater use prohibitions are in place*	*Controls maintained by DOE*	*Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions: K-1007-P1 Pond, K-901-A Pond, and K-720 Slough*	*Verify annually that controls are being implemented*

Table 8.1. LUCs for the ETTP (cont.)

LUCs – Sitewide requirements				
Type of control	**Duration**	**Implementation**	**Affected Areas**[a]	**Verification frequency**
	until the final decision is made on groundwater			
5. Engineered Remedy[b] (e.g., engineered caps, soil covers, treatment systems)	Until the concentration of hazardous substances are at such levels to allow for UU/UE; maintain integrity of the CERCLA remedy until final decision is made	Remedy maintained by DOE through operations, surveillance, and maintenance	Remediation systems, all waste management areas, and areas where hazardous substances are left in place at levels requiring land use and/or groundwater restrictions: K-1070-C/D OU K-1071 Concrete Pad soil cover K-1407-B/C Ponds CWTS K-1007-P1 Holding Pond (weir) K-901-A Holding Pond (weir) CNF Sumps	Verify annually that the remedies are being maintained

[a]*Affected areas – Specific locations identified in the post-ROD documents.*
[b]Engineered Remedy is included in this table to be all inclusive of necessary verifications.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CNF = Central Neutralization Facility
CWTS = Chromium Water Treatment System
DOE = U.S. Department of Energy
ETTP = East Tennessee Technology Park
LUC = land use control
OU = operable unit
RA = remedial action
ROD = Record of Decision
UU/UE = unlimited use/unrestricted exposure

The PCCRs completed under the Zone 1 Interim ROD state that the NFA decision means that an EU is available for unrestricted industrial use to a depth of 10 ft bgs subject to the LUCs specified in the Zone 1 Interim ROD. All Zone 1 EUs have been cleared for industrial use to a depth of 10 ft with the following exceptions:

- The Black Oak Ridge Conservation Easement (BORCE) is a Wildlife Management Area and State Natural Area. Several EUs in the northern section of Zone 1 are located in the BORCE, so the recreational end use of these EUs in the BORCE differs from the industrial end use identified in the Zone 1 Interim ROD. This discrepancy will be resolved in an amendment to the Zone 1 Interim ROD by demonstrating protectiveness for the recreational receptor.

- Groundwater beneath the K-720 Fly Ash Pile in EU Z1-11 is contaminated with semivolatile organic compounds, metals, and radionuclides. The Zone 1 Final Soil ROD remedy will address the fly ash pile and the impact on groundwater.

- Observations made during confirmatory radiological walkover and geophysical surveys indicated that asbestos-containing material and metal debris remain buried in EUs Z1-27-33. The Zone 1 Final Soil ROD remedy will address this issue.

- Potential contamination in electrical vaults in several EUs is being evaluated, and any additional RA will be performed under the Zone 1 Interim ROD.

8.2.2.1 Status of LUCs

Appendix A contains the Certification of LUCs for FY 2018. The Manager, DOE OREM, annually verifies in the RER that all approved RAR CMPs/LUCIPs are being implemented on the ORR. A summary of the implementation verification and status of the ETTP watershed LUCs follows:

Property record restrictions (deeds)

- As of the end of FY 2018, Property Record Restrictions have been recorded by DOE at the Roane County Register of Deeds office for fourteen parcels and fourteen buildings at ETTP (as of September 30, 2018) that have been transferred for private sector use/development. One of these parcels, Duct Island, was transferred on September 18, 2018. The ETTP RAR CMP LUC requirements (refer to Table 8.1) were verified as being included in the Covenant Deferral Requests and quitclaim deeds for this newly transferred property at ETTP. The property remains industrial use and is subject to the state law requiring owners to contact Tennessee 811 before they dig. If DOE/UCOR work is being performed on the transferred property, causing disturbance more than 10 ft bgs, then authorization is needed from the DOE EPP Program prior to digging. Information on previous transfers is contained in the 2016 FYR.

Property record notices

- Notice of land use restrictions must be filed in accordance with Tennessee statute *Tennessee Code Annotated* 68-212-225 when an RA includes land use restrictions. Land use restrictions, per the statute, may apply to activities on, over, or under the land, including groundwater and property use. The DOE filed the ETTP Property Record Notice with the Roane County Register of Deeds office on March 28, 2017. It is titled, "Notice of Land Use Restrictions for the East Tennessee Technology Park," and was filed as an Environmental Notation in Book 1605, pages 326 – 329. The notice requires restrictions that apply specifically to the ETTP watershed and restrict: 1) residential use of the Property, and 2) both access to and use of groundwater and surface water located in, on, or under the Property, unless permitted by DOE for monitoring, research, or operational activities.

- It was verified in FY 2018 that the DOE ETTP Property Record notice remains properly recorded at the Roane County Register of Deeds office.

EPP program

- An existing internal EPP program currently administered by DOE contractors requires workers/developers to obtain authorization before beginning subsurface excavation/penetration activities. DOE and/or its agent will maintain responsibility for the EPP program for contamination handling and locations for ongoing federal government activities at the site and for transferred land until the concentrations of hazardous substances are at levels to allow for UU/UE.

- In FY 2018, it was verified that the EPP program functioned according to established procedures and plans.

Access controls

DOE and/or its agent will maintain responsibility for the access controls until the concentrations of hazardous substances are at levels to allow for UU/UE. In the event of property transfer, DOE will document access controls in the transfer documents and deed and will verify they are maintained.

- Signs and access controls at the K-1070-C/D Burial Ground were inspected and maintained as a security requirement. Access controls are in place at the K-1007-P1 Holding Pond, K-901-A Holding Pond, and K-720 Slough and meet the intent of the LUC objectives. In FY 2018, signs were maintained to control access and surveillance patrols were conducted as part of routine S&M inspections.

- In FY 2018, DOE verified that the access controls documented for transferred properties were maintained.

The northern section of Zone 1 was identified as a conservation easement, the BORCE, on March 14, 2005 (Figure 8.2). The BORCE is utilized for recreational use, e.g., hiking, bicycling, and select controlled deer hunts. The trailhead is posted with a sign which designates the trails that are available for use in the conservation easement. Additionally, trail maps are located within the conservation easement at key intersections. The trailhead sign also states that there is no motorized use (except for select hunts) and users are to stay on the trails. However, the end use identified in the Zone 1 Interim ROD is unrestricted industrial, i.e., recreational use was not designated. The Human Health Risk Assessment contained in the *Final Zone 1 Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2561&D3) determined that the remediation levels established in the Zone 1 Interim ROD are more than sufficiently protective of a recreational user. Therefore, use of that portion of the BORCE in Zone 1 is protective, as documented in the Zone 1 Final Soil ROD submitted in February 2017.

8.3 ZONE 2 ROD

The Zone 2 ROD requires soil and subsurface infrastructure RAs for unrestricted industrial use to a depth of 10 ft and for sources of groundwater contamination. Zone 2 was divided into 44 EUs for evaluation purposes. Major components of the Zone 2 ROD (Figure 8.4) are:

- Assess data sufficiency for each EU and supplement data as necessary to determine if remediation levels are exceeded.

- Remove soil up to 10 ft in depth that exceeds remediation levels set to protect a future industrial worker.

- Remove soil to water table, bedrock, or acceptable levels of contamination, whichever is the shallowest, to protect underlying groundwater to MCLs and to protect human health and the environment.

- Remove or decontaminate the contaminated portions of slabs, vaults, basements, pits, tanks, pipelines, or any other subsurface structure that exceed the remediation levels to protect a future industrial worker to a depth no more than 10 ft. Use soil or concrete debris that meets Zone 2 remediation levels as backfill material in basements and deep excavations.

- Remove the debris in the K-1070-B Burial Ground, regardless of depth, to minimize potential future impact to surface water and soil that exceeds remediation levels for protection of workers (upper 10 ft) or protection of groundwater (water table or bedrock surface).

- Remove the debris and soil in the K-1070-C/D Burial Ground that exceed remediation levels for the protection of workers (upper 10 ft) or protection of groundwater (water table or bedrock surface).

- Verify all acreage in Zone 2 as compliant with soil remediation levels established by the ROD.

- Implement LUCs to prevent exposure to residual solid contamination left onsite and/or to prevent residential use of the land.

The recent activities under the Zone 2 ROD are summarized in Figure 8.4 and discussed below:

- Activity took place in EU-Z2-11 Poplar Creek area. Sampling of the K-1132, K-1133, K-1134-B, and K-1135 facilities, referred to as the Hydrofluoric Acid Tank Farm, determined that no remediation was necessary to meet Zone 2 requirements. An excavation action did occur in the area of a temporary waste storage area. DOE excavated approximately 420 yd^3 of cesium-contaminated soil and shipped it to EMWMF.

- Several characterization activities took place in Z2-EU-12 Poplar Creek area, including sampling in the K-1203 area Sludge Drying Bed and the Imhoff Tank, and the K-832 Basin. It was determined that an RA is needed for the Sludge Drying Bed and the K-832 sludges.

- A small soil RA was completed in the southern portion of EU-12 (Figure 8.5). Cs-137 and radium/thorium decay series contamination was found at levels exceeding the maximum remediation limits for Zone 2. Soil was excavated from an approximately 1976 ft^2 area with a depth of 4.5 ft, or approximately 567 yd^3 and shipped to EMWMF.

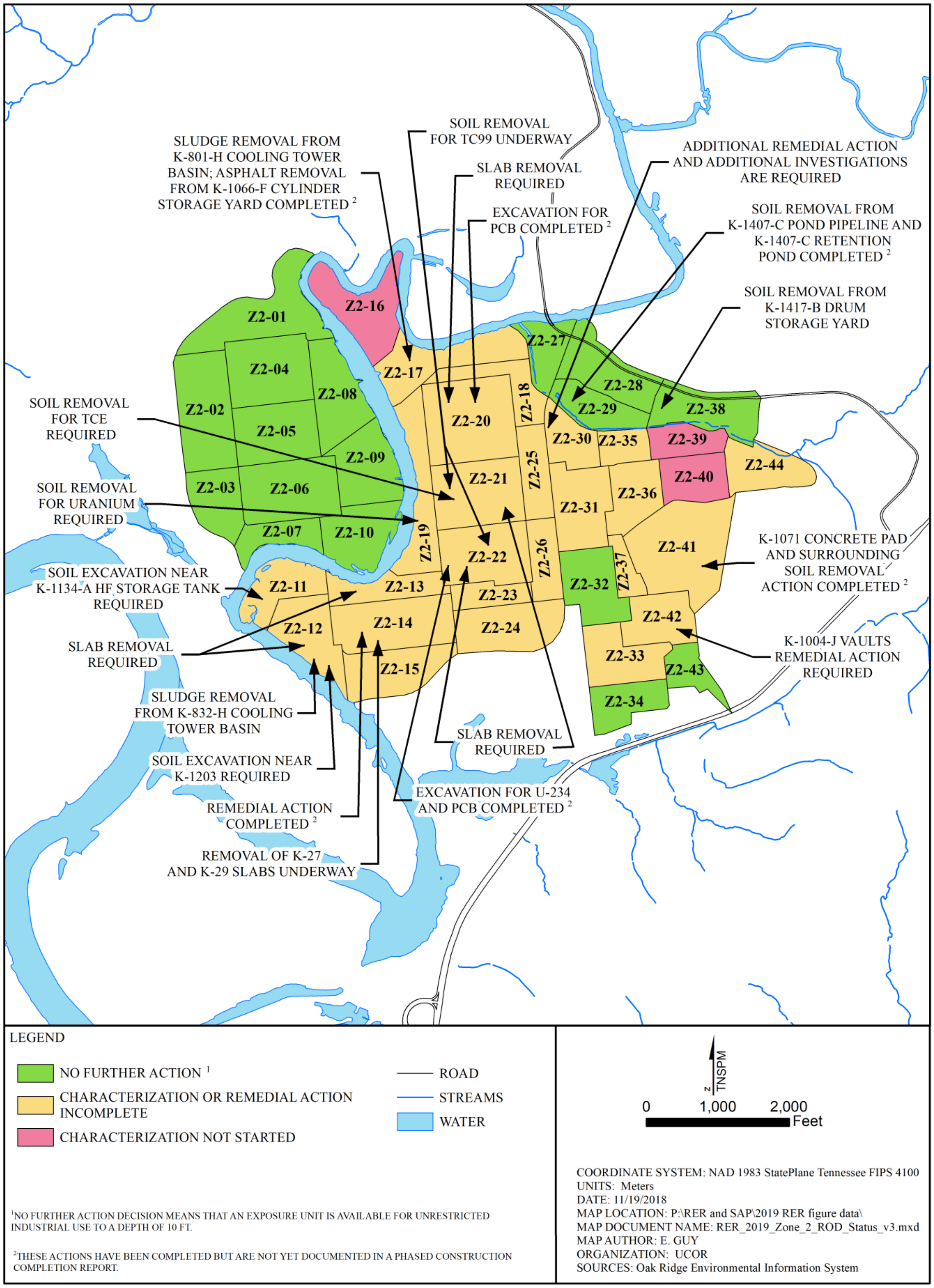

Figure 8.4. ETTP Zone 2 ROD status.

Figure 8.5. Zone 2 EU Z2-12 during remediation.

- A small soil RA was completed in Z2-EU-14, the former K-29 area, to remove Tc-99-contaminated soil.

- Three separate small RAs were completed in Z2-EU-22, the southern portion of the K-25 footprint. Two of the RAs were associated with removing soil contaminated with concentrations of U-234 exceeding the groundwater soil screening level and the third RA was associated with removing PCB contaminated soil with concentrations exceeding the Zone 2 ROD maximum remediation level for PCBs.

- Also within EU Z2-22 and Z2-21, DOE completed final delineation of the area requiring excavation to reduce the threat to groundwater from Tc-99 contaminated soils. The RA began in early 2018 and continued throughout the remainder of the FY. Remediation is scheduled to be completed in 2019. A separate PCCR is planned for this RA.

- The *Phased Construction Completion Report for Exposure Unit Z2-28 in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2746&D1) and the *Phased Construction Completion Report for Exposure Unit Z2-29 in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2747&D1) were submitted to EPA and TDEC for approval. Both documents recommended unrestricted industrial use to 10 ft bgs.

Completion of the Zone 2 ROD activities are documented in PCCRs listed in Table H.7 in Appendix H.

8.3.1 Performance Summary

The RAOs for Zone 2 are to:

- *Protect human health under an industrial land use to an excess cancer risk level at or below 1 x 10^{-4} and non-cancer risk levels at or below an HI [Hazard Index] of 1, and*

- *Protect groundwater to levels at or below MCLs.*

8.3.2 LUCs

LUCs for the Zone 2 ROD are listed in Table 8.1 and described below.

Zone 2 LUCs

The ETTP RAR CMP identifies LUCs, their objectives, and their verification requirements for Zone 1 and Zone 2 at ETTP.

The Zone 2 ROD establishes "industrial" as the land use to a depth of 10 ft. To implement restrictions that prohibit residential or agricultural use of this area under the ROD and to restrict access to this area until that end use has been achieved, LUCs will be implemented.

The PCCRs completed under the Zone 2 ROD state that the NFA decision means that an EU is available for unrestricted industrial use to a depth of 10 ft bgs subject to the LUCs specified in the Zone 2 ROD. Figure 8.3 illustrates EUs that have NFA decisions, EUs that have characterization yet to be completed, and EUs that will require RA.

8.3.2.1 Status of LUCs

Appendix A of this RER contains the Certification of the ETTP LUCs for FY 2018. A summary of the implementation verification and status of the ETTP LUCs is described in Section 8.2.2.1 under Zone 1. This section also includes a status of the property transfers for FY 2018.

8.4 SINGLE-PROJECT ACTIONS

Monitoring requirements for completed CERCLA single-projects actions are included in the ETTP RAR CMP and are listed in Table 8.2. This includes monitoring for sites such as the K-1070 C/D Burial Grounds, K-1407-B/C Ponds, K-901-A and K-1007-P1 Holding Ponds, and monitoring to determine the effectiveness of the Hexavalent Chromium Treatment Facility. Monitoring results of these actions are discussed in the following sections. Figure 8.1 shows the completed single project actions that require performance assessment monitoring.

Table 8.2. CERCLA action monitoring in ETTP[a]

CERCLA action	Performance goal	Performance standard	Monitoring location(s)	General schedule and monitored parameters
		Monitoring		
K-1070-C/D Burial Ground	Protect human health under an industrial land use to an ELCR at or below 1 x 10^{-4} and non-cancer risk levels at or below a HI of 1 Protect groundwater to levels at or below MCLs for drinking water	Drinking water MCLs	*Groundwater* TMW-011 UNW-064 UNW-114	Semiannual sampling (seasonally wet and dry conditions) Laboratory analyses for VOCs and water quality parameters
Long-term Reduction of Hexavalent Chromium Releases to Mitchell Branch (Non-time critical Removal Action)	Collect and treat hexavalent chromium-contaminated groundwater to reduce its toxicity prior to discharge into Mitchell Branch Protect water quality in Mitchell Branch at levels consistent with AWQC	Hexavalent chromium concentrations below 0.011 mg/L AWQC in Mitchell Branch immediately downstream of SD-170 discharge	*Surface water* MIK-0.79 SD-170 *Groundwater* TP-289 IW-416 and IW-417 *Treatment System Discharge*	Quarterly sampling of all monitoring locations Laboratory analyses (unfiltered samples) for total and hexavalent chromium in surface water, groundwater, and treatment system discharge samples Treatment system discharge samples also analyzed for pH, total uranium, VOCs, gross alpha and beta, and select radionuclides
K-1407-B/C Ponds RA	Reduce potential threats to human health and the environment posed by residual contamination in pond soils by providing isolation and shielding with rock fill and intact soil cover	Remediation target concentrations were not established in the CERCLA decision or post-decision documents	*Surface water* K-1700 Weir *Groundwater* UNW-003 UNW-009	Semiannual sampling Laboratory analyses for nitrate, VOCs, metals, gross alpha and beta, Tc-99, Sr-90, Cs-137, Th-230/232, and U-234/238 and field parameters

Table 8.2. CERCLA action monitoring in ETTP[a] (cont.)

CERCLA action	Performance goal	Performance standard	Monitoring location(s)	General schedule and monitored parameters
K-1007-P1 and K-901-A Holding Ponds and K-720 Slough RA	The goal of the ecological enhancement performed at the K-1007-P1 Holding Pond is to establish a new steady-state condition within the pond that reduces risks from PCBs by enhancing components of the ecology that minimize PCB uptake, which will reduce risks to human and piscivorous wildlife by interdicting contaminant exposure pathways associated with these receptors	PCB concentration of 1 mg/kg in fish fillets (2.3 mg/kg whole body)	Operational Monitoring at K-1007-P1 Holding Pond only:	
			1. Presence of original fish	1. Once, after fish removal
			2. PCBs in fish	2. Annually
			3. Condition of vegetation	3. 2x/yr during growing season
			4. Species of fish	4. Annually
			5. Water quality	5. 3x/yr during growing season
			6. PCBs in clams	6. Four locations annually for a four week exposure
			7. Geese/waterfowl population	7. Monthly identification and enumeration of all waterfowl in and around pond
			Performance Monitoring at K-1007-P1 & K-901-A Holding Ponds, and K-720 Slough:	
			1. PCBs in fish	1. Annually for four years, then reassess for every other year until acceptable risk documented for each pond
			2. Species of fish in K-1007-P1 Holding Pond only	2. Annually for four years (reassess after four years, as above)
			3. PCBs in clams in K-1007-P1 Holding Pond only	3. Four locations annually for a four week exposure (reassessed after four years, as above)

[a]Changes to performance monitoring for RAs require prior approval from the EPA and TDEC.

AWQC = ambient water quality criteria
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
ELCR = excess lifetime cancer risk
EPA = U.S. Environmental Protection Agency
ETTP = East Tennessee Technology Park

Table 8.2. CERCLA action monitoring in ETTP[a] (cont.)

HI = hazard index
IW = interceptor well
MCL = maximum contaminant level
MIK = Mitchell Branch kilometer
PCB = polychlorinated biphenyl
RA = remedial action
SD = storm drain
TDEC = Tennessee Department of Environment and Conservation
TP = temporary piezometer
VOC = volatile organic compound

8.4.1 K-1407-B/C Ponds

The *Record of Decision for the K-1407-B/C Ponds at the Oak Ridge K-25 Site, Oak Ridge, Tennessee* (DOE/OR/02-1125&D3) addressed potential risks associated with residual wastes and soils remaining in the K-1407-B/C Ponds from the initial removal of sludge conducted as a previous RCRA closure action. The location of the K-1407-B/C ponds at ETTP is shown in Figure 8.1 and Figure 8.6.

The major components of the selected remedy include:

- placement of clean soil and rock fill for isolation and shielding,
- maintenance of institutional controls, and
- groundwater monitoring to assess performance of the action and to develop information for use in reviewing the effectiveness of this remedy.

The K-1407-B Pond, constructed in 1943, was primarily used for settling metal hydroxide precipitates generated during neutralization and precipitation of metal-laden solutions treated in the K-1407-A Neutralization Unit. It also received discharge from the K-1420 Metals Decontamination Building and wastes from the K-1501 Steam Plant. The K-1407-C Pond, constructed in 1973, was primarily used to store potassium hydroxide scrubber sludge generated at K-25. It also received sludge from the K-1407-B Pond. When the K-1407-B Pond reached maximum sludge capacity, it was dredged, and the sludge was transferred to the K-1407-C Pond.

8.4.1.1 Performance monitoring

8.4.1.1.1 Performance monitoring goals and objectives

The objective of the K-1407-B/C Ponds remediation was to reduce potential threats to human health and the environment posed by residual metal, radiological, and VOC contamination within the pond soils (DOE/OR/02-1125&D3).

The *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin, Oak Ridge, Tennessee* (K-1407 B/C Ponds RAR; DOE/OR/01-1371&D1) proposed semiannual groundwater monitoring for nitrate, metals, and selected radionuclides, including gross alpha and beta activity, Tc-99, Sr-90, Cs-137, Th-230/232, and U-234/238. Target concentrations for these parameters were not established (DOE/OR/02-1125&D3; DOE/OR/01-1371&D1). However, as recommended by the EPA with concurrence from TDEC, performance monitoring for the constituents listed in Table 8.2 is conducted in wells UNW-003, UNW-009, and the Mitchell Branch weir (K-1700 Weir), shown on Figure 8.6. The ETTP RAR CMP accurately reflects these requirements.

8.4.1.1.2 Evaluation of performance monitoring data

The primary groundwater contaminants in the K-1407-B/C ponds area are VOCs. VOCs are widespread in this portion of ETTP, including contaminant sources upgradient of the ponds. Groundwater samples were collected at UNW-003 and UNW-009 in March and August 2018. VOCs are infrequently detected in shallow groundwater north of Mitchell Branch in well UNW-009 because the upgradient K-1407-C Pond was principally used as a sludge holding area rather than as primary wastewater holding unit. During FY 2018, cis-1,2-DCE was detected at concentrations of 0.82 J and 0.98 μg/L in March and August, respectively, and TCE was detected at 0.5 J μg/L in August in UNW-009.

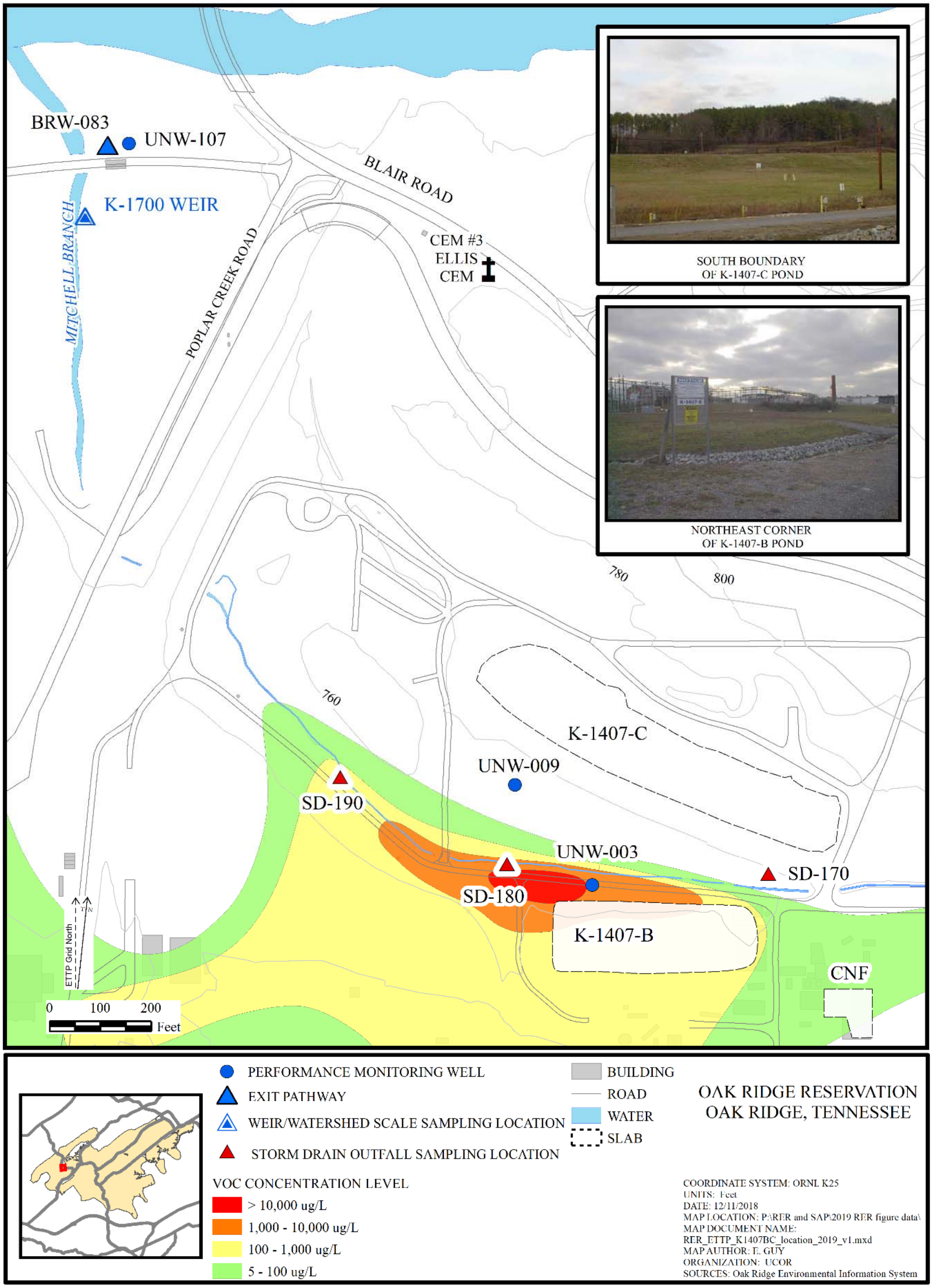

Figure 8.6. Location of K-1407-B/C Ponds.

Table 8.3 summarizes groundwater contaminant screening and trend evaluation for data collected within the past 10 years at well UNW-003. Alpha activity has a history of measurements greater than 80% of its 15 pCi/L MCL although maximum measured concentrations within the past five years have been less than 10 pCi/L. Arsenic also has a history of being present in groundwater in UNW-003 although it was apparently associated with filterable particulates as indicated by non-detect results in filtered sample aliquots. VOC concentration data for well UNW-003 for the time span 2001 through 2018 are shown on Figure 8.7. Over the past five years, VOC concentration trends have been predominantly stable with decreasing trends for 1,1-DCE and VC. DOE suspects a DNAPL source exists somewhere beneath the former pond site based on persistent high VOC concentrations in both shallow and deeper groundwater wells.

Table 8.3. Summary of groundwater contaminants and concentration trends at UNW-003 (FY 2009 – FY 2018)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. > MCL[b]		Freq. > 80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,1-Dichloroethene	UNW-003	mg/L	20 / 20	10 / 10	--	**1.6**	**1.6**	**0.6**	0.007	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Down
1,2-Dichloroethane	UNW-003	mg/L	15 / 20	10 / 10	0.125	**0.031**	**0.031**	**0.013**	0.005	13 / 20	8 / 10	13 / 20	8 / 10	No trend	Stable
Alpha activity	UNW-003	pCi/L	19 / 20	9 / 10	3.85	14	8.7	6	15	0 / 20	0 / 10	1 / 20	0 / 10	Stable	Stable
Arsenic	UNW-003	mg/L	3 / 20	3 / 10	0.005	0.008	0.008	0.004	0.01	0 / 20	0 / 10	1 / 20	1 / 10	No trend	Stable
	UNW-003(F)	mg/L	0 / 20	0 / 10	0.005	ND	ND	ND	0.01	0 / 20	0 / 10	0 / 20	0 / 10	--	--
cis-1,2-Dichloroethene	UNW-003	mg/L	20 / 20	10 / 10	--	**3.4**	**3.4**	**2.3**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Stable
Methylene chloride	UNW-003	mg/L	1 / 20	1 / 10	0.125	0.004	0.004	ND	0.005	0 / 20	0 / 10	1 / 20	1 / 10	No trend	Stable
Tetrachloroethene	UNW-003	mg/L	20 / 20	10 / 10	--	**1**	**1**	**0.45**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Stable
Trichloroethene	UNW-003	mg/L	20 / 20	10 / 10	--	**8.3**	**8.3**	**3.8**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	Stable
Vinyl chloride	UNW-003	mg/L	19 / 20	10 / 10	0.05	**0.15**	**0.15**	**0.079**	0.002	19 / 20	10 / 10	19 / 20	10 / 10	No trend	Down

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.
[b]MCL as of May 2018.
[c]Significant linear trend from the Mann-Kendall test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.
(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
FY = fiscal year
Freq. = frequency
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
M-K = Mann-Kendall
ND = not detected

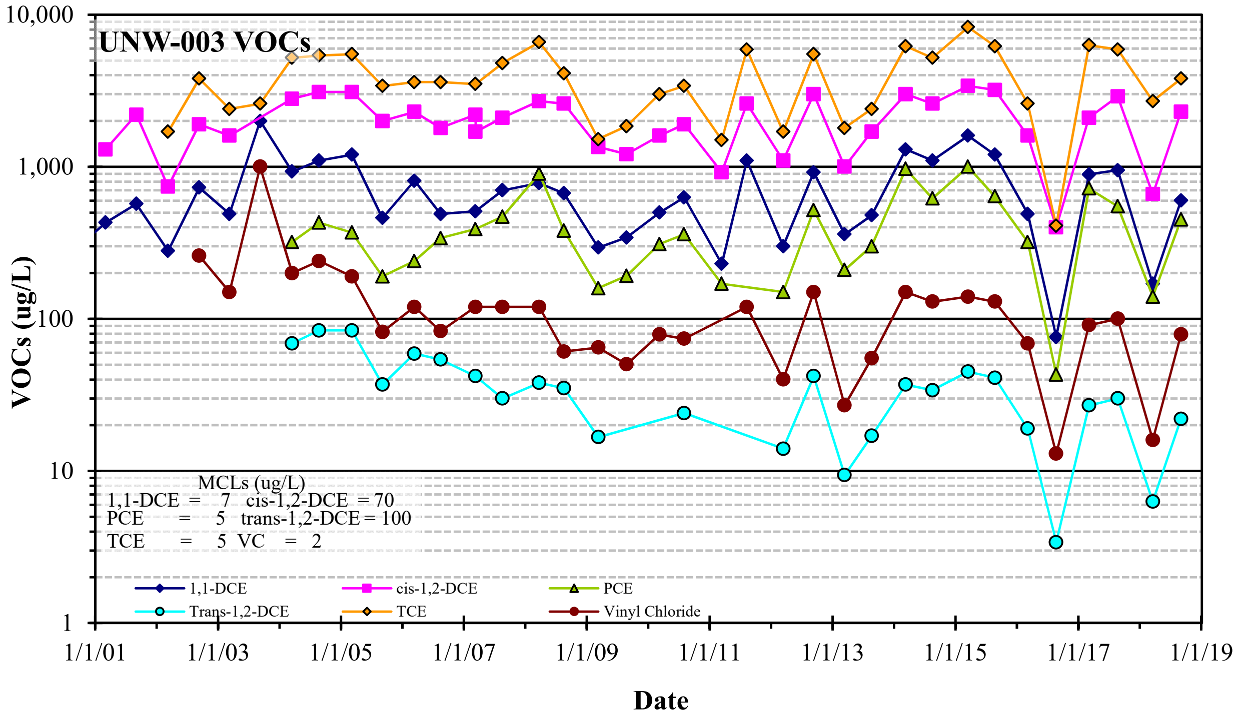

Figure 8.7. VOC concentrations in well UNW-003, 2001 – 2018.

8.4.1.2 Remedy integrity and LUCs

LUCs specified in the K-1407-B/C Ponds RAR were clarified in an erratum approved May 2015 and included maintenance of institutional controls (Table 8.1).

> The erratum states, *"Conduct annual inspections and perform radiological and industrial hygiene surveillance and other assessment activities only as needed if activities are conducted at the site that are necessary to keep the remediated ponds in compliance with environmental, safety, and health requirements and maintain records of all related activities."*

8.4.1.2.1 Status of remedy integrity and LUCs

The K-1407-C Pond was excavated in accordance with the Zone 2 ROD in 2017, and therefore performance inspections are no longer necessary and are no longer performed. Inspections of K-1407-B Pond will continue until RA is taken. Components of K-1407-B Pond inspected in FY 2018 by the ETTP S&M Program, including access controls and sign conditions; condition of vegetation including dead spots, excessive weeds or deep-rooted vegetation, grass mowing, and discoloration or withering of vegetation; soil/surface condition including evidence of soil erosion, gullies or rills, staining, and debris or trash. The site underwent routine mowing. Maintenance included cleaning up the K-1407-B Pond sign so contact information is legible.

8.4.2 ETTP Ponds

8.4.2.1 Performance monitoring

8.4.2.1.1 Performance monitoring goals and objectives

The *Action Memorandum for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment, Oak Ridge, Tennessee* (ETTP Ponds AM; DOE/OR/01-2314&D2) includes the following actions (Figure 8.1):

- K-1007-P1 Holding Pond
  - — Drain pond, modify the weir, remove undesirable fish, establish vegetation within the pond and the riparian zone, replace desirable fish, and adjust water quality to protect piscivorous wildlife and recreational fishermen.
  - — Implement institutional controls to prevent residential use.
  - — Monitor.
- K-901-A Holding Pond
  - — Implement institutional controls to prevent residential use.
  - — Monitor.
- K-720 Slough
  - — Implement institutional controls to prevent residential use.
  - — Monitor.
- K-770 Embayment
  - — No action (Institutional controls specified in Zone 1 Interim ROD remain in effect).
- K-1007-P3, P4, and P5 Holding Ponds
  - — No action (Institutional controls specified in Zone 1 Interim ROD remain in effect).

The goal of the removal action is to establish a new steady-state condition within the K-1007-P1 Holding Pond that reduces risks from PCBs by enhancing components of the ecology that minimize PCB uptake. Implementation details were provided in the *Removal Action Work Plan for the Removal Action at the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2359&D2). Completion of the removal action is documented in the *Removal Action Report for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment, Oak Ridge, Tennessee* (ETTP Ponds RmAR; DOE/OR/01-2456&D1/R1).

Major pond actions, including plant management, fish management, wildlife management, and water quality adjustments, were implemented over the 2009 – 2011 time period at the K-1007-P1 Holding Pond.

The desired end-state is a well vegetated, sunfish-dominated pond with conditions conducive to preventing PCB mobilization from sediments and minimizing PCB uptake in the food chain. Monitoring of the K-1007-P1 Holding Pond includes operational and performance monitoring phases, as documented in the ETTP RAR CMP. Operational monitoring has provided information used to make additional adjustments to the pond ecosystem; for example, continued fish management to help push the ecosystem towards the desired end-state.

Performance monitoring has focused on fish surveys and the changes in PCB concentrations in fish after the completed action and evaluation of fish PCB levels relative to the target concentrations. Per the ETTP Ponds AM, "*A PCB concentration level of 1 µg/g in fish fillets (2.3 µg/g whole body) was set based upon levels shown to be protective of piscivorous wildlife, consistent with surrounding water bodies, and below FDA recommendations.*"

As part of the 2016 FYR, performance monitoring at the ETTP ponds was evaluated. At the K-1007-P1 Holding Pond, there was some evidence of population increases in less desirable fish species (e.g., largemouth bass, gizzard shad) and reduction of plant cover in 2016, suggesting that additional management actions identified in the ETTP Ponds RmAR might be warranted. Similarly, evaluation of PCB trending data in fish from the K-901-A Holding Pond suggested that the pond would also benefit from fish and plant management actions that might reduce PCBs in fish. After discussions with EPA and TDEC, DOE agreed to conduct additional management actions at the K-1007-P1 and K-901-A Holding Ponds in FY 2017 and FY 2018 in an effort to decrease human and ecological risks from PCBs in fish. The additional activities are specified in letters from DOE to EPA and TDEC dated December 29, 2016 (for the K-1007-P1 Holding Pond), and September 7, 2017 (for the K-901-A Holding Pond). The additional actions included fish management (including fish removals and stocking) and plant management (including within pond and riparian areas). A comprehensive review of both the results of FY 2018 operational and performance monitoring at the ponds and the additional FY 2018 management actions are presented in Appendix C.2. A brief summary of the results are as follows:

Fish have not attained remediation goals at K-1007-P1 and K-901-A Holding Ponds. A FYR issue identified additional management actions for both ponds with annual reporting in the RER and the next FYR (2021). In FY 2018, PCB concentrations in caged clams increased in SD-100.

8.4.2.2 Remedy integrity and LUCs

The ETTP Ponds RmAR requires signs at K-1007-P1 Holding Pond, K-901-A Holding Pond, and K-720 Slough to provide notice or warning to prevent unauthorized access by fishermen and specific signs at the K-1007-P1 Holding Pond to provide notice or warning that prohibits mowing in the buffer zone. The RmAR also requires surveillance patrols be established and maintained to control and monitor access by fishermen (Table 8.1).

8.4.2.2.1 Status of remedy integrity and LUCs

Activities conducted at the ponds in FY 2018 included inspections by the ETTP S&M Program for visible evidence of storm or flood damage, inspections of the weirs for evidence of debris or vegetation or erosion of the banks, and inspections of the warning signs. Maintenance activities documented in LUM for FY 2018 included:

- Correcting the placement of the northernmost grate at the K-1007-P1 Holding Pond. Maintenance included closing and properly seating the grate against the apron.

- Removing 10 beavers from the K-1007-P1 Holding Pond. It was identified in FY 2017 that beavers had been causing debris in the K-1007-P1 Holding Pond weir.

- Repairing gravel washouts present beneath the barrier fence on the west side of the road that was a result of erosion due to receding flood waters from Poplar Creek and/or high volume flows exiting the K-1007-P1 Holding Pond (Figure 8.8). High precipitation over the weekend of February 10 – 12, 2018 resulted in elevated water levels in Poplar Creek which then back flowed into the K-1007-P1 Holding Pond.

- Monthly maintenance activities were ongoing at the K-1007-P1 Holding Pond weir to remove rip rap below the weir grates allowing them to close (Figure 8.9). It is estimated that this maintenance of the grates and weir takes anywhere from 240 to 360 hours a year to perform. When the weir becomes clogged it affects the NPDES permit sampling requirements at Outfall 100. This water level needs to stay below the effluent side of the SD-100 flume for the flow studies to remain accurate. Additionally, a consistent water depth in the pond needs to be maintained to benefit the pond vegetation.

Figure 8.8. Erosion beneath the K-1007-P1 Holding Pond fish barrier fence along Poplar Creek.

Figure 8.9. K-1007-P1 Holding Pond weir showing debris at the high-water mark and water level of Poplar Creek.

8.4.3 K-1070-C/D G-Pit and Concrete Pad

The K-1070-C/D G-Pit is the primary source of organic contaminant releases to soil and groundwater in the area. The K-1071 Concrete Pad, located in the southeastern portion of the K-1070-C/D area, was determined to pose an unacceptable health risk to workers from future exposure to soil radiological contaminants (DOE/OR/02-1486&D4). The location of the area at ETTP is shown in Figure 8.1 and Figure 8.10. Components of the remedy included:

- Excavation of the G-Pit contents (which began in December 1999 and was completed in January 2000), interim storage of the material, treatment, and disposal, and

- Placement of an interim 2 ft soil cover over the Concrete Pad until remediated.

In addition, monitoring for the K-1070-C/D Burial Ground is discussed in this section.

8.4.3.1 Evaluation of monitoring data

Monitoring locations, analytical parameters, and clean-up levels were not specified for groundwater monitoring at the K-1070-C/D Burial Ground, although the primary COCs in that area are VOCs. Semiannual samples collected at wells and surface water locations outside the perimeter of the K-1070-C/D Burial Ground are analyzed for VOCs and general water quality parameters (Figure 8.11). Monitoring at the site is focused on providing data for evaluating changes in contaminant concentrations near the source units or potentially discharging to surface water within the boundaries of the ETTP. Approximately 9,100 gal of mixed volatile organic liquids were disposed in G-Pit during its period of use between 1977 and 1979. Site characterization data collected at G-Pit in the mid-1990s showed the presence of 1,1,1-TCA (840 mg/L); 1,1-DCA (43 mg/L); toluene (74 mg/L); and TCE (220 mg/L). A RA was conducted in December 1999 − January 2000 to remove container remnants from G-Pit. The pit was backfilled with soil following the excavation. DOE's conceptual model for the G-Pit site includes probable DNAPL permeation of the unconsolidated and bedrock zones beneath the former liquid waste disposal site. The 1,1,1-TCA is amenable to biodegradation to 1,1-DCA by microbes in the *Dehalobacter* genus. Although 1,1-DCA is also amenable to degradation by some species of *Dehalobacter*, the presence of cis-1,2-DCE and VC tend to inhibit the biodegradation of 1,1-DCA. Cis-1,2-DCE and VC are common biodegradation products of PCE and TCE, which are also present in groundwater at the site along with 1,1-DCE, another biodegradation product of PCE and TCE.

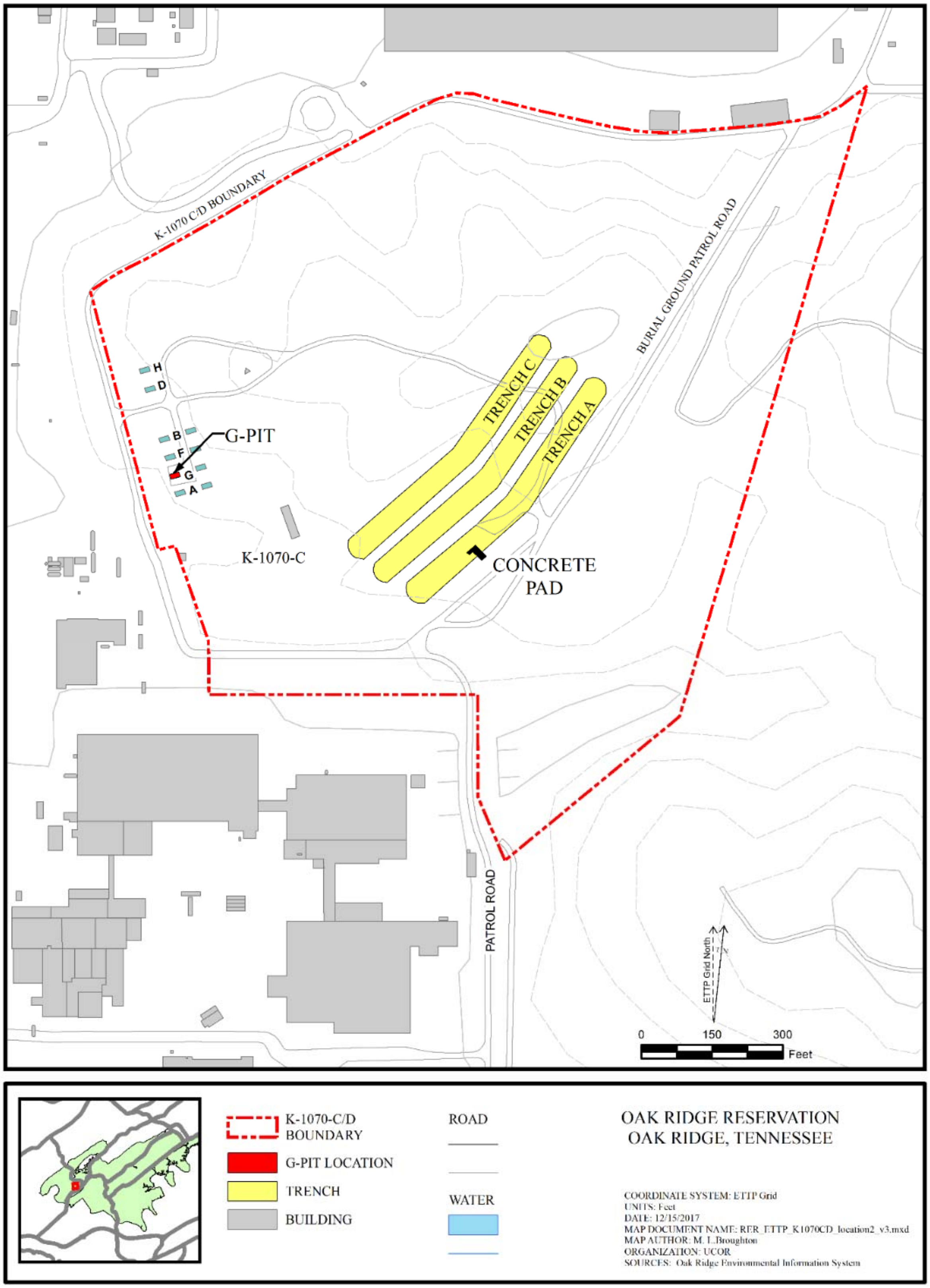

Figure 8.10. Location of K-1070-C/D G-Pit and K-1071 Concrete Pad.

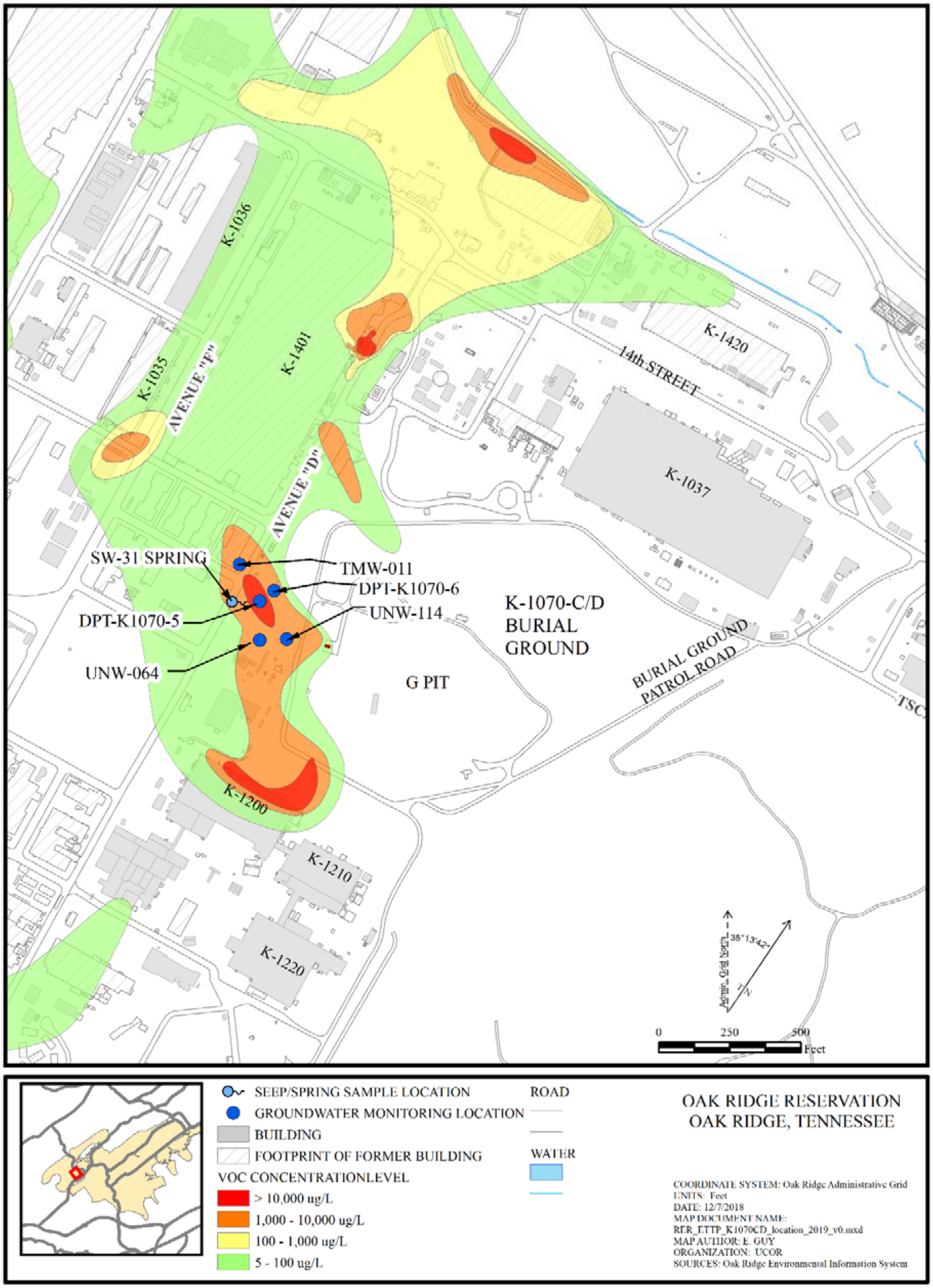

Figure 8.11. Location of monitoring locations downgradient of K-1070-C/D Burial Ground.

Following remediation of G-Pit, monitoring wells UNW-114, TMW-011, and UNW-064 (Figure 8.11) were selected to monitor the VOC plume leaving the K-1070-C/D Burial Grounds because they were located in the principal known downgradient groundwater pathway. Results of monitoring at these wells show elevated VOC concentrations. VOC concentrations at these three wells were decreasing prior to the excavation of the G-Pit contents (during FY 2000) and continue to decrease. Although 1,1,1-TCA was formerly present at concentrations far greater than its 200 µg/L MCL, natural biodegradation has reduced 1,1,1-TCA concentrations to less than the drinking water standard. Several direct push technology (DPT) monitoring points were installed to the west of UNW-114 during investigations conducted in support of a Sitewide Groundwater RI in 2005. The purpose of these monitoring points was to investigate groundwater contamination in an area along potential geologically controlled seepage pathways that may have connected the G-Pit contaminant source to the former SW-31 spring. DOE continues to monitor two of these points (DPT-K1070-5 and DPT-K1070-6) to measure VOC concentrations and their fluctuations.

DOE has compiled the analytical data for groundwater contaminants in the K-1070-C/D area to evaluate contaminant concentrations with respect to MCL and MCL-DC concentrations and to determine if statistically significant trends are occurring. Data are compared to EPA's National Primary Drinking Water Regulations MCLs or MCL-DCs for radionuclides. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants that may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations were conducted for data compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification.

Table 8.4 presents a summary of groundwater contaminants at K-1070-C/D that have exceeded 80% of their MCL concentrations within the past 10 years. Long term contaminant concentration graphs are provided for three wells monitored closest to the G-Pit contaminant source. Well UNW-114 is closest to the source area and has a screen interval elevation of 774.95 – 784.95 ft aMSL in unconsolidated material. Monitoring data for well UNW-114 (Figure 8.12) show that concentrations of most VOCs have been variable since 2005. Contaminant concentration trends in well UNW-114 show that 1,1-DCE and VC exhibited increasing concentration trends in the 10-year evaluation period although concentration variability of both these compounds has been great enough over the most recent five years so that a statistically confident trend direction could not be assigned. PCE and TCE both exhibit a decreasing trend in the 10-year evaluation. PCE continued that decreasing trend in the 5-year evaluation although the trend for TCE was stable. The increasing trend for 1,1-DCE and VC is attributed to natural degradation of chlorinated VOCs at the site. Metals analysis was added to UNW-114 fairly recently and nickel exceeds the state of Tennessee water quality criterion in both unfiltered and filtered sample aliquots which indicates that nickel is present as a dissolved contaminant in well UNW-114.

Well UNW-064 (well screen elevation 783.87 – 788.87 ft aMSL) is located slightly further downgradient from the contaminant source area than UNW-114 and its monitoring data exhibit a slightly different behavior. Similar to the overall trend observed at UNW-114, the majority of VOC concentrations at UNW-064 (Figure 8.13) decreased from about 2002 through 2005. Although 1,1-DCE and TCE are always detected in samples from well UNW-064, their concentrations are sufficiently variable to prevent assignment of concentration trend direction with statistical confidence. VC concentration trends have been decreasing in both the 10-year and 5-year evaluations. The FY 2018 maximum measured VC concentration in well UNW-064 was less than the MCL. At UNW-064, the 1,1-DCA, 1,1-DCE, cis-1,2-DCE, and TCE exhibit seasonal concentration fluctuations with higher concentrations during winter than during summer. This seasonal fluctuation suggests that contaminant mass transport responds to increased groundwater recharge and seepage through the plume. DOE suspects that increased seasonal recharge drives mass transfer in the plume through two combined mechanisms. One mechanism is a rise in groundwater elevation in the source area (residuals from liquid waste beneath G-Pit) which allows groundwater seepage through fractures of higher permeability at a somewhat shallower depth. The second mechanism is simply a higher flow volume through the source area and downgradient fractures caused by the higher head imposed on the whole saturated zone.

Well TMW-011 (screen just above bedrock at elevation 762.8 ft aMSL) is located furthest from the contaminant source area near the base of the hill below K-1070-C/D. VOC concentrations at TMW-011 tend to fluctuate in a fashion similar to those at UNW-064, except that the seasonal signature is reversed, with higher concentrations in summer than during winter. This relationship suggests that groundwater recharge during winter tends to dilute the VOCs near TMW-011 rather than cause a pulse of higher concentration groundwater as was observed at the mid-slope location near UNW-064. Trend evaluations for cis-1,2-DCE and VC in well TMW-011 show decreasing trends for the 10-year evaluation although the trends are stable in the 5-year evaluations for these two contaminants. Although the maximum measured TCE concentrations progressively decrease in the 10-year, 5-year, and FY 2018 results, the TCE trend evaluations are stable over the 10-year period and no statistically confident trend could be assigned over the most recent five years. Since 2012, VC has fluctuated, with wet season concentrations below the MCL and dry season concentrations exceeding the MCL (Figure 8.14).

Monitoring locations DPT-K1070-5 and DPT-K1070-6 (Figure 8.11; screened intervals 776.93 – 781.93 and 777.48 – 782.48 ft aMSL, respectively) were installed using DPT and therefore they sample groundwater just at, and somewhat above, the top of bedrock downgradient of the G-Pit VOC source. Both sample locations exhibit a fairly wide range of VOC contaminants, with DPT-K1070-5 being more highly contaminated than DPT-K1070-6. Figure 8.15 shows the concentration history for those constituents with the highest concentrations in the monitored K-1070-C/D DPT wells. Seasonal fluctuation signatures are apparent in the contaminant concentrations in these DPT wells prior to about 2016, before there was an unexplained change in behavior evidenced by increases in 1,1-DCE and 1,1,1-TCA in DPT-K1070-5 coincident with decrease in 1,1,1-TCA at DPT-K1070-6 and an increase in TCE at DPT-K1070-5. No activities other than grounds maintenance (mowing) occurred in the area upgradient of these wells during that time period.

As shown in Table 8.4, contaminant trends over the past 10 years have been predominantly decreasing (14) or stable (13) while nine results have been sufficiently variable to preclude assignment of a concentration trend. Three contaminants (1,1-DCE and VC at UNW-114 and cis-1,2-DCE at DPT-K1070-5) have exhibited increasing trends. Increasing trends for degradation products of the parent solvent compounds is an indication that natural degradation processes are ongoing in the area. Within the most recent five years somewhat more variability in trend directions has been observed with 10 decreasing trends, eight increasing trends, 11 stable trends, and 10 indeterminate trends.

Table 8.4. Summary of K-1070-C/D area groundwater contaminants (2008 – 2018)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,1,1-Trichloroethane	DPT-K1070-5	mg/L	20 / 20	10 / 10	--	**7.5**	**4.7**	**4.7**	0.2	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Up
	DPT-K1070-6	mg/L	19 / 19	9 / 9	--	**2.1**	**2.1**	**0.33**	0.2	19 / 19	9 / 9	19 / 19	9 / 9	**Down**	**Down**
1,1,2-Trichloroethane	DPT-K1070-5	mg/L	19 / 20	10 / 10	0.062	**0.063**	**0.05**	**0.041**	0.005	19 / 20	10 / 10	19 / 20	10 / 10	Down	Stable
	DPT-K1070-6	mg/L	18 / 19	9 / 9	0.02	**0.009**	**0.005**	0.002	0.005	5 / 19	1 / 9	6 / 19	2 / 9	Down	Down
1,1-Dichloroethene	DPT-K1070-5	mg/L	20 / 20	10 / 10	--	**5.9**	**5.7**	**5.7**	0.007	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Up
	DPT-K1070-6	mg/L	19 / 19	9 / 9	--	**0.87**	**0.58**	**0.14**	0.007	19 / 19	9 / 9	19 / 19	9 / 9	Down	Down
	UNW-064	mg/L	20 / 20	10 / 10	--	**0.068**	**0.068**	**0.068**	0.007	20 / 20	10 / 10	20 / 20	10 / 10	No trend	No trend
	UNW-114	mg/L	20 / 20	10 / 10	--	**0.037**	**0.037**	**0.023**	0.007	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
1,2-Dichloroethane	DPT-K1070-5	mg/L	18 / 20	10 / 10	0.062	**0.03**	**0.023**	**0.022**	0.005	18 / 20	10 / 10	18 / 20	10 / 10	Stable	Up
Arsenic	DPT-K1070-5	mg/L	2 / 3	2 / 3	0.003	**0.01**	**0.01**	**0.01**	0.01	0 / 3	0 / 3	1 / 3	1 / 3	No trend	No trend
Benzene	DPT-K1070-5	mg/L	18 / 20	10 / 10	0.062	**0.048**	**0.039**	**0.039**	0.005	18 / 20	10 / 10	18 / 20	10 / 10	Stable	Up
	DPT-K1070-6	mg/L	18 / 19	9 / 9	0.02	**0.012**	**0.007**	0.00099	0.005	6 / 19	2 / 9	7 / 19	3 / 9	Down	Down
cis-1,2-Dichloroethene	DPT-K1070-5	mg/L	20 / 20	10 / 10	--	**1.2**	**1.2**	**1.2**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	Up	Up
	DPT-K1070-6	mg/L	19 / 19	9 / 9	--	**0.13**	**0.13**	**0.036**	0.07	5 / 19	1 / 9	9 / 19	4 / 9	Down	Down
	TMW-011	mg/L	20 / 20	10 / 10	--	**0.097**	**0.035**	**0.019**	0.07	2 / 20	0 / 10	5 / 20	0 / 10	Down	Stable
	UNP-001	mg/L	20 / 20	10 / 10	--	**0.29**	**0.23**	**0.12**	0.07	19 / 20	9 / 10	19 / 20	9 / 10	Stable	Down
Methylene chloride	DPT-K1070-5	mg/L	18 / 20	10 / 10	0.062	**0.035**	**0.021**	**0.02**	0.005	18 / 20	10 / 10	18 / 20	10 / 10	Stable	Up
Nickel	UNW-114	mg/L	3 / 3	3 / 3	--	**0.15**	**0.15**	**0.15**	0.1	2 / 3	2 / 3	3 / 3	3 / 3	Stable	Stable
	UNW-114(F)	mg/L	3 / 3	3 / 3	--	**0.15**	**0.15**	**0.15**	0.1	**1 / 3**	**1 / 3**	**3 / 3**	**3 / 3**	Stable	Stable
Tetrachloroethene	DPT-K1070-5	mg/L	19 / 20	10 / 10	0.062	**0.11**	**0.11**	**0.094**	0.005	19 / 20	10 / 10	19 / 20	10 / 10	No trend	No trend
	DPT-K1070-6	mg/L	18 / 19	9 / 9	0.02	**0.03**	**0.024**	**0.008**	0.005	18 / 19	9 / 9	18 / 19	9 / 9	Stable	Down
	TMW-006	mg/L	11 / 20	8 / 10	0.003	0.004	0.00078	0.00053	0.005	0 / 20	0 / 10	1 / 20	0 / 10	Down	Stable
	UNP-001	mg/L	15 / 20	9 / 10	0.01	**0.028**	0.003	0.002	0.005	3 / 20	0 / 10	3 / 20	0 / 10	No trend	No trend
	UNW-114	mg/L	20 / 20	10 / 10	--	**0.034**	**0.014**	**0.007**	0.005	19 / 20	9 / 10	20 / 20	10 / 10	Down	Down

Table 8.4. Summary of K-1070-C/D area groundwater contaminants (2008 – 2018) (cont.)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. >MCL[b]		Freq. >80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Trichloroethene	BRW-046	mg/L	4 / 20	1 / 10	0.003	**0.005**	0.00035	ND	0.005	0 / 20	0 / 10	1 / 20	0 / 10	No trend	Stable
	DPT-K1070-5	mg/L	20 / 20	10 / 10	--	**1.5**	**1.3**	**1.2**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Up
	DPT-K1070-6	mg/L	19 / 19	9 / 9	--	**0.25**	**0.19**	**0.078**	0.005	19 / 19	9 / 9	19 / 19	9 / 9	Down	Stable
	TMW-011	mg/L	20 / 20	10 / 10	--	**0.14**	**0.062**	**0.048**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Stable	No trend
	UNP-001	mg/L	20 / 20	10 / 10	--	**0.17**	**0.092**	**0.056**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Stable	No trend
	UNW-064	mg/L	20 / 20	10 / 10	--	**0.031**	**0.031**	**0.031**	0.005	18 / 20	9 / 10	18 / 20	9 / 10	No trend	No trend
	UNW-114	mg/L	20 / 20	10 / 10	--	**0.11**	**0.011**	**0.007**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	Stable
Vinyl chloride	BRW-046	mg/L	19 / 20	10 / 10	0.001	**0.008**	**0.006**	**0.004**	0.002	18 / 20	10 / 10	18 / 20	10 / 10	Stable	Down
	DPT-K1070-5	mg/L	15 / 20	9 / 10	0.062	**0.037**	**0.024**	**0.024**	0.002	15 / 20	9 / 10	15 / 20	9 / 10	No trend	Up
	DPT-K1070-6	mg/L	18 / 19	9 / 9	0.02	**0.015**	**0.013**	**0.011**	0.002	18 / 19	9 / 9	18 / 19	9 / 9	No trend	No trend
	TMW-007	mg/L	20 / 20	10 / 10	--	**0.007**	**0.007**	**0.004**	0.002	16 / 20	7 / 10	17 / 20	8 / 10	Stable	Stable
	TMW-011	mg/L	17 / 20	9 / 10	0.01	**0.013**	**0.004**	0.002	0.002	11 / 20	5 / 10	11 / 20	5 / 10	Down	Stable
	UNP-001	mg/L	18 / 20	10 / 10	0.008	**0.037**	**0.02**	**0.006**	0.002	17 / 20	9 / 10	17 / 20	9 / 10	Down	Stable
	UNW-064	mg/L	18 / 20	9 / 10	0.004	**0.004**	0.002	0.001	0.002	7 / 20	0 / 10	11 / 20	3 / 10	Down	Down
	UNW-114	mg/L	19 / 20	10 / 10	0.01	**0.013**	**0.013**	**0.009**	0.002	19 / 20	10 / 10	19 / 20	10 / 10	Up	No trend

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[b]MCL as of May 2018.

[d]Significant linear trend from the M-K test at the 0.10 significance level.

Bold table entries indicate results that exceed MCL or MCL-DC values.

(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
DPT = direct push technology
Freq. = frequency
FY = fiscal year
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
M-K = Mann-Kendall
ND = not detected

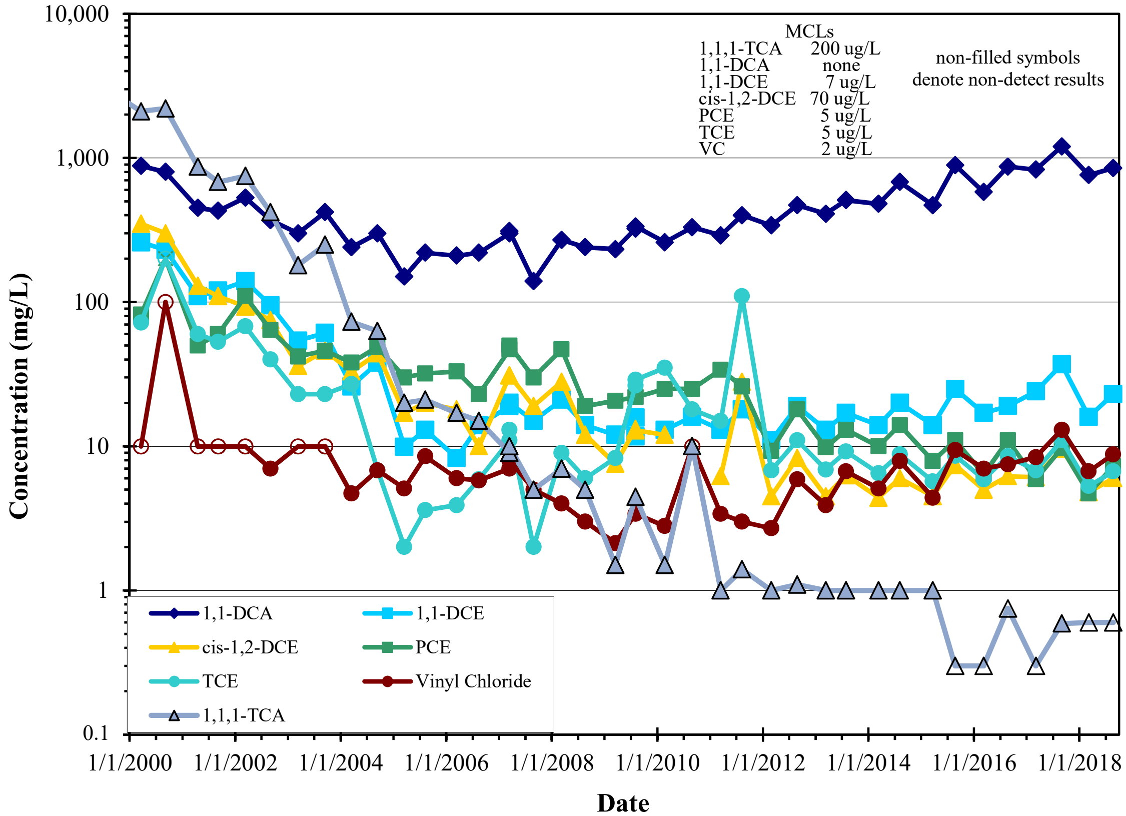

Figure 8.12. VOC concentrations in well UNW-114, FY 2000 – FY 2018.

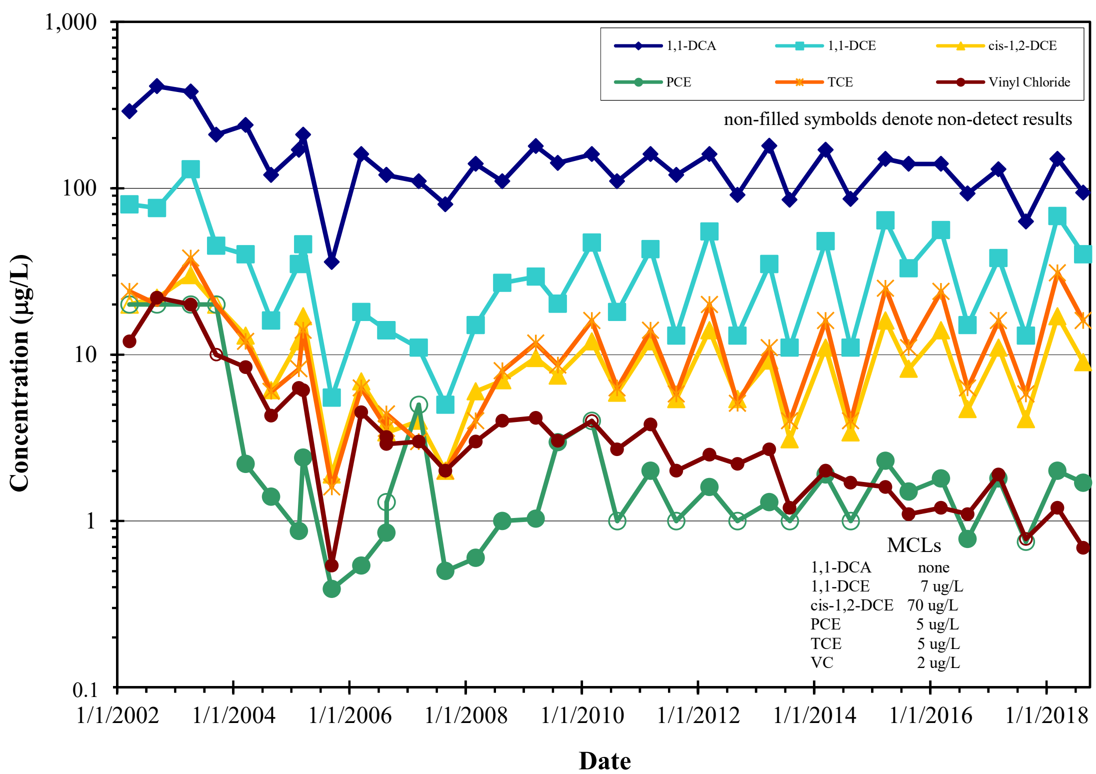

Figure 8.13. VOC concentrations in well UNW-064, FY 2002 – FY 2018.

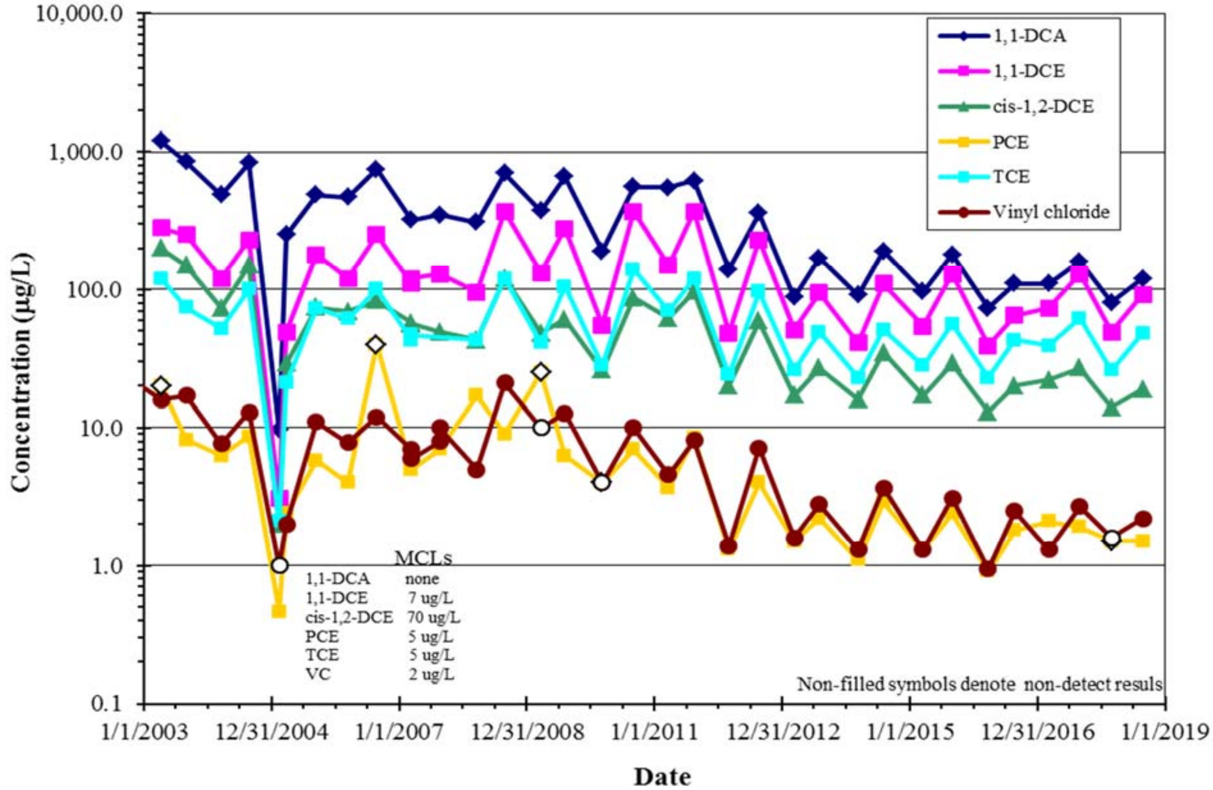

Figure 8.14. VOC concentrations in well TMW-011, FY 2001 – FY 2018.

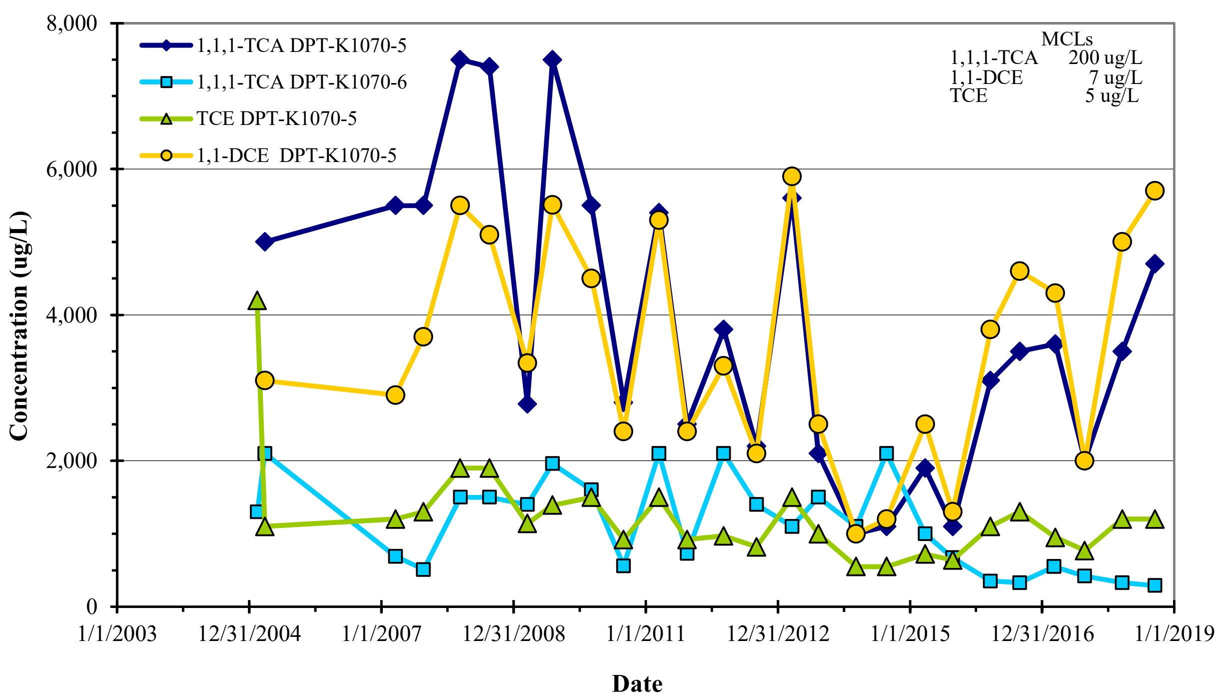

Figure 8.15. Concentrations of selected VOCs in DPT-K1070-5 and DPT-K1070-6.

The elevation and VOC concentration relationships among the monitoring wells demonstrate that the G-Pit plume is a heterogenous flow system and that DPT-K1070-5 and DPT-K1070-6 lie in a different flowpath from the area monitored by UNW-064 and UNW-114. Although the screen elevations of the two DPTs and well UNW-114 are essentially the same, the VOC concentrations in the DPT samples are much higher than those in well UNW-114. Bedrock wells have not been installed in the area to date to evaluate deeper groundwater conditions.

8.4.3.2 Remedy integrity and LUCs

The *Record of Decision for the K-1070-C/D Operable Unit, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/02-1486&D4) and *Remedial Action Report for the K-1070-C/D G-Pit and K-1071 Concrete Pad, East Tennessee Technology Park*, *Oak Ridge, Tennessee* (DOE/OR/01-1964&D2) require interim LUCs including maintaining institutional controls (see Table 8.1). An erratum to the K-1070-C/D G-Pit and K-1071 Concrete Pad RAR (DOE/OR/01-1964&D2) approved in May 2015 contains revised frequencies. Specifically, annual inspections of the soil cover over the pad are to be conducted to look for erosion; the grass on the cover is to be mowed as needed, but not less than annually; radiological walkover surveys are to be conducted only if there is activity in the area to confirm the effectiveness of the K-1071 Concrete Pad soil cover in preventing exposure to ionizing radiation; and inspections of the fence are to be performed as needed, but no less than annually. Existing institutional controls will continue to include ensuring the existing EPP program remains in place.

8.4.3.2.1 Status of remedy integrity and LUCs

The site was inspected by the ETTP S&M Program in FY 2018 for items that include condition of the warning signs and the condition of fencing and locked gate. Maintenance included updating contact information on signs. The K-1071 Concrete Pad was removed in FY 2017 in accordance with the Zone 2 ROD, inspections of the condition of the K-1071 Concrete Pad soil cover and maintenance of vegetation is no longer applicable.

8.4.4 Mitchell Branch Chromium Reduction

8.4.4.1 Performance monitoring

8.4.4.1.1 Performance monitoring goals and objectives

During FY 2007, hexavalent chromium was detected in surface water in Mitchell Branch at levels exceeding the applicable AWQC of 11 μg/L. The source of the discharge was determined to be from groundwater infiltration into the Outfall 170 (SD-170 on Figure 8.16) piping as well as seep flows through the outfall headwall. Figure 8.16 shows the locations of Mitchell Branch, relevant monitoring locations, the affected storm drain piping section, and the hexavalent chromium plume. The plume discharge resulted in levels of hexavalent chromium that exceeded the applicable AWQC. At Mitchell Branch kilometers (MIKs) 0.71 and 0.79, which are surveillance monitoring locations in Mitchell Branch immediately downstream from the Outfall 170 discharge point, hexavalent chromium levels were measured at levels as high as 780 μg/L.

On July 20, 2007, TDEC Division of Water Resources issued a Notice of Violation to DOE for the hexavalent chromium release. Since hexavalent chromium had not been used in process operations at ETTP for over 30 years, the release of hexavalent chromium into Mitchell Branch was determined to be a legacy issue and not an ongoing, current operations issue. Therefore, DOE, in coordination with EPA and TDEC, determined that the appropriate response to this release was a CERCLA time-critical removal action. On November 5, 2007, DOE notified the EPA and TDEC of their intent to conduct a CERCLA time-critical removal action to install and operate groundwater collection pumps to capture chromium-contaminated groundwater associated with the Outfall 170 discharge. The time-critical removal action to address releases of hexavalent chromium into Mitchell Branch was documented in the *Action Memorandum for Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2369&D1).

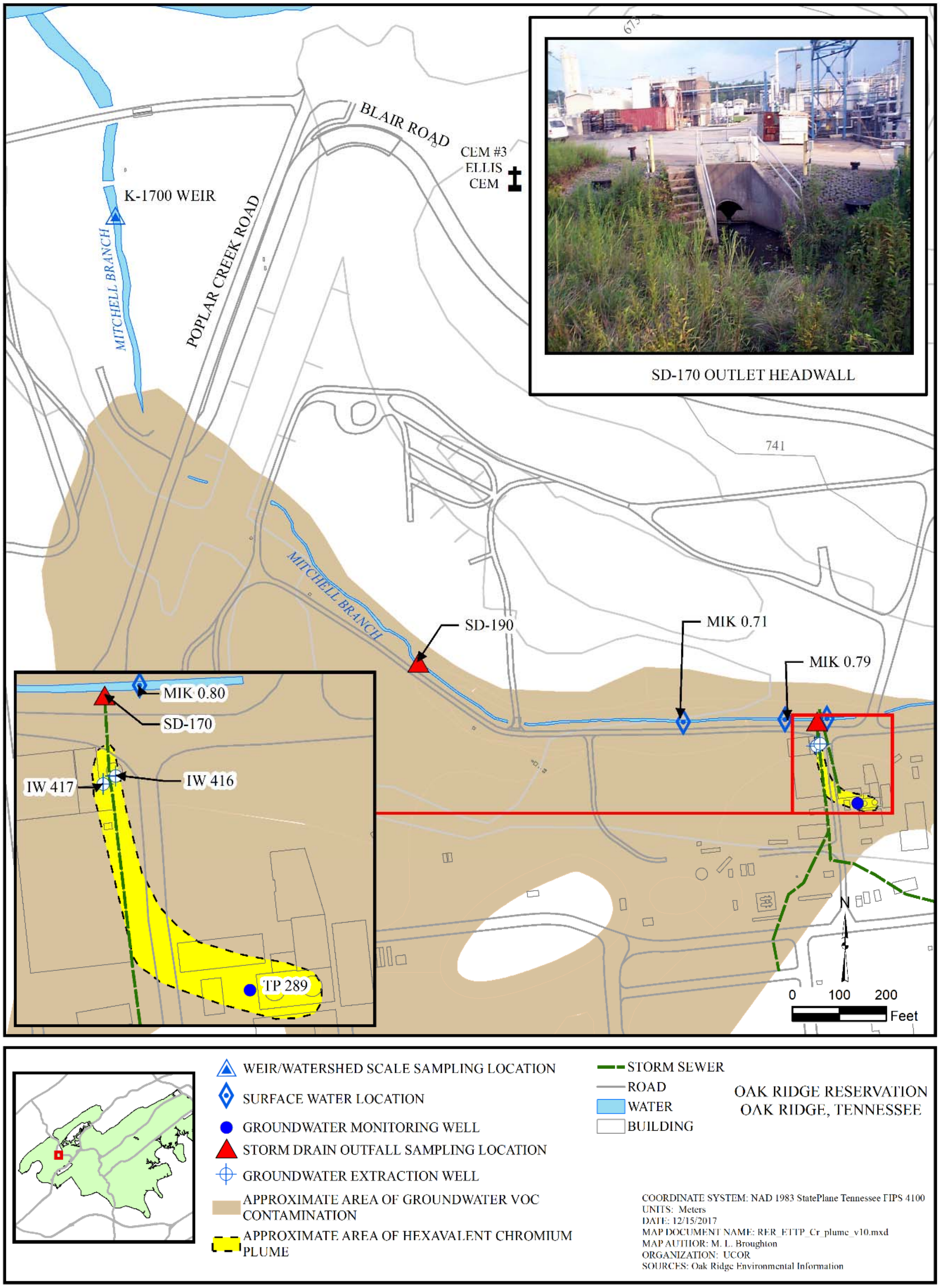

Figure 8.16. Map of hexavalent chromium releases to Mitchell Branch and monitoring locations.

Activities associated with the time-critical removal action included:

- Location of the hexavalent chromium release path to the Outfall 170 network and Mitchell Branch.

- Installation of a grout wall to impede the release of hexavalent chromium through Outfall 170 headwall seeps into Mitchell Branch.

- Installation of two interception wells into the gravel bed that surrounds the Outfall 170 discharge pipes to collect the hexavalent chromium groundwater plume before it infiltrates the Outfall 170 collection system network piping. These wells are labeled as interception well (IW) 416 and IW 417 on Figure 8.16.

- Initiating operating the two IWs in December 2007. The collected groundwater was initially treated at the Central Neutralization Facility (CNF). As CNF was being decommissioned, the Chromium Water Treatment System (CWTS) was built to treat the water from the collection wells (see discussion below). The treatment of the collected groundwater transitioned to the CWTS in FY 2012.

A *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2384&D1) for the time-critical removal action was issued in July 2008.

For a long-term solution to the release of hexavalent chromium to Mitchell Branch, an *Engineering Evaluation/Cost Analysis for the Reduction of Hexavalent Chromium Releases into Mitchell Branch, Oak Ridge, Tennessee* (DOE/OR/01-2422&D1) recommending *ex situ* treatment by chromium reduction was approved in December 2009. The non-time critical Mitchell Branch AM was approved on March 26, 2010, superseding the time-critical removal action (DOE/OR/01-2369&D1). The *Removal Action Work Plan for the Reduction of Hexavalent Chromium Releases into Mitchell Branch, Oak Ridge, Tennessee* (DOE/OR/01-2484&D1) was approved in November 2010.

Construction of the CWTS was initiated in the spring of 2011, with final process installation completed in FY 2012. The treatment unit initiated sustained continuous operations in May 2012. The Mitchell Branch RmAR was approved in April 2013 and documented the monitoring requirements of the removal action. Monitoring requirements for the Mitchell Branch chromium removal action are now included in the ETTP RAR CMP. The water quality performance monitoring data is evaluated by the ETTP Environmental Compliance and Protection (EC&P) organization, and the data is presented in the Annual Site Environmental Report and the annual RER. The Outfall 170 total chromium and hexavalent chromium quarterly sampling results are also reported in the NPDES Permit TN0002950 Discharge Monitoring Report, which is submitted to TDEC annually. The goals of the removal action are to collect and treat the hexavalent chromium-contaminated groundwater to reduce its toxicity prior to discharge, and to protect the water quality in Mitchell Branch at levels consistent with the AWQC. The total chromium and hexavalent chromium performance sampling points (Figure 8.16) are:

- Outfall 170 discharge point.

- Mitchell Branch in-stream location (MIK 0.79) located immediately downstream from Outfall 170. The in-stream location downstream of Outfall 170 provides an opportunity for the discharges from Outfall 170 to mix with the Mitchell Branch receiving stream. This is considered the appropriate location to compare hexavalent chromium concentrations with the AWQC value of 11 µg/L.

- CWTS collection system that captures the combined flow from IWs 416 and 417.

- Monitoring well TP-289, which is located in the chromium-contaminated groundwater plume.

8.4.4.1.2 Evaluation of performance monitoring data

The long-term water quality monitoring results for total chromium in Mitchell Branch downstream from Outfall 170 at MIK 0.79 are shown in Figure 8.17. Total chromium results were used for trending purposes instead of hexavalent chromium for several reasons:

- the historical sample result data set for total chromium is more extensive than the historical hexavalent chromium data set,
- historical analyses of the chromium in the groundwater and surface water Outfall 170 and MIK 0.79 locations have established that essentially all of the detected chromium is hexavalent chromium, and
- the total chromium analysis provides lower detection limits in comparison to hexavalent chromium analysis.

The results shown in Figure 8.17 confirm that the chromium collection system has been very effective in reducing the levels of total chromium from a maximum measured value of 780 µg/L in 2007 to levels that are now consistently well below the hexavalent chromium fish and aquatic life continuous AWQC value of 11 µg/L. During FY 2018, the in-stream hexavalent chromium results at all of the Mitchell Branch monitoring locations were at or below the laboratory detection level of 6 µg/L.

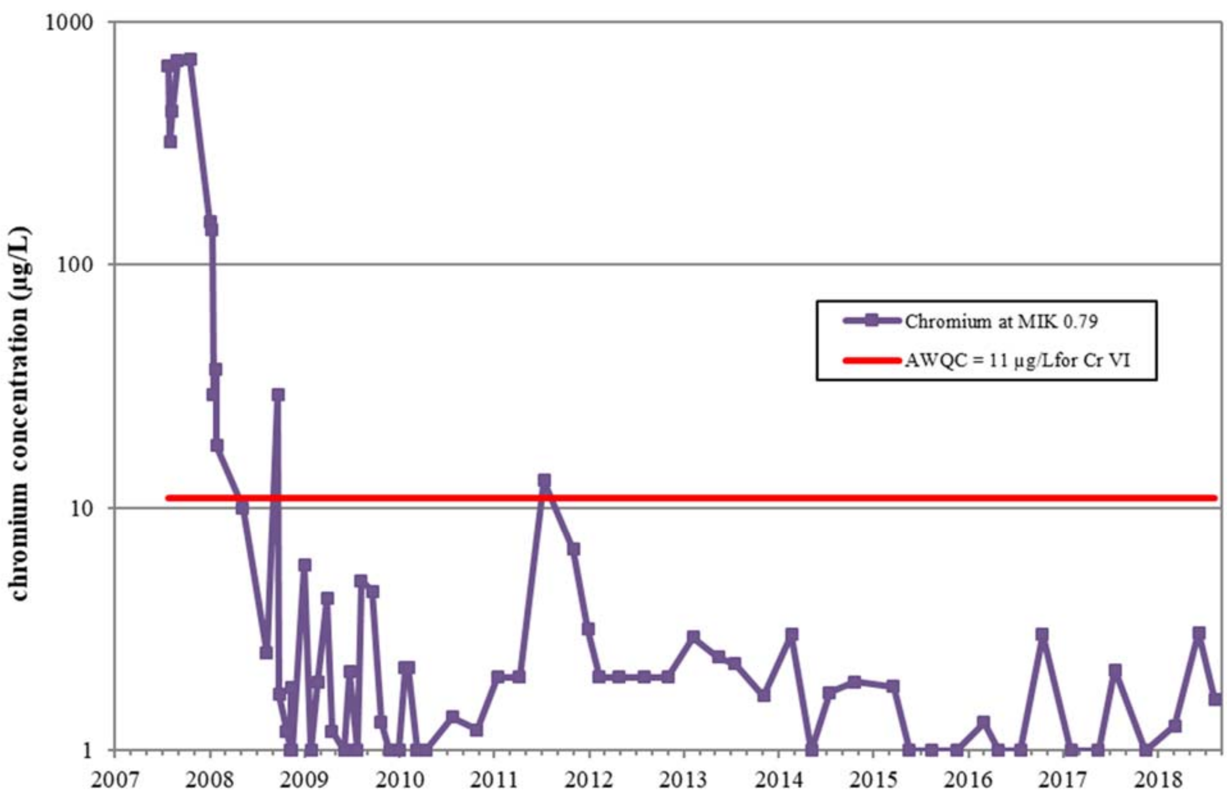

Figure 8.17. Mitchell Branch (MIK 0.79) total chromium concentrations, FY 2007 – 2018.

Table 8.5 provides results from the last year at the four locations where sampling is required. The results for hexavalent chromium at Outfall 170 varied from a maximum value of 10 µg/L in the fourth quarter of

FY 2018 to the non-detect level of less than 6 μg/L in the first quarter of FY 2018. As previously noted, the hexavalent chromium Mitchell Branch in-stream sampling results were at or below the detection level of 6 μg/L during all four quarters of FY 2018. The hexavalent chromium results for the CWTS influent (combined water flows that are collected in IWs 416 and 417) varied from a low of 120 μg/L to a maximum value of 160 μg/L. The hexavalent chromium results at well TP-289 varied from a low of 550 μg/L to a maximum value of 710 μg/L.

Table 8.5. FY 2018 performance monitoring results Mitchell Branch hexavalent chromium

Sample date	November 2017	March 2018	June 2018	August 2018
Location description	**Hexavalent chromium (μg/L)**	**Hexavalent chromium (μg/L)**	**Hexavalent chromium (μg/L)**	**Hexavalent chromium (μg/L)**
MIK 0.79 downstream from Outfall 170	6 U	6 U	6 U	6 U
Outfall 170	6 U	7.1	8.1	10
CWTS influent (CWTS-INF)	140	120	140	160
Well TP-289	590 D	550 D	560 D	710 D

CWTS = Chromium Water Treatment System
D = reported from a diluted analysis
FY = fiscal year
INF = influent
MIK = Mitchell Branch kilometer
U = not detected

Figure 8.18 provides hexavalent chromium results for the last eight years as a trend analysis of the four locations where sampling is required.

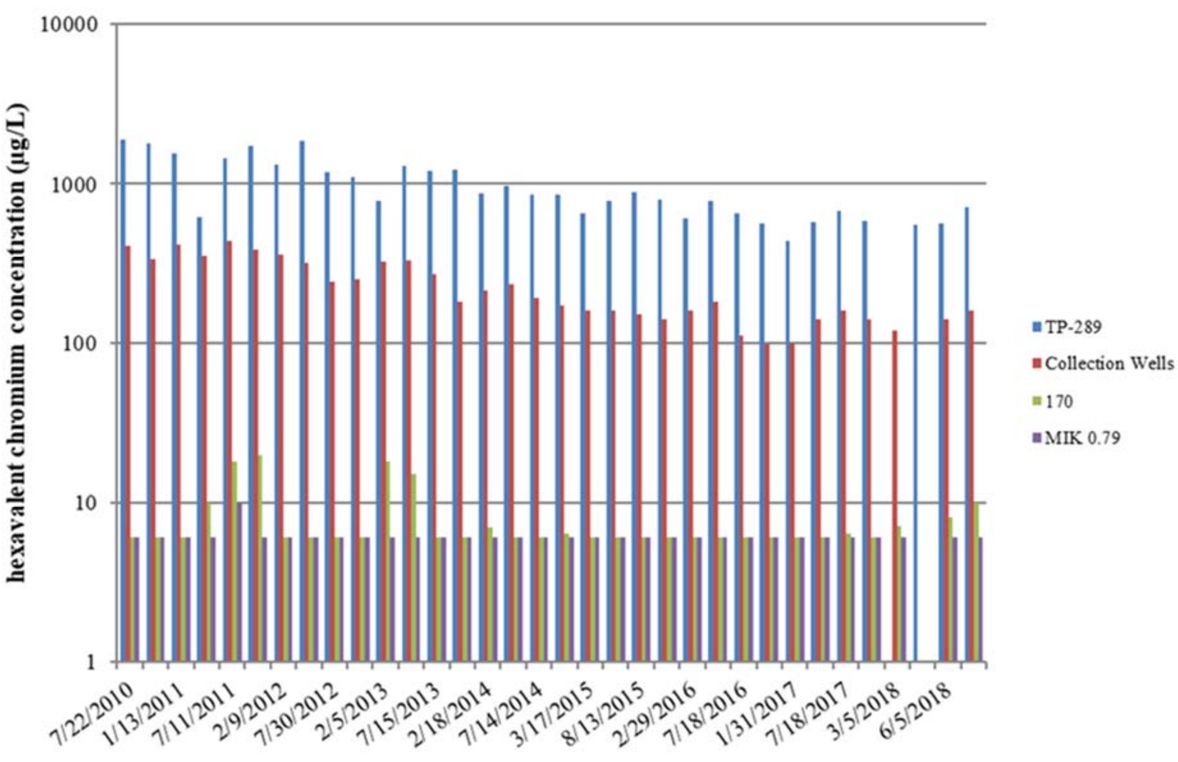

Figure 8.18. Hexavalent chromium performance trends, 2010 – 2018.

