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Strategic Plan for Mercury Remediation at the Y-12 National Security Complex Oak Ridge, Tennessee

This document is approved for public release per review by:

Melanie Underwood

Melanie L. Underwood
DOE ORO Acting Classification Officer
Date: 10/5/17

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APPROVAL

Brian T. Henry
Portfolio Federal Project Director

9-29-17
Date

Laura O. Wilkerson
Acting Deputy Manager

10/3/17
Date

John A. Mullis II
Acting Manager

10/6/17
Date

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Strategic Plan for Mercury Remediation at the Y-12 National Security Complex Oak Ridge, Tennessee

Date Issued—September 2017

Prepared by
Professional Project Services, Inc. (Pro2Serve®)
Oak Ridge, Tennessee

Prepared for the
U.S. Department of Energy
Oak Ridge Office of Environmental Management

Professional Project Services, Inc. (Pro2Serve®)
contributed to the preparation of this document and should not be considered an eligible contractor for its review.

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ACRONYMS

AFRI	Applied Field Research Initiative
AM	Action Memoranda/Memorandum
ARAR	applicable or relevant and appropriate requirements
ARRA	American Recovery and Reinvestment Act
ARTD	Applied Research and Technology Development
ATSDR	Agency for Toxic Substances and Disease Registry
ATS	Alternative Treatment Standards
AWQC	ambient water quality criteria
BCV	Bear Creek Valley
BDAT	Best Demonstrated Available Technology
BSWTS	Big Spring Water Treatment System
CD	Critical Decision
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMTS	Central Mercury Treatment System
CR/PC	Clinch River/Poplar Creek
CWA	Clean Water Act
D&D	deactivation and demolition
DOE	U.S. Department of Energy
DQO	data quality objective
EE/CA	Engineering Evaluation/Cost Analysis
EFPC	East Fork Poplar Creek
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
ETTP	East Tennessee Technology Park
EU	exposure unit
FFA	Federal Facility Agreement
FRS	Field Research Station
FS	Feasibility Study
FY	Fiscal Year
FYR	Five-Year Review
GAC	granular activated carbon

HEUMF	Highly Enriched Uranium Materials Facility
IFDP	Integrated Facility Disposition Program
LDR	land disposal restriction
LEFPC	Lower East Fork Poplar Creek
LLW	low-level waste
LM	legacy material
LMR	legacy material removal/disposition
LUC	Land Use Control
NNSA	National Nuclear Security Administration
NPDES	National Pollutant Discharge Elimination System
O	Order
OF200 MTF	Outfall 200 Mercury Treatment Facility
OREM	Oak Ridge Office of Environmental Management
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORR Landfills	ORR Industrial Landfills
OU	Operable Unit
PCCR	Phased Construction Completion Report
PIDAS	Perimeter Intrusion Detection and Assessment System
ppm	parts per million
ppt	parts per trillion
PTW	principal threat waste
QAPP	Quality Assurance Program Plan
RAO	Remedial Action Objective
RAR	Remedial Action Report
RAWP	Remedial Action Work Plan
RDWP	Remedial Design Work Plan
RER	Remedial Effectiveness Report
RI	Remedial Investigation
RmAWP	Removal Action Work Plan
RMPE	Reduction of Mercury in Plant Effluents
RCRA	Resource Conservation and Recovery Act ROD Record of Decision
S&M	surveillance and maintenance
SAP	Sampling and Analysis Plan
SC	Office of Science
SFA	Science Focus Area
SPSS	sulfur polymer solidification/stabilization

TBD	to be determined
TCLP	Toxicity Characteristic Leaching Procedure
TDEC	Tennessee Department of Environment and Conservation
TM	Technical Memorandum
TSCA	Toxic Substances Control Act
UEFPC	Upper East Fork Poplar Creek
UPF	Uranium Processing Facility
UTS	Universal Treatment Standards
VPD	venting, purging, draining
WAC	waste acceptance criteria
WEMA	West End Mercury Area
WHP	Waste Handling Plan
Y-12	Y-12 National Security Complex