In addition to the Mitchell Branch watershed monitoring locations, samples are also collected from the CWTS facility discharge to the Clinch River. In particular, samples were collected for TCE and hexavalent chromium in FY 2018. The TCE values were at nondetection levels, and the maximum hexavalent chromium value was 160 µg/L, which is less than 1% of the Clinch River discharge allowable concentration as established in the *Removal Action Report for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2598&D2).

8.4.4.2 Remedy integrity

Construction of CWTS was completed in FY 2012 as the facility transitioned to continuous operations in May 2012. As described in the Mitchell Branch RmAR, the CWTS is operated and maintained in accordance with contractor procedures. The procedures describe all components of the system, the operating instructions, alarm response, waste acceptance criteria, and surveillance monitoring.

The primary components of the completed removal action consist of:

- groundwater extraction wells;
- grout barrier wall installed in the Outfall 170 gravel bed;
- reduction of hexavalent chromium to trivalent chromium using steel wool;
- One-Flow Anti-Scaling System and phosphate injection system;
- removal of VOCs with an air stripper;
- discharge to the Clinch River;
- operations and maintenance; and
- monitoring.

8.4.4.2.1 Status of remedy integrity

During FY 2018, the chromium collection system wells operated during 100% of the days with only short duration periods where collection system pumping volumes were limited due to treatment facility operational constraints. The total volume of wastewater that was treated in FY 2018 was approximately 4.7 million gal.

An operational challenge for CWTS from the start of the pump and treat operations has been associated with high levels of calcium and magnesium in the plume groundwater that creates scale buildup on the facility pumps, valves, and piping. Additional operational enhancements conducted have significantly reduced the CWTS equipment scale buildup in FY 2018.

The *Action Memorandum for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (Mitchell Branch AM; DOE/OR/01-2448&D1) describes the removal action for the long-term reduction of hexavalent chromium releases into Mitchell Branch. The *Removal Action Report for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee* (Mitchell Branch RmAR; DOE/OR/01-2598&D2) documents completion of the non-time-critical removal action. Per the RmAR, *this removal action can be terminated when the concentration of hexavalent chromium in Mitchell Branch meets AWQC fish and aquatic life continuous criterion of 11 µg/L without treatment of the plume where the plume is captured in the collection wells before being discharged to the surface water of Mitchell Branch. The removal action can also be completed when the levels are determined to be protective of the designated uses of Mitchell Branch without collection and treatment as demonstrated through a risk-based stream analysis that is specific to Mitchell Branch aquatic life.*

8.5 OTHER ETTP MONITORING

The ETTP RAR CMP provides the monitoring requirements for groundwater, surface water, and biological media (e.g., fish, turtles, and biota surveys) for both CERCLA performance and baseline assessments of trends, regulatory compliance, future actions, and in support of the CERCLA FYR of remedy protectiveness. Figure 8.19 shows monitoring locations at ETTP (note that additional monitoring locations are shown on separate figures as indicated).

This section provides a summary of ETTP CMP groundwater, surface water, and aquatic biology monitoring that is not included in the performance assessments of the actions described in Sections 8.2, 8.3, and 8.4. As actions are completed under the Zone 1 and Zone 2 RODs and under future environmental media RODs, these monitoring requirements will continue to evolve.

8.5.1 Groundwater plumes

Extensive groundwater monitoring at the ETTP site, using SDWA MCLs as groundwater screening values, has identified VOCs as the most significant groundwater contaminant on site. The principal chlorinated hydrocarbon chemicals that were used at ETTP were PCE, TCE, and 1,1,1-TCA. During preparation of an RI/FS in 2007 in support of CERCLA decision-making for the ETTP site, the human health risk assessment summarized "*priority COCs in groundwater . . . for the industrial worker, which is the most likely of the future scenarios assessed for exposure to groundwater*." The evaluation of priority groundwater COCs identified the major groundwater contaminant source areas and associated plumes as listed in Table 8.6.

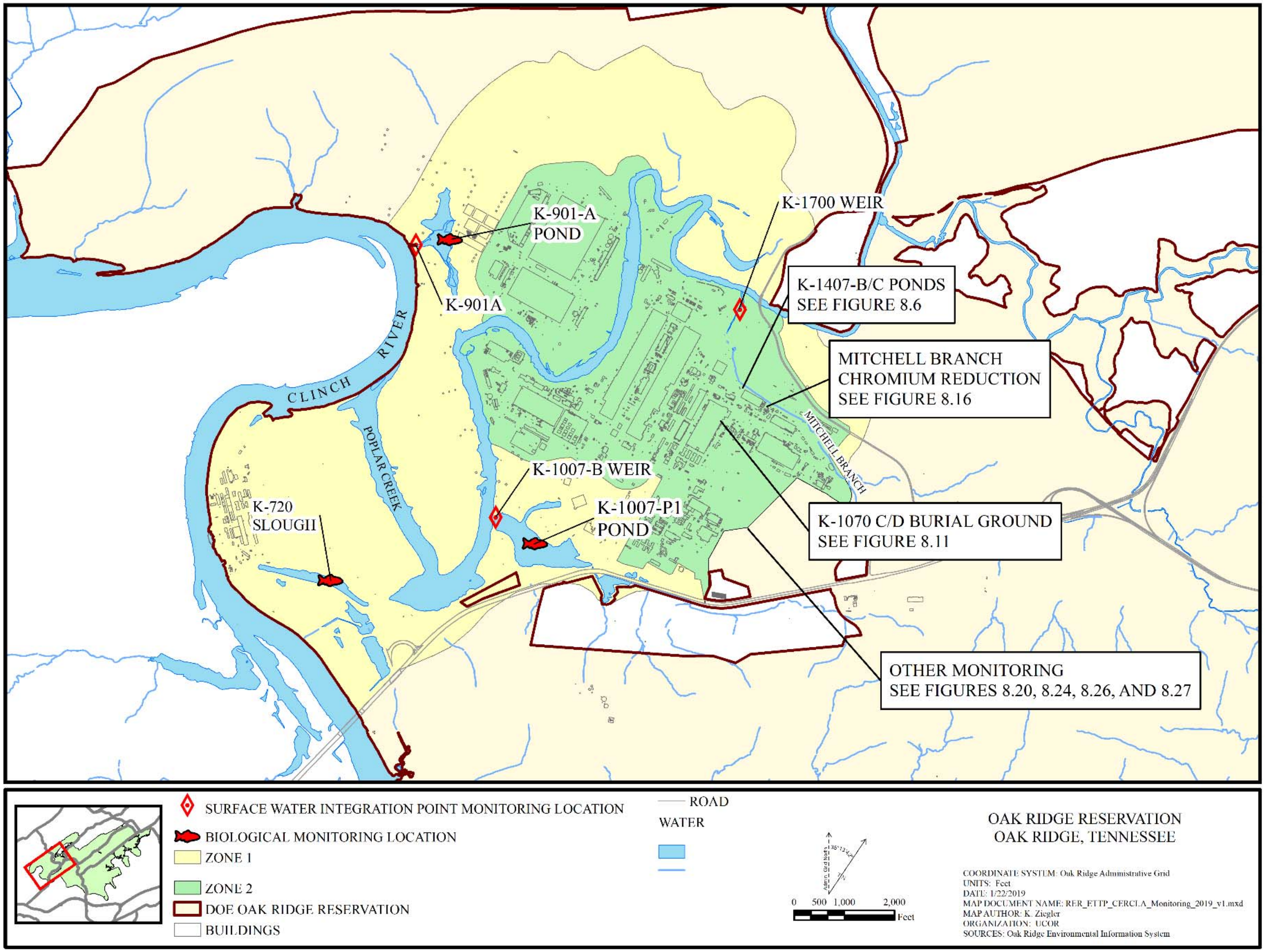

Figure 8.19. Monitoring locations at ETTP.

Table 8.6. Principal groundwater contaminant source areas and associated priority groundwater COCs

Source area/plume	1,1-DCE	Carbon tetrachloride	PCE	TCE	Cis-1,2-DCE	Manganese	VC
K-1070-C/D	X	X		X	X	X	
K-1035	X		X	X	X		
K-1401	X			X	X		X
K-1407-B	X		X	X	X		X
K-27/K-29				X			
K-1200			X				
K-1070-A	X	X		X			

Source: Table 7.12 of the *Final Sitewide Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2279&D3).

COC = contaminant of concern
DCE = dichloroethene
PCE = perchloroethene
TCE = trichloroethene
VC = vinyl chloride

Figure 8.20 shows the distribution and generalized concentrations of the sum of the primary chlorinated hydrocarbon chemicals and their degradation products at ETTP. Specific compounds included in the summation of chlorinated VOCs include chloroethenes (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC), chloroethanes (1,1,1-TCA, 1,1,2-TCA, 1,2-DCA, 1,1-DCA, and chloroethane), and chloromethanes (carbon tetrachloride, chloroform, and methylene chloride). Several plume source areas are identified within the regions of the highest VOC concentrations. In these areas, the primary chlorinated hydrocarbons have been present for decades and mature contaminant plumes have evolved. The degree of degradation, of the primary chlorinated hydrocarbon compounds is highly variable across the site. In the vicinity of the K-1070-C/D source (G-Pit and Concrete Pad, Section 8.4.3), a high degree of degradation has occurred, although a strong source of contamination still remains in the vicinity of the G-Pit, where approximately 9,000 gal of chlorinated hydrocarbon liquids were disposed in an unlined pit. Other areas where degradation is significant include the K-1401 Acid Line leak site, and the K-1407-B Pond area (Section 8.4.1). Degradation processes are weak or inconsistent at the K-1004 and K-1200 area, K-1035, K-1413, and K-1070-A Burial Ground, and little degradation of TCE is observed in the K-27/K-29 source and plume area.

VOC plumes shown on Figure 8.20 include significant revisions in the K-1401 area where subsurface characterization activities in support of the *Design Characterization Completion Report for the Sitewide Groundwater Treatability Study at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2768&D1) completed during FY 2018 defined the nature and extent of DNAPL and high concentrations of chlorinated solvent compounds in groundwater. In addition, ongoing soil characterization identified an area of TCE contaminated soil and groundwater within the footprint of the former K-25 building.

Figure 8.20 also shows the locations of monitoring wells throughout the ETTP site that are routinely sampled for known COCs. Designated groundwater exit pathway monitoring wells are identified and general facility areas are shown within which groundwater contaminant trends are discussed later in this section.

DOE has compiled the analytical data for groundwater contaminants in regularly sampled monitoring wells throughout the ETTP site for the past 10 years. The compiled data are compared to EPA's National Primary Drinking Water Regulations MCLs or MCL-DCs for radionuclides. Two screening levels were used – the full MCL concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants that may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. M-K trend evaluations were conducted for data compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification.

The results of trend evaluations for the designated exit pathway wells and for wells associated with completed CERCLA actions are presented within this RER report body. Additional trend evaluations for active monitoring wells in the broader ETTP site plume areas are included in Appendix D.

Groundwater exit pathways

Groundwater exit pathway monitoring sites are shown in Figure 8.20. Groundwater monitoring results for the designated exit pathway wells are discussed below: Table 8.7 presents a summary of contaminants detected in the exit pathway wells at concentrations greater than 80% of their respective MCL/MCL-DC concentrations within the past 10 years. Contaminant trend evaluations have been conducted and trend directions are included in Table 8.7.

Mitchell Branch – The Mitchell Branch groundwater exit pathway is monitored using surface water data from the K-1700 Weir on Mitchell Branch and wells BRW-083 and UNW-107. Section 8.5.1.2 and Appendix F includes discussion of the detected concentrations of VOCs in Mitchell Branch surface water.

Wells BRW-083 and UNW-107, located near the mouth of Mitchell Branch, have been monitored since 1994. Detection of VOCs in groundwater near the mouth of Mitchell Branch is considered an indication of the migration of the Mitchell Branch VOC plume complex. The intermittent detection of VOCs in this exit pathway is thought to be a reflection of variations in groundwater flowpaths that can fluctuate with seasonal hydraulic head conditions which are strongly affected by rainfall. During FY 2018, no chlorinated VOCs were detected in wells BRW-083 or UNW-107 and no concentrations of VOCs in the 5-year evaluation period exceeded 80% of their respective MCLs. Summary results of contaminant screening and trend evaluations for the Mitchell Branch exit pathway wells are included in Table 8.7.

K-1064 Peninsula area – Wells BRW-003 and BRW-017 monitor groundwater at the K-1064 Peninsula burn area. Metals and VOCs are monitored at the site. Metals detected in groundwater at the site include antimony, zinc, and arsenic; however, only arsenic concentrations exceeded 80% of its MCL. Arsenic was detected in both wells with maximum concentrations of 15 µg/L in well BRW-003 in the filtered sample in March 2018 and 14 µg/L in the filtered sample from well BRW-017 in September 2018.

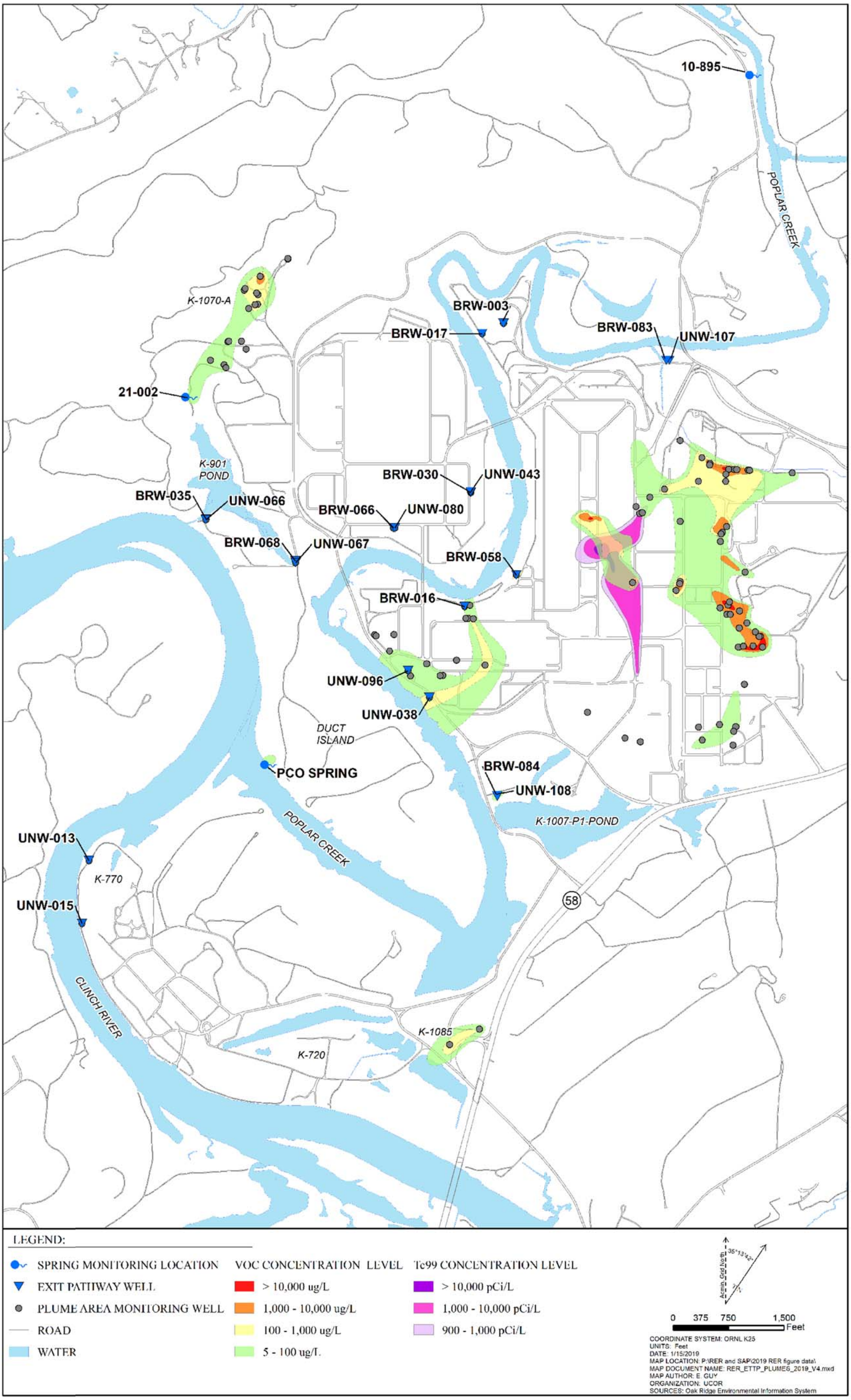

Figure 8.20. ETTP plume and exit pathways monitoring locations.

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Table 8.7. Exit pathway groundwater contaminant screening results and trend evaluations

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. > MCL[b]		Freq. > 80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Mitchell Branch Exit Pathway															
Alpha activity	UNW-107	pCi/L	16 / 20	10 / 10	2.61	14.3	14.3	2.48	15	0 / 20	0 / 10	1 / 20	1 / 10	No trend	No trend
Chromium	UNW-107	mg/L	10 / 20	5 / 10	0.005	**0.11**	0.064	0.002	0.1	1 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	UNW-107(F)	mg/L	9 / 20	4 / 10	0.005	0.027	0.009	0.002	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
Tetrachloroethene	BRW-083	mg/L	3 / 20	0 / 10	0.003	**0.007**	ND	ND	0.005	2 / 20	0 / 10	2 / 20	0 / 10	No trend	--
Trichloroethene	BRW-083	mg/L	4 / 20	0 / 10	0.001	**0.022**	ND	ND	0.005	3 / 20	0 / 10	3 / 20	0 / 10	Down	--
K-1064 Peninsula Exit Pathway															
Arsenic	BRW-003	mg/L	20 / 20	10 / 10	--	**0.035**	**0.024**	**0.011**	0.01	18 / 20	8 / 10	19 / 20	9 / 10	Down	Down
	BRW-003(F)	mg/L	20 / 20	10 / 10	--	**0.031**	**0.023**	**0.015**	0.01	19 / 20	9 / 10	20 / 20	10 / 10	Down	Stable
	BRW-017	mg/L	8 / 20	8 / 10	0.005	**0.016**	**0.016**	0.008	0.01	2 / 20	2 / 10	2 / 20	2 / 10	Up	No trend
	BRW-017(F)	mg/L	6 / 20	6 / 10	0.005	**0.014**	**0.014**	**0.014**	0.01	1 / 20	1 / 10	3 / 20	3 / 10	Up	Up
Trichloroethene	BRW-017	mg/L	20 / 20	10 / 10	--	**0.005**	0.004	0.003	0.005	2 / 20	0 / 10	6 / 20	0 / 10	Down	Down
K-31/K-33 Area Exit Pathway															
Alpha activity	UNW-080	pCi/L	2 / 6	2 / 6	4.72	**16.1**	**16.1**	2.35	15	1 / 6	1 / 6	1 / 6	1 / 6	No trend	No trend
Antimony	UNW-043	mg/L	5 / 20	4 / 10	0.003	**0.02**	0.00045	ND	0.006	1 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	UNW-043(F)	mg/L	4 / 20	4 / 10	0.003	3.7E-04	0.00037	0.00034	0.006	0 / 20	0 / 10	0 / 20	0 / 10	Stable	No trend
	UNW-080	mg/L	2 / 20	2 / 10	0.003	**0.026**	**0.026**	0.00005	0.006	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
	UNW-080(F)	mg/L	2 / 20	2 / 10	0.003	0.00017	0.00017	0.00008	0.006	0 / 20	0 / 10	0 / 20	0 / 10	Stable	No trend
Arsenic	UNW-043	mg/L	3 / 20	2 / 10	0.025	**0.035**	0.006	0.006	0.01	1 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	UNW-043(F)	mg/L	1 / 20	1 / 10	0.005	**0.011**	**0.011**	--	0.01	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
Chromium	BRW-030	mg/L	20 / 20	10 / 10	--	**0.11**	**0.11**	0.091	0.1	1 / 20	1 / 10	7 / 20	3 / 10	Stable	No trend
	BRW-030(F)	mg/L	20 / 20	10 / 10	--	0.12	0.12	0.096	0.1	2 / 20	2 / 10	6 / 20	3 / 10	Stable	No trend
	UNW-043	mg/L	20 / 20	10 / 10	--	**21**	**3.6**	0.057	0.1	17 / 20	7 / 10	17 / 20	7 / 10	Down	Down
	UNW-043(F)	mg/L	18 / 20	10 / 10	0.005	0.046	0.046	0.046	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
	UNW-080	mg/L	20 / 20	10 / 10	--	**1.2**	**1.2**	0.019	0.1	4 / 20	4 / 10	4 / 20	4 / 10	No trend	Down
	UNW-080(F)	mg/L	20 / 20	10 / 10	--	0.027	0.022	0.015	0.1	0 / 20	0 / 10	0 / 20	0 / 10	Stable	Stable

Table 8.7. Exit pathway groundwater contaminant screening results and trend evaluations (cont.)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. > MCL[b]		Freq. > 80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Lead	UNW-080	mg/L	4 / 20	4 / 10	0.003	**0.015**	**0.015**	ND	0.015	0 / 20	0 / 10	2 / 20	2 / 10	No trend	No trend
	UNW-080(F)	mg/L	0 / 20	0 / 10	0.003	ND	ND	ND	0.015	0 / 20	0 / 10	0 / 20	0 / 10	--	--
Nickel	UNW-043	mg/L	20 / 20	10 / 10	--	**3.4**	**1.3**	**0.55**	0.1	20 / 20	10 / 10	20 / 20	10 / 10	Stable	No trend
	UNW-043(F)	mg/L	20 / 20	10 / 10	--	**0.96**	**0.74**	**0.53**	0.1	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Stable
	UNW-080	mg/L	8 / 20	8 / 10	0.01	0.099	0.099	0.005	0.1	0 / 20	0 / 10	1 / 20	1 / 10	No trend	No trend
	UNW-080(F)	mg/L	6 / 20	6 / 10	0.01	0.004	0.004	0.003	0.1	0 / 20	0 / 10	0 / 20	0 / 10	Stable	Stable
Trichloroethene	BRW-066	mg/L	1 / 20	0 / 10	0.003	0.004	ND	ND	0.005	0 / 20	0 / 10	1 / 20	0 / 10	No trend	--
K-27 North Exit Pathway															
cis-1,2-Dichloroethene	BRW-058	mg/L	20 / 20	10 / 10	--	**0.11**	**0.11**	**0.11**	0.07	4 / 20	4 / 10	9 / 20	8 / 10	Up	Up
Trichloroethene	BRW-058	mg/L	15 / 20	9 / 10	0.003	**0.006**	**0.006**	0.00067	0.005	2 / 20	1 / 10	3 / 20	1 / 10	No trend	Stable
Vinyl chloride	BRW-016	mg/L	6 / 22	5 / 12	0.001	**0.002**	**0.002**	**0.002**	0.002	0 / 22	0 / 12	1 / 22	1 / 12	No trend	No trend
	BRW-058	mg/L	20 / 20	10 / 10	--	**0.028**	**0.028**	**0.028**	0.002	19 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
K-27 South/West Exit Pathway															
Chromium	UNW-038	mg/L	20 / 20	10 / 10	--	**0.46**	**0.13**	**0.018**	0.1	3 / 20	1 / 10	4 / 20	1 / 10	Down	No trend
	UNW-038(F)	mg/L	15 / 20	10 / 10	0.005	0.014	0.013	0.01	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
	UNW-096	mg/L	20 / 20	10 / 10	--	**0.16**	**0.16**	**0.16**	0.1	3 / 20	3 / 10	12 / 20	8 / 10	No trend	Up
	UNW-096(F)	mg/L	20 / 20	10 / 10	--	0.092	0.092	0.081	0.1	0 / 20	0 / 10	9 / 20	5 / 10	Stable	Stable
Nickel	UNW-038	mg/L	16 / 20	7 / 10	0.01	**0.86**	**0.13**	**0.13**	0.1	4 / 20	2 / 10	5 / 20	3 / 10	No trend	No trend
	UNW-038(F)	mg/L	13 / 20	5 / 10	0.01	**0.85**	0.093	0.067	0.1	2 / 20	0 / 10	4 / 20	2 / 10	No trend	No trend
	UNW-096	mg/L	8 / 20	8 / 10	0.01	**0.27**	**0.27**	**0.27**	0.1	3 / 20	3 / 10	3 / 20	3 / 10	Up	Up
	UNW-096(F)	mg/L	6 / 20	6 / 10	0.01	**0.23**	**0.23**	**0.23**	0.1	3 / 20	3 / 10	3 / 20	3 / 10	Up	Up
Trichloroethene	UNW-038	mg/L	20 / 20	10 / 10	--	**0.135**	**0.1**	**0.083**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	Down
	UNW-096	mg/L	20 / 20	10 / 10	--	**0.026**	**0.026**	**0.026**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	No trend
K-1007-P1 Holding Pond Exit Pathway															
Alpha activity	UNW-108	pCi/L	15 / 20	8 / 10	3.7	**18.6**	**18.6**	9.28	15	1 / 20	1 / 10	1 / 20	1 / 10	Stable	No trend
Trichloroethene	BRW-084	mg/L	1 / 20	1 / 10	0.003	**0.007**	**0.007**	ND	0.005	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend

Table 8.7. Exit pathway groundwater contaminant screening results and trend evaluations (cont.)

Chemical	Well	Units	Freq. of detection		Maximum detection limit[a]	Maximum detected			MCL[b]	Freq. > MCL[b]		Freq. > 80% of MCL[b]		Significant trend[c]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
K-901 Holding Pond Area Exit Pathway															
Alpha activity	UNW-066	pCi/L	15 / 20	8 / 10	3.75	**68.7**	**68.7**	7.16	15	4 / 20	3 / 10	4 / 20	3 / 10	No trend	No trend
	UNW-067	pCi/L	8 / 20	5 / 10	4.06	**52.8**	**52.8**	ND	15	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
K-770 Area Exit Pathway															
Alpha activity	UNW-015	pCi/L	15 / 15	10 / 10	--	**45.4**	12.7	8.02	15	**3 / 15**	0 / 10	**4 / 15**	**1 / 10**	Stable	**Up**

[a]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[b]MCL as of May 2018

[c]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.

(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum contaminant level
MCL-DC = maximum contaminant level derived concentration
M-K = Mann-Kendall
ND = not detected

Figure 8.21 shows arsenic concentration histories in samples from wells BRW-003 and BRW-017. Arsenic concentrations in both unfiltered and filtered samples from well BRW-003 have shown long term decreases during the period between 2004 and 2018. Summary results of contaminant screening and trend evaluations for the Mitchell Branch exit pathway wells are included in Table 8.7.

In the past, VOC contaminants exceeded MCLs in wells BRW-003 and BRW-017; however, regulated VOC concentrations have declined to levels below screening levels with the exception of TCE which has not exceeded its 0.005 mg/L MCL within the past five years (Table 8.7).

K-31/K-33 area – Groundwater is monitored in four wells (BRW-066, BRW-030, UNW-080, and UNW-043) that lie between the K-31/K-33 area and Poplar Creek. VOCs are not COCs in this area; however within the past 10 years five metals (antimony, arsenic, chromium, lead, and nickel) have exceeded 80% of their MCLs. As shown in Table 8.7, antimony, arsenic, chromium, and lead have decreased to concentrations less than their respective MCLs or have become non-detectable. Nickel exceeds the state of Tennessee water quality concentration (0.1 mg/L) in well UNW-043 in both the unfiltered and field filtered sample aliquots.

K-27/K-29 exit pathway areas – Groundwater discharges toward Poplar Creek in both a northward pathway beneath the K-1232 area and in a south to westward pathway as shown on Figure 8.20. Two wells (BRW-016 and BRW-058) in the northern plume near K-27/29 and two wells (UNW-038 and UNW-096) in the south/western plume have been designated for exit pathway monitoring.

As summarized in Table 8.7, VOCs have exceeded MCLs in the K-27/K-29 area northern pathway. TCE has decreased to concentrations less than its 0.005 mg/L MCL although cis-1,2-DCE and VC continue to exceed their respective MCLs. The presence of cis-1,2-DCE and VC in the area are indicative that natural degradation of the parent TCE is occurring in this part of the ETTP site.

In the south/west exit pathway from the K-27/K-29 area, TCE is persistent in the exit pathway wells with decreasing or indeterminate trends. Chromium and nickel exceed their respective MCLs. At well UNW-096, an increasing concentration in the unfiltered sample chromium content is indicated in Table 8.7 for the 5-year evaluation although the filtered aliquot data from that well have been below the 0.1 mg/L MCL. Nickel exceeds the state of Tennessee water quality criterion of 0.1 mg/L in unfiltered samples from wells UNW-038 and UNW-096 and also exceeds that criterion in the filtered samples from UNW-096, indicating that nickel is a dissolved phase contaminant at that location. Filtered and unfiltered nickel concentrations in well UNW-096 have increasing trends in both the 10-year and most recent 5-year evaluations.

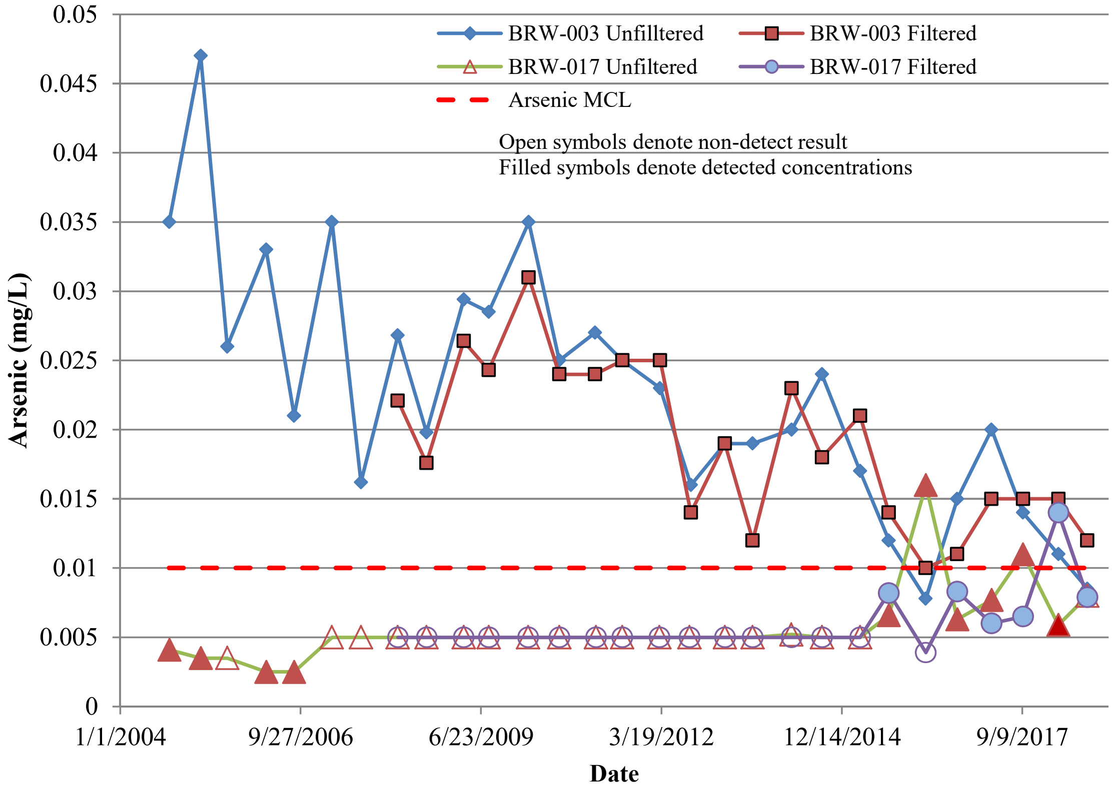

Figure 8.21. Arsenic concentrations in groundwater in the K-1064 Peninsula area.

K-1007-P1 Holding Pond area – Wells BRW-084 and UNW-108 are exit pathway monitoring locations at the northern edge of the K-1007-P1 Holding Pond (Figure 8.20). As shown in Table 8.7, within the past 10 years alpha activity and TCE have exceeded 80% of their respective MCLs. Alpha activity in well UNW-108 is measureable in nearly all samples and although the FY 2018 maximum concentration was well below the 15 pCi/L MCL, the alpha activity levels are sufficiently variable to prevent assignment of a trend direction with statistical confidence. In well BRW-084, TCE met the criterion (detected at ≥80% of its MCL within the past 10 years) for inclusion in Table 8.7 although TCE was detected in only one of 20 samples. No trend can be assigned to a single detected concentration.

K-901-A Holding Pond area – Exit pathway groundwater in the K-901-A Holding Pond area (Figure 8.20) is monitored by four wells (BRW-035, BRW-068, UNW-066, and UNW-067) and two springs (21-002 and PC-0). As shown in Table 8.7, alpha activity is the only regulated contaminant that exceeded 80% of its 15 pCi/L MCL at wells UNW-066 and UNW-067. The maximum measured FY 2018 alpha activity in the semi-annual samples from well UNW-066 was 7.16 pCi/L and alpha activity was not detected in the samples from well UNW-067.

TCE is the most significant groundwater contaminant detected in the springs, and the historic TCE concentrations are shown in Figure 8.22. Spring PC-0 was added to the sampling program in 2004. During April through October each year, spring PC-0 is submerged beneath the Watts Bar lake level. In the late winter of 2012, DOE installed a sampling pump in the spring mouth to allow year-round sampling. The contaminant source for the PC-0 spring is presumed to be disposed waste at the former Construction Spoil Area (K-1070-F) located on Duct Island. The TCE concentrations in PC-0 spring have varied between non-detectable levels and 26 µg/L and have decreased from their highest measured value in 2006 to concentrations less than or several times the drinking water standard.

TCE that originates from the now-remediated K-1070-A burial ground is the principal contaminant detected at spring 21-002 as well as the TCE at spring 10-895 located on the Poplar Creek floodplain along Blair Road (Figure 8.20). The TCE concentration at spring 21-002 tends to vary between less than 5 and 25 µg/L and this variation appears to be related to rainfall which affects groundwater discharge from the K-1070-A VOC plume. During FY 2018, the TCE detected concentrations ranged from a high of 19 µg/L detected in December 2017 to a low of 4.9 µg/L measured in April 2018.

Since the water that discharges from the springs monitored in the ETTP area originates mostly from shallow flow systems, the flow rates and dissolved contaminant concentrations are highly variable. For this reason no contaminant trend direction can be confidently assigned to the spring data.

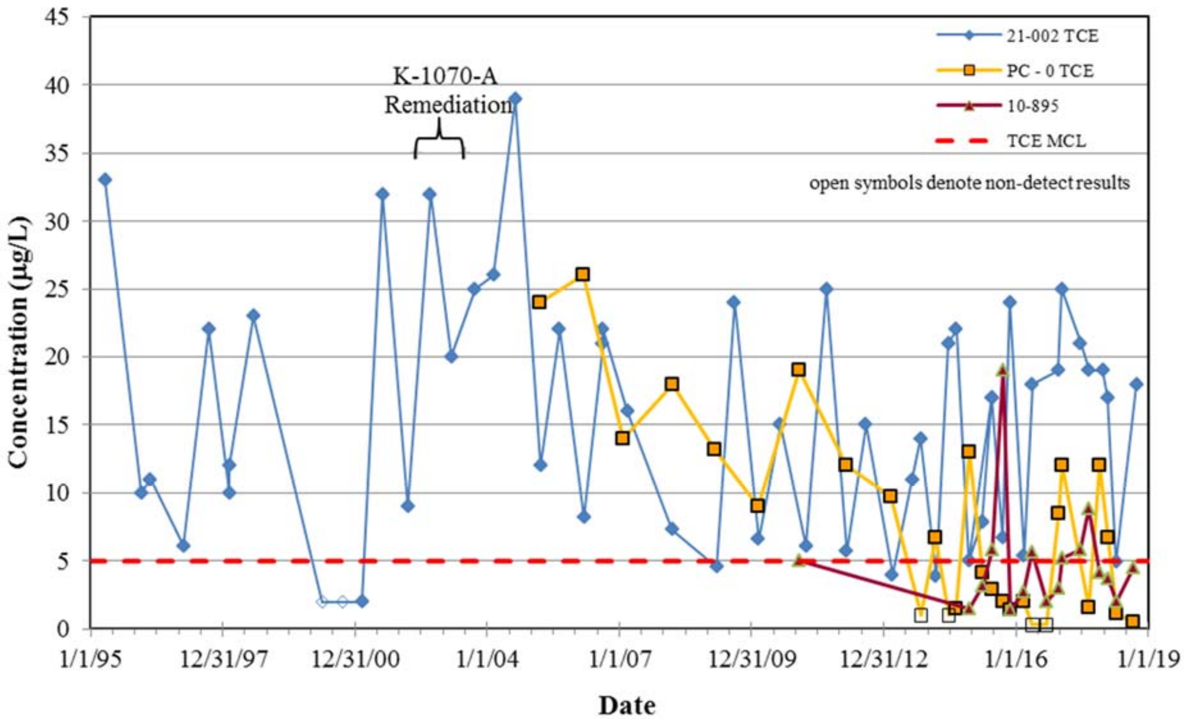

Figure 8.22. TCE concentrations in selected ETTP area springs.

K-770 area – Exit pathway groundwater monitoring is also conducted at the K-770 area, where wells UNW-013 and UNW-015 are used to assess radiological groundwater contamination along the Clinch River (Figure 8.20). Alpha activity measured in samples from well UNW-015 within the past 10 years have exceeded the 15 pCi/L MCL. Although the maximum measured alpha activities in well UNW-015 appear to have decreased sequentially in the 10-year, 5-year, and FY 2018 screening periods an upward trend is assigned for the most recent five years. Figure 8.23 shows the history of measured alpha activity in wells UNW-013 and UNW-015.

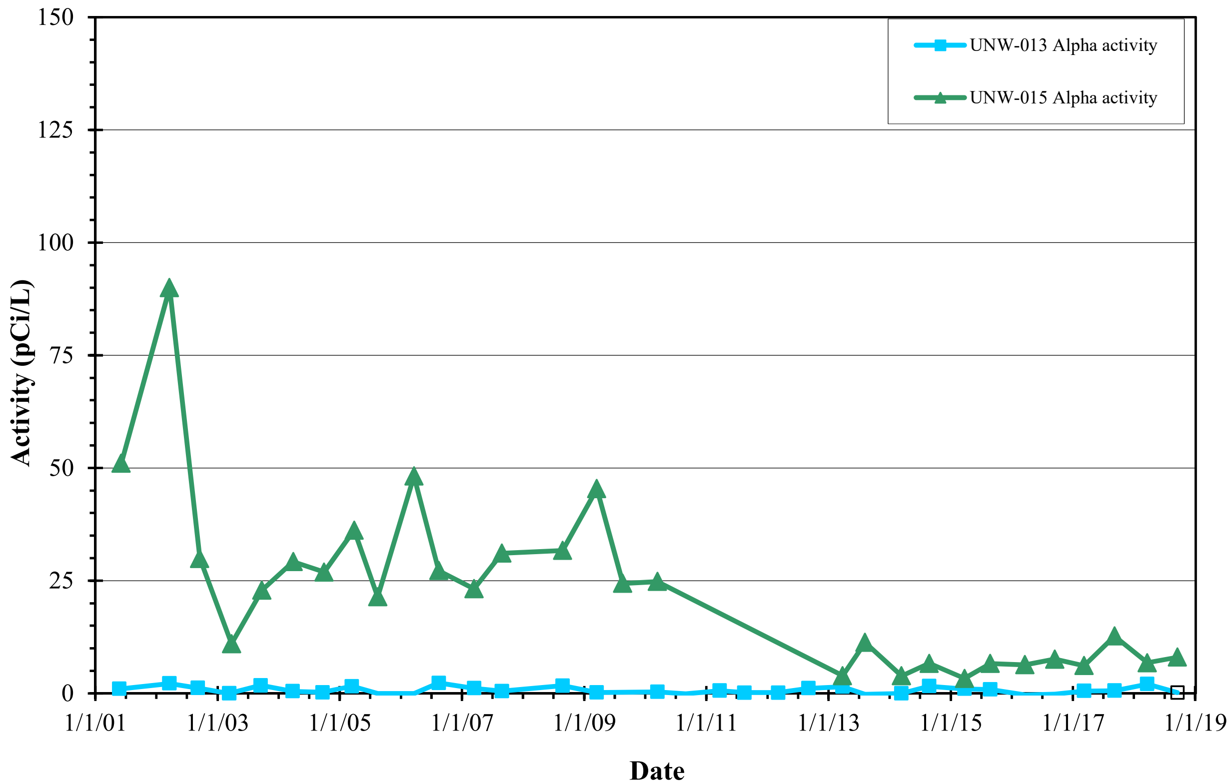

Figure 8.23. History of measured alpha activity in the K-770 area.

8.5.1.1 Tc-99 in ETTP site groundwater

Tc-99 is a beta particle-emitting radionuclide. The MCL-DC concentration is 900 pCi/L. Tc-99 has been a known groundwater contaminant at the ETTP site for many years. Past CERCLA investigations have sampled and analyzed for Tc-99 in groundwater. Historically, the highest Tc-99 activity levels (as high as 6,000+ pCi/L) have been observed beneath the K-1070-A burial ground, where concentrations at a couple of wells remain in the 200 – 500 pCi/L range. The area along Mitchell Branch near the former K-1407 Ponds has residual Tc-99 contaminated groundwater from the operational era of the ponds, and possibly from K-1420, with much lower activity levels (<100 pCi/L). Discussion of the Tc-99 values in Mitchell Branch surface water are included in Appendix F.

8.5.1.1.1 Background

The environmental fate of some metal contaminants in groundwater is strongly dependent on the pH and redox state of the water. A summary review of the environmental behavior of Tc-99 was published by Pacific Northwest National Laboratory (PNNL; PNNL-15372) related to tank wastes at Hanford.

In summary, the report concluded that microbial processes often occur in very localized regions in the subsurface where chemical conditions are favorable. This fact is evident in groundwater at the ETTP site where intrinsic microbial communities are known to slowly degrade chlorinated organic compounds in some areas but not in other areas. Factors that may favor microbial reduction of dissolved compounds include relatively slow groundwater movement, which limits influx of dissolved oxygen via groundwater recharge; presence of organic carbon that can serve as electron donor material; and presence of microbes capable of affecting the required molecular transformations.

8.5.1.1.2 FY 2018 distribution of Tc-99 in ETTP site groundwater

During demolition of the K-25 Building East Wing in the winter of 2013, fugitive dust suppression misting and rainfall carried Tc-99 off the work area. Contaminated runoff apparently percolated through soil and into subsurface utility lines and probably into backfill surrounding the buried utilities. The frequency of groundwater sampling for Tc-99 was increased in wells in the general vicinity of the East Wing and where wells were available along potential groundwater transport pathways.

Investigations conducted to understand the movement of Tc-99 away from the K-25 Building East Wing area documented that contamination entered and traveled through the sanitary sewer and the storm drain that discharges to the K-1007-P1 Holding Pond and that the amount of Tc-99 transport in backfill outside those pipes was minimal. The investigation also found that Tc-99 transport through the abandoned underground electrical ductbank was an important transport pathway along the east side of the K-25 Building as far south as ductbank manhole row 21 (Figure 8.24). RAs conducted in Zone 1 included plugging the ductbank manholes with cement grout from row 21 to the south and west to the former steam plant located near the Clinch River in the K-770 Area. To minimize the remaining available transport flow path, 38 additional manholes in Zone 2 were grouted starting with manhole row 22, moving northward all the way through the demolition area and beyond.

Consistent with requirements of the ETTP Zone 2 ROD for soil cleanup, Tc-99 contaminated soils beneath the K-25 Building East Wing slab are being excavated to protect groundwater from further contamination. The Tc-99 plume extent shown on Figure 8.20 and Figure 8.24 is based on current data and understanding of areas where Tc-99 exceeds the 900 pCi/L MCL-DC. Most of the area where the Tc-99 MCL is exceeded lies beneath, or very near the source area at the K-25 East Wing.

During FY 2018, groundwater was analyzed by the WRRP for Tc-99 in samples from 49 wells and two springs across the ETTP area. Figure 8.20 shows the resulting maximum FY 2018 Tc-99 concentration ranges in groundwater. Tc-99 concentrations have decreased significantly in the area along the inactive electrical ductbank as the Tc-99 contamination either disperses or is attenuated through geochemical adsorption or other attenuation processes.

8.5.1.2 Surface water

Surface water monitoring conducted during FY 2018 indicates that contaminant levels are generally stable and are consistent with the data from previous years. Surface water monitoring is conducted as shown in Figure 8.25 at 12 instream locations as identified in Figure 8.26. The surface water locations include exit pathways from sub-watersheds (K-1700 weir, K-1007-B weir, and K-901-A Holding Pond weir). Additional sampling is conducted in adjacent offsite ambient in-stream locations (Clinch River kilometer [CRK] 16; CRK 23; K-1710; K-716; K-702-A); and onsite Mitchell Branch in-stream locations (MIK 0.45, 0.59, 0.71, and 1.4). In addition, monitoring of storm water outfalls is conducted as per the requirements of the NPDES Permit Number TN0002950 to provide data and information in support of the CERCLA sitewide ROD surface water evaluations.

A summary of the results for monitoring of radionuclides, including Tc-99, VOCs, mercury, and PCBs is provided in Appendix F. These results reflect an integrated approach of evaluating Sitewide surface water at ETTP that combines aspects of the Storm Water Pollution Prevention (SWPP) program under the NPDES permit, the DOE Order 458.1 radiological sampling program, and surveillance sampling of legacy contaminants in support of current and future CERCLA decisions. The NPDES sampling includes investigative sampling as well as monitoring that is conducted during each NPDES permit cycle to generate the information required for permit renewal applications. This integrative approach with reporting through the RER and DOE Annual Site Environmental Report was developed to meet ETTP NPDES permit reporting requirements in coordination with CERCLA stakeholder expectations.

8.5.1.3 Aquatic biology

This section focuses on the annual ETTP Biological Monitoring and Assessment Program (BMAP) results from Mitchell Branch, a small stream within the ETTP site. Mitchell Branch biological sampling locations as well as associated sampling at reference sites is shown in Figure 8.27.

Biological monitoring in Mitchell Branch includes: (1) contaminant accumulation in fish, (2) fish community surveys, and (3) benthic macroinvertebrate surveys (Figure 8.28). Bioaccumulation monitoring has primarily focused on mercury and PCB uptake in fish and caged clams. Total mercury has been monitored in redbreast sunfish fillets at MIK 0.2 since 1987 (Figure 8.29). Mercury concentrations in fish were in the 0.1 to 0.2 µg/g range over the 1987 – 1991 time period, but then increased, with a couple exceptions, to the 0.3 – 0.5 µg/g range until FY 2017. In FY 2018, mean mercury concentrations in Mitchell Branch sunfish fillets were significantly lower than in recent years (0.28 µg/g), dropping below EPA's fish-based recommended AWQC for mercury (0.3 µg/g in fish) for the first time in over a decade. Declines in aqueous mercury concentrations reported since 2010 may finally be having an affect on fish bioaccumulation, although an anomalously low average has been seen previously and cannot be ruled out. Additional annual monitoring will help determine whether the decline continues. The AWQC value is used here for comparison purposes only and is not a specified performance objective.

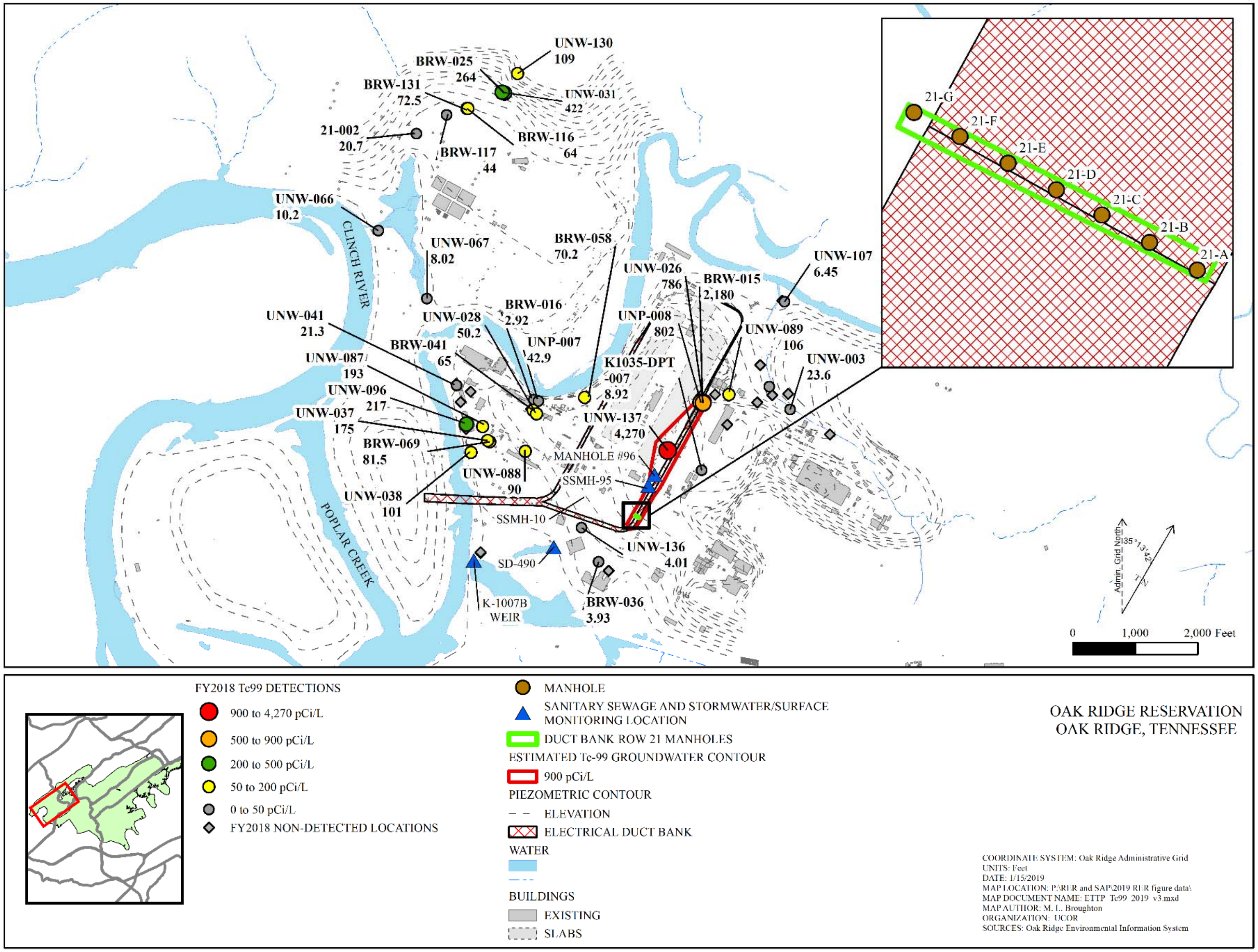

Figure 8.24. Sample locations and maximum detected Tc-99 in ETTP groundwater.

Figure 8.25. Surface water sampling in Mitchell Branch.

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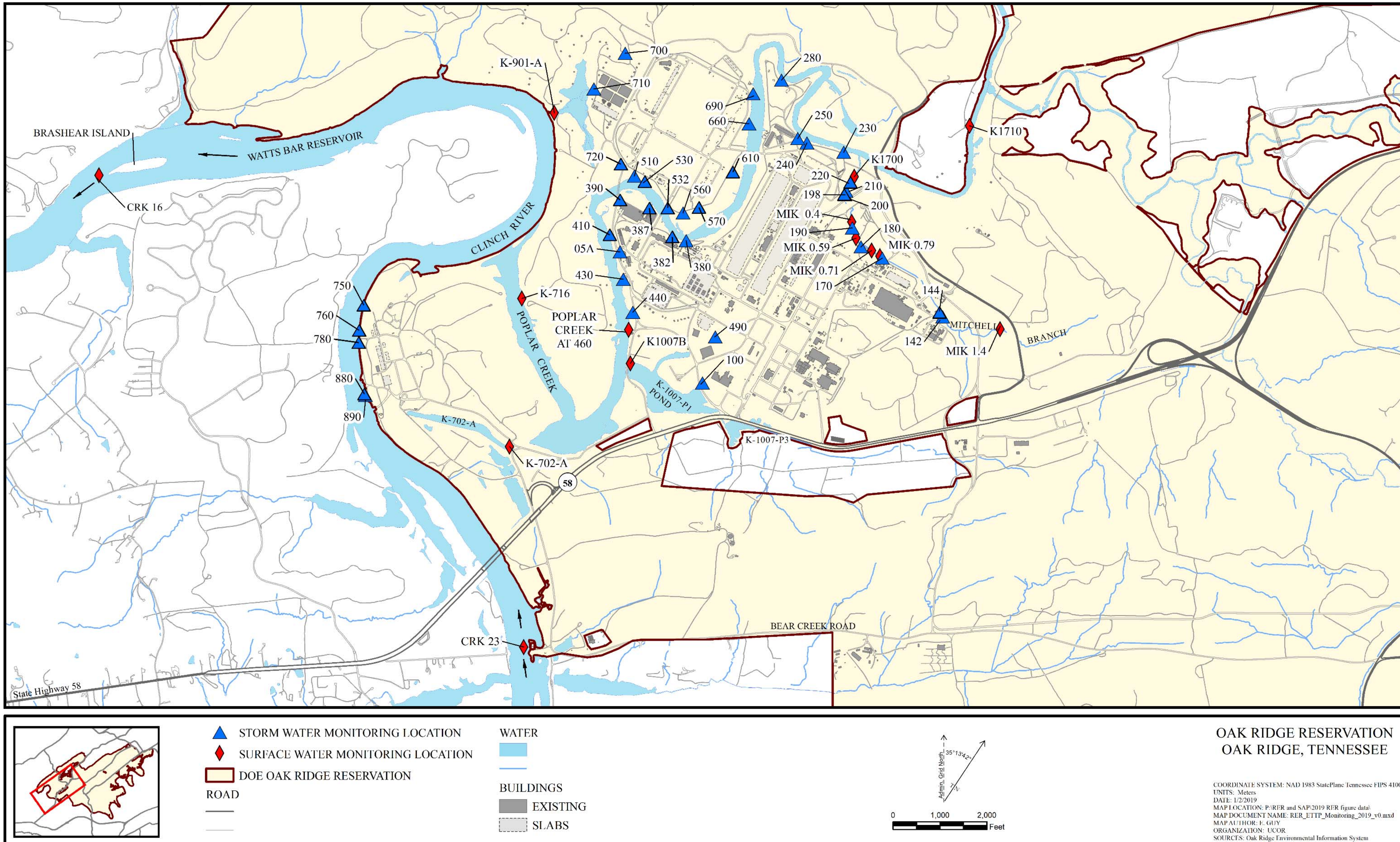

Figure 8.26. ETTP surface water and storm water monitoring locations.

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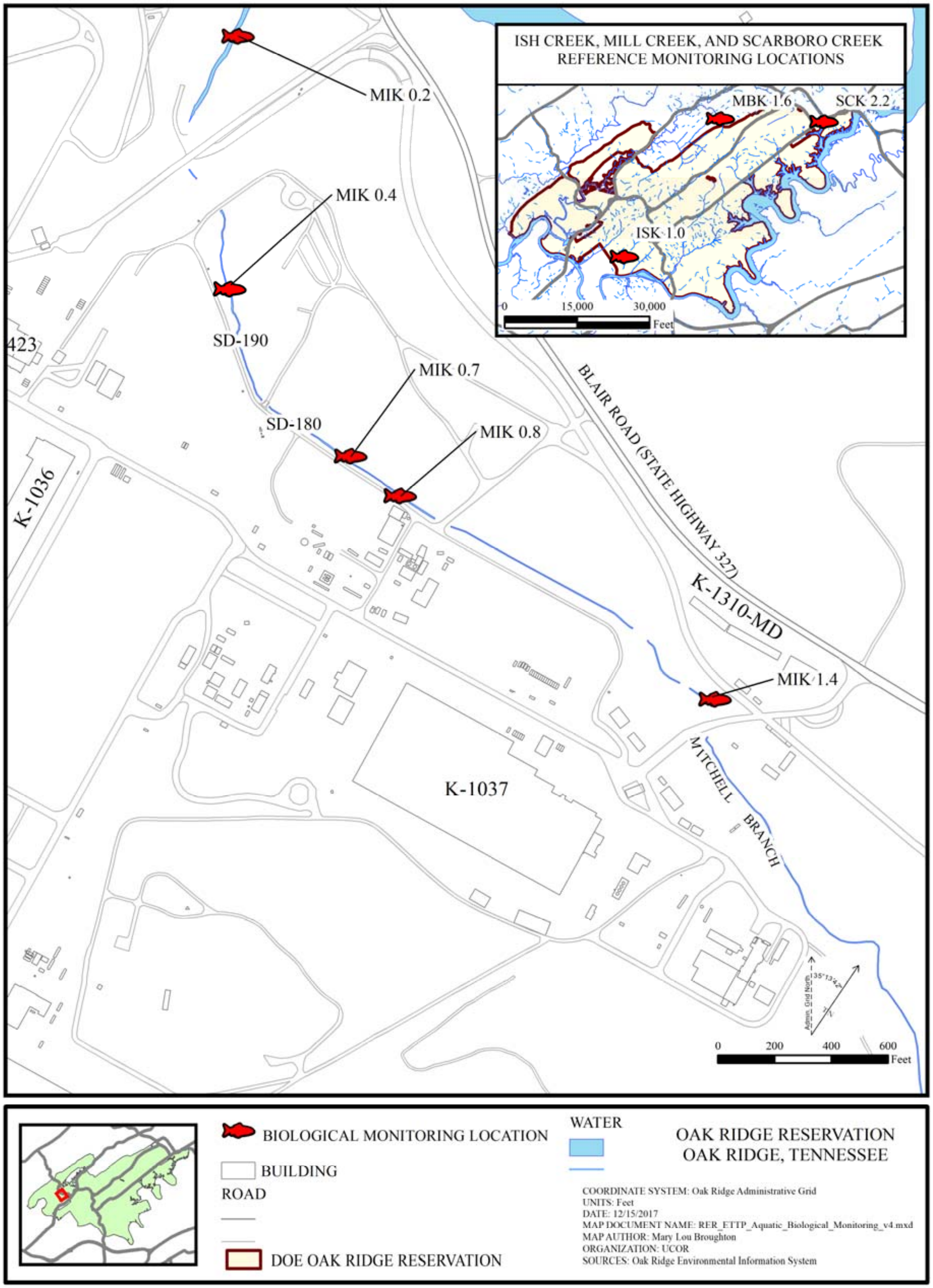


Figure 8.27. Mitchell Branch biological monitoring locations and associated reference locations.

Figure 8.28. Sampling for benthic macroinvertebrates with TDEC protocols.

Similar to patterns seen for mercury in sunfish collected from Mitchell Branch, mean PCB concentrations in FY 2018 were significantly lower than they have been in recent years, averaging 0.47 µg/g. This is the lowest concentration measured for MIK 0.2 since monitoring began in the late 1980's (Figure 8.30). Caged Asiatic clams (*Corbicula fluminea*) were placed in Mitchell Branch above and below storm drain discharges for a four-week exposure (May – June 2018) to evaluate the importance of PCB sources to the creek. As has historically been the case, clams placed in Mitchell Branch upstream of SD-190 were relatively low in PCBs (approximately 0.1 µg/g), while clams placed at SD-190 and in the creek downstream of SD-190 were relatively high (approximately 1 µg/g).

The species richness (number of species) of the fish communities in Mitchell Branch (MIK 0.4 and 0.7) has improved since the 1990s (Figure 8.31 and seems to be stabilized at slightly higher levels in samples taken after 2008. Species richness in spring 2018 samples remained the same as in 2017 at MIK 0.4 but diversity at MIK 0.7 was much lower (seven species observed in 2017, four in 2018). This is the least number of species reported from this site since 2000 (when three species were encountered), and the reason for the decline is unknown. The total number of fish species in Mitchell Branch was similar to the average reference site number the last two years at MIK 0.4, but lower than the reference site at MIK 0.7. Similarly, the number of resident sensitive species of fish, such as darters and suckers, are also lower at both sites. MIK 0.7 continues to be dominated by tolerant fish species such as largescale stonerollers (*Campostoma oligolepis*), which are adapted for stream conditions with poor riparian cover and bedrock-like substrate that occur in this remediated reach of stream. Observed improvements in riparian cover and stream habitat in Mitchell Branch, however, may encourage a more diverse fish community to establish in the future.

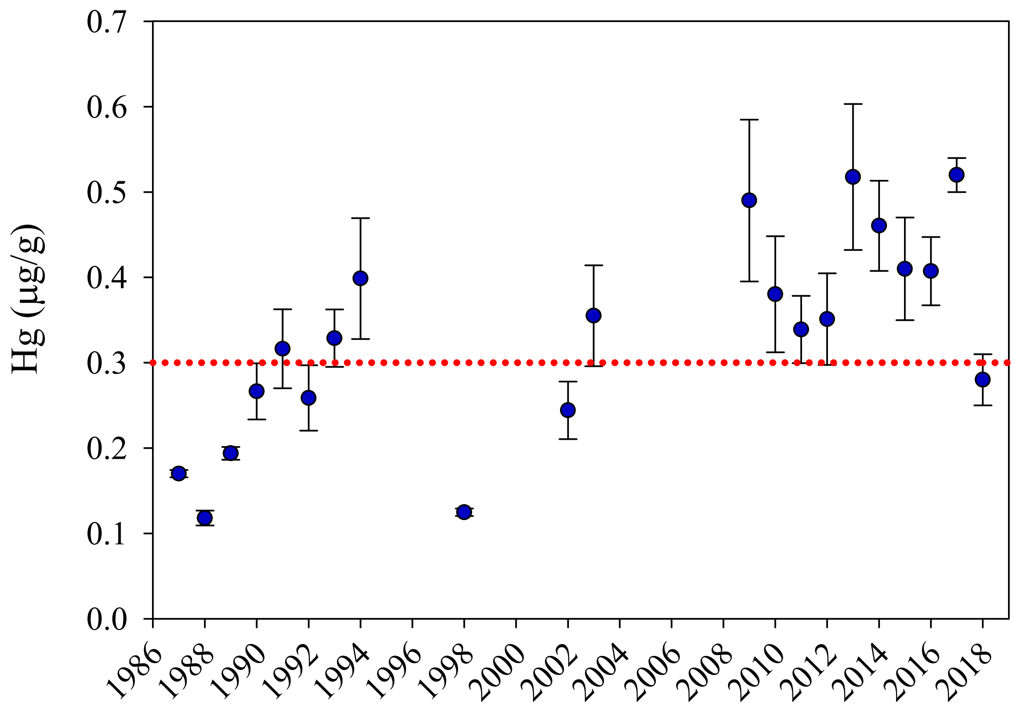


Figure 8.29. Mean mercury concentrations in redbreast sunfish from Mitchell Branch (MIK 0.2). FY 1987 – 2018.

Red dotted line signifies the EPA recommended AWQC for mercury in fish fillet (0.3 µg/g).

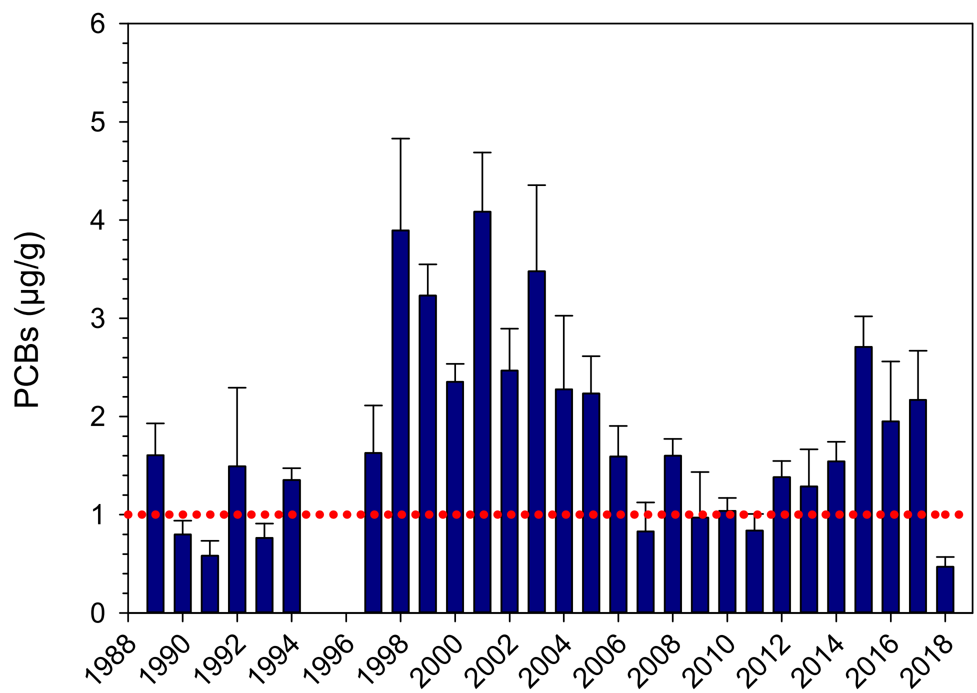


Figure 8.30. Mean PCB concentrations in redbreast sunfish from Mitchell Branch (MIK 0.2), FY 1989 – 2018.

Red dotted line signifies the remediation goal for the K-1007-P1 Holding Pond at ETTP (1 µg/g PCBs in fish fillet).

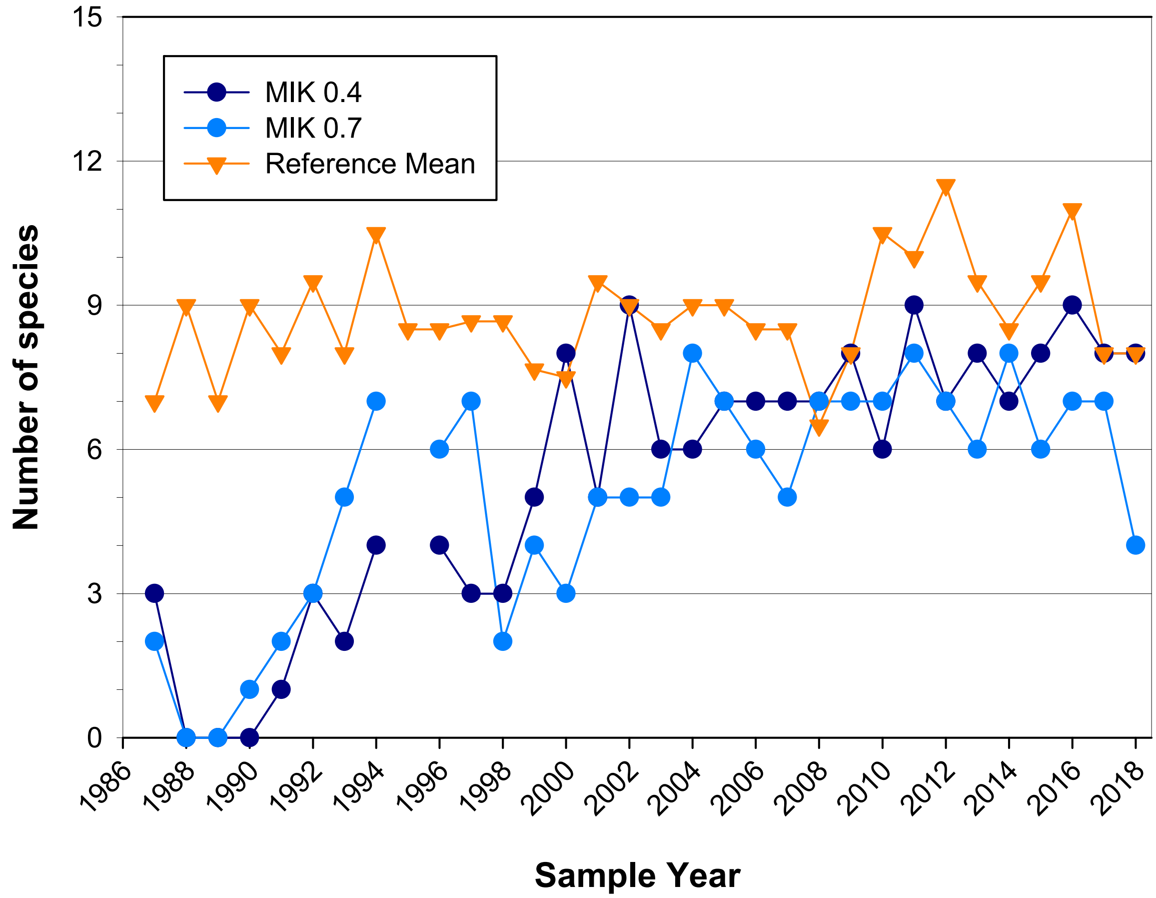
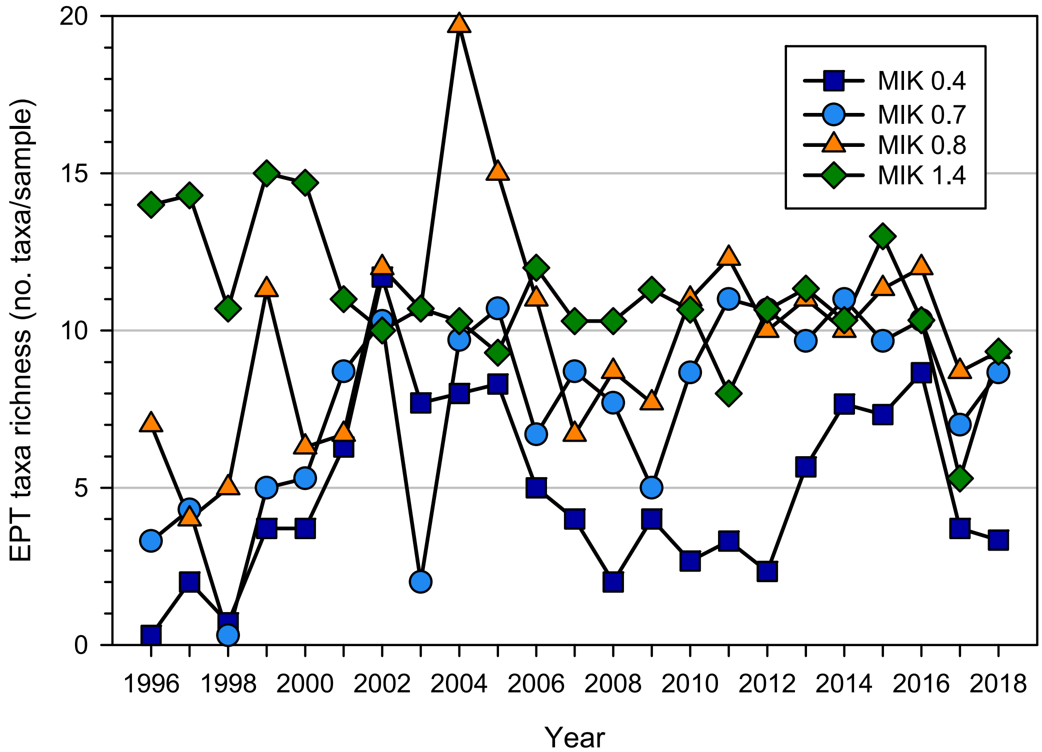


Figure 8.31. Species richness (number of species) in spring samples of the fish community in Mitchell Branch (MIK) and the mean value of three reference streams, Scarboro Creek, Mill Branch, and Ish Creek, 1987 – 2018[a]

[a]Interruptions in data lines indicate missing samples.

Based on ORNL protocols, Mitchell Branch sites showed some improvement in April 2018 compared to May 2017 for taxa richness (i.e., the total number of taxa per sample) and EPT taxa richness (i.e., the total number of pollution-intolerant EPT taxa per sample; Figure 8.32). EPT are mayflies, stoneflies, and caddisflies, respectively. These patterns remain divergent from values reported in recent previous years (2010 – 2016). As in 2017, EPT and total taxa richness at MIK 0.4, MIK 0.7, and MIK 0.8 remained low in 2018 compared to 2016 values. MIK 1.4 displayed increases in EPT richness from 2017, but values were still lower than those reported in 2016. Although 2018 values for EPT richness were lower than those 2016, EPT richness patterns among sites regained a resemblance of past patterns observed in 2010 – 2016, where EPT richness was highest upstream at MIK 1.4 and lowest at MIK 0.4.



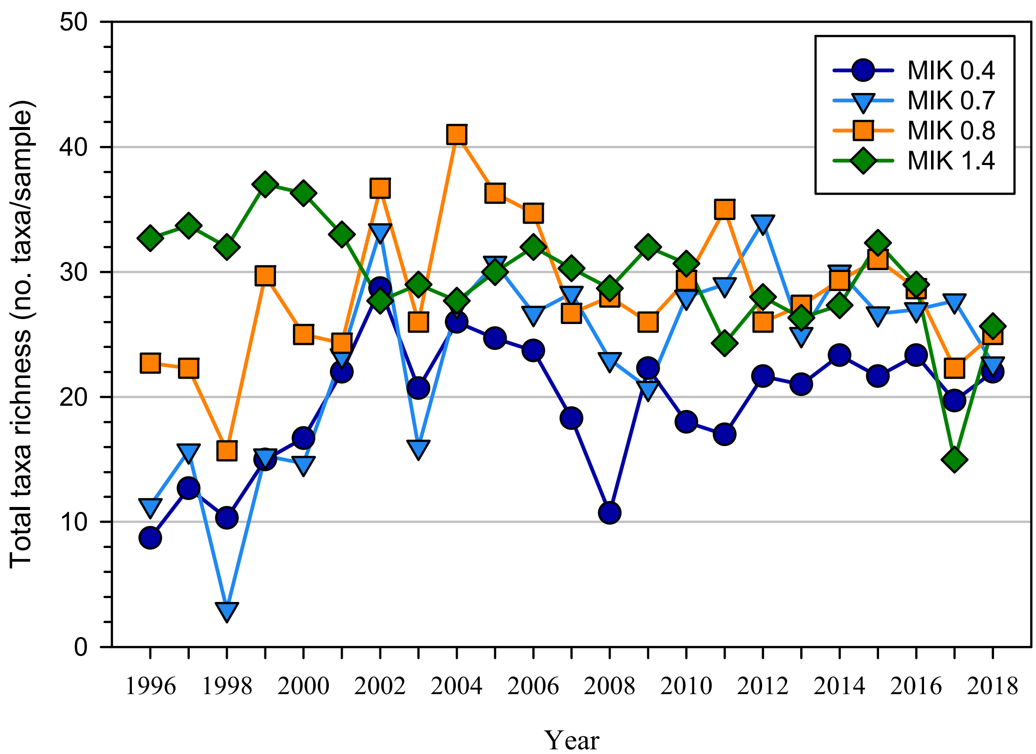


Figure 8.32. Mean (n = 3) taxonomic richness (top) and percent density (bottom) of the pollution-intolerant taxa (EPT taxa) for the benthic macroinvertebrate community at sites in Mitchell Branch, April sampling periods, 1996 – 2018.

EPT = Ephemeroptera, Plecoptera, and Trichoptera, or mayflies, stoneflies and caddisflies.
MIK 1.4 results represent the upstream reference site.

8.6 ETTP ISSUES AND RECOMMENDATIONS

There are no issues and recommendations for ETTP (Table 8.8).

Table 8.8. Summary of technical issues and recommendations

Issue[a]	Action/recommendation	Responsible parties Primary/support	Target response date
New issue			
None			
Issues carried forward[b]			
None			
Completed/resolved issues			
None			

[a]A "New Issue" is an issue identified during evaluation of FY 2018 data for inclusion in the 2019 RER. Issues are identified in the table as an "Issue Carried Forward" to indicate that the issue is carried forward from a previous year's RER so as to track the issue through resolution.

[b]The year in which the issue originated is provided in parentheses, e.g., (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report

8.7 REFERENCES

DOE/OR/01-1371&D1. *Remedial Action Report for the K-1407-B Holding Pond and the K-1407-C Retention Basin, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1964&D2. *Remedial Action Report for the K-1070-C/D G-Pit and K-1071 Concrete Pad, East Tennessee Technology Park*, *Oak Ridge, Tennessee,* 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1997&D2. *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee,* 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2161&D2. *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2005, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2261&D2/A3. *Addendum 3 to the Phased Construction Completion Report for the Duct Island and K-901 Area in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2279&D3. *Final Sitewide Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee*, 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2314&D2. *Action Memorandum for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment, Oak Ridge, Tennessee,* 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2359&D2. *Removal Action Work Plan for the Removal Action at the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee,* 2008, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2369&D1. *Action Memorandum for Reduction of Hexavalent Chromium Releases Into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee,* 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2384&D1. *Removal Action Report for the Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2008, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2422&D1. *Engineering Evaluation/Cost Analysis for the Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2009, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2448&D1. *Action Memorandum for the Long-Term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Ten*nessee, 2010, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2456&D1/R1. *Removal Action Report for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment, Oak Ridge, Tennessee,* 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2477&D3. *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2484&D1. *Removal Action Work Plan for the Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2010, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2561&D3. *Final Zone 1 Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee,* 2013, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2598&D2. *Removal Action Report for the Long-term Reduction of Hexavalent Chromium Releases into Mitchell Branch at the East Tennessee Technology Park, Oak Ridge, Tennessee,* 2013, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2711&D2. *Record of Decision for Final Soil Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2736&D2. *Phased Construction Completion Report for the Remediation of the Zone 1 Powerhouse Duct Bank, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2746&D1. *Phased Construction Completion Report for Exposure Unit Z2-28 in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2747&D1. *Phased Construction Completion Report for Exposure Unit Z2-29 in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2017U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2765&D1. *K-31/K-33 Area Groundwater Remedial Site Evaluation Report for the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2768&D1. *Design Characterization Completion Report for the Sitewide Groundwater Treatability Study at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2781&D2. *Explanation of Significant Differences Related to the Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/01-1997&D2) Addressing Identified Ecological Impacts at Duct Island, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1125&D3. *Record of Decision for the K-1407-B/C Ponds at the Oak Ridge K-25 Site, Oak Ridge, Tennessee*, 1993, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/02-1486&D4. *Record of Decision for the K-1070-C/D Operable Unit, East Tennessee Technology Park, Oak Ridge, Tennessee*, 1998, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

PNNL-15372. *Advances in Geochemical Testing of Key Contaminants in Residual Hanford Tank Waste*, 2005, Pacific Northwest National Laboratory, Richland, WA.

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9. CERCLA ACTIONS AT OTHER SITES

9.1 INTRODUCTION AND STATUS

9.1.1 Introduction

The two CERCLA actions evaluated in this chapter are not physically situated within one of the areas with existing watershed-scale RODs or Chestnut Ridge, but are located on the ORR. Figure 9.1 shows the locations of the CERCLA actions at these two 'other sites' that have required monitoring or LUCs. In subsequent sections, the effectiveness of each completed action is assessed by reviewing performance monitoring objectives and results and verifying LUCs.

Table H.8 in Appendix H lists all completed CERCLA actions at other sites and the corresponding completion documents, and identifies whether monitoring or LUCs are required. Figure H.8 in Appendix H is a location map of the actions.

For a complete discussion of background information and performance metrics for each remedy, a compendium of all CERCLA decisions at these other sites is provided in Chapter 11 of Volume 1 of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2). This information is updated in the RER and published every fifth year in the CERCLA FYR.

9.1.2 Status Update

No additional CERCLA actions were implemented or completed at the WWSY or the ORAU SCF during FY 2018. Monitoring in support of performance assessments and evaluations continued.

9.2 ASSESSMENT SUMMARY

A summary of the assessment of the 'other sites' for FY 2018 is provided below, followed by more detailed evaluations.

9.2.1 Performance Summary

WWSY. No performance monitoring is required at the WWSY site.

ORAU SCF. The *Record of Decision for Oak Ridge Associated Universities South Campus Facility, Oak Ridge, Tennessee* (ORAU SCF ROD; DOE/OR/02-1383&D3) specified groundwater monitoring at a VOC contaminated area and defined LUCs that include a groundwater use restriction. Low concentrations of VOCs continue to be detected in groundwater at ORAU SCF; however, all detections in FY 2018 were less than drinking water standards. Drinking water standards are used for comparison purposes only and are not a specified ROD goal. No VOCs were detected in surface water at the site during FY 2018.

9.2.2 LUC Protectiveness

All LUCs determined necessary for protection of the environment and/or human health are in place and have been maintained.

9.3 WWSY

The WWSY, also referred to as WAG 11, is located north of the western end of BCV (Figure 9.1 and Figure 9.2). This RA removed contaminated surface debris retrievable without excavation. Buried material remains at the site.

9.3.1 Remedy Integrity and LUCs

There are no remedy integrity or LUC specifics in the *Interim Record of Decision for the Oak Ridge National Laboratory Waste Area Grouping 11 Surface Debris, Oak Ridge, Tennessee* (DOE/OR-1055&D4). However, as shown in Table 9.1, the *Interim Remedial Action Postconstruction Report for Waste Area Grouping 11 at Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1263&D2) states, *"because the interim remedial action was to remove debris, no operation and maintenance are necessary as a result of the interim action. However, long-term S&M will continue until decisions are made for future and/or final CERCLA remedial actions at the site."*

9.3.2 Status of Remedy Integrity and LUCs

The Y-12 S&M Program performed monthly inspections in FY 2018 to inspect components including deteriorating access road conditions; damaged or missing gate locks or unlocked gate; debris buildup or blockage at the fence/creek boundaries; unauthorized materials placed within the area; and damage to site perimeter fencing. Additionally, inspections included the separate fenced-in area west of the scrap yard. S&M personnel inspected the fencing by walking the entire perimeter of the site and the west fenced area. Site maintenance in FY 2018 included removing trees that had fallen on the fencing and also trees that had fallen at the fence intersection with the creek. The site identification sign was also updated with facility manager contact information.

9.4 ORAU SCF

9.4.1 Performance Monitoring

9.4.1.1 Performance monitoring goals and objectives

The SCF is a former experimental station where the radionuclide effects on animals were studied (Figure 9.1 and Figure 9.3). The approved ORAU SCF ROD specified groundwater monitoring at a VOC-contaminated area and defined LUCs that include a groundwater-use restriction. The alternative prescribed in the ROD included periodic sampling to ensure that evaluations completed in support of the RI are accurate and natural attenuation in the zone of contamination continues as expected.

The ROD specified four monitoring wells (ultimately renamed GW-841, GW-842, GW-843, and GW-844) and a surface water seep to be sampled once every two years for as long as TCE contamination above acceptable levels is present. DOE increased the frequency of sampling to collect wet- and dry-season samples on an annual basis beginning in FY 2001. The *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review* (DOE/OR/01-2289&D3) noted that although concentrations have decreased significantly since the ROD was signed, TCE and cis-1,2-DCE are sometimes detected in wells GW-841 and GW-842 at concentrations above the MCL. Trace concentrations of TCE and cis-1,2-DCE were detected at one of two seeps sampled during the winter of 2005. Therefore, both wells GW-841 and GW-842 continue to be sampled annually along with seep SCF-WS2 to monitor concentration trends. Although not required, a second seep (SCF-WS1) is monitored for informational purposes.

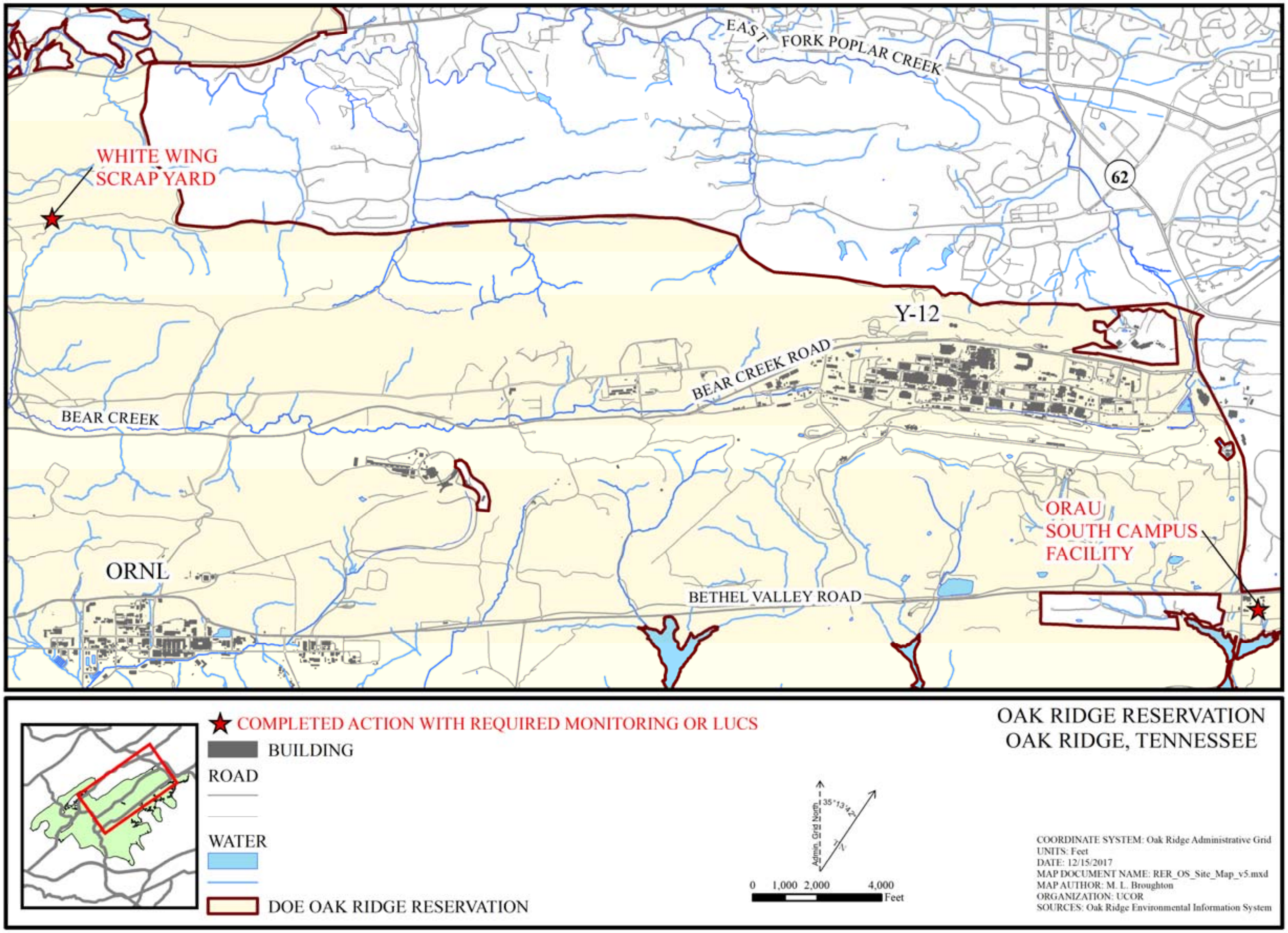

Figure 9.1. Completed CERCLA actions at other sites with required monitoring or LUCs.

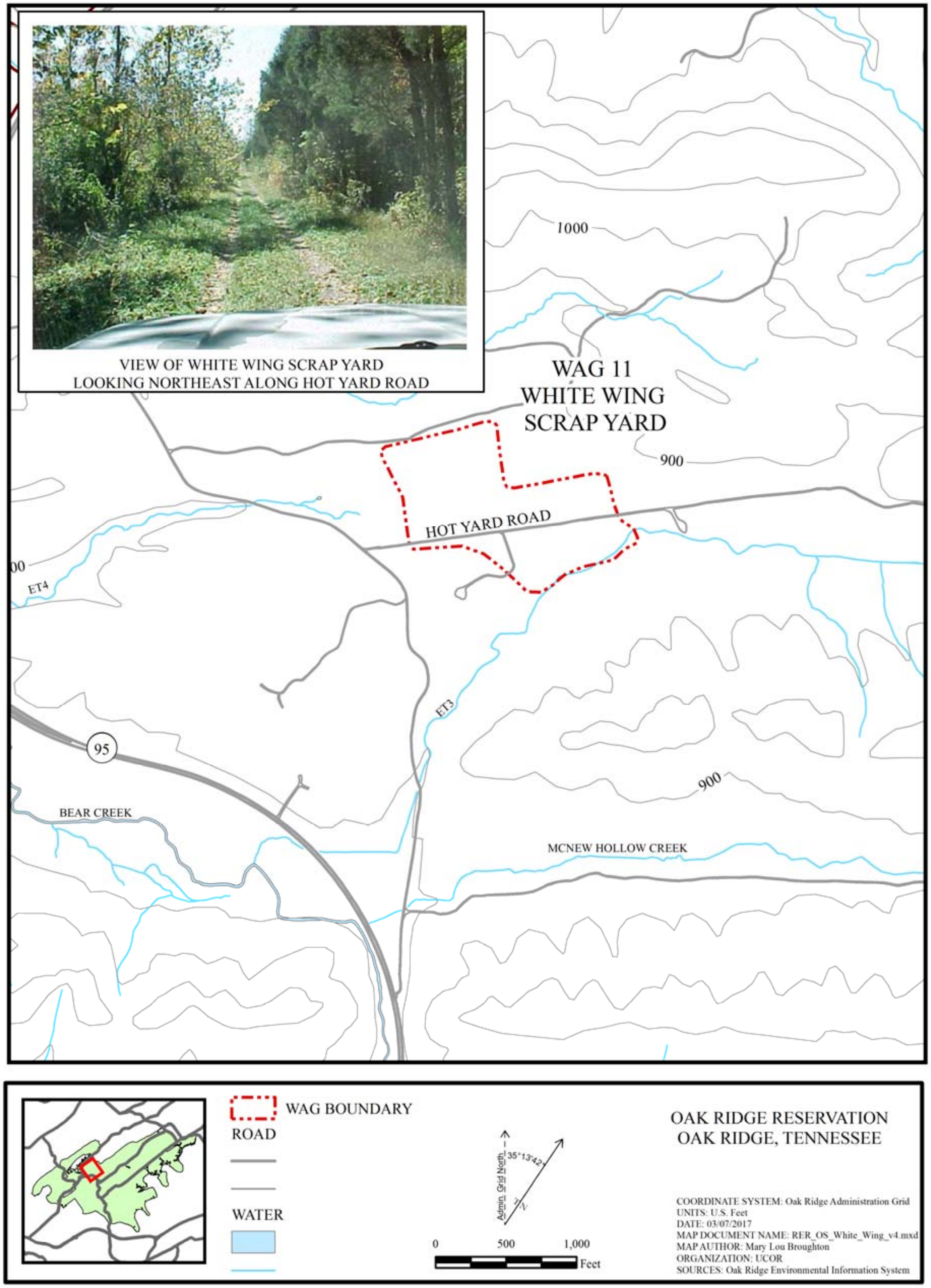

Figure 9.2. Location of WWSY.

Table 9.1. LUCs for Other Sites

LUCs for completed actions Other Sites[a]			
Specific areas	**Project documents**	**LUCs**	**Frequency/implementation**
WWSY (WAG 11) Surface Debris	PCR (DOE/OR/01-1263&D2)	**Remedy integrity:** • Because the interim RA was to remove the debris, no operation and maintenance are necessary as a result of the interim action. However, long-term S&M will continue until decisions are made for future and/or final CERCLA RAs at the site.	• Long-term S&M will continue until decisions are made for future and/or final CERCLA RAs at the site.
ORAU SCF	ROD (DOE/OR/02-1383&D3) RAR (DOE/OR/02-1474&D2)	**LUCs:** • A notification will be added to the Deeds of Records at the Anderson County Courthouse alerting potential owners to the TCE contamination.	• FYRs are required until natural attenuation in the zone of contamination decreases TCE concentrations below regulatory levels of concern.

[a]LUCs for specific areas are determined by each remediation project and listed in the project specific completion report.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
FYR = Five-Year Review
LUC = land use control
ORAU = Oak Ridge Associated Universities
PCR = Post-Construction Report
RA = remedial action
RAR = Remedial Action Report
ROD = Record of Decision
S&M = surveillance and maintenance
SCF = South Campus Facility
TCE = trichloroethene
WAG = Waste Area Grouping
WWSY = White Wing Scrap Yard

9.4.1.2 Evaluation of performance monitoring data

During FY 2018, samples were collected from wells GW-841 and GW-842 and surface water locations SCF-WS1 and SCF-WS2 and were analyzed for VOCs. TCE and cis-1,2-DCE are the only VOCs detected in groundwater at the site. VC was not detected in samples from either groundwater monitoring well in FY 2018. No VOCs were detected in surface water at the site during FY 2018.

Figure 9.4 shows the detected VOCs in wells GW-841 and GW-842 from FY 1994 through FY 2018 have exhibited a long-term decreasing concentration history. Drinking water standards are used for comparison purposes only and are not a specified ROD goal. The FY 2018 results show that TCE in well GW-841 increased from 1.5 J µg/L to 3.8 J µg/L and remains less than the 5 µg/L drinking water standard. TCE in well GW-842 decreased from a concentration of 7 µg/L in FY 2017 to 2.2 µg/L in FY 2018, which is less than the 5 µg/L drinking water standard. Cis-1,2-DCE was detected in the sample from GW-841 at 4.2 J µg/L, which is a slight increase from the 2 J µg/L concentration measured in FY 2017. In well GW-842, cis-1,2-DCE was detected at 0.6 J µg/L in FY 2018. The measured cis-1,2-DCE levels in groundwater are much less than the 70 µg/L drinking water standard.

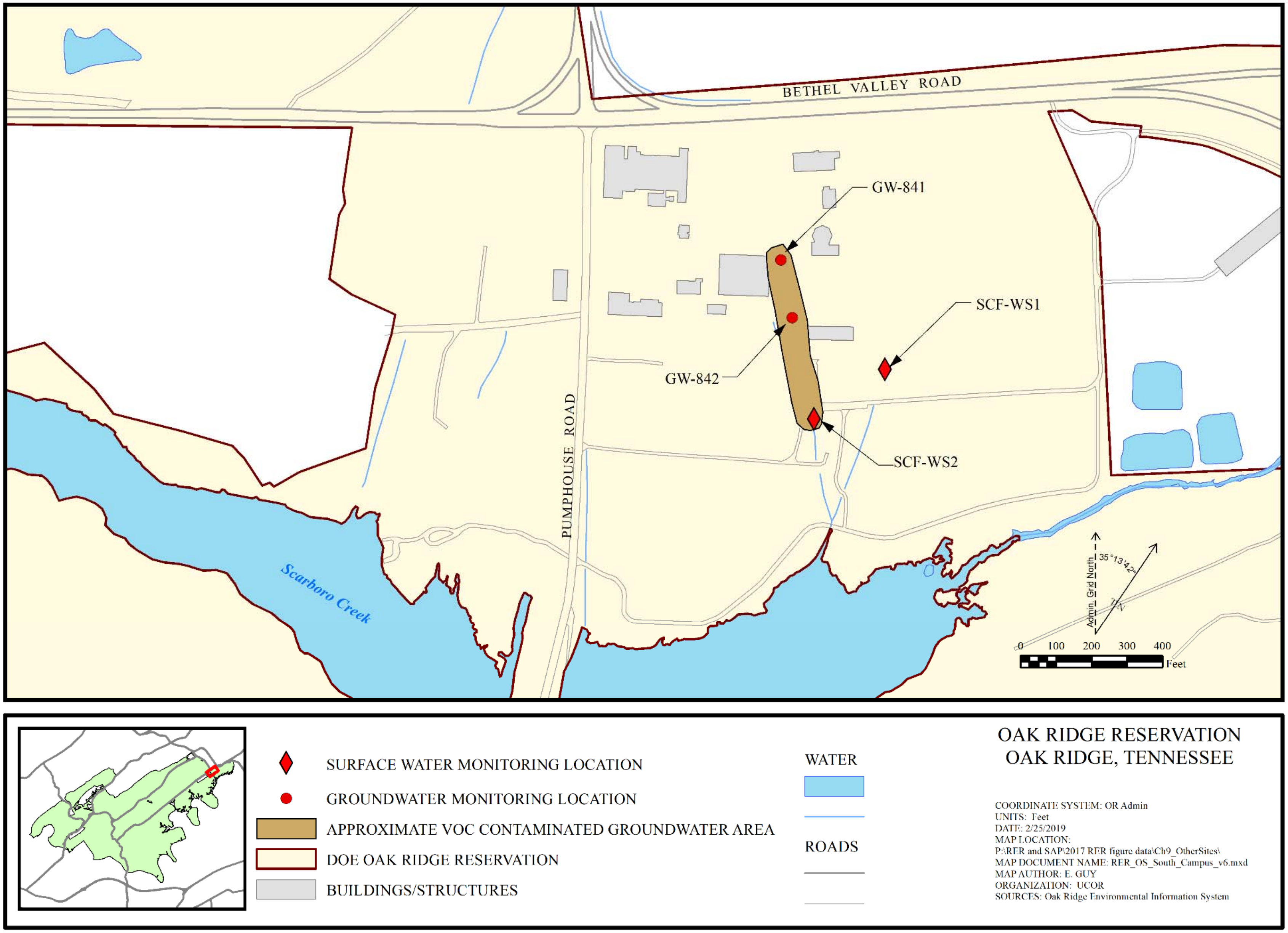

Figure 9.3. ORAU SCF monitoring locations.

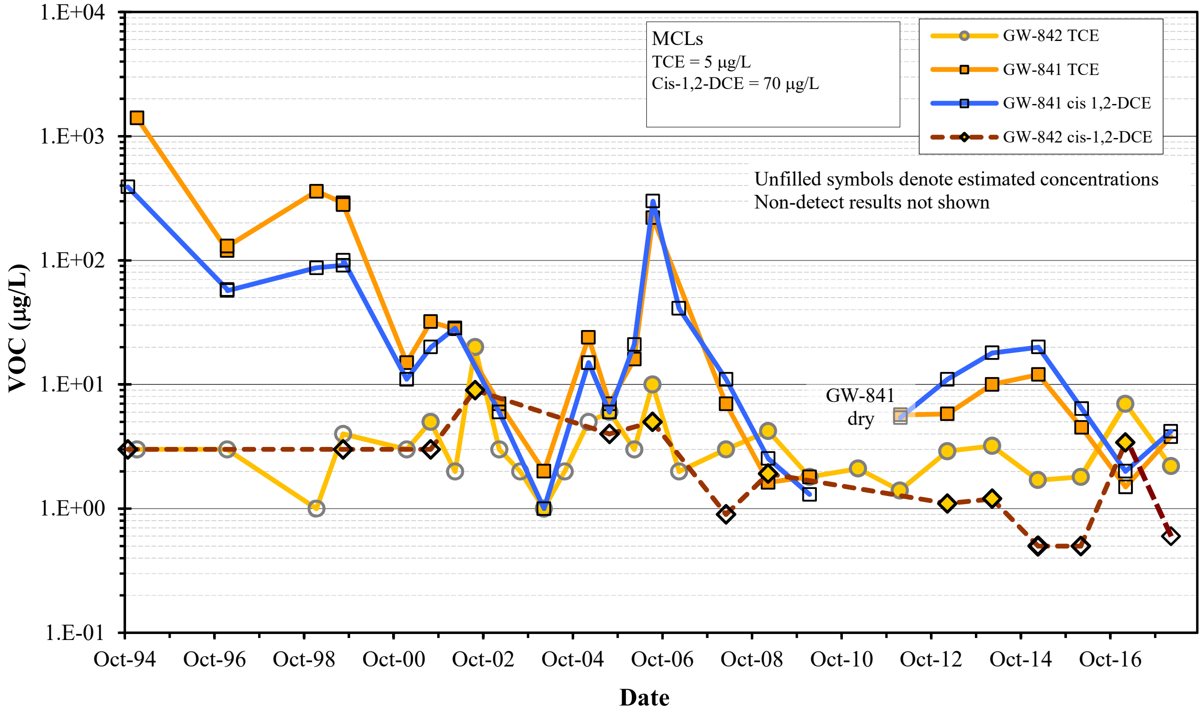

Figure 9.4. Organic compound concentrations in wells GW-841 and GW-842 at ORAU SCF.

9.4.2 LUCs

LUCs for the SCF are listed in Table 9.1.

The ORAU SCF ROD requires that a notification of the contamination be placed in the property title to alert potential owners of risk. A notice was filed with the Anderson County Register of Deeds on August 28, 1996.

9.4.2.1 Status of LUCs

The land use restrictions have been maintained and groundwater monitoring has been conducted at the site. An online search of the Anderson County Register of Deeds web site conducted in FY 2018 verified the notice remains filed. An adjoining property was sold on September 28, 2017 from DOE to ZYP Holdings, LLC. There are no CERCLA controls or DOE property record notice associated with that clean parcel. Figure 9.3 has been updated to reflect the transfer of that parcel out of the DOE footprint.

9.5 OTHER SITES ISSUES AND RECOMMENDATIONS

There are no issues and recommendations for other sites (Table 9.2).

Table 9.2. Other Sites issues and recommendations

Issue[a]	Action/recommendation	Responsible parties Primary/support	Target response date
New issue			
None			
Issue carried forward			
None			
Completed/resolved issues[b]			
None			

[a]A "New Issue" is an issue identified during evaluation of FY 2018 data for inclusion in the 2019 RER. An "Issue Carried Forward" is an issue identified in a previous year's RER so the issue can be tracked through resolution. Any additional discussion will occur at the appropriate regulatory level.

[b]The year in which the issue originated is in parentheses, e.g., (2013 RER).

FY = fiscal year
RER = Remediation Effectiveness Report

9.6 REFERENCES

DOE/OR/01-1263&D2. *Interim Remedial Action Postconstruction Report for Waste Area Grouping 11 at Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 1994, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/01-2289&D3. *2006 Remediation Effectiveness Report/Second Reservation-wide CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee,* 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review for the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1383&D3. *Record of Decision for Oak Ridge Associated Universities South Campus Facility, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR-1055&D4. *Interim Record of Decision for Oak Ridge National Laboratory Waste Area Grouping 11 Surface Debris, Oak Ridge, Tennessee*, 1992, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

APPENDIX A
CERTIFICATION OF LAND USE CONTROL IMPLEMENTATION
FISCAL YEAR 2018

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CERTIFICATION OF LAND USE CONTROL IMPLEMENTATION FISCAL YEAR 2018

This certification is provided for fiscal year 2018, comprising the period October 1, 2017, through September 30, 2018.

Monitoring and field inspections have been conducted, during this period, to determine whether the current land use implemented for the identified waste units in Melton Valley (MV), Bethel Valley (BV) and at the East Tennessee Technology Park (ETTP) remains protective and consistent with all remedial action objectives. I, therefore, certify based on the information and belief formed after reasonable inquiry, that the approved, implemented land use controls for the MV, BV, and ETTP remain in effect and are protective for the intended land use.

John A. Mullis II, Manager Oak Ridge Office of Environmental Management	Date

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APPENDIX B
SELECTED OAK RIDGE NATIONAL LABORATORY GROUNDWATER DATA

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CONTENTS

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B.1 BETHEL VALLEY SOLID WASTE STORAGE AREA 3 GROUNDWATER HYDROGRAPHS

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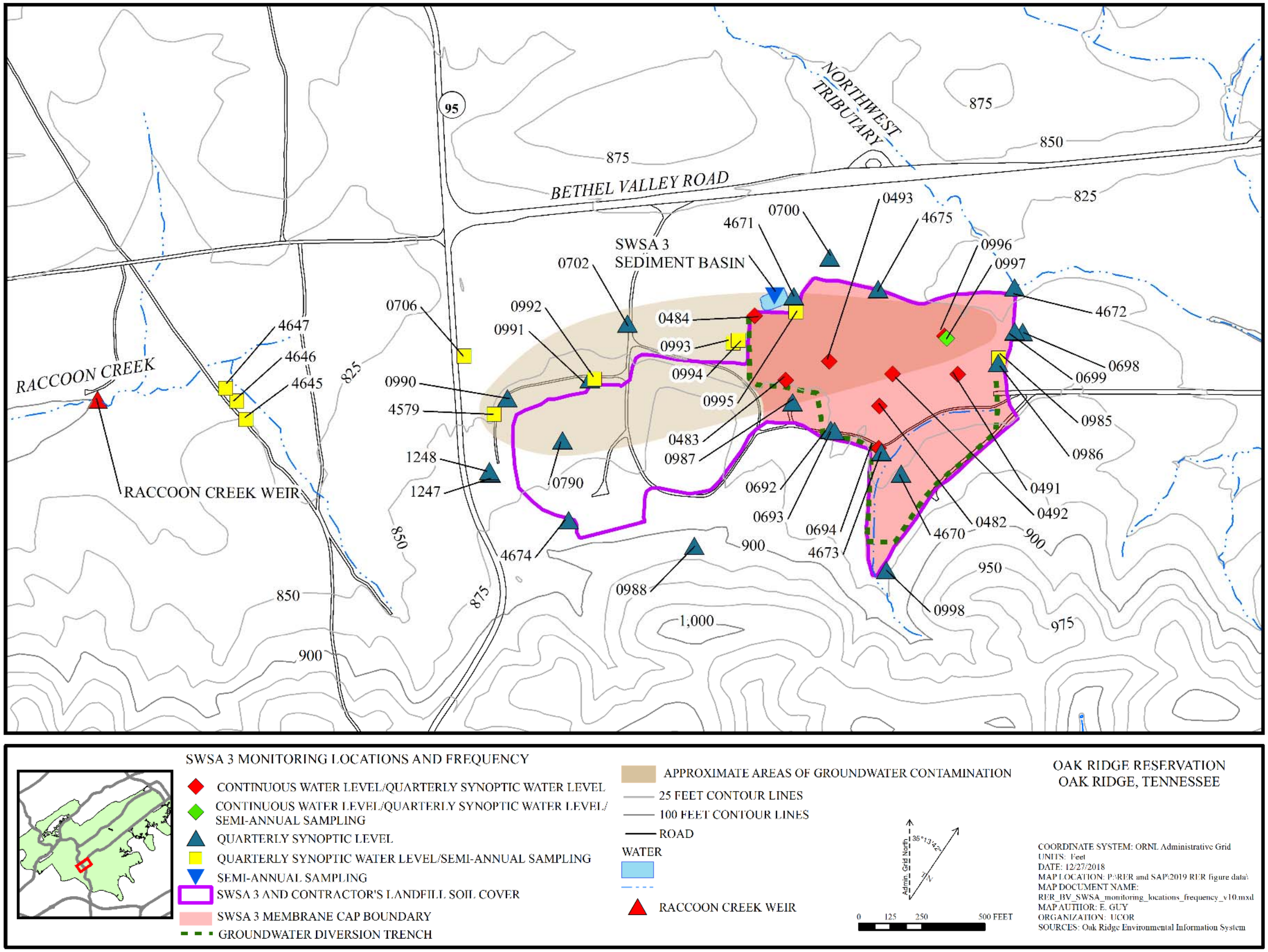

Figure B.1.1. Groundwater monitoring locations at Solid Waste Storage Area (SWSA) 3.

Table B.1.1. SWSA 3 target groundwater elevations and FY 2018 average levels

Well	Bedrock Elevation (ft aMSL)[a]	Groundwater Elevation goal (ft aMSL)	FY 2018 average groundwater elevation (ft aMSL)
0482	~830	823[b]	**826.62**
0483	~834	835	828.99
0484	~823	824	816.66
0491	~823	816[b]	**823.58**
0492	~826	818.5[b]	**822.73**
0493	~831	829	820.99
0694	838.33	838.33	836.79
0996	814.31	814.31	808.21
0997	818.64	818.64	811.83

[a]Bedrock elevations preceded by "~" are estimates based on average depth to bedrock (approximately 14 ft bgs) from documented pre-RA well logs on the SWSA 3 perimeter.

[b]Groundwater target elevation is significantly below bedrock surface and below bottom of buried waste zone.

Bold table entries indicate wells that have not attained their groundwater elevation goal.

aMSL = above Mean Sea Level
bgs = below ground surface
FY = fiscal year
RA = remedial action
SWSA = Solid Waste Storage Area

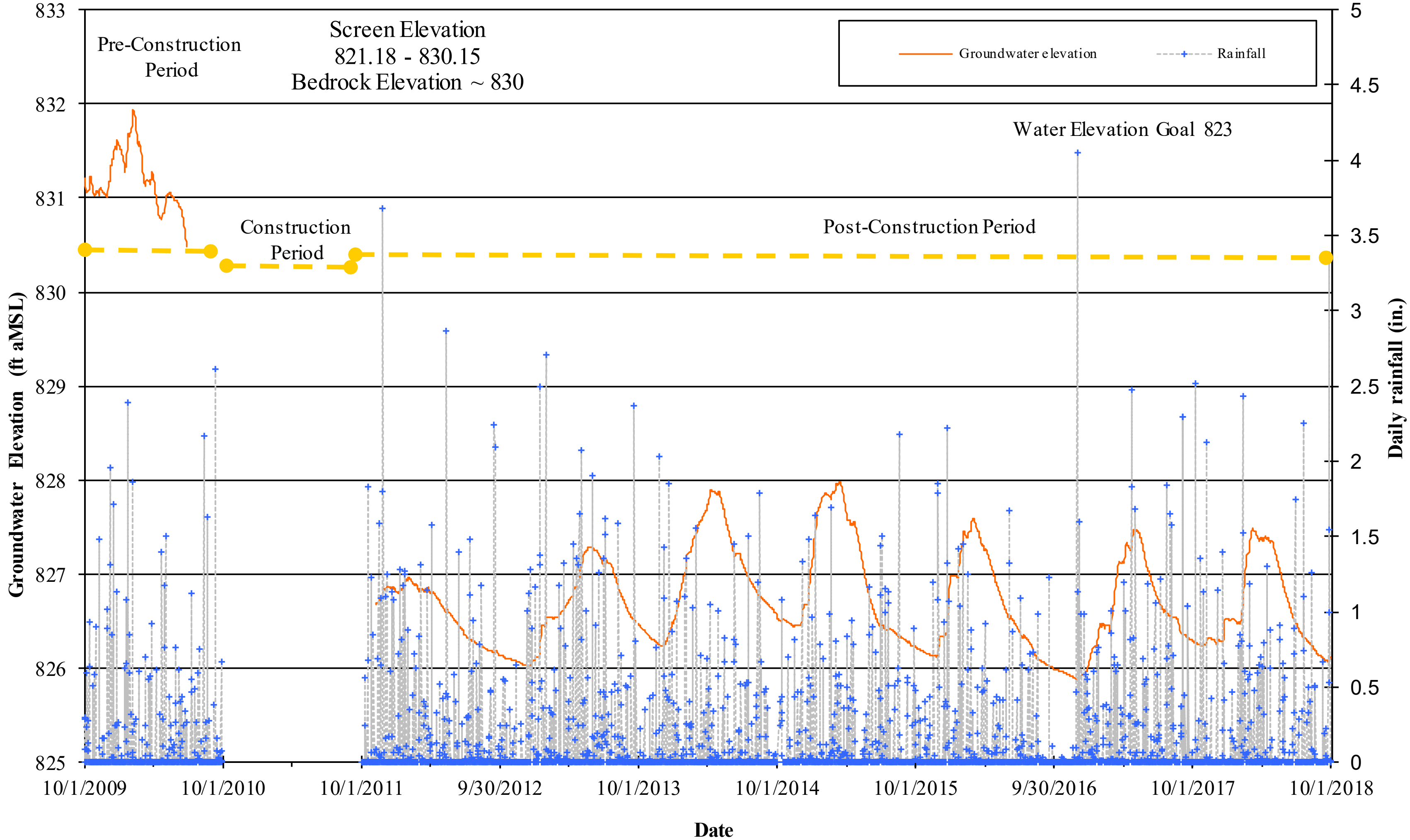

Figure B.1.2. Well 0482 hydrograph.

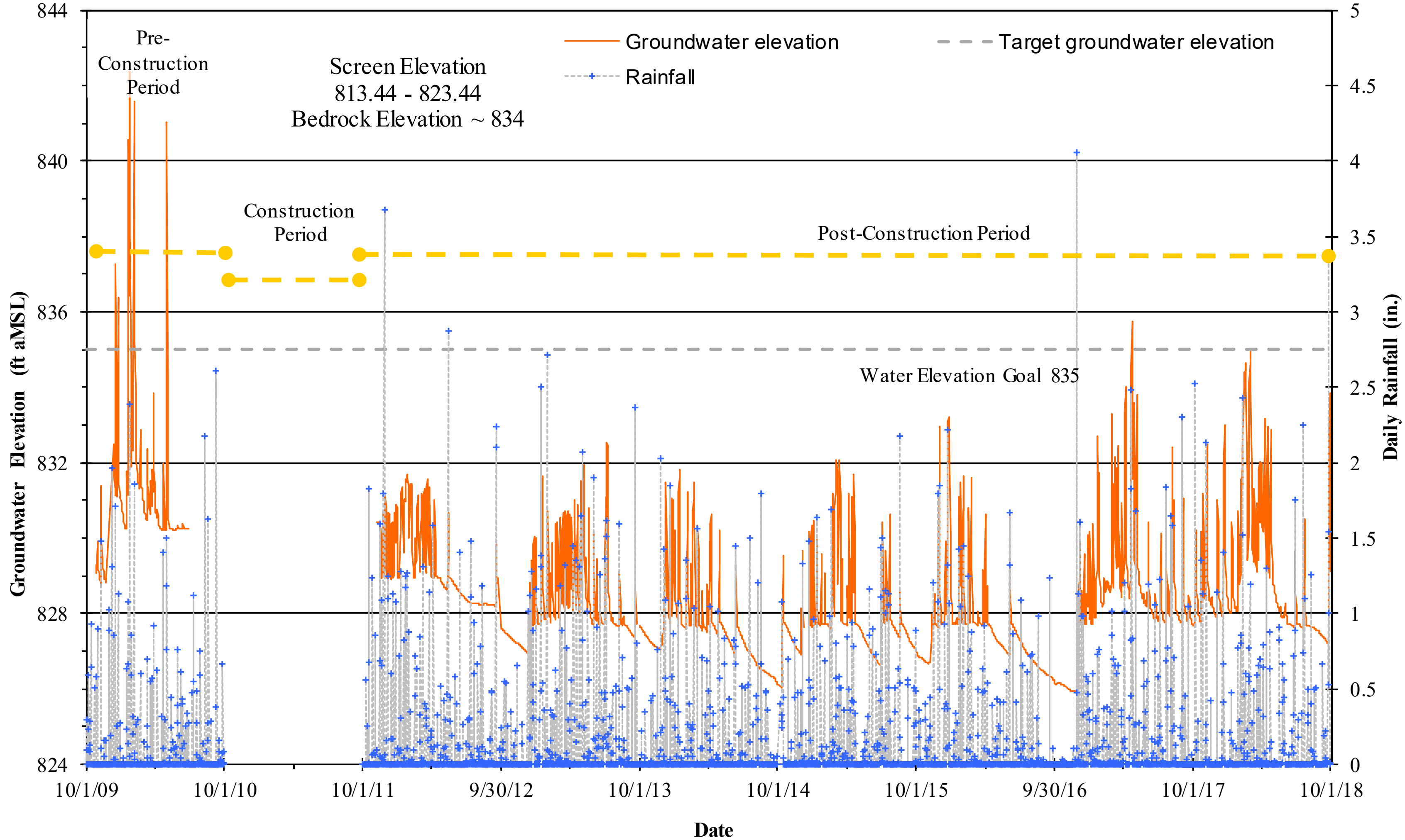

Figure B.1.3. Well 0483 hydrograph.

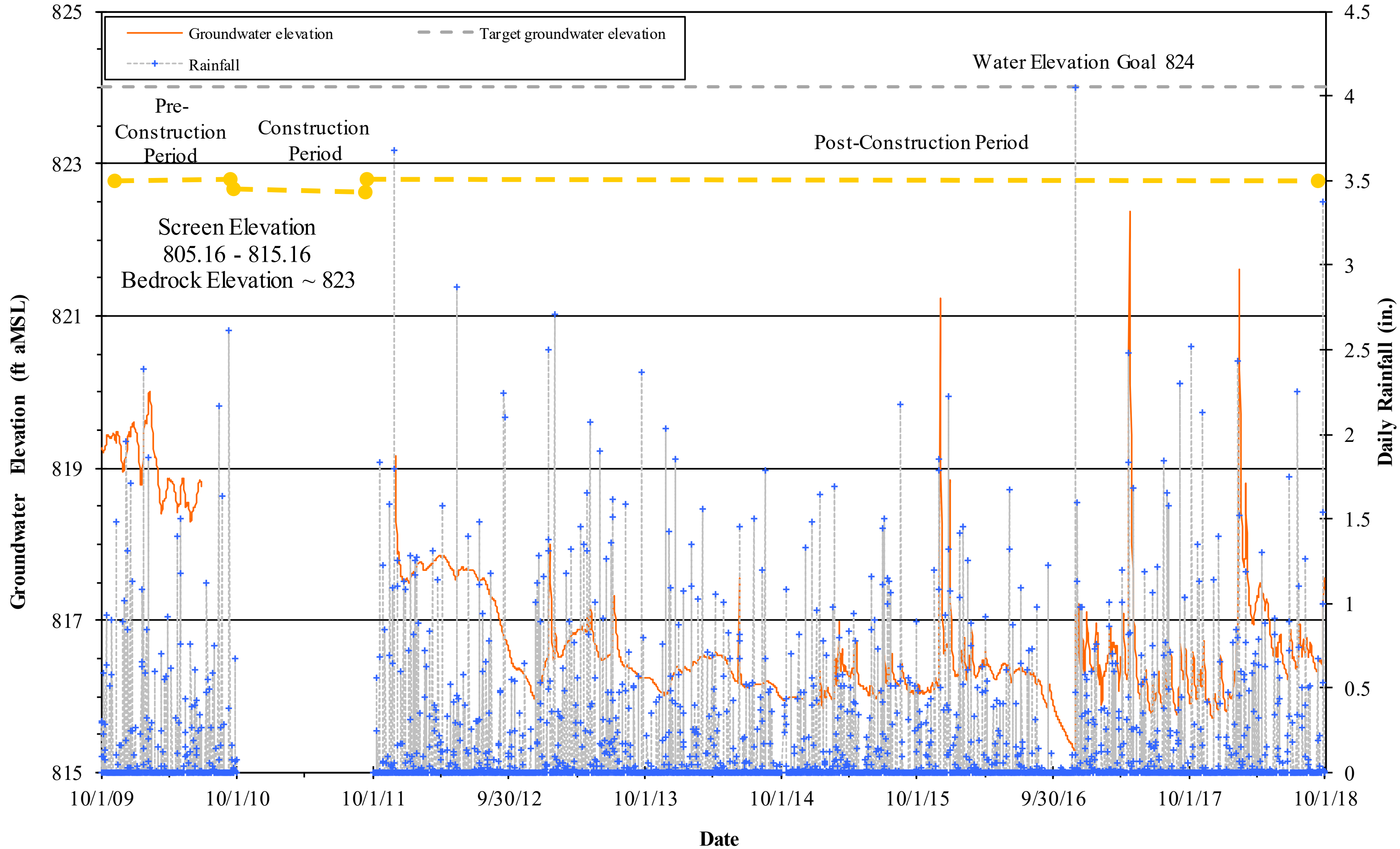

Figure B.1.4. Well 0484 hydrograph.

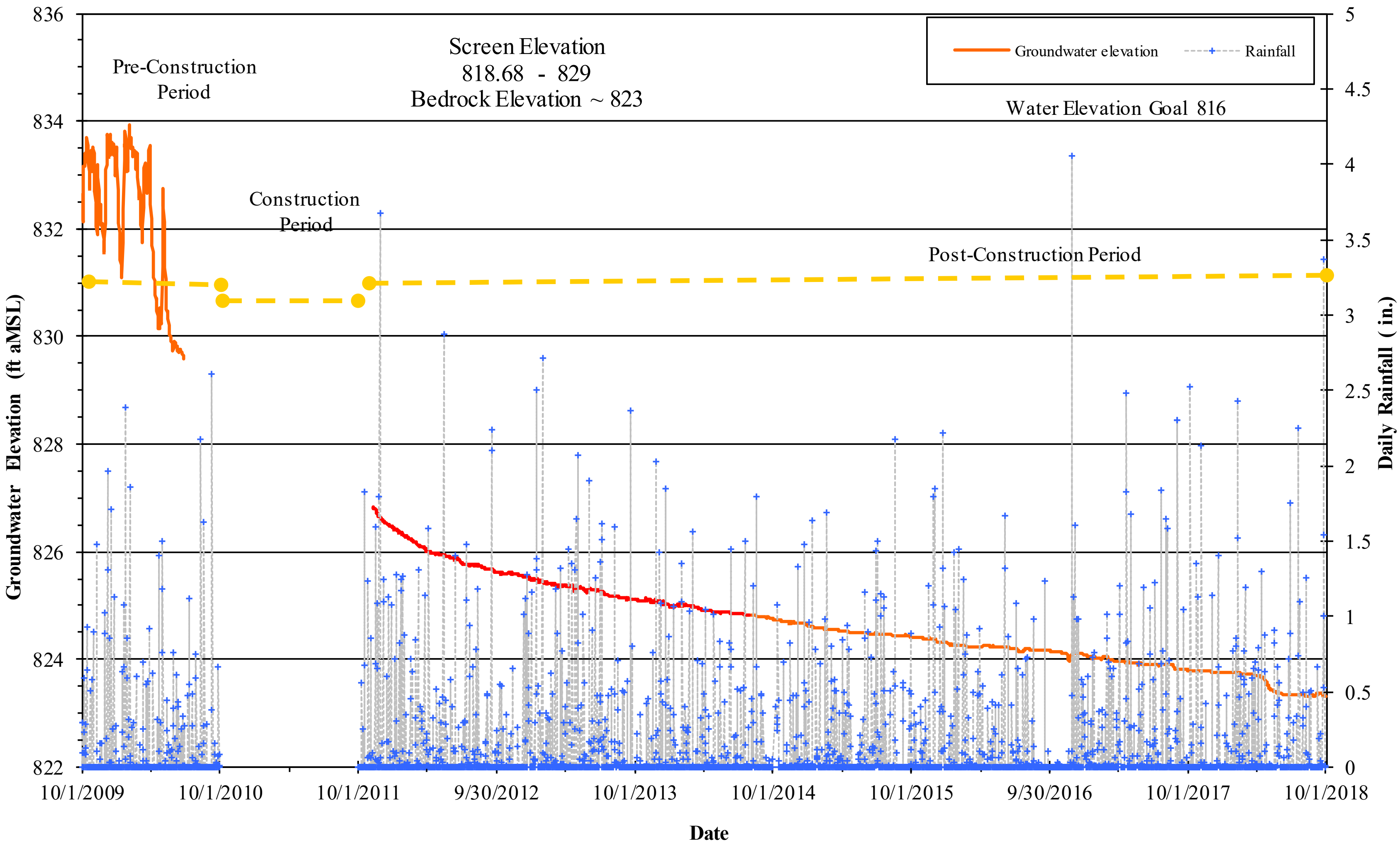

Figure B.1.5. Well 0491 hydrograph.

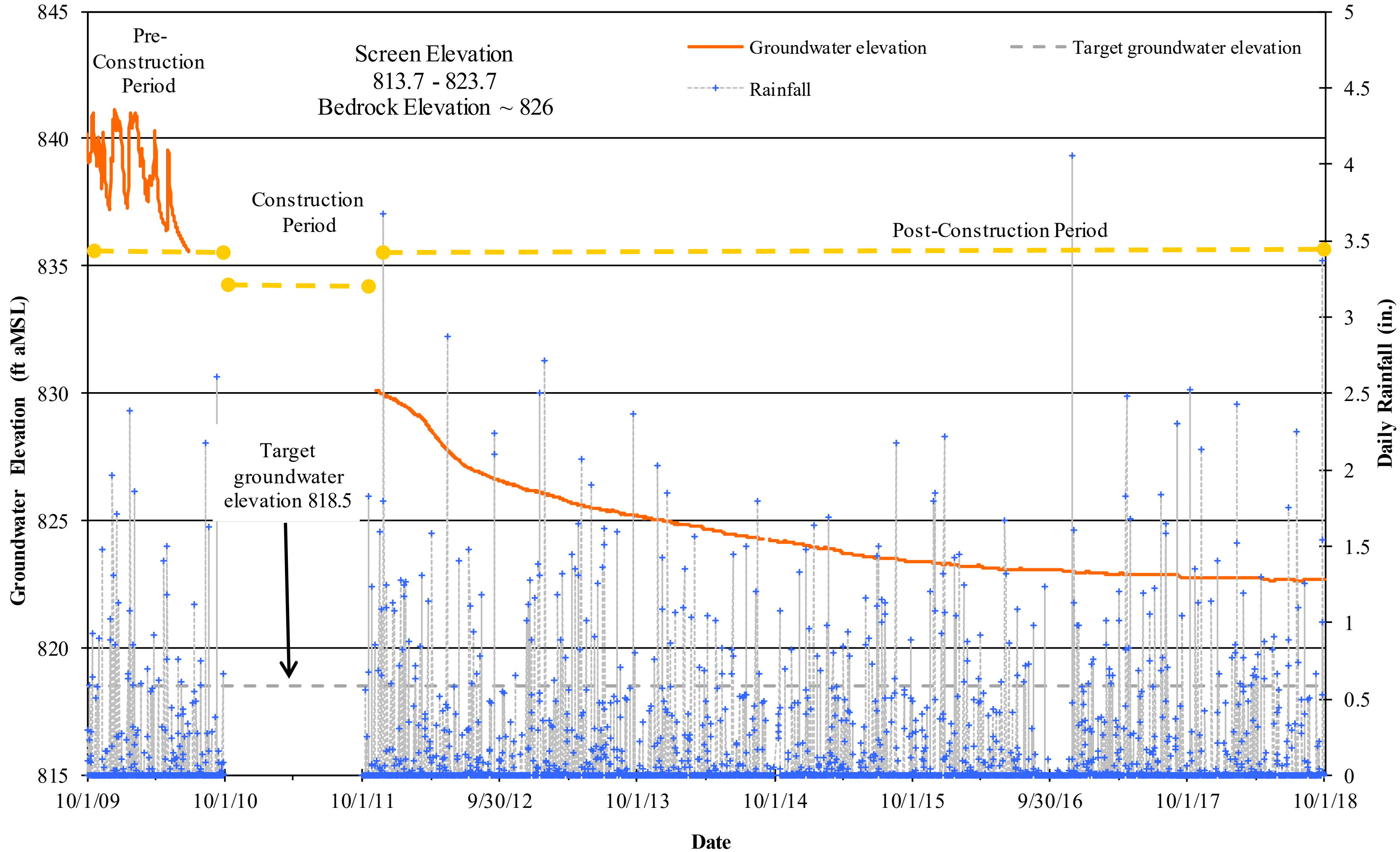

Figure B.1.6. Well 0492 hydrograph.

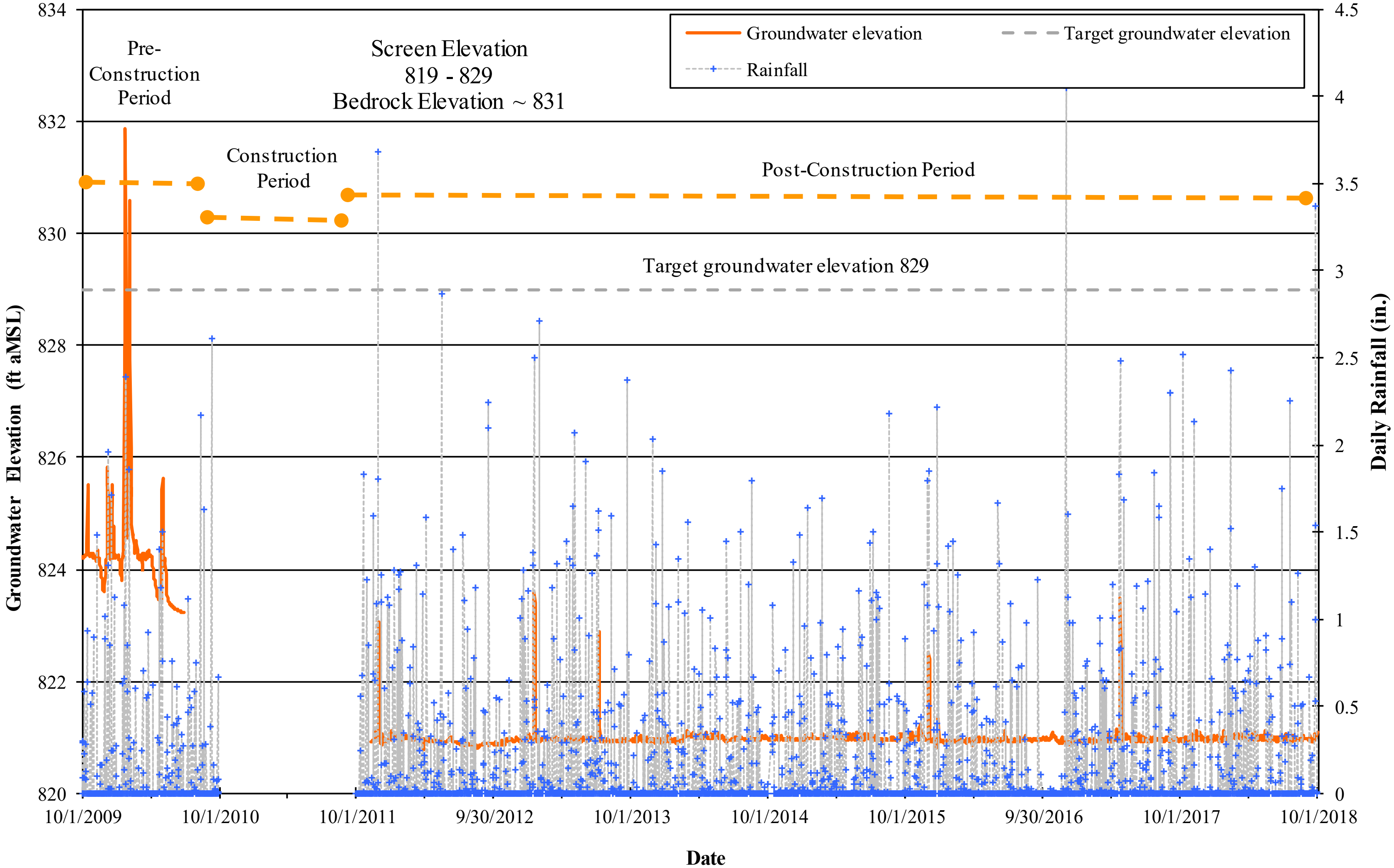

Figure B.1.7. Well 0493 hydrograph.

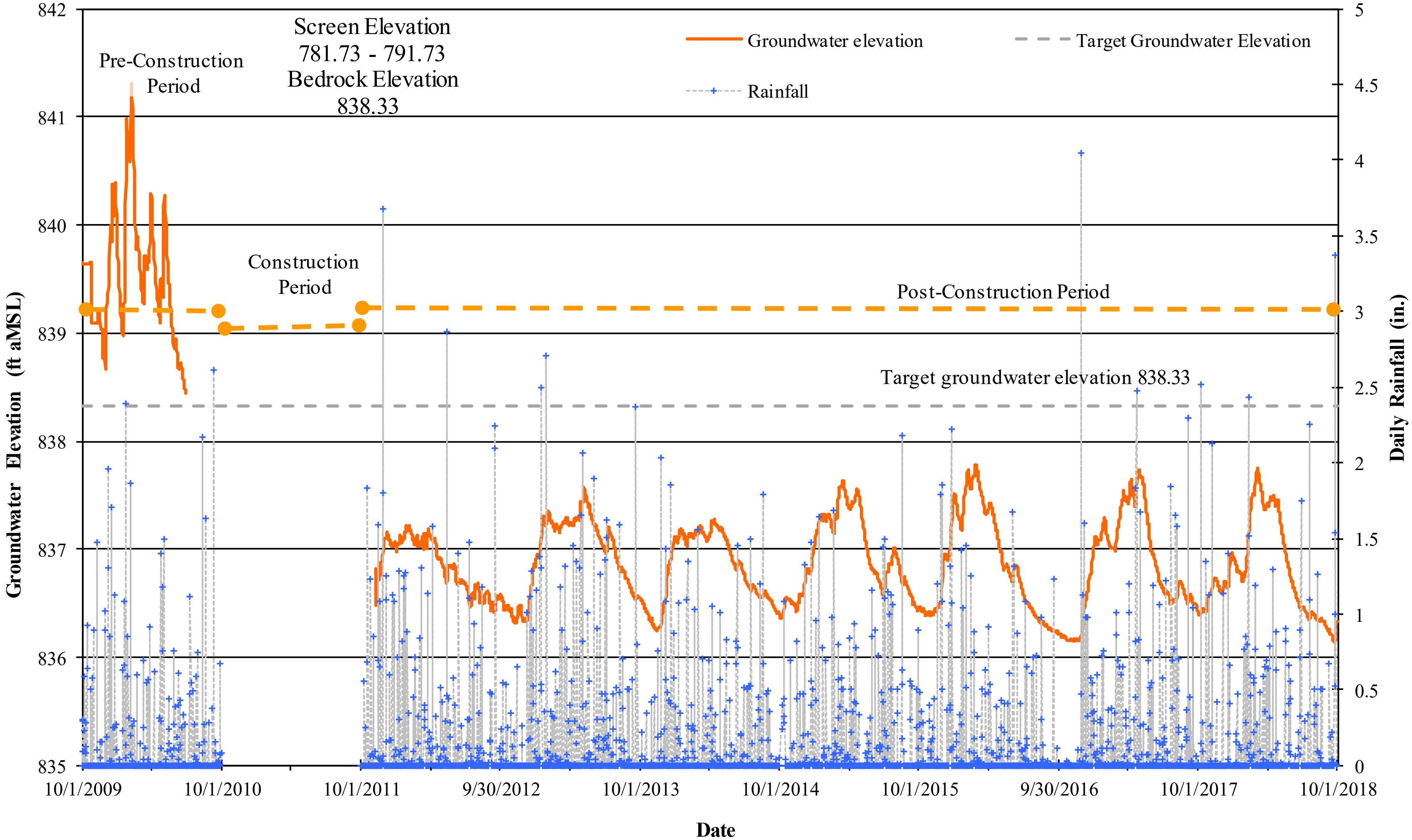

Figure B.1.8. Well 0694 hydrograph.

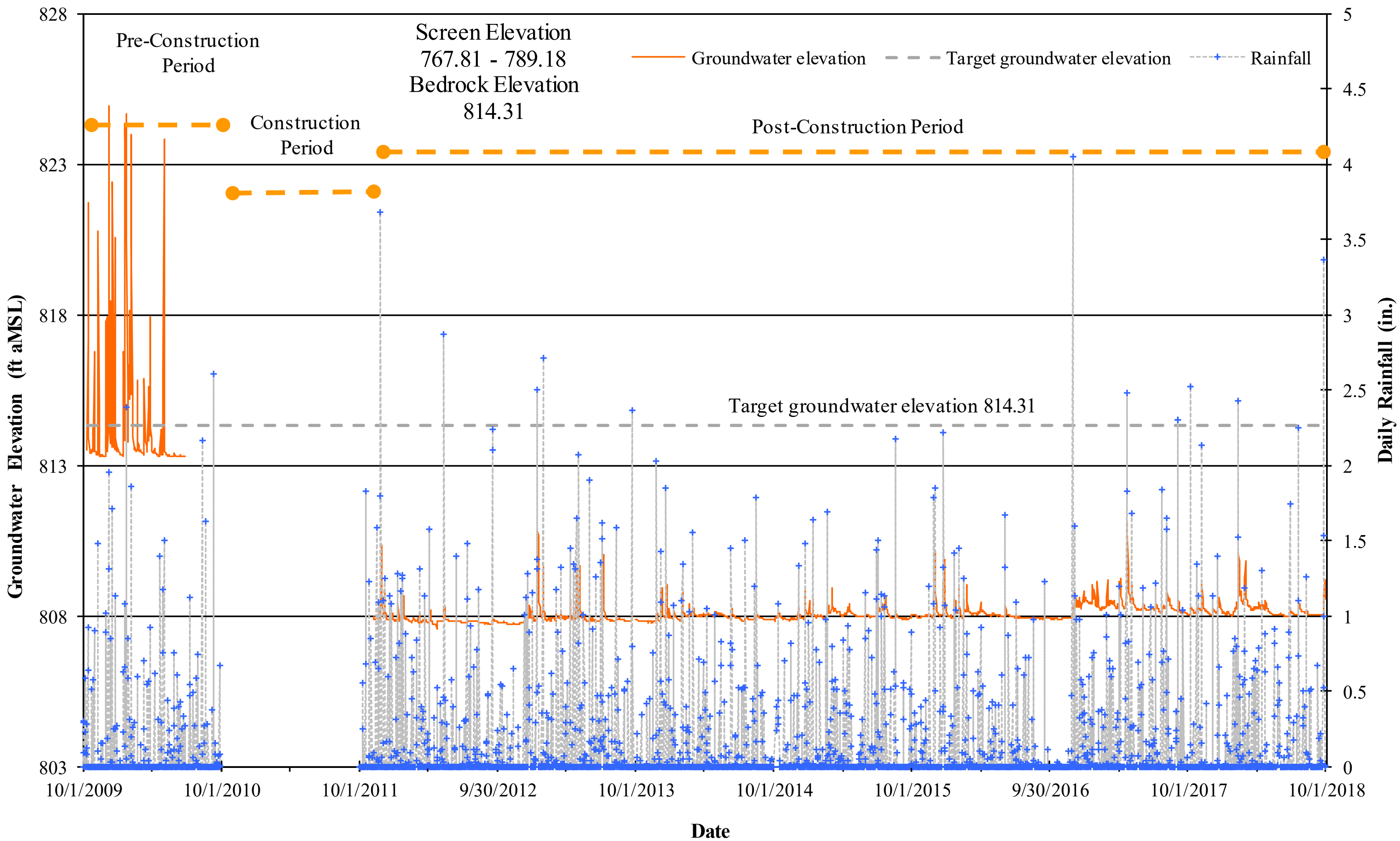

Figure B.1.9. Well 0996 hydrograph.

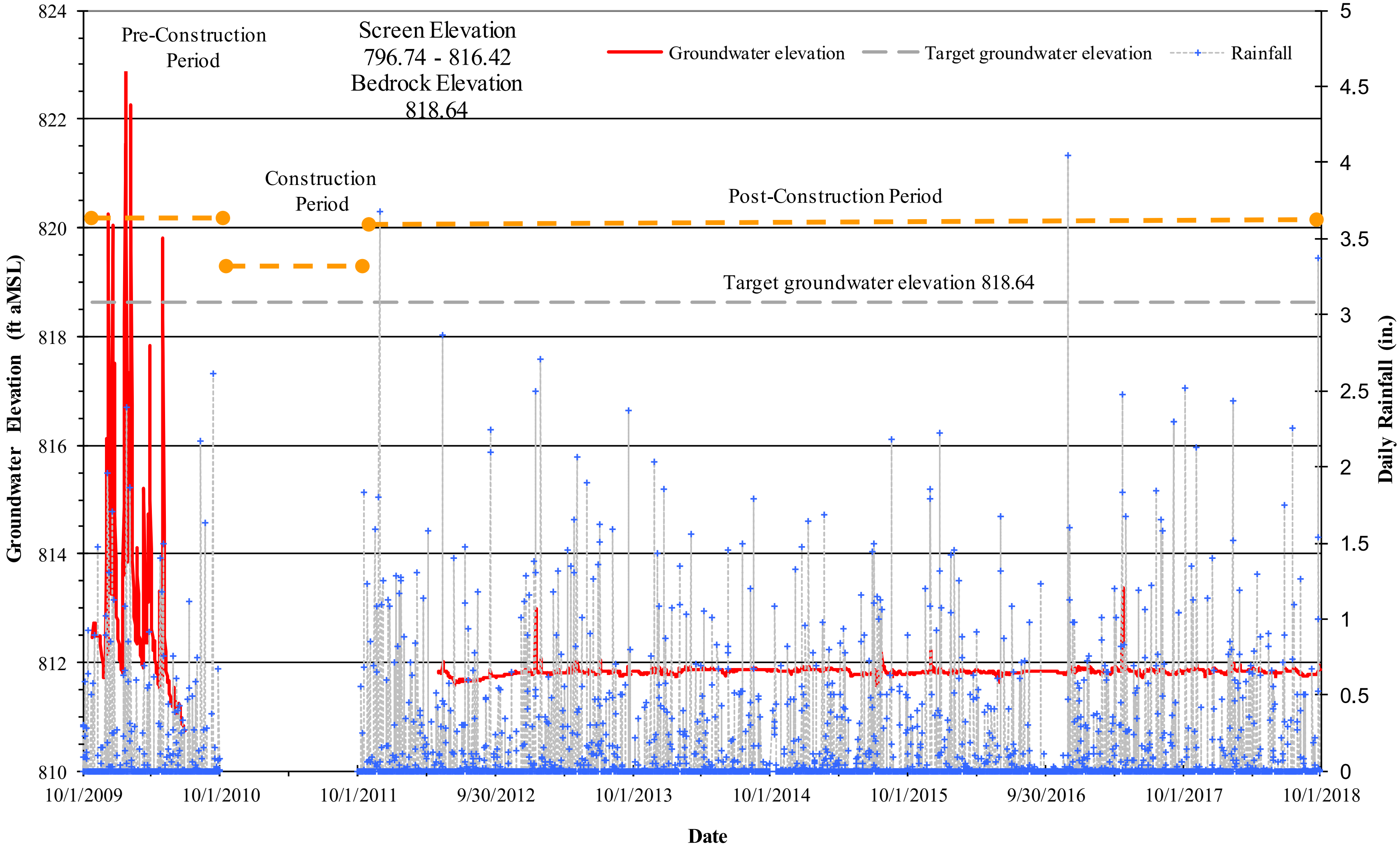

Figure B.1.10. Well 0997 hydrograph.

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B.2 MELTON VALLEY GROUNDWATER LEVEL PERFORMANCE AND HYDROGRAPHS

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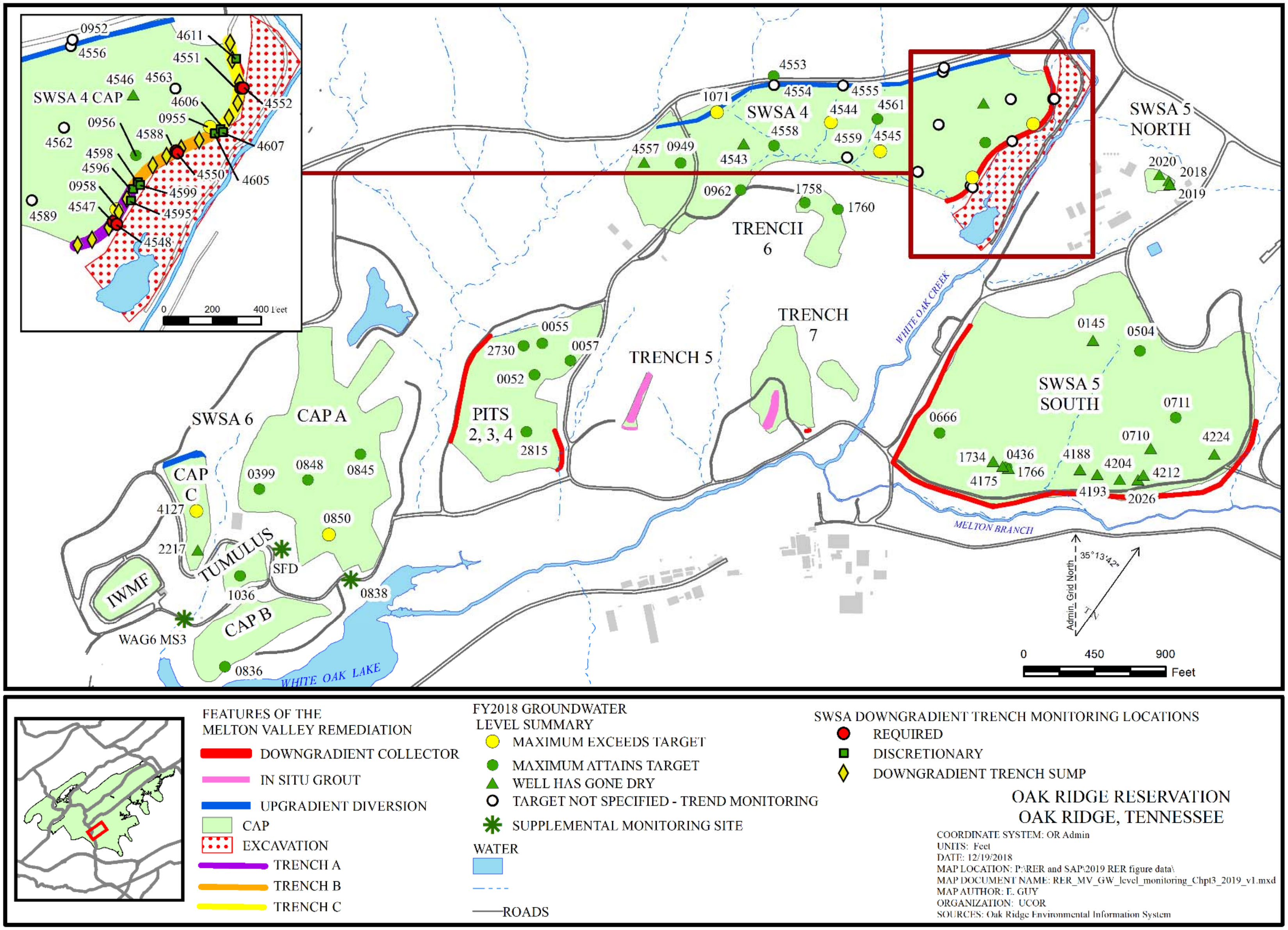


Figure B.2.1. Locations of groundwater elevation monitoring in Melton Valley (MV).

Table B.2.1. FY 2018 MV groundwater level summary

Well	Area	Measurement frequency	Maximum elevation	Observed range	Target elevation	Target range	Meets target elevation	Meets fluct	Comment
0052	PT-2,3,4	M	780.87	0.68	791.0	--	Y	--	
0055	PT-2,3,4	C	785.33	0.99	795.00	--	Y	--	Fluctuates below waste zone
0057	PT-2,3,4	M	784.26	2.7	795.00	--	Y	--	Fluctuates below waste zone
2730	PT-2,3,4	M	779.02	0.85	791.00	--	Y	--	Fluctuates below waste zone
2815	PT-2,3,4	M	770.23	1.18	789.00	--	Y	--	Fluctuates below waste zone
1758	PT-Trench 6	M	831.05	4.20	836	4.42	Y	Y	Fluctuates below waste zone
1760	PT-Trench 6	M	821.81	2.32	836	1.00	Y	N	Fluctuates below waste zone
0949	SWSA 4	C	802.17	1.06	813.78	1.48	Y	Y	Fluctuates below waste zone
0952	SWSA 4	M	816.17	4.58	810.44	--	--	--	Outside Cap, UGT Monitoring
0955	SWSA 4	M	769.07	10.61	759.42	1.03	N	N	Near SWSA 4 DGT-- fluctuates with DGT level
0956	SWSA 4	C	767.11	0.26	770.49	0.40	Y	Y	
0958	SWSA 4	Q	762.69	2.91	761.25	0.72	N	N	Near SWSA 4 DGT-- fluctuates with DGT level
0962	SWSA 4	Q	819.82	2.69	822.85	0.57	Y	N	At cap edge
1071	SWSA 4	C	803.25	0.97	802.44	0.79	N	N	
4543	SWSA 4	C	dry	--	803.31	--	Y	--	
4544	SWSA 4	C	793.1	3.7	791.89	--	N	--	
4545	SWSA 4	C	777.71	0.57	777.25	--	N	--	
4546	SWSA 4	M	dry	--	--	1.1	--	--	
4553	SWSA 4	M	818.93	2.7	--	--	--		Outside Cap, UGT Monitoring
4554	SWSA 4	M	810.65	1.01	--	--	--		UGT Monitoring
4555	SWSA 4	C	810.65	0.88	--	1.25	--	Y	UGT Monitoring
4556	SWSA 4	C	807.81	2.39	--	--	--		UGT Monitoring
4557	SWSA 4	M	dry	--	--	--	--	--	
4558	SWSA 4	M	790.03	0.12	--	0.18	--	Y	
4559	SWSA 4	M	777.41	0.29	--	0.38	--	Y	
4561	SWSA 4	C	791.96	0.5	--	--	--		
4562	SWSA 4	M	782.24	0.27	--	--	--		
4563	SWSA 4	C	776.63	0.38	--	--	--		
2018	SWSA 5-N	M	dry	--	822.2	2.5	Y	--	Dry on 12 of 12 measurement dates

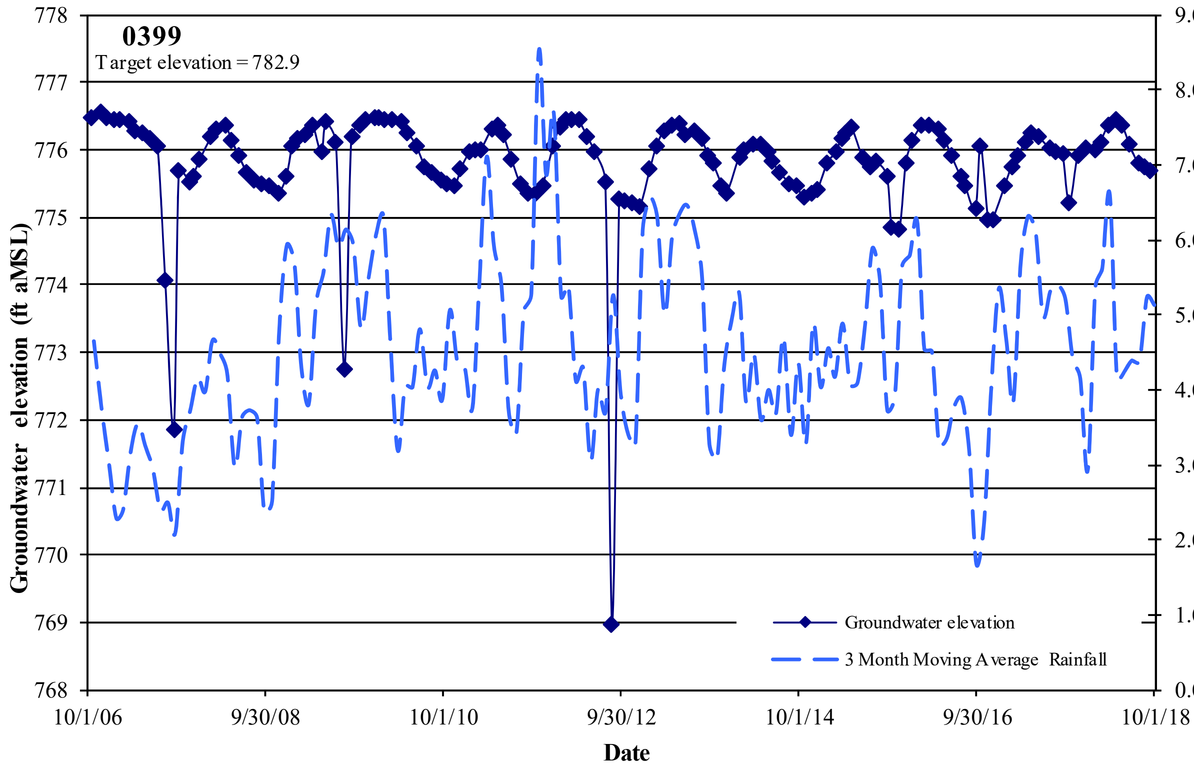
Table B.2.1. FY 2018 MV groundwater level summary (cont.)

Well	Area	Measurement frequency	Maximum elevation	Observed range	Target elevation	Target range	Meets target elevation	Meets fluct	Comment
2019	SWSA 5-N	M	dry	--	824.30	1.67	Y	--	Dry on 12 of 12 measurement dates
2020	SWSA 5-N	M	dry	--	828.20	0.78	Y	--	Dry on 12 of 12 measurement dates
0145	SWSA 5-S	M	dry	--	829.10	1.9	Y	--	
0436	SWSA 5-S	M	765.12	0.79	773.90	2.35	Y	Y	
0504	SWSA 5-S	M	810.81	0	813.10	1.83	Y	Y	
0666	SWSA 5-S	M	767.55	0.56	776.10	1.35	Y	Y	
0710	SWSA 5-S	M	dry	--	791.50	1.10	Y	N	
0711	SWSA 5-S	M	797.87	1.45	806.1	2.9	Y	Y	
1734	SWSA 5-S	M	dry	--	776.70	2.2	Y	--	
1766	SWSA 5-S	M	dry	--	773.9	2.1	Y	--	
2026	SWSA 5-S	M	772.76	0.6	773.3	1.2	Y	Y	Dry on 1 of 12 measurement dates
4175	SWSA 5-S	M	dry	--	775.80	4.10	Y	--	
4188	SWSA 5-S	M	dry	--	772.90	1.63	Y	--	
4193	SWSA 5-S	M	dry	--	775.40	1.32	Y	--	
4204	SWSA 5-S	M	dry	--	773.00	1.40	Y	--	
4212	SWSA 5-S	M	dry	--	773.7	1.68	Y	--	
4224	SWSA 5-S	M	dry	--	781.6	1.88	Y	--	
0399	SWSA 6	M	776.45	1.24	782.90	1.36	Y	Y	
0836	SWSA 6	M	748.17	3.05	753.00	--	Y	--	Near cap edge, fluctuates below waste zone
0845	SWSA 6	M	783.25	2.21	784.10	0.82	Y	N	Bedrock well, fluctuates below waste zone
0848	SWSA 6	M	777.8	1.19	779.20	0.27	Y	N	Bedrock well
0850	SWSA 6	C	767.56	1.66	765.90	2.1	N	Y	Seasonally exceeds target elevation
1036	SWSA 6	C	764.42	4.42	768.00	--	Y	--	
2217	SWSA 6	M	dry	--	767.6	2.5	Y	--	
4127	SWSA 6	M	774.15	1.51	772.30	2.25	N	Y	Bedrock well monitoring confined head
4588	SWSA 4	C	761.99	4.53	--	--	--	--	DGT Monitoring
4589	SWSA 4	C	771.12	0.38	--	--	--	--	DGT Monitoring
4547	SWSA 4 DGT	C	763.59	6.51	--	--	--	--	DGT Monitoring
4548	SWSA 4 DGT	C	763.41	4.56	--	--	--	--	DGT Monitoring
4550	SWSA 4 DGT	M	761.99	7.59	--	--	--	--	DGT Monitoring

Table B.2.1. FY 2018 MV groundwater level summary (cont.)

Well	Area	Measurement frequency	Maximum elevation	Observed range	Target elevation	Target range	Meets target elevation	Meets fluct	Comment
4551	SWSA 4 DGT	C	765.1	5.37	--	--	--	--	DGT Monitoring
4552	SWSA 4 DGT	C	765.36	5.9	--	--	--	--	DGT Monitoring
4595	SWSA 4 DGT	C	763.57	3.92	--	--	--	--	DGT Monitoring
4596	SWSA 4 DGT	C	763.54	7.24	--	--	--	--	DGT Monitoring
4598	SWSA 4 DGT	C	762.02	4.59	--	--	--	--	DGT Monitoring
4599	SWSA 4 DGT	C	763.05	3.84	--	--	--	--	DGT Monitoring
4605	SWSA 4 DGT	C	762.06	4.11	--	--	--	--	DGT Monitoring
4606	SWSA 4 DGT	C	764.41	5.91	--	--	--	--	DGT Monitoring
4607	SWSA 4 DGT	C	763.65	5.83	--	--	--	--	DGT Monitoring
4611	SWSA 4 DGT	C	764.54	5.3	--	--	--	--	DGT Monitoring

-- = not applicable, not available, or insufficient data to calculate the value
C = continuous groundwater level monitoring using pressure transducer and data logger
DGT = downgradient trench
fluct = meets performance goal of attaining a >75% reduction in groundwater level fluctuations
FY = fiscal year
M = monthly manual groundwater level measurements
MV = Melton Valley
N = no
PT = pits and trenches
Q = quarterly manual groundwater level measurements
SWSA = Solid Waste Storage Area
UGT = upgradient trench
Y = yes



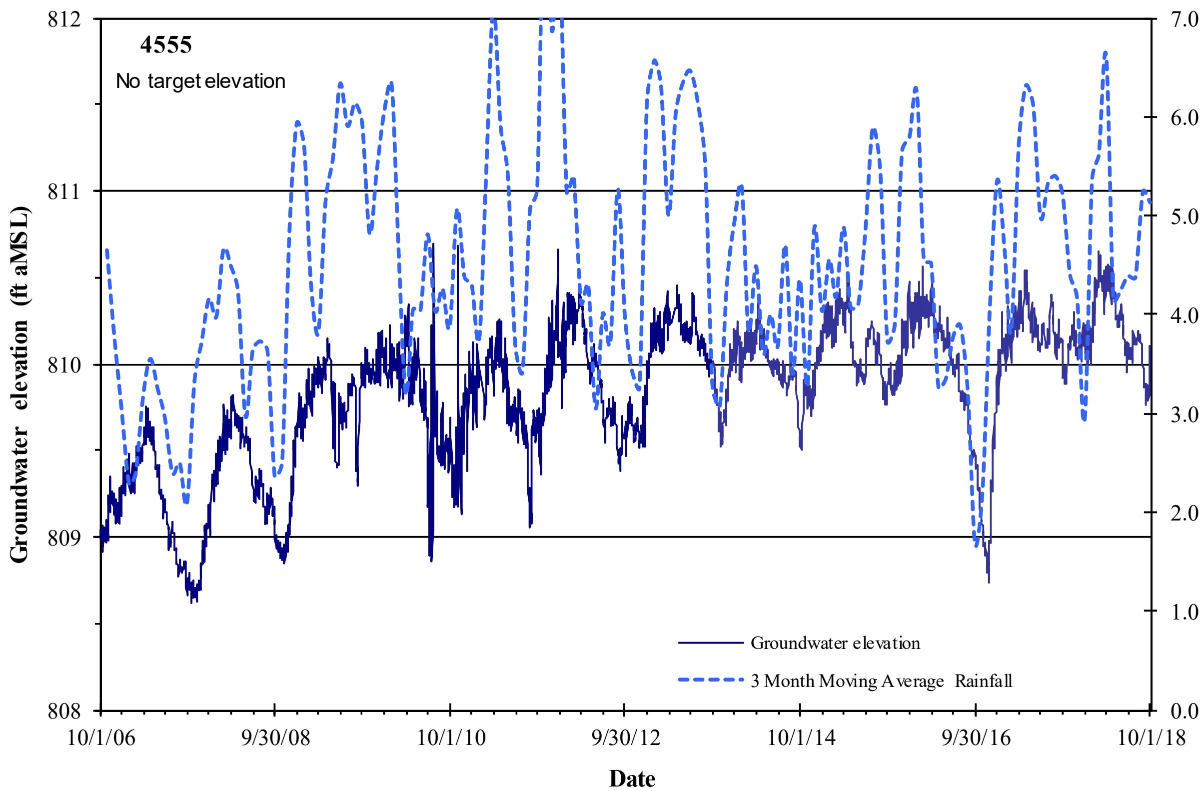
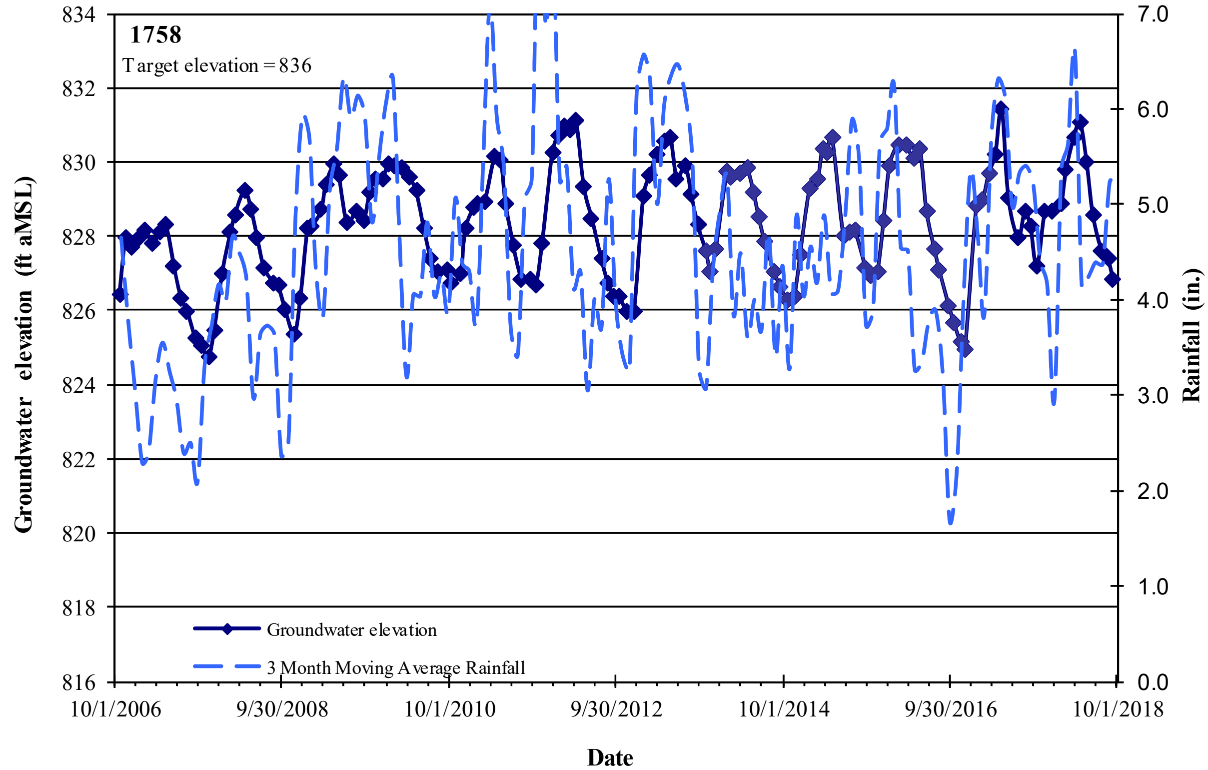


Figure B.2.2. Well hydrographs for wells 0399 and 4555.



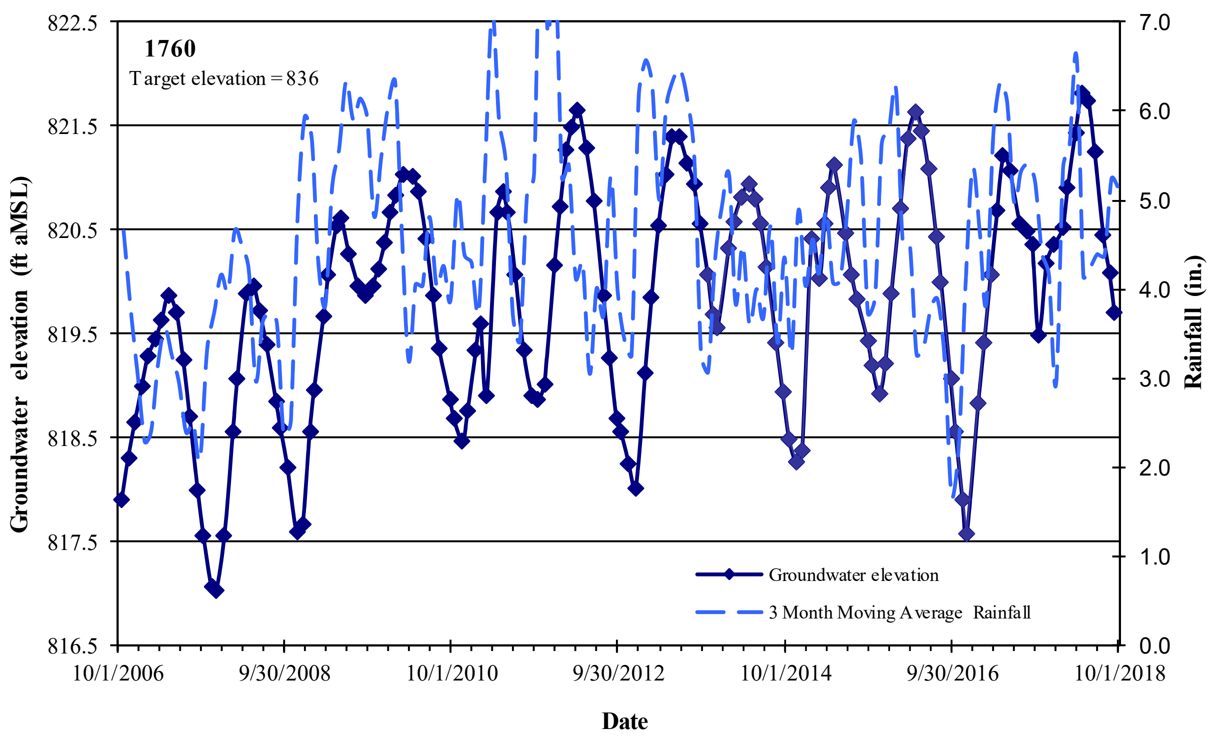
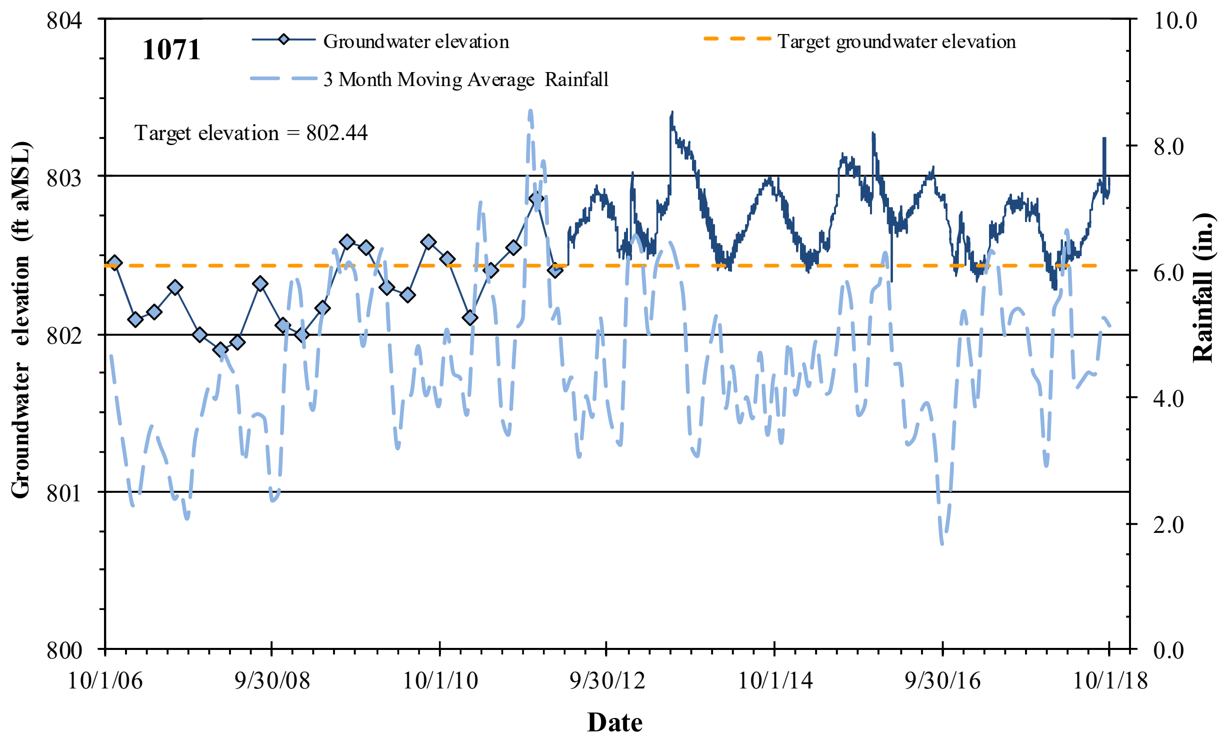


Figure B.2.3. Well hydrographs for wells 1758 and 1760.



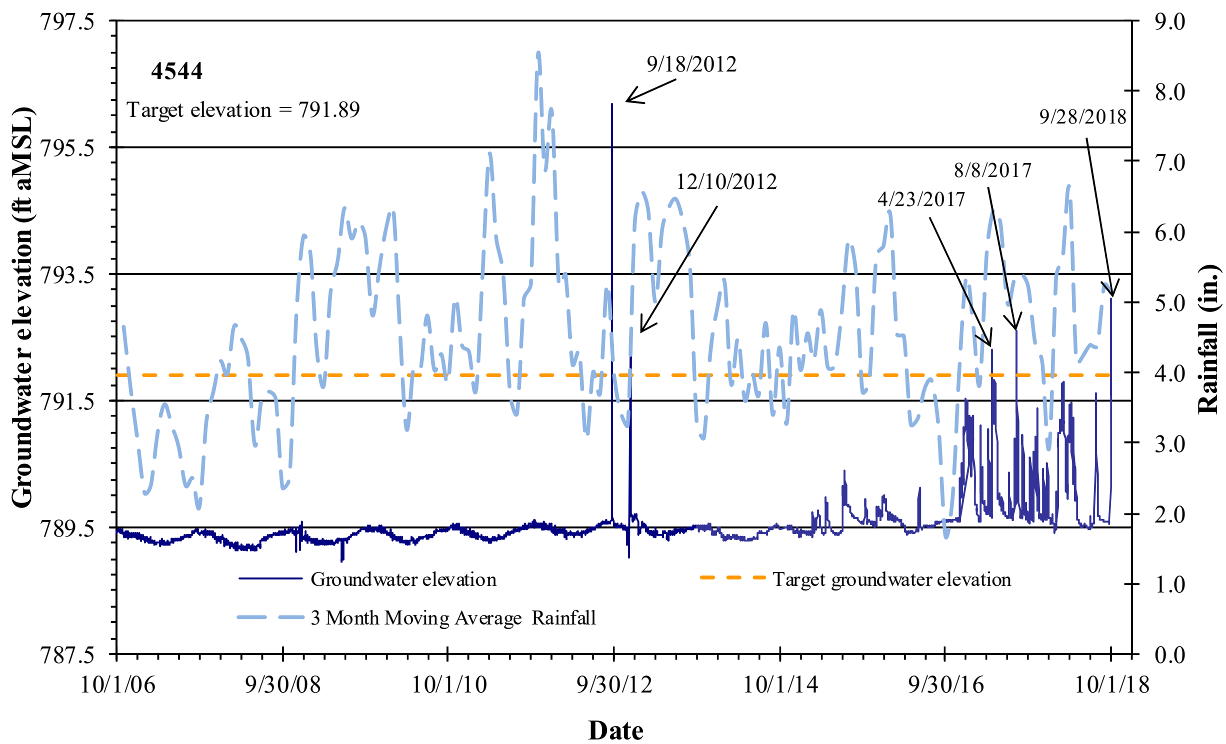


Figure B.2.4. Well hydrographs for wells 1071 and 4544.

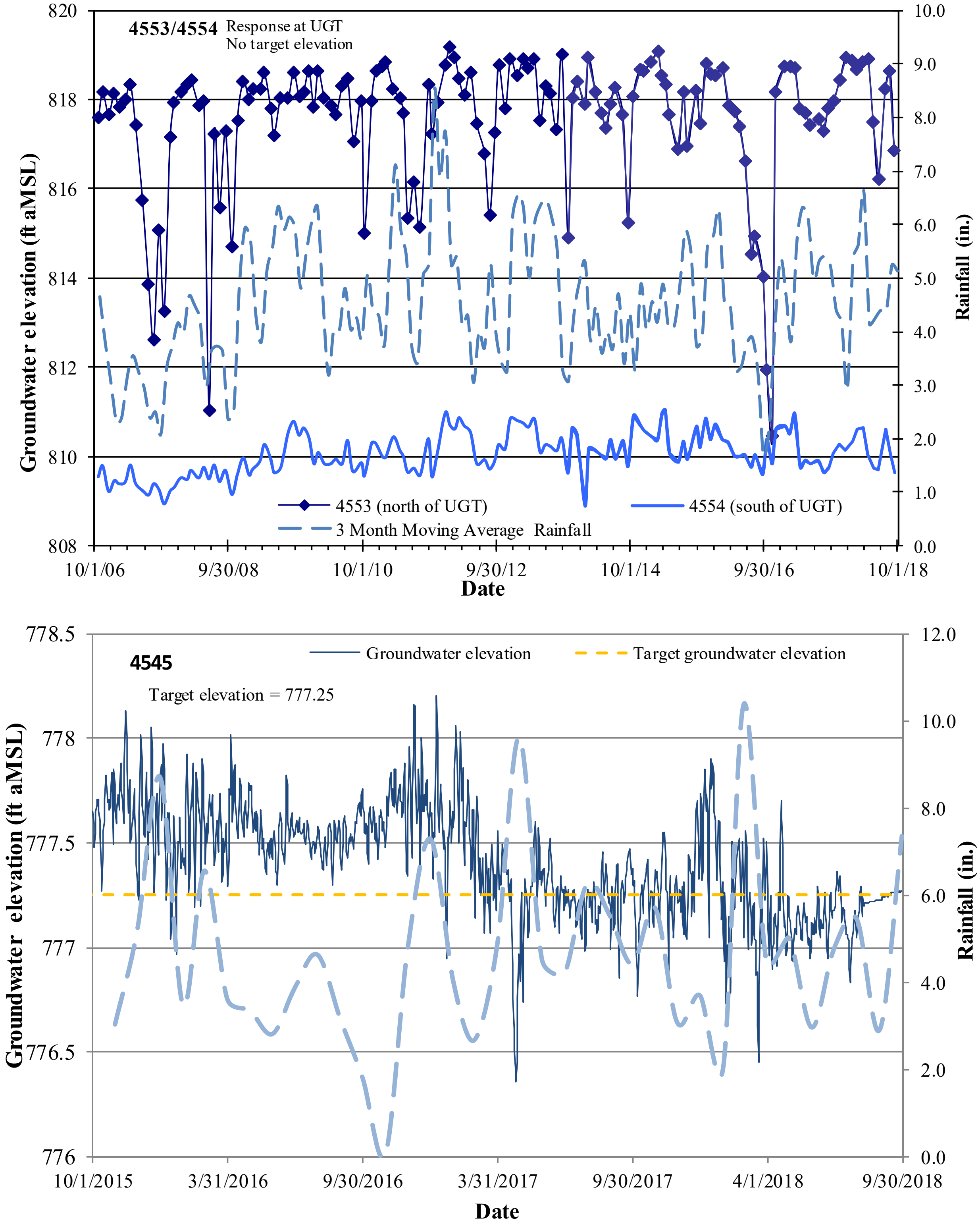
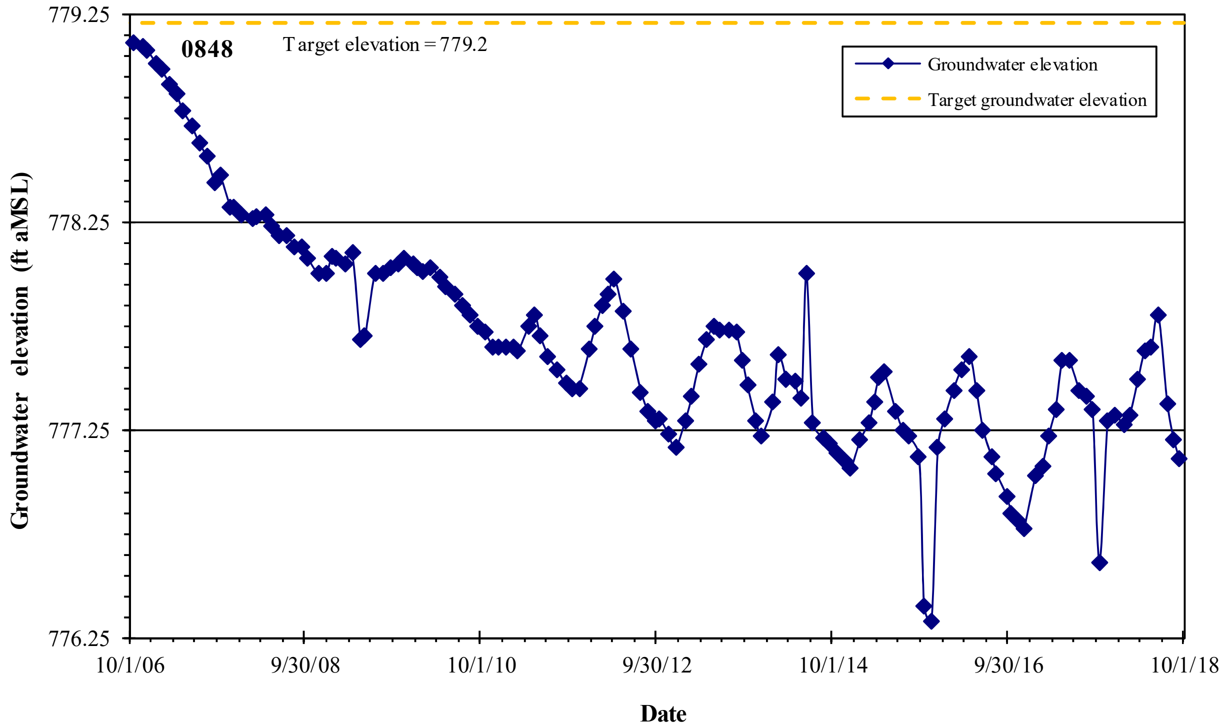


Figure B.2.5. Well hydrographs for wells 4553/4554 and 4545.



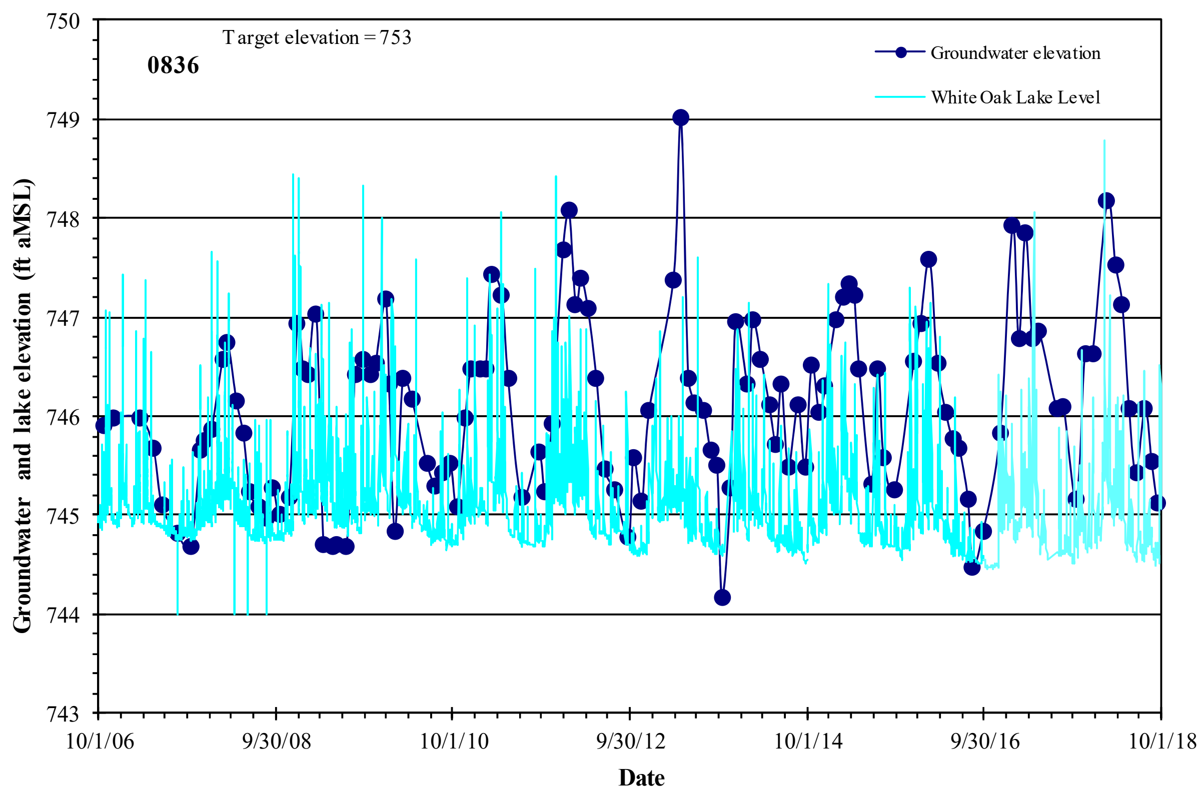
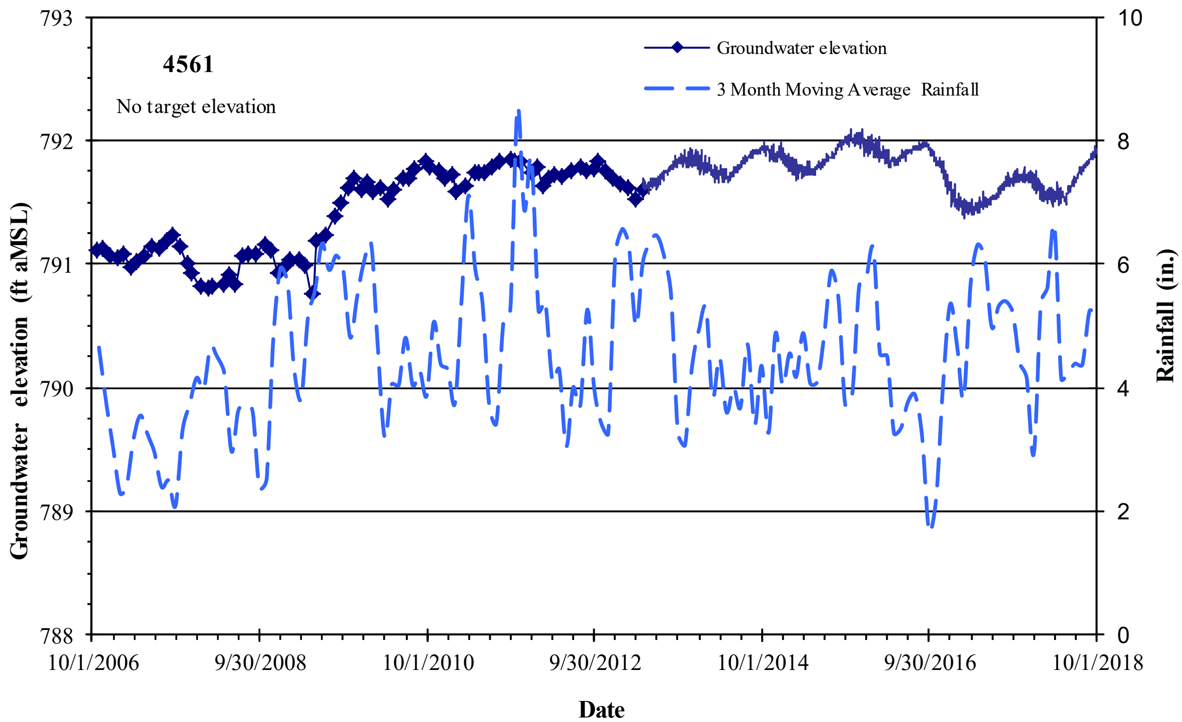


Figure B.2.6. Well hydrographs for wells 0848 and 0836.



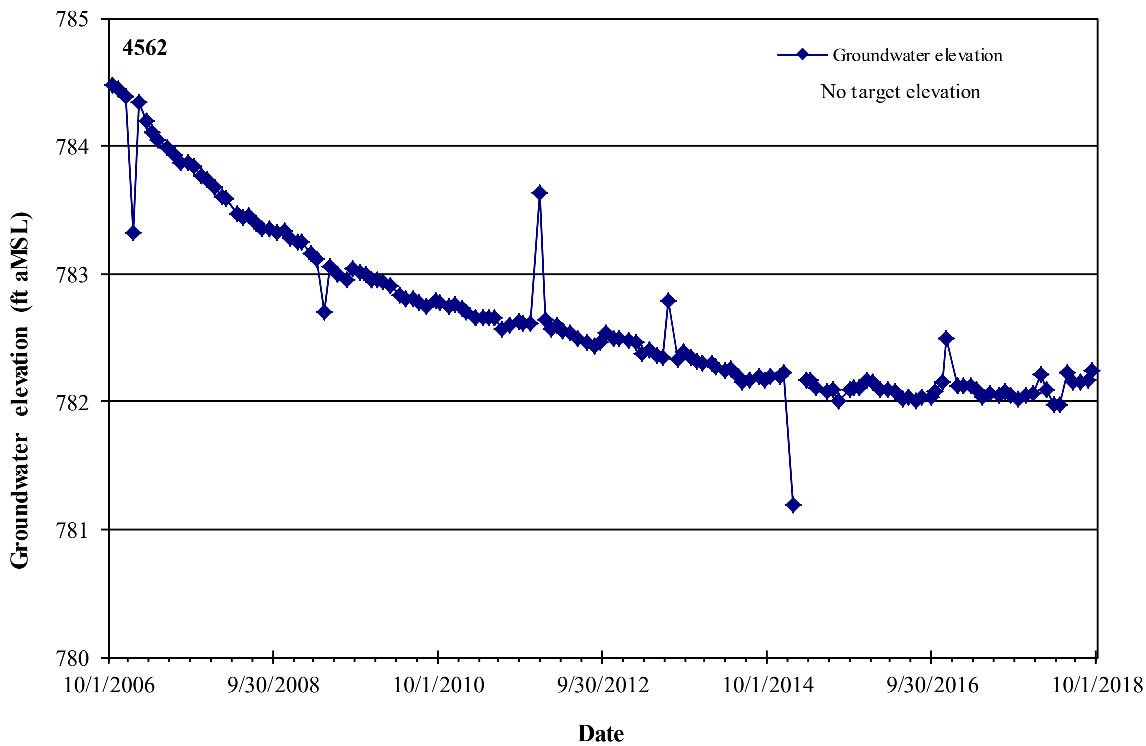
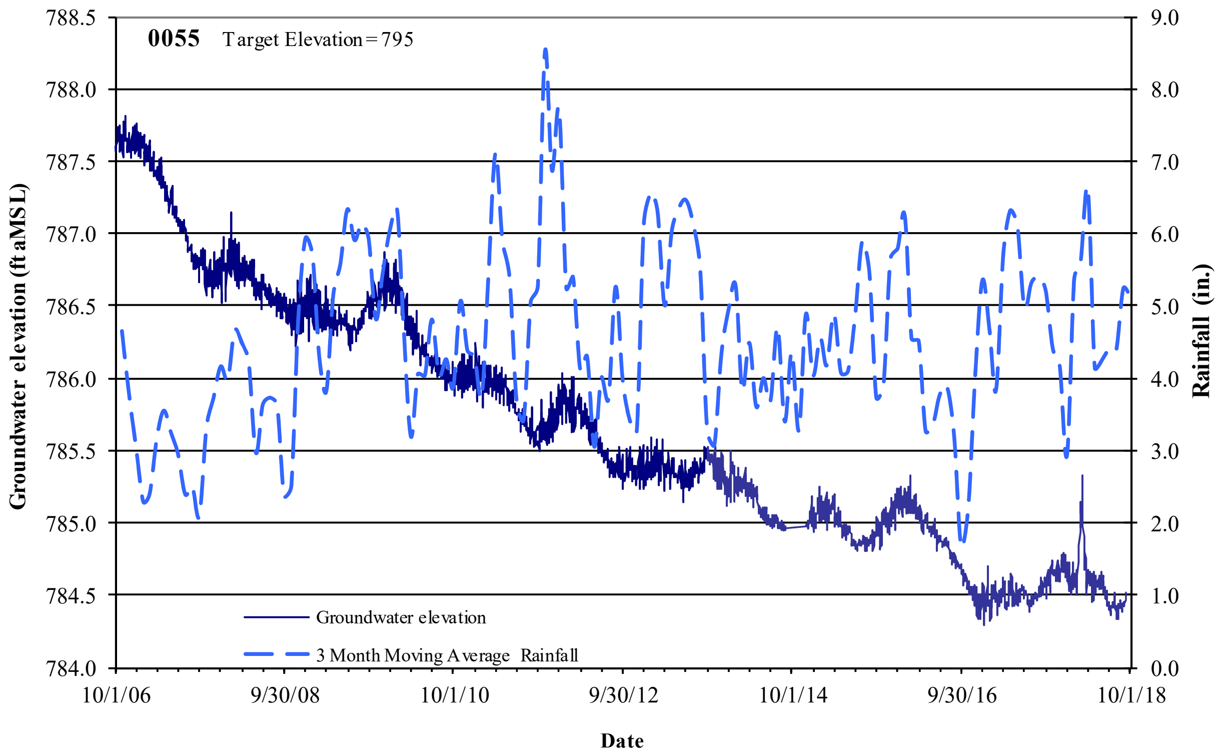


Figure B.2.7. Well hydrographs for wells 4561 and 4562.