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EXECUTIVE SUMMARY

The U.S. Department of Energy Oak Ridge Office of Environmental Management, along with the Tennessee Department of Environment and Conservation, and the U.S. Environmental Protection Agency, has identified mercury contamination at the Y-12 National Security Complex (Y-12) as the greatest environmental risk on the Oak Ridge Reservation (ORR). The historic loss of mercury to the environment dwarfs any other contaminant release on the ORR. Efforts over the last 20 years to reduce mercury levels leaving the site in the surface waters of Upper East Fork Poplar Creek have not resulted in achieving acceptable mercury concentrations in fish throughout the creek. While mercury flux in surface water leaving the site has decreased since 2013, notable increases in flux occurred in a few preceding years (2011-2013) and were attributed to storm sewer system cleanup activities. These observations indicate future demolition and remediation activities may cause an increase in mercury flux at Station 17 (just upstream of the point the creek becomes publicly accessible).

Large-scale demolition of several process facilities – totaling approximately 1.8 million square feet – historically contaminated with radioisotopes and mercury, along with accompanying soil remediation activities are planned to begin within the next decade. These efforts will include removal and/or stabilization/containment of major mercury sources and generation of waste debris and soil requiring disposal. Some significant portion of this waste will require treatment prior to disposal.

Planning and development activities in preparation of future mercury-related demolition and remedial action projects, notably activities aimed at defining waste treatment/disposal/endstates involving mercury, are warranted. Strategic planning for mercury remediation at Y-12 includes the following actions:

- Implement near-term mercury reduction actions to achieve a decrease in mercury flux in East Fork Poplar Creek.
- Assess mercury surface water concentration reductions and fish mercury tissue responses, and implement further interim actions as deemed necessary through tri-party agreement.
- Identify, develop, and apply proven technologies for mercury contamination remediation and protection of workers and the environment through “progressive” treatment and demolition steps, to gain experience through progressively larger and/or more complex treatment and demolition activities.
- Prepare, from both regulatory and technical standpoints, for execution of large-scale mercury-related demolition and remediation activities as well as for the management of resultant wastes: contact water, debris, and soil that will require treatment and disposal.
- Sequence the large-scale demolition and remediation work efficiently.
- Comply with applicable state and Federal agreements and regulations.

Extensive mercury-related demolition and remediation may result in worker risk and environmental releases that must be minimized and controlled. Consequently, coordinated efforts under an adaptive management approach are needed to effectively and safely advance mercury cleanup efforts as well as address continued, elevated fish tissue mercury concentrations.

A centrally located water treatment facility for mercury removal is a key component of this strategy. This facility will serve multiple purposes by assisting in the reduction of mercury in the headwaters of the Upper East Fork Poplar Creek, which may increase during future demolition and remediation activities.

Other completed, continuing, and future efforts supporting the mercury cleanup include:

- Treatability studies/demonstrations to determine interim and final waste forms for contaminated soils and debris that meet waste acceptance criteria for an onsite disposal facility, land disposal restrictions, and other applicable regulatory requirements.
- Mercury removal from storm sewer systems, modification of building/other drainage to redirect storm runoff away from known/suspected mercury-contaminated areas, and legacy material disposition.
- Development of required planning documents with an emphasis on producing documents that will serve multiple areas/projects as appropriate.
- Small-scale equipment decontamination, demolition, treatment, and disposal (e.g., COLEX equipment located at the west end of Alpha-4) with an emphasis on increasing knowledge of conditions that may be encountered in large-scale future work (progressive treatment/ demolition) and continually improving approaches.
- Ongoing studies and proposed future efforts to better understand processes that control mercury uptake in fish and distribution in the environment.

These efforts have been and will continue to be implemented in a phased, adaptive approach to reduce uncertainties; to better define and target fish tissue mercury reductions; to increase efficiencies in characterization, targeted removal, and waste treatment and disposition; and to ensure continual improvement in worker protection.