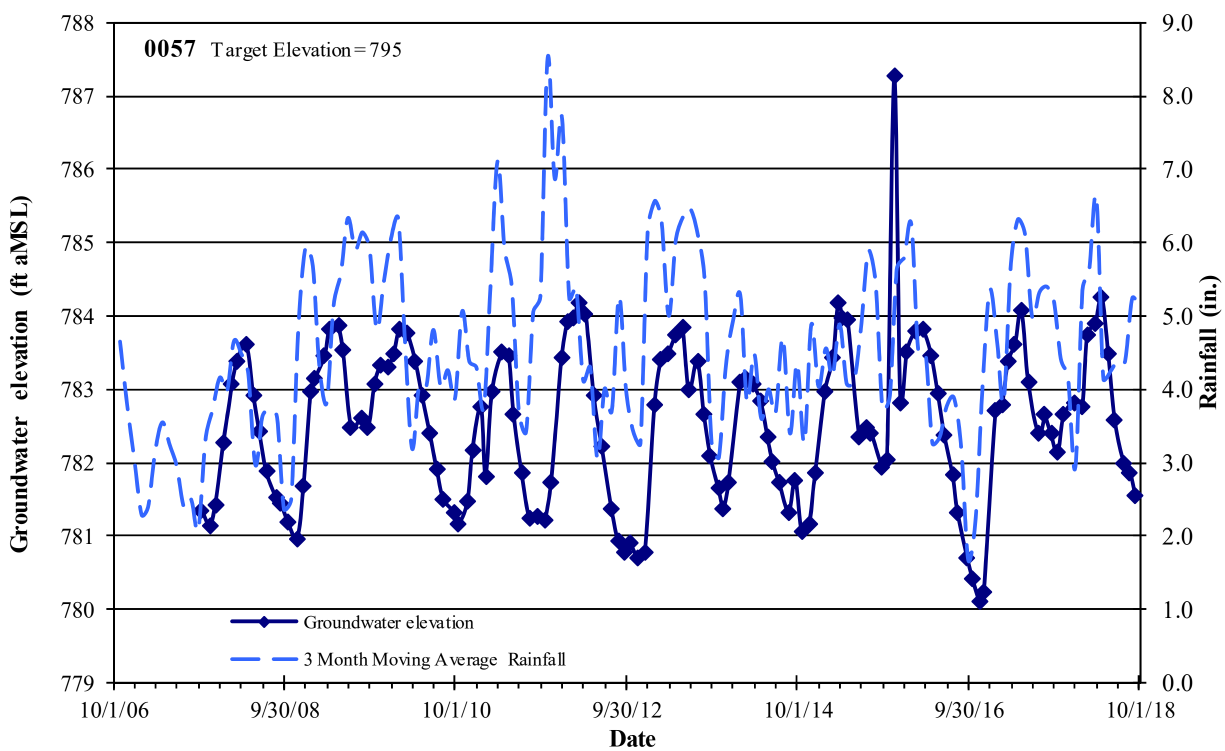
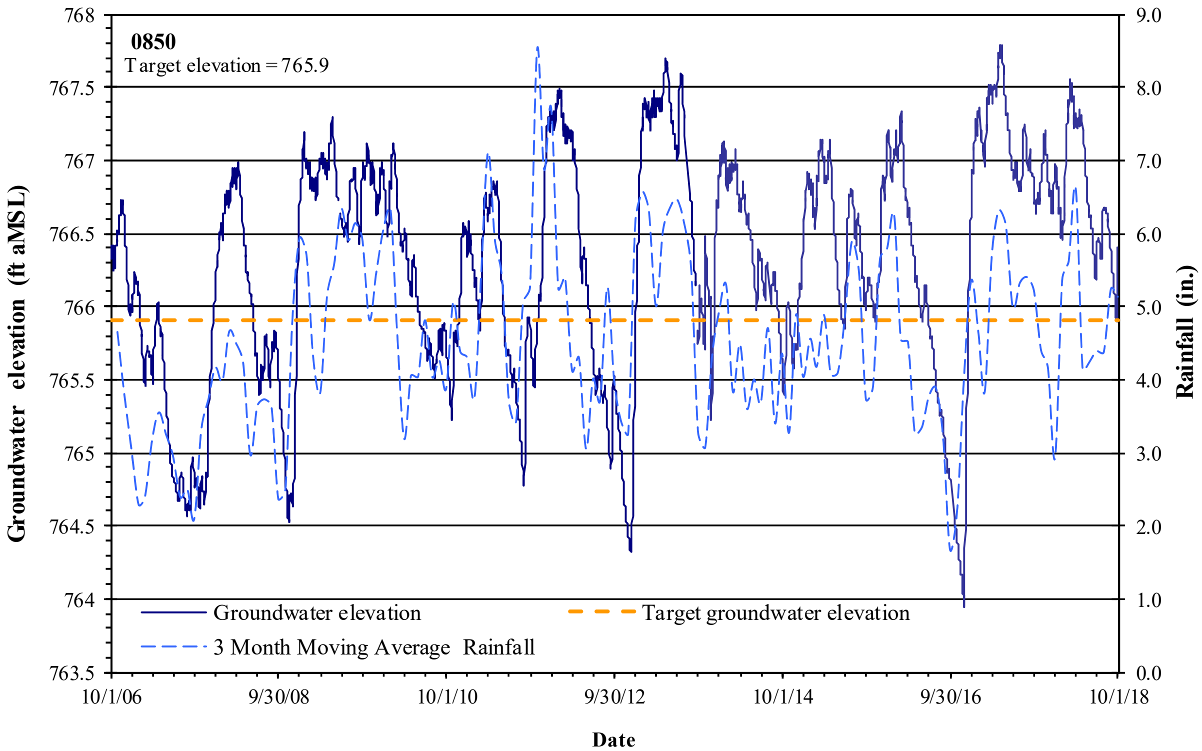


Figure B.2.8. Well hydrographs for wells 0055 and 0057.



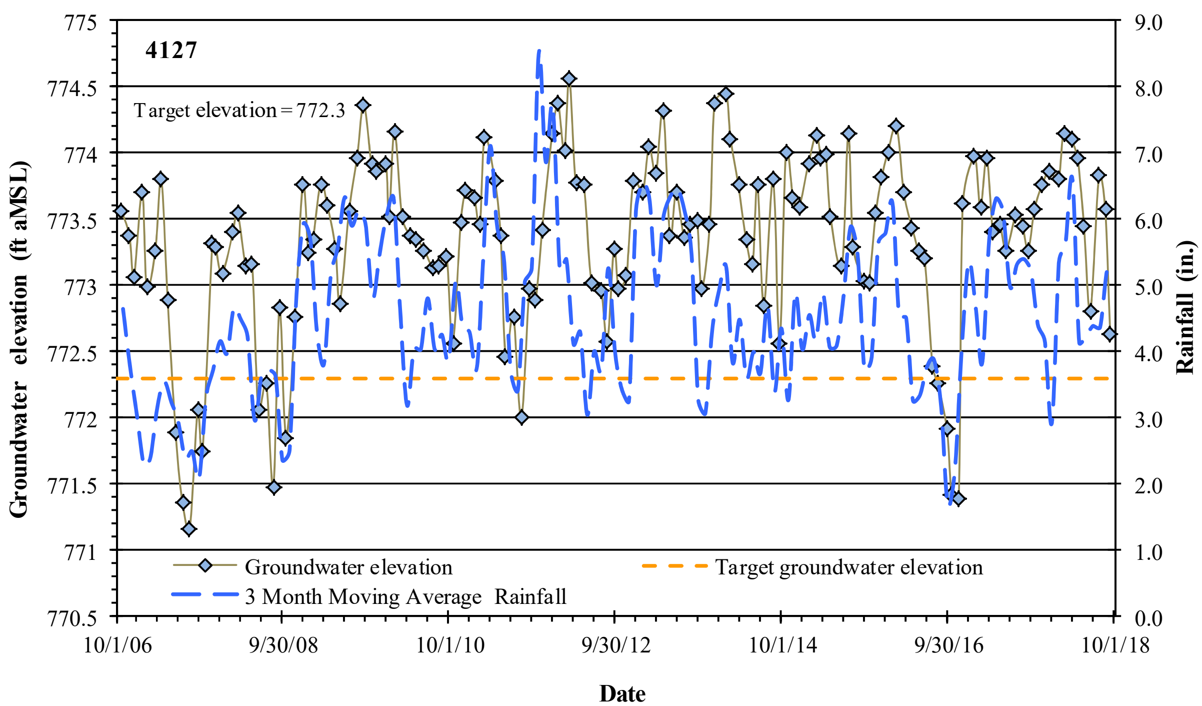
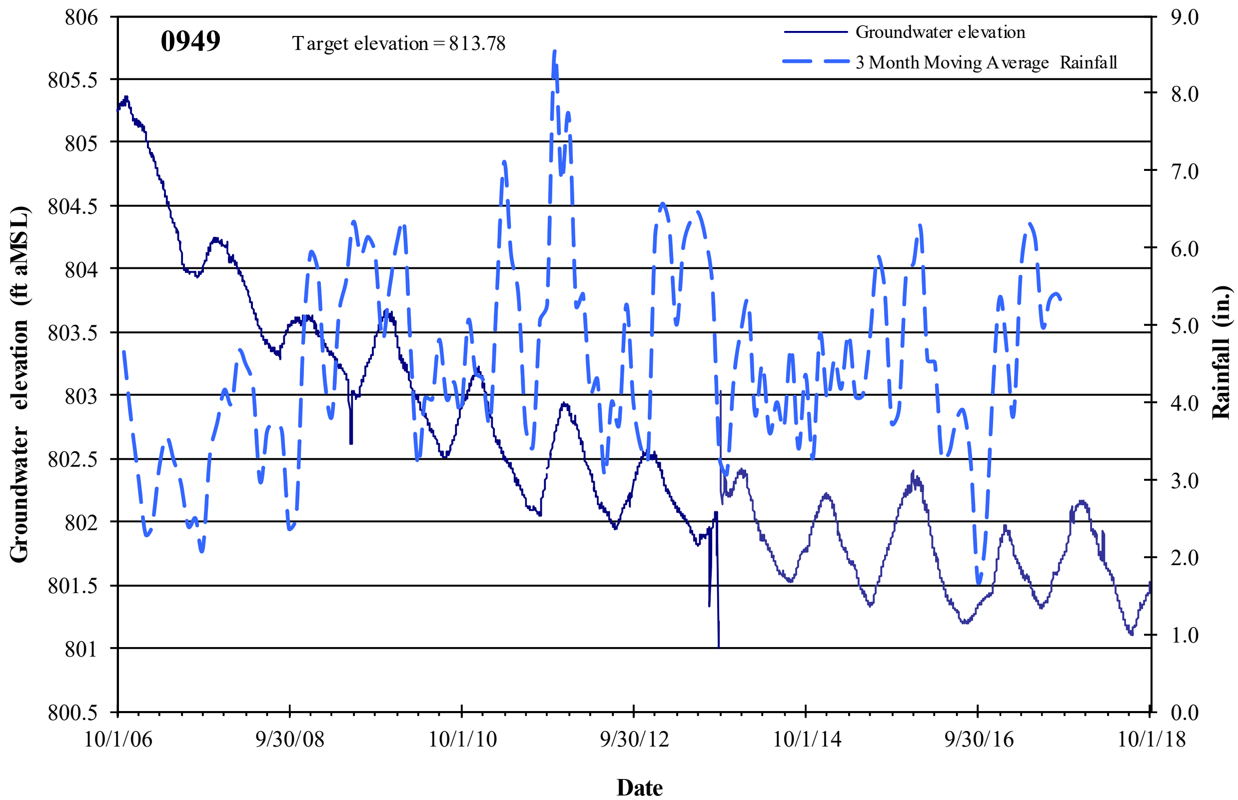


Figure B.2.9. Well hydrographs for wells 0850 and 4127.



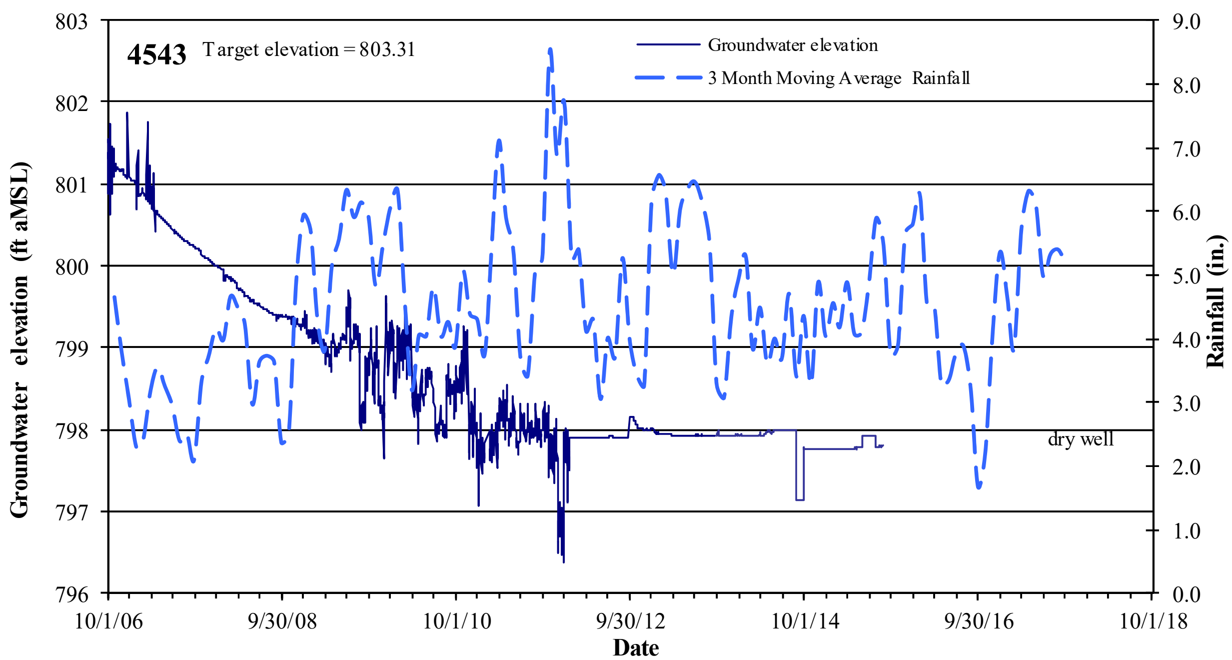
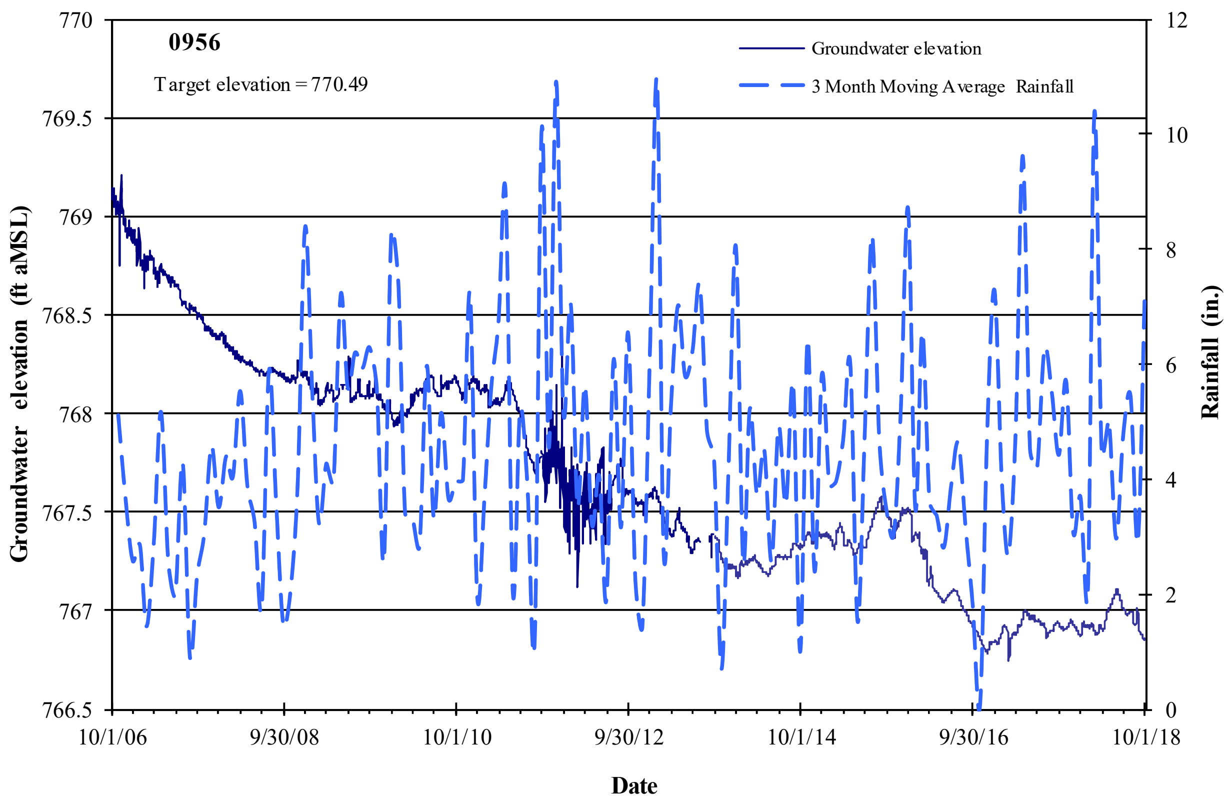


Figure B.2.10. Well hydrographs for wells 0949 and 4543.



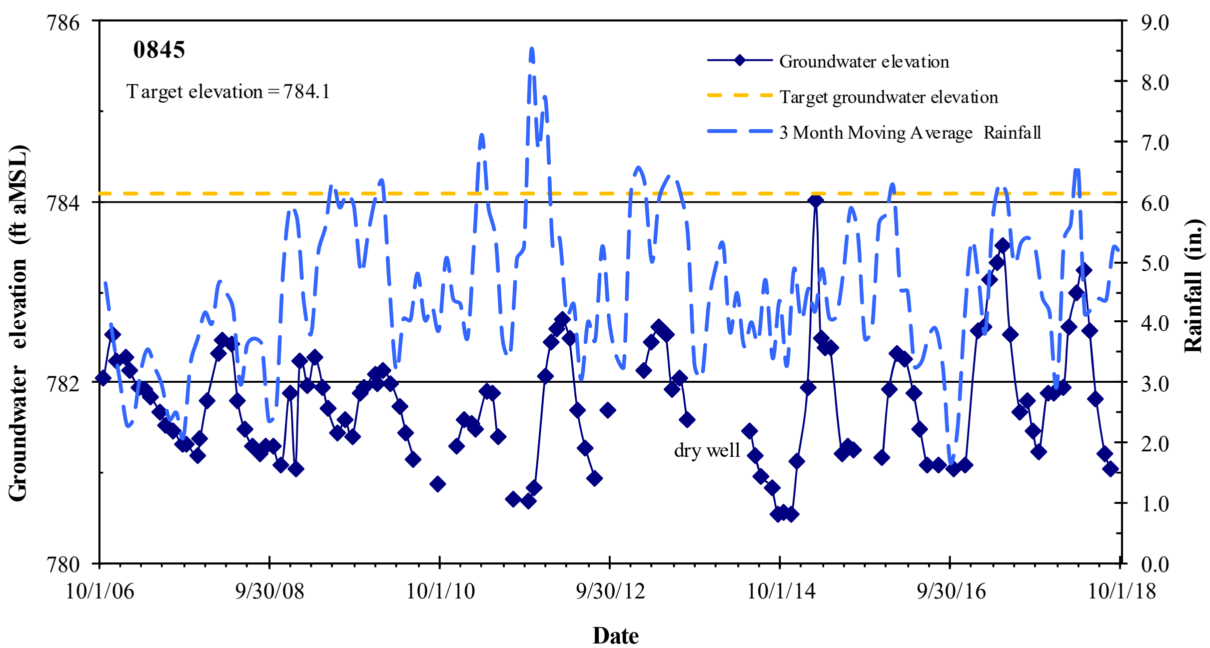
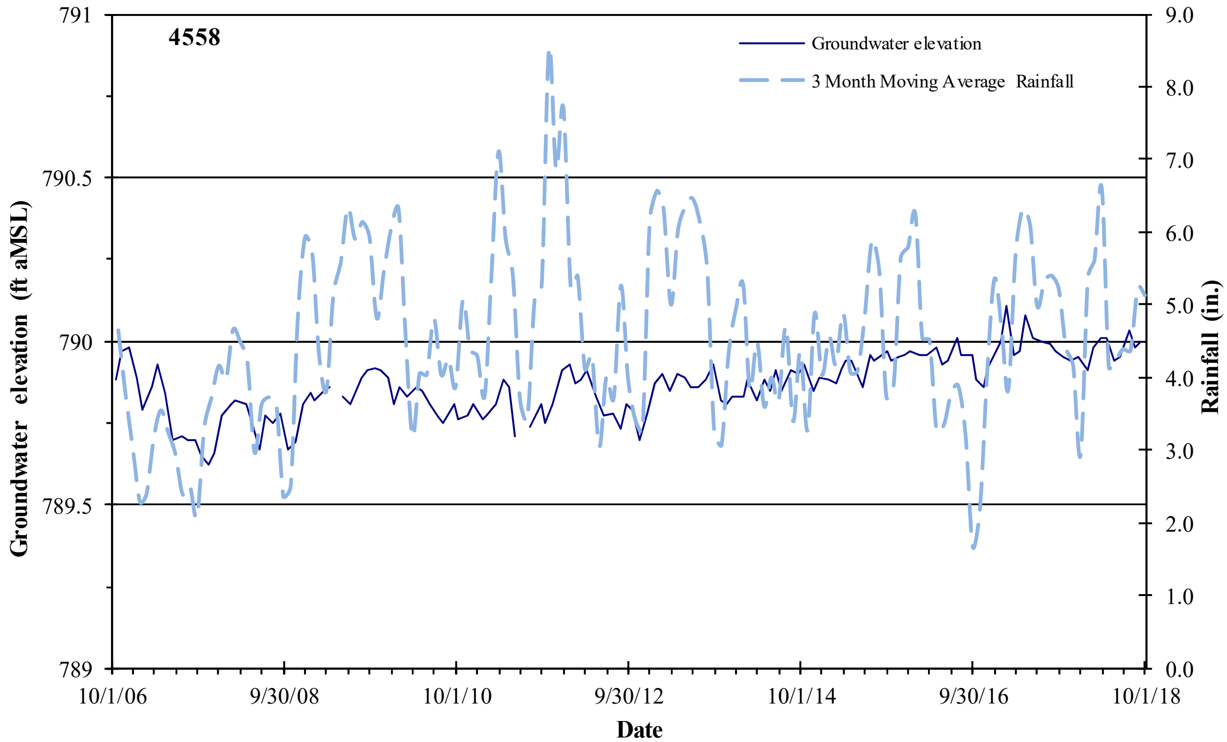


Figure B.2.11. Well hydrographs for well pair 0956 and well 0845.



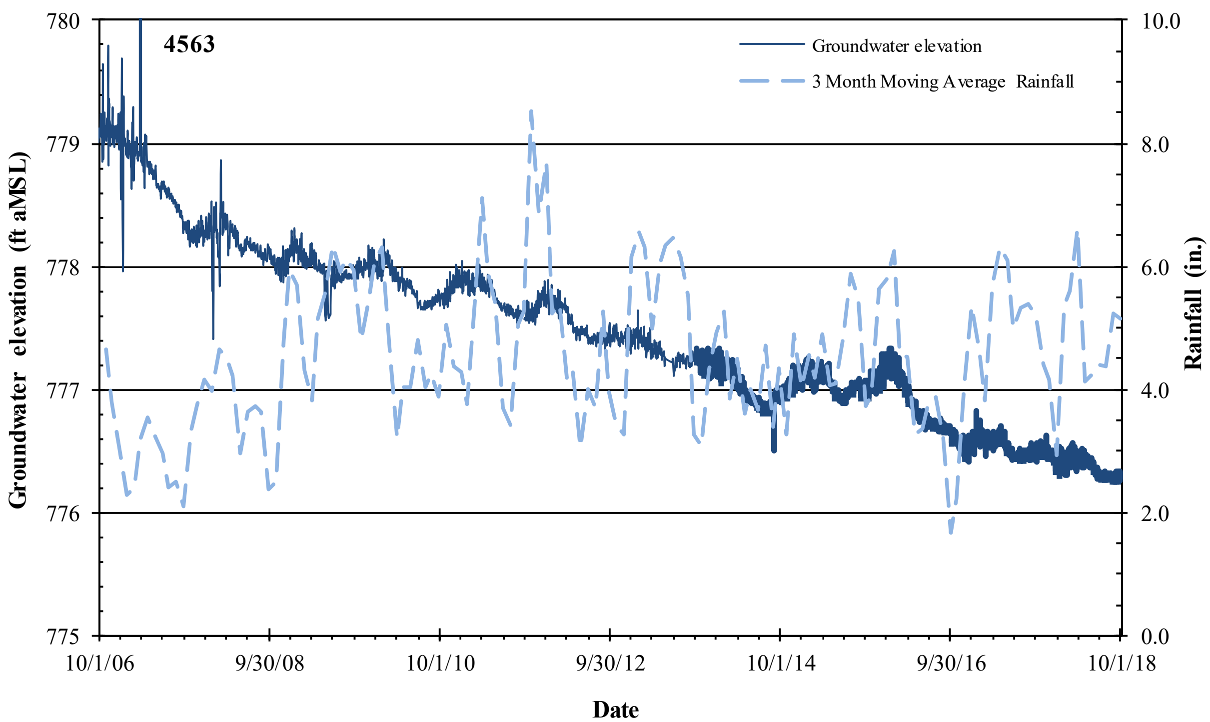
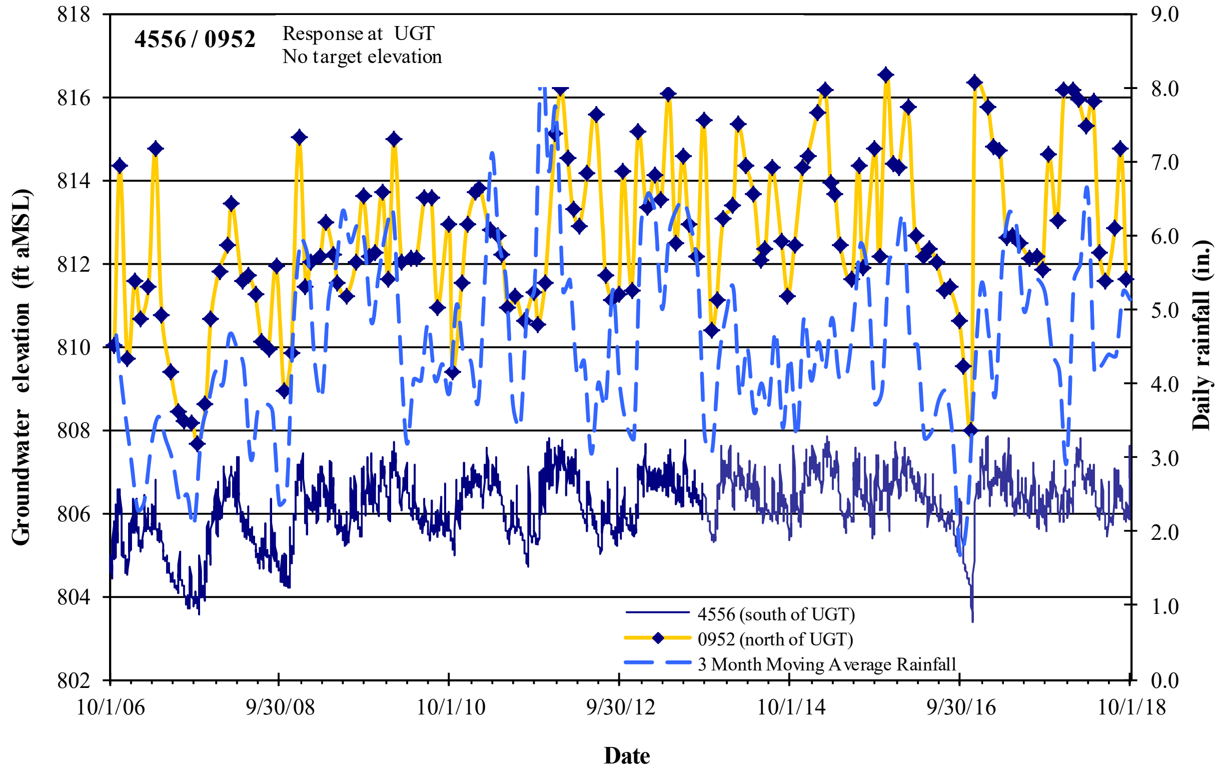


Figure B.2.12. Well hydrographs for wells 4558 and 4563.



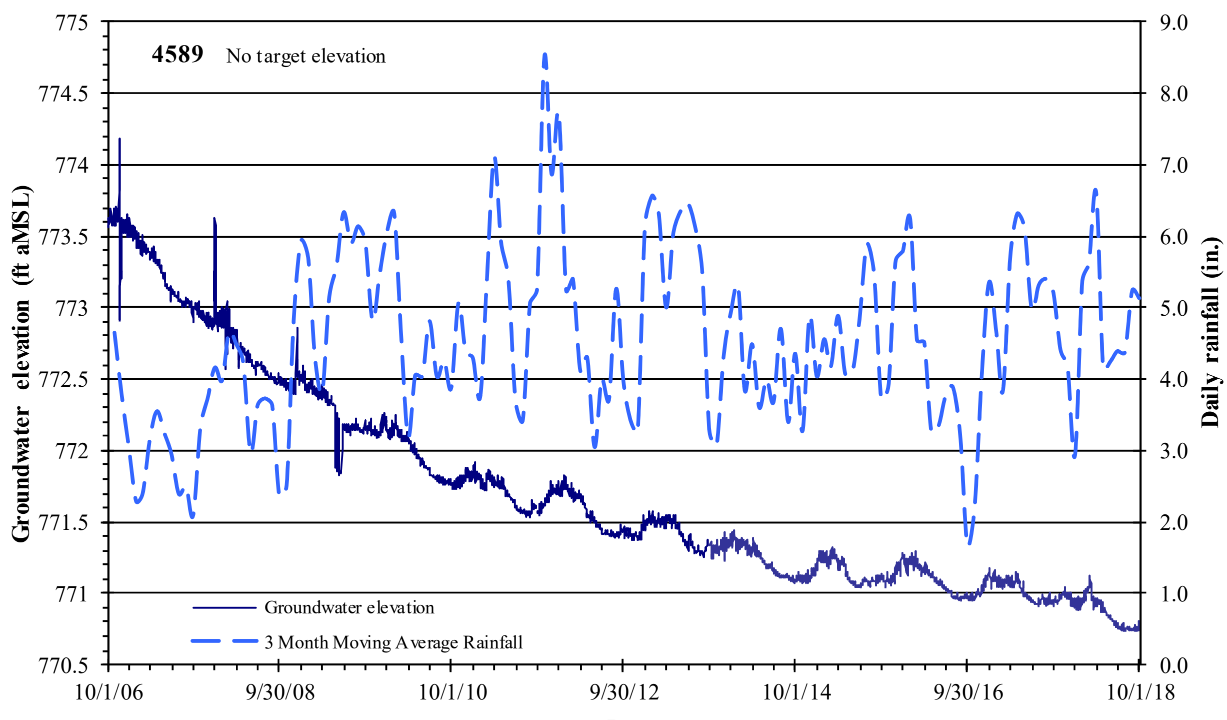


Figure B.2.13. Well hydrographs for wells 4556/0952 and 4589.

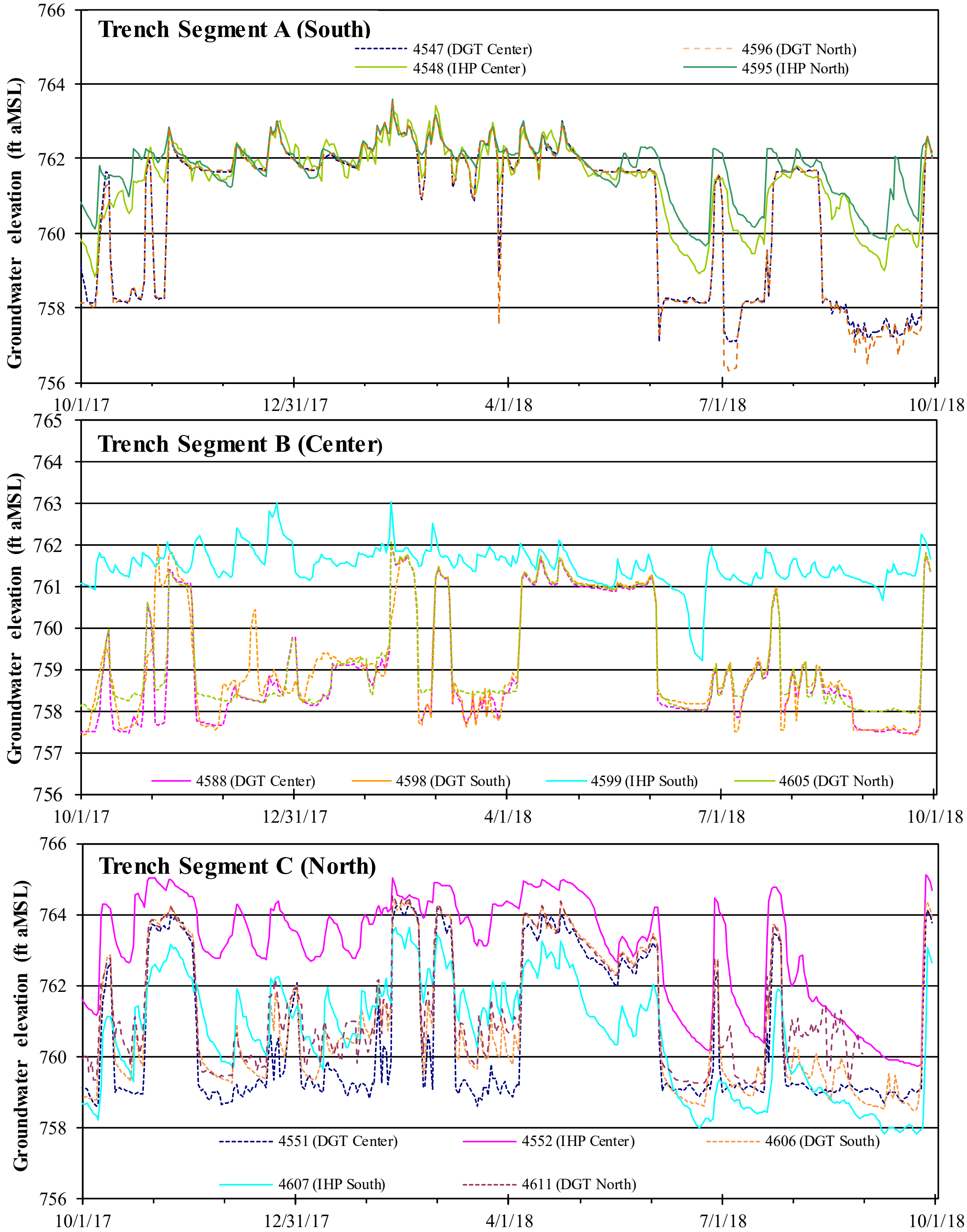
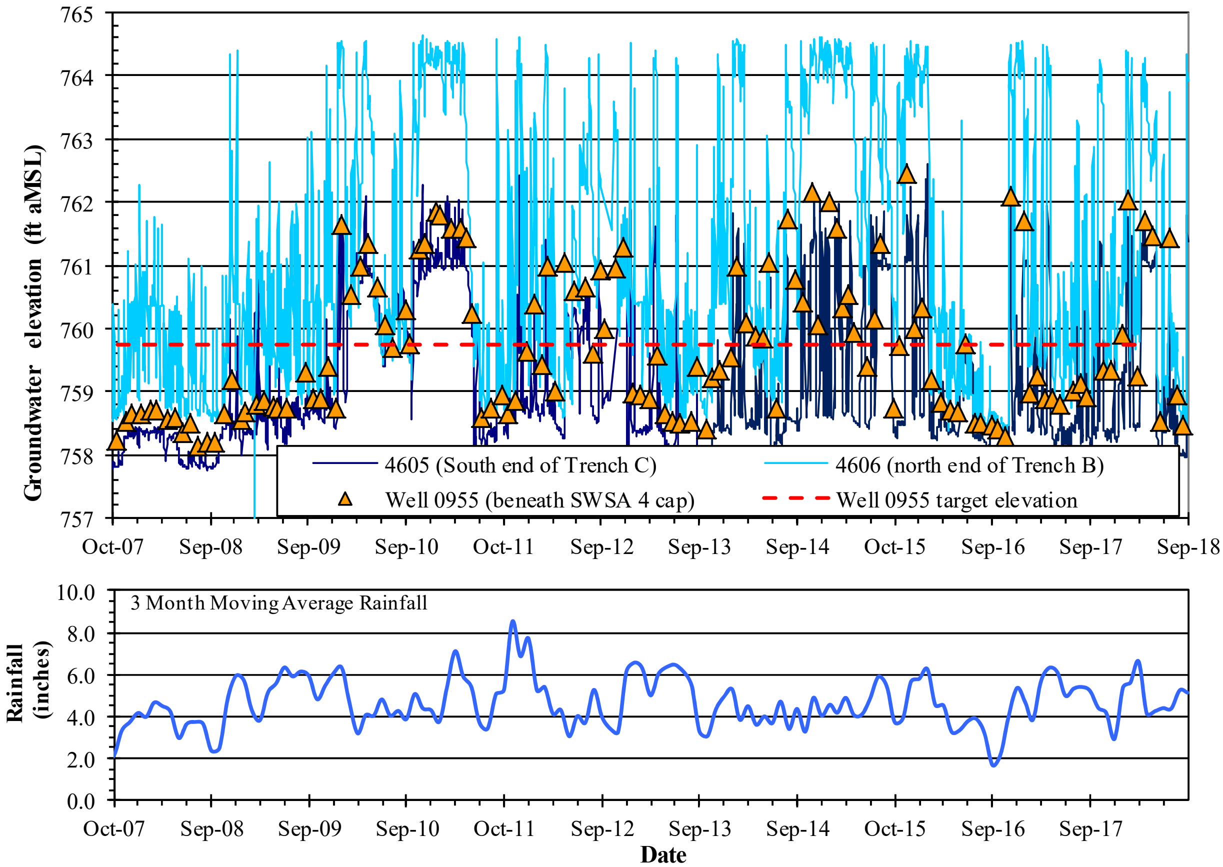


Figure B.2.14. Well hydrographs for wells at the SWSA 4 downgradient trench (fiscal year 2018).



DGT - downgradient trench IHP = Intermediate Holding Pond SWSA = solid waste storage area

Figure B.2.15. Well hydrograph for wells 0955, 4605, and 4606.

B.3 SWSA 6 GROUNDWATER TRITIUM GRAPHS

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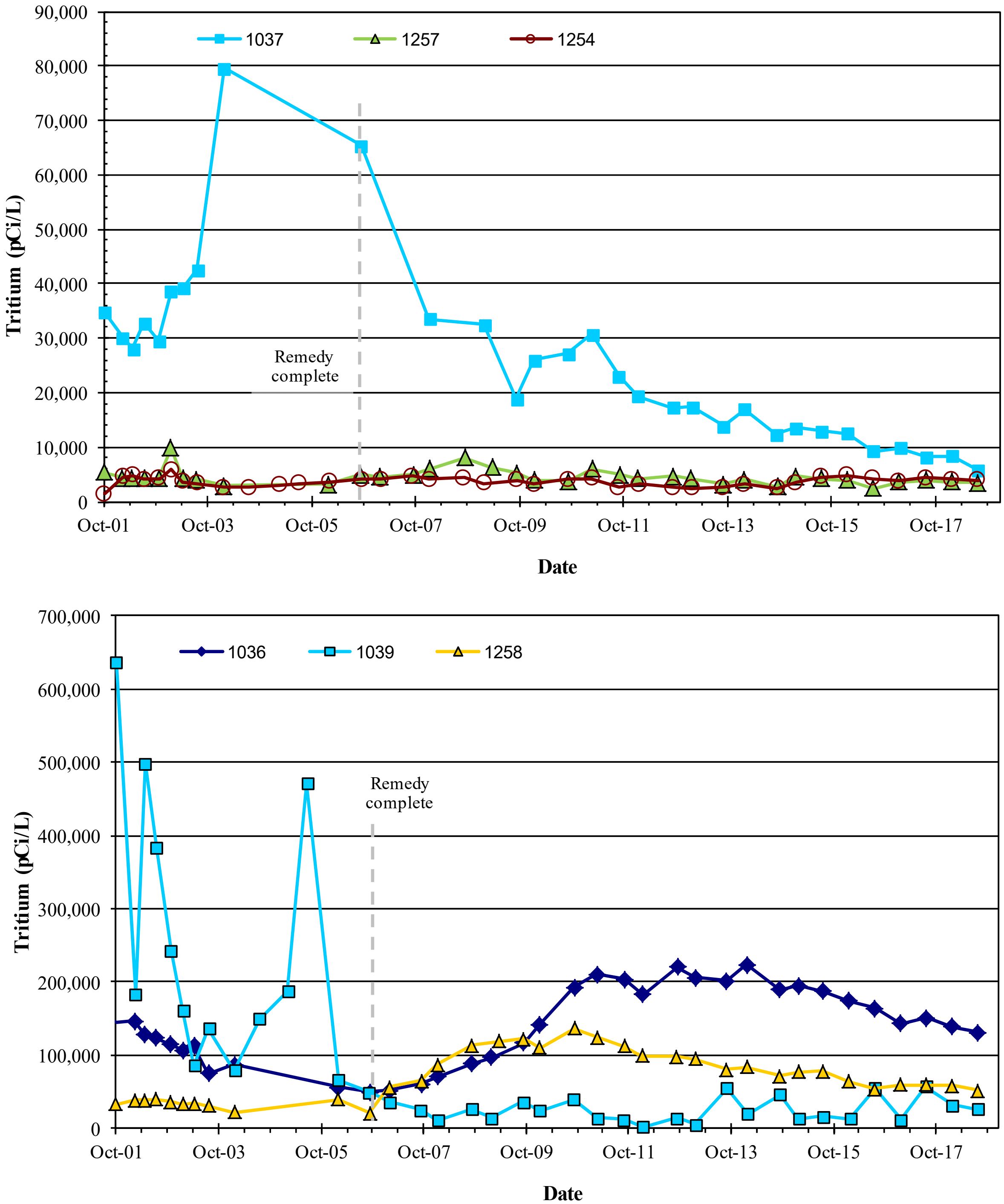

Figure B.3.1. SWSA 6 Tumulus groundwater tritium time histories.

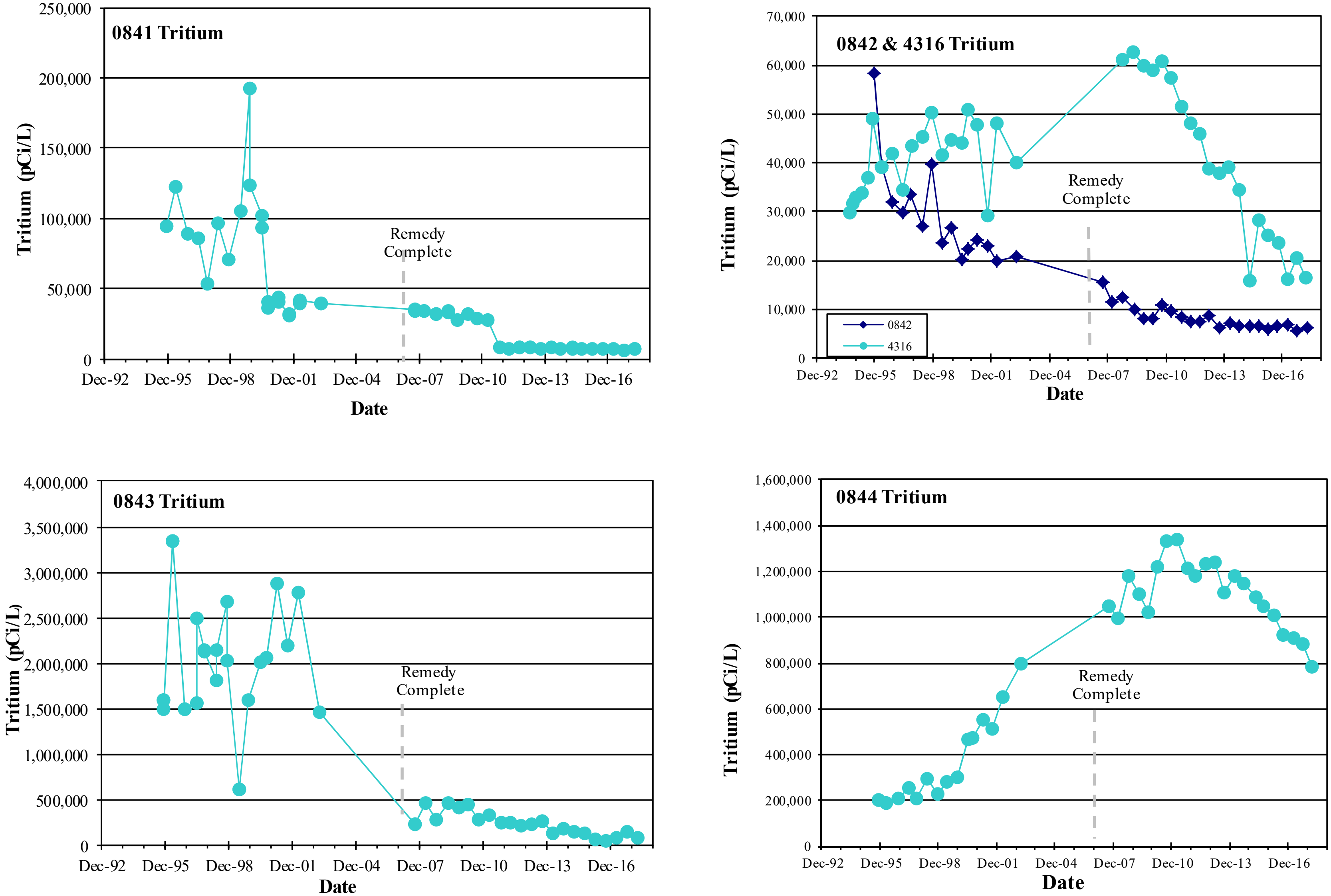

Figure B.3.2. Tritium concentrations in groundwater along the eastern boundary of SWSA 6.

B.4 MV OFFSITE MONITORING WELL HYDROGRAPHS

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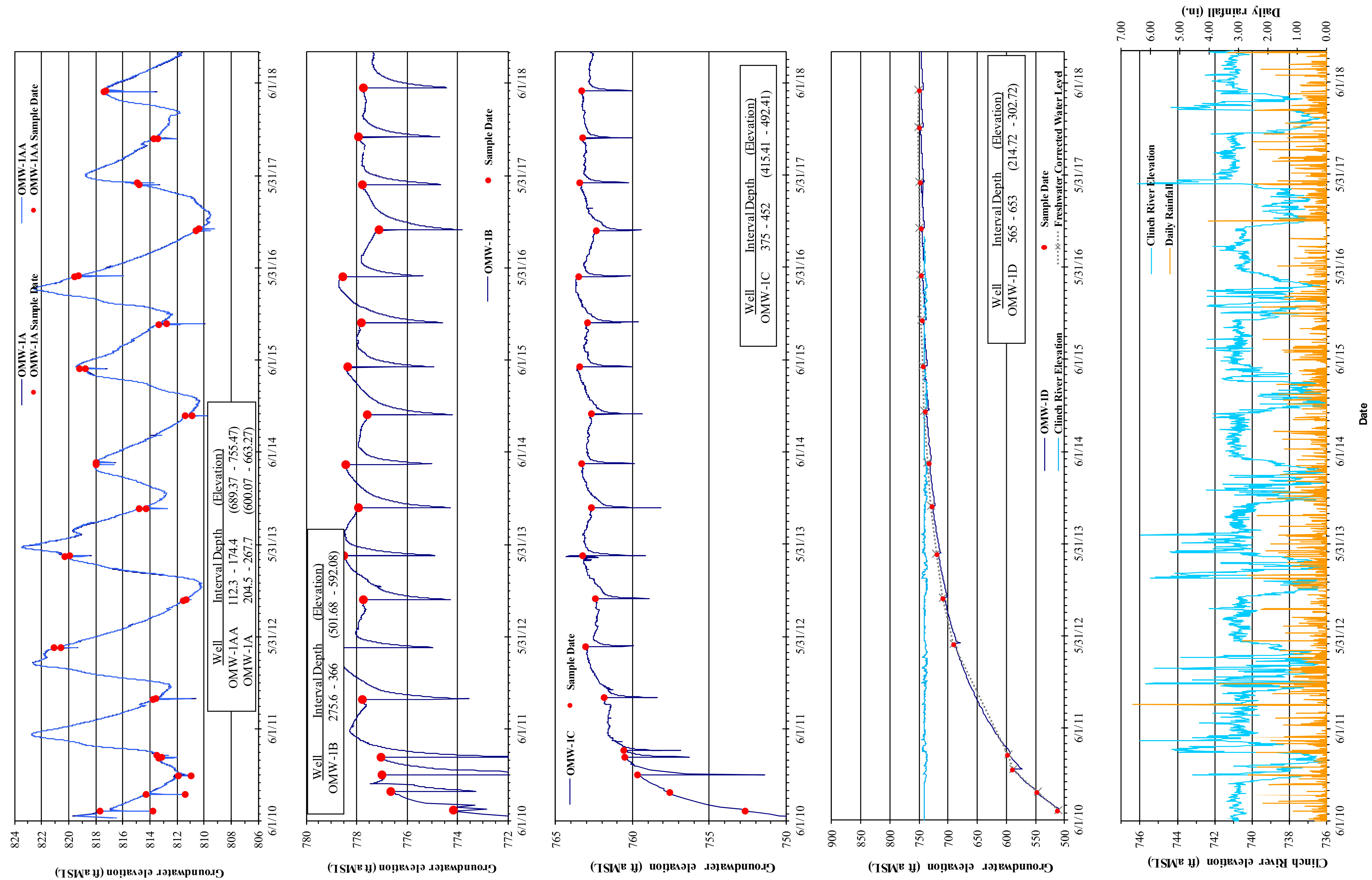

Figure B.4.1. Hydrographs for wells in cluster OMW-1.

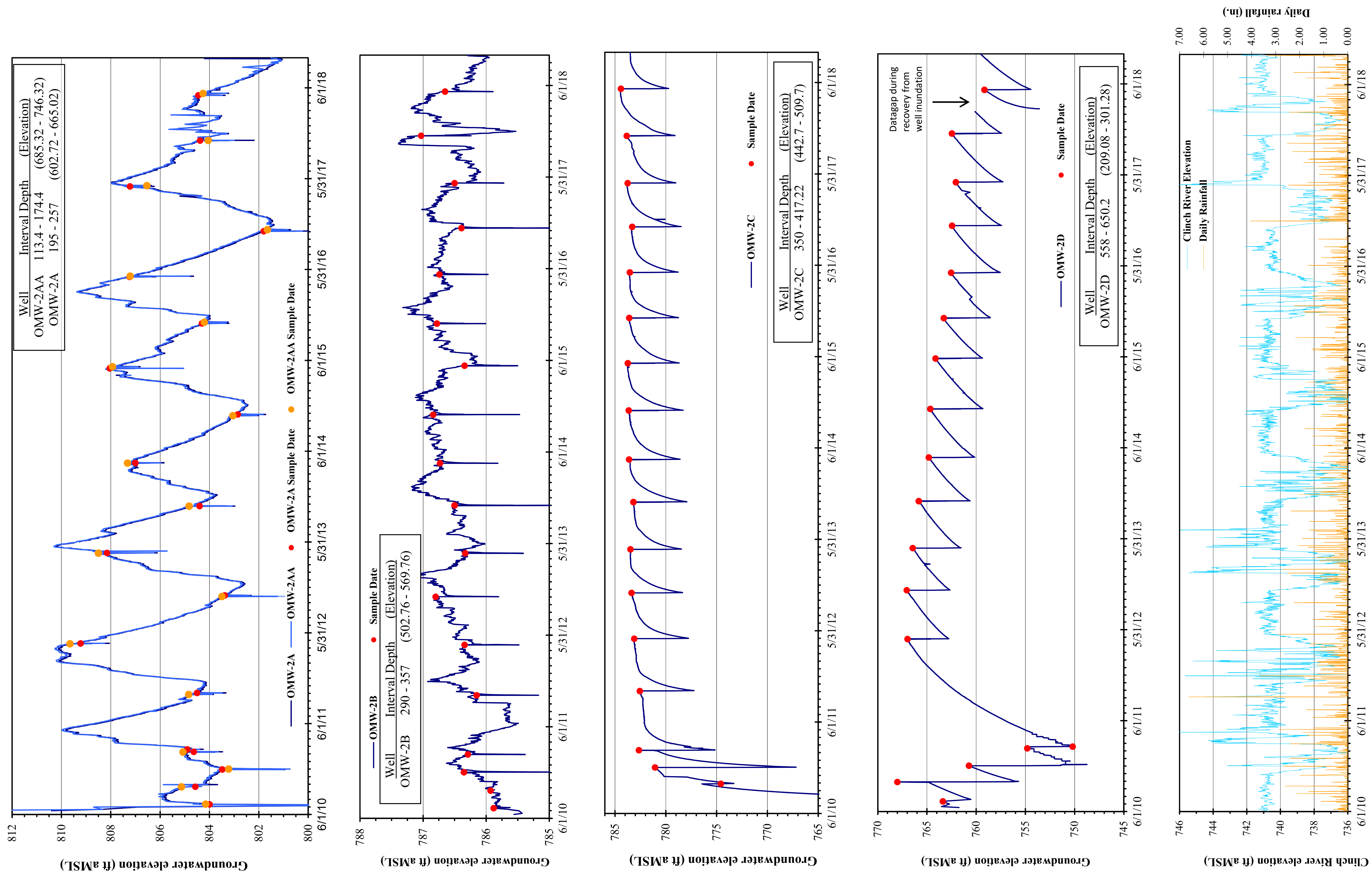

Figure B.4.2. Hydrographs for wells in cluster OMW-2.

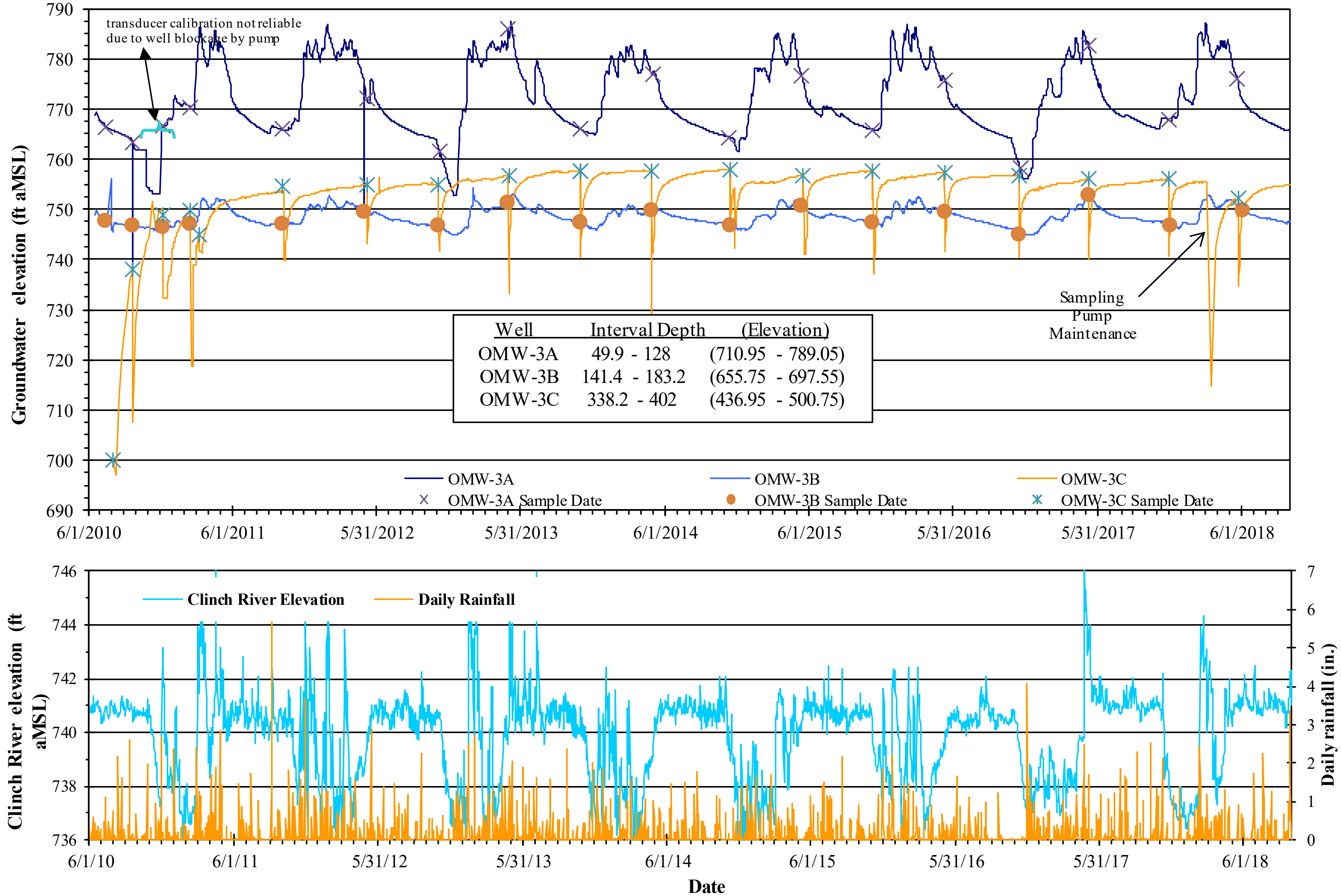

Figure B.4.3. Hydrographs for monitoring zones in OMW-3.

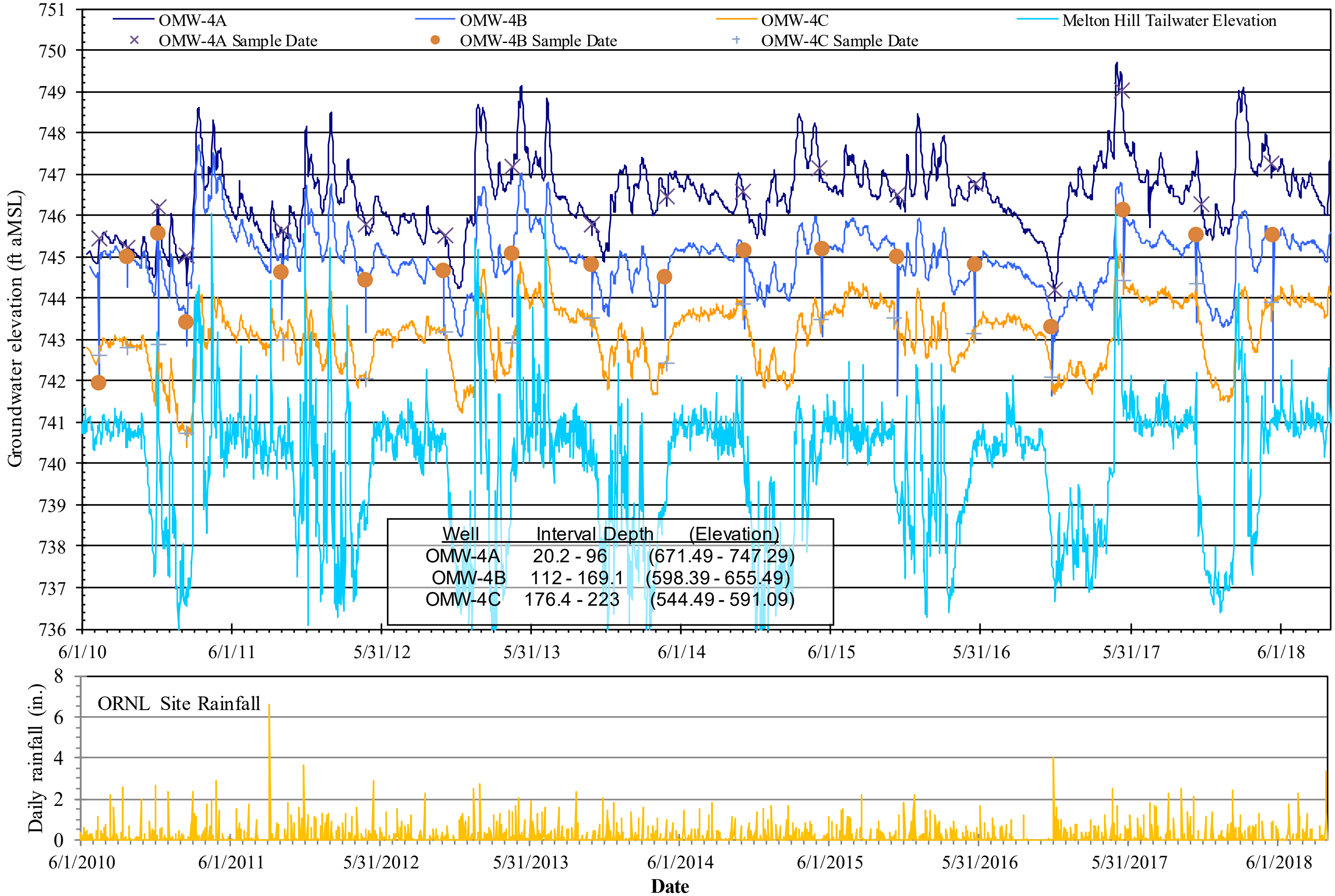

Figure B.4.4. Hydrographs for monitoring zones in well OMW-4.

APPENDIX C
ACTION PLANS IDENTIFIED FROM THE 2016 FOURTH RESERVATION-WIDE CERCLA FIVE-YEAR REVIEW

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C.1 EVALUATION OF THE FILLED COAL ASH POND PASSIVE TREATMENT WETLAND AND UPPER MCCOY BRANCH AND ROGERS QUARRY

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ACTION PLAN
Chestnut Ridge Operable Unit 2
Filled Coal Ash Pond and Vicinity

STATUS:
2016 FYR ISSUE: CR-1
CERCLIS OU: #26

The following italicized issue and recommendation for the Filled Coal Ash Pond (FCAP) is from the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2).

ISSUE: *FCAP ROD: A protectiveness statement for aquatic life cannot be made at this time. Additionally, the effectiveness of the passive wetland system may be diminishing over time. Water flow across the wetlands is channelized along the outer edges, rather than flowing across the entire wetland due to build-up of sediment or organic matter, and an invasive plant species is displacing the indigenous cattail community.*

RECOMMENDATION: *It is recommended that further investigations be completed to accurately estimate the fish population and health in Rogers Quarry downstream from FCAP. Also, a better quantification and source of the selenium exposure in the quarry should be examined. The wetland needs to be reexamined to determine if improvements to the physical conditions are necessary to increase efficiency. These monitoring results and S&M will be utilized to develop the FYR addendum with the final protectiveness determination.*

C.1.1 INTRODUCTION

The *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2) identified an issue with the effectiveness of the passive wetland system, which has diminished over time. A site visit in February 2016 indicated that water flow through the wetlands is limited to channels along the outer edges rather than across the entire wetland, perhaps due to build-up of sediment or organic matter, and the wetlands area was dominated by a thick growth of a then-dormant, grassy plant species that was displacing the cattail community that dominated the area in the past. The 2016 FYR recommendations to address this issue included further investigations be completed to accurately estimate the fish population and health in Rogers Quarry downstream from Filled Coal Ash Pond (FCAP); better quantification and source of the selenium exposure in the quarry; and reexamination of the wetland to determine if improvements to the physical conditions are necessary to increase efficiency. Additionally, fish sampling in fiscal year (FY) 2016 and FY 2017 resulted in the observation of deformities in largemouth bass. As a result of this issue, the 2016 FYR protectiveness determination was deferred until the additional investigations could be completed and reported in the FY 2018 and 2019 Remediation Effectiveness Reports (RERs).

The investigation plan to address this issue FYR was presented to and agreed upon by the regulators at a meeting on April 19, 2017 and elements of the plan were executed during FY 2017 and FY 2018. The path forward included:

- Evaluating the current condition of the wetland
- Evaluating the sediment basin
- Assessing material transport within the system through enhanced monitoring (enhanced monitoring of the FCAP, McCoy Branch, Rogers Quarry system included the establishment of five new surface water monitoring locations [four flumes with composite samplers and one grab sample location, Figure C.1.1])
- Continuing annual biological monitoring in McCoy Branch and Rogers Quarry
- Performing additional investigations to examine the Rogers Quarry fish population and to better understand the spatial pattern of metal bioaccumulation in the watershed

Results from continued annual biological monitoring in McCoy Branch and Rogers Quarry are reported in Chapter 5 of this RER.

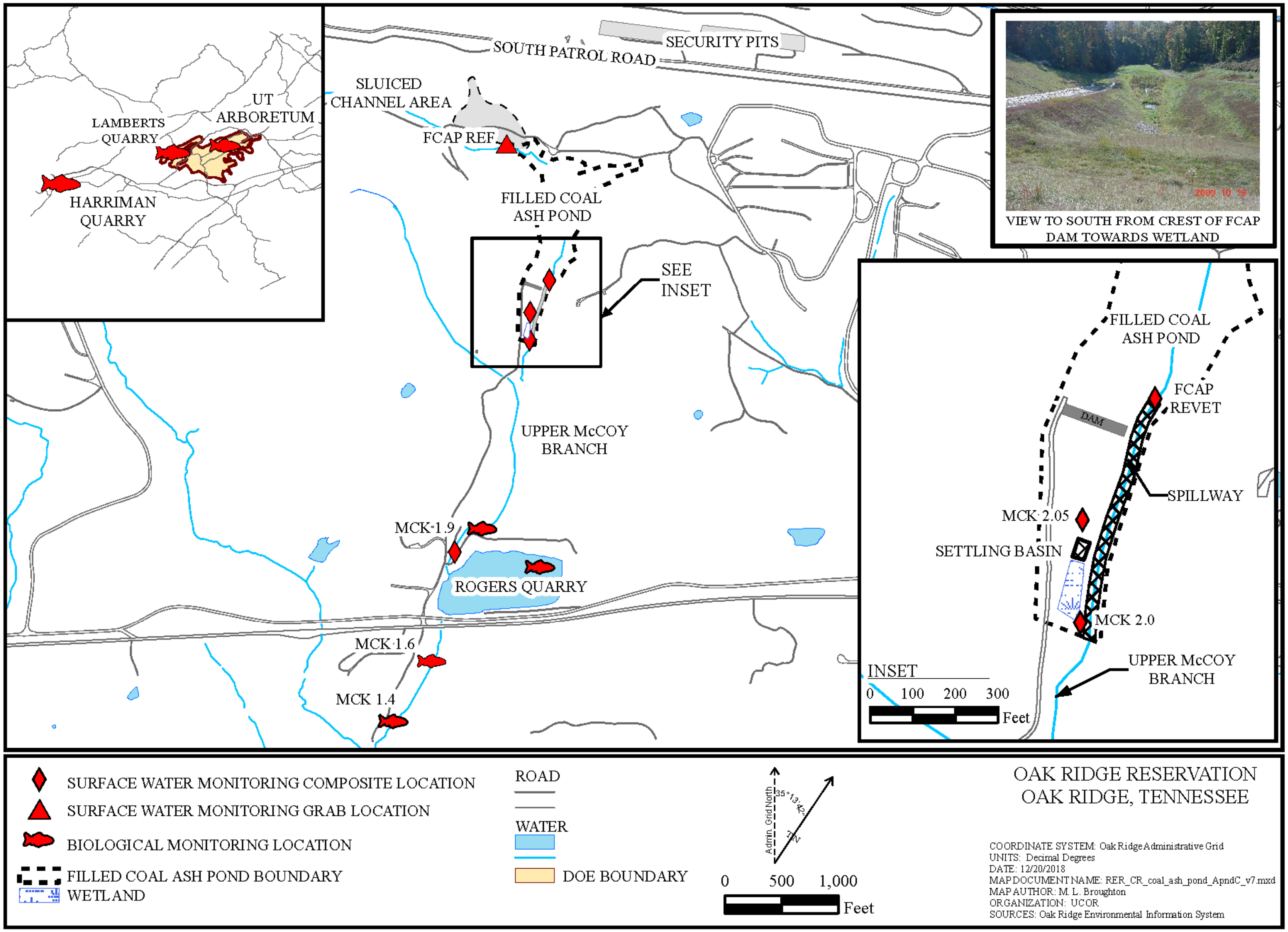

Figure C.1.1. FCAP monitoring locations.

C.1.2 EVALUATION OF WETLAND CONDITIONS

Characterization activities of the passive treatment wetland were performed throughout FY 2018. Buildup of sediment in the settling basin near the effluent seepage source and the center of the wetland have potentially altered treatment functionality over time. The objectives of the evaluation were to provide baseline data that document the current performance parameters of the wetland and to support determinations of potential improvements to physical conditions that may be necessary to increase metals removal efficiency.

At the April 2017 meeting, the results of a topographical survey performed in February 2017 to assess the current condition of wetland surface features were presented to the regulators. A total of 190 spot elevations were measured along twelve transects surveyed perpendicular to the direction of flow within the wetland footprint and influent channel. Comparison of these survey data to the as-built survey of the wetland substrate surface verified the buildup of material in the center and downstream portion of the area. In addition, erosional downcutting of channels near the east and west edges of the wetland was identified. Cross sections at Transect 2 and Transect 4 of the topographical survey represent the mounding and erosion evident at the downstream end of the wetland (Figure C.1.2). To characterize current flow conditions within the wetland, two surface water monitoring stations with flow-paced sampling equipment were installed at the leachate influent (McCoy Branch kilometer [MCK] 2.05; see Figure C.1.3) and effluent (MCK 2.0; see Figure C.1.4) locations and flow data have been collected from June 2017 through FY 2018.

The reduced removal efficiency of arsenic in effluent treated by the FCAP passive treatment wetland since the remedial action (RA) is discussed in Chapter 5. Although removal rates for arsenic in wetlands are relatively low compared to other metallic elements (Marchand et al., 2010) and the literature regarding the processes through which arsenic removal occurs is limited, studies have shown significant capacity for treatment of arsenic containing waters in constructed wetlands (Lizama et al., 2011). While metals uptake and accumulation by wetland plants plays a minor role in wetlands in water treatment, the interactions that occur in the soil rhizosphere primarily affect the transformation of contaminants in wetland systems (Fitz et al., 2002; Stottmeister et al., 2003). Studies of cattails (*Typha latifolia)* (Taylor et al., 1984) have described the formation of oxidized iron plaques on the root surface and have shown strong adsorption of arsenic within ferric root coatings (Blute et al., 2004) suggesting the sequestration and immobilization of the element in wetland habitats dominated by cattail. For cattails to most effectively attenuate arsenic in the wetland environment, the cattails should dominate the plant community.

Visual evaluations of the wetland during the last two growing seasons (2017 and 2018) have noted the presence and vigorous encroachment of tall fescue (*Festuca arundinacea*), a non-native facultative upland grass species, within habitat that previously supported indigenous, hydrophilic cattails. The successful spread of tall fescue indicates portions of the wetland remain dry enough during the year to facilitate its colonization of previously inundated areas that formerly limited grass growth with a compensatory reduction of the cattail population.

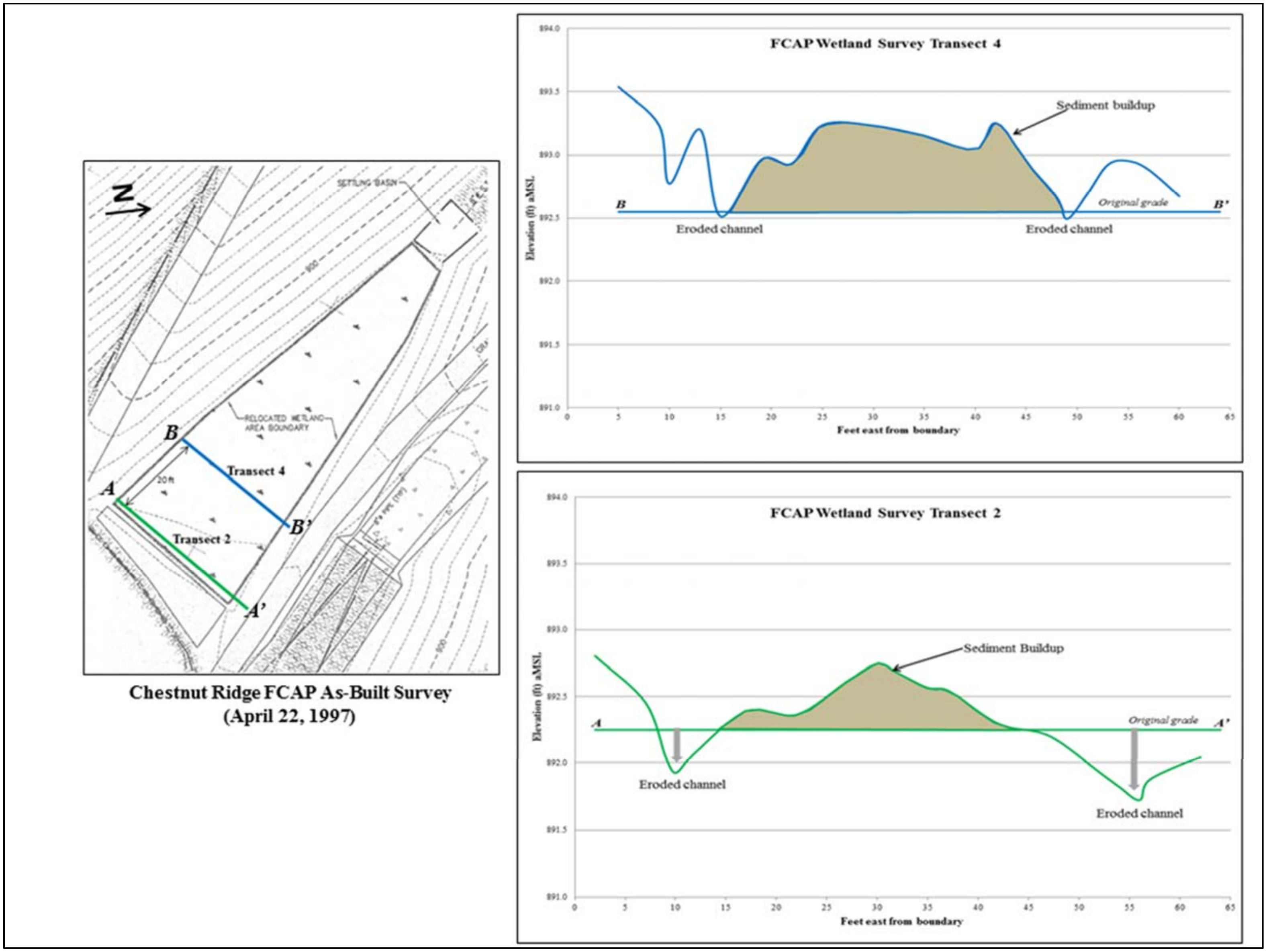

Figure C.1.2. Cross sections of February 2017 FCAP topographical survey transects.

Figure C.1.3. Leachate influent (MCK 2.05) monitoring station.

Figure C.1.4. Leachate effluent (MCK 2.0) monitoring station.

C.1.2.1 WETLAND HYDROLOGIC RESIDENCE TIME EVALUATION

A dye test was conducted in the FCAP wetland on May 1 – 2, 2018 to evaluate the residence time of water in the wetland under current site conditions. The test used fluorescein dye (20 g dissolved in 100 mL of water) and Teledyne-ISCO® autosamplers equipped with 24-bottle carousel sample bottles. Two autosamplers were set up to allow collection of 48 discreet samples within the desired 24-hr period. The sample collection interval was set at five minutes for the first 30 minutes of the test with increasing time intervals later in the test. Figure C.1.5 shows the sample intervals and sampling duration.

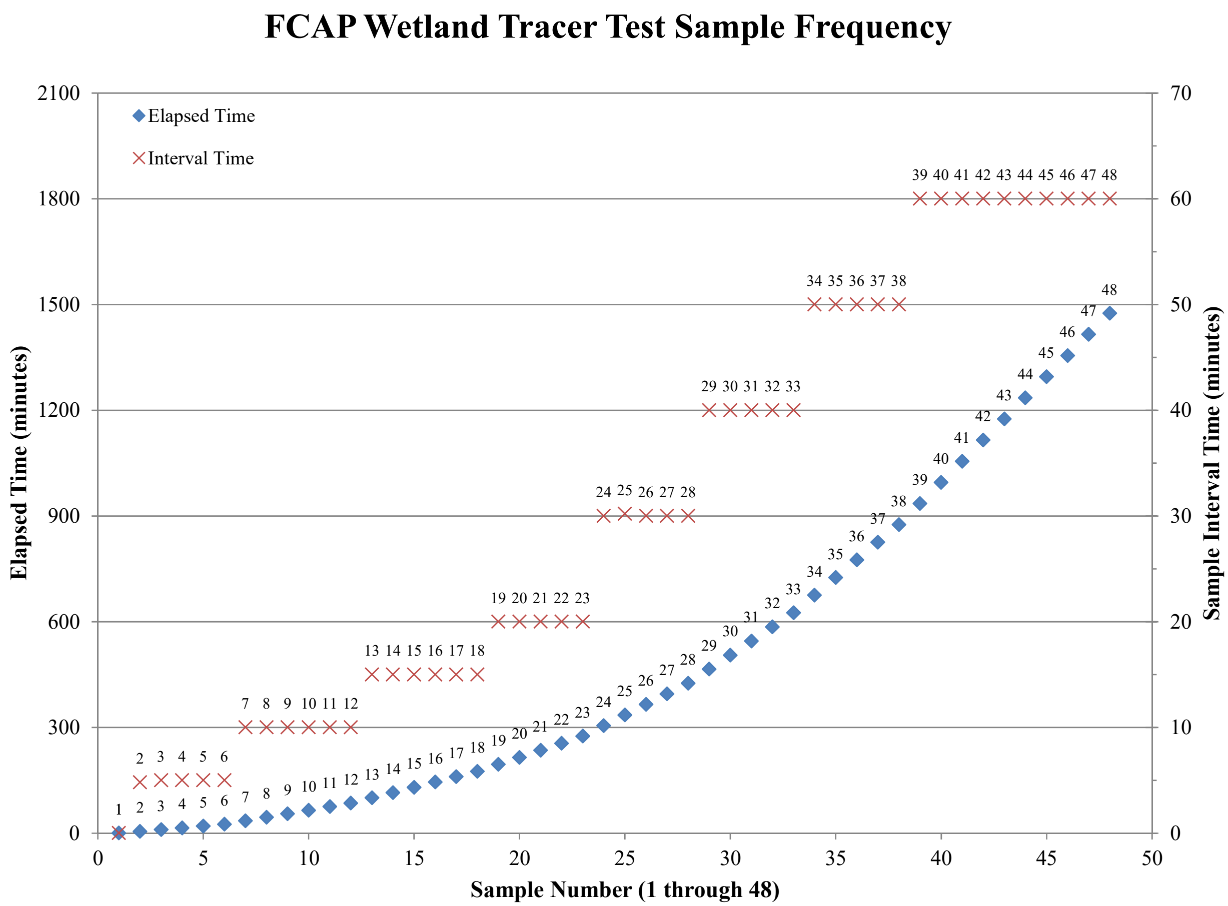

Figure C.1.5. FCAP wetland water residence time tracer test sample frequencies.

Measurements indicated that the flow rate at the two flumes were about 82 gpm at the upstream (MCK 2.05) wetland influent flume and about 62 gpm at the downstream (MCK 2.0) wetland effluent flume. The dye was released at the downstream end of the MCK 2.05 flume at approximately 10:13AM on May 1, 2018. Visual arrival of the dye at MCK 2.0 occurred at approximately 23 minutes elapsed time following the dye release. Figure C.1.6 shows the measured fluorescein concentrations throughout the 24 hours of sampling. The dye concentrations at MCK 2.0 increased rapidly from non-detectable at 20 minutes elapsed time to 220 µg/L at 25 elapsed minutes and the maximum measured concentration of 4,400 µg/L occurred at 35 minutes elapsed time.

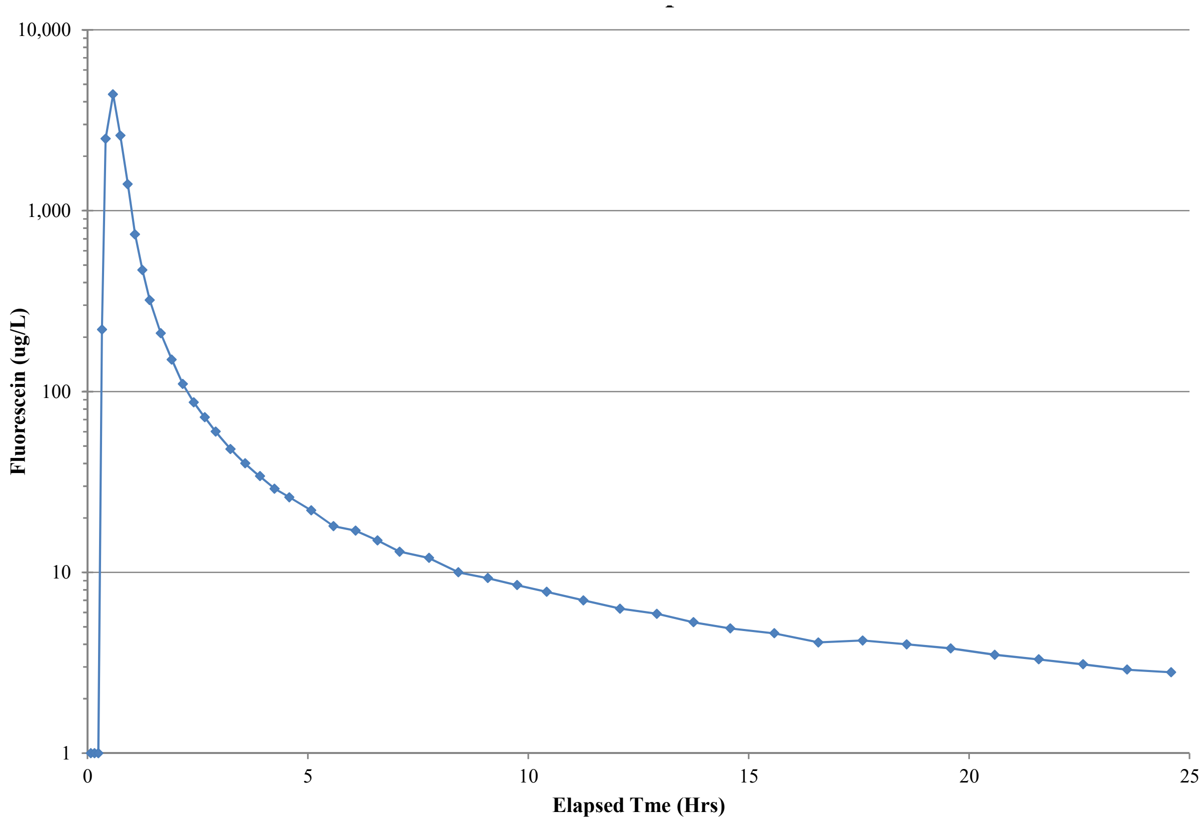

Figure C.1.6. Measured fluorescein concentration vs. elapsed time throughout the test.

The flow rate was measured continuously throughout the test to allow calculation of the dye mass exiting the wetland at MCK 2.0. Figure C.1.7 shows the mass of dye measured at each sample time as well as the cumulative calculated dye mass. The calculated dye mass recovered (approximately 20.6 g) is slightly greater than the mass released (20 g). This slight excess of estimated tracer recovery is attributed to mass calculation uncertainty during the rapidly changing tracer concentration during the passage of the dye slug between elapsed times of about 30 to 90 minutes. Use of the simple average concentrations between the successive samples resulted in large overestimates of tracer recovery. To bring the mass recovery estimate into a more reasonable range the interval estimated concentrations were adjusted by factors ranging between 0.25 to 0.9 times the simple average.

To assess the residence time of water within the wetland area the cumulative percentage of total recovered fluorescein dye mass over time was plotted in Figure C.1.8 and shows that the water residence time within the wetland is relatively short. The 50th percentile of tracer mass passed out of the wetland at about 50 minutes, the 75th percentile of tracer mass passed out of the wetland at about 1.6 hours residence time, and the 90th percentile of tracer mass passed out of the wetland at about 4.6 hours elapsed time.

Maintenance activities during FY 2019 are planned to restore the area and volume of habitat desired for metals capture within the wetland. A repeat tracer residence test following that maintenance and re-establishment of a suitable environment will be completed to assess the value of longer water residence time within the wetland treatment area.

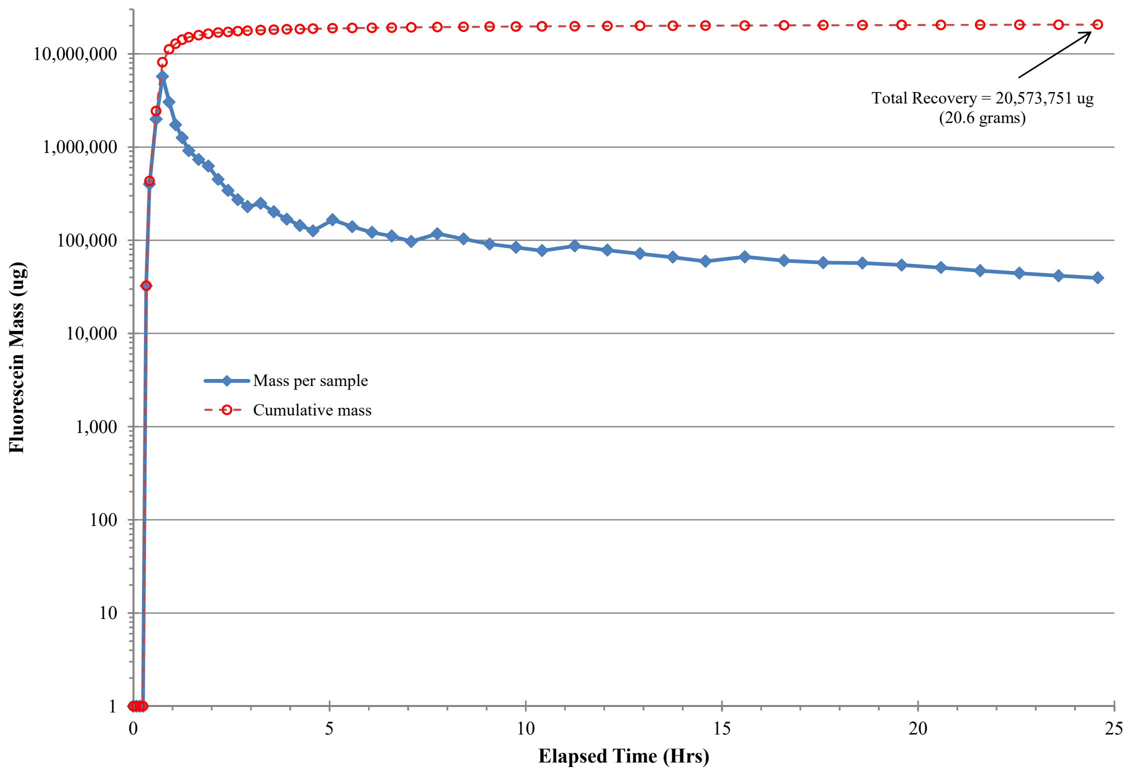

Figure C.1.7 Fluorescein dye mass measured during the FCAP wetland water residence time test.

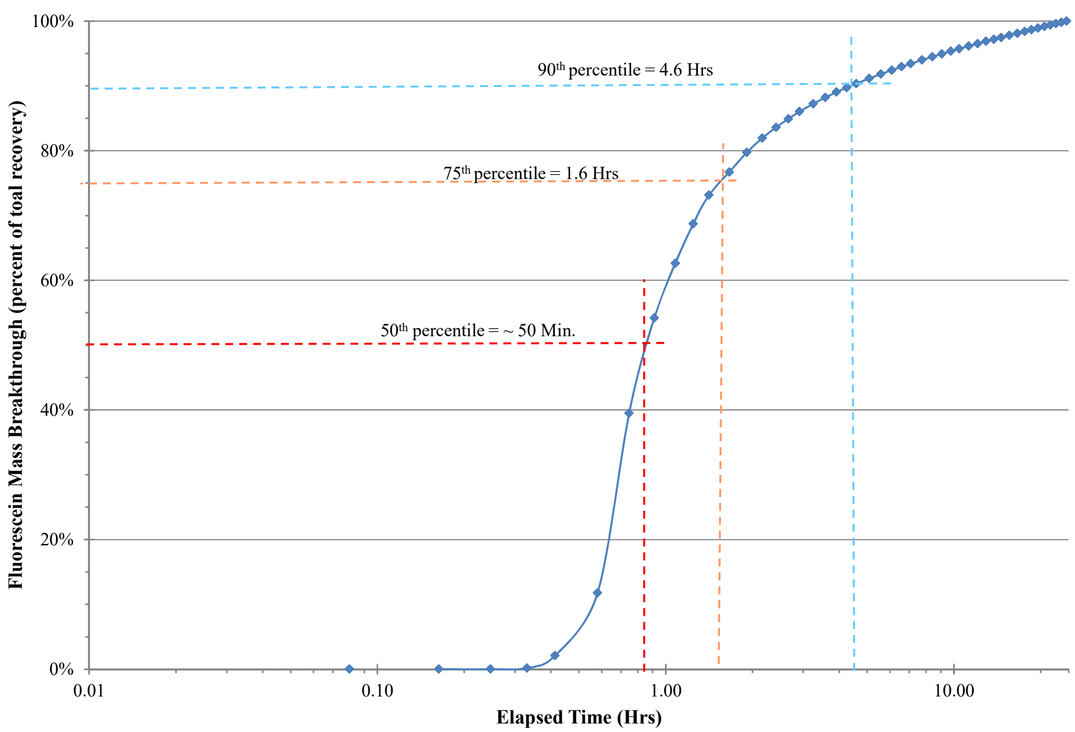

Figure C.1.8. Tracer mass breakthrough and residence time within the wetland area.

C.1.3 EVALUATION OF THE SEDIMENTATION BASIN

The February 2017 topographical survey included an evaluation of the sedimentation basin at the head of the wetland (see Figure C.1.1 inset). The infilling of the basin area was verified as approximately one meter of sediment was encountered via push probe within the basin footprint. Early in 2018, the persistent, invasive vegetation (e.g., autumn olive, privet, blackberry, etc.) present on the wetland boundary was cleared to facilitate better access to the sedimentation basin and temporary monitoring locations. Maintenance activities to remove accumulated sediment to re-establish basin functionality are scheduled for FY 2019.

C.1.4 MATERIAL TRANSPORT ASSESSMENT

To evaluate material transport through the system, flow-paced monitoring stations were placed at the FCAP revetment (REVET) monitoring location at the head of the FCAP REVET spillway (see Figure C.1.9) and the MCK 1.9 station located just upstream of the Rogers Quarry culvert (see Figure C.1.10) in addition to the monitoring stations at the wetland influent and effluent locations. These temporary flow measurement stations were installed to provide flow data for estimation of chemical fluxes at each of the monitored locations and for evaluation of potential source contributions to Upper McCoy Branch and Rogers Quarry. Although most metals are considered non-problematic, investigation of the efficiency of arsenic removal from leachate flow through the wetland is necessary to determine if the remedy is working at utmost effectiveness. The FCAP reference (REF) monitoring station located upstream of the FCAP impoundment (see Figure C.1.1) served as the surface water reference site. Surface water monitoring activities at the FCAP and vicinity in FY 2018 included:

- Collection of 24-hr composite samples for total and dissolved metals and total suspended solids (TSS) under baseflow and stormflow conditions during the plant-dormant, wet season in late winter,

- Collection of 24-hr composite samples for total and dissolved metals and TSS under baseflow and stormflow conditions during the plant-active, dry season in mid-summer, and

- Collection of flow-paced, bulk composite water samples for suspended sediment to assess the volume and physical composition of transported sediment within the watershed system.

Figure C.1.9. Revetment spillway (FCAP REVET) monitoring station.

Figure C.1.10 McCoy Branch (MCK 1.9) monitoring station.

C.1.4.1 Surface water monitoring results

The surface water monitoring scope included sampling and analysis at each location for dissolved (field filtered) and total (unfiltered) metals and TSS. The sampling plan for the flow measurement and sampling locations was to collect 24-hr composite samples for the baseflow condition and for two storm events during both wet and dry seasons at stations MCK 1.9, MCK 2.0, MCK 2.05, and FCAP REVET (Figure C.1.1), however, weather-related constraints limited wet season baseflow monitoring to one event, and a single grab sample was collected at reference location FCAP REF during that baseflow sampling event. For the ORR, wet season conditions are those associated with the winter and spring seasons when deciduous trees and shrubs and annual plants are dormant. During this time period rainfall and snowmelt percolation through the surface soils allows the maximum groundwater recharge and surface water runoff to occur. The wet season generally includes the months of December through April. The dry season is generally defined to be those months during which deciduous trees and shrubs and annual plants are fully leaved, growing, and undergoing maximum evapotranspiration. During the dry season the percolation of rainfall to recharge the groundwater system is limited by the soil moisture buffering effect of surface soils in the plant root zone. The dry season is considered to include the months May through November.

Both inductively coupled plasma mass spectrometry Method SW-846 6010B and Method EPA-1638 were used at selected locations during the investigation for analysis of arsenic. The EPA-1638 method is thought to be less susceptible to interferences during analysis than is the SW846-6010B method. The net effect of potentially lower interferences is that the EPA-1638 method may more accurately quantify the arsenic concentration than the SW846-6010B method.

C.1.4.1.1 Arsenic and suspended solids flux evaluation

Tables C.1.1 and C.1.2 contain sample data summary information for the wet and dry season sampling events, respectively. The sample summary tables contain the following for each location: the sample event types and dates with rainfall event summary; sample duration and average flow rate; total flow volume during the sampling period; total and dissolved arsenic concentrations; total and dissolved arsenic concentration reduction percentages at the wetland effluent (MCK 2.0); total and dissolved arsenic fluxes and flux rates; total and dissolved flux rate reduction percentages at the wetland influent (MCK 2.0); TSS concentration; and suspended solids flux rate. All sample results that exceed the ambient water quality criteria (AWQC) screening level of 10 µg/L are shown in bold font.

As shown in Table C.1.1 wet season sampling was conducted during the time period from March 15 – 26, 2018. A single 24-hr baseflow composite sample was collected on March 15 – 16, 2018 and two storm composite samples were collected on March 20 – 21 and March 25 – 26, 2018. Table C.1.2 shows the two baseflow composite samples collected on August 14 – 15 and August 27 – 28, 2018 and the two storm samples collected on July 21 – 22 and September 10 – 11, 2018.

Review of the total arsenic concentrations in general shows that the highest arsenic concentrations in the McCoy Branch watershed are associated with the FCAP wetland and water discharges into the spillway at the top of the revetment. Seasonal total arsenic concentrations in wetland influent (MCK 2.05) and effluent (MCK 2.0) ranged from 35 to 165 µg/L and the dissolved arsenic concentrations ranged from 5.2 to 26 µg/L. At MCK 1.9 upstream of Rogers Quarry only one sample result exceeded the 10 µg/L AWQC (12 µg/L total arsenic and 8.5 µg/L dissolved arsenic during the largest storm event on July 21 – 22, 2018). At FCAP REVET, where runoff from above the FCAP embankment enters the spillway, one of the four total arsenic samples exceeded the AWQC. That sample, collected during the July 21 – 22, 2018 storm, had 50 µg/L total arsenic with 9.2 µg/L dissolved arsenic. The sample period was only 1.1 hours which suggests the sample is analogous to a “first flush” of water running across the FCAP surface features in the form of sheet erosion. Similarly, the TSS concentration (180 mg/L) and flux rate (15.9 kg/hr) for this high-intensity event far exceeded the previous maximum TSS concentration (6.8 mg/L) and flux rate (0.2 kg/hr) measured during the March 20 – 21, 2018 event.

Performance of the wetland for arsenic removal is evaluated based on both the change in total and dissolved arsenic concentration differences between the wetland influent and effluent, and the differences in hourly arsenic flux rate between the wetland influent and effluent locations. The reason to consider the hourly arsenic flux rates as a wetland performance metric is that during storm events the sample period duration may not be consistent for the influent and effluent locations so normalization based on the hourly rate removes some of the sample duration variable.

As shown in Tables C.1.1 and C.1.2, the data show that for one-each of the wet season and dry season storm events the wetland was actually a source of total arsenic discharge as indicated by both the arsenic concentration and flux rate differences between wetland influent and effluent although dissolved arsenic did experience reduction. This is attributed to arsenic associated with suspended solid materials that are flushed out of the wetland. The wetland functioned as a source of arsenic discharge during one of the dry season baseflow sampling events although the dissolved arsenic reduction factors were in the 50 – 58% range based on the two different analytical method results. Overall, dissolved arsenic effluent reduction was better than the total arsenic effluent reduction.

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Table C.1.1. Summary of wet season 2018 baseflow and stormflow data for arsenic and suspended solids

Sample event type	Date	Station	Sample duration (hrs) [average flow rate (L/min)]	Total flow (L)	Total As (µg/L)	Total As % conc. reduction	Total As flux (g)	Total As flux rate (g/hr)	Total As % flux rate reduction in wetland	Diss. As (µg/L)	Diss. As % conc. Reduction	Diss. As Flux (g)	Diss. As Flux Rate (g/hr)	Diss. As % flux rate reduction in wetland	TSS (mg/L)	TSS flux rate (kg/hr)
Baseflow Total Rainfall = 0.0 in.	3/15 – 16/2018	FCAP REF	Grab	--	3.2 J	--	--	--	--	<3.2	--	--	--	--	<4	--
		FCAP REVET	27.8 [105]	175,700	7	--	1.2	0.04	--	<3.2	--	<0.56	<0.02	--	6.4	0.04
		MCK 2.05	27.4 [306]	503,386	**35**	--	17.6	0.6	--	**26**	--	13.1	0.5	--	<4	<0.07
		MCK 2.0	27.7 [224]	371,895	**48**[a]	-37%	17.9	0.6	0%	**14**[a]	46%	5.2	0.2	61%	10	0.13
					38.5[b]	-10%	14.3	0.5	20%	**10.3**[b]	60%	3.8	0.1	71%		
		MCK 1.9	27.9 [1,027]	1,719,544	8.3[a]	--	14.3	0.5	--	4.1[a]	--	7.1	0.3	--	<4	<0.25
					1.7[b]	--	2.9	0.1	--	1.5[b]	--	2.6	0.1	--		
Storm 1 Total Rainfall = 0.73 in. Rain intensity – 0.26 in./5 min.	3/20 – 21/2018	FCAP REVET	36.6 [480]	1,052,461	3.3	--	3.5	0.1	--	6.3	--	6.6	0.2	--	6.8	0.20
		MCK 2.05	36.3 [344]	749,139	**62**	--	46.4	1.3	--	**19**	--	14.2	0.4	--	5.4	0.11
		MCK 2.0	36.9 [256]	566,183	**110**[a]	-77%	62.3	1.7	-32%	7.8[a]	59%	4.4	0.1	69%	34	0.52
					96.7[b]	-56%	54.8	1.5	-16%	**10.5**[b]	45%	5.9	0.2	59%		
					120[a,c]	-94%[c]	67.9[c]	1.8[c]	-44%[c]	**13**[a,c]	32%[c]	7.4[c]	0.2[c]	49%[c]		
					103[b,c]	-66%[c]	58.3[c]	1.6[c]	-24%[c]	**10.5**[b,c]	19%[c]	5.9[c]	0.2[c]	59%[c]		
		MCK 1.9	36.5 [1,622]	3,551,662	7[a]	--	24.9	0.7	--	<3.2[a]	--	<11.4	<0.3	--	15	1.46
					3.5[b]	--	12.3	0.3	--	2.0[b]	--	7.0	0.2	--		
Storm 2 Total Rainfall = 0.86 in. Rain intensity – 0.09 in./5 min.	3/25 – 26/2018	FCAP REVET	27.8 [761]	1,267,612	<3.2	--	<4.1	<0.15	--	<3.2	--	<4.1	<0.15	--	<4	<0.6
		MCK 2.05	49.2 [356]	1,051,530	**56**	--	58.9	1.2	--	**22**	--	23.1	0.5	--	4.4	0.09
		MCK 2.0	45.7 [250]	683,984	**58**[a]	-4%	39.7	0.9	27%	5.2[a]	76%	3.6	0.1	83%	16	0.02
					57.5[b]	-3%	39.3	0.9	28%	**10.1**[b]	54%	6.9	0.2	68%		
		MCK 1.9	39.7 [1,811]	4,318,072	5.3[a]	--	22.9	0.6	--	4[a]	--	17.3	0.4	--	11	1.20
					2.7[b]	--	11.7	0.3	--	1.6[b]	--	7.1	0.2	--		

[a]Analysis by Method SW846-6010B.
[b]Analysis by Method EPA-1638.
[c]Results of field replicate sample.

Bold As concentrations are greater than the 10 µg/L AWQC.

-- = not applicable
As = arsenic
AWQC = ambient water quality criteria
Diss. = dissolved (<0.45 µ)
EPA = U.S. Environmental Protection Agency
FCAP = Filled Coal Ash pond
J = estimated value
MCK = McCoy Branch kilometer
REF =reference
REVET = revetment
TSS = total suspended solids

Table C.1.2. Summary of dry season 2018 baseflow and stormflow data for arsenic and suspended solids

Sample event type	Date	Station	Sample duration (hrs) [average flow rate (L/min)]	Total flow (L)	Total As (µg/L)	Total As % conc. reduction	Total As flux (g)	Total As flux rate (g/hr)	Total As % flux rate reduction in wetland	Diss. As (µg/L)	Diss. As % conc. reduction	Diss. As flux (g)	Diss. As flux rate (g/hr)	Diss. As % flux rate reduction in wetland	TSS (mg/L)	TSS flux rate (kg/hr)
Baseflow 1 Total rainfall = 0.0 in.	8/14 – 15/2018	FCAP REVET	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
		MCK 2.05	24.1 [118]	241,952	**55.3**[a]	--	13.9	0.58	--	**20.6**[a]	--	5.2	0.22	--	<4	<0.03
					58[b]	--	14.6	0.61	--	**24**[b]	--	6.1	0.25	--		
		MCK 2.0	24.0 [174]	170,904	**42**[a]	24%	7.2	0.30	48%	**12**[a]	42%	2.1	0.08	62%	8.2	0.09
					52[b]	10%	8.9	0.37	39%	**11.4**[b]	53%	2.0	0.08	68%		
		MCK 1.9	23.3 [917]	1,279,671	2.8	--	3.6	0.15	--	2.3	--	2.9	0.12	--	9.8	0.54
Baseflow 2 Total rainfall = 0.0 in.	8/27 – 28/2018	FCAP REVET	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
		MCK 2.05	24.1 [153]	221,014	**54**[a]	--	11.9	0.49	--	**13**[a]	--	2.9	0.12	--	<4	<0.003
					53.7[b]	--	11.9	0.49	--	**20.4**[b]	--	4.5	0.19	--		
		MCK 2.0	24.1 [110]	158,463	**95**[a]	-76%	15.1	0.62	-26%	9.1[a]	30%	1.4	0.06	50%	34	0.22
					101[b]	-88%	16.0	0.66	-35%	**12**[b]	41%	1.9	0.08	58%		
		MCK 1.9	23.3 [811]	1,132,010	1.3	--	1.5	0.06	--	1.0	--	1.1	0.05	--	11	0.02
Storm 1 Total rainfall = 2.35 in. Rain intensity – 0.32 in./5 min.	7/21 – 22/2018	FCAP REVET	1.1 [1,512]	97,074	**50**	--	4.9	4.5	--	9.2	--	0.9	0.8	--	180	15.9
		MCK 2.05	31.4 [229]	430,445	**84**[a]	--	36.2	1.15	--	**13**[a]	--	5.6	0.18	--	13	0.18
					74.1[b]	--	35.1	1.02	--	**17.6**[b]	--	10.8	0.24	--		
		MCK 2.0	36.9 [253]	749,139	**52**[a]	38%	28.0	0.79	32%	**12**[a]	8%	6.5	0.18	-2%	16	0.25
					49.4[b]	33%	26.6	0.75	26%	**12.4**[b]	30%	6.7	0.19	22%		
					56[a,c]	33%[c]	30.1[c]	0.90[c]	22%[c]	**13**[a,c]	0%[c]	7.0[c]	0.14[c]	20%[c]	17	0.23
					49.3[b,c]	33%[c]	26.5[c]	0.80[c]	21%[c]	**12.3**[b,c]	30%[c]	6.6[c]	0.19[c]	23%[c]		
		MCK 1.9	9.09 [3,065]	1,671,816	**12**[a]	--	20.1	2.21	--	5.1[a]	--	8.5	0.94		68	12.51
Storm 2 Total rainfall = 0.53 in. Rain intensity – 0.1 in./5 min.	9/10 – 11/2018	FCAP REVET	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
		MCK 2.05	24.2 [149]	215,843	**54**[a]	--	11.7	0.48	--	**20**[a]	--	4.3	0.18	--	<4	<0.003
					59.9[b]	--	12.9	0.54	--	**21.4**[b]	--	4.6	0.19	--		
		MCK 2.0	24.7 [98]	145,416	**150**[a]	-178%	21.8	0.88	-83%	**15**[a]	25%	2.2	0.09	51%	53	0.31
					165[b]	-175%	24.0	0.97	-82%	**16.4**[b]	23%	2.4	0.10	49%		
		MCK 1.9	24.6 [999]	1,473,501	4.2[a]	--	6.2	0.25	--	4.6[a]	--	6.8	0.28	--	6.7	0.40

[a]Analysis by Method SW846-6010B.
[b]Analysis by Method EPA-1638.
[c]Results of field replicate sample.

Bold As concentrations are greater than the 10 µg/L AWQC.

-- = not applicable
As = arsenic
AWQC = ambient water quality criteria
Diss. = dissolved (<0.45 µ)
EPA = U.S. Environmental Protection Agency
FCAP = Filled Coal Ash pond
J = estimated value
MCK = McCoy Branch kilometer
REVET = revetment
TSS = total suspended solids

C.1.4.2 SUSPENDED SEDIMENT CHARACTERIZATION

Bulk composite water samples were collected during a single storm event for the purpose of measuring the amount of suspended sediment transported during a storm and to provide sediment material that could be physically characterized. On March 29, 2018, the autosamplers deployed at each of the four surface water monitoring stations were initiated after the site received 0.26 in. of precipitation in a 45-min. period with a maximum intensity of 0.08 in. received in one 5-min. interval during that time. The total precipitation for the event was 0.70 in. received in a 12.5-hr period.

Following collection, sediments were separated from the water samples via vacuum filtration. Sediments were collected on 0.45 µm filter disks and oven dried prior to weighing. The dried sediments were then sent for analysis to determine the percentage of fly ash by polarized light microscopy (PLM). The FCAP REVET monitoring station is located at the top of the revetment spillway which serves as the surface water discharge point of the filled coal ash pond. Table C.1.3 shows the mass of material collected from each monitoring station and the percentage ash determination by PLM. Figures C.1.11 through C.1.14 are photomicrographs from each of the four monitoring stations generated during fly ash determination analyses. Photographs are annotated to show examples of spherical fly ash particles where applicable.

The wetland influent location at MCK 2.05 contained 1% fly ash, and no ash was detected at wetland effluent location MCK 2.0. Sediments collected at the FCAP REVET contained the highest percentage of fly ash at 47%. The total mass (80.9 mg) and concentration (0.059 µg/L) of suspended sediment transported from the surface of FCAP during this storm event suggest that while the composition of sediments included a high proportion of ash, the total amount of material eroding from the surface was low. The MCK 1.9 sediment collected from Upper McCoy Branch just above the Rogers Quarry influent contained 24% ash with a total sediment mass of 89.6 mg and concentration of 0.028 µg/L again indicating that total amount of material transported is low, but source contributions of fly ash from upstream of the quarry remain active.

Historical and anecdotal evidence suggests that beaver activity within the watershed, specifically in the section of Upper McCoy Branch just upstream MCK 1.9 monitoring station, potentially affects material transport dynamics. Sedimentation due to damming and the resulting outwash following dam removal activities may create erosional and depositional events of ash-containing materials of a greater magnitude than those under normal baseflow and stormflow conditions.

Table C.1.3. Mass of transported material and percent fly ash from sediment characterization storm event.

Sample event type	Date	Station	Sample duration (hrs) [average flow rate (L/min)]	Total flow (L)	Total sediment mass (mg)	Sediment Concentration (µg/L)	Total sediment % ash
Storm Flow Total Rainfall = 0.70 in. Rain intensity – 0.08 in./5 min.	3/29 – 30/2018	FCAP REVET	16.3 [342]	1,362,374	80.9	0.059	47
		MCK 2.05	17.4 [101]	514,320	109.8	0.213	1
		MCK 2.0	17.8 [76]	380,801	105	0.276	ND
		MCK 1.9	17.8 [679]	3,172,251	89.6	0.028	24

FCAP = Filled Coal Ash Pond
MCK = McCoy Branch kilometer
ND = non-detect
REVET = revetment

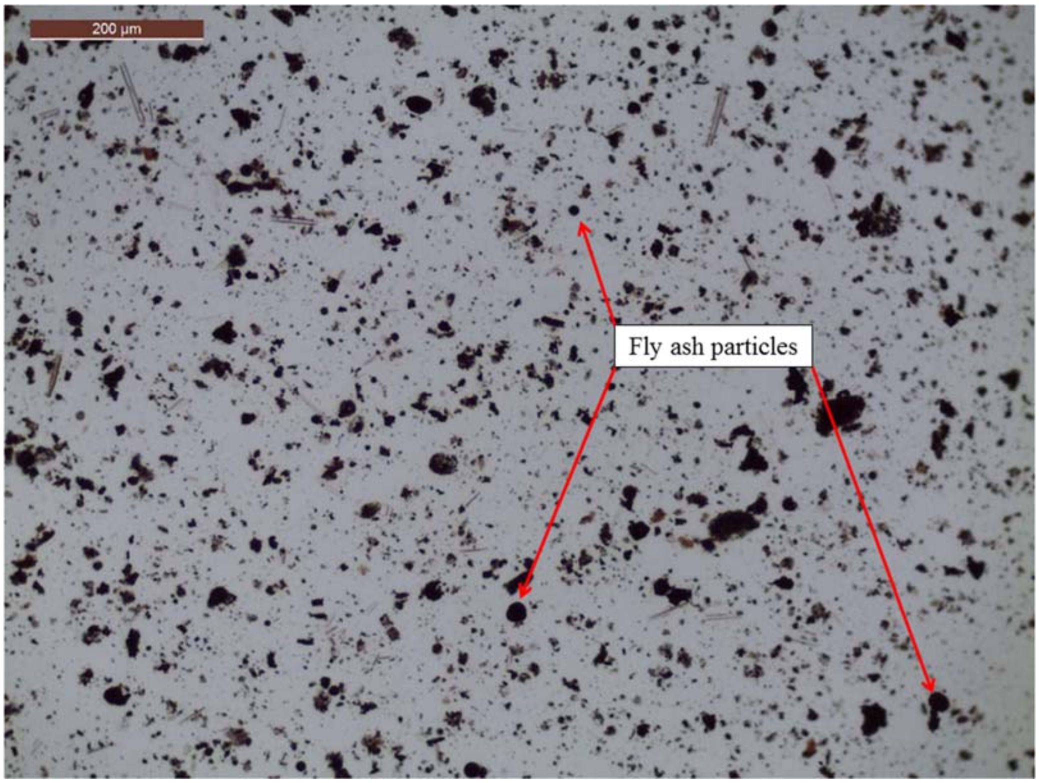

Figure C.1.11. FCAP REVET Photomicrograph with fly ash particles noted.

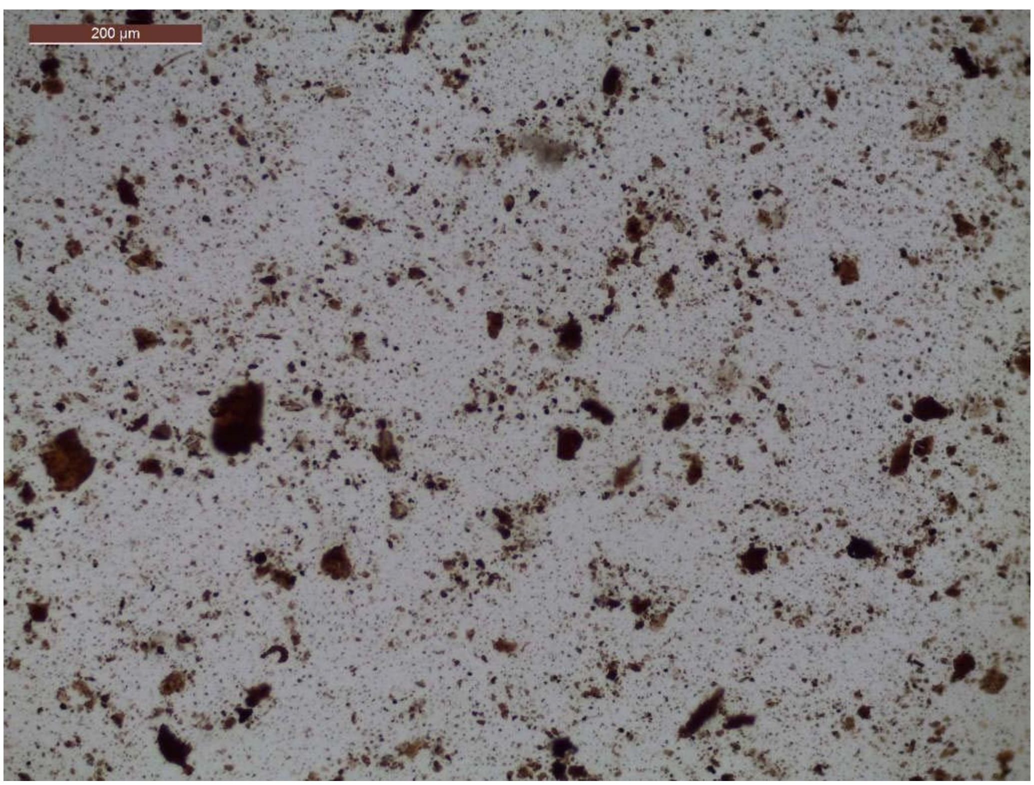

Figure C.1.12. MCK 2.05 photomicrograph.

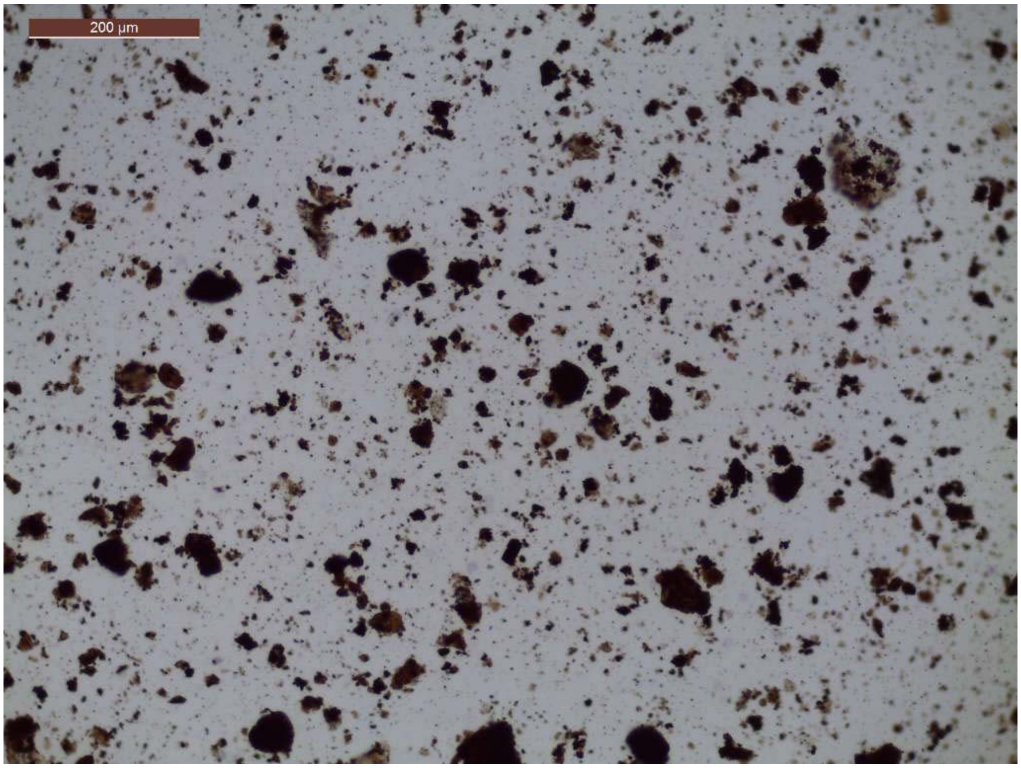

Figure C.1.13. MCK 2.0 photomicrograph.

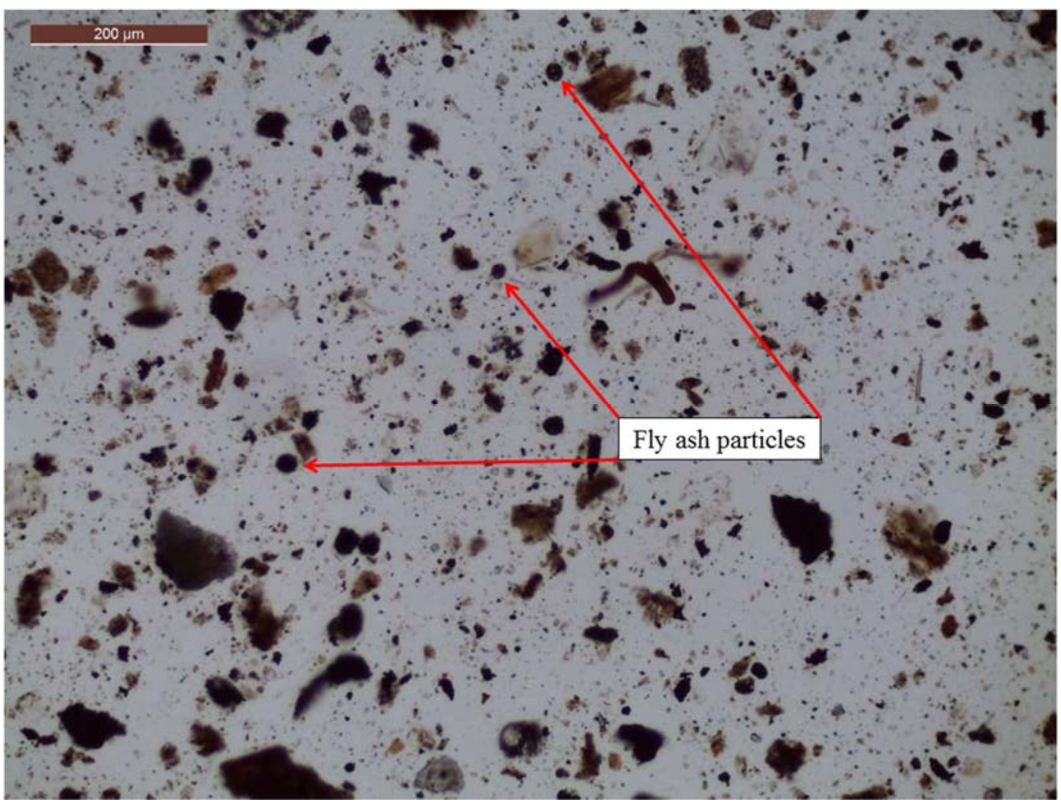

Figure C.1.14. MCK 1.9 photomicrograph with fly ash particles noted.

C.1.5 ADDITIONAL INVESTIGATIONS OF FISH HEALTH

The observation of fish morphological abnormalities in the 2016 bioaccumulation sampling from Rogers Quarry prompted a more detailed investigation of the Rogers Quarry and McCoy Branch fish populations in 2017 and 2018. The prevalence of abnormalities in wild fish populations reflects the combined effects of all stressors to which fish are exposed and provides a readily measurable index of fish health and water quality. A high prevalence of abnormalities suggests that fish populations are under stress, while long-term changes in prevalence suggest changes in stress or contaminant exposure.

Additional investigations in 2017 centered on the possibility that selenium exposure from sources upstream or within the quarry were the cause of the abnormal fish health observations. Whole body fish were collected from three McCoy Branch locations and analyzed for selenium, arsenic, and mercury. In Rogers Quarry, ovaries in fish were analyzed for selenium consistent with EPA's recommended fish-based criteria for selenium, and water chemistry and limnological analyses of water was conducted to evaluate within-quarry factors on contaminant exposure. The prevalence of fish emaciation or deformity was evaluated in the Rogers Quarry fish population during two mark and recapture events in 2017. In 2018, fish sampling was extended to include three nearby quarry reference sites—Harriman Quarry (HQ), Lambert Quarry (LQ), and the University of Tennessee Arboretum (UTA) Quarry (Figure C.1.1)—to provide context to the 2017 and 2018 findings in Rogers Quarry (Table C.1.4). Each of the quarries was sampled for water quality parameters (e.g., temperature, depth, contaminant concentration) as well as for fish population size and fish health. The sampling of multiple reference quarries not impacted by coal ash provides some insight on whether poor prey availability – potentially endemic to quarries – could be contributing to the emaciated condition of Rogers Quarry fish.

Table C.1.4. Descriptions of Rogers and reference quarries (i.e., Harriman, Lambert, UT Arboretum) including quarry size in hectares, recreational fishing pressure on the fish community, and species in the fish community

Quarry name (abbreviation)	Latitude/ longitude	Size	Fishing pressure	Fish community	Sampling date
Rogers Quarry (RQ)	35.969908, -84.248129	4.2	Closed to fishing	Largemouth bass, bluegill, green sunfish, hybrid sunfish	April 30, 2018
Lamberts Quarry (LQ)	35.971000, -84.353545	4.2	Private access only, some unauthorized fishing	Largemouth bass, bluegill, white crappie	May 7, 2018
Harriman Quarry (HQ)	35.899489, -84.617217	1.3	Officially closed to fishing, some unauthorized fishing	Largemouth bass, bluegill, hybrid sunfish	May 16, 2018
UT Arboretum (UTA)	36.006635, -84.211243	0.3	Closed to fishing	Largemouth bass, bluegill, hybrid sunfish, redbreast sunfish, common carp	June 5, 2018

Bioaccumulation results

As was presented in Chapter 5, annual monitoring of Rogers Quarry determined that average wet weight selenium concentrations in largemouth bass fillets in 2018 (1.48 µg/g) were significantly lower than in 2017 but were within the range of concentrations seen in recent years. Using the percentage of moisture for fish fillets, this concentration would be 5.4 µg/g on a dry weight basis, which is below the 11.3 µg/g dry weight tissue criterion for selenium in fillets. For the first time, selenium concentrations in ovaries from largemouth bass at this site were measured. The average wet weight selenium concentration in ovaries was 1.70 µg/g. Using the percentage of moisture for ovaries, the dry weight concentration would be 4.85 µg/g, below the 15.1 µg/g dry weight tissue criterion for selenium in ovaries. Average wet weight mercury concentrations in largemouth bass fillets in 2018 (0.55 µg/g) were slightly lower than in 2017 but remained above the 0.3 µg/g fish tissue criterion.

Average wet weight arsenic and selenium concentrations in fillets of largemouth bass collected from Rogers Quarry were significantly higher than at the three reference quarries (analysis of variance, $p < 0.05$) (Figure C.1.15). Thallium, another bioaccumulative metalloid associated with coal ash, was also significantly higher in fish collected in Rogers Quarry. Mercury concentrations were not significantly different among quarries ($p > 0.05$). This may be because Hg, which is associated with coal ash, is also transported atmospherically through coal combustion. All four of these quarries are within close proximity and would be expected to receive similar wet deposition rates and atmospheric mercury exposures.

The elevated mercury concentrations in the quarry fish is of interest given the lack of point sources of aqueous mercury to these quarries. Mercury methylation preferentially occurs in anoxic conditions or at the interface between oxic and anoxic zones. An examination of the physico-chemical properties of these quarries showed thermal stratification and low dissolved oxygen with depth, suggesting that quarries could be efficient in mercury methylation. Rogers Quarry clearly stratifies resulting in seasonally high methylmercury (MeHg) in the anoxic deep zones of the quarry, that is then mixed upon pond turnover, potentially bringing MeHg to surface waters (Figure C.1.16). Fish found at shallower depths could be exposed to high MeHg concentrations at that time. It's unknown but possible that other metals such as selenium may have similar seasonal changes in exposure in Rogers Quarry. The mercury phenomenon appears to be evident at the other quarries where aqueous MeHg concentrations were elevated with depth when dissolved oxygen concentrations were low (Figure C.1.17).

In the Rogers Quarry-McCoy Branch watershed, mercury concentrations in whole body fish collected from three McCoy Branch sites were similar in 2017, but in 2018 there was a significant increase in fish with distance downstream. This suggests that Rogers Quarry is a source of mercury (specifically MeHg) to downstream locations. Despite the increase in concentrations downstream of the quarry (MCK 1.6), concentrations remained below the 0.3 ppm in fish AWQC. For the other coal ash contaminants, spatial patterns in whole body fish concentrations are in general opposite to those for mercury and are more typical of point source contamination. Selenium and arsenic are highest in fish at upstream locations closest to the FCAP and decreased with increasing distance downstream. The exception was in one species of fish (banded sculpin) that was substantially higher in arsenic downstream of the quarry in 2017. These fish feed at a higher trophic level than the other two species collected at this site. Selenium concentrations in whole body forage fish collected at the two upper McCoy Branch sites were above the tissue criterion for selenium in whole body fish in both 2017 and 2018 (Figure C.1.18).

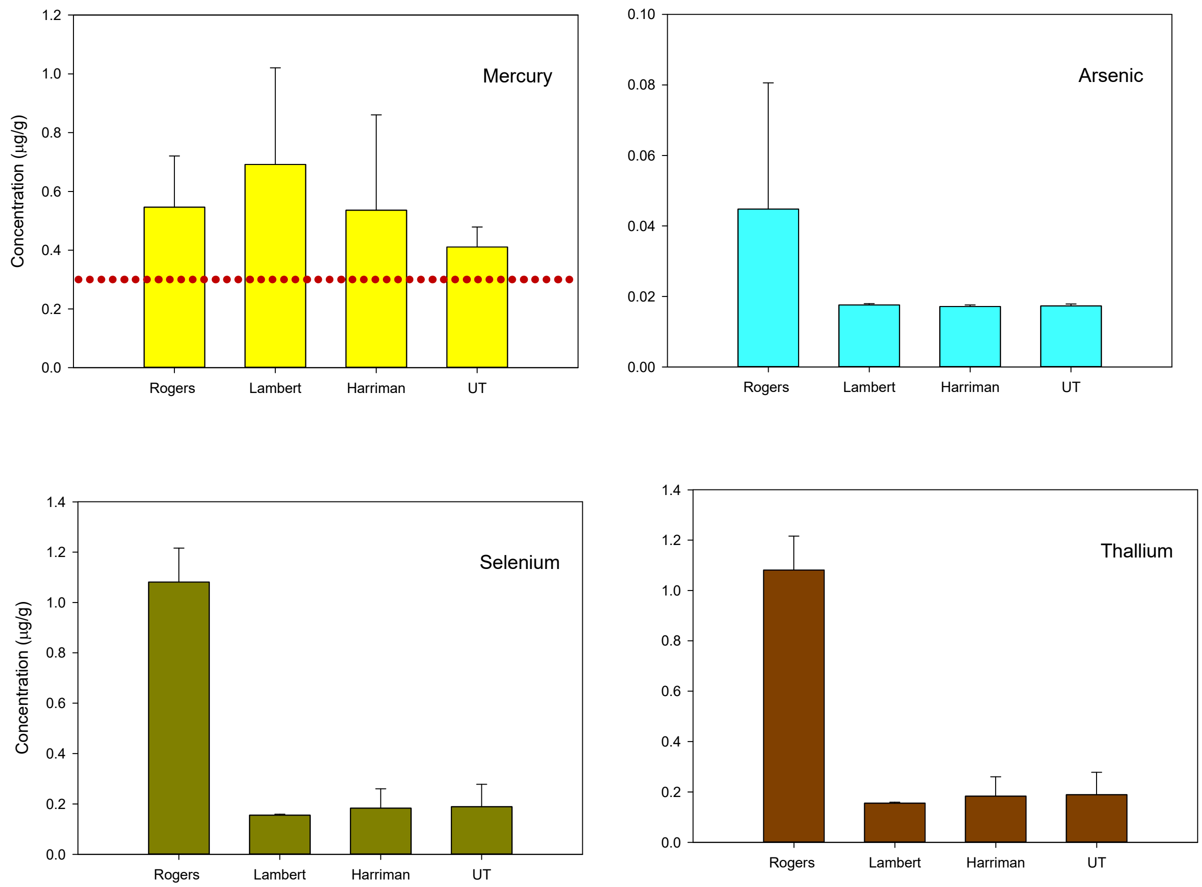

Figure C.1.15. Mean (± 1 standard deviation) concentrations in fillets of largemouth bass collected from Rogers Quarry and three reference quarries.

Results analyzed and presented on a wet weight basis. Red dotted line depicts fish tissue criterion for mercury (0.3 µg/g Hg in fish fillet).

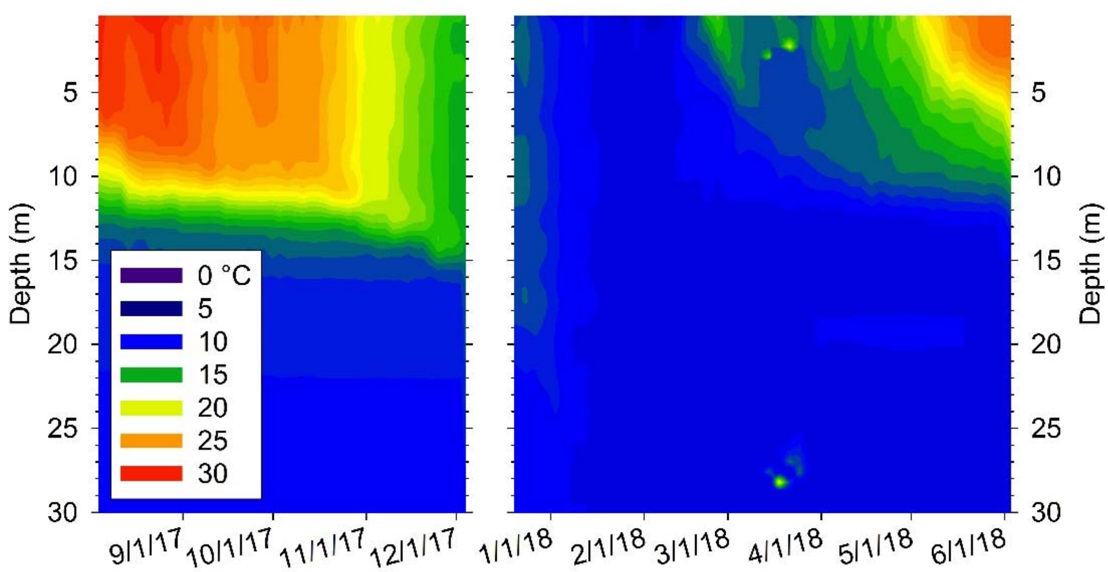

Figure C.1.16. Water temperature as a function of depth in Rogers Quarry from August 2017 to June 2018.

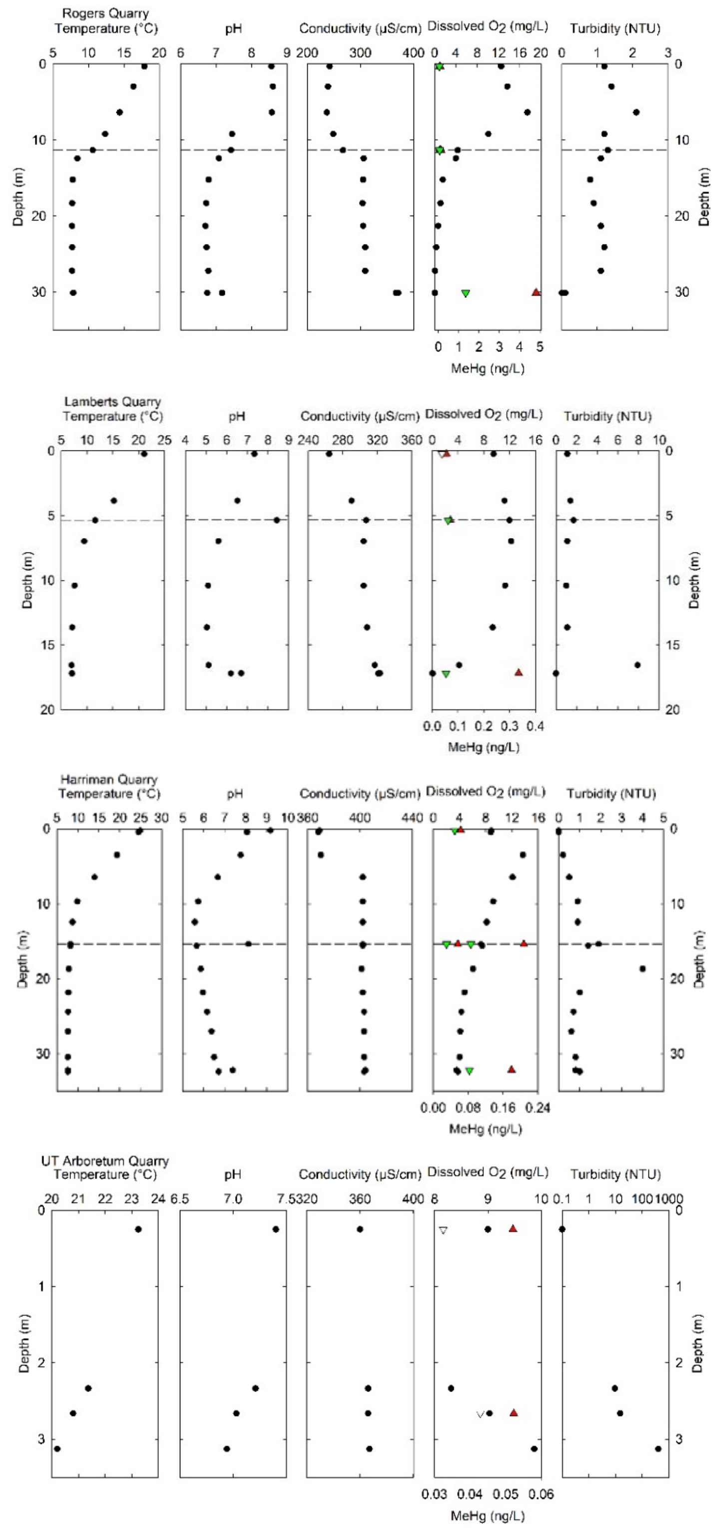

Figure C.1.17. Field parameters as a function of depth for Rogers, Lambert's, Harriman, and the UT Arboretum quarries.

The horizontal dashed line represents the depth of the thermocline sample. On the dissolved oxygen graphs, the upright red triangles and the inverted green triangles represent total MeHg and dissolved MeHg, respectively. Open symbols are below the reporting limit.

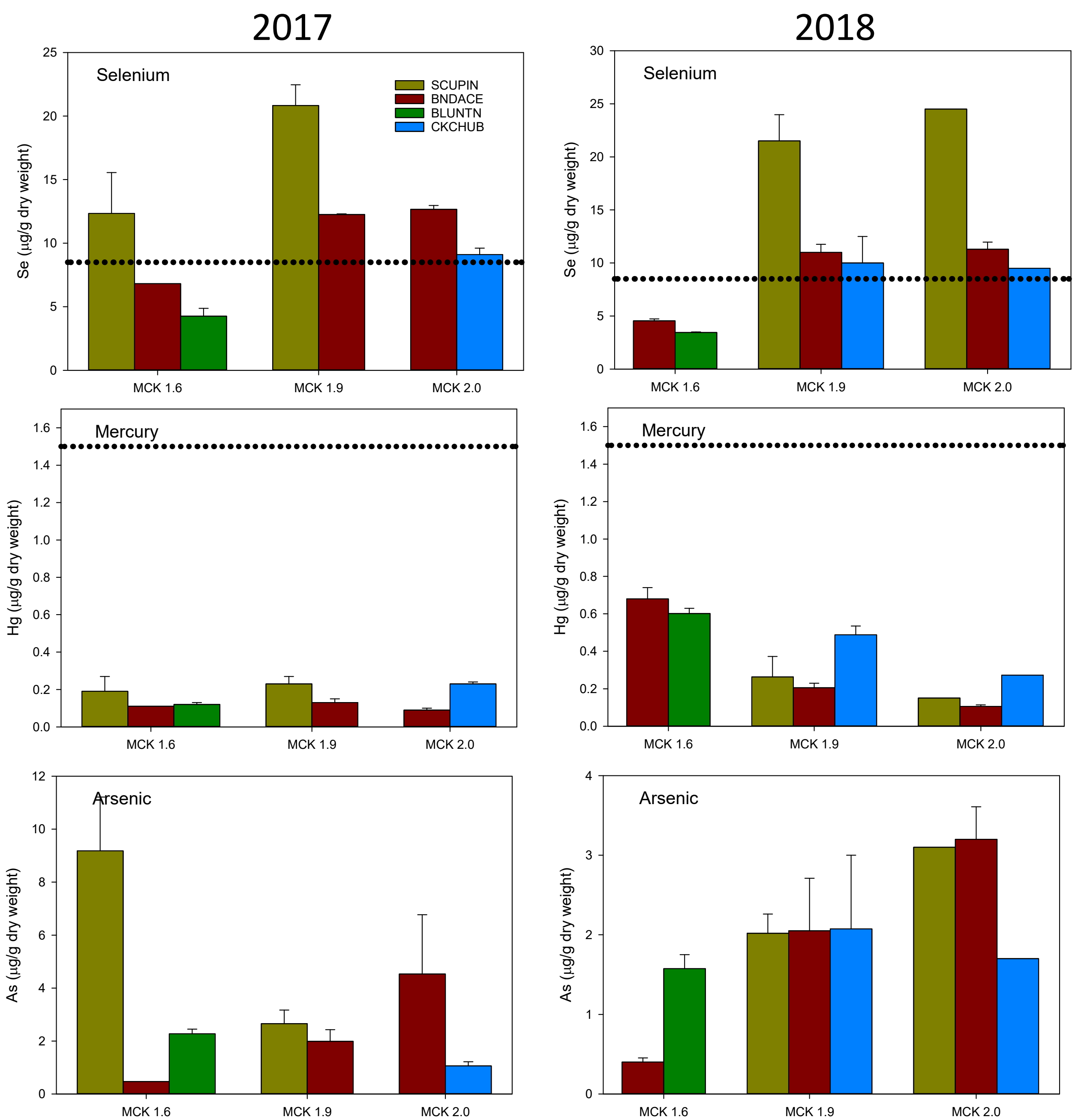

Figure C.1.18. Mean (± 1 standard error) selenium, arsenic, and mercury concentrations (µg/g dry weight) in composites of whole-body forage fish collected from McCoy branch in FY 2017 and FY 2018.

Dotted lines represent fish tissue criteria for selenium (8.5 µg/g dry weight in whole-body fish) and for mercury (0.3 µg/g in fish fillets, converted to 1.5 µg/g dry weight using moisture content).

Fish health and population estimates

To quantify the prevalence of abnormalities and to determine the likelihood that these deformities were due to exposure to selenium or other stressors, it was critical to have a reliable estimate of the population of largemouth bass in Rogers Quarry. Fish for mark-recapture estimation were collected by angling, marked using passive integrated transponder tags, and released for later recapture sampling. To provide a robust largemouth bass population estimate, two population estimation techniques were used in 2018—a full-likelihood closed-capture model and a Jolly-Seber model—both calculated using Program MARK (White and Burnham 1999). Fish characteristics such as length, weight, and condition of the fish at time of capture were also noted in all quarries. Scales were collected from each fish so that an estimate of population age structure could be made.

Fish health was assessed by several methods, including in-field and in-laboratory external visual evaluation for abnormalities (e.g., apparent deformities, injuries, fin irregularities, skin and gill parasites), meristic measurements, condition, blood chemistry, and measures of reproductive health (e.g., fecundity estimates, gonadal abnormalities). Fish with suspected deformities were photographed in the lab for meristic measurements—measurements between physical landmarks on a fish, such as front of eye to opercle margin, that can be used to quantify their physical characteristics. Meristic measurements were conducted as described in Perea et al. (2016) from photographs of fish taken with standardized position and lighting conditions.

Both types of population estimates conducted in 2018 suggest that Rogers Quarry has approximately 300 largemouth bass. No deformed fish were collected in 2018, and only one emaciated fish. This is a big change from 2016 and 2017 when a number of fish were found to be emaciated or deformed.

Although there were some differences in blood chemistry indicative of liver and kidney conditions among the four quarry sites, there were no consistent patterns of differences among quarries in 2018. Fish from the reference quarries were not emaciated or deformed and fish condition factors were similar to Rogers Quarry in 2018. Based on these results, there is no evidence that the general conditions of quarries are a cause of deformities or highly emaciated conditions in fish.

Selenium toxicity in fish has been linked to skeletal, fin, and cranial deformities; and meristic data suggest that some largemouth bass from Rogers Quarry in 2016 and 2017 have significantly different cranial and fin proportions compared with fish from reference quarries. Several of the meristic differences between Rogers Quarry and the reference quarries were in head measurements. There are no definitive meristic criteria for selenium deformity, but this record of differences in cranial measurements is not inconsistent with previously reported impacts of selenium from coal ash (Lemly 1992).

The determination of fish age may provide some insight on changing fish health over time. Deformed fish collected in 2016 and 2017 were age 7 – 9, which suggests that the deformed fish might have been at the egg stage when their parent fish were exposed to high selenium concentrations (see selenium concentrations in fish, Chapter 5). The oldest fish collected in Rogers Quarry in 2018 were age 8, suggesting that there are no more surviving fish from the year class or year classes that contained deformed fish. Deformed fish when encountered have been removed. If deformities are linked to selenium exposure from coal ash, and high levels of exposure are not thought to occur each year, it stands to reason that only certain year classes may be impacted and that deformities may not always be measurable as was the case in 2018. Monitoring of the fish population in future years can help elucidate whether selenium exposure conditions and fish health change.

C.1.6 CONCLUSIONS AND RECOMMENDATIONS

The 2016 FYR identified the effectiveness of the passive wetland system as an issue at the FCAP (Chestnut Ridge Operable Unit [OU] 2) and recommended that the wetland be re-examined to determine if improvements to the physical conditions are necessary to increase efficiency. Further investigation of the Rogers Quarry fish population and health was also recommended after fish morphological abnormalities were found during the 2016 bioaccumulation sampling of Rogers Quarry.

Through a topographical survey, the investigation verified that the substrate surface of the wetland is affected by both sedimentation and erosion. Mounds of sediment and organic matter have formed in the central, downstream portion of the wetland while channels have developed along the outer margins. The functionality of the settling basin downstream of the FCAP leachate influent (MCK 2.05) is greatly reduced as sediment has filled the capacity of the structure. As a result of the drier, mounded topography, grass species have colonized much of the wetland area. To quantify the effects of channelization a dye trace study was performed in May 2018 that verified the limited residence time of influent moving through the wetland.

Flow-paced composite sampling was performed at four surface water monitoring stations during wet and dry season baseflow and storm events to assess wetland performance and material transport in the system. Flux calculations determined that arsenic reduction in the wetland was variable and that the wetland at times served as a source of arsenic in both wet and dry seasons. The current performance monitoring frequency for the wetland is semi-annual and comprised of single surface water grab samples collected the wetland influent (MCK 2.05) and effluent (MCK 2.0) locations in the wet and dry seasons. To more accurately quantify wetland removal efficiency it is recommended that a composite sampling regime is implemented to account for seasonal hydrologic and temporal fluctuations that may occur in the system. For each month of the respective seasons (January, February, March for the wet season; July, August, September for the dry season) a weekly composite sample will be collected. Enhanced monitoring will provide a more rigorous examination of wetland performance over an extended time period to better represent treatment conditions.

The "first flush" indicated by FCAP REVET arsenic and TSS results from the July 21 – 22, 2018 storm event suggests that sheet erosion and limited erosion of surface channels in the ash upstream of the revetment spillway associated with high intensity precipitation are primary contributors to transport of ash-containing sediments. In addition to the erosion associated with sheet flow and gully erosion during heavy rains, surface sediments are subject to displacement associated with frost heave. Freezing and thawing at the sediment/air interface may contribute to the erodibility of FCAP sediments. The *Feasibility Study for the Y-12 Chestnut Ridge Operable Unit 2 Filled Coal Ash Pond, Oak Ridge, Tennessee* (DOE/OR/02-1259&D2) estimated a volume of 3,300 m^3 of coal ash was left in place along the floodplain of Upper McCoy Branch and exposed areas of stream bank may contain significant amounts of erodible material. Erosion monitoring at the surface of the FCAP and within Upper McCoy Branch ash deposits via erosion pins or similar method is recommended to estimate the volume of ash-containing source material that may be transported to Rogers Quarry.

Maintenance activities to improve the physical condition of the wetland are planned for FY 2019 and include regrading of the wetland interior and restoring the sedimentation basin and outlet structures. Following re-contouring of the surface substrate and re-establishment of wetland vegetation, an additional dye trace study is recommended to determine the hydrologic residence time within the modified treatment system.

Study findings show that fish in McCoy Branch exceed EPA's recommended fish-based criteria for selenium, and historical exposures of fish to selenium was a likely cause of observed fish health problems in Roger Quarry fish. The most recent sampling of Rogers Quarry in 2018 found no deformed fish and only one emaciated fish, suggesting that detrimental exposures are transitory (only older fish were negatively affected) and there is an overall improving trend. Wetland modifications may further improve water quality conditions downstream. Based on the results of the recent investigations, additional sampling and analysis is recommended to be conducted annually in conjunction with routine biological monitoring of McCoy Branch and Rogers Quarry. When fish community surveys in McCoy Branch are conducted, additional whole fish will be collected and analyzed for coal ash associated metals (selenium, arsenic, and mercury). When fish are collected annually from Rogers Quarry for bioaccumulation, the fish population and fish health will also be evaluated. The augmented monitoring will help evaluate whether there are changes in selenium exposure or fish health and inform assessments of remedial effectiveness and future decision-making in the watershed.

The episodic nature of historical fish exposures recorded in Rogers Quarry may be related to varying stream dynamics and depositional environments due to beaver activity in Upper McCoy Branch. It is recommended that an additional component be added to ongoing site inspections to identify this activity along the stream from downstream of the FCAP REVET spillway to the Rogers Quarry influent.

This closes the FYR issues regarding the FCAP investigations.

C.1.7 REFERENCES

Blute, N.E., D.J. Brabander, H.F. Hemond, S.R. Sutton, M.G. Newville, and M.L. Rivers 2004. *Arsenic Sequestration by Ferric Iron Plaque on Cattail Roots,* Environmental Science Technology 38, 6074-6077.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/02-1259&D2. *Feasibility Study for the Y-12 Chestnut Ridge Operable Unit 2 Filled Coal Ash Pond, Oak Ridge, Tennessee,* 1995, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, Tennessee.

Fitz, W.J. and W.W. Wenzel 2002. *Arsenic Transformations in the Soil-Rhizosphere-Plant System: Fundamentals and Potential Application to Phytoremediation.* Journal of Biotechnology 99, 259-278.

Lemly, A.D. (1992). A teratogenic deformity index for evaluating impacts of selenium on fish populations. Ecotoxicology and Environmental Safety 37(3), 259–266.

Lizama, K.A., T.D Fletcher, and G. Sun 2011. *Removal Process for Arsenic in Constructed Wetlands.* Chemsphere 84, 1032-1043.

Marchand, L., M. Mench, D.L. Jacob, and M.L. Otte 2010. *Metal and Metalloid Removal in Constructed Wetlands, with Emphasis on the Importance of Plants and Standardized Measurements: A Review.* Environmental Pollution 158, 3447-3461.

Perea, S., Vukić, J., Šanda, R., and Doadrio, I. (2016). "Ancient mitochondrial capture as factor promoting mitonuclear discordance in freshwater fishes: A case study in the genus Squalius (Actinopterygii, Cyprinidae) in Greece," PloSone 11(12), e0166292.

Stottmeister, U., A. Wiessner, P. Kuschk, U. Kappelmeyer, M. Kaestner, O. Berderski, R.A. Mueller, and H. Moormann 2003. *Effects of Plants and Microorganisms in Constructed Wetlands for Wastewater Treatment.* Biotechnology Advances 22, 93-117.

Taylor, G.J., A.A. Crowder, and R. Rodden 1984. *Formation and Morphology of an Iron Plaque on the Roots of Typha Latifolia L. Grown in Solution Culture.* American Journal of Botany 71(5), 666-675.

White, G.C. and K.P. Burnham (1999). "Program MARK: survival estimation from populations of marked animals." Bird Study 46(sup1): S120-S139.

C.2 ADDITIONAL MANAGEMENT ACTIONS AT EAST TENNESSEE TECHNOLOGY PARK PONDS

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ACTION PLAN
East Tennessee Technology Park Ponds
K-1007-P1 Pond and K-901-A Pond

STATUS:
2016 FYR: Additional Finding
CERCLIS OU: #21

The following italicized additional finding for the East Tennessee Technology Park (ETTP) Ponds is from the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2).

FINDING: *ETTP Ponds RmA: Performance monitoring at the* ***K-1007-P1 Pond*** *suggests that PCB concentrations in fish and clams are declining and the "remediation levels are trending toward a successful endpoint." However, there is some evidence of population increases in less desirable fish species (e.g., largemouth bass, gizzard shad) and reduction of plant cover in 2016. Furthermore, monitoring at the* ***K-901-A Pond*** *indicates the common carp and gizzard shad fish have not attained the PCB concentration goals identified in the RmA Report.*

RECOMMENDATION:
K-1007-P1 Pond: *Additional management actions identified in the RmAR for the Ponds RmA (DOE/OR/01-2456&D1R1) should be implemented. These ecological management actions, specifically fish and plant management and operational monitoring at the K-1007-P1 Pond, will be conducted in 2017 and 2018 as specified in a letter from DOE to EPA and TDEC (dated December 29, 2016). Performance monitoring will also be conducted during the period from 2017 through the next FYR in 2021. Results assessing recent management actions will be reported in the annual RERs and the next FYR.*

K-901-A Pond: *Additional management actions for the K-901-A Pond should be evaluated and an approach by DOE submitted. These actions will be reported in the annual RERs and the next FYR.*

C.2.1 INTRODUCTION

As part of the *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee* (2016 FYR; DOE/OR/01-2718&D2), performance monitoring results from three East Tennessee Technology Park (ETTP) Ponds (K-1007-P1 Holding Pond, K-901-A Holding Pond, and K-720 Slough) were evaluated. All three sites are monitored for polychlorinated biphenyl (PCB) accumulation in fish (see results through 2017 in Section C.2.4). At the K-720 Slough, fish in recent years are largely below the human health target of 1 ppm and the ecological risk target of 2.3 ppm. At the K-1007-P1 Holding Pond, where an ecological management and enhancement approach was taken starting in 2009, results suggest that PCB concentrations in fish and clams are declining and the "remediation levels are trending toward a successful endpoint." However, fish still exceed risk limits, depending on species. At the K-901-A Holding Pond, PCB concentrations in carp and gizzard shad exceed the human and ecological risk goals. Although largemouth bass, common carp, and Asiatic clam monitoring suggests PCB concentrations in biota are not increasing, there is a significant increase in gizzard shad PCB concentrations since 1996.

After discussions with U.S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC), U.S. Department of Energy (DOE) agreed to conduct additional management actions at the K-1007-P1 Holding Pond and the K-901-A Holding Pond in fiscal year (FY) 2017 and FY 2018 in an effort to decrease human and ecological risks from PCBs in fish. The additional activities are specified in letters from DOE to EPA and TDEC dated December 29, 2016 (for the K-1007-P1 Holding Pond), and September 7, 2017 (for the K-901-A Holding Pond). The additional actions included fish management (including fish removals and stocking) and plant management (including within pond and riparian areas). A fish removal data update is provided in Section C.2.4. A summary of the FY 2017 management actions conducted at K-1007-P1 Holding Pond and K-901-A Holding Pond are provided in Sections C.2.2 and C.2.3 below, respectively. The results of FY 2018 operational and performance monitoring at the ponds are presented in Section C.2.4.

C.2.2 K-1007-P1 HOLDING POND

In 2017 – 2018, a strategic approach to fish removals was implemented, including sampling early in the season to avoid the dense aquatic vegetative cover, and isolation of remote areas of the pond by using block nets and deploying gill nets in open water habitat. The gill nets resulted in an increased capture rate of some species such as common carp and both species of bullhead, but were not as effective as was hoped on other species such as gizzard shad and largemouth bass. As a result, gill nets were not deployed in 2018. The decreasing numbers of gizzard shad observed in the pond in recent years may partially explain the poor collection success for this species by the gill nets which are often very effective in reservoir systems where shad are abundant in large schools.

Overall, electrofishing was the most successful method employed to remove nuisance fish from the pond. Collection efforts earlier in the season were also more successful than late summer collections at removing some of the species such as largemouth bass. The reduced vegetative cover facilitated access to shoreline habitat where these predatory fish are often located.

In conjunction with these removal efforts, bluegill were again stocked in 2018. Sixteen thousand juvenile bluegill were purchased from a commercial hatchery and released to the pond in late summer. These fish will continue to augment the already dominant sunfish population in an effort to potentially "overwhelm" other species such as largemouth bass during the spring spawn, when juvenile fish are all feeding on similar prey items.

In addition to strategic fish removal and stocking efforts mentioned above, targeted aquatic plantings were continued in 2018 on the northern and west end of the K-1007-P1 Holding Pond. Sixty-three lotus were planted within and east of the slough utilizing the same method that was successful there in FY 2017. New planting procedures were developed for areas where vegetation was desired but had limited plant survival due to poor substrate. Six hundred plants, comprising eleven species, were planted into coconut fiber wattles and straw bales which could provide better substrate for plant growth, as well as more protection from muskrats. A dozen coconut wattles were secured within the old boat launch area where the heavily graveled-soils proved to be inconducive to plant growth in FY 2017. Coconut wattles were secured near the shore and extended into the deeper water to provide a gradient of planting depths. Planting was done in August, and by September plants were taking root in the wattles. Similarly, the straw bales were placed south of the weir outfall and planted with a mix of species.

C.2.3 K-901-A HOLDING POND

Fish removal efforts were conducted multiple times throughout the year in the K-901-A Holding Pond. These efforts were conducted using an electrofishing boat. In total 422 fish were removed from the population. These included largemouth bass, common carp, and gizzard shad, among others. Fish species removed represent those which are longer lived or higher trophic level. In addition to fish removal, fish populations in the K-901-A Holding Pond were augmented with stocking of six thousand bluegill from a commercial hatchery in 2018. These fish were released to the pond in late summer. Similar to efforts at the K-1007-P1 Holding Pond, it is hoped that these additional fish will "shift" the fish population to be dominated by short lived, low trophic level sunfish. Additional monitoring will determine the success of these efforts.

Lotus plants were added to the K-901-A Holding Pond in September of 2017, but none of these plants appeared to have survived in 2018. The late planting is thought to the be the reason for the lack of success. In FY 2018, planting was conducted earlier in the year at the K-901-A Holding Pond (June and July). Over 2,600 plants, comprising fifteen species, were planted. Lotus were germinated, bagged, and planted following the same procedure used at K-1007-P1 Holding Pond. All other species were purchased from native aquatic nurseries and planted as plugs or bare roots directly into the pond sediment. Because water level in the K-901-A Holding Pond fluctuates throughout the year, plant selection focused on species that could tolerate the greatest fluctuation in water level and tolerate being inundated for part of the year. For example, pickerelweed (*Pontederia cordata*) was planted when water levels were high in July and have survived as water levels dropped in the following months.

C.2.4 EVALUATION OF OPERATIONAL MONITORING DATA AT ETTP PONDS

Operational monitoring is conducted at the K-1007-P1 Holding Pond (Figure C.2.1) and K-901-A Holding Pond to ensure that the ecological enhancement measures have been implemented as intended. Monitoring of plants, wildlife, water quality, and fish (which is also a performance metric) was conducted in 2018 in accordance with the *Removal Action Report for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment* (DOE/OR/01-2456&D1/R1). The ecological information obtained is used to evaluate whether modifications are needed to attain the desired end state (i.e., a heavily vegetated, clear water pond dominated by sunfish with significantly diminished or at least downwardly trending PCB levels).

A quantitative fish population survey was conducted on the K-901-A Holding Pond on March 22, 2018 (Table C.2.1). The survey revealed 12 species of fish to be present in the pond. Of these, bluegill were the most dominant fish found in the pond comprising approximately 48% of the population followed by gizzard shad which comprise approximately 29%. Overall the pond is very open and provides little cover from vegetation or other structure creating abundant suitable habitat for gizzard shad and common carp. This resembles conditions in the K-1007-P1 Holding Pond before remediation efforts began in 2009. It is hoped that the planting efforts begun in earnest summer 2018 will soon create a more sheltered pond habitat less suitable to open water fish and more appropriate for sunfish while stabilizing sediments at the same time.

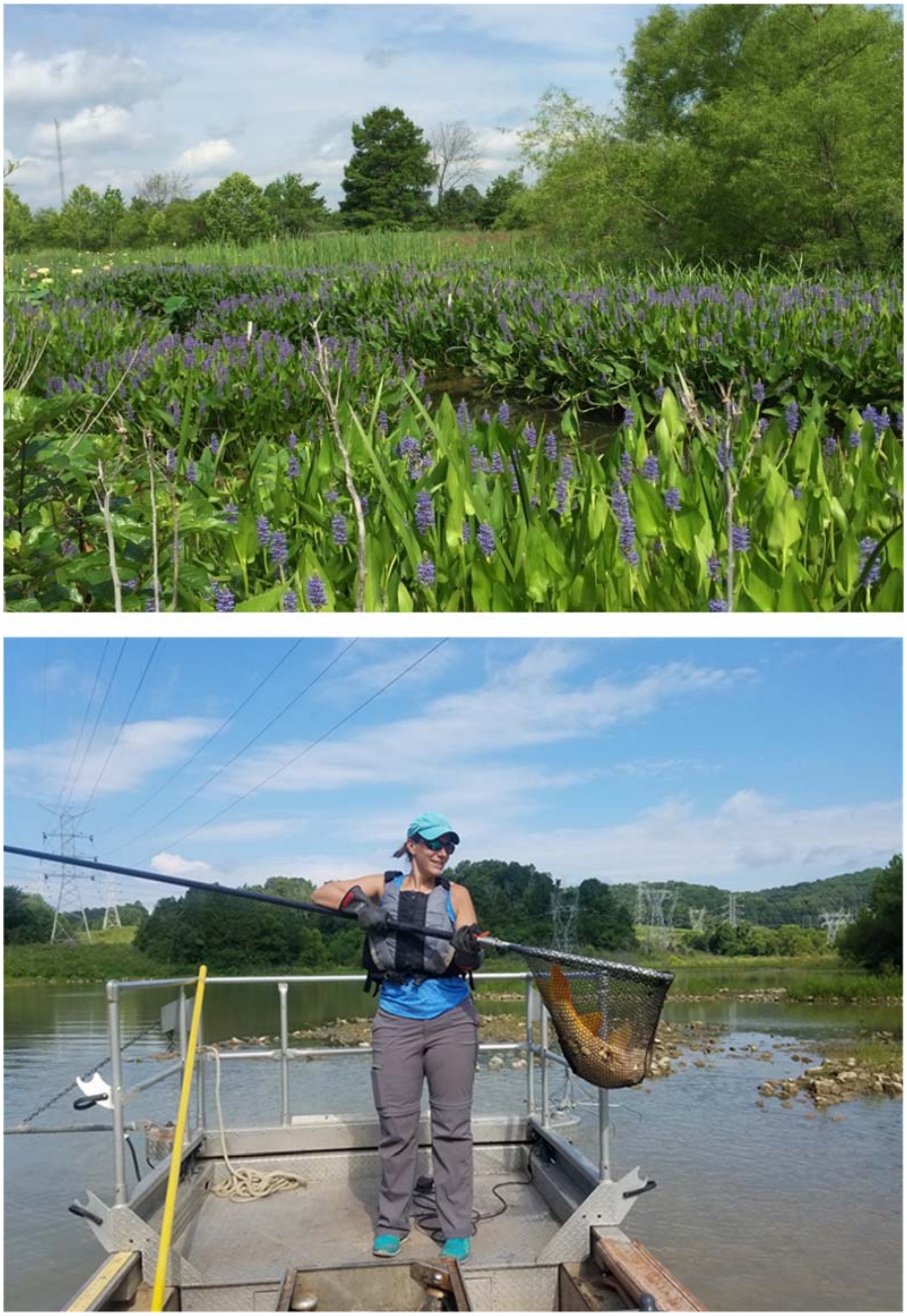


Figure C.2.1. Heavy vegetation (top) and fish sampling (bottom) at the K-1007-P1 Holding Pond and K-901-A Holding Pond.

Table C.2.1. Actual catch per minute of electrofishing during fish community surveys in the K-901-A Holding Pond, 2018

Species	March 2018	Total number individuals collected
Spotted gar (*Lepisosteus oculatus*)	0.02	1
Gizzard shad (*Dorosoma cepedianum*)	2.15	129
Common carp (*Cyprinus carpio*)	0.32	19
Golden shiner (*Notemigonus crysoleucas*)	0.03	2
Green sunfish (*Lepomis cyanellus*)	0.32	19
Warmouth (*Lepomis gulosus*)	0.18	11
Bluegill (*L. macrochirus*)	3.52	211
Redear sunfish (*Lepomis microlophus*)	0.40	24
Hybrid sunfish (*Lepomis*)	0.03	2
Largemouth bass (*Micropterus salmoides*)	0.17	10
White crappie (*Pomoxis annularis*)	0.08	5
Black crappie (*P. nigromaculatus*)	0.10	6
		Total: 439

The fish community in the K-1007-P1 Holding Pond was sampled in:

- May 2007 (baseline conditions; two years prior to piscicide application).
- 2009 – 2018 following management activities, including piscicide application, native plantings, and ongoing fish removal efforts.

The fish diversity in K-1007-P1 Holding Pond has reached or exceeded levels observed in 2007, prior to the initiation of remediation efforts and pond manipulations. Only two of the 10 species recorded in the pond during the baseline sampling in 2007 have not been recorded since, white crappie (*Pomoxis annularis*), a species that at the time comprised approximately 12% of all fish in the pond, and spotted gar (*Lepisosteus oculatus*). Bluntnose minnows (*Pimephales notatus*), spotted suckers (*Minytrema melanops*), western mosquitofish (*Gambusia affinis*), and redear sunfish (*Lepomis microlophus*) were known to occur in the pond prior to remediation efforts, but were not collected during the 2007 survey. Those species are again present in the pond, with bluntnose minnows, western mosquitofish, and redear sunfish having been stocked.

Changes in the fish community of the K-1007-P1 Holding Pond have been considerable since the 2007 survey (Figure C.2.2). Bluegill are consistently the most dominant fish species observed each year and this trend continued in 2018 when they composed approximately 70% of the fish community. Bluegill reproduction continues to be successful, and year classes zero – five were present when the pond was sampled in February 2018. Bluegill lifespan averages five – six years (Etnier and Starnes 1993). Their presence, in combination with the abundance of other sunfish species present (redear sunfish, warmouth [*Lepomis gulosus*], green sunfish [*Lepomis cyanellus*], and hybrid sunfish [*Lepomis sp.*]), continues to demonstrate that sunfish are doing well in the pond (approximately 80% of individuals collected). Gizzard shad continue to be present in the pond and it is suspected that they are reproducing, however they only constitute approximately 13% of the fish population at present, thanks in large part to the removal efforts. Another factor limiting this fish is its preference for open pelagic systems, where it feeds predominantly on phytoplankton and zooplankton. Because aquatic vegetation continues to dominate open areas of the pond during the growing season, the shad population may be limited in preferred habitat and could eventually experience reduced success in recruitment of age classes to the next generation if conditions persist.

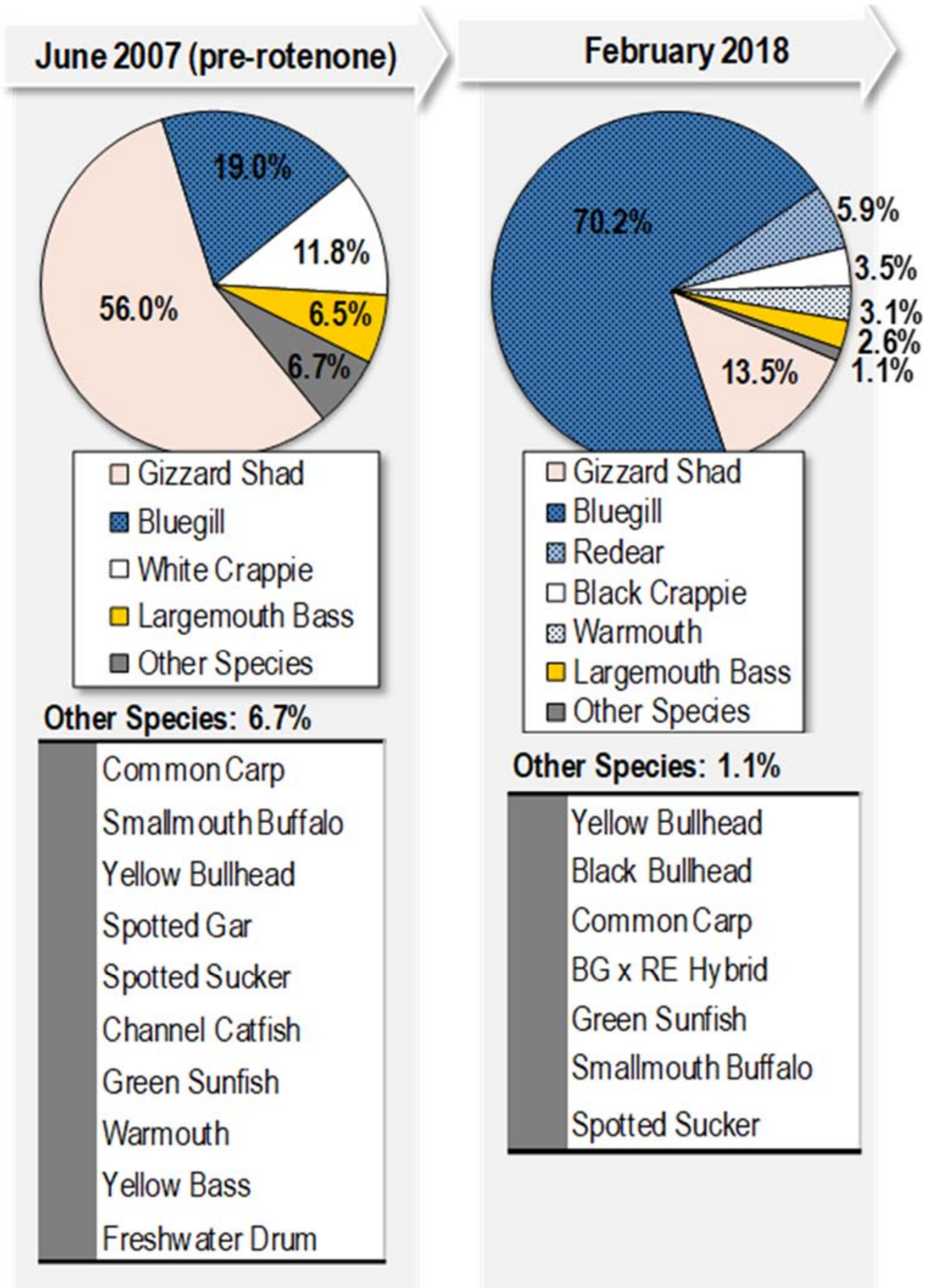


Figure C.2.2. Comparison of K-1007-P1 Holding Pond fish community (%composition) since pre-remediation efforts, 2007 – 2018.

(Note: BG x RE hybrid = bluegill/redear sunfish hybrid).

Positive changes in the fish community of the K-1007-P1 Holding Pond post-action are increased sunfish densities, the total removal of grass carp, which were known to negatively impact aquatic vegetation, and the low numbers of common carp and smallmouth buffalo in the 2013 – 2018 surveys. Largemouth bass, which are also deemed an undesirable species for the pond, become reproductively mature at age two to three, depending on when they were spawned, so any removal efforts that target these individuals should be effective at reducing the presence of this species from the ponds. Since the weir breach in 2010, 1207 bass have been removed from the pond annually. The majority of these fish were from age class two and three and these removal efforts should help reduce the next generation of bass spawned in the pond.

In addition to the fish community, the plant community within K-1007-P1 Holding Pond has also changed dramatically since the pond was re-contoured and vegetation planted as part of the remediation action. In 2007, the pond was largely devoid of plants except for algae. In 2010 – 2018, surveys found coverage had increased as much as seven-fold along some transects, reaching nearly 100% coverage, including one transect (T4) where soils were not added during remediation (Figure C.2.3). A notable change in the plant community was apparent starting in 2016 when large areas of the pond were dominated by the carnivorous humped bladderwort (*Utricularia gibba*) (Figure C.2.4). This species is relatively common in middle and far west Tennessee but is a fairly unusual find in east Tennessee. The species is not rooted and may negatively impact the pond community through shading of submergent plant species and predation on zooplankton that eat algae. However, the species was less dominant in 2018.

Despite population changes over the years in individual species such as bladderwort and Lotus, plant richness overall remained stable in 2018. There were only slight fluctuations in the four transects (Figure C.2.5), including both species planted during the removal action and volunteer species that may have been present along the periphery of the pond. The establishment of the plant community in the K-1007-P1 Holding Pond is highlighted by aerial photo comparisons between 2009, 2011, 2014, and 2018 (Figure C.2.6). By the end of the growing season in 2018, floating leaf plants had extended across the pond to cover about 65% of the pond's surface. This is less than 2014 – 2015 when emergent plant growth (mostly American lotus *Nelumbo lutea*) covered over 80% of the water surface of the pond. Aquatic environments experience natural fluctuations in plant communities and the community at the K-1007-P1 Holding Pond is likely still experiencing some adjustments as the numerous plant species present compete for limited resources.

In addition to the plant surveys completed at the K-1007-P1 Holding Pond in 2018, there were three transects established in the K-901-A Holding Pond. These will be surveyed annually in the summer growing season to assess plant establishment and community within that pond. These transects were surveyed one time in summer 2018 to establish a baseline for assessing future plant growth. They currently are very limited in both diversity and coverage with only 10 species of plants observed within the three transects combined and an average cover less than 15%.

The success of vegetation growth in the K-1007-P1 Holding Pond may be due, in part, to control of Canada geese (*Branta canadensis*) and herbivorous fish species such as grass carp (*Ctenopharyngodon idella*). Canada geese are aggressive herbivores known to damage freshly planted aquatic vegetation, and grass carp, well known for controlling overgrowth of aquatic vegetation, are almost entirely herbivorous. Improvements in habitat, coupled with a decrease in the goose population (Figure C.2.7), have no doubt contributed to increased use of the pond by ducks (Figure C.2.8) and other waterbirds, such as grebes, herons, and sandpipers.

After completion of pond remediation in 2009, total suspended solids (TSS) concentrations in K-1007-P1 Holding Pond have remained <10 mg/L (Figure C.2.9, bottom graph). Compared with very low results from 2012 − 2014, TSS concentrations have been slightly higher over the 2015 – 2018 time period. The higher concentrations of TSS may be due, in part, to an increased amount of suspended fragments of dead lotus leaves. Water clarity (i.e., Secchi disk depth) in 2017 and 2018 has been substantially lower than previous years (Figure C.2.9, top graph). The reason for decreased water clarity is unknown, but the reduced vegetation cover the last couple years in the pond, coupled with higher flows in 2017 after drought conditions in 2016, may be a factor. As has been observed in past years, as the summer progresses, water clarity decreases and suspended solids increases.

In summary, the operational performance data suggest that the natural resource enhancements including water quality, plant community, and wildlife manipulations are progressing well toward the desired end state. The fish community has had some positive developments in removing or controlling carp species and maintaining a healthy and dominant sunfish community. However, some undesirable species that entered the pond after the weir breach, especially largemouth bass and shad, remain. FY 2018 represents the last year of operational monitoring of the pond. Performance monitoring in FY 2019 and beyond will evaluate whether the additional fish and plant management actions in FY 2018, including fish removals and restocking of sunfish and addition of pond plants in the west end of the pond, were successful.

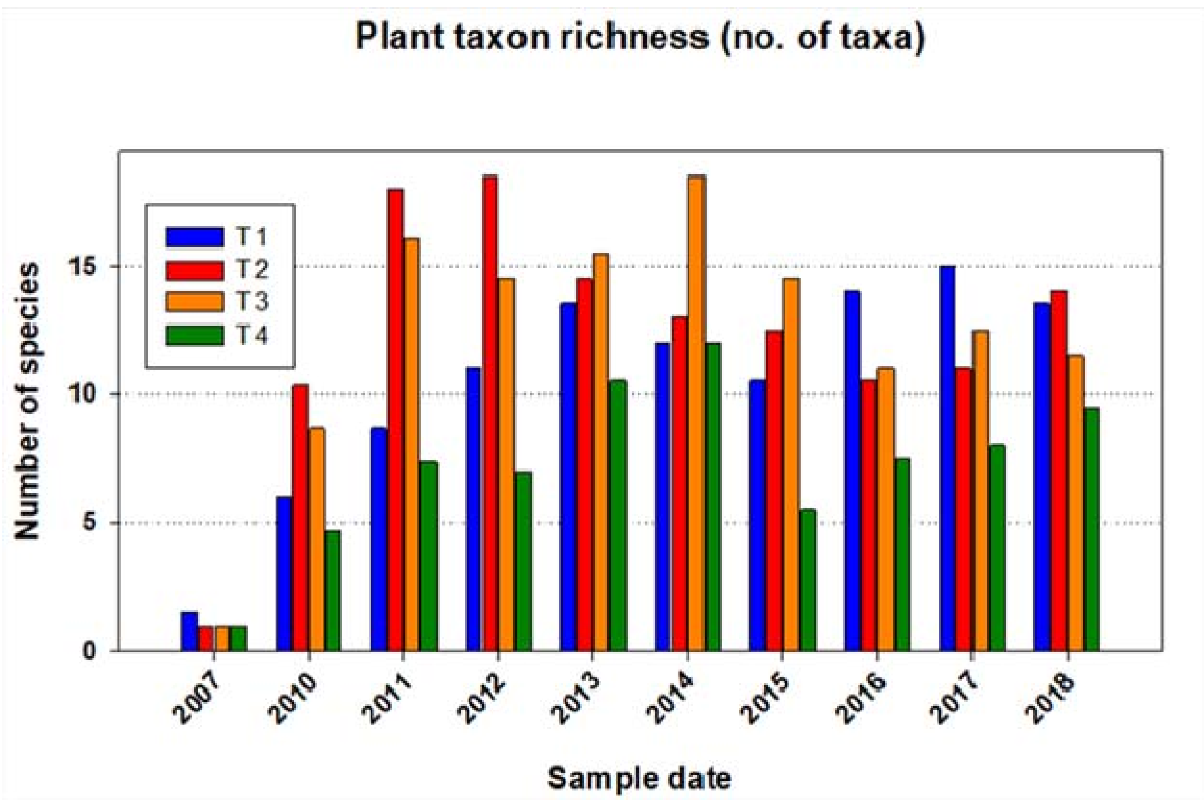


Figure C.2.3. Mean percent vascular plant cover for four transect survey lines in K-1007-P1 Holding Pond prior to and after the remediation in 2009.

Figure C.2.4. Humped bladderwort (*Utricularia gibba*) and flower in the K-1007-P1 Holding Pond during 2015.

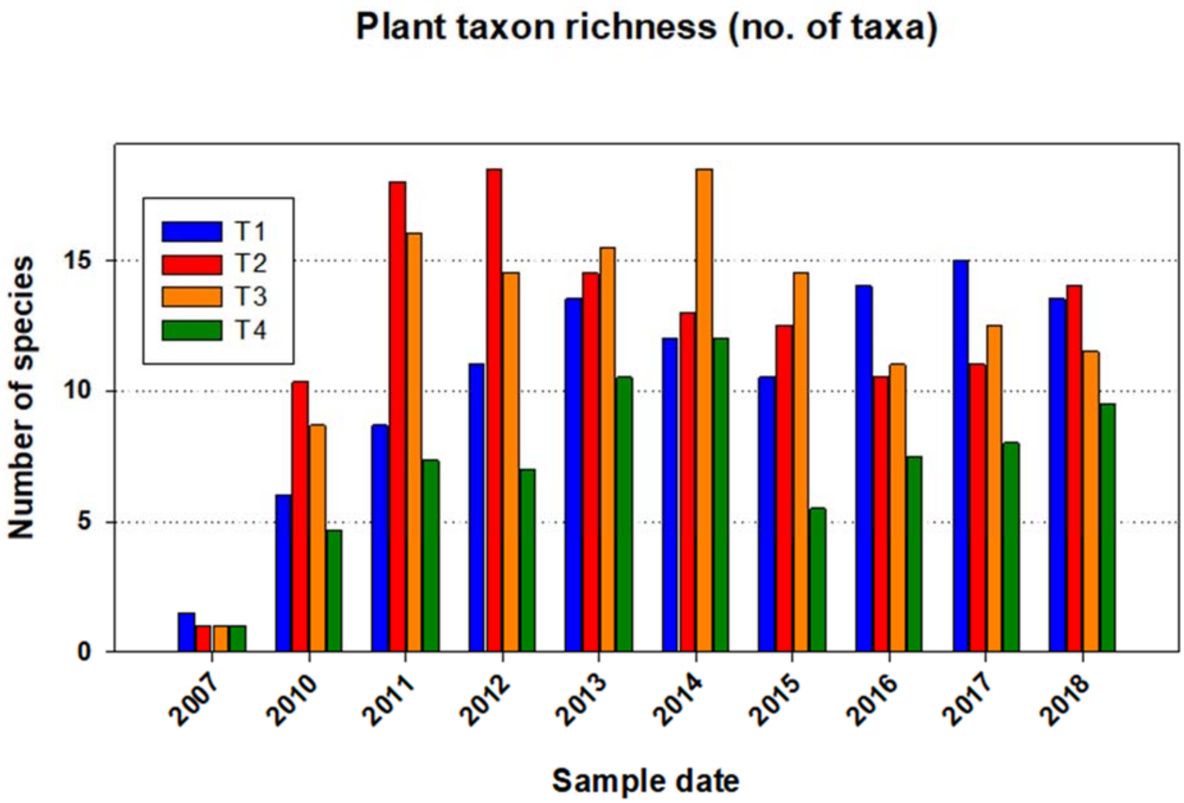


Figure C.2.5. Mean plant taxon richness for four transect survey lines in K-1007-P1 Holding Pond prior to and after the remediation in 2009.

Figure C.2.6. Aerial photos of the K-1007-P1 Holding Pond showing changes in plant coverage between the end of the first year of planting, 2009 (top), after the growing season, in 2011 (top middle), after the growing season in 2014 (bottom middle) and after growing season in 2018 (bottom).

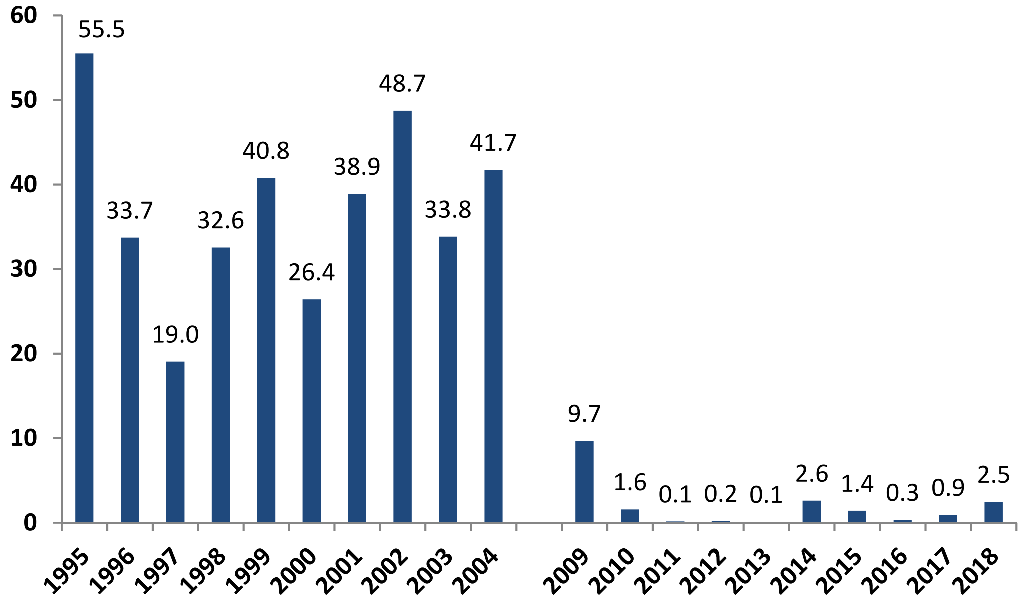


Figure C.2.7. Mean numbers of geese observed per survey at the K-1007-P1 Holding Pond, before (1995 – 2004) and after (2009 – 2018) RAs.

All observations are based on calendar years, except that 2009 contains no data from January through April and 2018 contains no data after September. The number of surveys conducted each year is as follows: 1995–1997, 1999, and 2013 ($n = 24$); 1998 and 2015 ($n = 22$); 2000 ($n = 17$); 2001 ($n = 18$); 2002 and 2004 ($n = 11$); 2003 ($n = 12$); 2005–2008 (no formal surveys conducted); 2009 ($n = 30$); 2010 ($n = 49$); 2011 ($n = 44$); 2012 ($n = 50$); 2014 ($n = 14$); and 2016 and 2017 ($n = 9$); 2018 ($n = 11$).

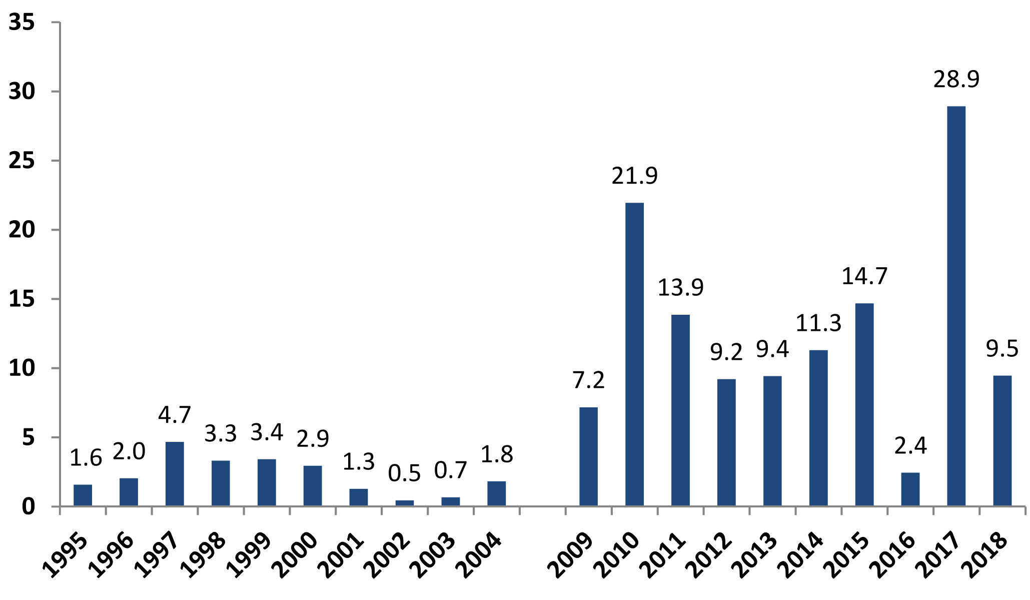
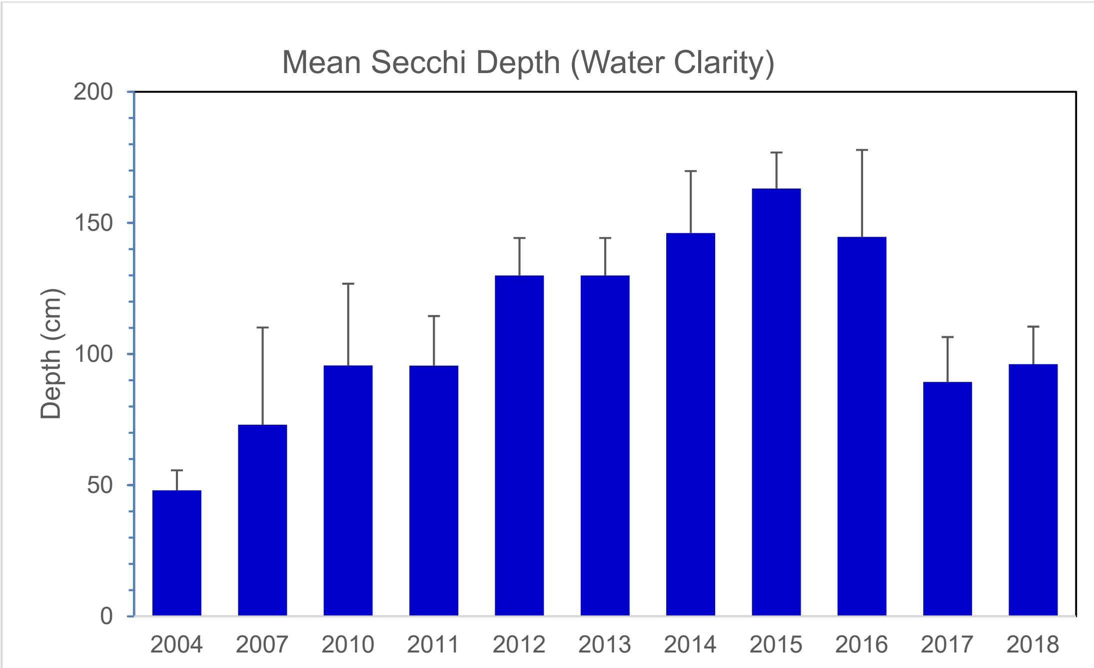


Figure C.2.8. Mean numbers of ducks (all species) observed per survey at the K-1007-P1 Holding Pond, before (1995 − 2004) and after (2009 – 2018) RAs.

All observations are based on calendar years, except that 2009 contains no data from January through April. The number of surveys conducted each year is as follows: 1995–1997, 1999, and 2013 ($n = 24$); 1998 and 2015 ($n = 22$); 2000 ($n = 17$); 2001 ($n = 18$); 2002 and 2004 ($n = 11$); 2003 ($n = 12$); 2005–2008 (no formal surveys conducted); 2009 ($n = 30$); 2010 ($n = 49$); 2011 ($n = 44$); 2012 ($n = 50$); 2014 ($n = 14$); 2016 ($n = 9$); 2017 ($n = 12$); and 2018 ($n = 11$).



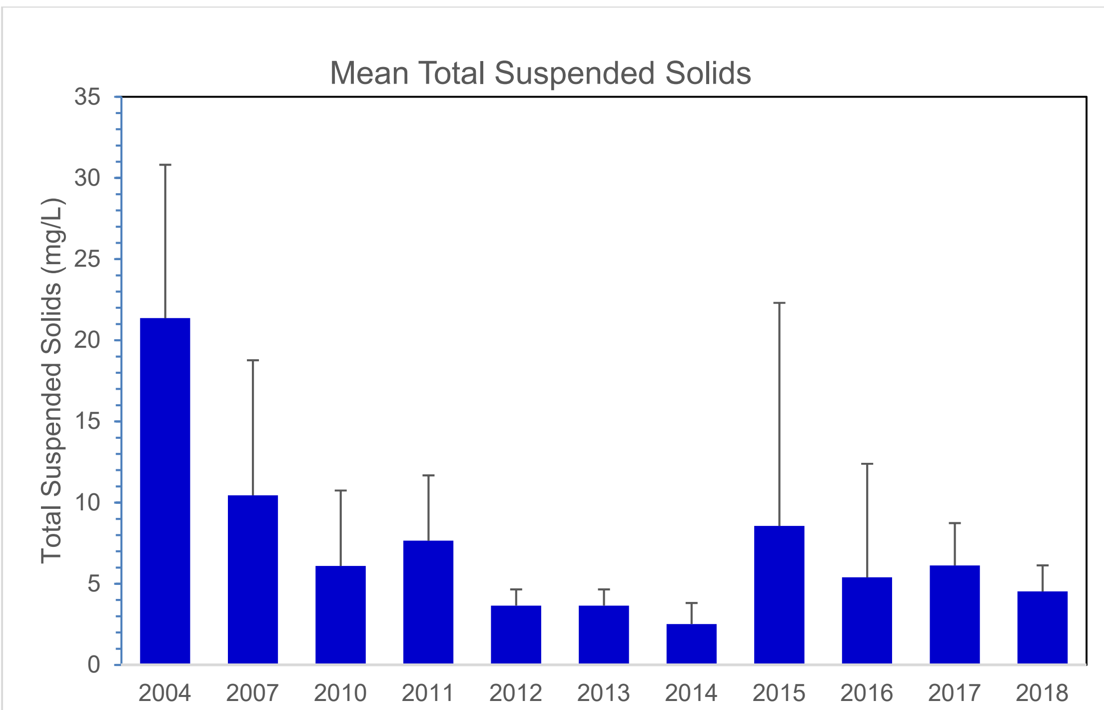


Figure C.2.9. Summary of annual mean Secchi depth (water clarity, top graph) and mean total suspended solids (TSS, bottom graph) at the K-1007-P1 Holding Pond, ±standard deviation, 2004 − 2018.

Transects run from north to south and are located approximately 506 m (Transect A), 305 m (Transect B), and 152 m (Transect C) from the pond's dam. Since 2012, Secchi depths have been equal to water depths in all sampling cells along Transect A.