As a National Priorities List site, with cleanup implemented under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and governed by the Federal Facility Agreement among U.S. Department of Energy, U.S. Environmental Protection Agency, and Tennessee Department of Environment and Conservation, a prescriptive documentation and communication process is followed to plan, gain approval, implement, and monitor the scope of CERCLA response actions on the ORR. The identified activities in this plan support mitigation of mercury contamination released from known sources, soil remediaiton for Federally-controlled industrial use in accordance with CERCLA decisions, and reduction of water-borne contamination in surface water. No single solution exists to solve the mercury contamination issue at Y-12; therefore, a multi-pronged, adaptive approach is necessary in order to reach endstates that are acceptable on many levels and to all stakeholders. Given the enormity

of mercury contamination cleanup, it is essential that economies of scale be implemented and the remediation/waste disposition path forward be well defined and in place prior to initiation of large-scale efforts to demolish buildings and remediate media where significant quantities of mercury were historically utilized resulting in releases to the environment.

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1.0 INTRODUCTION

This document presents the U.S. Department of Energy (DOE) Oak Ridge Office of Environmental Management (OREM) Strategic Plan to safely and cost-effectively remediate mercury contamination at the Y-12 National Security Complex (Y-12) and, as necessary, in East Fork Poplar Creek (EFPC). This contamination issue is the result of decades of nuclear weapons development at the site. Y-12 is one of four production facilities in the National Nuclear Security Administration's (NNSA) Nuclear Security Enterprise with a unique emphasis in the processing and storage of uranium, and development of technologies associated with those activities. While decades of precision machining experience, along with earlier isotope enrichment activities, make Y-12 a production facility with capabilities unequaled nationwide, these activities have left the site with a legacy of contaminated facilities requiring replacement and/or demolition, as well as soils and ground/surface water in need of remediation, where mercury is the most main contaminant. This strategy takes into account completed work regarding environmental mercury contamination reduction, and ongoing and proposed near-term actions to reduce mercury in the environment, as well as presents the complete long-term scope and schedule of projects to remove/stabilize the building and soil mercury contamination sources. Several key factors and goals guided the development of this mercury remediation strategy:

- Mercury contamination at Y-12 has been prioritized as the highest environmental risk on the Oak Ridge Reservation (ORR). *Goal: propose mercury reduction projects to (a) take actions to achieve near-term results in reducing the amount of mercury leaving the site and mercury concentrations in fish tissue and (b) plan for large-scale mercury cleanup projects in an effort to reduce risk and ultimately protect human health and the environment.*
- Cleanup is implemented under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), in accordance with the Federal Facility Agreement (FFA) among the U.S. Environmental Protection Agency (EPA), Tennessee Department of Environment and Conservation (TDEC) and DOE (DOE 1992). *Goal: propose activities that meet, or make progress toward meeting, regulatory requirements and approved endstates (e.g., state water quality standards, disposed debris forms).*
- Cleanup is integrated with the NNSA ongoing missions. *Goal: coordinate mercury remediation activities with ongoing missions work.*
- Strategy considers actions to reduce overall cost to the taxpayer. *Goal: propose actions that will consider ways to save costs such as (a) sequence work to produce efficiencies, (b) combine projects to achieve economies-of-scale, (c) develop technologies to reduce costs/increase efficiencies, (d) plan for the safest and most efficient disposal of large waste volumes of debris/soil, and (e) plan and define risk mitigation activities and opportunities.*

The Agency for Toxic Substances and Disease Registry (ATSDR) completed an in-depth study to determine the human health effects of mercury releases from the Y-12 site, which conclusively determined that no adverse human health effects have been suffered due to "most past and current exposure pathways" of mercury releases (ATSDR 2012). However, as much as two million pounds of mercury were lost to the environment or were unaccounted for during its historical use at the site. Mercury that has persisted in the environment continues to have impacts which must be addressed, as evidenced by the plateauing of fish tissue mercury concentrations in recent years. Fish tissue mercury concentration is directly related to human health concerns through ingestion pathways. While human health has not been affected to date, it is imperative to preserve this record with a strategy that acknowledges potential future risks and provides appropriate plans and funding for risk avoidance or mitigation while addressing the environmental impact.

This strategy aims to accomplish the given goals through an adaptive management[1] plan that includes:

- Completion of early action tasks to reduce mercury leaving the plant boundary from the average of 43 grams per day measured over the last six years (at Station 17)[2].
- Identification and execution of desirable studies in terms of data gathering/analyses and technology development/demonstration to better understand mercury-water-fish relationships and suggest methodologies that promote reduction of fish mercury concentrations.
- Identification and execution of desirable studies in terms of data gathering/analyses and technology development/demonstration to support building demolition and soil remediation projects.
- Prioritization and sequencing of projects while considering cost, mercury release reduction efficiencies that may be implemented, and reduction of risk to workers.

A roadmap for the strategic process is given that accounts for risk management, technology development, regulatory considerations, and funding/budgeting considerations. Figure 1 illustrates the many issues and actions regarding mercury remediation that this strategy aims |to address.

As an adaptive plan, this strategy is expected to evolve as results of implemented actions are obtained and assessed, with modifications proposed as necessary. It will be updated to serve as a flexible, yet stable roadmap for the progress to be made in remediating mercury at Y-12 and in affected portions of the EFPC area.

[1] As used here "adaptive management" encompasses the concept of decision-making under uncertainty about the outcomes of specific actions with the goal of identifying effective environmental remedies based on observing effectiveness of interim actions as well as on results of scientific research comparing multiple causative hypotheses; e.g., waterborne versus sediment-borne mercury as the dominant source of mercury in fish.

[2] Results for composite samples collected and analyzed by the OREM Program.

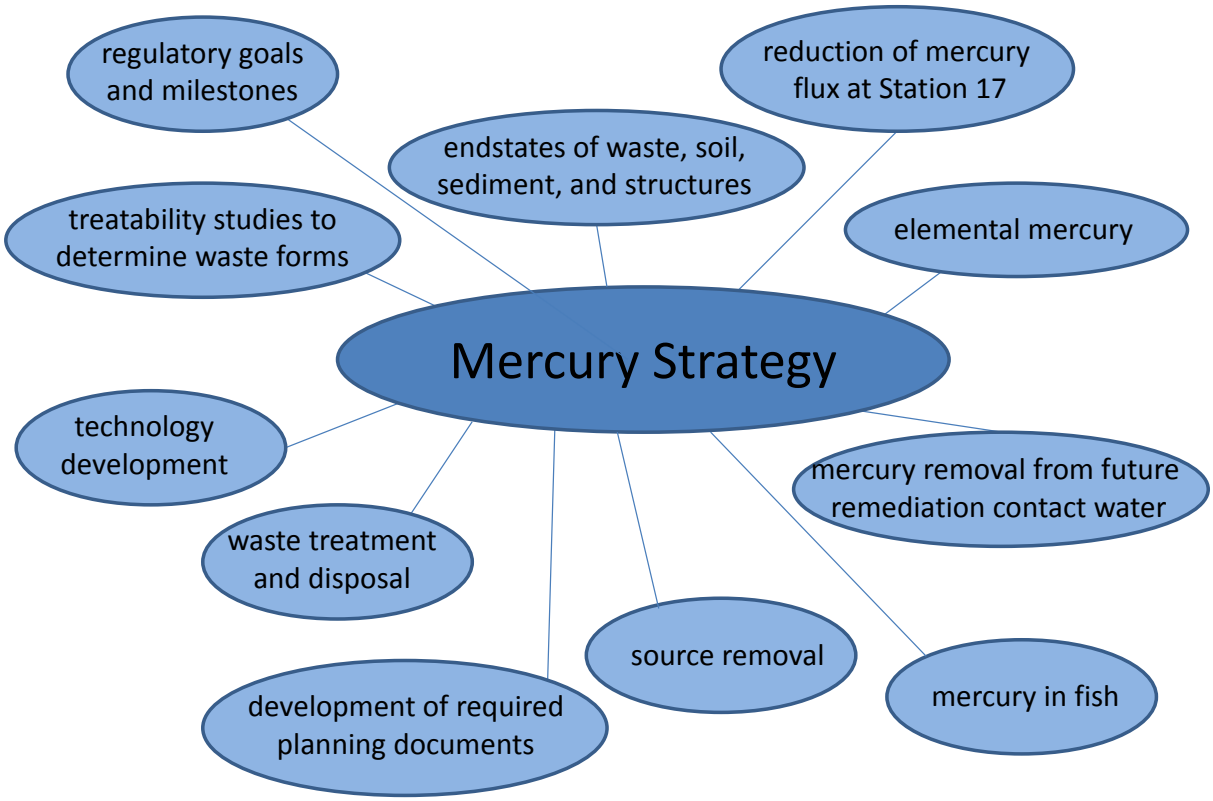


Figure 1. Issues and Actions Addressed by the Mercury Strategic Plan

2.0 BACKGROUND

2.1 Y-12 NATIONAL SECURITY COMPLEX SITE HISTORY

Releases of mercury during operations at Y-12 in the 1950s and early 1960s resulted in contamination of both environmental media and facilities within the complex, as well as downstream water bodies including EFPC and the Lower Watts Bar Reservoir. Subsequent transport from these sources continues to threaten the creek and ecological receptors both onsite and offsite. Remediation efforts, which began in the 1980s, have reduced waterborne mercury concentrations both within the Y-12 