C.2.4.1 Evaluation of performance monitoring data

Assessment of PCB exposure and bioaccumulation in the ETTP Ponds (i.e. the K-1007-P1 Holding Pond, the K-901-A Holding Pond, and the K-720 Slough) continued in 2018, with the primary emphasis on monitoring PCBs in fish and caged clams. Since the 2009 RA to remove fish from the K-1007-P1 Holding Pond, the target species for fish bioaccumulation monitoring in this pond has been bluegill sunfish (*Lepomis macrochirus*). As in previous years, fillets from 20 individual bluegill and six whole body composites (10 bluegill per composite) from the K-1007-P1 Holding Pond were analyzed for PCBs in 2018 to assess the ecological and human health risks associated with PCB contamination in this pond.

Average PCB concentrations in biota collected from the K-1007-P1 Holding Pond appear to be generally decreasing despite significant fluctuations in the seven years post-remediation. For example, the mean concentration in whole body composites of bluegill collected from the K-1007-P1 Holding Pond was higher in 2018 (4.00 µg/g) than in 2017 (2.58 µg/g). While this concentration is above the ecological risk goal of 2.3 ppm for whole body fish in this pond (Table C.2.2, Figure C.2.10, and Figure C.2.11), it is below whole body concentrations seen at the time of pre-remediation activities at this site (>5 µg/g in 2008 – 2009). The mean concentration (1.23 µg/g) in bluegill fillets in 2018 was slightly above the remediation goal of 1 µg/g, but remains comparable to concentrations seen in this pond for the past two years.

Caged Asiatic clams (*Corbicula fluminea*) collected from the Little Sewee Creek reference site were placed near and within various storm drains entering the K-1007-P1 Holding Pond for a four-week exposure period (May – June 2018) (Figures C.2.12 and C.2.13). PCB concentrations in clams placed at the K-1007-P1 Holding Pond outfall were higher than in the past three years, but were comparable to concentrations seen just after remediation actions in this pond (Figure C.2.12). Like the increase seen in bluegill whole bodies at this site, this increase may be due to a higher aqueous inputs to the pond in 2018 than in the previous years. PCB concentrations in clams placed at lower SD-100 have fluctuated significantly since remediation actions in 2009, and were on an overall decreasing trajectory until the significant increase seen in 2017 and 2018 (Figure C.2.13).

The target fish species for analysis of PCBs in the K-901-A Holding Pond and K-720 Slough were gizzard shad (*Dorosoma cepedianum*) and largemouth bass (*Micropterus salmoides*). It was not possible to collect the target number of bass (20) from each body of water, and so common carp (*Cyprinus carpio*) and smallmouth buffalo (*Ictiobus bubalus*) were collected to provide a combined total of 20 fish. Carp and buffalo were selected as surrogate species for bass because they are widely distributed, they are present at both locations, and they have been used historically in other monitoring efforts on the ORR for contaminant analyses. A total of three largemouth bass and 17 carp were collected from the K-901-A Holding Pond, and four bass, four smallmouth buffalo, and 12 carp were collected from the K-720 Slough in 2018.

At the K-901-A Holding Pond, PCBs concentrations in largemouth bass have fluctuated annually. While mean concentrations in largemouth bass in 2018 (0.50 µg/g) were lower than in 2017 (1.26 µg/g) such that they were below the target concentration for PCBs set for the K-1007-P1 Holding Pond of 1 µg/g, mean concentrations in carp fillets in 2018 (1.31 µg/g) were similar to those in 2017 and were again above this target concentration (Figure C.2.14). Whole body gizzard shad from the K-901-A Holding Pond, collected as a measure of potential ecological risk to terrestrial wildlife, were substantially higher in concentration (2.96 µg/g) than the fillets of bass and carp, but were lower than the concentrations seen in this species in the past three years (Figure C.2.11). Routine bioaccumulation monitoring in the K-720 Slough began in 2009. In all cases, PCB concentrations in fish collected from the K-720 Slough were significantly lower than in the K-901-A Holding Pond for the same species (Figure C.2.11). PCB concentrations in largemouth bass collected from the K-720 Slough were significantly lower than in the other monitored ponds, averaging 0.11 µg/g in 2018 (Table C.2.2). Concentrations in carp and buffalo collected from the Slough were higher than in bass, averaging 0.51 µg/g and 0.28 µg/g respectively.

PCBs were analyzed in bluegill and gizzard shad whole bodies from Poplar Creek and the Clinch River in 2018 as an assessment of how pond fish bioaccumulation compares to offsite locations. In general, PCB concentrations in offsite fish were substantially lower than the K-1007-P1 and K-901-A Holding Ponds but comparable to concentrations in fish from the K-720 slough (Table C.2.2).

Table C.2.2. PCB concentrations (expressed as the sum of Aroclors 1248, 1254, and 1260, in µg/g) in fish from the K-1007-P1 Holding Pond, K-720 Slough, and K-901-A Holding Pond, 2018

Site	Species	Sample type	Sample size (n)	Total PCBs (mean ± SE)	Range of PCB values	No. > target[a] (PCBs)/n
K-1007-P1 Pond	Bluegill	Fillets	20	1.21 ± 0.12	0.34 – 2.49	10/20
		Whole body composites	6	4.00 ± 0.47	3.32 – 6.30	6/6
K-901-A Pond	Largemouth bass	Fillets	3	0.50 ± 0.06	0.44 - 0.61	0/3
	Common carp	Fillets	17	1.31 ± 0.20	0.44 - 2.25	11/17
	Bluegill	Fillets	20	0.48 ± 0.09	0.13 - 1.83	3/20
		Whole body composites	6	1.22 ± 0.05	0.98 - 1.43	0/6
	Gizzard shad	Whole body composites	6	2.96 ± 0.11	2.79 - 3.48	6/6
K-720 Slough	Largemouth bass	Fillets	4	0.11 ± 0.01	0.09 - 0.14	0/4
	Smallmouth buffalo	Fillets	6	0.28 ± 0.11	0.03 - 0.60	0/6
	Common carp	Fillets	12	0.51 ± 0.12	0.05 - 1.53	1/12
	Gizzard shad	Whole body composites	6	0.28 ± 0.02	0.23 – 0.33	0/6
CRM 11.0	Bluegill	Whole body composites	6	0.05 ± 0.001	0.04 - 0.05	0/6
	Gizzard shad	Whole body composites	6	0.15 ± 0.02	0.11 - 0.22	0/6
PCM 1.0	Bluegill	Whole body composites	6	0.17 ± 0.01	0.14 - 0.20	0/6
	Gizzard shad	Whole body composites	6	0.41 ± 0.03	0.33 - 0.51	0/6

[a]1 µg/g total PCBs in fish fillet and 2.3 µg/g in whole body fish.

CRM = Clinch River mile
No. = number
PCB = polychlorinated biphenyl
PCM = Poplar Creek mile
SE = standard error

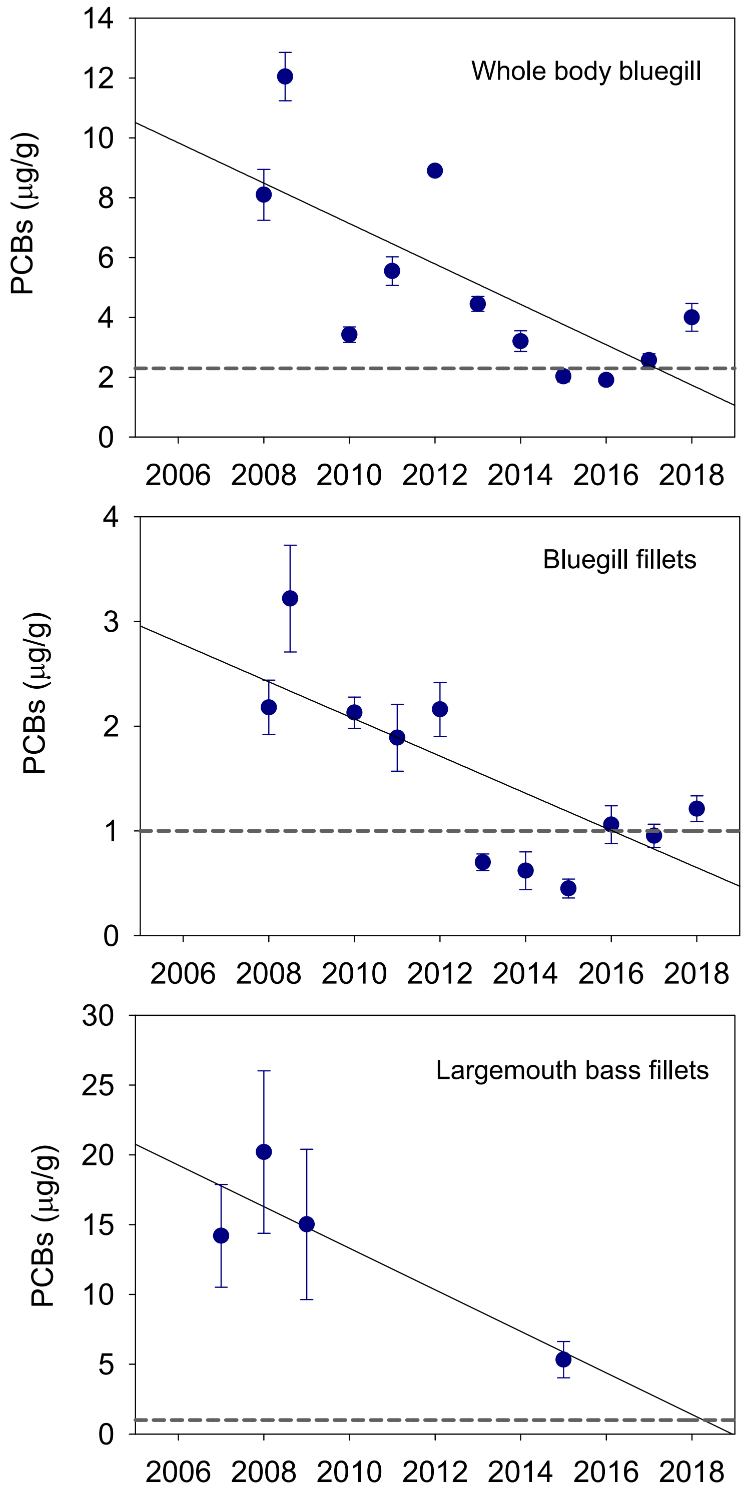


Figure C.2.10. Mean concentrations of PCBs in fish from K-1007-P1 Holding Pond, 2007 – 2018.

Dashed line signifies PCB goal of 1 µg/g in fillets, and 2.3 µg/g whole body.

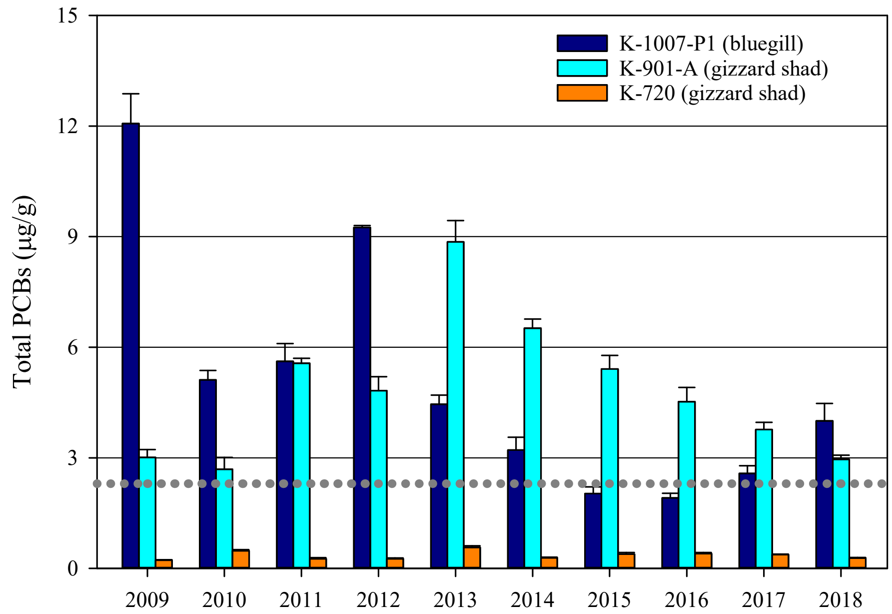


Figure C.2.11. Mean concentrations of PCBs in whole body fish from K-1007-P1 Holding Pond, K-901-A Holding Pond, and K-720 Slough, 2009 – 2018.

Dotted gray line signifies goal of 2.3 µg/g total PCB concentrations in whole body fish collected from ETTP ponds.

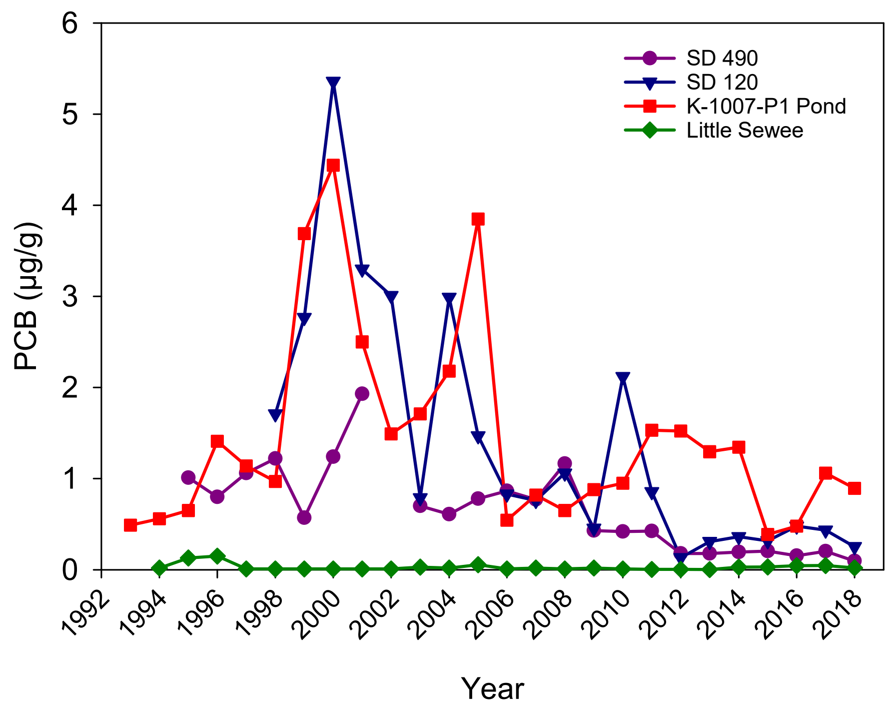


Figure C.2.12. Mean total PCB concentrations (µg/g, wet wt; 1993 – 2018) in the soft tissues of caged Asiatic clams deployed in the K-1007-P1 Holding Pond near the weir and SD-490 and SD-120.

N=2 composites of 10 clams each per year. Shown in green are data for clams collected from the reference site, Little Sewee Creek (Sweetwater, Tennessee). Total PCBs defined as the sum of Aroclors 1248, 1254, and 1260.

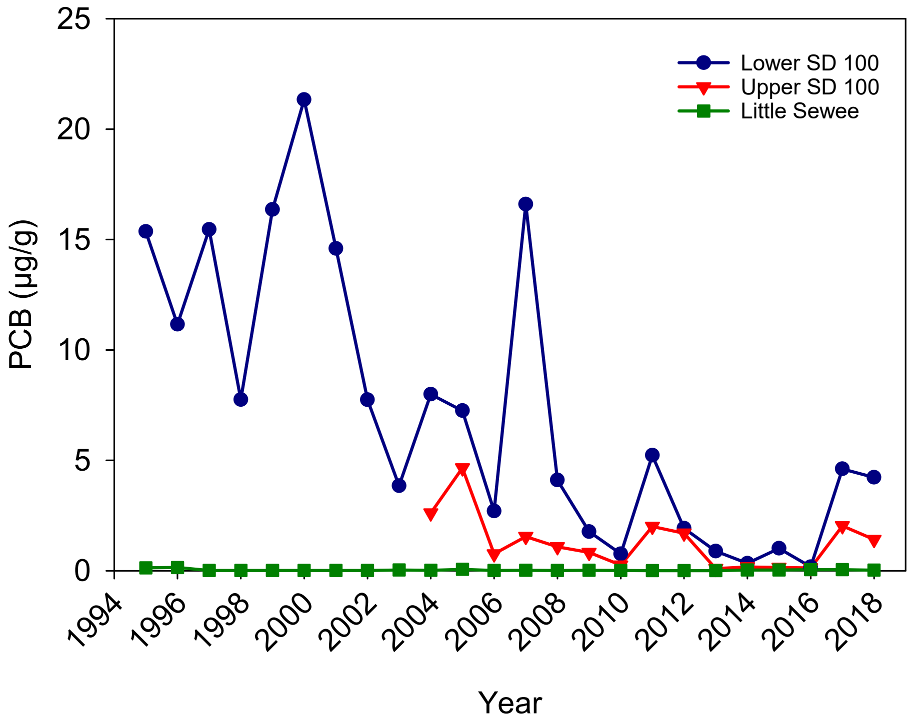


Figure C.2.13. Mean total PCB concentrations (µg/g, wet wt; 1995 – 2018) in the soft tissues of caged Asiatic clams deployed at two locations in SD-100: "upper SD-100," upstream of any possible pond related sources, and "lower SD-100" at the culvert entering the pond and influenced by pond sediment sources.

N=2 composites of 10 clams each per year. Shown in orange are data for clams collected from the reference site, Little Sewee Creek (Sweetwater, Tennessee). Total PCBs defined as the sum of Aroclors 1248, 1254, and 1260.

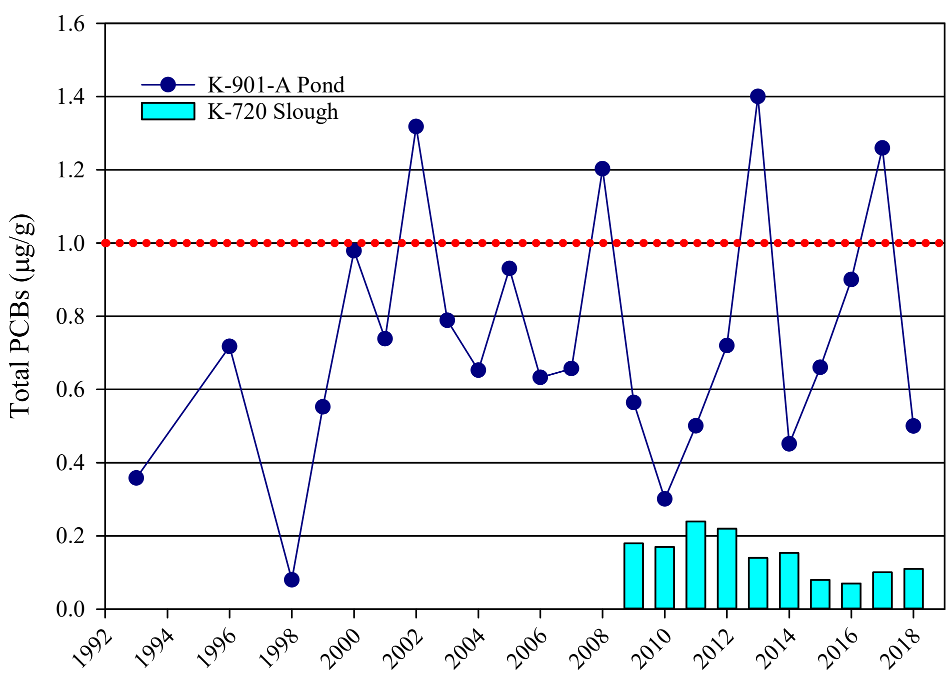


Figure C.2.14. Mean concentrations of PCBs in largemouth bass fillets from K-901-A Holding Pond and K-720 Slough, 1993 – 2018.

Dotted red line signifies goal of 1 µg/g total PCB concentrations in fillets of fish collected from ETTP ponds.

C.2.5 REFERENCES

DOE/OR/01-2456&D1/R1. *Removal Action Report for the Ponds at the East Tennessee Technology Park, Oak Ridge, Tennessee: K-1007-P Holding Ponds, K-901-A Holding Pond, K-720 Slough, and K-770 Embayment*, 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, Tennessee.

DOE/OR/01-2718&D2. *2016 Fourth CERCLA Five-Year Review of the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

Etnier, D.A. and W.C. Starnes 1993. *The Fishes of Tennessee*, The University of Tennessee Press, Knoxville, TN.

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APPENDIX D
STATUS OF GROUNDWATER CONTAMINATION AT EAST TENNESSEE TECHNOLOGY PARK

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D.1 STATUS OF GROUNDWATER CONTAMINATION

This appendix provides an area-by-area status update on groundwater contamination levels and trends within the past decade at East Tennessee Technology Park (ETTP).

The principal groundwater contaminants at ETTP are chlorinated volatile organic compounds (VOCs) (primarily trichloroethene [TCE] and its degradation products such as 1,2-dichloroethene and vinyl chloride) and Tc-99. Despite the fact that ETTP is a former gaseous diffusion plant used for uranium enrichment, the occurrence of elevated uranium concentrations in groundwater is relatively uncommon at the site. The reason for this is that the uranium enrichment process used gaseous uranium hexafluoride (UF_6) which was contained inside process equipment and depleted UF_6 was returned to storage cylinders where it returned to solid form upon cooling. Chromium and nickel (and less frequently lead) are the most common metal contaminants in groundwater and they are relatively widespread at ETTP as well as elsewhere on the Oak Ridge Reservation (ORR). Chromium was used in the hexavalent form in the recirculating cooling water and fire protection water systems to prevent corrosion of pipes. Leaks of pipes that circulated the corrosion inhibiting additives were common and in some cases were of quite large volume. In a localized area in the Mitchell Branch plume area near the former K-1420 facility, hexavalent chromium in groundwater is collected and treated prior to discharge to protect the water quality in Mitchell Branch and maintain instream chromium concentrations compliant with the 0.011 mg/L ambient water quality criteria. The origin of nickel as a groundwater contaminant is not readily tied to site processes that would have created releases of soluble nickel to the subsurface. Lead was widely used at the U.S. Department of Energy (DOE) facilities as shielding material and for other typical industrial purposes. Lead materials were sometimes stored outdoors, in the open, and some was disposed in waste burial areas either as material shielding or as waste.

Chromium, nickel, and lead are widespread in ORR soils. The ORR background soils report indicates that for Knox and Chickamauga group soils the chromium concentrations are in the range of about 40 – 50 µg/kg at 95^{th} percentile of the median. Nickel concentrations in Knox and Chickamauga group soils are in the ranges of about 10 – 30 µg/kg in the Knox and about 25 – 45 µg/kg in the Chickamauga group soils. Lead concentrations in soils are typically somewhat higher than the chromium and nickel levels. Chromium and nickel are also constituents of the stainless steel that comprises many of the monitoring well casings and screens. There is literature documentation that microbial induced corrosion can cause elevated chromium and nickel in groundwater monitoring wells at levels that can exceed the water quality criterion. In many instances, metals contamination detected in ETTP groundwater monitoring is particle associated material as demonstrated by either much lower, or non-detect concentrations measured in field-filtered sample aliquots than in the unfiltered aliquots. These factors lead to uncertainty in the interpretation of chromium and nickel (and other metals) data from groundwater monitoring because of multiple potential sources of metals – especially when data indicate that the metals are particle associated in the samples.

Figure D.1 is a current groundwater contamination plume map showing the extent of VOCs and the Tc-99 contaminated groundwater area associated with the K-25 East Wing. VOC plumes are based on the sum of chlorinated VOCs measured in fiscal year (FY) 2018 Water Resources Restoration Program (WRRP) groundwater monitoring. Figure D.1 shows designated exit pathway groundwater monitoring wells, as well as the locations where routine groundwater monitoring was conducted during FY 2018. In addition to showing the groundwater plumes and wells, Figure D.1 is annotated with stand-alone plumes or plume subareas related to contaminant sources. Groundwater data summary tables and trend evaluations are provided below for wells within each of the stand-alone plumes or plume subareas.

DOE has compiled the analytical data for groundwater contaminants in wells included in the routine WRRP monitoring program at ETTP to evaluate contaminant concentrations with respect to U.S. Environmental

Protection Agency's (EPA's) National Primary Drinking Water Regulations maximum contaminant levels (MCLs) and maximum contaminant level derived concentrations (MCL-DCs) and to determine if statistically significant trends are occurring. Data are compared to MCLs or MCL-DC for radionuclides. Two screening levels were used – the full MCL/MCL-DC concentrations and an arbitrary value of 80% of the MCL/MCL-DC. The 80% level was selected to indicate the presence of contaminants the may be approaching the MCL/MCL-DC in the event that increasing concentration trends are occurring. Mann-Kendall (M-K) trend evaluations were conducted for data compartmentalized into a maximum time period of 10 years for longer duration trend evaluation and a secondary time period of five years to evaluate more recent trends. In the M-K trend evaluation it is desirable to have at least 10 data results per analyte to allow the method to attain a 90% confidence interval on the trend identification.

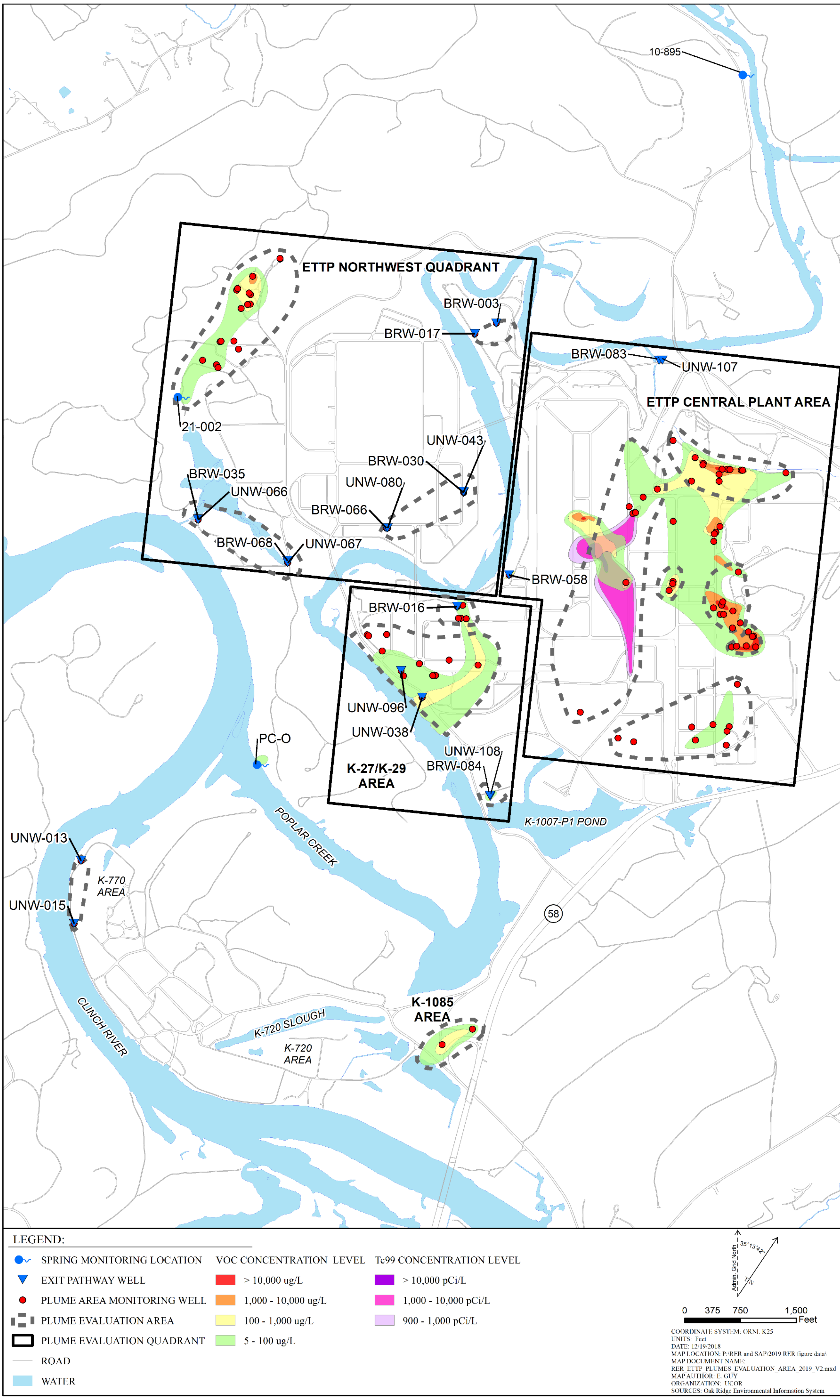

Figure D.1. ETTP VOC and Tc-99 Plumes.

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D.2 K-27/K-29 AREA GROUNDWATER CONTAMINANTS AND TRENDS

Buildings K-27 and K-29 were gaseous diffusion uranium enrichment process buildings. Figure D.2 shows the K-27/K-29 area, actively monitored wells in the area, and the FY 2018 VOC plume configuration. A number of process support facilities, including wastewater treatment, were located to the north of building K-27 and south of Poplar Creek. Groundwater contamination in the K-27/K-29 area includes alpha activity, metals (including uranium), and VOCs. Contaminant concentration trends are quite mixed with some increasing, some decreasing, and many for which no trend can be confidendly assigned. Tables D.1 and D.2 include the summary of groundwater contaminants and their concentration trends for the K-27/K-29 northern plume pathway and the K-27/K-29 south to west plume pathway.

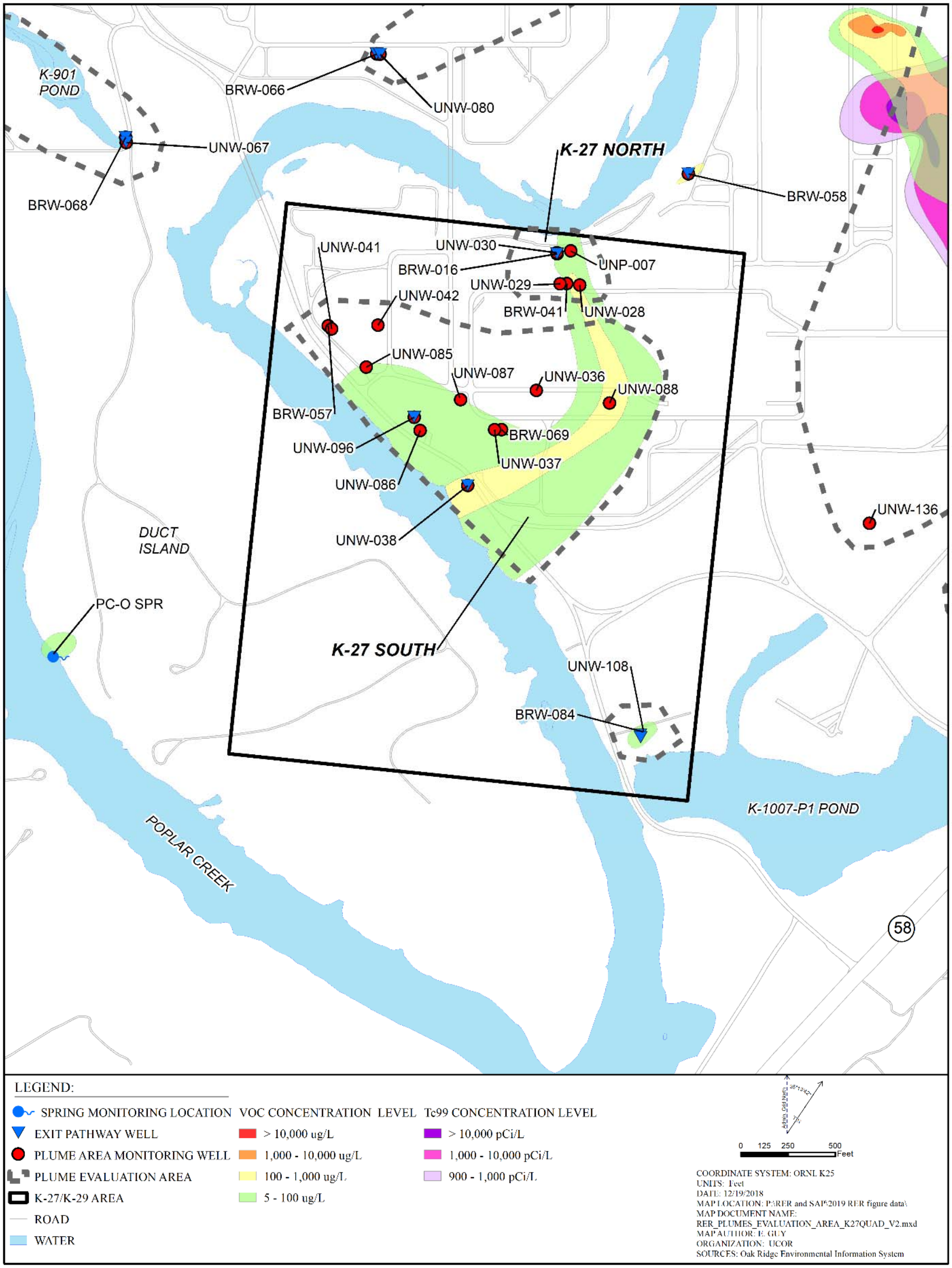

Figure D.2. K-27, K-1007, and Duct Island areas.

Table D.1. Summary of K-27/K-29 Area North groundwater contaminants and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Alpha activity	UNP-007	pCi/L	8 / 8	8 / 8	--	**158**	**158**	**158**	15	8 / 8	8 / 8	8 / 8	8 / 8	Up	Up
	UNW-029	pCi/L	5 / 6	5 / 6	3.6	**19.4**	**19.4**	**19.4**	15	2 / 6	2 / 6	2 / 6	2 / 6	Up	Up
Antimony	UNP-007	mg/L	5 / 8	5 / 8	0.001	0.005	0.005	0.001	0.006	0 / 8	0 / 8	1 / 8	1 / 8	No trend	No trend
	UNP-007(F)	mg/L	5 / 5	5 / 5	--	0.001	0.001	0.00091	0.006	0 / 5	0 / 5	0 / 5	0 / 5	Stable	Stable
Arsenic	UNP-007	mg/L	2 / 8	2 / 8	0.005	**0.01**	**0.01**	**0.01**	0.01	0 / 8	0 / 8	1 / 8	1 / 8	No trend	No trend
	UNP-007(F)	mg/L	2 / 5	2 / 5	0.005	0.005	0.005	0.005	0.01	0 / 5	0 / 5	0 / 5	0 / 5	No trend	No trend
	UNW-029	mg/L	3 / 6	3 / 6	0.003	0.009	0.009	0.009	0.01	0 / 6	0 / 6	1 / 6	1 / 6	No trend	No trend
	UNW-029(F)	mg/L	0 / 3	0 / 3	0.003	ND	ND	ND	0.01	0 / 3	0 / 3	0 / 3	0 / 3	--	--
Chromium	UNW-028	mg/L	6 / 6	6 / 6	--	**0.33**	**0.33**	**0.27**	0.1	4 / 6	4 / 6	4 / 6	4 / 6	Stable	Stable
	UNW-028(F)	mg/L	3 / 3	3 / 3	--	0.015	0.015	0.005	0.1	0 / 3	0 / 3	0 / 3	0 / 3	Stable	Stable
cis-1,2-Dichloroethene	BRW-058	mg/L	20 / 20	10 / 10	--	**0.11**	**0.11**	**0.11**	0.07	4 / 20	4 / 10	9 / 20	8 / 10	Up	Up
Lead	UNP-007	mg/L	5 / 8	5 / 8	0.003	**0.025**	**0.025**	**0.025**	0.015	1 / 8	1 / 8	1 / 8	1 / 8	Up	Up
	UNP-007(F)	mg/L	0 / 5	0 / 5	0.003	ND	ND	ND	0.015	0 / 5	0 / 5	0 / 5	0 / 5	--	--
	UNW-029	mg/L	5 / 6	5 / 6	0.002	**0.016**	**0.016**	**0.016**	0.015	1 / 6	1 / 6	1 / 6	1 / 6	No trend	No trend
	UNW-029(F)	mg/L	0 / 3	0 / 3	0.002	ND	ND	ND	0.015	0 / 3	0 / 3	0 / 3	0 / 3	--	--
Nickel	UNW-028	mg/L	6 / 6	6 / 6	--	**0.12**	**0.12**	0.058	0.1	1 / 6	1 / 6	1 / 6	1 / 6	No trend	No trend
	UNW-028(F)	mg/L	3 / 3	3 / 3	--	**0.11**	**0.11**	0.044	0.1	1 / 3	1 / 3	1 / 3	1 / 3	Stable	Stable
	UNW-029	mg/L	6 / 6	6 / 6	--	**0.12**	**0.12**	**0.111**	0.1	2 / 6	2 / 6	2 / 6	2 / 6	Stable	Stable
	UNW-029(F)	mg/L	3 / 3	3 / 3	--	0.039	0.039	0.039	0.1	0 / 3	0 / 3	0 / 3	0 / 3	Stable	Stable

Table D.1. Summary of K-27/K-29 Area North groundwater contaminants and trends (cont.)

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Trichloroethene	BRW-041	mg/L	6 / 6	6 / 6	--	**0.264**	**0.264**	**0.264**	0.005	6 / 6	6 / 6	6 / 6	6 / 6	No trend	No trend
	BRW-058	mg/L	15 / 20	9 / 10	0.003	**0.006**	**0.006**	0.00067	0.005	2 / 20	1 / 10	3 / 20	1 / 10	No trend	Stable
	UNP-007	mg/L	8 / 8	8 / 8	--	**0.018**	**0.018**	**0.018**	0.005	4 / 8	4 / 8	4 / 8	4 / 8	Stable	Stable
	UNW-028	mg/L	6 / 6	6 / 6	--	**0.037**	**0.037**	**0.037**	0.005	6 / 6	6 / 6	6 / 6	6 / 6	No trend	No trend
	UNW-029	mg/L	6 / 6	6 / 6	--	**0.017**	**0.017**	**0.017**	0.005	3 / 6	3 / 6	3 / 6	3 / 6	No trend	No trend
Uranium	UNP-007	mg/L	8 / 8	8 / 8	--	**0.27**	**0.27**	**0.27**	0.03	7 / 8	7 / 8	8 / 8	8 / 8	Up	Up
	UNP-007(F)	mg/L	5 / 5	5 / 5	--	**0.26**	**0.26**	**0.26**	0.03	4 / 5	4 / 5	5 / 5	5 / 5	Up	Up
Vinyl chloride	BRW-016	mg/L	6 / 22	5 / 12	0.001	**0.002**	**0.002**	**0.002**	0.002	0 / 22	0 / 12	1 / 22	1 / 12	No trend	No trend
	BRW-058	mg/L	20 / 20	10 / 10	--	**0.028**	**0.028**	**0.028**	0.002	19 / 20	10 / 10	20 / 20	10 / 10	Up	No trend

[a]Wells shown on Figure D.2 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.

[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[c]MCL as of May 2018.

[d]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.

(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

Table D.2. K-27/K-29 South to west plume pathway summary of groundwater contaminants and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Alpha activity	BRW-057	pCi/L	3 / 5	3 / 5	3.98	13.7	13.7	13.7	15	0 / 5	0 / 5	1 / 5	1 / 5	No trend	No trend
	UNW-037	pCi/L	5 / 6	5 / 6	3.86	**21.6**	**21.6**	4.6	15	1 / 6	1 / 6	1 / 6	1 / 6	No trend	No trend
Arsenic	BRW-057	mg/L	3 / 6	2 / 5	0.004	0.009	0.009	0.009	0.01	0 / 6	0 / 5	1 / 6	1 / 5	Stable	No trend
	BRW-057(F)	mg/L	1 / 6	1 / 5	0.005	0.003	0.003	0.003	0.01	0 / 6	0 / 5	0 / 6	0 / 5	No trend	No trend
	UNW-041	mg/L	5 / 6	5 / 5	0.005	**0.021**	**0.021**	**0.012**	0.01	2 / 6	2 / 5	4 / 6	4 / 5	No trend	Stable
	UNW-041(F)	mg/L	5 / 6	5 / 5	0.005	**0.019**	**0.019**	**0.011**	0.01	3 / 6	3 / 5	3 / 6	3 / 5	Stable	Stable
	UNW-086	mg/L	3 / 5	3 / 5	0.004	**0.012**	**0.012**	**0.012**	0.01	1 / 5	1 / 5	1 / 5	1 / 5	No trend	No trend
	UNW-086(F)	mg/L	2 / 5	2 / 5	0.004	0.006	0.006	0.006	0.01	0 / 5	0 / 5	0 / 5	0 / 5	No trend	No trend
Beryllium	BRW-057	mg/L	2 / 6	2 / 5	0.002	**0.004**	**0.004**	**0.004**	0.004	1 / 6	1 / 5	1 / 6	1 / 5	No trend	No trend
	BRW-057(F)	mg/L	0 / 6	0 / 5	0.002	ND	ND	ND	0.004	0 / 6	0 / 5	0 / 6	0 / 5	--	--
Carbon tetrachloride	UNW-088	mg/L	18 / 20	10 / 10	0.003	**0.007**	**0.007**	**0.006**	0.005	4 / 20	3 / 10	5 / 20	4 / 10	Up	Up
Chromium	BRW-057	mg/L	6 / 6	5 / 5	--	**0.55**	**0.55**	**0.55**	0.1	2 / 6	2 / 5	2 / 6	2 / 5	No trend	No trend
	BRW-057(F)	mg/L	1 / 6	0 / 5	0.003	0.008	ND	ND	0.1	0 / 6	0 / 5	0 / 6	0 / 5	No trend	--
	UNW-037	mg/L	5 / 5	5 / 5	--	**5.4**	**5.4**	**1.9**	0.1	4 / 5	4 / 5	4 / 5	4 / 5	Stable	Stable
	UNW-037(F)	mg/L	5 / 5	5 / 5	--	0.012	0.012	0.01	0.1	0 / 5	0 / 5	0 / 5	0 / 5	No trend	No trend
	UNW-038	mg/L	20 / 20	10 / 10	--	**0.46**	**0.13**	**0.018**	0.1	3 / 20	1 / 10	4 / 20	1 / 10	Down	No trend
	UNW-038(F)	mg/L	15 / 20	10 / 10	0.005	0.014	0.013	0.01	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
	UNW-042	mg/L	5 / 6	4 / 5	0.001	**0.12**	**0.12**	**0.12**	0.1	1 / 6	1 / 5	1 / 6	1 / 5	No trend	No trend
	UNW-042(F)	mg/L	2 / 6	2 / 5	0.005	0.025	0.025	ND	0.1	0 / 6	0 / 5	0 / 6	0 / 5	No trend	No trend
	UNW-087	mg/L	5 / 5	5 / 5	--	**0.25**	**0.25**	**0.23**	0.1	5 / 5	5 / 5	5 / 5	5 / 5	No trend	No trend
	UNW-087(F)	mg/L	5 / 5	5 / 5	--	**0.26**	**0.26**	**0.22**	0.1	5 / 5	5 / 5	5 / 5	5 / 5	Stable	Stable
	UNW-088	mg/L	13 / 20	10 / 10	0.005	0.098	0.064	0.017	0.1	0 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	UNW-088(F)	mg/L	4 / 20	4 / 10	0.005	0.01	0.01	0.01	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
	UNW-096	mg/L	20 / 20	10 / 10	--	**0.16**	**0.16**	**0.16**	0.1	3 / 20	3 / 10	12 / 20	8 / 10	No trend	Up
	UNW-096(F)	mg/L	20 / 20	10 / 10	--	0.092	0.092	0.081	0.1	0 / 20	0 / 10	9 / 20	5 / 10	Stable	Stable

Table D.2. K-27/K-29 South to west plume pathway summary of groundwater contaminants and trends (cont.)

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Lead	BRW-057	mg/L	5 / 6	4 / 5	0.003	**1.1**	**1.1**	**1.1**	0.015	4 / 6	3 / 5	4 / 6	3 / 5	No trend	No trend
	BRW-057(F)	mg/L	0 / 6	0 / 5	0.003	ND	ND	ND	0.015	0 / 6	0 / 5	0 / 6	0 / 5	--	--
Mercury	UNW-088	mg/L	5 / 5	5 / 5	--	**0.004**	**0.004**	**0.004**	0.002	2 / 5	2 / 5	3 / 5	3 / 5	No trend	No trend
Nickel	BRW-057	mg/L	6 / 6	5 / 5	--	**0.38**	**0.38**	**0.38**	0.1	1 / 6	1 / 5	1 / 6	1 / 5	No trend	No trend
	BRW-057(F)	mg/L	0 / 6	0 / 5	0.01	ND	ND	ND	0.1	0 / 6	0 / 5	0 / 6	0 / 5	--	--
	UNW-037	mg/L	5 / 5	5 / 5	--	**0.23**	**0.23**	**0.093**	0.1	1 / 5	1 / 5	3 / 5	3 / 5	Stable	Stable
	UNW-037(F)	mg/L	4 / 5	4 / 5	0.003	0.017	0.017	0.006	0.1	0 / 5	0 / 5	0 / 5	0 / 5	Stable	Stable
	UNW-038	mg/L	16 / 20	7 / 10	0.01	**0.86**	**0.13**	**0.13**	0.1	4 / 20	2 / 10	5 / 20	3 / 10	No trend	No trend
	UNW-038(F)	mg/L	13 / 20	5 / 10	0.01	**0.85**	0.093	0.067	0.1	2 / 20	0 / 10	4 / 20	2 / 10	No trend	No trend
	UNW-087	mg/L	5 / 5	5 / 5	--	**0.097**	**0.097**	**0.011**	0.1	0 / 5	0 / 5	1 / 5	1 / 5	No trend	No trend
	UNW-087(F)	mg/L	3 / 5	3 / 5	0.003	0.041	0.041	ND	0.1	0 / 5	0 / 5	0 / 5	0 / 5	Down	Down
	UNW-088	mg/L	18 / 20	10 / 10	0.01	**0.1**	**0.1**	0.017	0.1	0 / 20	0 / 10	1 / 20	1 / 10	No trend	Stable
	UNW-088(F)	mg/L	18 / 20	10 / 10	0.01	0.093	0.093	0.015	0.1	0 / 20	0 / 10	1 / 20	1 / 10	Stable	Stable
	UNW-096	mg/L	8 / 20	8 / 10	0.01	**0.27**	**0.27**	**0.27**	0.1	3 / 20	3 / 10	3 / 20	3 / 10	Up	Up
	UNW-096(F)	mg/L	6 / 20	6 / 10	0.01	**0.23**	**0.23**	**0.23**	0.1	3 / 20	3 / 10	3 / 20	3 / 10	Up	Up
Trichloroethene	BRW-057	mg/L	3 / 6	3 / 5	0.001	**0.007**	**0.007**	0.00063	0.005	1 / 6	1 / 5	1 / 6	1 / 5	No trend	No trend
	BRW-069	mg/L	20 / 20	10 / 10	--	**0.016**	**0.016**	**0.015**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Stable
	UNW-037	mg/L	6 / 6	6 / 6	--	**0.039**	**0.039**	**0.039**	0.005	6 / 6	6 / 6	6 / 6	6 / 6	No trend	No trend
	UNW-038	mg/L	20 / 20	10 / 10	--	**0.135**	**0.1**	**0.083**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	Down
	UNW-041	mg/L	4 / 6	4 / 5	0.001	0.004	0.004	0.00066	0.005	0 / 6	0 / 5	1 / 6	1 / 5	Stable	Stable
	UNW-085	mg/L	15 / 15	10 / 10	--	**0.013**	**0.013**	**0.005**	0.005	11 / 15	7 / 10	13 / 15	9 / 10	No trend	No trend
	UNW-087	mg/L	14 / 14	10 / 10	--	**0.044**	**0.044**	**0.044**	0.005	10 / 14	6 / 10	11 / 14	7 / 10	Stable	No trend
	UNW-088	mg/L	20 / 20	10 / 10	--	**1.9**	**1.9**	**1.7**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
	UNW-096	mg/L	20 / 20	10 / 10	--	**0.026**	**0.026**	**0.026**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	No trend
Vinyl chloride	UNW-086	mg/L	13 / 14	10 / 10	0.001	**0.003**	**0.003**	**0.002**	0.002	1 / 14	1 / 10	6 / 14	6 / 10	No trend	No trend

[a]Wells shown on Figure D.2 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.

[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

Table D.2. K-27/K-29 South to west plume pathway summary of groundwater contaminants and trends (cont.)

[c]MCL as of May 2018.
[d]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.
(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

D.3 ETTP CENTRAL PLANT AREA PLUMES

The central plant area of ETTP includes the majority of the former gaseous diffusion process and support facilities including:

- the K-25 building
- the K-1401 and K-1420 decontamination facilities
- the K-1407-A neutralization facility
- K-1407-B liquid waste pond
- the K-1407-C pond sludge basin
- the K-1070-C/D waste burial ground
- groundwater contamination in the K-1004 administrative area

Figure D.3 shows groundwater plume evaluation areas, actively monitored wells in the area, and several VOC plume areas. In addition, Figure D.3 shows the Tc-99 plume beneath and adjacent to the southern portion of the K-25 Building East Wing. TCE is the principal chlorinated solvent that comprises the volatile organic compound (VOC) plume sources although lesser amounts of tetrachloroethene, 1,1,1-trichloroethane, and Freon-113 are present in selected areas. TCE-rich dense non-aqueous phase liquid (DNAPL) has been confirmed to be present beneath the former K-1401 facility where parts cleaning using vapor degreasing facilities occurred. DNAPL is suspected to be present in the central portion of the K-1070-C/D plume area based on liquid waste disposal records for the "G-Pit" site. On the basis of continuing high concentration TCE signatures in groundwater, DNAPL is also suspected to be present at the K-1070-C/D South/K-1200 area, the K-1035 site, and near Mitchell Branch related to the K-1407-A neutralization pit and/or the K-1407-B Pond. The Zone 2 remedial action (RA) program has identified a significant source of TCE beneath the center of the K-25 building where a soil RA will be required consistent with the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2). No monitoring wells exist in that area to allow ongoing groundwater sampling and thus no groundwater trend evaluations are possible in that area. The Tc-99 contamination beneath the K-25 Building East Wing is being remediated by excavation and much of the Tc-99 plume shown on figures is based on groundwater grab samples obtained from exploratory soil sample borings. Since these samples were obtained from uncased borings with no wells, there will not be further sampling of the locations to allow trend evaluation. Ongoing groundwater investigations in support of a groundwater feasibility study for the central plant area will include installation of wells that will provide the possibility of future monitoring at selected locations.

Five plume evaluation areas have been established within the central plant area (Figure D.3). Tables D.3 through D.7 include the results of the groundwater contaminant screening and trend evaluations for the five evaluation areas. For information concerning conditions at the K-1401 site, readers are referred to *Design Characterization Completion Report for the Sitewide Groundwater Treatability Study at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2768&D1) which includes the detailed characterization of the confirmed DNAPL source area.

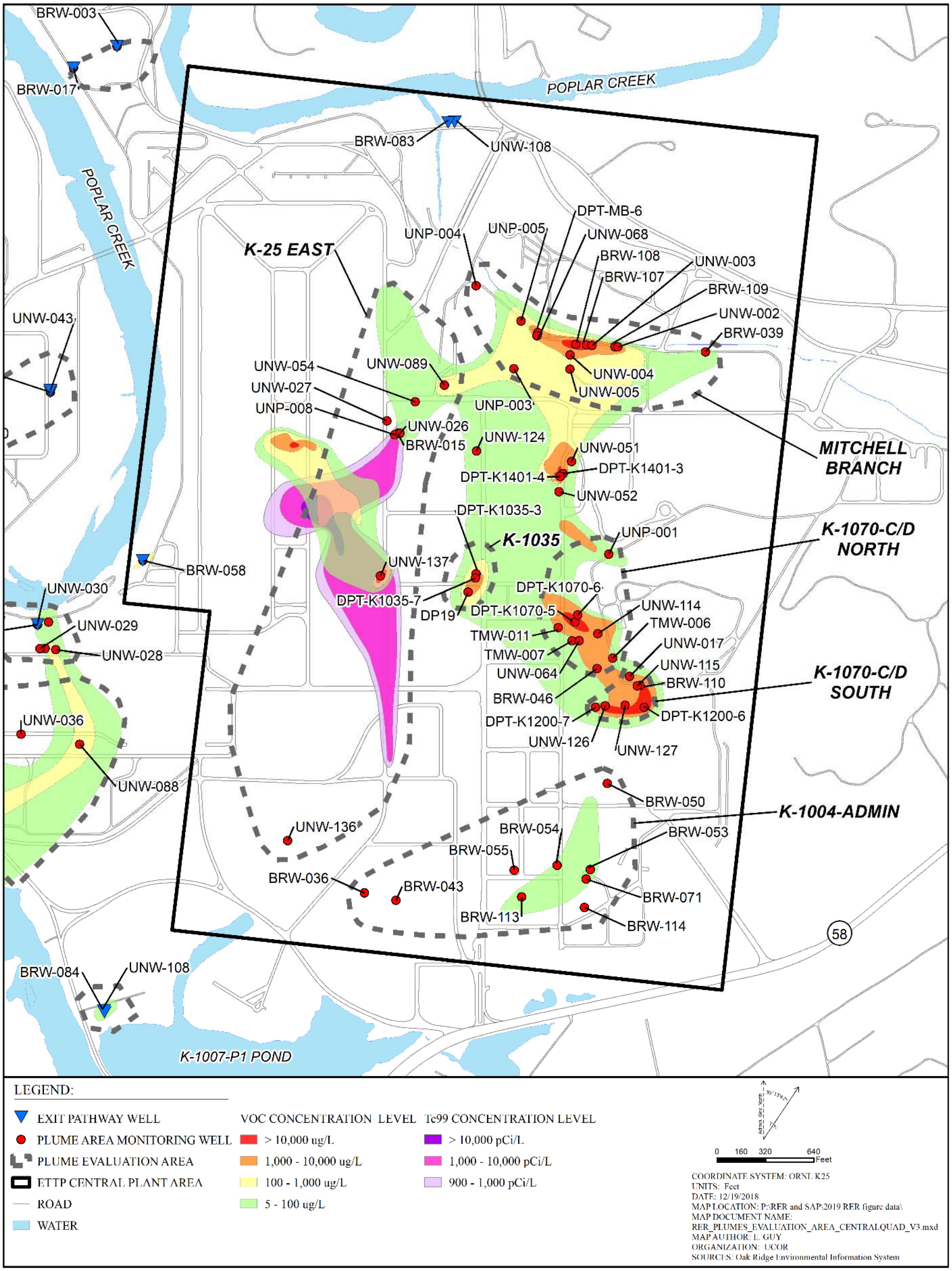

Figure D.3. Central Plant Area plumes.

Table D.3. Summary of K-25 East Wing area groundwater contaminants and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,1-Dichloroethene	UNW-054	mg/L	10 / 20	3 / 10	0.175	**0.007**	0.003	0.001	0.007	0 / 20	0 / 10	1 / 20	0 / 10	Down	No trend
Alpha activity	UNW-137	pCi/L	1 / 1	1 / 1	--	**13.5**	**13.5**	**13.5**	15	0 / 1	0 / 1	1 / 1	1 / 1	--	--
Chromium	UNW-026	mg/L	11 / 20	8 / 10	0.005	**0.27**	**0.27**	0.09	0.1	1 / 20	1 / 10	2 / 20	2 / 10	No trend	Up
	UNW-026(F)	mg/L	1 / 20	0 / 10	0.005	0.006	ND	ND	0.1	0 / 20	0 / 10	0 / 20	0 / 10	Stable	--
cis-1,2-Dichloroethene	UNW-054	mg/L	18 / 20	8 / 10	3.0E-04	**0.14**	**0.072**	0.05	0.07	8 / 20	1 / 10	9 / 20	1 / 10	Down	No trend
Lead	UNW-027	mg/L	14 / 20	6 / 10	0.003	**0.027**	**0.017**	0.003	0.015	4 / 20	2 / 10	4 / 20	2 / 10	No trend	Down
	UNW-027(F)	mg/L	2 / 20	1 / 10	0.003	0.016	0.00047	0.00047	0.015	1 / 20	0 / 10	1 / 20	0 / 10	No trend	Stable
Nickel	UNW-026	mg/L	9 / 20	9 / 10	0.01	**0.13**	**0.13**	0.049	0.1	1 / 20	1 / 10	1 / 20	1 / 10	Up	No trend
	UNW-026(F)	mg/L	8 / 20	8 / 10	0.01	0.035	0.035	0.015	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
Technetium-99	BRW-015	pCi/L	10 / 10	10 / 10	--	**7,430**	**7,430**	**2,180**	900	9 / 10	9 / 10	9 / 10	9 / 10	Stable	Stable
	UNP-008	pCi/L	10 / 10	10 / 10	--	**24,000**	**24,000**	802	900	8 / 10	8 / 10	9 / 10	9 / 10	Down	Down
	UNW-026	pCi/L	11 / 19	11 / 11	10.7	**16,200**	**16,200**	786	900	7 / 19	7 / 11	8 / 19	8 / 11	No trend	Down
	UNW-137	pCi/L	10 / 10	10 / 10	--	**16,300**	**16,300**	**4,300**	900	10 / 10	10 / 10	10 / 10	10 / 10	Down	Down
	UNW-144	pCi/L	12 / 12	12 / 12	--	**6,620**	**6,620**	**3,940**	900	11 / 12	11 / 12	11 / 12	11 / 12	Stable	Stable
	UNW-145	pCi/L	12 / 12	12 / 12	--	**3,150**	**3,150**	611	900	1 / 12	1 / 12	1 / 12	1 / 12	No trend	No trend
	UNW-146	pCi/L	12 / 12	12 / 12	--	830	830	830	900	0 / 12	0 / 12	1 / 12	1 / 12	Stable	Stable
Trichloroethene	BRW-119	mg/L	2 / 2	2 / 2	--	**0.012**	**0.012**	ND	0.005	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	BRW-120	mg/L	2 / 2	2 / 2	--	**0.033**	**0.033**	ND	0.005	1 / 2	1 / 2	1 / 2	1 / 2	No trend	No trend
	UNW-027	mg/L	19 / 20	9 / 10	0.001	**0.31**	**0.018**	**0.017**	0.005	12 / 20	4 / 10	12 / 20	4 / 10	Down	Up
	UNW-054	mg/L	20 / 20	10 / 10	--	**2**	**0.97**	**0.45**	0.005	15 / 20	5 / 10	15 / 20	5 / 10	Down	No trend
	UNW-089	mg/L	20 / 20	10 / 10	--	**0.36**	**0.23**	**0.18**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	No trend
	UNW-137	mg/L	10 / 10	10 / 10	--	**2.1**	**2.1**	**2.1**	0.005	10 / 10	10 / 10	10 / 10	10 / 10	No trend	No trend
	UNW-152	mg/L	1 / 1	1 / 1	--	**0.005**	**0.005**	ND	0.005	1 / 1	1 / 1	1 / 1	1 / 1	--	--
Vinyl chloride	UNW-054	mg/L	3 / 20	2 / 10	0.05	**0.005**	**0.005**	0.00046	0.002	2 / 20	1 / 10	2 / 20	1 / 10	No trend	No trend

Table D.3. Summary of K-25 East Wing area groundwater contaminants and trends (cont.)

[a]Wells shown on Figure D.3 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.
[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.
[c]MCL as of May 2018.
[d]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.
(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

Table D.4. Summary of K-1070-C/D South/K-1200 area groundwater contaminants and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,1,2-Trichloroethane	BRW-110	mg/L	1 / 20	0 / 10	0.04	**0.075**	ND	ND	0.005	1 / 20	0 / 10	1 / 20	0 / 10	No trend	--
1,1-Dichloroethene	DPT-K1200-6	mg/L	2 / 2	2 / 2	--	0.006	0.006	0.006	0.007	0 / 2	0 / 2	1 / 2	1 / 2	Stable	Stable
	UNW-017	mg/L	19 / 20	10 / 10	0.01	**0.04**	**0.023**	**0.016**	0.007	13 / 20	6 / 10	15 / 20	7 / 10	Stable	No trend
	UNW-126	mg/L	5 / 20	3 / 10	0.1	**0.126**	**0.062**	ND	0.007	5 / 20	3 / 10	5 / 20	3 / 10	No trend	No trend
	UNW-127	mg/L	5 / 20	3 / 10	0.088	**0.105**	**0.081**	ND	0.007	5 / 20	3 / 10	5 / 20	3 / 10	No trend	No trend
Benzene	DPT-K1200-7	mg/L	2 / 2	2 / 2	--	**0.005**	**0.005**	**0.005**	0.005	1 / 2	1 / 2	1 / 2	1 / 2	No trend	No trend
Carbon tetrachloride	DPT-K1200-7	mg/L	2 / 2	2 / 2	--	**0.057**	**0.057**	**0.057**	0.005	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
Chloroform	DPT-K1200-7	mg/L	2 / 2	2 / 2	--	**0.49**	**0.49**	**0.49**	0.08	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
cis-1,2-Dichloroethene	BRW-110	mg/L	20 / 20	10 / 10	--	**1.4**	**0.85**	**0.82**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	No trend	No trend
	DPT-K1200-6	mg/L	2 / 2	2 / 2	--	**0.4**	**0.4**	**0.4**	0.07	2 / 2	2 / 2	2 / 2	2 / 2	No trend	No trend
	UNW-017	mg/L	20 / 20	10 / 10	--	**1.1**	**0.51**	**0.31**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Stable
	UNW-115	mg/L	20 / 20	10 / 10	--	**0.18**	**0.18**	**0.16**	0.07	7 / 20	7 / 10	12 / 20	10 / 10	Up	Up
	UNW-126	mg/L	17 / 20	9 / 10	0.5	**0.092**	**0.023**	**0.023**	0.07	5 / 20	0 / 10	6 / 20	0 / 10	No trend	Up
	UNW-127	mg/L	16 / 20	10 / 10	0.062	**0.093**	**0.093**	**0.041**	0.07	6 / 20	4 / 10	8 / 20	6 / 10	No trend	Stable
Methylene chloride	BRW-110	mg/L	1 / 20	0 / 10	0.04	**0.01**	ND	ND	0.005	1 / 20	0 / 10	1 / 20	0 / 10	No trend	--
	DPT-K1200-7	mg/L	2 / 2	2 / 2	--	**0.009**	**0.009**	**0.009**	0.005	1 / 2	1 / 2	1 / 2	1 / 2	No trend	No trend
	UNW-126	mg/L	3 / 20	2 / 10	0.25	**0.005**	**0.005**	ND	0.005	0 / 20	0 / 10	1 / 20	1 / 10	No trend	No trend
	UNW-127	mg/L	7 / 20	4 / 10	0.063	**1.64**	0.002	ND	0.005	2 / 20	0 / 10	3 / 20	0 / 10	No trend	Stable
Tetrachloroethene	BRW-110	mg/L	20 / 20	10 / 10	--	**8.61**	**0.59**	**0.33**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	Down
	DPT-K1200-6	mg/L	2 / 2	2 / 2	--	**0.24**	**0.24**	**0.24**	0.005	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	UNW-017	mg/L	20 / 20	10 / 10	--	**0.26**	**0.26**	**0.023**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	No trend	No trend
	UNW-115	mg/L	20 / 20	10 / 10	--	**0.066**	**0.066**	**0.066**	0.005	19 / 20	10 / 10	19 / 20	10 / 10	Up	Up
	UNW-126	mg/L	20 / 20	10 / 10	--	**3.3**	**2.2**	**2.2**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Stable
	UNW-127	mg/L	19 / 20	9 / 10	2.0E-04	**5.6**	**1.8**	**0.34**	0.005	19 / 20	9 / 10	19 / 20	9 / 10	Down	Stable

Table D.4. Summary of K-1070-C/D South/K-1200 area groundwater contaminants and trends (cont.)

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Trichloroethene	BRW-110	mg/L	20 / 20	10 / 10	--	**0.474**	**0.17**	**0.12**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	Down
	DPT-K1200-6	mg/L	2 / 2	2 / 2	--	**0.75**	**0.75**	**0.75**	0.005	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	DPT-K1200-7	mg/L	2 / 2	2 / 2	--	**0.029**	**0.029**	**0.029**	0.005	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	UNW-017	mg/L	20 / 20	10 / 10	--	**0.79**	**0.23**	**0.11**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
	UNW-115	mg/L	20 / 20	10 / 10	--	**0.39**	**0.39**	**0.39**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	Up
	UNW-126	mg/L	20 / 20	10 / 10	--	**0.277**	**0.12**	**0.1**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	Stable
	UNW-127	mg/L	20 / 20	10 / 10	--	**0.19**	**0.19**	**0.054**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Stable
Vinyl chloride	BRW-110	mg/L	9 / 20	8 / 10	0.04	**0.004**	**0.004**	**0.004**	0.002	1 / 20	1 / 10	1 / 20	1 / 10	No trend	Up

[a]Wells shown on Figure D.3 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.
[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.
[c]MCL as of May 2018.
[d]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.
(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

Table D.5. Summary of K-1004 Administrative area groundwater contamination and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Tetrachloroethene	BRW-054	mg/L	13 / 20	8 / 10	0.003	**0.01**	0.004	0.004	0.005	1 / 20	0 / 10	1 / 20	0 / 10	No trend	Up
	BRW-113	mg/L	20 / 20	10 / 10	--	**0.031**	**0.028**	**0.021**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Stable
Trichloroethene	BRW-036	mg/L	9 / 9	9 / 9	--	**0.005**	**0.005**	0.004	0.005	0 / 9	0 / 9	2 / 9	2 / 9	Up	Up
	BRW-053	mg/L	15 / 15	10 / 10	--	**0.038**	**0.033**	0.003	0.005	8 / 15	3 / 10	8 / 15	3 / 10	Down	No trend
	BRW-054	mg/L	20 / 20	10 / 10	--	**0.02**	**0.007**	**0.007**	0.005	11 / 20	5 / 10	16 / 20	9 / 10	Stable	Up
	BRW-071	mg/L	10 / 20	8 / 10	0.003	0.004	0.003	0.003	0.005	0 / 20	0 / 10	1 / 20	0 / 10	No trend	Up
	BRW-113	mg/L	20 / 20	10 / 10	--	**0.048**	**0.048**	**0.036**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
Vinyl chloride	BRW-053	mg/L	13 / 15	9 / 10	0.001	**0.003**	**0.002**	**0.002**	0.002	4 / 15	1 / 10	6 / 15	2 / 10	Stable	Stable

[a]Wells shown on Figure D.3 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.
[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.
[c]MCL as of May 2018.
[d]Significant linear trend from the M-K test at the 0.10 significance level.

Bold table entries indicate results that exceed MCL or MCL-DC values.
(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

Table D.6. Summary of K-1035 area groundwater contamination and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,1,2-Trichloroethane	DP19	mg/L	16 / 19	9 / 9	0.005	**0.007**	**0.007**	**0.006**	0.005	7 / 19	6 / 9	12 / 19	9 / 9	Up	Up
1,1-Dichloroethene	DPT-K1025-7	mg/L	2 / 2	2 / 2	--	**0.028**	**0.028**	**0.028**	0.007	1 / 2	1 / 2	1 / 2	1 / 2	No trend	No trend
	DPT-K1035-5	mg/L	19 / 20	10 / 10	0.004	**0.03**	**0.029**	**0.017**	0.007	13 / 20	8 / 10	13 / 20	8 / 10	Up	Stable
Arsenic	DP19	mg/L	4 / 19	3 / 9	0.005	**0.017**	**0.017**	0.005	0.01	2 / 19	1 / 9	3 / 19	2 / 9	No trend	No trend
	DP19(F)	mg/L	0 / 19	0 / 9	0.005	ND	ND	ND	0.01	0 / 19	0 / 9	0 / 19	0 / 9	--	--
	DPT-K1035-7	mg/L	2 / 2	2 / 2	--	**0.015**	**0.015**	**0.015**	0.01	1 / 2	1 / 2	2 / 2	2 / 2	Stable	Stable
	DPT-K1035-7(F)	mg/L	0 / 2	0 / 2	0.003	ND	ND	ND	0.01	0 / 2	0 / 2	0 / 2	0 / 2	--	--
	DPT-K1035-5	mg/L	5 / 20	3 / 10	0.005	**0.01**	**0.01**	0.004	0.01	0 / 20	0 / 10	1 / 20	1 / 10	Stable	Stable
	DPT-K1035-5(F)	mg/L	3 / 20	3 / 10	0.015	0.004	0.004	0.004	0.01	0 / 20	0 / 10	0 / 20	0 / 10	Stable	Stable
Beryllium	DP19	mg/L	17 / 19	8 / 9	0.001	**0.02**	**0.017**	0.003	0.004	8 / 19	4 / 9	10 / 19	4 / 9	No trend	No trend
	DP19(F)	mg/L	0 / 19	0 / 9	0.001	ND	ND	ND	0.004	0 / 19	0 / 9	0 / 19	0 / 9	--	--
Cadmium	DP19	mg/L	17 / 19	7 / 9	1.3E-04	**0.006**	**0.005**	0.00068	0.005	1 / 19	0 / 9	2 / 19	1 / 9	Stable	No trend
	DP19(F)	mg/L	2 / 19	0 / 9	1.3E-04	0.00018	ND	ND	0.005	0 / 19	0 / 9	0 / 19	0 / 9	Stable	--
Chromium	DPT-K1035-7	mg/L	2 / 2	2 / 2	--	**0.21**	**0.21**	**0.21**	0.1	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	DPT-K1035-7(F)	mg/L	2 / 2	2 / 2	--	0.045	0.045	0.045	0.1	0 / 2	0 / 2	0 / 2	0 / 2	Stable	Stable
cis-1,2-Dichloroethene	DPT-K1035-5	mg/L	14 / 20	9 / 10	0.005	**1.1**	**1.1**	0.002	0.07	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
Lead	DP19	mg/L	15 / 19	7 / 9	0.003	**0.056**	**0.047**	0.009	0.015	6 / 19	4 / 9	6 / 19	4 / 9	No trend	No trend
	DP19(F)	mg/L	0 / 19	0 / 9	0.003	ND	ND	ND	0.015	0 / 19	0 / 9	0 / 19	0 / 9	--	--
	DPT-K1035-7	mg/L	2 / 2	2 / 2	--	**0.13**	**0.13**	**0.13**	0.015	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	DPT-K1035-7(F)	mg/L	0 / 2	0 / 2	0.002	ND	ND	ND	0.015	0 / 2	0 / 2	0 / 2	0 / 2	--	--
	DPT-K1035-5	mg/L	12 / 20	5 / 10	0.003	**0.02**	**0.02**	0.005	0.015	1 / 20	1 / 10	2 / 20	1 / 10	Stable	No trend
	DPT-K1035-5(F)	mg/L	1 / 20	1 / 10	0.006	0.00066	0.00066	0.00066	0.015	0 / 20	0 / 10	0 / 20	0 / 10	Stable	Stable

Table D.6. Summary of K-1035 area groundwater contamination and trends (cont.)

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Nickel	DP19	mg/L	16 / 19	8 / 9	0.01	**0.18**	**0.13**	0.027	0.1	2 / 19	1 / 9	3 / 19	2 / 9	No trend	Stable
	DP19(F)	mg/L	0 / 19	0 / 9	0.01	ND	ND	ND	0.1	0 / 19	0 / 9	0 / 19	0 / 9	--	--
	DPT-K1035-7	mg/L	2 / 2	2 / 2	--	**0.45**	**0.45**	**0.45**	0.1	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	DPT-K1035-7(F)	mg/L	1 / 2	1 / 2	0.003	0.002	0.002	0.002	0.1	0 / 2	0 / 2	0 / 2	0 / 2	Stable	Stable
Tetrachloroethene	DPT-K1035-7	mg/L	2 / 2	2 / 2	--	**0.034**	**0.034**	**0.034**	0.005	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	DPT-K1035-5	mg/L	19 / 20	10 / 10	0.003	**0.061**	**0.061**	**0.039**	0.005	17 / 20	9 / 10	18 / 20	9 / 10	No trend	No trend
Thallium	DPT-K1035-7	mg/L	2 / 2	2 / 2	--	**0.003**	**0.003**	**0.003**	0.002	1 / 2	1 / 2	1 / 2	1 / 2	Stable	Stable
	DPT-K1035-7(F)	mg/L	1 / 2	1 / 2	0.000004	0.00002	0.00002	0.00002	0.002	0 / 2	0 / 2	0 / 2	0 / 2	No trend	No trend
Trichloroethene	DP19	mg/L	19 / 19	9 / 9	--	**1.4**	**1.4**	**0.98**	0.005	19 / 19	9 / 9	19 / 19	9 / 9	Up	No trend
	DPT-K1035-7	mg/L	2 / 2	2 / 2	--	**1.3**	**1.3**	**1.3**	0.005	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	DPT-K1035-5	mg/L	20 / 20	10 / 10	--	**0.55**	**0.55**	**0.33**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	No trend
Vinyl chloride	DPT-K1035-5	mg/L	1 / 20	1 / 10	0.001	**0.07**	**0.07**	ND	0.002	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend

[a]Wells shown on Figure D.3 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.
[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.
[c]MCL as of May 2018.
[d]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.
(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
DPT =Direct Push Technology well
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

Table D.7. Summary of Mitchell Branch area groundwater contaminants and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,1,1-Trichloroethane	BRW-007	mg/L	19 / 20	10 / 10	0.02	0.164	0.11	0.11	0.2	0 / 20	0 / 10	1 / 20	0 / 10	Down	No trend
	BRW-108	mg/L	17 / 20	10 / 10	0.5	0.19	0.19	0.11	0.2	0 / 20	0 / 10	3 / 20	3 / 10	No trend	Down
1,1-Dichloroethene	BRW-007	mg/L	20 / 20	10 / 10	--	**0.85**	**0.85**	**0.85**	0.007	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Up
	BRW-108	mg/L	18 / 20	10 / 10	0.35	**3.6**	**3.6**	**3.6**	0.007	18 / 20	10 / 10	18 / 20	10 / 10	Up	Stable
	BRW-109	mg/L	17 / 20	10 / 10	0.7	**0.012**	**0.012**	**0.011**	0.007	12 / 20	7 / 10	13 / 20	7 / 10	No trend	Stable
	DPT-MB-6	mg/L	2 / 2	2 / 2	--	**0.016**	**0.016**	**0.016**	0.007	1 / 2	1 / 2	2 / 2	2 / 2	No trend	No trend
	UNW-002	mg/L	19 / 20	9 / 10	0.002	**0.007**	0.006	0.002	0.007	0 / 20	0 / 10	4 / 20	2 / 10	Stable	Down
	UNW-003	mg/L	20 / 20	10 / 10	--	**1.6**	**1.6**	**0.6**	0.007	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Down
	UNW-004	mg/L	18 / 20	10 / 10	0.07	**0.56**	**0.56**	**0.56**	0.007	18 / 20	10 / 10	18 / 20	10 / 10	No trend	No trend
	UNW-005	mg/L	2 / 2	2 / 2	--	**0.007**	**0.007**	0.002	0.007	0 / 2	0 / 2	1 / 2	1 / 2	Stable	Stable
	UNW-068	mg/L	18 / 20	9 / 10	0.014	**0.029**	**0.029**	**0.023**	0.007	16 / 20	9 / 10	17 / 20	9 / 10	Up	Stable
1,2-Dichloroethane	BRW-007	mg/L	7 / 20	5 / 10	0.05	**0.011**	**0.009**	**0.009**	0.005	7 / 20	5 / 10	7 / 20	5 / 10	Stable	No trend
	UNW-003	mg/L	15 / 20	10 / 10	0.125	**0.031**	**0.031**	**0.013**	0.005	13 / 20	8 / 10	13 / 20	8 / 10	No trend	Stable
Alpha activity	UNP-004	pCi/L	16 / 18	9 / 10	2.52	**21.3**	**21.3**	**21.3**	15	1 / 18	1 / 10	1 / 18	1 / 10	No trend	No trend
	UNP-005	pCi/L	16 / 18	9 / 10	5.47	**110**	**39.9**	**15.6**	15	6 / 18	4 / 10	7 / 18	4 / 10	No trend	Stable
	UNW-003	pCi/L	19 / 20	9 / 10	3.85	14	8.7	6	15	0 / 20	0 / 10	1 / 20	0 / 10	Stable	Stable
	UNW-068	pCi/L	14 / 18	8 / 10	3.34	**17.3**	7.37	2.11	15	3 / 18	0 / 10	3 / 18	0 / 10	Down	Stable
Arsenic	UNP-004	mg/L	2 / 18	2 / 10	0.005	0.009	0.009	ND	0.01	0 / 18	0 / 10	1 / 18	1 / 10	Stable	Stable
	UNP-004(F)	mg/L	1 / 18	1 / 10	0.005	0.002	0.002	0.002	0.01	0 / 18	0 / 10	0 / 18	0 / 10	Stable	Stable
	UNP-005	mg/L	7 / 18	6 / 10	0.005	**0.022**	**0.01**	0.006	0.01	1 / 18	0 / 10	2 / 18	1 / 10	No trend	Stable
	UNP-005(F)	mg/L	1 / 18	1 / 10	0.005	0.004	0.004	ND	0.01	0 / 18	0 / 10	0 / 18	0 / 10	No trend	No trend
	UNW-003	mg/L	3 / 20	3 / 10	0.005	0.008	0.008	0.004	0.01	0 / 20	0 / 10	1 / 20	1 / 10	No trend	Stable
	UNW-003(F)	mg/L	0 / 20	0 / 10	0.005	ND	ND	ND	0.01	0 / 20	0 / 10	0 / 20	0 / 10	--	--
Cadmium	UNP-005	mg/L	18 / 18	10 / 10	--	**0.008**	0.003	0.002	0.005	1 / 18	0 / 10	1 / 18	0 / 10	No trend	No trend
	UNP-005(F)	mg/L	10 / 18	7 / 10	0.00013	0.00030	0.00030	0.00020	0.005	0 / 18	0 / 10	0 / 18	0 / 10	Stable	Stable

Table D.7. Summary of Mitchell Branch area groundwater contaminants and trends (cont.)

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
cis-1,2-Dichloroethene	BRW-007	mg/L	20 / 20	10 / 10	--	**19**	**19**	**19**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Up
	BRW-108	mg/L	20 / 20	10 / 10	--	**28**	**28**	**24**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	Up	Stable
	BRW-109	mg/L	20 / 20	10 / 10	--	**0.86**	**0.68**	**0.63**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	Stable	No trend
	DPT-MB-6	mg/L	2 / 2	2 / 2	--	**0.23**	**0.23**	**0.23**	0.07	2 / 2	2 / 2	2 / 2	2 / 2	No trend	No trend
	UNP-003	mg/L	20 / 20	10 / 10	--	**0.27**	**0.18**	**0.17**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	Down	No trend
	UNP-004	mg/L	19 / 20	9 / 10	0.00033	**0.8**	**0.078**	0.00094	0.07	10 / 20	1 / 10	10 / 20	1 / 10	Down	Down
	UNP-005	mg/L	19 / 20	10 / 10	0.005	**0.25**	0.032	0.002	0.07	2 / 20	0 / 10	3 / 20	0 / 10	No trend	No trend
	UNW-002	mg/L	20 / 20	10 / 10	--	**0.17**	**0.17**	**0.17**	0.07	16 / 20	6 / 10	18 / 20	8 / 10	Down	No trend
	UNW-003	mg/L	20 / 20	10 / 10	--	**3.4**	**3.4**	**2.3**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Stable
	UNW-004	mg/L	20 / 20	10 / 10	--	**1.3**	**0.96**	**0.96**	0.07	19 / 20	9 / 10	19 / 20	9 / 10	Stable	No trend
	UNW-005	mg/L	2 / 2	2 / 2	--	**0.51**	**0.51**	**0.31**	0.07	2 / 2	2 / 2	2 / 2	2 / 2	Stable	Stable
	UNW-068	mg/L	20 / 20	10 / 10	--	**1.2**	**1.2**	**1.2**	0.07	20 / 20	10 / 10	20 / 20	10 / 10	Up	Up
Lead	UNP-004	mg/L	3 / 18	3 / 10	0.003	**0.021**	**0.021**	0.003	0.015	1 / 18	1 / 10	1 / 18	1 / 10	No trend	No trend
	UNP-004(F)	mg/L	0 / 18	0 / 10	0.003	ND	ND	ND	0.015	0 / 18	0 / 10	0 / 18	0 / 10	--	--
	UNP-005	mg/L	8 / 18	4 / 10	0.003	**0.074**	0.01	0.01	0.015	1 / 18	0 / 10	1 / 18	0 / 10	No trend	No trend
	UNP-005(F)	mg/L	0 / 18	0 / 10	0.003	ND	ND	ND	0.015	0 / 18	0 / 10	0 / 18	0 / 10	--	--
Methylene chloride	BRW-007	mg/L	1 / 20	1 / 10	0.05	**0.016**	**0.016**	**0.016**	0.005	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
	BRW-108	mg/L	3 / 20	3 / 10	0.31	**0.067**	**0.067**	**0.033**	0.005	3 / 20	3 / 10	3 / 20	3 / 10	No trend	No trend
	UNP-003	mg/L	1 / 20	1 / 10	0.025	**0.009**	**0.009**	**0.009**	0.005	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
	UNW-003	mg/L	1 / 20	1 / 10	0.125	0.004	0.004	ND	0.005	0 / 20	0 / 10	1 / 20	1 / 10	No trend	Stable
	UNW-004	mg/L	1 / 20	1 / 10	0.05	**0.007**	**0.007**	**0.007**	0.005	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
	UNW-005	mg/L	1 / 2	1 / 2	0.001	**0.006**	**0.006**	**0.006**	0.005	1 / 2	1 / 2	1 / 2	1 / 2	No trend	No trend
Nickel	UNP-005	mg/L	14 / 18	9 / 10	0.01	**0.22**	**0.11**	**0.11**	0.1	3 / 18	2 / 10	4 / 18	3 / 10	Up	No trend
	UNP-005(F)	mg/L	7 / 18	7 / 10	0.01	0.007	0.007	0.005	0.1	0 / 18	0 / 10	0 / 18	0 / 10	No trend	No trend
Tetrachloroethene	BRW-007	mg/L	20 / 20	10 / 10	--	**3.85**	**1.9**	**1.9**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	No trend
	BRW-039	mg/L	2 / 17	0 / 7	0.003	**0.013**	ND	ND	0.005	1 / 17	0 / 7	2 / 17	0 / 7	No trend	--
	BRW-108	mg/L	14 / 20	10 / 10	0.31	**0.2**	**0.054**	**0.042**	0.005	14 / 20	10 / 10	14 / 20	10 / 10	No trend	Stable
	UNW-002	mg/L	20 / 20	10 / 10	--	**0.082**	**0.078**	**0.037**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Down

Table D.7. Summary of Mitchell Branch area groundwater contaminants and trends (cont.)

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
	UNW-003	mg/L	20 / 20	10 / 10	--	**1**	**1**	**0.45**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	No trend	Stable
	UNW-004	mg/L	15 / 20	9 / 10	0.05	**0.04**	**0.04**	**0.038**	0.005	3 / 20	2 / 10	3 / 20	2 / 10	no trend	no trend
trans-1,2-Dichloroethene	BRW-108	mg/L	17 / 20	10 / 10	0.5	**0.65**	**0.65**	**0.65**	0.1	14 / 20	10 / 10	16 / 20	10 / 10	Up	no trend
Trichloroethene	BRW-007	mg/L	20 / 20	10 / 10	--	**24**	**24**	**24**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	no trend	Up
	BRW-108	mg/L	20 / 20	10 / 10	--	**53**	**53**	**51**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	stable
	BRW-109	mg/L	20 / 20	10 / 10	--	**4.73**	**3.7**	**3.5**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	stable
	DPT-MB-6	mg/L	2 / 2	2 / 2	--	**0.1**	**0.1**	**0.1**	0.005	2 / 2	2 / 2	2 / 2	2 / 2	no trend	no trend
	UNP-003	mg/L	20 / 20	10 / 10	--	**0.111**	**0.088**	**0.088**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Down	no trend
	UNP-004	mg/L	20 / 20	10 / 10	--	**0.54**	**0.043**	**0.002**	0.005	15 / 20	5 / 10	15 / 20	5 / 10	Down	Down
	UNP-005	mg/L	13 / 20	8 / 10	0.003	**0.006**	**0.004**	**0.002**	0.005	2 / 20	0 / 10	2 / 20	0 / 10	no trend	no trend
	UNW-002	mg/L	20 / 20	10 / 10	--	**0.19**	**0.17**	**0.051**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	stable	Down
	UNW-003	mg/L	20 / 20	10 / 10	--	**8.3**	**8.3**	**3.8**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	stable
	UNW-004	mg/L	19 / 20	10 / 10	0.05	**0.68**	**0.68**	**0.68**	0.005	19 / 20	10 / 10	19 / 20	10 / 10	Down	no trend
	UNW-005	mg/L	2 / 2	2 / 2	--	**0.011**	**0.011**	**0.003**	0.005	1 / 2	1 / 2	1 / 2	1 / 2	stable	stable
	UNW-068	mg/L	20 / 20	10 / 10	--	**0.83**	**0.83**	**0.83**	0.005	20 / 20	10 / 10	20 / 20	10 / 10	Up	Up
Vinyl chloride	BRW-007	mg/L	20 / 20	10 / 10	--	**0.58**	**0.58**	**0.58**	0.002	20 / 20	10 / 10	20 / 20	10 / 10	Up	Up
	BRW-108	mg/L	16 / 20	10 / 10	0.31	**3.2**	**3.2**	**3.2**	0.002	16 / 20	10 / 10	16 / 20	10 / 10	Up	no trend
	BRW-109	mg/L	12 / 20	8 / 10	0.2	**0.015**	**0.009**	**0.008**	0.002	10 / 20	7 / 10	11 / 20	8 / 10	no trend	no trend
	DPT-MB-6	mg/L	2 / 2	2 / 2	--	**0.031**	**0.031**	**0.031**	0.002	2 / 2	2 / 2	2 / 2	2 / 2	no trend	no trend
	UNP-003	mg/L	20 / 20	10 / 10	--	**0.054**	**0.037**	**0.037**	0.002	20 / 20	10 / 10	20 / 20	10 / 10	Down	no trend
	UNP-004	mg/L	6 / 20	0 / 10	0.05	**0.018**	ND	ND	0.002	4 / 20	0 / 10	4 / 20	0 / 10	Down	--
	UNP-005	mg/L	18 / 20	10 / 10	0.001	**0.064**	**0.017**	0.002	0.002	11 / 20	5 / 10	12 / 20	5 / 10	no trend	no trend
	UNW-002	mg/L	20 / 20	10 / 10	--	**0.021**	**0.021**	**0.021**	0.002	19 / 20	9 / 10	19 / 20	9 / 10	Up	no trend
	UNW-003	mg/L	19 / 20	10 / 10	0.05	**0.15**	**0.15**	**0.079**	0.002	19 / 20	10 / 10	19 / 20	10 / 10	no trend	Down
	UNW-004	mg/L	19 / 20	9 / 10	3.0E-04	**0.099**	**0.075**	**0.075**	0.002	19 / 20	9 / 10	19 / 20	9 / 10	stable	no trend
	UNW-005	mg/L	2 / 2	2 / 2	--	**0.12**	**0.12**	**0.1**	0.002	2 / 2	2 / 2	2 / 2	2 / 2	stable	stable
	UNW-068	mg/L	20 / 20	10 / 10	--	**0.083**	**0.083**	**0.078**	0.002	20 / 20	10 / 10	20 / 20	10 / 10	Up	Up

[a]Wells shown on Figure D.3 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.

Table D.7. Summary of Mitchell Branch area groundwater contaminants and trends (cont.)

[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[c]MCL as of May 2018.

[d]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.

(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
DPT =Direct Push Technology well
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected -- = not applicable

D.4 ETTP NORTHWEST QUADRANT

The ETTP Northwest Quadrant includes former K-1070-A burial ground, the K-31/K-33 area, K-1064, and the K-901 Pond. Figure D.4 shows the groundwater plume evaluation areas, actively monitored wells in the area, and the VOC plume at K-1070-A. The K-1070-A burial ground was remediated by excavation of buried waste materials in the early 2000's and a TCE-dominated groundwater plume remains. At the K-1064 site, various waste handling and material storage activities occurred during the gaseous diffusion process operations and low concentration residual groundwater contaminants include arsenic and TCE. The K-31 and K-33 buildings were gaseous diffusion process buildings that have undergone decontamination and decommissioning. The principal groundwater contaminants at K-31/K-33 are metals that have mostly decreased in concentration to levels less than their MCLs. At the K-901 groundwater exit pathway, the only groundwater contaminant that has been present at greater than 80% of its MCL within the past decade is alpha activity which has decreased in concentration to levels less than 50% of the MCL or non-detectable levels.

Table D.8 presents summaries of the groundwater contaminant screening and trend evaluations for the K-1070-A plume area. Table D.9 presents summaries of the groundwater contaminant screening and trend evaluations for the K-901, K-31/K-33, and K-1064 areas.

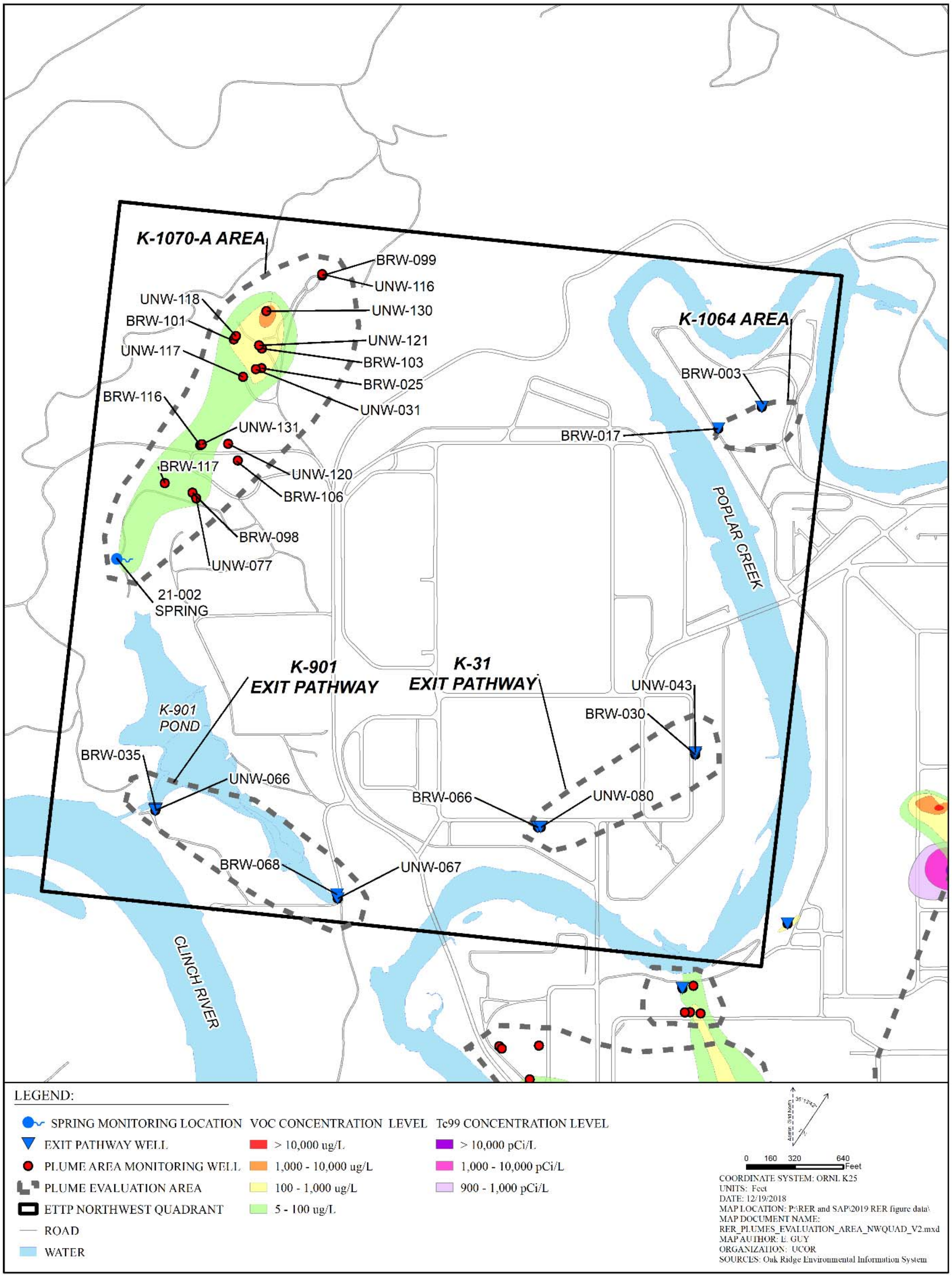

Figure D.4. Northwest quadrant plume areas and active monitoring wells.