facility and in the EFPC ecosystem; however, elevated levels of mercury remain in the soil, sediment, water, and biota, as well as in the building structures and equipment where the mercury operations took place. Industrial development and separation processes involving mercury were conducted in several buildings, including Buildings 9201-2 (Alpha-2), 9204-4 (Beta-4), 9201-4 (Alpha-4), and 9201-5 (Alpha-5), beginning in the 1950s but were discontinued in 1963. Building 81-10 (only the slab remains

today) in the southern portion of Y-12-housed equipment (roaster and condenser) to recover mercury. These facilities are shown on the map, Figure 2, along with other major mercury-related site features. Figure 3 shows photographs of the four large mercury-use buildings. The estimated total historical release of mercury to air, surface water, and soil at Y-12 is provided in Table 1 (UCC 1983).

Table 1. Historical Losses of Mercury at Y-12[a]

Mercury Losses	Major Pathway	Mercury	
		(Pounds)	(Kilograms)
Lost to air (1950 – 1963)	Ventilation systems	~51,000	23,000
Lost to East Fork Poplar Creek (1950 – 1982)	Process waste stream	~239,000	109,000
Lost to soils at Y-12 Complex	Accidents/spills	~428,000	195,000
Lost to sediment in New Hope Pond	Building drains	~15,000	7,000
Not accounted for [b]	Not received, buildings, other	~1,292,000	587,000
Total		**~2,025,000**	**921,000**

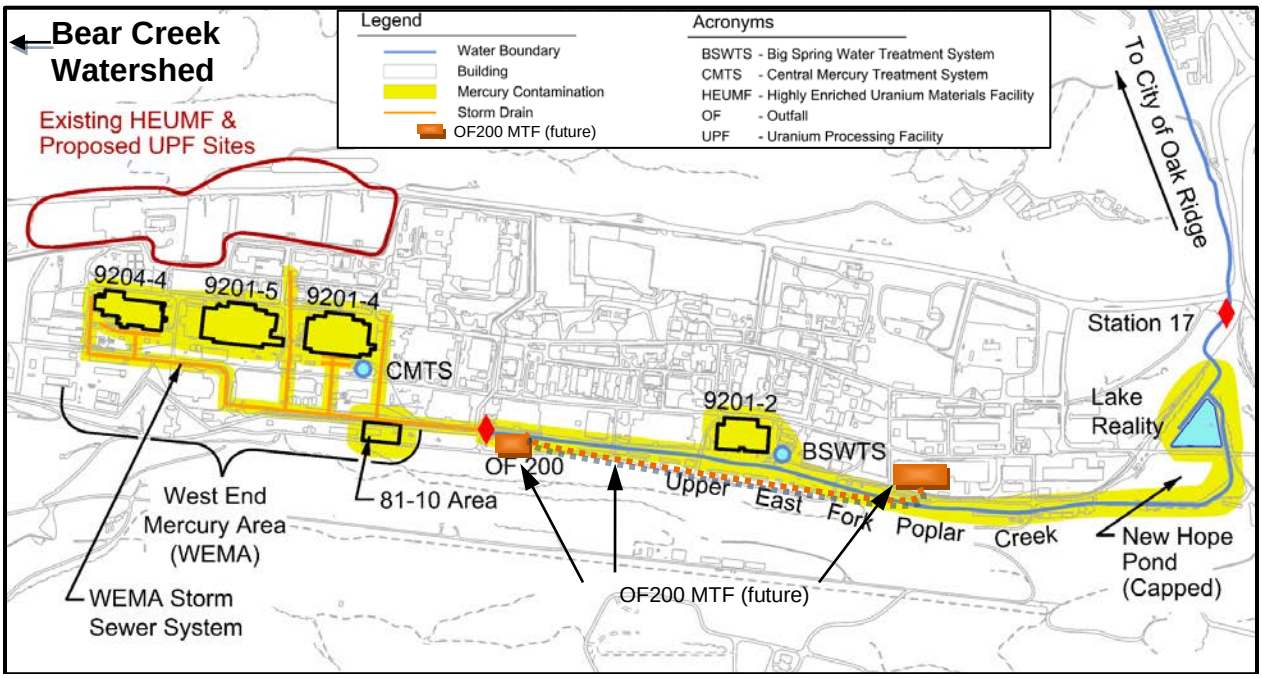
[a] *Mercury at the Y-12 Plant, a Summary of the 1983 UCC-ND Task Force Study*, Y/EX-23, November 1983. (UCC 1983)
[b] This mass of unaccounted for mercury has been estimated at closer to 650,000 pounds, when historical knowledge regarding shortage of receipts, losses to building structures, and other specific losses are taken into account. (UCC 1983)