Table D.8. Summary of K-1070-A groundwater contamination and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
1,1-Dichloroethene	BRW-025	mg/L	21 / 21	10 / 10	--	**0.022**	**0.02**	**0.014**	0.007	21 / 21	10 / 10	21 / 21	10 / 10	Stable	Stable
	BRW-101	mg/L	21 / 21	10 / 10	--	**0.019**	**0.018**	**0.018**	0.007	18 / 21	9 / 10	20 / 21	10 / 10	No trend	No trend
	BRW-117	mg/L	13 / 13	10 / 10	--	**0.007**	0.005	0.003	0.007	0 / 13	0 / 10	1 / 13	0 / 10	Stable	Stable
	UNW-031	mg/L	21 / 21	10 / 10	--	**0.097**	**0.097**	**0.097**	0.007	19 / 21	10 / 10	20 / 21	10 / 10	No trend	No trend
	UNW-117	mg/L	19 / 19	10 / 10	--	**0.055**	**0.046**	**0.041**	0.007	19 / 19	10 / 10	19 / 19	10 / 10	Stable	Stable
	UNW-118	mg/L	19 / 21	10 / 10	0.004	**0.039**	**0.039**	**0.039**	0.007	18 / 21	10 / 10	19 / 21	10 / 10	Up	Up
	UNW-121	mg/L	21 / 21	10 / 10	--	**0.055**	**0.031**	**0.031**	0.007	21 / 21	10 / 10	21 / 21	10 / 10	Down	Stable
	UNW-130	mg/L	13 / 13	10 / 10	--	**0.97**	**0.97**	**0.74**	0.007	13 / 13	10 / 10	13 / 13	10 / 10	Stable	Stable
Alpha activity	BRW-025	pCi/L	1 / 1	--	--	**12.4**	ND	ND	15	0 / 1	--	1 / 1	--	--	--
	UNW-120	pCi/L	1 / 1	--	--	**85.7**	ND	ND	15	1 / 1	--	1 / 1	--	--	--
Benzene	UNW-130	mg/L	9 / 13	9 / 10	0.005	**0.005**	**0.005**	0.002	0.005	0 / 13	0 / 10	2 / 13	2 / 10	Down	Down
Carbon tetrachloride	BRW-025	mg/L	21 / 21	10 / 10	--	**0.027**	**0.023**	**0.014**	0.005	21 / 21	10 / 10	21 / 21	10 / 10	Down	Stable
	BRW-101	mg/L	21 / 21	10 / 10	--	**0.031**	**0.016**	**0.014**	0.005	20 / 21	10 / 10	20 / 21	10 / 10	Down	Stable
	BRW-103	mg/L	21 / 21	10 / 10	--	**0.038**	**0.038**	**0.022**	0.005	21 / 21	10 / 10	21 / 21	10 / 10	No trend	No trend
	BRW-116	mg/L	12 / 13	9 / 10	0.00015	**0.005**	0.003	0.003	0.005	0 / 13	0 / 10	1 / 13	0 / 10	Stable	No trend
	BRW-117	mg/L	13 / 13	10 / 10	--	**0.006**	**0.005**	0.004	0.005	1 / 13	0 / 10	5 / 13	3 / 10	Stable	No trend
	UNW-031	mg/L	21 / 21	10 / 10	--	**0.007**	**0.007**	**0.007**	0.005	1 / 21	1 / 10	1 / 21	1 / 10	Stable	No trend
	UNW-130	mg/L	13 / 13	10 / 10	--	**0.34**	**0.34**	**0.25**	0.005	13 / 13	10 / 10	13 / 13	10 / 10	No trend	Stable
	UNW-131	mg/L	10 / 13	9 / 10	0.001	**0.005**	**0.005**	0.004	0.005	1 / 13	1 / 10	2 / 13	2 / 10	Up	Up
Chloroform	UNW-130	mg/L	13 / 13	10 / 10	--	**0.21**	**0.21**	**0.17**	0.08	13 / 13	10 / 10	13 / 13	10 / 10	Stable	Stable
Chromium	UNW-031	mg/L	20 / 20	10 / 10	--	**0.22**	**0.22**	**0.16**	0.1	6 / 20	4 / 10	9 / 20	4 / 10	Stable	Stable
	UNW-031(F)	mg/L	19 / 20	10 / 10	0.005	0.017	0.015	0.015	0.1	0 / 20	0 / 10	0 / 20	0 / 10	Stable	No trend
Lead	UNW-116	mg/L	3 / 14	3 / 9	0.003	**0.016**	**0.016**	**0.009**	0.015	1 / 14	1 / 9	1 / 14	1 / 9	No trend	No trend
	UNW-116(F)	mg/L	0 / 14	0 / 9	0.003	ND	ND	ND	0.015	0 / 14	0 / 9	0 / 14	0 / 9	--	--
Nickel	UNW-031	mg/L	20 / 20	10 / 10	--	**0.45**	**0.11**	0.095	0.1	9 / 20	1 / 10	13 / 20	4 / 10	Down	Stable
	UNW-031(F)	mg/L	20 / 20	10 / 10	--	**0.41**	**0.12**	0.091	0.1	9 / 20	1 / 10	13 / 20	4 / 10	Down	Stable

Table D.8. Summary of K-1070-A groundwater contamination and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Tetrachloroethene	BRW-103	mg/L	20 / 21	10 / 10	0.001	**0.005**	**0.005**	0.003	0.005	0 / 21	0 / 10	1 / 21	1 / 10	Up	No trend
	UNW-130	mg/L	13 / 13	10 / 10	--	**0.014**	**0.014**	0.008	0.005	13 / 13	10 / 10	13 / 13	10 / 10	Stable	Down
Trichloroethene	BRW-025	mg/L	21 / 21	10 / 10	--	**0.218**	**0.17**	**0.13**	0.005	21 / 21	10 / 10	21 / 21	10 / 10	Down	No trend
	BRW-098	mg/L	5 / 5	2 / 2	--	**0.007**	0.001	ND	0.005	1 / 5	0 / 2	1 / 5	0 / 2	Stable	No trend
	BRW-101	mg/L	21 / 21	10 / 10	--	**0.16**	**0.096**	**0.086**	0.005	21 / 21	10 / 10	21 / 21	10 / 10	Down	Stable
	BRW-103	mg/L	21 / 21	10 / 10	--	**0.17**	**0.17**	**0.11**	0.005	21 / 21	10 / 10	21 / 21	10 / 10	No trend	Stable
	BRW-116	mg/L	13 / 13	10 / 10	--	**0.047**	**0.029**	**0.028**	0.005	13 / 13	10 / 10	13 / 13	10 / 10	Stable	No trend
	BRW-117	mg/L	13 / 13	10 / 10	--	**0.049**	**0.038**	**0.031**	0.005	13 / 13	10 / 10	13 / 13	10 / 10	Down	Stable
	UNW-031	mg/L	21 / 21	10 / 10	--	**0.23**	**0.23**	**0.23**	0.005	21 / 21	10 / 10	21 / 21	10 / 10	Stable	No trend
	UNW-116	mg/L	1 / 14	1 / 9	0.001	**0.007**	**0.007**	**0.007**	0.005	1 / 14	1 / 9	1 / 14	1 / 9	No trend	No trend
	UNW-117	mg/L	19 / 19	10 / 10	--	**0.055**	**0.042**	**0.036**	0.005	19 / 19	10 / 10	19 / 19	10 / 10	Stable	No trend
	UNW-118	mg/L	21 / 21	10 / 10	--	**0.014**	**0.014**	**0.014**	0.005	19 / 21	10 / 10	21 / 21	10 / 10	Up	Up
	UNW-120	mg/L	5 / 5	2 / 2	--	**0.006**	0.003	ND	0.005	1 / 5	0 / 2	1 / 5	0 / 2	Stable	No trend
	UNW-121	mg/L	21 / 21	10 / 10	--	**0.126**	**0.07**	**0.055**	0.005	21 / 21	10 / 10	21 / 21	10 / 10	Down	Stable
	UNW-130	mg/L	13 / 13	10 / 10	--	**5.8**	**5.8**	**5**	0.005	13 / 13	10 / 10	13 / 13	10 / 10	Stable	Stable
	UNW-131	mg/L	13 / 13	10 / 10	--	**0.049**	**0.049**	**0.035**	0.005	11 / 13	8 / 10	11 / 13	8 / 10	Up	Up

[a]Wells shown on Figure D.4 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.

[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[c]MCL as of May 2018.

[d]Significant linear trend from the M-K test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.

(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year

MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

Table D.9. Summary of K-901, K-31/K-33, and K-1064 groundwater contaminants and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
K-901 Exit Pathway															
Alpha activity	UNW-066	pCi/L	15 / 20	8 / 10	3.75	**68.7**	**68.7**	7.16	15	4 / 20	3 / 10	4 / 20	3 / 10	No trend	No trend
	UNW-067	pCi/L	8 / 20	5 / 10	4.06	**52.8**	**52.8**	ND	15	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
K-31 / K-33 Area Exit Pathway															
Alpha activity	UNW-080	pCi/L	2 / 6	2 / 6	4.72	**16.1**	**16.1**	2.35	15	1 / 6	1 / 6	1 / 6	1 / 6	No trend	No trend
Antimony	UNW-043	mg/L	5 / 20	4 / 10	0.003	**0.02**	0.00045	ND	0.006	1 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	UNW-043(F)	mg/L	4 / 20	4 / 10	0.003	3.7E-04	0.00037	0.00034	0.006	0 / 20	0 / 10	0 / 20	0 / 10	Stable	No trend
	UNW-080	mg/L	2 / 20	2 / 10	0.003	**0.026**	**0.026**	0.00005	0.006	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
	UNW-080(F)	mg/L	2 / 20	2 / 10	0.003	0.00017	0.00017	0.00008	0.006	0 / 20	0 / 10	0 / 20	0 / 10	Stable	No trend
Arsenic	UNW-043	mg/L	3 / 20	2 / 10	0.025	**0.035**	0.006	0.006	0.01	1 / 20	0 / 10	1 / 20	0 / 10	No trend	No trend
	UNW-043(F)	mg/L	1 / 20	1 / 10	0.005	**0.011**	**0.011**	ND	0.01	1 / 20	1 / 10	1 / 20	1 / 10	No trend	No trend
Chromium	BRW-030	mg/L	20 / 20	10 / 10	--	**0.11**	**0.11**	0.091	0.1	1 / 20	1 / 10	7 / 20	3 / 10	Stable	No trend
	BRW-030(F)	mg/L	20 / 20	10 / 10	--	0.12	0.12	0.096	0.1	2 / 20	2 / 10	6 / 20	3 / 10	Stable	No trend
	UNW-043	mg/L	20 / 20	10 / 10	--	**21**	**3.6**	0.057	0.1	17 / 20	7 / 10	17 / 20	7 / 10	Down	Down
	UNW-043(F)	mg/L	18 / 20	10 / 10	0.005	0.046	0.046	0.046	0.1	0 / 20	0 / 10	0 / 20	0 / 10	No trend	No trend
	UNW-080	mg/L	20 / 20	10 / 10	--	**1.2**	**1.2**	0.019	0.1	4 / 20	4 / 10	4 / 20	4 / 10	No trend	Down
	UNW-080(F)	mg/L	20 / 20	10 / 10	--	0.027	0.022	0.015	0.1	0 / 20	0 / 10	0 / 20	0 / 10	Stable	Stable
Lead	UNW-080	mg/L	4 / 20	4 / 10	0.003	**0.015**	**0.015**	ND	0.015	0 / 20	0 / 10	2 / 20	2 / 10	No trend	No trend
	UNW-080(F)	mg/L	0 / 20	0 / 10	0.003	ND	ND	ND	0.015	0 / 20	0 / 10	0 / 20	0 / 10	--	--
Nickel	UNW-043	mg/L	20 / 20	10 / 10	--	**3.4**	**1.3**	**0.55**	0.1	20 / 20	10 / 10	20 / 20	10 / 10	Stable	No trend
	UNW-043(F)	mg/L	20 / 20	10 / 10	--	**0.96**	**0.74**	**0.53**	0.1	20 / 20	10 / 10	20 / 20	10 / 10	Stable	Stable
	UNW-080	mg/L	8 / 20	8 / 10	0.01	0.099	0.099	0.005	0.1	0 / 20	0 / 10	1 / 20	1 / 10	No trend	No trend
	UNW-080(F)	mg/L	6 / 20	6 / 10	0.01	0.004	0.004	0.003	0.1	0 / 20	0 / 10	0 / 20	0 / 10	Stable	Stable
Trichloroethene	BRW-066	mg/L	1 / 20	0 / 10	0.003	0.004	ND	ND	0.005	0 / 20	0 / 10	1 / 20	0 / 10	No trend	--

Table D.9. Summary of K-901, K-31/K-33, and K-1064 groundwater contaminants and trends (cont.)

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
K-1064 Peninsula Exit Pathway															
Arsenic	BRW-003	mg/L	20 / 20	10 / 10	--	**0.035**	**0.024**	**0.011**	0.01	18 / 20	8 / 10	19 / 20	9 / 10	Down	Down
	BRW-003(F)	mg/L	20 / 20	10 / 10	--	**0.031**	**0.023**	**0.015**	0.01	19 / 20	9 / 10	20 / 20	10 / 10	Down	Stable
	BRW-017	mg/L	8 / 20	8 / 10	0.005	**0.016**	**0.016**	0.008	0.01	2 / 20	2 / 10	2 / 20	2 / 10	Up	No trend
	BRW-017(F)	mg/L	6 / 20	6 / 10	0.005	**0.014**	**0.014**	**0.014**	0.01	1 / 20	1 / 10	3 / 20	3 / 10	Up	Up
Trichloroethene	BRW-017	mg/L	20 / 20	10 / 10	--	**0.005**	0.004	0.003	0.005	2 / 20	0 / 10	6 / 20	0 / 10	Down	Down

[a]Wells shown on Figure D.4 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.

[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[c]MCL as of May 2018.

[d]Significant linear trend from the M-KL test at the 0.10 significance level. Dashes "--" for significant trends indicates that all results were non-detect and no trend analysis was conducted.

Bold table entries indicate results that exceed MCL or MCL-DC values.

(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

D.5 K-1085 DRUM BURIAL/OLD FIREHOUSE BURN AREA AND K-770 AREAS

The K-1085 and K-770 areas lie at the southwestern edge of the ETTP site. Figure D.5 shows the VOC plume at K-1085 and the K-770 exit pathway monitoring well locations.

In October 2000, the Tennessee Department of Transportation encountered three buried drums adjacent to TN Highway 58 during a road widening project. This discovery triggered a Comprehensive Environmental Response, Compensation, and Liability Act of 1980 removal action to identify buried waste at the site and to excavate and dispose of the waste at the Environmental Management Waste Management Facility. Approximately 77 m^3 of mixed Resource Conservation and Recovery Act of 1976, Toxic Substances Control Act of 1976, and low-level waste were excavated from five separate locations at the 12,000 ft^2 site. In 2005, the area was further characterized, and in 2008 an additional 300 yd^3 of soil were removed for disposal. During 2010 − 2011, four groundwater monitoring wells were installed at the site. One bedrock well (BRW-118) was installed at the downslope edge of the excavation area to monitor contaminants in the bedrock groundwater zone, which might indicate the presence of DNAPLs beneath the site. Three unconsolidated zone wells were installed radial to the excavation site in directions of potential groundwater movement. Initial sampling of all four wells showed the presence of VOC contamination in two of the wells, BRW-118 and UNW-135. Wells BRW-118 and UNW-135 are sampled semiannually to provide contaminant trend data. Table D.10 includes the results of groundwater contaminant screening and trend evaluations for the K-1085 site.

The K-770 area is the site of the former electrical generating powerhouse that provided the first electrical power for the gaseous diffusion plant in 1944. A portion of the northern K-770 area was used for the storage of radioactively contaminated scrap metal for many years. Radiological materials associated with that scrap metal caused contamination of the underlying soil and groundwater. The scrap metal was removed and disposed and a RA was conducted to remove contaminated soil. Groundwater contamination is indicated by alpha activity which has decreased in concentration over time to levels below the 15 pCi/L MCL. Table D.11 includes the alpha activity screening and trend evaluation results.

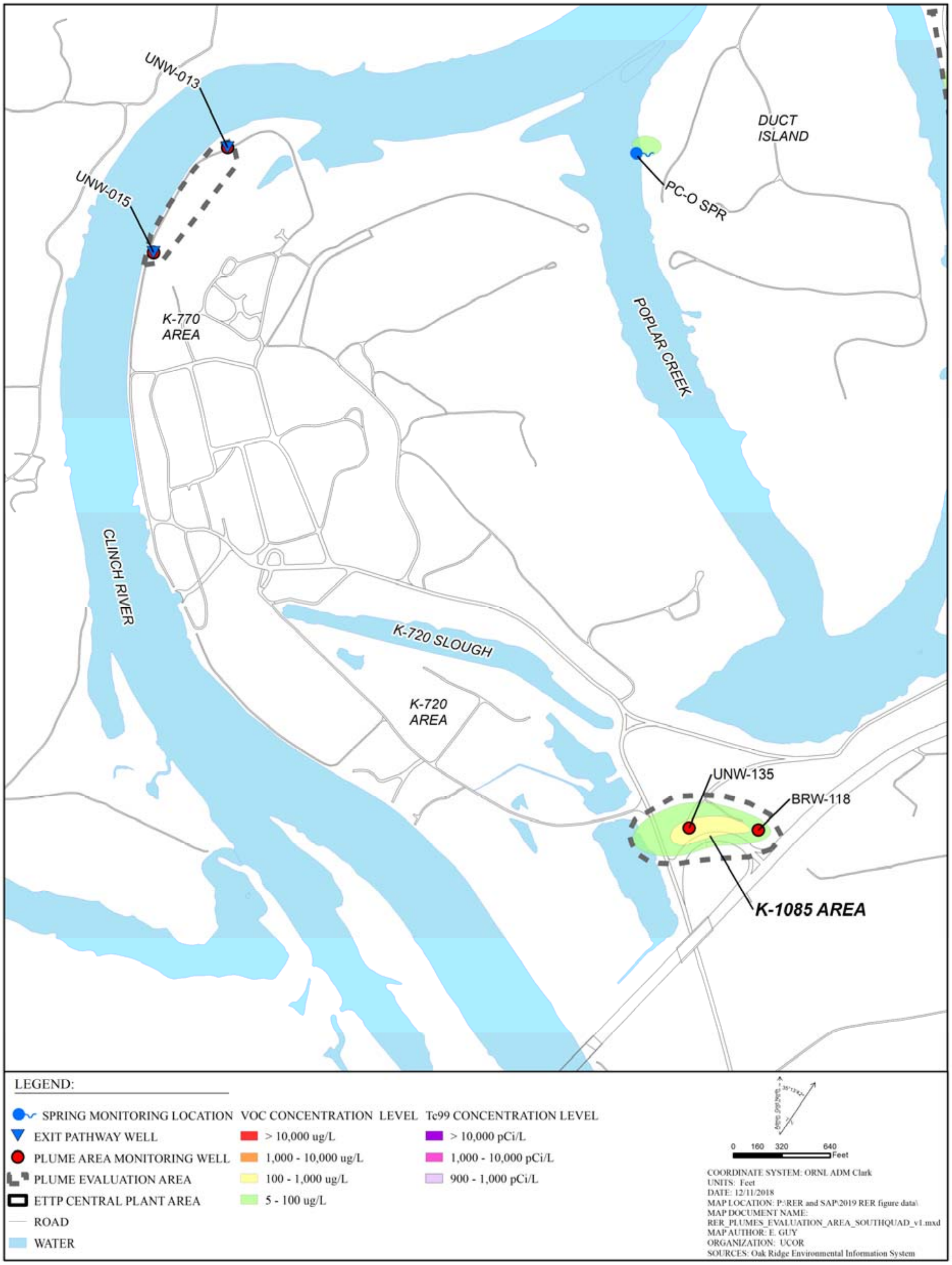

Figure D.5. K-1085 and K-770 Area.

Table D.10. Summary of K-1085 Old Firehouse Burn Area groundwater contaminants and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
cis-1,2-Dichloroethene	UNW-135	mg/L	13 / 13	10 / 10	--	**0.17**	**0.15**	**0.11**	0.07	8 / 13	5 / 10	11 / 13	8 / 10	No trend	Up
Tetrachloroethene	BRW-118	mg/L	13 / 13	10 / 10	--	**0.065**	**0.065**	**0.047**	0.005	13 / 13	10 / 10	13 / 13	10 / 10	Stable	Stable
Trichloroethene	BRW-118	mg/L	13 / 13	10 / 10	--	**0.073**	**0.073**	**0.043**	0.005	13 / 13	10 / 10	13 / 13	10 / 10	Stable	Stable
	UNW-135	mg/L	13 / 13	10 / 10	--	**0.34**	**0.17**	**0.13**	0.005	13 / 13	10 / 10	13 / 13	10 / 10	Stable	No trend

[a]Wells shown on Figure D.5 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.

[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[c]MCL as of May 2018.

[d]Significant linear trend from the Mann-Kendall test at the 0.10 significance level.

Bold table entries indicate results that exceed MCL or MCL-DC values.

(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

Table D.11. Summary of K-770 Powerhouse Area groundwater contaminants and trends

Chemical	Well[a]	Units	Freq. of detection		Maximum detection limit[b]	Maximum detected			MCL[c]	Freq. >MCL[c]		Freq. >80% of MCL[c]		Significant trend[d]	
			10 yr	5 yr		10 yr	5 yr	FY 2018		10 yr	5 yr	10 yr	5 yr	10 yr	5 yr
Alpha activity	UNW-015	pCi/L	15 / 15	10 / 10	--	**45.4**	12.7	8.02	15	3 / 15	0 / 10	4 / 15	1 / 10	Stable	Up

[a]Wells shown on Figure D.5 but not included above did not have contaminants ≥80 of their MCL or MCL-DC within the past 10 years.

[b]The maximum detection limit is highest value assigned to a non-detect over the 10-year evaluation period. Dashes "--" for the maximum detection limit indicates that all results were detections and the maximum detection limit does not apply. Detection limits assigned to non-detects were used in evaluation of the M-K trends.

[c]MCL as of May 2018.

[d]Significant linear trend from the Mann-Kendall test at the 0.10 significance level.

Bold table entries indicate results that exceed MCL or MCL-DC values.
(F) denotes metals analysis results from field filtered sample aliquots from the designated sample location.

The M-K Test statistic (S) for each time series trend is calculated and plotted on a 90% confidence level chart. When the calculated S statistic (positive or negative) plots above the equivalent 90% confidence interval for the applicable number of sampling events, the time-series data define an *Increasing* trend if S >0, or a *Decreasing* trend if S <0. When the calculated S statistic plots below the equivalent 90% confidence interval and the associated CV is <1, then the time series data define a *Stable* trend. When the calculated S statistic is > 0 but confidence is < 90% or S is ≤0 and CV is ≥0 the conclusion is no trend can be confidently assigned to the data.

-- = not applicable
CV = coefficient of variation
Freq. = frequency
FY = fiscal year
MCL = maximum detection limit
MCL-DC = maximum detection limit derived concentration
M-K = Mann-Kendall
ND = not detected

D.6 REFERENCES

DOE/OR/01-2768&D1. *Design Characterization Completion Report for the Sitewide Groundwater Treatability Study at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2161&D2. *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2005, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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APPENDIX E
FISCAL YEAR 2018 DETECTION MONITORING DATA FOR THE EAST CHESTNUT RIDGE WASTE PILE

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E.1 Introduction

Semiannual groundwater monitoring at the East Chestnut Ridge Waste Pile (ECRWP) during fiscal year (FY) 2018 was performed in January 2018 in accordance with the general and site-specific requirements of the *RCRA Post-closure Permit for the Chestnut Ridge Hydrogeologic Regime* (TNHW-128) and in July 2018 per the equivalent requirements transitioned to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 process and specified in the *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2466&D4).

FY 2018 analytical data from the ECRWP is included in Table E.1 (organic and inorganic constituents) and in Table E.2 (radionuclide constituents). For inorganic analytes, the background values are upper tolerance limits calculated from groundwater sampling/analysis results for upgradient/background well GW-294 and other selected wells on Chestnut Ridge. The respective analytical detection limit serves as the background value for each volatile organic compound. Background values for gross alpha and gross beta are assumed to equal 15 pCi/L and 50 pCi/L, respectively, which represent the drinking water maximum contaminant level for gross alpha and the Safe Drinking Water Act screening level for gross beta. Analytical data from a leachate sample collected at the above-ground storage tank at the ECRWP is provided on Table E.3.

A summary of the performance monitoring results at the ECRWP is provided in Section 5.7.

E.2 References

DOE/OR/01-2466&D4. *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2018, U.S. Department of energy, Office of Environmental Management, Oak Ridge, TN

TNHW-128. *RCRA Post-closure Permit for the Chestnut Ridge Hydrogeologic Regime, 2006, Y-12 National Nuclear Security Complex, Oak Ridge, Tennessee*, EPA I.D. No. TN3 89 009 0001, September 2006, Tennessee Department of Environment and Conservation-Division of Solid Waste Management.

Table E.1 Inorganic and organic constituents, ECRWP

Monitoring Purpose		Upgradient/Background		Point of Compliance	
Well		GW-294		GW-161	
Date Sampled / Sample Type		01/03/18	07/10/18	01/04/18	07/10/18
Field Measurements					
Time Sampled		1359	910	1405	922
Measuring Point Elev. (ft)		1083.60	1083.60	1093.54	1093.54
Depth to Water (ft)		96.61	95.35	159.05	158.36
Groundwater Elevation (ft)		986.99	988.25	934.49	935.18
Conductivity (µmho/cm)		384	451	310	334
Dissolved Oxygen (ppm)		8.26	7.04	1.52	3.02
Oxidation/Reduction (mV)		261	-58	140	158
Temperature (degrees C)		12.6	18.7	13.7	15.8
Turbidity (NTU)		1	2	15	16
pH		7.36	7.25	7.58	7.35
Inorganics (mg/L)	UTL[a]				
Antimony	0.05	0.0006 U	0.0006 U	0.0006 U	0.0006 U
Arsenic	0.05	0.005 U	0.005 U	0.005 U	0.005 U
Barium	0.05	**0.011**	**0.011**	**0.0096**	**0.0091**
Boron	0.12	0.05 U	0.05 U	0.05 U	0.05 U
Cadmium	0.003	0.0001 U	0.0001 U	0.0001 U	0.0001 U
Chloride	13	**11**	**12**	**3**	**3.1**
Chromium	0.026	0.01 U	0.01 U	0.01 U	0.01 U
Cobalt	0.02	0.005 U	0.005 U	0.005 U	0.005 U
Copper	0.027	0.01 U	0.01 U	0.01 U	0.01 U
Iron	15	0.1 U	0.1 U	**1.3**	**1.3**
Lead	0.05	0.003 U	0.003 U	0.003 U	0.003 U
Lithium	0.026	0.01 U	0.01 U	0.01 U	0.01 U
Manganese	0.29	0.005 U	0.005 U	0.005 U	0.005 U
Mercury	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Nickel	0.05	0.01 U	0.01 U	0.01 U	0.01 U
Nitrate (as N)	3	**1.6**	**1.5**	**0.36**	**0.19**
Selenium	0.05	0.005 U	0.005 U	0.005 U	0.005 U
Sulfate	43	**1.6**	**2.1**	**4.4**	**1.5**
Thallium	0.01	0.002 U	0.002 NU	0.002 U	0.002 U
Uranium	0.004	0.004 U	0.004 U	0.004 U	0.004 U
Zinc	0.12	0.02 U	0.02 U	0.02 U	0.02 U
Organic Compounds (µg/L)					
Benzene		5 U	5 U	5 U	5 U
Carbon Tetrachloride		5 U	5 U	5 U	5 U
Chloroethane		5 U	5 U	5 U	5 U
Chloroform		5 U	5 U	5 U	5 U
Chloromethane		10 U	10 U	10 U	10 U
1,1-Dichloroethane		5 U	5 U	5 U	5 U
1,1-Dichloroethene		5 U	5 U	5 U	5 U
1,2-Dichloroethane		5 U	5 U	5 U	5 U
cis-1,2-Dichloroethene		5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene		5 U	5 U	5 U	5 U
Methylene Chloride		5 U	5 U	5 U	5 U
Tetrachloroethene		5 U	5 U	5 U	5 U
1,1,1-Trichloroethane		5 U	5 U	5 U	5 U
Trichloroethene		5 U	5 U	5 U	5 U
Vinyl Chloride		2 U	2 U	2 U	2 U

Table E.1 Inorganic and organic constituents, ECRWP (cont.)

Monitoring Purpose		**Point of Compliance**					
Well		**GW-296**				**GW-298**	
Date Sampled		**01/04/18**		**07/10/18**		**01/04/18**	**07/10/18**
Sample Type			**Dup**		**Dup**		
Field Measurements							
Time Sampled		935	--	1405	--	940	1414
Measuring Point Elev. (ft)		1090.99	--	1090.99	--	1049.01	1049.01
Depth to Water (ft)		118.49	--	118.17	--	109.10	107.29
Groundwater Elevation (ft)		972.50	--	972.82	--	939.91	941.72
Conductivity (µmho/cm)		373	--	386	--	220	336
Dissolved Oxygen (ppm)		6.59	--	7.06	--	2.05	2.03
Oxidation/Reduction (mV)		245	--	-108	--	204	122
Temperature (degrees C)		12.7	--	15.8	--	6.2	21.6
Turbidity (NTU)		1	--	3	--	2	3
pH		7.3	--	7.31	--	8.01	7.76
Inorganics (mg/L)	**UTL**[a]						
Antimony	0.05	0.0006 U	0.0006 U	0.0006 U	0.0006 U	0.0006 U	0.0006 U
Arsenic	0.05	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Barium	0.05	**0.014**	**0.012**	**0.011**	**0.013**	**0.019**	**0.016**
Boron	0.12	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Cadmium	0.003	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U
Chloride	13	**4**	**4**	**5.1**	**5.1**	**0.85**	**0.98**
Chromium	0.026	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Cobalt	0.02	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Copper	0.027	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Iron	15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Lead	0.05	0.003 U	0.003 U	0.003 U	0.003 U	0.003 U	0.003 U
Lithium	0.026	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Manganese	0.29	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Mercury	0.0002	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Nickel	0.05	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Nitrate (as N)	3	**0.17**	**0.17**	**0.17**	**0.16**	**0.16**	**0.045**
Selenium	0.05	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Sulfate	43	1 U	1 U	1 U	1 U	**5.7**	**4.9**
Thallium	0.01	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
Uranium	0.004	0.004 U	0.004 U	0.004 U	0.004 U	0.004 U	0.004 U
Zinc	0.12	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Organic Compounds (µg/L)							
Benzene		5 U	5 U	5 U	5 U	5 U	5 U
Carbon Tetrachloride		5 U	5 U	5 U	5 U	5 U	5 U
Chloroethane		5 U	5 U	5 U	5 U	5 U	5 U
Chloroform		5 U	5 U	5 U	5 U	5 U	5 U
Chloromethane		10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane		5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene		5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane		5 U	5 U	5 U	5 U	5 U	5 U
cis-1,2-Dichloroethene		5 U	5 U	5 U	5 U	5 U	5 U
trans-1,2-Dichloroethene		5 U	5 U	5 U	5 U	5 U	5 U
Methylene Chloride		5 U	5 U	5 U	5 U	5 U	5 U
Tetrachloroethene		5 U	5 U	5 U	5 U	5 U	5 U
1,1,1-Trichloroethane		5 U	5 U	5 U	5 U	5 U	5 U
Trichloroethene		5 U	5 U	5 U	5 U	5 U	5 U
Vinyl Chloride		2 U	2 U	2 U	2 U	2 U	2 U

Table E.1 Inorganic and organic constituents, ECRWP (cont.)

Bold text indicates a detected result.
-- = not measured because it is a field duplicate.

[a] For inorganics, the UTLs are the fixed site-specific background values. For organics, the project quantitation levels are background values.
Dup = field duplicate sample.
ECRWP = East Chestnut Ridge Waste Pile.
N = nitrogen.
U = not detected at the project quantitation level.
UTL = upper tolerance limit.

Table E.2 Radiochemical constituents, ECRWP

Monitoring Purpose	Well	Date Sampled	Alpha Activity (pCi/L)[a]			Beta Activity (pCi/L)[a]		
			Result	TPU	MDA	Result	TPU	MDA
Upgradient/ Background	GW-294	01/03/18	-0.437 U	1.45	4.13	--	--	--
	GW-294	07/10/18	-0.00533 U	0.95	2.34	0.865 U	1.41	3.04
Point of Compliance	GW-161	01/04/18	-0.871 U	0.94	3.25	--	--	--
	GW-161	07/10/18	0.248 U	1.01	2.32	**3.35**	1.5	2.74
	GW-296	01/04/18	-0.193 U	1.41	3.86	--	--	--
	GW-296 Dup	01/04/18	0.133 U	1.16	3.07	--	--	--
	GW-296	07/10/18	1.07 U	1.53	3.22	1.16 U	1.44	3.07
	GW-296 Dup	07/10/18	0.173 U	1.55	3.69	0.668 U	1.36	2.97
	GW-298	01/04/18	1.6 U	1.49	2.82	--	--	--
	GW-298	07/10/18	1.91 U	1.49	2.68	2.21 U	1.44	2.85

Bold text indicates a detected result.
-- = not analyzed.
[a] For alpha activity, the background value is 15 pCi/L. For beta activity, the background value is 50 pCi/L.
Dup = field duplicate sample.
ECRWP = East Chestnut Ridge Waste Pile.
MDA = minimum detectable activity.
TPU = total propagated uncertainty (two standard deviations).
U = not detected.

Table E.3 ECRWP leachate sampling in August 2018, detected results

Analyte	Monitored[a]	Sample Date	Results			Detection Limit
Inorganic Analytes (mg/L)						
Barium	Y	08/14/18	0.02			0.0026
Boron	Y	08/14/18	0.06			0.036
Chloride	Y	08/14/18	14			0.06
Copper	Y	08/14/18	0.0022	J		0.00051
Iron	Y	08/14/18	0.039	J		0.03
Lithium	Y	08/14/18	0.017	E		0.00032
Manganese	Y	08/14/18	0.052			0.00049
Nickel	Y	08/14/18	0.0021	J		0.0011
Nitrate/Nitrite as Nitrogen	Y	08/14/18	1.4			0.003
Potassium		08/14/18	6.9			0.13
Sodium		08/14/18	4.7			0.038
Strontium		08/14/18	0.15			0.00055
Sulfate	Y	08/14/18	7.7			0.3
Uranium	Y	08/14/18	0.0071			0.0000049
Vanadium		08/14/18	0.00073	J		0.00043
Zinc	Y	08/14/18	0.039	E		0.00062
Volatile Organic Compounds (μg/L)						
1,1,1-Trichloroethane	Y	08/14/18	3			0.3
1,1-Dichloroethane	Y	08/14/18	44			0.3
Chloroethane	Y	08/14/18	3.9			0.3
cis-1,2-Dichloroethene	Y	08/14/18	27			0.3
Tetrachloroethene	Y	08/14/18	0.32	J		0.3
trans-1,2-Dichloroethene	Y	08/14/18	0.31	J		0.3
Vinyl chloride	Y	08/14/18	0.4	J		0.15
Radioanalytes (pCi/L)					**TPU**	**MDA**
Alpha activity	Y	08/14/18	2.2	J	2.01	3.79
Beta activity	Y	08/14/18	11.4		2.95	3.68

[a] Analytes with a "Y" are monitored parameters for detection monitoring at the ECRWP.

E = Estimated value, possible interferences.

ECRWP = East Chestnut Ridge Waste Pile

J = Estimated value.

MDA = minimum detectable activity.

TPU = total propagated uncertainty.

APPENDIX F
OTHER SURFACE WATER MONITORING AT EAST TENNESSEE TECHNOLOGY PARK

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F.1 INTRODUCTION

A summary of the results for monitoring of radionuclides, including Tc-99, volatile organic compounds (VOCs), mercury, and polychlorinated biphenyls (PCBs) is provided in this appendix. These results reflect an integrated approach of evaluating the East Tennessee Technology Park (ETTP) watersheds that combines aspects of the Storm Water Pollution Prevention (SWPP) Program under the National Pollutant Discharge Elimination System (NPDES) permit, the U.S. Department of Energy (DOE) Order 458.1 radiological sampling, and surveillance sampling of legacy contaminants in support of current and future Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) decisions. The NPDES sampling includes investigative sampling as well as monitoring that is conducted during each NPDES permit cycle to generate the information required for the ETTP NPDES permit renewal application. This integrated approach, with reporting through the Remediation Effectiveness Report and DOE Annual Site Environmental Report, was developed to meet ETTP NPDES permit reporting requirements in coordination with CERCLA stakeholder expectations. A map of surface water and storm water monitoring locations is provided in Figure F.1.

F.2 RADIONUCLIDES

During fiscal year (FY) 2018, surface water radionuclides were all well below any applicable comparison standards at all locations across the ETTP site for the individual radionuclides, as well as those evaluated on a cumulative sum of fraction basis. The ETTP radionuclides of concern are Tc-99 and the uranium isotopes (U-234, U-235, U-238), and these were sampled across all locations with the exception of Mitchell Branch Kilometer [MIK] 0.45, MIK 0.59, and MIK 0.71 which were only sampled for Tc-99.

ETTP surface water samples were collected from twelve locations across the ETTP, which were analyzed for radionuclides either quarterly (K-1700, MIK 0.45, MIK 0.59, MIK 0.71, and MIK 1.4) or semiannually (K-702-A, K-716, K-901-A, K-1007-B, K-1710, Clinch River kilometer [CRK] 16, and CRK 23), and the results were compared with Derived Concentration Standard (DCS) values from DOE Standard DOE-STD-1196-2011. The DCS values are not CERCLA performance objectives or goals, and are used for comparison purposes only.

Radiological data are reported as sum of fractions of the DCSs in Figure F.2 so that the cumulative effect of each radionuclide can be determined as part of the overall impact at each location. If the sum of fractions of the DCSs at a sample location exceeds a screening level of 4% of the DCSs for the year, a source field investigation is conducted to determine if there are changing conditions within the watershed that are leading to increased radiological discharge levels. The screening level of 4% of the DCSs is based upon an effective dose equivalent of 4 mrem as a general drinking water level comparison.

The FY 2018 sum of fractions of the DCSs are summarized in Figure F.2. All results from monitoring at the surface water surveillance locations were well below the 4% of the DCSs screening level in FY 2018, with the maximum sum of fractions value recorded at K-1700 at less than 2% of the DCSs. To provide some examples of the very low individual radionuclide values that were measured during FY 2018, a review of the K-1700 results includes the following maximum results compared to the individual DCS value for the 4% screening level.

- Tc-99 maximum value of 19.8 pCi/L: 4% of DCS value 1,760 pCi/L
- U-234 maximum result 8.5 pCi/L: 4% of DCS value 28 pCi/L
- U-235 maximum result 0.71 pCi/L: 4% of DCS value 29 pCi/L

- U-238 maximum result 4 pCi/L: 4% of DCS value 30 pCi/L

ETTP surface water radiological monitoring of storm water discharges is conducted to determine compliance with applicable dose standards. ETTP also applies the As Low as Reasonably Achievable process to minimize potential exposures to the public. Sampling for gross alpha and gross beta radioactivity, as well as specific radionuclides, is conducted as part of the routine SWPP Program sampling efforts.

Analytical results shown in Table F.1 are used to estimate the total discharge of each radionuclide from ETTP via the storm water discharge system for reservation dose assessment purposes. Each outfall location that is included and sampled in Table F.1 is identified on Figure F.1. As noted within the table, the only outfall with a value above the screening level was Outfall 382. Outfall 382 receives storm water runoff from a portion of Building K-131. Operations in this facility included uranium hexafluoride feed enrichment, as well as uranium recovery from decontamination solutions. Discharges from this outfall have historically contained radiological contaminants above screening levels due to past operations at Building K-131. The gross alpha radiation result for Outfall 382 of 22.5 pCi/L exceeded the screening level of 15 pCi/L; however, the sum of fractions of the DCSs for the isotopic results were well below the action level of 1.0. All other results at the other outfalls sampled for radionuclides in FY 2018 were well below the individual DCS values with the majority of results being at non-detect levels.

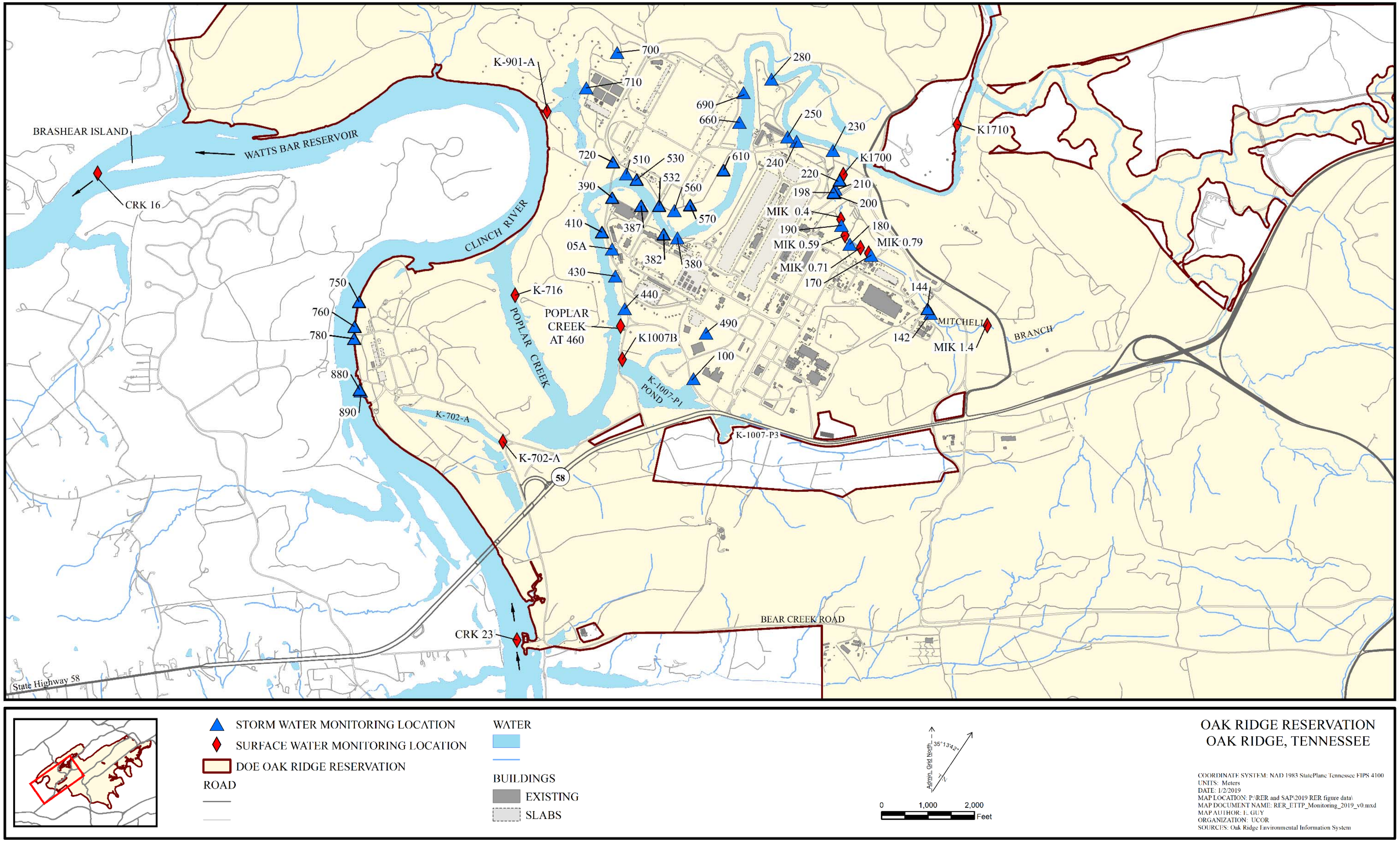

Figure F.1. ETTP surface water and storm water monitoring locations.

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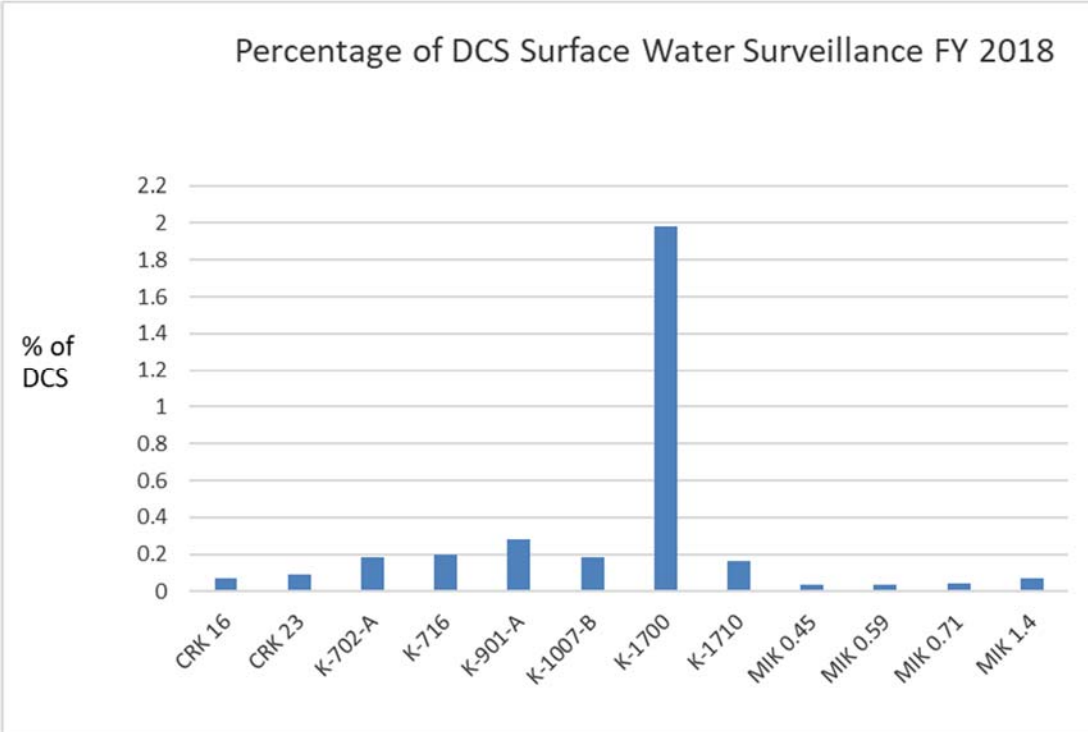

Figure F.2. Percentage of DCSs at ETTP surface water surveillance locations.

Note: only Tc-99 was monitored at MIK 0.45, MIK 0.59, and MIK 0.71.

Table F.1. Analytical results for routine radiological monitoring at ETTP storm water outfalls

Parameter	Screening level[a]	Outfall 198	Outfall 382	Outfall 660	Outfall 750	Outfall 760
Alpha activity (pCi/L)	15	1.95 U	**22.5**	2.82 U	4.17 U	3.11 U
Beta activity (pCi/L)	50	5.38	8.8	2.1 U	5.07	1.44 U
Tc-99 (pCi/L)	1,760	1.32 U	5.59 U	-2.28 U	4.08 U	3.34 U
U-233/234 (pCi/L)	28	0.46 U	10.3	1.1	3.46	2.16
U-235/236 (pCi/L)	29	0.164 U	0.9	0.0477 U	0.704	0.295 U
U-238 (pCi/L)	30	0.154 U	10	0.787	2.35	1.02

[a]The screening levels for Tc-99 and uranium isotopes are 4% of the DCS values.

Bold indicates screening level exceeded.

DCS = Derived Concentration Standard
ETTP = East Tennessee Technology Park
U = not detected

Tc-99 focus sampling actions. Surface water, storm water, and sewage system locations at ETTP were sampled during FY 2018 to continue to track and trend releases of Tc-99. All Tc-99 results at ETTP for FY 2018 were well below the applicable maximum contaminant level derived concentration (MCL-DC) value of 900 pCi/L.

As shown in Figure F.3, the maximum Tc-99 measurement at the Mitchell Branch K-1700 exit weir in FY 2018 was 19.8 pCi/L; this is more than an order of magnitude below the MCL-DC of 900 pCi/L.

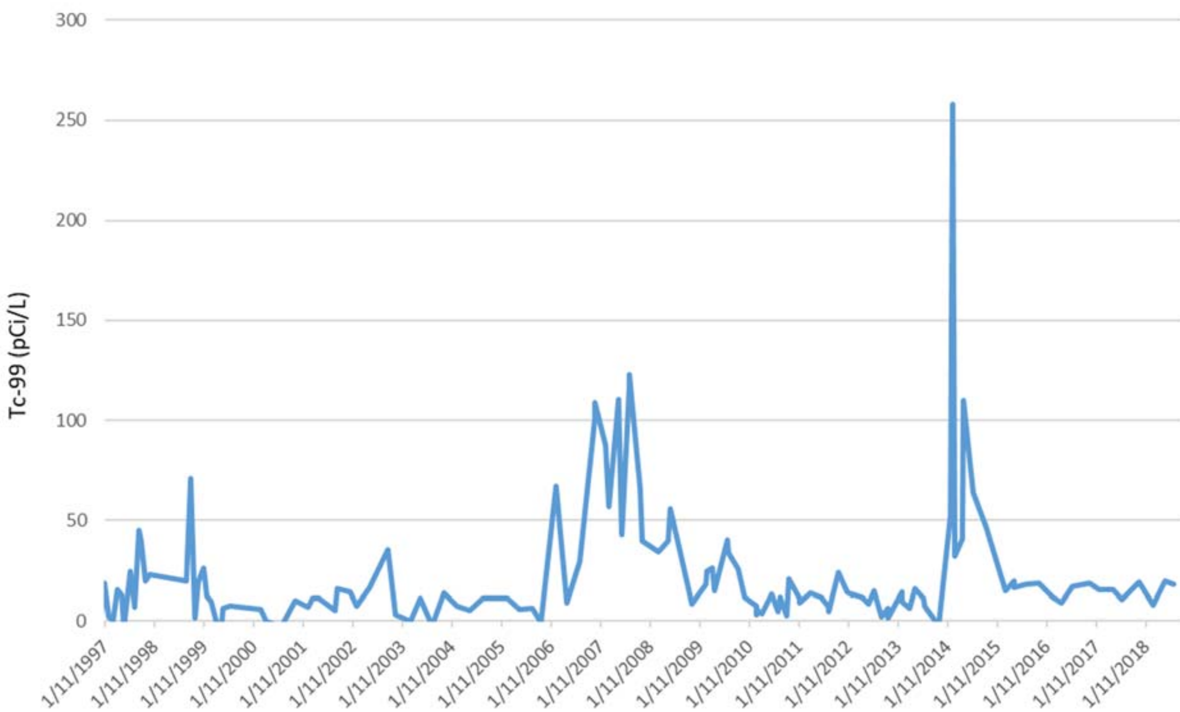

Figure F.3. Tc-99 monitoring at Mitchell Branch K-1700 Weir.

ETTP storm water outfall sampling results for FY 2018 indicate that all Tc-99 results were below the MCL-DC of 900 pCi/L. Results for ETTP storm outfalls are as follows:

- Mitchell Branch Outfall 190 Tc-99 results were all at non-detectable levels, and Outfall 210 had a maximum Tc-99 value of 18.3 pCi/L.
- K-1007-P1 Holding Pond Outfall 490 Tc-99 results ranged from 52 pCi/L to 361 pCi/L.

The Tc-99 sewage network and discharge operational trend-sampling summary for FY 2018 is as follows:

- The sewage results at Manhole 92 downstream from the K-25 Building Demolition area ranged from a high of 324 pCi/L to a low of 7 pCi/L.
- Concentrations at the Rarity Ridge Sewage Treatment Plant Lift Station #1 influent ranged from a high of 73 pCi/L to a low of 5 pCi/L.
- Concentrations at the Rarity Ridge Biological Treatment Aeration Basins ranged from a high of 3,540 pCi/L to a low of 109 pCi/L.
- Concentrations at the Rarity Ridge Sewage Treatment Plant Digester ranged from a high of 40,100 pCi/L to a low of 32,800 pCi/L.

- During FY 2018, four tanker shipments of approximately 5,000 gal per tanker of digester sludge were pumped and shipped offsite for treatment as low-level waste.

The Tc-99 sewage treatment network influent and effluent concentrations in FY 2018 were both significantly below DOE Order annual sum-of-fraction requirements and more than an order of magnitude below the Tc-99 MCL-DC of 900 pCi/L. The concentrations at the Rarity Ridge Sewage Treatment Plant Effluent Weir ranged from a high of 17 pCi/L to a low of a non-detect measurement.

F.3 VOCS

During FY 2018, surface water VOC levels were all well below any applicable comparison standards at all locations across the site.

The primary VOC detected in samples from Mitchell Branch is trichloroethene (TCE). Figure F.4 illustrates the concentrations of TCE at the Mitchell Branch monitoring locations, which are the only surface water monitoring locations where VOCs are regularly detected. Concentrations of TCE ranged from less than 1 µg/L to 41 µg/L in samples collected in FY 2018. These levels are well below the recreation organisms only ambient water quality criteria (AWQC) for TCE (300 µg/L). Other VOCs such as 1,2-dichloroethene (1,2-DCE) and vinyl chloride (VC) were routinely detected at the Mitchell Branch monitoring locations, but were measured at levels well below AWQC values.

The maximum FY 2018 TCE value at MIK 0.45 of 27 µg/L and the downstream TCE result of 41 µg/L at K-1700 were only a small fraction of the AWQC level. The November 2016 values were substantially higher than the maximum historical range of values going back to 2010. Additional VOCs such as DCE and VC also showed the same elevated pattern during the November 2016 sampling event. The MIK 0.45 location is within an area of the Mitchell Branch watershed that includes TCE and other VOCs in the groundwater, but no distinct seeps or discharges have been identified. A field investigation was conducted of the MIK 0.45 subwatershed after the November 2016 results were received. No project activities were identified that could have contributed to these elevated TCE results. During the remainder of FY 2017 and all of FY 2018, there were seven additional quarterly TCE sampling events at K-1700. These results, as well as all other VOC results, were back to within the historical FY 2010 to FY 2018 range. This indicates that the November 2016 result was an isolated measurement and is not indicative of a trend.

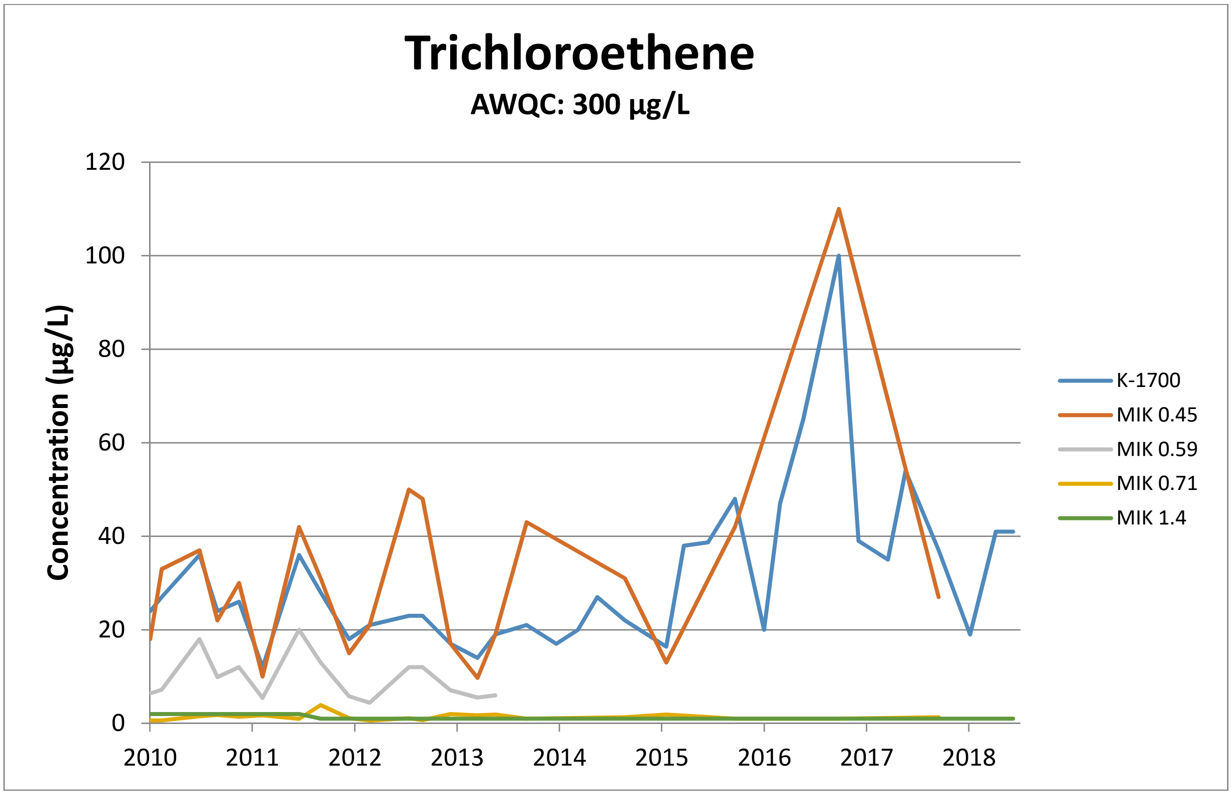

Figure F.4. TCE trends at Mitchell Branch surface water surveillance locations.

F.4 MERCURY

In FY 2018, mercury levels that exceed the recreation water and organisms AWQC of 51 ng/L at ETTP have been identified in the Mitchell Branch watershed, as well as in a number of storm water outfalls, and in surface water locations at ETTP.

In samples collected as part of the ETTP SWPP Program in FY 2018, mercury was detected at levels above the AWQC in discharges from storm water Outfalls 05A, 180, 190, 250, and 780. In addition to these outfalls, other storm water outfalls where mercury has been detected in samples collected as part of the ETTP SWPP Program at levels above the AWQC over the past five years include Outfalls 100, 210, 230, and 240. Storm water outfalls where mercury has been measured in samples collected as part of the ETTP SWPP Program at levels above the screening level of 25 ng/L (approximately 50% of the AWQC value) in FY 2018 include those listed above as well as Outfalls 410 and 530.

Activities involving mercury that were conducted at ETTP included usage, handling, and recovery operations. Mercury usage and handling were common in such equipment as manometers, switches, mass spectrometers, mercury diffusion pumps, mercury traps, and laboratory operations. Large quantities of mercury-bearing wastes from the onsite gaseous diffusion plant operations and support buildings, Oak Ridge National Laboratory, and Y-12 National Security Complex (Y-12), were processed and stored at ETTP. Mercury from soils and spill cleanups was processed onsite as well. Mercury recovery operations were conducted in a number of buildings. Many buildings were located in watersheds that discharged primarily to Mitchell Branch.

Quarterly monitoring for mercury is conducted at selected outfalls as part of the ETTP storm water sampling as identified in Figure F.1. Table F.2 contains analytical data from the routine quarterly mercury sampling performed at Outfalls 180, 190, and 05A during FY 2018. Figures F.5 through F.7 provide the mercury trend graphs for Outfalls 180, 190, and 05A from calendar year (CY) 2010 to present.

Table F.2. Quarterly storm water mercury monitoring results – FY 2018

Sampling location	1st Quarter FY 2018 (ng/L)	2nd Quarter FY 2018 (ng/L)	3rd Quarter FY 2018 (ng/L)	4th Quarter FY 2018 (ng/L)
Outfall 180	**63.7**	28.4	**235**	33.5
Outfall 190	16.6	39.1	29.1	23.2
Outfall 05A	**427**	**68.4**	**87.3**	**232**

Note: Results in **bold** exceed the AWQC for mercury (51 ng/L).

AWQC = ambient water quality criteria
FY = fiscal year

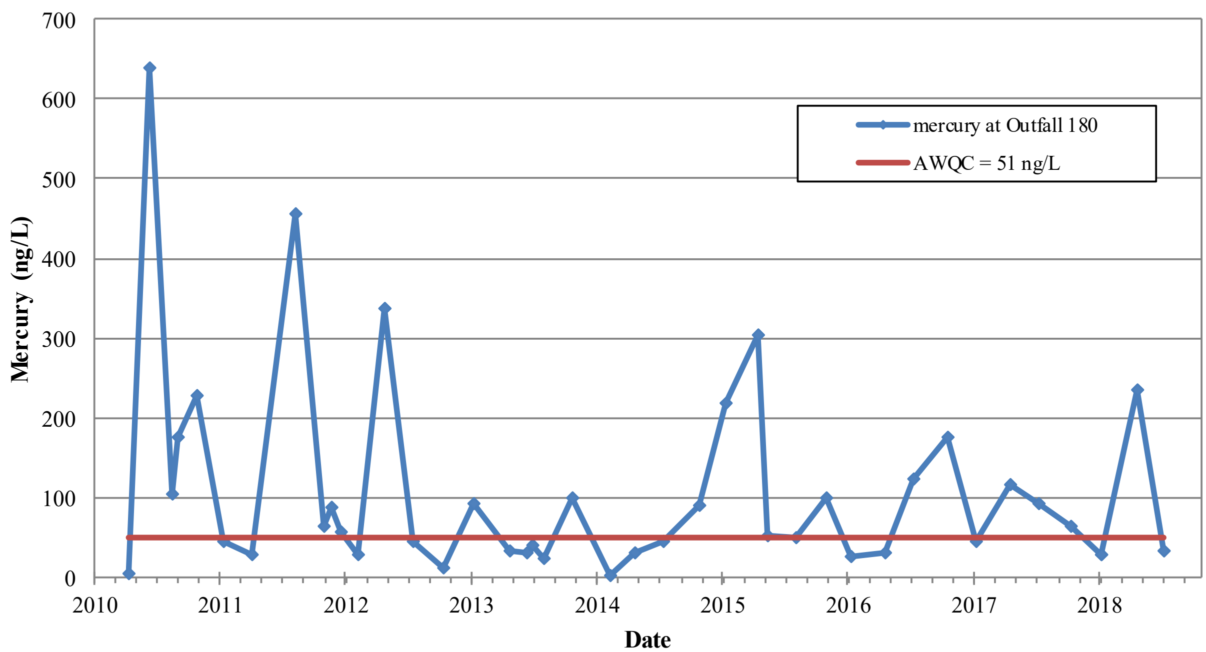

Figure F.5. Mercury concentrations at Outfall 180.

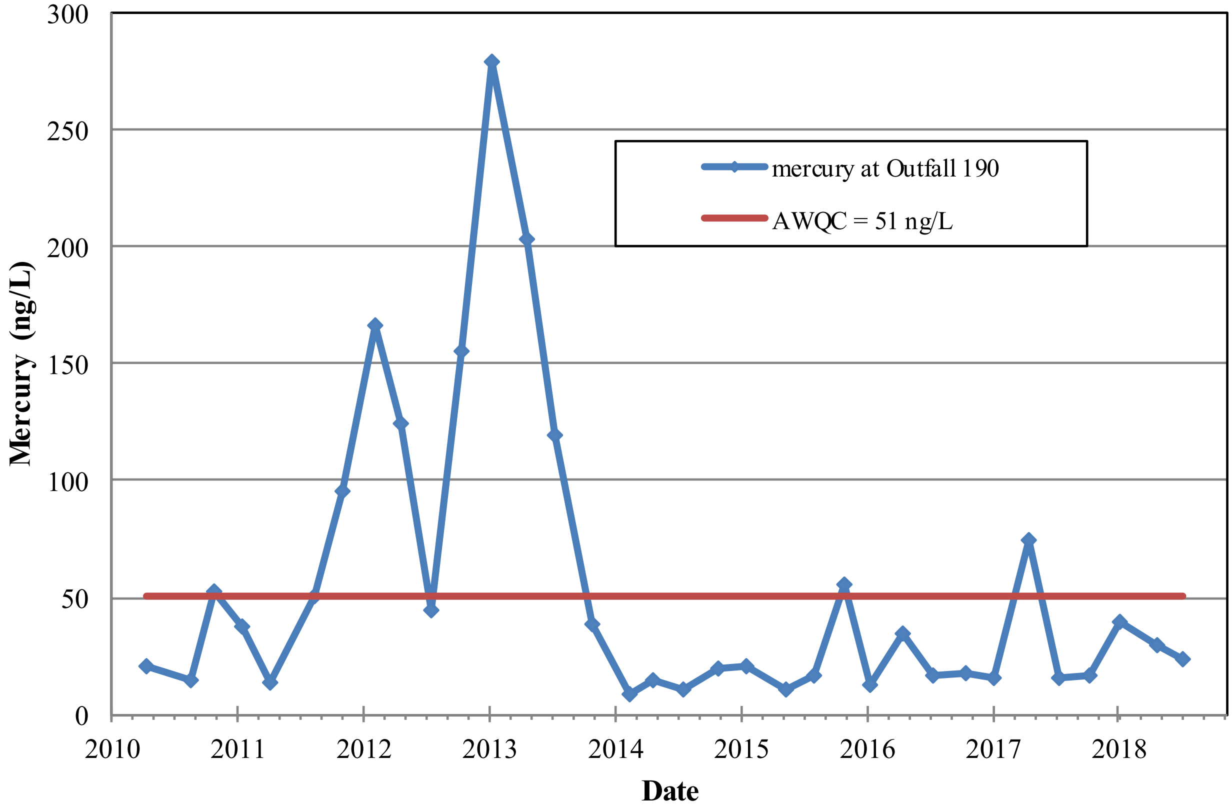

Figure F.6. Mercury concentrations at Outfall 190.

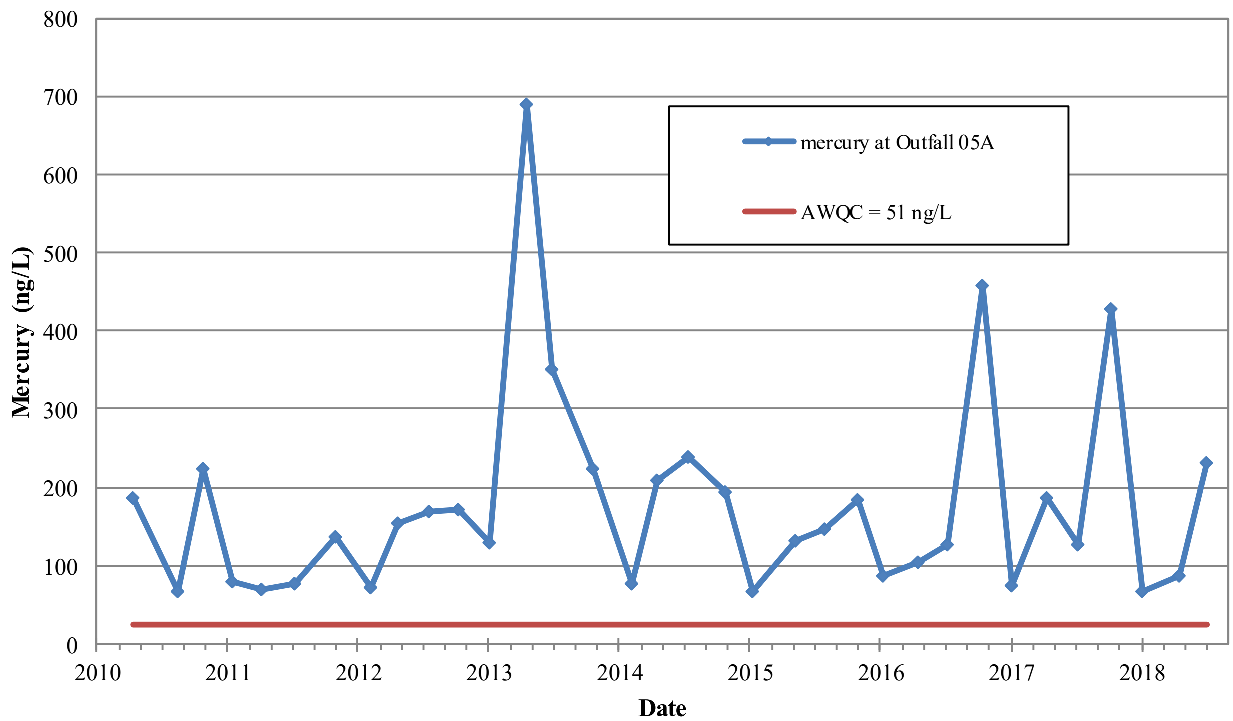

Figure F.7. Mercury concentrations at Outfall 05A.

There are numerous legacy mercury historical operations within the storm water Outfall 180 and 190 network areas and overall Mitchell Branch watershed. Collectively, these are potential contributors to the continuing legacy mercury discharges to Mitchell Branch due to contaminated sediment within storm water networks and potential infiltration sources into the piping. Potential sources of mercury to the Mitchell Branch area storm water outfalls include former mercury recovery operations at the K-1401 and K-1420 buildings that led to downstream waste disposal areas such as the K-1407 ponds and K-1070-B Burial Ground. Also, the K-1035 Building instrument shop with associated mercury activities discharged liquids through building acid pits to the storm drain network. In addition to the continuing contributions from the storm drain outfalls, the instream sediments within Mitchell Branch are a potential contributor to water column measurements and fish bioaccumulation. Mitchell Branch mercury levels are monitored routinely at the K-1700 weir as part of the ETTP surface water locations. Figure F.8 shows mercury levels at the K-1700 weir from CY 2010 through FY 2018. In FY 2018, all results at K-1700 were within the AWQC.

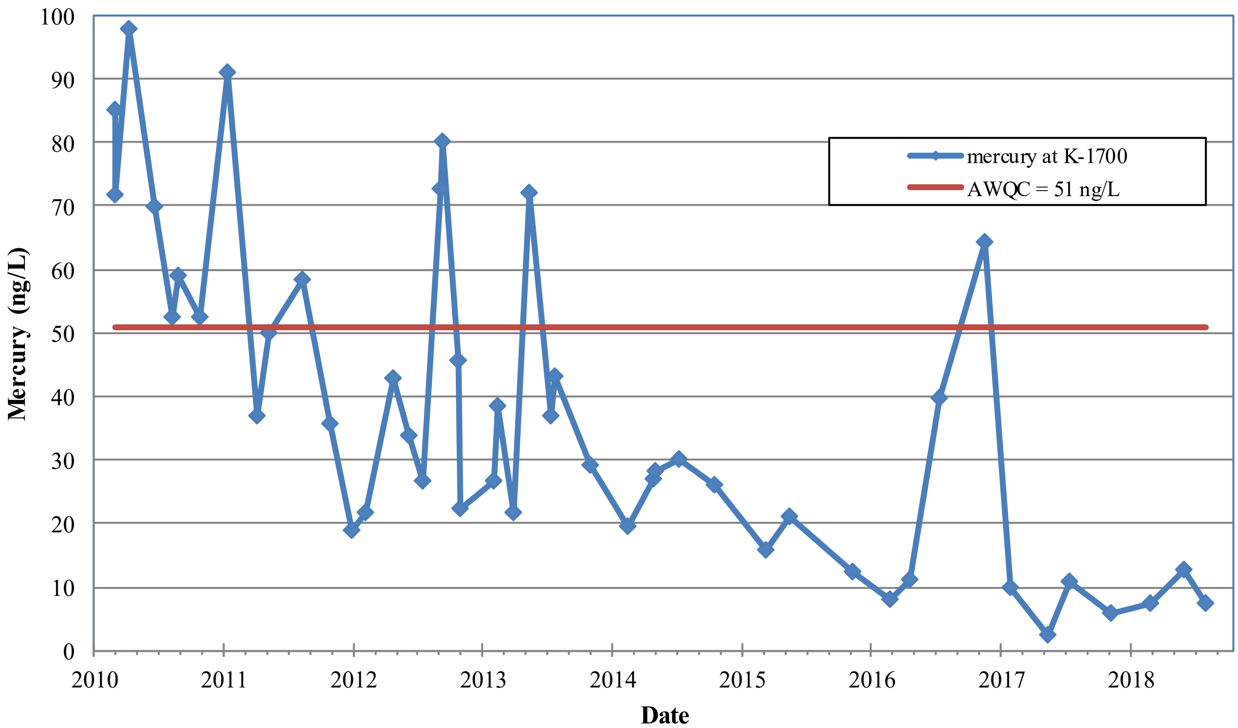

Figure F.8. Mercury concentrations at the K-1700 weir.

Storm water Outfall 05A, shown in Figure F.1, drains portions of the former K-1203 Sewage Treatment Plant (STP) area that discharge into the K-1203-10 sump. Soils and facility components from the K-1203 STP, including inactive piping, facilities, and basins, are contaminated with mercury from historical treatment operations from sources such as plant laboratory discharges. The decontamination and decommissioning (D&D) of the K-1203 STP was completed in early CY 2018. As part of the FY 2018 ETTP SWPP Program, Outfall 05A was monitored for contamination associated with the K-1203 facility demolition and storm water runoff. Initial sampling was performed at Outfall 05A to provide baseline data for conditions present before demolition began. Sampling was conducted following each 1 in. or greater rainfall event while D&D activities were being conducted. Storm water runoff monitoring was performed for each qualifying rain event for the duration of demolition and waste handling activities, as well as for any potential post-demolition mitigation actions. Mercury was detected at levels exceeding the AWQC of

51 ng/L as part of sampling conducted throughout the D&D activities performed at the site as indicated in Table F.3.

Table F.3. Results over screening levels for the K-1203 STP D&D monitoring[a]

Sampling location	Mercury (ng/L)
Screening level	51
OUTFALL 05A	
10/23/17	418
11/7/17	1,620
12/6/17	306
12/20/17	240

[a]Sampling was conducted following each 1 in. or greater rainfall event while D&D activities were being conducted at the K-1203 STP.

D&D = decontamination and decommissioning
STP = Sewage Treatment Plant

The D&D work at the K-1203 STP did not include the K-1203-10 sump, which collects the water that discharges through Outfall 05A. It will likely be addressed as part of a future corrective action (CA).

Building K-1232 was built in 1974. The facility was operated in conjunction with K-1231 to process classified material until 1980. Beginning in 1984, K-1232 was used to treat corrosive wastewaters from Y-12 by neutralization, metal removal, and carbon filtration. Two types of Y-12 wastes were treated, nitrate wastes and non-nitrate wastes. The nitrate wastes were basic solutions contaminated with nitrates, heavy metals, organics, and small amounts of uranium. The non-nitrate waste included plating wastewaters and cleaning solutions from production facilities. Demolition activities began at the K-1232 facility in September 2018. Initial sampling was performed at Outfall 380, shown in Figure F.1, on August 20, 2018, before demolition began in order to provide baseline data. Mercury was detected at a level of 119 ng/L as part of this sampling effort. Sampling will be conducted following each qualifying rain event while D&D activities are ongoing. Storm water runoff monitoring will be performed for the duration of demolition and waste handling activities, as well as for any potential post-demolition mitigation actions. A final monitoring event will occur at the conclusion of demolition, waste handling, and any potential post-demolition mitigation actions.

Outfalls 180 and 190, shown in Figure F.1, are two of the major outfalls that contribute flow to Mitchell Branch. Because the discharges from Outfalls 180 and 190 routinely contain mercury at levels above the screening level, these outfalls are thought to be the major contributors of mercury to Mitchell Branch as well. Mitchell Branch mercury levels are monitored routinely at the K-1700 weir as part of the ETTP surface water locations. Figure F.8 shows mercury levels at the K-1700 weir from CY 2010 through FY 2018. In FY 2018, all mercury results at K-1700 weir were well below the AWQC.

Mercury levels that exceed the state of Tennessee AWQC of 51 ng/L at ETTP have been identified in the Mitchell Branch watershed, as well as in a number of storm water outfalls, surface water locations, and groundwater monitoring wells. Updated analytical techniques for mercury have resulted in much lower detection limits than were previously attainable. In addition, knowledge of known historical mercury processes at the facility has greatly expanded. These factors have led to an ongoing facility investigation to more precisely detect and quantify the extent of any mercury contamination that may exist.

Factors being considered as part of the mercury investigation are the weather conditions (wet vs. dry), D&D activities (before, during, and after demolition of ETTP facilities), and types of monitoring locations chosen for sampling (in-stream, outfall, ambient, catch basin). Additionally, mercury is being sampled under other programs such as the ETTP Environmental Monitoring Program groundwater monitoring, the Biological Monitoring and Abatement Program D&D and remedial action activity support, and the NPDES permit renewal application.

The NPDES permit authorizes discharges from 91 storm water outfalls at ETTP, but only 27 "representative outfalls" are required to be sampled on an annual basis and for permit renewal. Certain non-representative outfalls were selected to be sampled for mercury as part of the FY 2018 ETTP SWPP Program. This sampling effort was performed to determine if non-representative outfalls might be contributing mercury to site waterways. All samples collected as part of this effort were manual grab samples that were collected according to the guidelines specified in Sections. 3.1.2 and 3.3.1 of U.S. Environmental Protection Agency (EPA) 833-B-92-001 and applicable procedures that have been developed by the sampling subcontractor. The mercury results from the samples collected at these outfalls are presented in Table F.4. Outfall locations are indicated in Figure F.1.

Table F.4. Analytical results from mercury sampling at storm water outfalls

Sampling location	Mercury (ng/L)
Outfall 200	15.4
Outfall 220	2.05
Outfall 250	**58.7**
Outfall 380	16.8
Outfall 382	7.78
Outfall 390	8.02
Outfall 410	25.1
Outfall 440	6.75
Outfall 530	46.1
Outfall 532	5.88
Outfall 570	11.3
Outfall 760	5.02
Outfall 780	**691**

Note: Results in **bold** exceed the AWQC for mercury (51 ng/L).

AWQC = ambient water quality criteria

As shown in Table F.4, the only mercury results of significant concern from this sampling effort came from storm water Outfalls 250 and 780.

A mercury sample was collected at Outfall 250 in June 2018. Outfall 250 is an open ditch that receives storm water runoff from the K-802 area, which is located northwest of the K-25 Building. An investigation into the potential sources of mercury at this outfall was undertaken, but no conclusive results were obtained. It is believed that the mercury at Outfall 250 may have come from historical discharge of mercury-contaminated sediments from Poplar Creek as part of the operation of the K-802 pumphouse.

A mercury sample was collected at Outfall 780 in March 2018. Outfall 780 once carried storm water runoff from Buildings. K-724 and K-725, which were located in the Powerhouse area. These buildings were originally part of the S-50 thermal diffusion plant. Building K-725 was used for beryllium processing in its later life. However, K-725 also contained mercury traps that occasionally released mercury. The mercury was reportedly "swept down the floor drains" in cleanup activities performed at the building in the 1970s. Mercury may have also been present in the dust collection system of the building. This presents a couple of routes whereby mercury could have entered the Outfall 780 piping system. The floor drains of the building were likely tied to the storm drain system, so any mercury swept to the floor drains likely wound up in the storm drain network. In addition, any mercury present in the dust collection system of the building was likely disturbed during demolition of the building in the mid-1990s and may have been transported to the storm drain system via storm water runoff from the building dust collection system debris. Therefore, the mercury analyzed in the March 1, 2018, sample could have been present in sediments contained in the piping system for many years and flushed from the piping system with the >5 in. of rain that fell in the week before this sample was collected.

No recent activities conducted in this area are suspected to have led to this elevated mercury level. The only ongoing activity being conducted in this drainage area is the Oak Ridge Forest Products wood chip mill.

Monitoring of pollutant loading (flux monitoring) is being conducted as part of the mercury investigation defined in the rationale portion of the ETTP NPDES Permit. In order to properly monitor mercury flux, accurate flow estimates and mercury concentrations measured during storm events are needed. Flow monitoring and mercury sampling activities are being conducted as part of ETTP SWPP Program sampling activities.

As a requirement stated in the rationale portion of the ETTP NPDES Permit, flow monitoring is being conducted at Outfalls 100, 170, 180, and 190. The rainfall events for which flow monitoring is required are defined as follows:

- 0.1 – 0.5 in. rain event
- 0.5 – 1.5 in. rain event
- 1.5 in. or greater rain event

These measured flows are being utilized to compare against flows generated using the Natural Resources Conservation Service Technical Report-55 (210-VI-TR-55), which is the current flow modeling technique utilized to estimate storm water flows at ETTP. This comparison is being done to increase the accuracy of the TR-55 flow modeling process. In FY 2018, adjustments were made to the TR-55 flow modeling parameters used for Outfalls 100 and 190 to achieve a much better correlation with flow measurements in the field over the three specified ranges of rainfall events. For Outfall 100 the base flow was reduced and the percent impervious increased in the TR-55 model. For Outfall 190 the base flow was reduced and the curve number was increased in the TR-55 model.

The ETTP NPDES Permit requires flow proportional composite mercury sampling at Outfalls 180 and 190. The results of this monitoring and the adjusted TR-55 flow modeling for these two outfalls will be used to calculate mercury flux. In FY 2018 flow proportional sampling was conducted twice for mercury at Outfall 180. Results are shown in Table F.5.

Table F.5. Analytical results from flow-proportional composite sampling at Outfall 180

Location	Parameter	Date sampled	Rainfall amount (in)	Results (ng/L)
Outfall 180	Mercury	9/11/18	0.33	**497**
Outfall 180	Mercury	9/25/18	1.35	**342**

Note: Results in **BOLD** indicate exceedance of screening level of 25 ng/L for mercury.

The flume designed for Outfall 100 was installed, and collection of flow data for Outfall 100 began in February 2018. The flume designed for Outfall 180 was installed, and collection of flow data for Outfall 180 began in September 2018. Collection of flow data at these two outfalls will continue well into CY 2019.

The ETTP NPDES Permit renewal application will be submitted to Tennessee Department of Environment and Conservation in CY 2019. Sampling required for the completion of the permit application was initiated as part of the FY 2015/2016 SWPP Program and continued as part of the FY 2017 and FY 2018 SWPP Programs. The permit renewal application sampling was completed in FY 2018. None of the representative outfalls sampled as part of the FY 2018 NPDES Permit renewal application sampling effort exceeded the AWQC for mercury. However, mercury was detected at Outfall 210 at a level of 80.6 ng/L, which exceeds the AWQC of 51 ng/L for mercury. Outfall 210 had been a representative outfall in previous ETTP NPDES permits, but it was not selected as a representative outfall for the current ETTP NPDES permit. All appropriate sampling will be performed to allow an EPA 2F form to be submitted for Outfall 210 as part of the ongoing application process for the next ETTP NPDES Permit. Outfall 210 may become a representative outfall under the next ETTP NPDES Permit. Outfall 210 collects runoff from the exterior portion of the northwest corner of the K-25 Building slab. D&D activities for the K-25 Building were completed in July 2014. Activities conducted in the K-25 Building during its operation included the isotopic enrichment of uranium by gaseous diffusion. The building was known to be contaminated with mercury due to the large numbers of electrical switches, gauges, and other instruments used while the building was operational.

F.5 PCB MONITORING AT ETTP STORM WATER OUTFALLS

PCBs were once ubiquitous across the ETTP. As a result, PCB contamination has been detected in several waterways and in storm water outfalls at ETTP. As part of the storm water monitoring activities conducted in FY 2018, PCBs were identified above the detection level in Outfalls 660 and 780. In addition to these outfalls, over the past several years PCBs have been detected in the following storm water outfalls at ETTP: Outfalls 100, 142, 190, 210, 230, 240, 280, 382, 430, 490, 510, 560, 610, 690, 700, 710, and 890.

The K-31 parcel, which is comprised of 46.8 acres, was recently made available by DOE Environmental Management for transfer to Community Reuse Organization of East Tennessee. Consolidated Nuclear Security, LLC (CNS) leased the property before the start of construction for the Uranium Processing Facility (UPF) Mechanical Electrical Building. The K-31 parcel is being developed to meet the infrastructure needs of the UPF project in order to provide an outdoor laydown area, temporary warehouse facility, temporary fabrication facility, and in-processing center for receipt of material. In order to determine if storm water outfalls in the K-31 area could be removed from the ETTP NPDES permit as part of the transfer of the property to CNS, and in an effort to determine the feasibility of leasing other portions of the K-31/K-33 area, sampling was performed at 12 outfalls within the drainage areas of these building footprints as part of the FY 2018 SWPP Program sampling effort. No PCBs were detected at any of the locations sampled with the exception of Outfall 510 which is shown in Figure F.1. PCB-1254 was detected at Outfall 510 at a level of 0.0456 µg/L as part of this sampling effort. Outfall 510 receives storm water runoff from a portion of the former K-31 Building area. K-31 was utilized in the isotopic enrichment of uranium. A variety of oils, lubricants, and solvents were in use in the K-31 Building as part of the enrichment process. Some of these materials are believed to have been contaminated with PCBs. The presence of PCBs in the storm water runoff from Outfall 510 may be related to past activities conducted in the K-31 Building and the associated D&D action.

An evaluation of PCB data collected as part of the ETTP SWPP Program from CY 2000 to the present was performed to identify locations where PCBs have been detected at storm water outfall locations. Non-representative outfalls that were grouped with the representative outfalls where PCBs have been detected and that have not been sampled in several years were selected to be sampled as part of the FY 2018 SWPP Program. This sampling effort was performed to determine if non-representative outfalls may be contributing PCBs to site waterways. Analytical results from samples collected as part of this sampling effort are shown in Table F.6.

Table F.6. Analytical results from FY 2018 SWPP Program PCB sampling

Location	Parameter	Date sampled	Screening level detectable
Outfall 144	Individual PCBs	1/29/18	No detectable PCBs
Outfall 220	Individual PCBs	4/16/18	No detectable PCBs
Outfall 382	Individual PCBs	3/12/18	No detectable PCBs
Outfall 440	Individual PCBs	3/12/18	No detectable PCBs
Outfall 530	Individual PCBs	6/28/18	No detectable PCBs
Outfall 720	Individual PCBs	4/24/18	No detectable PCBs
Outfall 780	Individual PCBs	3/1/18	PCB-1260—0.626 J µg/L
Outfall 880	Individual PCBs	3/1/18	No detectable PCBs

FY = fiscal year
J = estimated value
PCB = polychlorinated biphenyl
SWPP = Storm Water Pollution Prevention

PCB-1260 was detected in samples collected from Outfall 780 in March 2018. Outfall 780 once carried storm water runoff from buildings K-724 and K-725, which were located in the Powerhouse area. Outfall 780 also receives storm water runoff from the K-722 area. Approximately 1000 gal of oil was landfarmed for dust suppression in 1982 on the roads in the vicinity of the K-722 area. Oil used for landfarming in this area was required only to have a PCB content of 5 ppm or less. The analytical results from this sampling event may be showing the presence of low-level PCBs that could have been present in some of the oil that was landfarmed.

In the 1990s, buildings K-1314-G, K-1314-H, and K-1314-J were constructed adjacent to the K-1066-E uranium hexafluoride (UF_6) cylinder yard. The buildings functioned as a location where UF_6 cylinders could be sandblasted and repainted. The paint that had originally been applied to the UF_6 cylinders contained PCBs; therefore, the K-1314 buildings and the concrete pad they were built on became contaminated with PCBs. D&D of these buildings was initiated in the first quarter of CY 2018. These buildings are located in the storm water Outfall 387 drainage area. Outfall 387 is listed on the ETTP NPDES permit, but it is not a representative outfall. No samples had been collected from the outfall in almost 20 years. Samples for PCBs were collected any time the outfall was observed to be discharging during demolition of these facilities. Also, samples were to be collected after all D&D activities had been completed at these buildings. All of the samples were collected as manual grab samples. On February 26, 2018, samples of the discharge from Outfall 387 were collected before demolition of the K-1314 buildings was initiated. No qualifying rainfall events occurred during the time D&D activities were being conducted at these buildings. D&D activities at the K-1314 buildings were completed in early April 2018. Samples were collected on June 25, 2018 after demolition of the K-1314 buildings had been completed. Results over screening levels are presented in Table F.7.

Table F.7. Analytical results over screening levels from sampling at Outfall 387

	Date sampled	PCB-1260 (μg/L)
		Screening level detectable
Outfall 387	2/26/18 (prior to D&D activities)	0.0555 J
	6/25/18 (after completion of D&D activities)	0.0489 J

D&D = decontamination and decommissioning
J = estimated value
PCBs = polychlorinated biphenyl

As stated in Section F.4, D&D of the K-1203 STP facility was conducted in FY 2018. As part of the *East Tennessee Technology Park Storm Water Pollution Prevention Program Sampling and Analysis Plan, Oak Ridge, Tennessee* (UCOR-4028) for FY 2018, Outfall 05A was monitored for contamination associated with the K-1203 facility demolition and storm water runoff. PCBs were detected in samples collected at Outfall 05A during D&D activities, as shown in Table F.8.

Table F.8. Results over screening levels for the K-1203 STP D&D monitoring

Sampling location	PCB-1254 (μg/L)	PCB-1260 (μg/L)
Screening level	Detectable	Detectable
OUTFALL 05A		
11/7/17	0.082 J	0.0392 J

D&D = decontamination and decommissioning
J = estimated value
PCB = polychlorinated biphenyl
STP = Sewage Treatment Plant

The D&D work at the K-1203 STP did not include the K-1203-10 sump, which collects the water that discharges through Outfall 05A. It will likely be addressed as part of a future CA.

F.6 REFERENCES

210-VI-TR-55, Second Edition, June 1986. *Urban Hydrology for Small Watersheds TR-55*, 1986, U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C.

DOE-STD-1196-2011. *Derived Concentration Technical Standard*, 2011, U.S. Department of Energy, Washington, D.C.

UCOR-4028. *East Tennessee Technology Park Storm Water Pollution Prevention Program Sampling and Analysis Plan, Oak Ridge, Tennessee*, 2017, latest revision, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

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APPENDIX G
BUILDING DECONTAMINATION AND DECOMMISSIONING AND PROVISIONAL MANAGEMENT ACTIVITIES

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INTRODUCTION

This appendix:

- provides an update on removal actions that do not address the contamination of environmental media but generally address facility demolition or modification,
- verifies the integrity of the remedy,
- verifies that required land use controls are in place, and
- verifies that the provisional management of potentially contaminated slabs at the East Tennessee Technology Park was performed.

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G.1. BETHEL VALLEY

G.1.1 METAL RECOVERY FACILITY

Under the *Action Memorandum for the Demolition of the Metal Recovery Facility, Building 3505, at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1843&D2), surface structures were removed to slab, leaving in place the concrete floor slab, foundation, and other subsurface structures. The floor slab was sealed, and the slab and surrounding yard were covered with a minimum 2 in. of gravel. Final disposition of the slab and subsurface structures has been deferred to the *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (DOE/OR/01-1862&D4). The location of the Metal Recovery Facility is shown on Figure H.1 in Appendix H.

G.1.1.1 Remedy Integrity and Land Use Controls

The *Removal Action Report for the Metal Recovery Facility, Building 3505, at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-2000&D2/R1) requires the integrity of the gravel cover be maintained and posting as an underground contamination area. In the event that the gravel cover is disturbed, the minimum 2 in. gravel protective cover over the epoxy barrier coating must be restored.

G.1.1.2 Status of Remedy Integrity and Land Use Controls

The site underwent an annual inspection in fiscal year (FY) 2018 performed by the Oak Ridge National Laboratory Surveillance and Maintenance (S&M) Program to monitor the condition of the gravel cover and ensure that the signs denoting underground contamination are visible and firmly in place.

G.2. UPPER EAST FORK POPLAR CREEK

G.2.1 Y-12 NATIONAL SECURITY COMPLEX FACILITIES DECONTAMINATION AND DECOMMISSIONING UPDATE

Work performed in FY 2018 on projects implemented under the *Action Memorandum for the Y-12 Facilities Non-Time-Critical Removal Action Deactivation/Demolition Project, Oak Ridge, Tennessee* (DOE/OR/01-2462&D2) is described below.

Demolition of exterior portions of Colex process on the west side of Alpha 4. Work was completed in FY 2018 to remove mercury from and demolish the column exchange (Colex) process piping, tanks, and equipment outside on the west side of Alpha 4 (Building 9201-4, see Figure G.1). An *Addendum to the Removal Action Work Plan for the Y-12 Facilities Deactivation/Demolition Project, Oak Ridge, Tennessee* (DOE/OR/01-2479&D1/A1) that describes the approach was approved in FY 2017 by the regulators.

Figure G.1. Colex process pipe located outside on the west side of the Alpha 4 building.

Biology Complex. Buildings 9743-2 and 9770-2 were demolished, and the *Phased Construction Completion Report, Buildings 9743-2 and 9770-2 Demolition Project, Oak Ridge, Tennessee* (DOE/OR/01-2790&D1) was submitted to U.S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC) for approval. Deactivation of the remaining Biology Complex buildings started in FY 2018 to prepare them for demolition.

***Beta 4 Complex*.** The *Waste Handling Plan for the Demolition of the Beta 4 Complex Located at the Y-12 National Security Complex, Oak Ridge, Tennessee* (DOE/OR/01-2766&D1) was submitted to EPA and TDEC in FY 2018.

G.2.2 SECONDARY PATHWAYS PROJECT

The purpose of the Secondary Pathways Project was to identify and/or correct potential mercury infiltration and migration points at each of the three major mercury use facilities at Y-12 National Security Complex (Y-12). The project scope included completion of mercury reduction actions outside Buildings 9201-5 (Alpha 5) and 9201-4 (Alpha 4). Additional actions included the investigation, identification and confirmation of potential mercury source points inside both facilities and Building 9204-4 (Beta 4) using available drawings of piping systems and floor drains. The project consisted of work to improve and control storm water runoff from the north and south sides of Alpha 5 and the south side of Alpha 4. The work included modifying drains, drainage systems, and installing graded impervious surfaces to route runoff to storm drains, thus reducing percolation through mercury contaminated soil. Work inside Alpha 5 and Beta 4 identified and confirmed the location of existing open drains inside each building. Prior activities in Alpha 4 have already been completed to eliminate potential mercury migration pathways.

G.2.2.1 Remedy Integrity

The Secondary Pathways Project is included in Table 6.7 in Chapter 6 and remedy maintenance is described below.

The *Phased Construction Completion Report for the Secondary Pathways Project, Y-12 National Security Complex, Oak Ridge, Tennessee* (Secondary Pathways PCCR; DOE/OR/01-2596&D1) states that the Y-12 Utilities Management Division is responsible for long-term operation and maintenance associated with the drainage improvements. Clean out and other maintenance work will be performed as needed.

G.2.2.2 Status of Remedy Integrity

Remedy maintenance as specified in the Secondary Pathways PCCR was verified in FY 2018. The drainage improvements were maintained as part of the routine inspections that include Alpha 4 and Alpha 5. This site is not inspected in Land Use Manager. There is an ongoing division of responsibility discussion regarding these inspection requirements.

G.3. EAST TENNESSEE TECHNOLOGY PARK

G.3.1 EAST TENNESSEE TECHNOLOGY PARK BUILDINGS DECONTAMINATION AND DECOMMISSIONING UPDATE

The *Action Memorandum for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1988&D2; DOE/OR/01-2259&D1; DOE/OR/01-2582&D1) requires the Buildings K-25 and K-27 be demolished to slab. Completion of demolition progress has been documented by several PCCRs and a completion report (Table H.7 in Appendix H). The *Removal Action Report for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2729&D2) documenting demolition of Buildings K-25 and K-27 was approved in FY 2018.

The *Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2049&D2) requires approximately 500 facilities be demolished to slab. Demolition progress has been documented by numerous PCCRs (Table H.7 in Appendix H). The *Fiscal Year 2017 Phased Construction Completion Report for the Low Risk/Low Complexity and Predominantly Uncontaminated Facilities of the Remaining Facilities Demolition Project at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2763&D2) was approved in FY 2018 and contained no provisional management requirements. The *Phased Construction Completion Report for Demolition of the Central Neutralization Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee* (CNF Demolition PCCR; DOE/OR/01-2782&D1) to document demolition of the CNF was submitted to the Regulators for approval in FY 2018 and contained no provisional management requirements. This supersedes the provisional management requirements previously included in the *Phased Construction Completion Report for Decommissioning the Central Neutralization Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee* (CNF PCCR; DOE/OR/01-2619&D2).

Buildings K-413, and K-1231, and K-1233 were demolished in 2008 and 2009, and the demolition is documented in the *Phased Construction Completion Report for Poplar Creek High-Risk Facilities K-1231, K-1233, and K-413 at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2444&D2). Per the PCCR for Buildings K-413 and K- 1231, "The concrete slab remains and is posted as a Fixed Contamination Area." Subsequent to the PCCR, demolition of the tie line along the south edge of the K-1231 and K-1233 slabs has resulted in additional fixed contamination in the area. In accordance with the *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee* (Zone 2 RDR/RAWP; DOE/OR/01-2224&D5) the provisional management requirements for Buildings K-413, K-1231, and K-1233 slabs were documented in a concurrence form signed May 16, 2018. Additional approvals for inclusion of these provisional management requirements into the *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (RAR CMP; DOE/OR/01-2477&D3) are not required.

G.3.2 PROVISIONAL MANAGEMENT OF SLABS

The demolition of buildings at East Tennessee Technology Park (ETTP) under the Comprehensive Environmental Responses, Compensation, and Lability Act of 1980 does not include removal of the underlying slab. The management of potentially contaminated slabs following building demolition is described in Appendix K of the Zone 2 RDR/RAWP. Remedial action (RA) concurrence forms document the provisional management of the slab (e.g., inspections, fixative, monitoring, and land use controls) to be implemented while awaiting remediation. Provisional management ends when the slab is remediated.