The EFPC can be divided into several discrete sections. The portion that occurs within the Y-12 Plant (approximately 1.5 miles in length) is referred to as Upper EFPC (UEFPC), see Figure 2. The approximately 14 miles of EFPC flowing from Bear Creek Road/Station 17 to its confluence with Poplar Creek near the East Tennessee Technology Park (ETTP) is generally referred to as Lower EFPC ([LEFPC], see Figure 2 inset) and passes through the city of Oak Ridge. UEFPC leaves the ORR, entering public property shortly downstream of Station 17. Outfall 200, just east of the major processing facilities within Y-12, is located at the headwaters of UEFPC. A complex underground storm sewer system draining the West End Mercury Area (WEMA), as shown in Figure 2, feeds Outfall 200, where the future Mercury Treatment Facility (OF200 MTF) headworks will be located. A pipeline corridor will transfer the wastewater collected at the headworks to the treatment facility downstream (see Figure 2).

Although impacted to a much lesser extent by mercury use at Y-12, Bear Creek, with its origin just west of the Y-12 Plant, displays elevated mercury levels in some surface waters, and fish living in Bear Creek currently exceed the methylmercury regulatory target of 0.3 mg/kg in tissue (SAIC 1997, Mathews et al. 2013).

While the release of high concentrations of mercury from the plant stopped in 1963, mercury continues to be released into EFPC from various point and nonpoint sources. The existing conceptual model indicates dry weather loading of mercury to the UEFPC has multiple sources, including infiltration of contaminated shallow groundwater into the storm sewer system, dissolution of mercury trapped incontaminated pipes, advection of contaminated sediment into the surface flow, and emergence of contaminated groundwater from the karst system in springs

and seeps (DOE 1994a). Further information on historical releases and sources is available in *Conceptual Model of Primary Mercury Sources, Transport, Pathways, and Flux at the Y-12 Complex and Upper East Fork Poplar Creek, Oak Ridge, Tennessee* (ORNL 2011). Mercury loading in LEFPC is summarized in *Sources of Mercury to East Fork Poplar Creek Downstream from the Y-12 National Security Complex: Inventories and Export Rates* (ORNL 2010) as well as in Mathews et al. 2013.



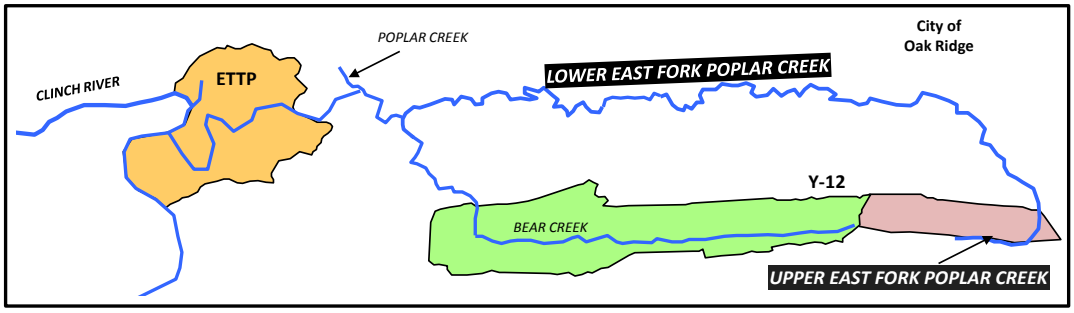


Figure 2. (Upper) Y-12 Site Layout Showing Major Features in UEFPC Watershed and Expected Areas of Mercury Contamination; (Lower) All of East Fork Poplar Creek, including LEFPC