G.3.2.1 Provisional Management

Provisional management of the K-29 slab includes radiological surveys of the slab, and verification monitoring at SD-490 and K-1007-P1 Holding Pond weir to ensure potential contamination is not migrating from the slab. Inspections of the fixative are specified at the K-1058 slab and the K-1416 slab, but no additional verification monitoring is required. These three slabs were added to the RAR CMP and are listed in Table G.1.

Buildings K-413, K-1231, and K-1233 slabs were added to the RAR CMP in FY 2018. The provisional management of the slabs includes radiological surveys of the slabs, and verification monitoring at SD-362, SD-380, and Poplar Creek location K-716 to ensure potential contamination is not migrating from the slab. These three slabs are listed in Table G.1.

G.3.2.2 Status of Provisional Management

The provisional controls for K-413 slab, K-1231 slab, K-1233 slab, K-29 slab, K-1058 slab, and K-1416 slab were performed in FY 2018. Annual radiological surveys and inspections of postings were conducted by UCOR, an AECOM-led partnership with Jacobs, Radiation Protection Program at ETTP. Monitoring was conducted by UCOR's Environmental Compliance and Protection Organization. Facility inspections were performed by the ETTP S&M Program. Removal of the K-29 slab as a RA under the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2719&D2) was initiated in FY 2018. When removal is complete, provisional management requirements will no longer be required.

Table G.1. Slab provisional management

Slab	Location[a]	Type[a]	Parameters[a]	Frequency[a]	FY 2018 results
K-29 Slab	*Storm Drain 490*	*Environmental*	*Gross alpha, gross beta, uranium isotopic, technetium-99, and PCBs*	*Storm water discharges are characterized during each NPDES permitting period. The maximum amount of time a NPDES permit can be issued is 5 years*[b]	All uranium isotopic and Tc-99 results <1% of DCS.
K-29 Slab	*K-1007-P1 Pond Weir*	*Environmental*	*Gross alpha, gross beta, uranium isotopic, technetium-99, and PCBs*	*Annual*	Gross alpha/beta results below screening levels. Uranium isotopic and Tc-99 results <1% of DCS. No PCBs detected.
K-29 Slab	*Building K-29 Slab*	*Radiological*	*Removable*	*Annual*	No removable activity above CFR §835 limits detected.
K-1058 Slab	*K-1058 Slab*	*Surveillance and Maintenance*	*Inspect integrity and conduct maintenance as necessary to maintain a protective sealant cover*	*Quarterly*	Slab was inspected in FY 2018. Maintenance request is in place to repair sealant and remove vegetation.

Table G.1. Slab provisional management (cont.)

Slab	Location[a]	Type[a]	Parameters[a]	Frequency[a]	FY 2018 results
K-1416 Slab	*K-1416 Slab*	*Surveillance and Maintenance*	*Inspect integrity and conduct maintenance as necessary to maintain a protective sealant cover*	*Quarterly*	Slab was inspected in FY 2018. Maintenance request is in place to reapply sealant.
K-413, K-1231, and K-1233 slabs	*Storm Drain 362 and 380*	*Environmental*	*Gross alpha, gross beta, uranium isotopic, technetium-99*	*At least once per NPDES permitting period*	SD-362 not sampled in FY 2018. SD-380 sampled in FY 2018;Uranium isotopic results <2% of DCS.
K-413, K-1231, and K-1233 slabs	*Poplar Creek location K-716*	*Environmental*	*Gross alpha, gross beta, uranium isotopic, technetium-99*	*Annual*	Gross alpha/beta results below screening levels. Uranium isotopic and Tc-99 results <0.1% of DCS.
K-413, K-1231, and K-1233 slabs	*Building K-413, K-1231, and K-1233 slabs*	*Radiological*	*Gross alpha, gross beta, removable alpha, removable beta*	*Annual*	No removable activity above CFR §835 limits detected.

[a]Source: *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2477&D3).
[b]Source: *Phased Construction Completion Report for Building K-29 of the Remaining Facilities Demolition Project at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2336&D2). The K-29 slab is currently being removed in FY 2019.

CFR = *Code of Federal Regulations*
DCS = Derived Concentration Standard
FY = fiscal year
NPDES = National Pollutant Discharge Elimination System
PCB = polychlorinated biphenyl
SD = storm drain

G.3.3 DEMOLITION PROJECTS

The scope of demolition projects is the demolition of above-grade structures to slab or to grade. The scope of remediation of the slabs, subsurface structures, and underlying soils is addressed under the *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-1997&D2) and the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2). Therefore, demolition projects normally do not include land use controls because they are included in the RA completion documents.

G.3.3.1 CNF

The CNF was a batch wastewater treatment facility for mixed waste, low-level radioactive waste, Resource Conservation and Recovery Act of 1976 (RCRA) waste, and industrial wastewater. The treatment process included pH adjustment, chemical precipitation, filtration, sludge dewatering, air stripping, and carbon absorption. The facility operated under a permit-by-rule for the treatment of mixed radioactive and hazardous waste. The CNF PCCR and the subsequent erratum document the completion of the CNF decommissioning activities to remove all RCRA hazardous waste from the facility, verify all components of the facility were decontaminated to RCRA clean-closure performance standards, and identify provisional controls, e.g., postings, annual surveys and inspections. The decommissioning and demolition of CNF took place from December 2012 to May 2018. The CNF Demolition PCCR was submitted to the Regulators for approval in FY 2018 and contained no provisional management requirements. This supersedes the provisional management requirements previously included in the CNF PCCR.

G.3.3.1.1 Provisional Management

While waiting for demolition and remediation of CNF, provisional controls were in place per the CNF PCCR. These requirements have been superseded by the CNF Demolition PCCR submitted to Regulators for approval in FY 2018. Currently there are no provisional management requirements for CNF facilities. This action will be removed from the Remediation Effectiveness Report pending Regulatory approval of the demolition PCCR.

G.3.3.1.2 Status of Provisional Management

Currently, there are no provisional management requirements for CNF facilities.

G.4. REFERENCES

DOE/OR/01-1843&D2. *Action Memorandum for the Demolition of the Metal Recovery Facility, Building 3505, at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2000, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1862&D4. *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1988&D2. *Action Memorandum for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1997&D2. *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2000&D2/R1. *Removal Action Report for the Metal Recovery Facility, Building 3505, at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2008, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2049&D2. *Action Memorandum for the Remaining Facilities Demolition Project at East Tennessee Technology Park, Oak Ridge, Tennessee*, 2003, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2161&D2. *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2005, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2224&D5. *Remedial Design Report/Remedial Action Work Plan for Zone 2 Soils, Slabs, and Subsurface Structures, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2259&D1. *Notification of Non-Significant Change to the Action Memorandum for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park, Oak Ridge, Tennessee: Preservation of North Wing and Placement of Concrete Rubble in East and West Wing Vaults of the K-25 Building*, 2005, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2336&D2. *Phased Construction Completion Report for Building K-29 of the Remaining Facilities Demolition Project at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01 2444&D2. *Phased Construction Completion Report for Poplar Creek High-Risk Facilities K-1231, K-1233, and K-413 at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2010, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2462&D2. *Action Memorandum for the Y-12 Facilities Non-Time-Critical Removal Action Deactivation/Demolition Project, Oak Ridge, Tennessee*, 2010, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2477&D3. *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2479&D1/A1. *Addendum to the Removal Action Work Plan for the Y-12 Facilities Deactivation/Demolition Project, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2582&D1. *Notification of Non-Significant Change to the Action Memorandum for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park, Oak Ridge, Tennessee: Demolition of the North Wing and Retaining Walls*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2596&D1. *Phased Construction Completion Report for the Secondary Pathways Project Y-12 National Security Complex, Oak Ridge, Tennessee*, 2013, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2619&D2. *Phased Construction Completion Report for Decommissioning the Central Neutralization Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2014, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2729&D2. *Removal Action Report for the Decontamination and Decommissioning of the K-25 and K-27 Buildings, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2763&D2. *Fiscal Year 2017 Phased Construction Completion Report for the Low Risk/Low Complexity and Predominantly Uncontaminated Facilities of the Remaining Facilities Demolition Project at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2766&D1. *Waste Handling Plan for the Demolition of the Beta 4 Complex Located at the Y-12 National Security Complex, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2782&D1. *Phased Construction Completion Report for Demolition of the Central Neutralization Facility at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2790&D1. *Phased Construction Completion Report, Buildings 9743-2 and 9770-2 Demolition Project, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

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APPENDIX H
TABLES AND LOCATION MAPS OF COMPLETED CERCLA ACTIONS

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Table H.1. Completed CERCLA actions in BV

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
Monitoring and LUC requirements for the BV Watershed are managed in RAR CMP			
Watershed-scale actions			
BV Interim Actions	ROD (DOE/OR/01-1862&D4): 05/02/02 – NSC (DOE/OR/01-2152&D1), addition of Hot Storage Garden (3597): 06/25/04 – NSC, delineates area of land transferred for multi-program research facility: 12/03/04 – NSC, addition of IFDP facilities: 09/10/09 – NSC, errata to NSC submitted 09/10/09; no approval required: 10/26/09 – ESD (DOE/OR/01-2446&D2), changes to SWSA 3 remedy: 10/05/10 – NSC, clarification of risk reduction goals at 7500 Bridge: 11/16/13 – NSC, remove Building 2643 structure; letter submitted 3/21/16; no approval required	Watershed-scale requirements provided in ROD.	Yes (see Table 2.3)/ Yes (see Table 2.14)
		PCCR for Hot Storage Garden (DOE/OR/01-2265&D1) approved 01/10/06	No/No
		PCCR for the Tanks T-1, T-2, and HFIR (DOE/OR/01-2238&D1) approved 11/16/05	Superseded by the RAR for Melton Valley Watershed (DOE/OR/01-2343&D1/A1)
		PCCR for the BV Mercury Sumps Groundwater Action (DOE/OR/01-2472&D1) approved 08/27/10	Yes/Yes
		PCCR for Corehole 8 Extraction System (DOE/OR/01-2534&D1/A1) approved 04/23/12	Yes/Yes
		PCCR for Northwest Quadrant Slabs and Soils (DOE/OR/01-2579&D1) approved 11/05/12	No/No
		PCCR for D&D of General Maintenance Facilities (DOE/OR/01-2552&D2) approved 10/09/12	No/No
		PCCR for D&D of Small Facilities and Southeast Contaminated Lab Facilities (DOE/OR/01-2573&D2) approved 10/09/12	No/No
		PCCR for Isotopes Row Facilities Legacy Material Removal (DOE/OR/01-2557&D2) approved 09/21/12	No/No

Table H.1. Completed CERCLA actions in BV (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
		PCCR for BVBGs (DOE/OR/01-2533&D2) approved 05/11/12	Yes/Yes
		PCCR for 4500 Gaseous Waste Reconfiguration and Stabilization (DOE/OR/01-2614&D1) approved 11/20/13	No/No
		PCCR for Building 3026 C Hot Cell Demolition (DOE/OR/01-2629&D1) approved 11/21/13	No/No
		PCCR for Building 3038 Legacy Material Removal (DOE/OR/01-2617&D2) approved 01/27/14	No/No
		PCCR for 3550 Slab (DOE/OR/01-2627&D1) approved 11/04/13	No/No
		PCCR for Building 3042 Reactor Pool Seep (DOE/OR/01-2710&D1) approved 09/01/16	No/No
		PCCR for Buildings 3026 and 3038 RAs (DOE/OR/01-2744) approved 09/11/17	No/ No
Single-project actions			
WAG 1 Corehole 8 (Plume Collection)	AM (DOE/OR/02-1317&D2): 11/10/94 • Addendum AM (Letter): 04/22/98 • Addendum AM (DOE/OR/01-1831&D2): 09/30/99	RmAR (DOE/OR/01-1380&D1) approved 09/11/95 Phase I Operations Report (DOE/OR/01-1832&D2) submitted 11/02/99 Phase II Operations Report (DOE/OR/01-1882&D1) approved 06/21/00	Superseded by PCCR for Corehole 8 Extraction System (DOE/OR/01-2534&D1/A1)
Building 3001 Canal	AM (DOE/OR/02-1533&D2): 11/18/96	RmAR (DOE/OR/01-1599&D2) approved 08/22/97	No/No[c]
SIOU	ROD (DOE/OR/02-1630&D2): 09/25/97	RAR for Impoundments A and B (DOE/OR/01-2086&D2) approved 05/17/04	No/Yes
		RAR for Impoundments C and D (DOE/OR/01-1784&D2) approved 04/19/99	No/No
Metal Recovery Facility	AM (DOE/OR/01-1843&D2): 03/3/00	RmAR ([DOE/OR/01-2000&D2/R1] approved with the acceptance of the Completion Letter [waste disposition] 06/18/08)	No/Yes

Table H.1. Completed CERCLA actions in BV (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
WAG 1 Tank WC-14 (1) Liquid removal	AM (DOE/OR/02-1322&D2): 02/16/95	RmAR (DOE/OR/01-1397&D1) approved 08/21/95	Discontinued/No
WAG 1 Tank WC-14 (2) Sludge removal	AM (DOE/OR/02-1598&D2): 09/3/97	RmAR (DOE/OR/01-1738&D2) approved 12/15/98	No/No
Waste Evaporator Facility	AM (DOE/OR/02-1381&D2): 07/28/95	RmAR (DOE/OR/01-1460&D1) approved 12/12/96	No/No
GAAT Operable Unit	ROD (DOE/OR/02-1591&D3): 09/2/97	RAR (DOE/OR-01-1955&D1) approved 10/2/01	No/No
Inactive Liquid LLW Tanks	AM (DOE/OR/01-1813&D1): 05/26/99 • AM Addendum (DOE/OR/01-1833&D2): 09/30/99	RmAR (DOE/OR/01-1953&D2) approved 10/2/01	No/No
		RmAR II Addendum (DOE/OR/01-1953&D2/A2) submitted 09/26/01	No/No
		RmAR Addendum (DOE/OR/01-1953&D2/A3) submitted 09/30/04	No/No
GAAT Shells/Risers	AM (DOE/OR/01-1957&D2): 07/13/01	RmAR (DOE/OR/01-2010&D1) approved 08/21/02	No/No
Corehole 8 Plume Source (Tank W-1A)	AM (DOE/OR/01-1749&D1): 09/17/98 Amended in 1999	RmAR (DOE/OR/01-1969&D3) approved 08/30/12	No/Yes
2000 Complex D&D	AM (DOE/OR/01-2412&D1): 09/03/09	RmAR for 2000 Complex (DOE/OR/01-2501&D1) approved 08/25/11	No/No
3026 C&D D&D Wooden Superstructure	AM (DOE/OR/01-2402&D2) 03/24/09	RmAR (Wooden Superstructure) (DOE/OR/01-2470&D1) submitted 03/22/11 (approval not required)	No/No
Buildings 3074, 3136 and 3020 Stack D&D	AM (DOE/OR/01-2407&D1): 04/09/09	RmAR (DOE/OR/01-2641&D2) submitted 05/22/15 (approval not required)	No/No

[a]Monitoring and LUC requirements from completion/post-decision documents are managed in the *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2478&D3).

[b]Monitoring is those environmental media monitoring activities tied to the effectiveness of the remedy. LUCs include protectiveness requirements needed to ensure the integrity of the remedy.

[c]The *Removal Action Report on the Building 3001 Canal at Oak Ridge National Laboratory Oak Ridge, Tennessee* (DOE/OR/01-1599&D2) required monthly inspections of the grout and paint for one year only. The monthly checks were conducted through 2006 and are no longer reported in the RER.

AM = Action Memorandum
BV = Bethel Valley
BVBG = Bethel Valley Burial Ground
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
D&D = decontamination and decommissioning
ESD = Explanation of Significant Difference
GAAT = Gunite and Associated Tanks
HFIR = High Flux Isotope Reactor
IFDP = Integrated Facility Disposition Project
LLW = low-level waste

Table H.1. Completed CERCLA actions in BV (cont.)

LUC = land use control
NSC = Non-Significant Change
PCCR = Phased Construction Completion Report
RA = remedial action
RAR = Remedial Action Report
RER = Remediation Effectiveness Report
RmAR = Removal Action Report
ROD = Record of Decision
SIOU = Surface Impoundments Operable Unit
SWSA = Solid Waste Storage Area
WAG = Waste Area Grouping

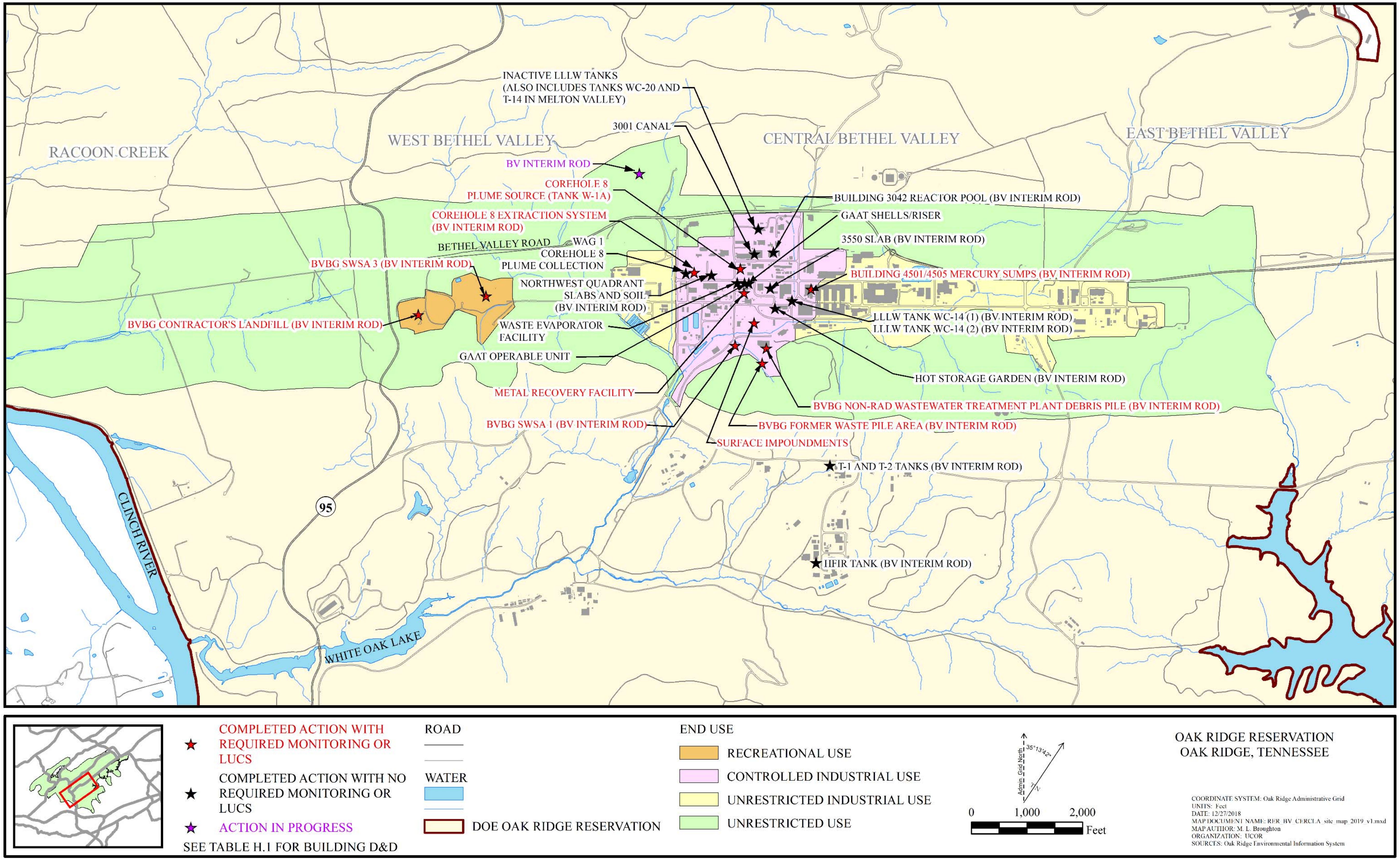

Figure H.1. Completed CERCLA actions and end uses in Bethel Valley.

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Table H.2. Completed CERCLA actions in MV

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
Monitoring requirements for the MV Watershed are managed in RAR CMP[a]			
Watershed-scale actions			
MV Interim Actions	ROD (DOE/OR/01-1826&D3): 09/21/00 – ROD Amendment (DOE/OR/01-2170&D1): 09/07/04, Changes remediation approach for Trenches 5 & 7 to *in situ* grouting – ESD (DOE/OR/01-2040&D2): 03/12/04, Adds Tumulus 1 and 2 and the Intermediate Waste Management Facility to the scope of the Interim ROD – ESD (DOE/OR/01-2165&D1): 09/07/04, Modifies requirements for 11 waste units – ESD (DOE/OR/01-2249&D1): 09/13/05, Removes seven facilities from MSRE D&D – ESD (DOE/OR/01-2333&D1): 12/27/06, Removes five shielded transfer tanks from D&D scope – LUCIP (DOE/OR/01-1977&D6): 05/24/06	Watershed-scale requirements provided in ROD.	Yes (see Table 3.2)/ Yes (see Table 3.14)
		RAR (DOE/OR/01-2343&D1) approved 09/05/07	Yes/Yes
		– (DOE/OR/01-2343&D1/A1) erratum approved 06/25/09	No/Yes
		– (DOE/OR/01-2343&D1/A2) erratum submitted 10/19/09 (no approval required)	No/Yes
		– (DOE/OR/01-2343&D1/A3/R1) addendum to remove RCRA administrative requirements from SWSA 6, approved 08/22/14	No/No
		• PCCR for Hydrofracture Well Plugging & Abandonment (DOE/OR/01-2138&D1) approved 07/14/06	Superseded by RAR (DOE/OR/01-2343&D1)
		• PCCR for New Hydrofracture Facility D&D (DOE/OR/01-2306&D1) approved 07/31/06	
		• PCCR for Trenches 5 and 7 and HRE Fuel Wells In Situ Grouting (DOE/OR/01-2302&D1) approved 08/14/06	
		• PCCR for Hydrologic Isolation at SWSA 6 (DOE/OR/01-2285&D1) approved 09/06/06	

Table H.2. Completed CERCLA actions in MV (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
		• PCCR for SWSA 4 and IHP (DOE/OR/01-2300&D1) approved 09/11/06	
		• PCCR for Old Hydrofracture Facility D&D (DOE/OR/01-2014&D2) approved 09/26/06	
		• PCCR for Hydrologic Isolation at Seepage Pits and Trenches (DOE/OR/01-2310&D1) approved 10/02/06	
		• PCCR for Soils and Sediments (DOE/OR/01-2315&D1) approved 10/02/06	
		• PCCR for HRE Ancillary Facilities D&D (DOE/OR/01-2307&D1) approved 10/04/06	
		• PCCR for 7841 Equipment Storage Area and 7802F Storage Shed D&D (DOE/OR/01-2323&D1) approved 10/05/06	
		• PCCR for Hydrologic Isolation at SWSA 5 (DOE/OR/01-2286&D1) approved 11/06/06	
Single-project actions			
WOCE	AM (Letter): 11/9/90	RmAR (ORNL/ER/Sub/91-KA931/4) approved 09/30/92	No/Yes
WAG 13 Cesium Plots	Interim ROD (DOE/OR-1059&D4): 10/06/92	RAR Post-construction report (DOE/OR/01-1218&D2) approved 08/25/94	No/Yes
WAG 5 Seep C	AM (DOE/OR/02-1235&D2): 03/30/94	RmAR Post-construction Report (DOE/OR/01-1334&D2) approved 06/22/95 – System shutdown prior to capping	Superseded by MV ROD (DOE/OR/01-1826&D3)
WAG 5 Seep D	AM (DOE/OR/02-1283&D2): 07/26/94	RmAR Post-construction Report (DOE/OR/01-1334&D2) approved 06/22/95 – Collection of contaminated groundwater ongoing	Superseded by MV ROD (DOE/OR/01-1826&D3)
WAG 4 Seep Control	AM (DOE/OR/02-1440&D2): 02/12//96	RmAR (DOE/OR/01-1544&D2) approved 03/05/98	Superseded by MV ROD (DOE/OR/01-1826&D3)
MSRE D&D Reactive Gas	AM (Letter): 06/12/95	RmAR (DOE/OR/01-1623&D2) approved 02/12/98	No/No
MSRE D&D Uranium Deposit Removal	AM (DOE/OR/02-1488&D2): 08/6/96	RmAR (DOE/OR/01-1918&D2) approved 12/18/01	No/Yes

Table H.2. Completed CERCLA actions in MV (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
Old Hydrofracture Tank Sludges	AM (DOE/OR/02-1487&D2): 09/12/96	RmAR (DOE/OR/01-1759&D1) approved 12/15/98	No/No
Old Hydrofracture Tanks and Impoundment	AM (DOE/OR/01-1751&D3): 05/14/99 AM Addendum (DOE/OR/01-1866&D2): 03/31/00	RmAR (DOE/OR/01-1908&D2) approved 05/11/01	Superseded by MV ROD (DOE/OR/01-1826&D3)
White Oak Dam	AM (Time Critical) for Corrective Actions at White Oak Dam (DOE/OR/01-2460&D1): 7/23/10	RmAR (DOE/OR/01-2509&D1) approved 11/08/11	Yes/Yes
		– (DOE/OR/01-2509&D1) erratum submitted 10/23/12 (no approval required)	No/Yes
MSRE D&D Fuel Salt Removal	ROD (DOE/OR/02-1671&D2): 07/07/98 ESD (DOE/OR/01-2088&D2) approved: 01/19/07 Deletes requirement to convert U-233 to an oxide	PCCR (DOE/OR/01-2256&D1 [removal and transfer of uranium from the MSRE Facility]) approved 10/10/08	No/No
		PCCR (DOE/OR/01-2671&D1) for waste characterized and disposed in FY 2014 approved 01/13/15	No/No
		PCCR (DOE/OR/01-2694&D1) for waste characterized and disposed in FY 2015 approved 03/7/16	No/No
		PCCR (DOE/OR/01-2733&D1) for waste characterized and disposed in FY 2016 approved 05/1/17	No/No
		PCCR (DOE/OR/01-2767&D1) for waste characterized and disposed in FY 2017 approved 03/5/18	No/No
TRU Waste Processing Complex Sludge Test Area Buildout	AM (DOE/OR/01-2621&D1) 08/02/13	RmAR (DOE/OR/01-2672&D1) approved 03/20/15	No/No

[a]Monitoring requirements from completion/post-decision documents are managed in the *Water Resources Restoration Program Sampling and Analysis Plan for the Melton Valley Watershed, Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1982&D3). The addition of LUC requirements currently included in the *Land Use Control Implementation Plan for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE/OR/01-1977&D6) to the RAR CMP is planned.

[b]Monitoring is those environmental media monitoring activities tied to the effectiveness of the remedy. LUCs include protectiveness requirements needed to ensure the integrity of the remedy.

AM = Action Memorandum
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
D&D = decontamination and decommissioning
ESD = Explanation of Significant Difference
FY = fiscal year
HRE = Homogeneous Reactor Experiment
IHP = Intermediate Holding Pond
LUC = land use control

Table H.2. Completed CERCLA actions in MV (cont.)

LUCIP = Land Use Control Implementation Plan
MSRE = Molten Salt Reactor Experiment
MV = Melton Valley
PCCR = Phased Construction Completion Report
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976
RmAR = Removal Action Report
ROD = Record of Decision
SWSA = Solid Waste Storage Area
TRU = transuranic
WAG = Waste Area Grouping
WOCE = White Oak Creek Embayment

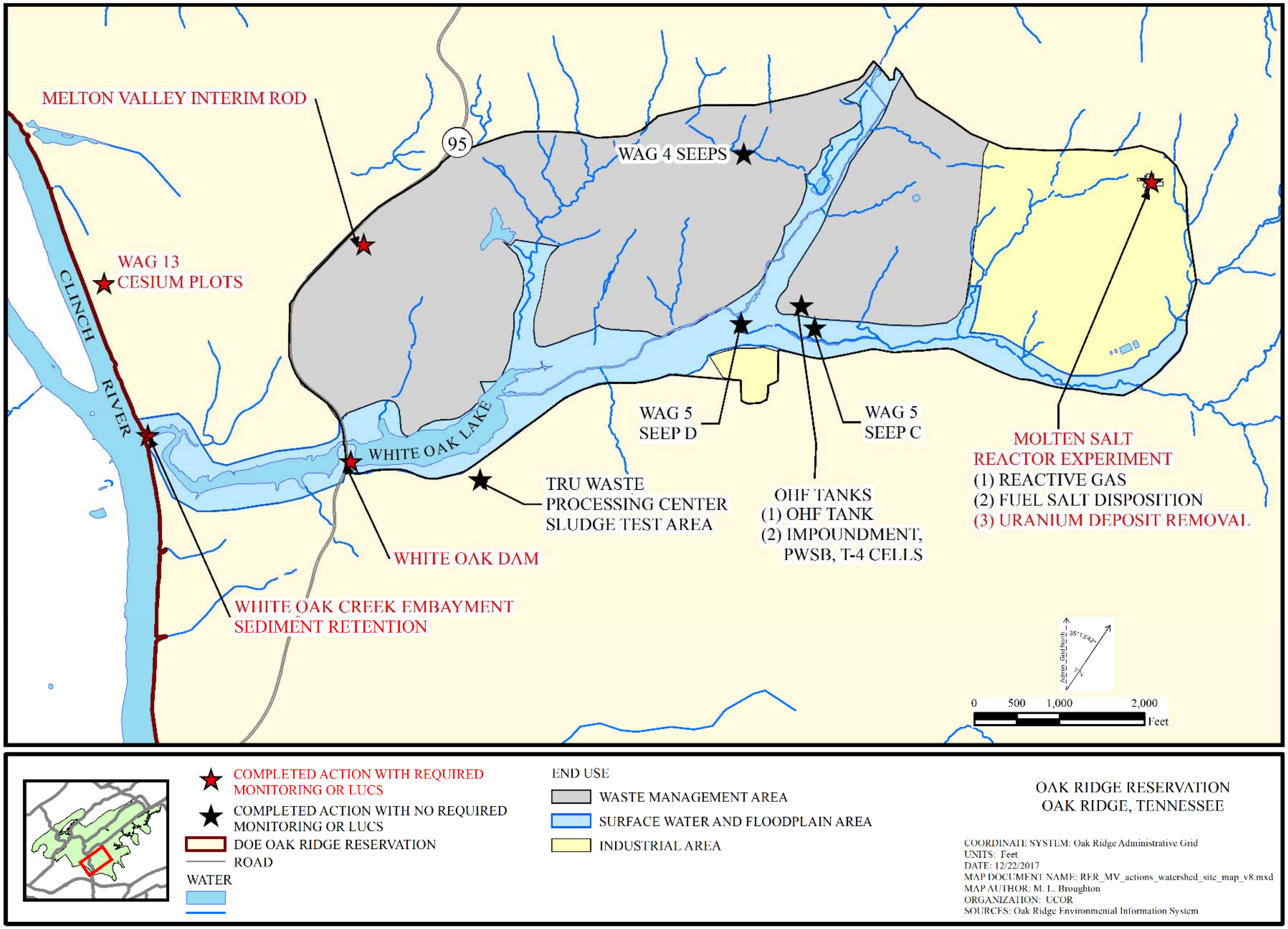

Figure H.2. Completed CERCLA actions and end uses in Melton Valley.

Table H.3. Completed CERCLA actions in BCV

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
Monitoring requirements for the BCV Watershed are managed in RAR CMP[a]			
Watershed-scale actions			
BCV Phase I ROD	ROD (DOE/OR/01-1750&D4): 06/16/00 – NSC, allows soils at the DARA Storage Facility to be disposed at the onsite EMWMF: 07/10/17	Watershed-scale requirements provided in ROD.	Yes (see Table 4.4)/ Yes (see Table 4.13)
		• BYBY PCCR (DOE/OR/01-2077&D2) approved 01/12/04	Yes/Yes
		• Oil Landfarm Soils Containment Pad RAR (DOE/OR/01-1937&D2) approved 07/16/01	No/No
		Monitoring and LUC requirements for the Bear Creek Burial Grounds (A-North, A-South, C-West)/Walk-In-Pits to be managed in RAR CMP	Yes[c]/Yes
		Monitoring and LUC requirements for the S-3 Ponds Site to be managed in RAR CMP	Yes[c]/Yes
		Monitoring and LUC requirements for the Oil Landfarm to be managed in RAR CMP	Yes[c]/Yes
Single-project actions			
BCV OU 2 (Spoil Area 1, SY-200 Yard)	ROD (DOE/OR/02-1435&D2): 01/23/97	No additional actions required; institutional control and S&M ongoing	No/Yes
S-3 Site Tributary Interception (Pathways 1 and 2)	AM (DOE/OR/01-1739&D1): 06/25/98	RmAR (DOE/OR/01-1945&D2): approved 02/11/02	Terminated
	AM Addendum (DOE/OR/01-1739&D1/A1): 10/20/00	RmAR Addendum (DOE/OR/01-1836&D1/A1): approved 06/20/07 (shutdown Pathways 1 and 2 system)	Terminated
BCBGs Unit D-East	AM (DOE/OR/01-2036&D1): 08/12/02	RmAR (DOE/OR/01-2048&D2): approved 05/09/03	No/No
EMWMF Haul Road Construction	ROD (DOE/OR/01-1791&D3: 11/02/99 ESD (DOE/OR/01-2194&D2): 01/11/05	PCCR (DOE/OR/01-2296&D1): approved 04/02/06 (Haul Road)	No/No[d]

[a] Monitoring requirements from completion/post-decision documents are managed in the *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-2457&D3). The addition of post-RCRA monitoring and LUC requirements to the RAR CMP is in preparation.

[b] Monitoring is those environmental media monitoring activities tied to the effectiveness of the remedy. LUCs include protectiveness requirements needed to ensure the integrity of the remedy.

[c] All monitoring data associated with these post-RCRA sites is already included in the Zone 1 and Zone 2 groundwater summaries.

[d] The EMWMF Haul Road Construction is a completed action under the EMWMF ROD. Operation of the EMWMF is an ongoing CERCLA action to dispose waste from CERCLA response actions on the ORR. The CERCLA action status of the EMWMF is evaluated in a separate report.

Table H.3. Completed CERCLA actions in BCV (cont.)

AM = Action Memorandum
BCBG = Bear Creek Burial Ground
BCV = Bear Creek Valley
BYBY = Boneyard/Burnyard
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = comprehensive monitoring plan
DARA = Disposal Area Remedial Action
ESD = Explanation of Significant Differences
EMWMF = Environmental Management Waste Management Facility
LUC = land use control
NSC = Non-Significant Change
ORR = Oak Ridge Reservation
OU = operable unit
PCCR = Phased Construction Completion Report
RAR = Remedial Action Report
RmAR = Removal Action Report
ROD = Record of Decision
S&M = surveillance and maintenance

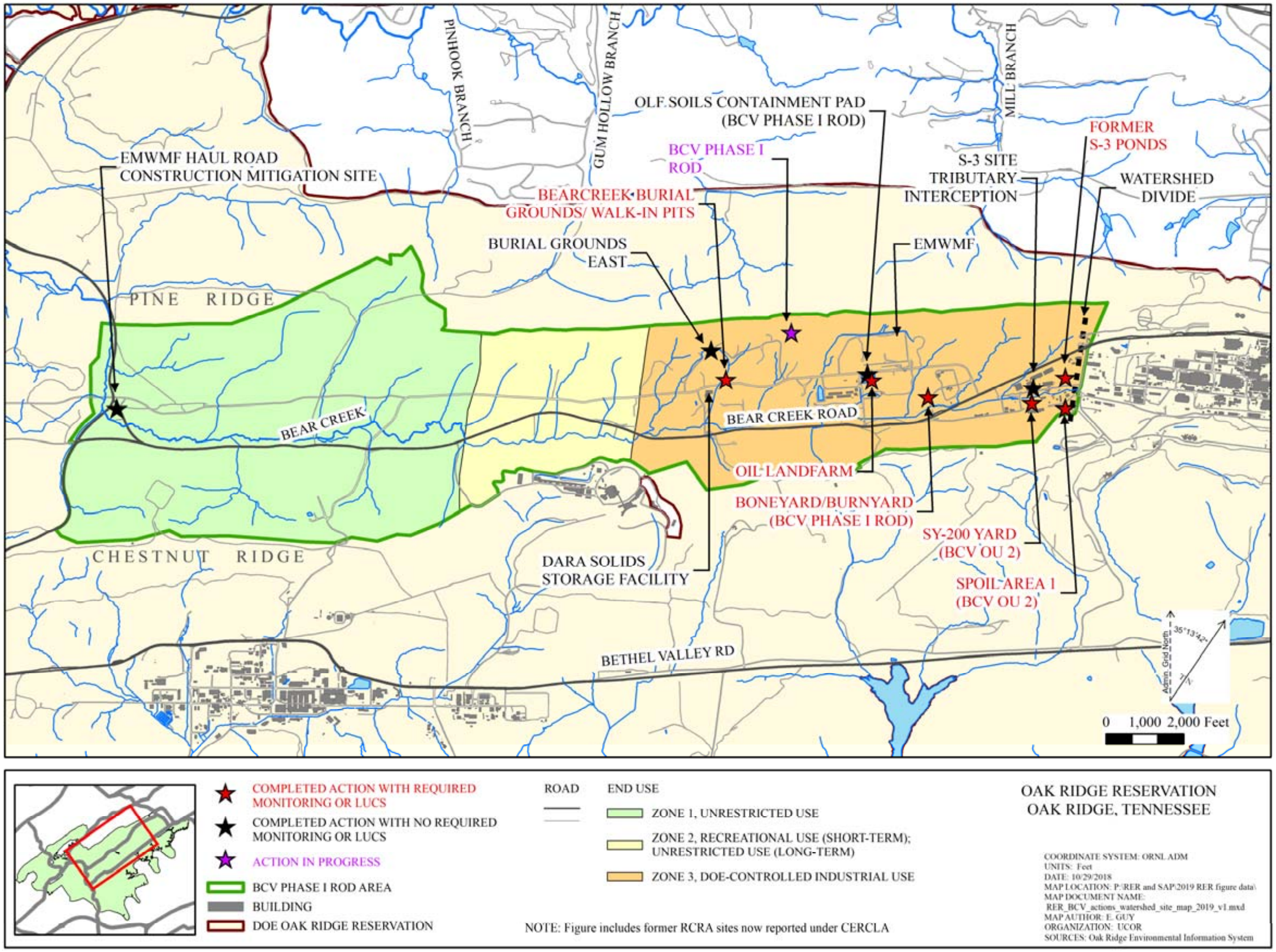

Figure H.3. Completed CERCLA actions and end uses in Bear Creek Valley.

Table H.4. Completed CERCLA actions in Chestnut Ridge

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
Monitoring requirements for Chestnut Ridge Watershed are managed in RAR CMP[a]			
Single-project actions			
UNC Disposal Site	ROD: 06/28/91	PCR (DOE/OR/01-1128&D1) approved 09/06/94	Yes/Yes
KHQ[c]	NFA ROD (DOE/OR/02-1398&D2): 09/29/95	RA completed under approved RCRA closure plan Monitoring and LUC requirements for KHQ to be managed in RAR CMP	Yes/Yes
FCAP/Upper McCoy Branch	ROD (DOE/OR/02-1410&D3): 02/21/96	RAR (DOE/OR/01-1596&D1) approved 06/03/97	Yes/Yes
CRSDB[d]		Monitoring and LUC requirements for the CRSDB to be managed in RAR CMP	Yes/Yes
CRSP[d]		Monitoring and LUC requirements for the CRSP to be managed in RAR CMP	Yes/Yes
ECRWP[d]		Monitoring and LUC requirements for the ECRWP to be managed in RAR CMP	Yes/Yes

[a]Monitoring requirements from completion documents are managed in the *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2466&D4). The addition of LUC requirements to the RAR CMP is planned.

[b]Monitoring is those environmental media monitoring activities tied to the effectiveness of the remedy. LUCs include protectiveness requirements needed to ensure the integrity of the remedy.

[c]All monitoring and LUC requirements for the KHQ included in the *Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/02-1398&D2) are now managed in the *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2466&D4).

[d]Sites were closed under RCRA and managed under a post-closure permit until 2018 when TDEC denied the permit re-applications at DOE's request and allowed the substantive requirements for post-closure care, monitoring, and reporting be integrated into the CERCLA process.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
CRSDB = Chestnut Ridge Sediment Disposal Basin
CRSPs = Chestnut Ridge Security Pits
DOE = U.S. Department of Energy
ECRWP = East Chestnut Ridge Waste Pile
FCAP = Filled Coal Ash Pond
KHQ = Kerr Hollow Quarry
LUC = land use control
NFA = No Further Action
PCR = Post-Completion Report
RA = remedial action
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision
TDEC = Tennessee Department of Environment and Conservation
UNC = United Nuclear Corporation

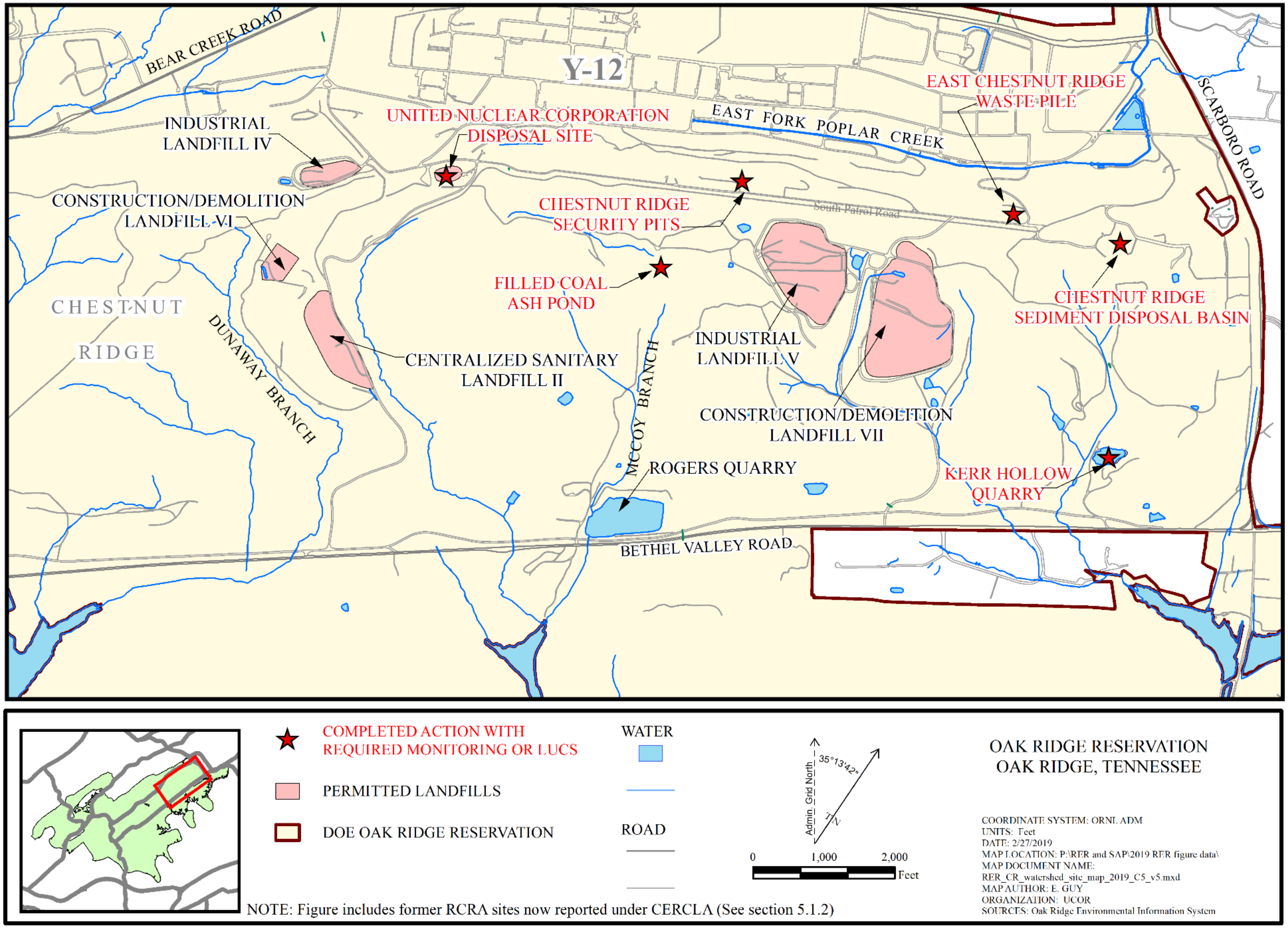

Figure H.4. Completed CERCLA actions on Chestnut Ridge.

Table H.5. Completed CERCLA actions in UEFPC

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/ LUC[b]
Monitoring requirements for UEFPC Watershed to be managed in RAR CMP[a]			
Watershed-scale actions			
Phase I Interim Source Control Actions	ROD (DOE/OR/01-1951&D3): 05/02/02 - NSC: 10/05/06, mercury monitoring NSC: 05/17/07, 9201-5 sump water - Erratum to the 10/05/06 NSC: 06/09/08, sampling at Outfall 163 NSC: 09/30/09; sump water - ESD (DOE/OR/02-1539&D2): 08/29/12, updates to selected remedy - NSC: submitted 03/14/14; UEFPC monitoring to be managed in RAR CMP - ROD amendment: 05/24/16, Outfall 200 Water Treatment Facility	Watershed-scale requirements provided in ROD	Yes (see Table 6.1)/ Yes (see Table 6.7)
		PCCR for BSWTS for Building 9201-2 (DOE/OR/01-2218&D1) approved 07/01/05	Yes/Yes
		PCCR WEMA storm sewer remediation (DOE/OR/01-2526&D2) approved 08/31/12	Yes/No
		LUC requirements for New Hope Pond to be managed in RAR CMP	No/Yes
		Monitoring requirements for Eastern S-3 Groundwater Plume to be managed in RAR CMP	Yes/No
Phase II Interim RA for Contaminated Soils and Scrapyard	ROD (DOE/OR/01-2229&D3): 04/21/06	Watershed-scale requirements provided in ROD	No/Yes (see Table 6.7)
		PCCR for Y-12 Salvage Yard – Scrap Removal (DOE/OR/01-2481& D1) approved 10/11/11	No/No
		PCCR for Y-12 Salvage Yard Soil (DOE/OR/01-2564&D1) approved 11/01/12	No/No
		(DOE/OR/01/-2481&D1/A1) addendum for removal and disposal of five tanks approved 02/11/14	No/No

Table H.5. Completed CERCLA actions in UEFPC (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/ LUC[b]
Single-project actions			
Y-12 EEVOC plume	AM (DOE/OR/01-1819&D2): 06/25/99 NSC: 03/06/13	RmAR (DOE/OR/01-2297&D1) approved 06/07/06 – Erratum to establish monitoring POC: submitted 03/05/13 (no approval required)	Yes/Yes
Union Valley	Interim ROD (DOE/OR/02-1545&D2): 07/10/97	--[c]	No/Yes
Mercury Tanks (Tanks 2100-U, 2101-U, 2104-U)	Interim ROD (DOE/OR/02-1164): 09/26/91	RAR (DOE/OR/01-1169&D1) approved 03/02/94	No/No
Plating Shop Container Areas	ROD (DOE/OR-1049&D3): 09/30/92	NFA	No/No
Abandoned Nitric Acid Pipeline (UEFPC Operable Unit 2)	ROD (DOE/OR/02-1265&D2): 09/12/94	NFA	No/No
Building 9201-4 Exterior Process Piping	AM (DOE/OR/02-1571&D2): 04/22/97	RmAR (DOE/OR/02-1650&D1) approved 09/30/99	No/No
Lead Source Removal of Former YS-860, Firing Range Removal Action	AM (DOE/OR/02-1622&D1): 03/10/98	RmAR (DOE/OR/01-1774&D2) approved 02/24/99	No/No
9822 Sediment Basin and 81-10 Sump Removal Action	AM (DOE/OR/01-1716&D2): 06/19/98	RmAR (DOE/OR/01-1763&D2) approved 02/24/99	No/No
Removal of Mercury from Storm Sewer System	Time-critical AM (DOE/OR/01-2574&D1): 07/19/12	RmAR for Mercury Reduction Project (DOE/OR/01-2595&D1) approved 02/11/14	Superseded by DOE/OR/01-2595&D1/R1
		RmAR for Mercury Reduction Project revision to document objectives have been met and to terminate action (DOE/OR/01-2595&D1/R1) approved 08/28/17	No/No
Removal of Debris and Soil from the Haul Road Ravine Disposal Area	Time-critical AM (DOE/OR/01-2662&D1): 10/06/14	RmAR (DOE/OR/01-2668&D1) approved 12/03/15	No/No
Demolition Projects			
Removal of legacy materials from Buildings 9201-5 and 9204-4	Time-critical AM (DOE/OR/01-2404&D1): 05/04/09 Addendum (DOE/OR/01-2404&D1/A1): 10/03/11	RmAR (DOE/OR/01-2519&D2) approved 02/27/12	No/No
Demolition of Buildings 9735 and 9206 filterhouse	Time-critical AM (DOE/OR/01-2405&D1): 05/04/09	RmAR (DOE/OR/01-2502&D1) approved 02/15/12	No/No

Table H.5. Completed CERCLA actions in UEFPC (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/ LUC[b]
Demolition of Buildings 9211, 9220, 9224, and 9769 (Biology Complex)	Time-critical AM (DOE/OR/01-2406&D1): 05/04/09	RmAR (DOE/OR/01-2508&D2) approved 02/13/12	No/No
Y-12 Facilities Deactivation/Demolition	AM (DOE/OR/01-2462&D2): 09/29/10	Project Completion Report (Beta-3 Legacy Material) (DOE/OR/01-2570&D1) approved 11/05/12	No/No
		RmAR Just In Case Yard (DOE/OR/01-2532&D1) approved 11/05/12	No/No
		PCCR for Secondary Pathways Project (DOE/OR/01-2596&D1) approved 02/11/14	No/Yes
		PCCR for Building 9206 Duct and Fan Removal (DOE/OR/01-2613&D1) approved 07/21/14	No/No
		PCCR for Building 9808 Demolition (DOE/OR/01-2696/D1) approved 9/27/16 (completion letter)	No/No
		PCCR for Biology Buildings 9743-2 and 9770-2 (DOE/OR/01-2790&D1) submitted on 8/20/2018	No/No

[a]Monitoring requirements from completion/post-decision documents are managed in the *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2466&D4). The addition of post-RCRA monitoring and LUC requirements to the RAR CMP is planned.
[b]Monitoring is those environmental media monitoring activities tied to the effectiveness of the remedy. LUCs include protectiveness requirements needed to ensure the integrity of the remedy.
[c]This action was completed prior to uniform adherence to the RAR process; hence, no RAR exists for this decision.

-- = not applicable, not available, or insufficient data to calculate the statistic
AM = Action Memorandum
BSWTS = Big Spring Water Treatment System
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
ESD = Explanation of Significant Difference
EEVOC = East End Volatile Organic Compound
LUC = land use control
NFA = No Further Action
NSC = Non-Significant Change
PCCR = Phased Construction Completion Report
POC = point-of-compliance
RA = remedial action
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976
RmAR = Removal Action Report
ROD = Record of Decision
UEFPC = Upper East Fork Poplar Creek
WEMA = West End Mercury Area
Y-12 = Y-12 National Security Complex

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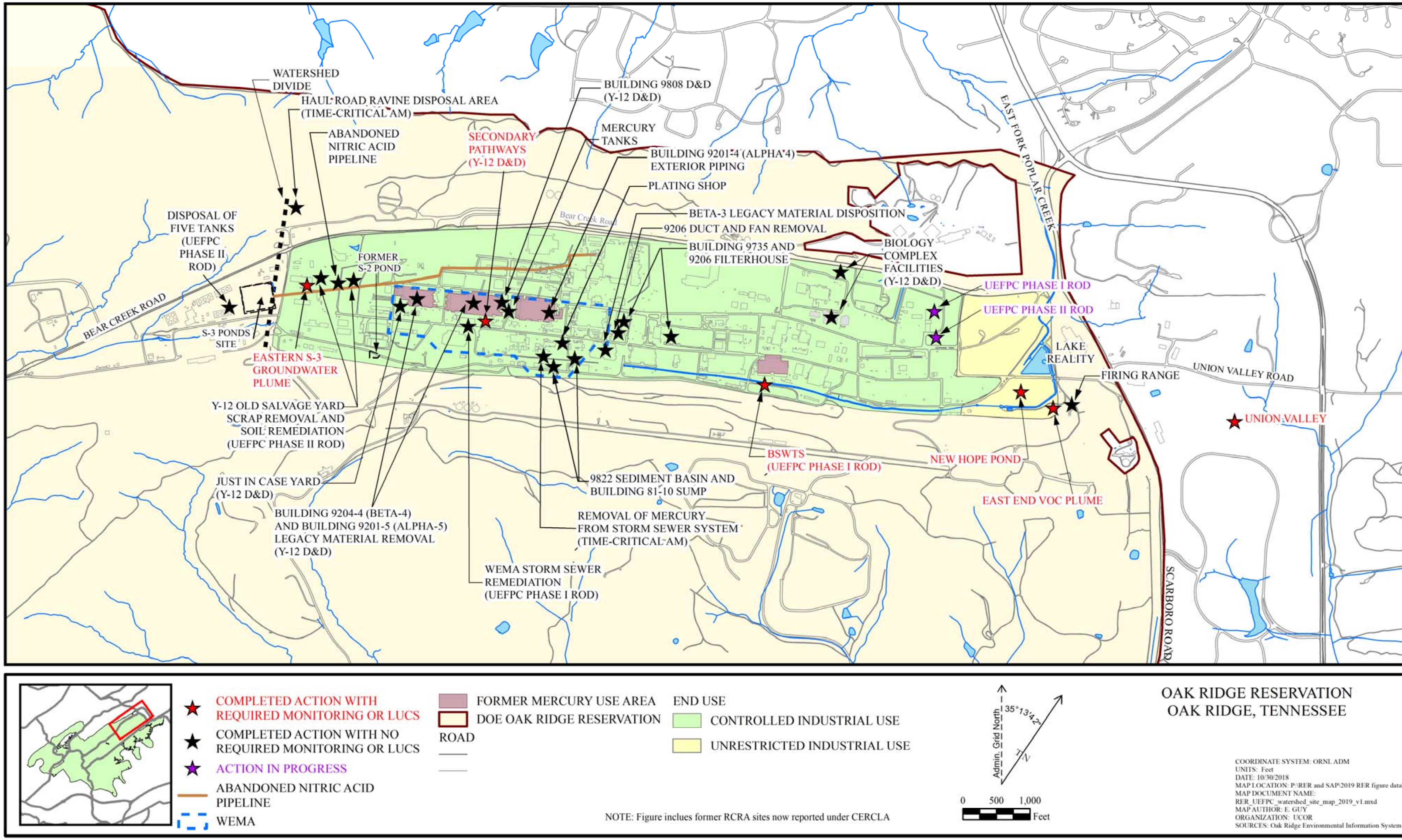

Figure H.5. Completed CERCLA actions and end uses in Upper East Fork Poplar Creek.

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Table H.6. Completed CERCLA actions at offsite locations

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
Monitoring requirements for offsite locations are managed in RAR CMP[a]			
Completed actions			
LEFPC	ROD (DOE/OR/02-1370&D2): 08/17/95 – ESD (DOE/OR/02-1443&D2): 11/15/96, increase in soil excavation volume	RAR (DOE/OR/01-1680&D5) approved 08/15/00	Yes/Yes
Clinch River/Poplar Creek	ROD (DOE/OR/02-1547&D3): 09/23/97	RAR (DOE/OR/02-1627&D3) approved 06/14/99 • LWBR and Clinch River/Poplar Creek Watershed RAR CMP (DOE/OR/01-1820&D3)	Yes/Yes
LWBR	ROD (DOE/OR/02-1373&D3): 09/29/95 NSC: approved 11/04/14, ecological protection clarification	RAWP[c] (DOE/OR/02-1376&D3) approved 05/25/96 • LWBR and Clinch River/Poplar Creek Watershed RAR CMP (DOE/OR/01-1820&D3)	Yes/Yes

[a]Monitoring requirements from completion/post-decision documents are managed in the *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1820&D3).

[b]Monitoring is those environmental media monitoring activities tied to the effectiveness of the remedy. LUCs include protectiveness requirements needed to ensure the integrity of the remedy.

[c]This action was completed prior to uniform adherence to the RAR process; hence, no RAR exists for this decision.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
ESD = Explanation of Significant Difference
LEFPC = Lower East Fork Poplar Creek
LUC = land use control
LWBR = Lower Watts Bar Reservoir
NSC = Non-Significant Change
RAR = Remedial Action Report
RAWP = Remedial Action Work Plan
ROD = Record of Decision

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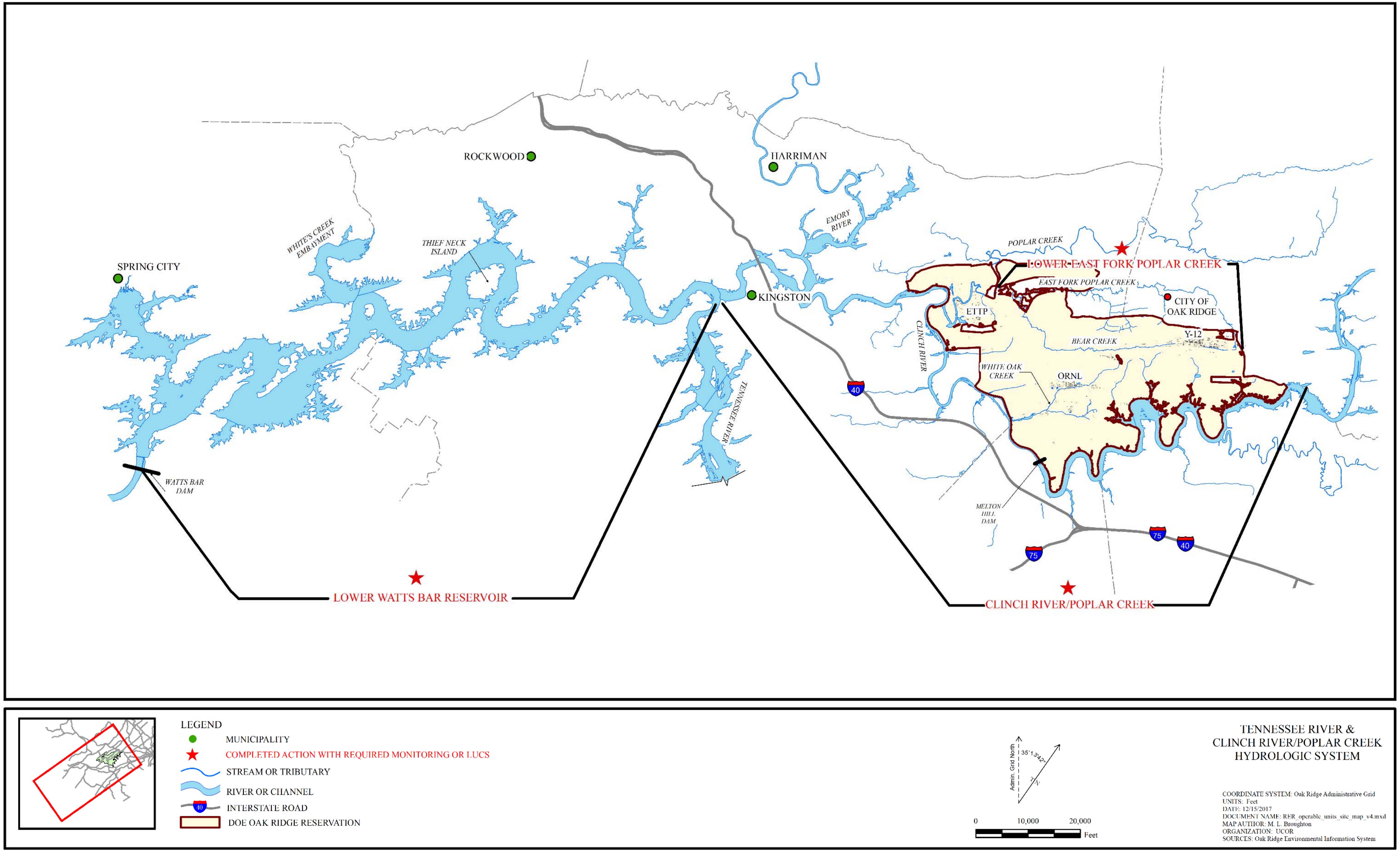

Figure H.6. Completed CERCLA actions at offsite locations.

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Table H.7. Completed CERCLA actions at ETTP

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
Monitoring and LUC requirements for the ETTP Watershed are managed in RAR CMP[a]			
Watershed-scale actions			
Zone 1 Interim Actions	ROD (DOE/OR/01-1997&D2): 11/08/02	Watershed-scale requirements provided in ROD.	No/Yes (see Table 8.1)
	- ESD (DOE/OR/01-2781&D2): 08/28/18, adds RAs at Duct Island that address ecological risks, specifically threats to terrestrial wildlife to the remedy		No/No
	- ESD (DOE/OR/01-2784&D1) submitted on 06/28/18 to add a soil cover to the K-770 Area		See footnote f
		Duct Island/K-901 Area PCCR (DOE/OR/01-2261&D2) approved 04/03/06	No/No
		• Duct Island/K-901 Area PCCR Addendum (DOE/OR/01-2261&D2/A1/R2) approved 02/28/11	No/No
		• Duct Island/K-901 Area PCCR Addendum 2 (DOE/OR/01-2261&D2/A2/R1) approved 02/28/17	No/No
		• Duct Island/K-901 Area PCCR Addendum 3 (DOE/OR/01-2261&D2/A3) approved 11/22/17	No/No
		K-1007 Ponds/Powerhouse PCCR (DOE/OR/01-2294&D2) approved 10/04/06	No/No
		• K-1007 Ponds/Powerhouse PCCR Addendum (DOE/OR/01-2294&D2/A1/R1) approved 12/31/11	No/No
		K-770 Scrap Removal PCCR (DOE/OR/01-2348&D1) approved 05/30/07	No/No
		• K-770 Scrap Removal PCCR Addendum (DOE/OR/01-2348&D1/A1) approved 12/03/10	No/No[c]
		FY 2008 PCCR for Units Z1-01, Z1-03, Z1-38, Z1-49 (DOE/OR/01-2367&D2) approved 04/23/08	No/No

Table H.7. Completed CERCLA actions at ETTP (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
		Powerhouse Duct Bank PCCR D2 (DOE/OR/01-2736&D2) submitted 06/07/18	No/Yes[e]
Zone 2 Soil, Buried Waste, and Subsurface Structure Interim Actions	ROD (DOE/OR/01-2161&D2)	Watershed-scale requirements provided in ROD	Yes (see Table 8.2)[g]/ Yes (see Table 8.1)
	– NSC (DOE/OR/01-22161&D2/R1) signed by DOE on 10/11/17 to replace Central Neutralization Facility with mobile treatment unit		No/No
		FY 2006 PCCR for EUs 2, 7, 9, 10, 27, and 42 (DOE/OR/01-2317&D2) approved 02/08/07	No/No
		• FY 2006 PCCR Addendum for EUs 2, 7, 9, 10, 27, and 42 (DOE/OR/01-2317&D2/A1) approved 04/08/16	No/No
		FY 2007 PCCR for EUs 1, 3, 8, 23, 24, 28, 33, 34, 35, 36, 37, 41, 43, and 44 (partial) (DOE/OR/01-2723&D2) approved 06/09/08	No/No
		• FY 2007 PCCR Addendum for EU 44 (DOE/OR/01-2723&D2/A1) approved 10/07/14 with submission of Erratum	No/No
		• FY 2007 PCCR Addendum for EU Z2-03 (DOE/OR/01-2723&D2/A2) approved 12/16/2016	No/No
		FY 2008 PCCR for EU Z2-33 (DOE/OR/01-2368&D2/R1) approved 09/28/09	No/No
		• FY 2008 PCCR for EU Z2-33 – Erratum (DOE/OR/01-2368&D2/R2 approved 12/16/09	No/No
		FY 2009 PCCR for EU Z2-36 (DOE/OR/01-2399&D1) approved 06/03/09	No/No
		FY 2009 PCCR for EUs 11, 12, 17, 18, 29, 38 (DOE/OR/01-2415&D2) approved 04/02/10	No/No

Table H.7. Completed CERCLA actions at ETTP (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
		FY 2010 PCCR for EU Z2-31 (DOE/OR/01-2443&D2) approved 10/22/10	No/No
		FY 2010 PCCR for EU Z2-32 (DOE/OR/01-2452&D1) approved 04/08/10	No/No
		PCCR for EU Z2-30 (K-1070-B Burial Ground) (DOE/OR/01-2521&D2) approved 03/15/13	No/No
		• PCCR for EU Z2-30 – Erratum (K-1070-B Burial Ground) (DOE/OR/01-2521&D2) submitted 5/16/13 (no approval required)	No/No
		PCCR for EUs 4 and 5 (K-33 slab) (DOE/OR/01-2590&D1) approved 02/11/13	No/No
		• PCCR Addendum for EUs 4 and 5 (K-33 slab) (DOE/OR/01-2590&D1/A1) approved 07/26/16	No/No
		PCCR for EU 35 Sumps (DOE/OR/O1-2618&D2) approved 05/07/14	No/No
		PCCR for EU 28 (DOE/OR/01-2746&D1) submitted 10/14/17	No/No
		PCCR for EU 29 (DOE/OR/01-2747&D1) submitted 07/11/18	No/No
		PCCR for EU Z2-06 (DOE/OR/01-2699&D2) approved 02/24/17	No/No
Single-project actions			
K-1417-A/B Drum Storage Yards	ROD (DOE/OR-991&D1): 09/19/91	RAR (Letter) approved 03/02/95	No/No
K-1070-C/D SW-31 Spring	Interim ROD (DOE/OR-1050&D2): 09/30/92 ESD (DOE/OR/02-1132&D2): 07/08/93	RAER (DOE/OR/01-1520&D1/R1) approved 12/11/96	Superseded by RAER Addendum – Erratum (DOE/OR/01-1520&D1/R1/A1) to eliminate monitoring
		• RAER Addendum (DOE/OR/01-1520&D1/R1/A1) to terminate action approved 02/28/07	
		• RAER Addendum – Erratum (DOE/OR/01-1520&D1/R1/A1) to eliminate monitoring approved 10/03/13	No/No

Table H.7. Completed CERCLA actions at ETTP (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
K-1407-B/C Ponds	ROD (DOE/OR/02-1125&D3): 09/30/93 (Also, closed under RCRA)	RAR (DOE/OR/01-1371&D1) approved 08/16/95	Superseded by RAR Erratum
		• RAR Erratum (DOE/OR/01-1371&D1) approved 05/26/15	Yes/Yes
K-1401 and K-1420 Sumps	AM (DOE/OR/02-1610&D1): 08/18/97 NSC (DOE/OR/02-1610/R1): 10/23/07 (reroute K-1401 sump discharge to sanitary wastewater treatment)	RmAR (DOE/OR/01-1754&D2) approved 02/01/99	Terminated by RmAR Addendum (DOE/OR/01-1754&D2/A1)
		• RmAR Addendum (DOE/OR/01-1754&D2/A1) to terminate operation approved 04/21/06	
K-1070-C/D and Mitchell Branch	AM (DOE/OR/02-1611&D2): 08/25/97	RmAR (DOE/OR/01-1728&D3) approved 03/02/99	Terminated
		• Approval to terminate operation of non-cost effective system 12/17/04	
K-901-A and K-1007-P1 Pond	AM (DOE/OR/02-1550&D2): 10/15/97 (superseded by AM) (DOE/OR/01-2314&D2)	RmAR (DOE/OR/01-1767&D2) approved 11/12/99	Superseded by RmAR (DOE/OR/01-2456&D1/R1)
K-1070-C/D G-Pit and Concrete Pad	ROD (DOE/OR/02-1486&D4): 01/23/98	RAR (DOE/OR/01-1964&D2) approved 10/15/03	Superseded by RAR Erratum
		• Completion letter (waste) approved 10/29/03	No/No
		• RAR Erratum (DOE/OR/01-1964&D2) approved 03/13/15	No/Yes[d]
K-1070-A Burial Ground	ROD (DOE/OR/01-1734&D3): 01/13/00	RAR (DOE/OR/01-2090&D1) approved 11/28/03	Superseded by Duct Island/K-901 Area PCCR (DOE/OR/01-2261&D2) approved 04/03/06
K-1085 Old Firehouse Burn Area Drum Burial Site Removal Action	AM (DOE/OR/01-1938&D1): 03/27/01	RmAR (DOE/OR/01-2050&D1) conditionally approved 02/18/03	No/No
		Completion Letter approved 01/19/07	
Outdoor LLW Removal	AM (DOE/OR/01-2109&D1): 11/14/03	RmAR (DOE/OR/01-2225&D2) approved 08/24/05	No/No
ETTP Ponds removal action	AM (DOE/OR/01-2314&D2): 03/12/07 (K-1007-P and K-901-A holding ponds, K-720 Slough, and 770 Embayment) (supersedes DOE/OR/01-1550&D2)	RmAR (DOE/OR/01-2456&D1/R1) approved 03/10/11 (supersedes DOE/OR/01-1767&D2)	Yes/Yes

Table H.7. Completed CERCLA actions at ETTP (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
Mitchell Branch Chrome Reduction	AM (DOE/OR/01-2369&D1): 12/20/07 (Reduction of Hexavalent Chromium Releases to Mitchell Branch Time-Critical)	RmAR (DOE/OR/01-2384&D1) submitted 07/30/08; review and approval suspended 10/09/08	Superseded by RmAR (DOE/OR/01-2598&D2)
	AM (DOE/OR/01-2448&D1) (Long-Term Reduction of Hexavalent Chromium Releases to Mitchell Branch) approved 04/13/10 (supersedes DOE/OR/01-2369&D1)	RmAR (DOE/OR/01-2598&D2) approved 04/04/13	Yes/Yes
		• RmAR Addendum (DOE/OR/01-2598&D2/A1) approved 10/06/16	Yes/No
		• RmAR Addendum (DOE/OR/01-2598&D2/A1/R1) approved 08/07/17	Yes/No
Demolition projects			
K-25 Auxiliary Facilities Group I Building Demolition removal action	AM (DOE/OR/02-1507&D2): 01/17/97	RmAR (DOE/OR/01-1829&D1) issued August 1999	No/No
		• RmAR Addendum I (DOE/OR/01-1829&D1/A1) approved 06/02/05	No/No
		• RmAR Addendum II (DOE/OR/01-1829&D1/A2) approved 06/05/06	No/No
K-29, K-31, and K-33 Equipment Removal and Building Decontamination removal action	AM (DOE/OR/02-1646&D1): 09/30/97	RmAR (DOE/OR/01-2290&D3) approved 06/08/07	No/No
		• RmAR Addendum (DOE/OR/01-2290&D3/A2) approved 03/16/09	No/No
K-25 Auxiliary Facilities Group II, Phase I Building Demolition, Main Plant removal action	AM (DOE/OR/01-1868&D2): 08/03/00	RmAR (DOE/OR/01-2116&D2) approved 09/24/04	No/No
K-25 Auxiliary Facilities Group II, Phase II Building Demolition, K-1064 Peninsula Area removal action	AM (DOE/OR/01-1947&D2): 07/31/02	• PCCR (DOE/OR/01-2183&D1) approved 01/31/06	Superseded by RmAR (DOE/OR/01-2339&D1)
		• PCCR Addendum (DOE/OR/01-2183&D1/A1) approved 04/10/06	
		• PCCR Addendum (DOE/OR/01-2184&D1/A2) approved 10/03/06	
		RmAR (DOE/OR/01-2339&D1) approved 06/27/07	No/No
K-25 and K-27 Buildings Demolition removal action	AM (DOE/OR/01-1988&D2): 02/13/02	PCCR for Hazardous Materials Abatement conditionally (DOE/OR/01-2275&D1) approved 12/19/05	No/No

Table H.7. Completed CERCLA actions at ETTP (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
	NSC (DOE/OR/01-2259&D1): 12/16/05 NSC (DOE/OR/01-2582&D1): 08/09/12	Completion of mercury ampoules disposal in accordance with the PCCR (DOE/OR/01-2275&D1) approved 03/17/06	No/No
		Completion Letter, Disposition of Centrifuge and Y-12 Materials, Excess Materials Removal, K-25/K-27 D&D approved 06/30/08	No/No
		PCCR for FY 2008 Earned Value (DOE/OR/01-2396&D2) approved 09/17/09	No/No
		• PCCR for FY 2008 Earned Value – Erratum (DOE/OR/01-2396&D2) submitted 10/30/09 (no response required)	No/No
		PCCR for FY 2009 Earned Value (DOE/OR/01-2436&D2) approved 06/29/10	No/No
		PCCR for Excess Material Removal (DOE/OR/01-2392&D4) approved 04/23/12	No/No
		PCCR for FY 2010 Earned Value (DOE/OR/01-2494&D2) approved 08/03/11	No/No
		PCCR (K-25 East Wing Characterization, Foaming, NE Bridge) (DOE/OR/01-2538&D2) approved 04/28/12	No/No
		PCCR for FY 2012 (DOE/OR/01-2577&D2) approved 08/27/14	No/No
		PCCR for FY 2013 (DOE/OR/01-2624&D2) approved 10/6/16	No/No
		• PCCR for FY 2013 – Erratum (DOE/OR/01-2624&D2) submitted 06/16/14 (no approval required)	No/No
		K-25 Completion Report (DOE/OR/01-2651&D3) approved 12/5/16	No/No
		PCCR for FY 2014 (DOE/OR/01-2681&D2) approved 08/25/15	No/No
		RmAR (DOE/OR/01-2729&D2) submitted on 2/17/18	No/Yes

Table H.7. Completed CERCLA actions at ETTP (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
K-25 Group II, Phase 3 Building Demolition, Remaining Facilities removal action	AM (DOE/OR/01-2049&D2): 09/30/03	FY 2004 PCCR PUF (DOE/OR/01-2193&D2) approved 03/28/05	No/No
		FY 2005 PCCR PUF (DOE/OR/01-2269&D2) approved 02/15/06	No/No
		FY 2005 PCCR LR/LC Facilities (DOE/OR/01-2270&D2) approved 02/15/06	No/No
		FY 2006 PCCR PUF (DOE/OR/01-2326&D2) approved 11/05/09	No/No
		FY 2006 PCCR LR/LC Facilities (DOE/OR/01-2327&D2) approved 12/02/09	No/No
		Balance of Site-Laboratory Area Facilities PCCR (DOE/OR/01-2309&D2) approved 08/30/07	No/No
		FY 2007 PCCR PUF (DOE/OR/01-2363&D2) approved 06/25/08	No/No
		FY 2007 PCCR LR/LC Facilities (DOE/OR/01-2362&D3) approved 09/27/10	No/No
		K-29 PCCR (DOE/OR/01-2336&D2) approved 10/18/07	No/No
		• K-29 PCCR Addendum (DOE/OR/01-2336&D2/A1) approved 12/05/16	No/No
		K-1420 PCCR (DOE/OR/01-2341&D2) approved 10/26/07	No/No
		Building K-1401 PCCR (DOE/OR/01-2365&D2) approved 02/27/09	No/No
		• Building K-1401 PCCR Erratum (DOE/OR/01-2365&D2/A1) approved 04/08/09	No/No
		FY 2008 PCCR LR/LC Facilities (DOE/OR/01-2394&D1) approved 03/13/09	No/No
		FY 2008 PCCR PUF (DOE/OR/01-2395&D1) approved 02/09/09	No/No
		FY 2009 PCCR for LR/LC Facilities (DOE/OR/01-2434&D2) approved 09/14/11	No/No

Table H.7. Completed CERCLA actions at ETTP (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
		FY 2009 PCCR for PUF (DOE/OR/01-2435&D2) approved 04/12/10	No/No
		PCCR for Poplar Creek 3 High Risk Facilities (DOE/OR/01-2444&D2) approved 07/28/10	No/No
		PCCR (SW-31 Spring Transfer Line) (DOE/OR/01-2520&D1) approved 02/10/12	No/No
		PCCR for K-33 (DOE/OR/01-2541&D1) approved 02/06/12	No/No
		PCCR for K-33 above-ground utility piping (DOE/OR/01-2541&D2 approved 07/03/13	No/No
		FY 2011 PCCR for Poplar Creek – four tie lines (DOE/OR/01-2524&D3) approved 12/28/12	No/No
		FY 2011 PCCR for LR/LC Facilities (DOE/OR/01-2547&D2) approved 07/09/12	No/No
		FY 2011 PCCR PUF (DOE/OR/01-2554&D2) approved 05/31/12	No/No
		Building K-33 PCCR (DOE/OR/01-2541&D2) approved 07/03/13	No/No
		PCCR for K-33/K-31 Process Tie Line (DOE/OR/01-2620&D2) approved 05/25/17	No/No
		PCCR for Decommissioning Central Neutralization Facility (DOE/OR/01-2619&D2) approved 11/24/14	Superseded by Central Neutralization Facility PCCR for demolition (DOE/OR/01-2782&D1) submitted on 09/27/18
		• PCCR for Decommissioning Central Neutralization Facility – Erratum (DOE/OR/01-2619&D2) approved 11/24/14	Superseded by Central Neutralization Facility PCCR for demolition (DOE/OR/01-2782&D1) submitted on 09/27/18
		FY 2014 PCCR for LR/LC Facilities (DOE/OR/01-2679&D2) approved 09/09/15	No/No
		FY 2014 PCCR PUF (DOE/OR-01-2680&D2) approved 07/01/15	No/No

Table H.7. Completed CERCLA actions at ETTP (cont.)

CERCLA action	Decision document, date signed (mm/dd/yy)	Completion document[a]	Monitoring/LUC[b]
		Building K-31 PCCR (DOE/OR/01-2692&D2) approved 04/11/16	No/No
		FY 2015 PCCR for LR/LC Facilities (DOE/OR/01-2706&D2) approved 07/19/16	No/No
		FY 2017 PCCR LR/LC and PU Facilities (DOE/OR/01-2763&D2) approved on 7/30/18	No/No
		Central Neutralization Facility PCCR for demolition (DOE/OR/01-2782&D1) submitted on 09/27/18	No/No

[a]Monitoring and LUC requirements from completion documents are managed in the *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2477&D3).

[b]Monitoring is those environmental media monitoring activities tied to the effectiveness of the remedy. LUCs include protectiveness requirements needed to ensure the integrity of the remedy.

[c]The *Addendum II to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2294&D2/A2) documents the characterization and remediation of the associated EUs and recommends NFA because all remediation levels were met. The EPA and TDEC have not approved the *Addendum* but have no technical disagreement with the conclusions. Therefore, the interim LUCs specified in the *Phased Construction Completion Report for the K-770 Scrap Removal Project of the Zone 1 Remediation at the East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2348&D1) is no longer required for areas in these Zone 1 EUs. The buried asbestos in EUs Z1-29, -30, and -31 is being addressed in the Zone 1 Final Soils ROD.

[d]The action for the K-1071 concrete pad is an interim action, and a final RA will be performed under the *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2161&D2).

[e]The *Phased Construction Completion Report for Remediation of the Zone 1 Powerhouse Duct Bank, Oak Ridge, Tennessee* (DOE/OR/01-2736&D2) recommends land use controls for the Duct Bank corridor but states that they will be finalized in the *Record of Decision for Final Soil Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee* (DOE/OR/01-2711&D2).

[f]*Explanation of Significant Differences Related to the Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/01-1997&D2) Addressing Identified Ecological Impacts at Duct Island, Oak Ridge, Tennessee* (DOE/OR/01-2781&D2) will be converted to a ROD Amendment. The ROD Amendment will include LUCs when approved.

[g]Monitoring requirements for completed CERCLA single-projects actions are included in the *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2477&D3).

AM = Action Memorandum
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
D&D = decontamination and decommissioning
DOE = U.S. Department of Energy
EPA = U.S. Environmental Protection Agency
ESD = Explanation of Significant Difference
ETTP = East Tennessee Technology Park
EU = exposure unit
FY = fiscal year
LLW = low-level waste
LR/LC = Low Risk/Low Complexity
LUC = land use control
NE = northeast
NFA = no further action
NSC = Non-Significant Change
PCCR = Phased Construction Completion Report
PU = Predominantly Uncontaminated
PUF = Predominantly Uncontaminated Facilities

Table H.7. Completed CERCLA actions at ETTP (cont.)

RA = remedial action
RAER = Remedial Action/Effectiveness Report
RAR = Remedial Action Report
RCRA = Resource Conservation and Recovery Act of 1976
RmAR = Removal Action Report
ROD = Record of Decision
TDEC = Tennessee Department of Environment and Conservation
Y-12 = Y-12 National Security Complex

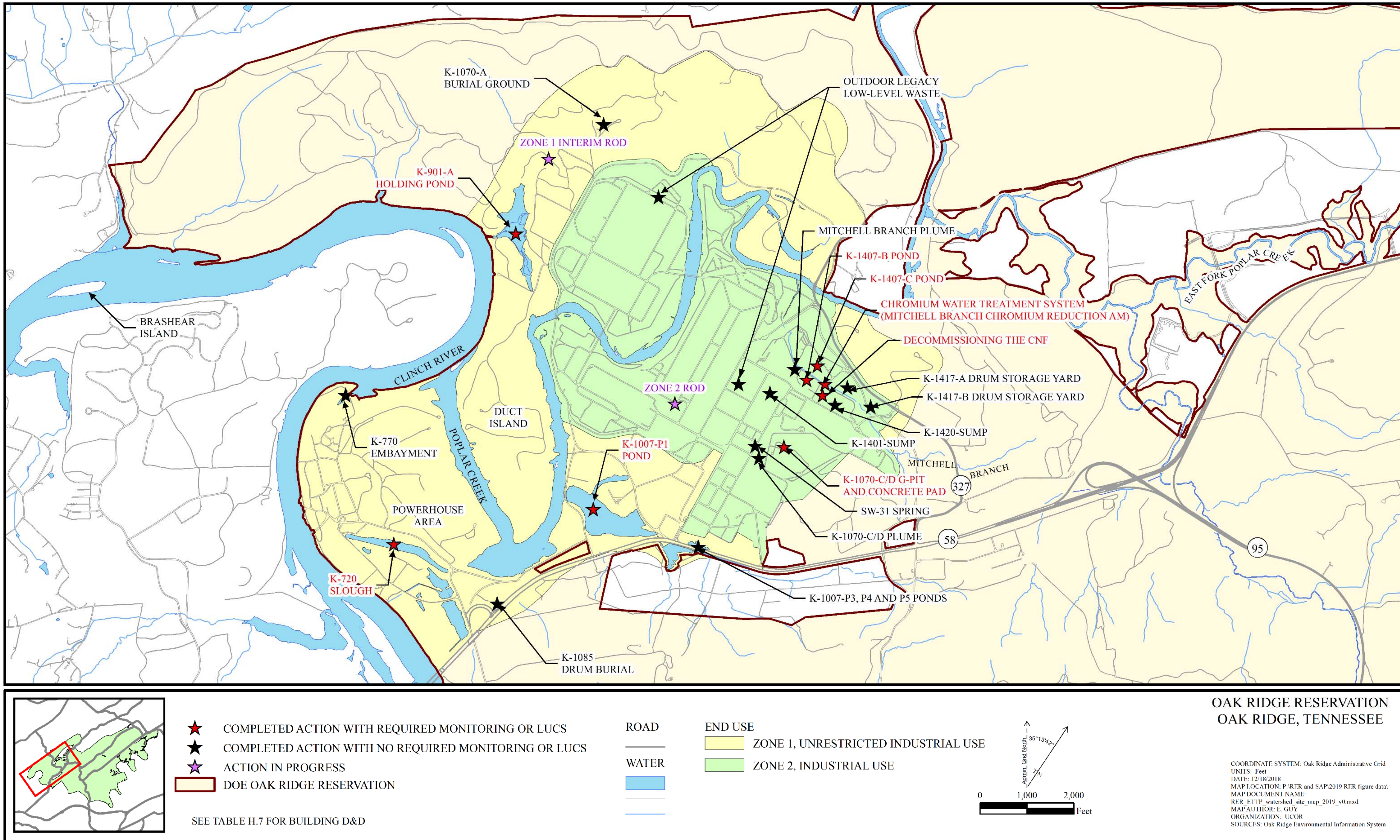

Figure H.7. Completed CERCLA actions and end uses at East Tennessee Technology Park.

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Table H.8. CERCLA actions at Other Sites on the ORR

CERCLA action	Decision document, date signed (mm/dd/yy)	Action/document status	Monitoring/LUC[a]
WWSY (WAG 11) Surface Debris	Interim ROD (DOE/OR-1055&D4): 10/06/92	PCR[b] (DOE/OR/01-1263&D2) approved 09/14/94	No/Yes
ORAU SCF	ROD (DOE/OR/02-1383&D3): 12/28/95	RAR[c] (DOE/OR/02-1474&D2) approved 08/20/96	Yes/Yes

[a]Monitoring is those environmental media monitoring activities tied to the effectiveness of the remedy. LUCs include protectiveness requirements needed to ensure the integrity of the remedy.

[b] WWSY LUC requirements will be added to the *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan* (DOE/OR/01-2457&D3) currently in preparation.

[c]Monitoring requirements for ORAU SCF are managed in the *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee* (DOE/OR/01-2466&D4). The addition of LUC requirements to the RAR CMP is planned.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CMP = Comprehensive Monitoring Plan
LUC = land use control
ORAU SCF = Oak Ridge Associated Universities South Campus Facility
ORR = Oak Ridge Reservation
PCR = Post-Construction Report
RAR = Remedial Action Report
ROD = Record of Decision
WAG = Waste Area Grouping
WWSY = White Wing Scrap Yard

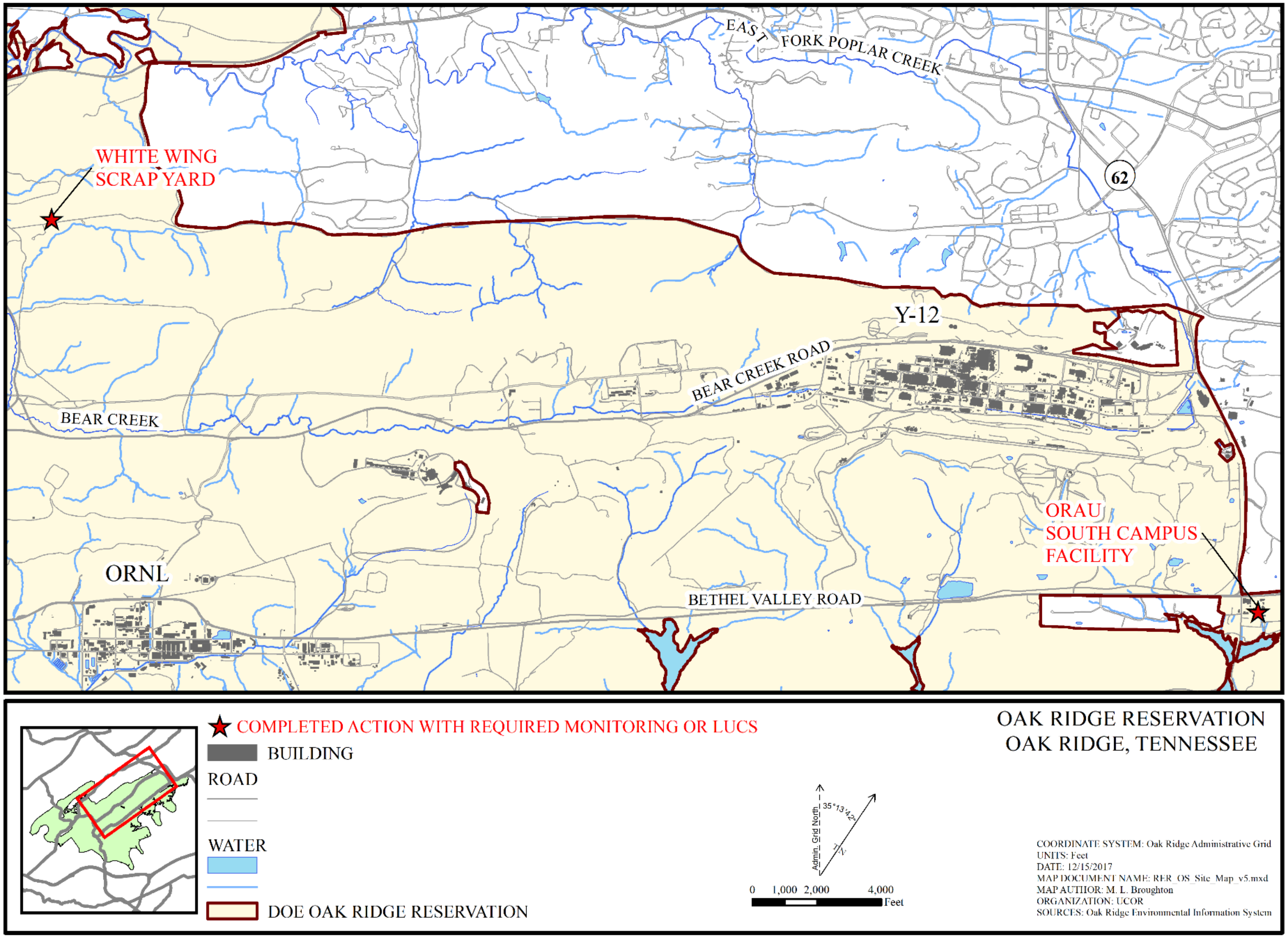

Figure H.8. Completed CERCLA actions at Other Sites on the Oak Ridge Reservation.

REFERENCES

DOE/OR/01-1599&D2. *Removal Action Report on the Building 3001 Canal at Oak Ridge National Laboratory Oak Ridge, Tennessee*, 1997, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/01-1820&D3. *Combined Monitoring Plan for the Lower Watts Bar Reservoir and Clinch River/Poplar Creek Operable Units at the Oak Ridge Reservation, Oak Ridge, Tennessee*, 2004, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1977&D6. *Land Use Control Implementation Plan for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*, 2006, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1982&D3. *Water Resources Restoration Program Sampling and Analysis Plan for the Melton Valley Watershed, Oak Ridge Reservation, Oak Ridge, Tennessee*, 2012, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-1997&D2. *Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee Oak Ridge, Tennessee*, 2002, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/01-2161&D2. *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2005, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2294&D2/A2. *Addendum II to the Phased Construction Completion Report for the K-1007 Ponds Area and Powerhouse North Area in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2011, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2348&D1. *Phased Construction Completion Report for the K-770 Scrap Removal Project of the Zone 1 Remediation at the East Tennessee Technology Park, Oak Ridge, Tennessee*, 2007, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2457&D3. *Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2466&D4. *East Fork Poplar Creek and Chestnut Ridge Administrative Watersheds Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2477&D3. *East Tennessee Technology Park Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2478&D3. *Bethel Valley Administrative Watershed Remedial Action Report Comprehensive Monitoring Plan, Oak Ridge, Tennessee*, 2016, U.S. Department of Energy, Office of Environmental Management, Oak Ridge, TN.

DOE/OR/01-2711&D2. *Record of Decision for Final Soil Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee*, 2017, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/01-2736&D2. *Phased Construction Completion Report for the Remediation of the Zone 1 Powerhouse Duct Bank, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/01-2781&D2. *Explanation of Significant Differences Related to the Record of Decision for Interim Actions in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee (DOE/OR/01-1997&D2) Addressing Identified Ecological Impacts at Duct Island, Oak Ridge, Tennessee*, 2018, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

DOE/OR/02-1398&D2. *Record of Decision for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, 1995, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Oak Ridge, TN.

APPENDIX I
CONVERSION FACTORS, UNITS, AND CHEMICAL AND RADIONUCLIDE NAMES

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Table I.1. Conversion factors and units

Conversion factors								
Name		kilo	deci	centi	milli	micro	nano	pico
Symbol		k	d	c	m	µ	n	p
Conversion factor	10^0	10^3 1000.0	10^{-1} 0.1	10^{-2} 0.01	10^{-3} 0.001	10^{-6} 0.000001	10^{-9} 0.000000001	10^{-12} 0.000000000001

Equivalencies

ppb = µg/L = µg/kg
ppm = mg/L = mg/kg = µg/g
ppt = ng/L = ng/kg

Units

µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µR/hr	microroentegens per hour
Ci	curie
cm	centimeter
d	day
ft	feet
g/d	grams per day
gal	gallons
in.	inch
in./yr	inches per year
kg/yr	kilograms per year
km	kilometer
m	meter
mCi/mo	millicuries per month
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mo.	month
mV	millivolt
ng/kg	nanograms per kilogram
ng/L	nanograms per liter
pCi	picocurie
pCi/L	picorcuries per liter
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
psig	pounds per square inch
R	roentegen
yd^3	cubic yard
yr	year

Table I.2. Chemical and radionuclide names

Name	Abbreviation
Metals	
Hexavalent chromium	Cr VI
Mercury	Hg
Methylmercury	MeHg
Organics	
1,1-dichloroethane	1,1-DCA
1,1-dichloroethene	1,1-DCE
1,1,1-trichloroethane	1,1,1-TCA
1,2-dichloroethane	1,2-DCA
1,2-dichloroethene	1,2-DCE
1,1,2-trichloroethane	1,1,2-TCA
cis-1,2-dichloroethene	cis-1,2-DCE
Dichloroethane	DCA
Dichloroethene	DCE
Polychlorinated biphenyl	PCB
Perchloroethene	PCE
Tetrachloroethene	PCE
trans-1,2-dichloroethene	trans-1,2-DCE
Trichloroethene	TCE
Vinyl chloride	VC
Other	
Total suspended solids	TSS
Radionuclides	
Americium-241	Am-241
Bismuth-212	Bi-212
Calcium-45	Ca-45
Carbon-14	C-14
Cerium-144	Ce-144
Cesium-137	Cs-137
Cobalt-60	Co-60
Curium-244	Cm-244
Lead-210	Pb-210
Lead-212	Pb-212
Neptunium-237	Np-237
Nickel-63	Ni-63

Table I.2. Chemical and radionuclide names (cont.)

Name	Abbreviation
Plutonium-238	Pu-238
Plutonium-242	Pu-242
Potassium-40	K-40
Proactinium-234m	Pa-234m
Promethium-147	Pm-147
Radium-226	Ra-226
Radium-228	Ra-228
Radium-alpha	Ra-alpha
Strontium-89	Sr-89
Strontium-90	Sr-90
Technetium-99	Tc-99
Thorium-228	Th-228
Thorium-230	Th-230
Thorium-232	Th-232
Tritium	H-3
Uranium-232	U-232
Uranium-233	U-233
Uranium-234	U-234
Uranium-235	U-235
Uranium-236	U-236
Uranium-238	U-238
Zinc-65	Zn-65

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DOE/OR/01-2787&D1

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