Figure 3. Mercury-Use Buildings at Y-12

2.2 REGULATORY FRAMEWORK FOR CLEANUP

Portions of both the ORR and the LEFPC Operable Unit (OU)[3] were placed on the National Priorities List by EPA in 1989. The FFA, which coordinates the corrective actions under Resource Conservation and Recovery Act of 1976 (RCRA) and Toxic Substances Control Act of 1976 (TSCA) with CERCLA response actions, became effective on January 1, 1992. Parties to the FFA agreed that implementation of CERCLA actions would be in compliance with RCRA and other appropriate environmental laws as applicable and relevant or appropriate requirements

(ARARs) to be specified in the CERCLA decision documents, including requirements for waste characterization, treatment to meet land disposal restrictions (LDRs), and waste handling, storage, and disposal.

[3] The LEFPC release site OU, outside of the ORR, is limited to areas (soil, sediment, and groundwater) within the 100-year floodplain and does not extend to areas outside the floodplain, with the exception of soils that may have been taken from the floodplain and used in other areas as fill (e.g., Sewer Line Beltway) (DOE 1995b). The CERCLA risk assessment process confirmed that Sewer Line Beltway soils present no significant risk (1995 1944b,c).

2.2.1 Comprehensive Environmental Response, Compensation, and Liability Act

Remediation of the ORR, from a CERCLA regulatory standpoint, is divided up by watersheds. There are two watersheds defined within the Y-12 area, Bear Creek and UEFPC. UEFPC activities are addressed in this strategy since it is the watershed most affected by mercury contamination; however, the LEFPC OU is also briefly addressed. Cleanup projects in the Bear Creek Watershed are addressed as part of the overall Y-12 project prioritization and sequencing discussed in Chapter 4; effects of the mercury cleanup on Bear Creek are also examined.

Per CERCLA, a Remedial Investigation (RI) of the UEFPC watershed was completed in 1998, which identified and defined areas of mercury contamination (as well as all other contamination) and established risks associated with that contamination (SAIC 1998). Alternatives for remediation of all watershed media were evaluated and screened in a Feasibility Study (FS) (BJC 1999). A phased, interim decision approach was developed with the regulators, and an FS Addendum (BJC 2000) was subsequently prepared for the initial CERCLA decision, an interim action for remediation to protect surface water. A Proposed Plan (DOE 2001) was prepared, and the selected remedy was documented in the Phase I Interim Source Control Actions Record of Decision (ROD) (BJC 2002), which focused on addressing contamination that contributed to surface water contamination. A Focused Feasibility Study addressing interim actions to remediate soil contamination to protect industrial workers, groundwater, and surface water was prepared for the next phase, and the site was defined as a characterization area and broken into exposure units (EUs), as shown in Figure 4 (BJC 2004). A Proposed Plan, which documented the selected cleanup alternatives, was issued and the Phase II Interim Remedial Actions for contaminated soils and scrapyard ROD was approved (DOE 2005a) [see Section 2.2.1.1]. Building deactivation and demolition (D&D) decisions were subsequently addressed in an Engineering Evaluation/ Cost Analysis (EE/CA) and Action Memorandum (AM) [see Section 2.2.1.2]. Likewise, the CERCLA sequence of RI, FS, Proposed Plan, and ROD was followed for the LEFPC OU (DOE 1994b, 1994c, 1994d, 1995a, 1995b).

2.2.1.1 Soils, Sediments, and Subsurface Structures

Remediation of the UEFPC watershed is being conducted in stages using a phased approach under multiple CERCLA decision documents. The Phase I ROD was signed in May 2002 (BJC 2002). Phase I presents selected interim actions for remediation of mercury-contaminated soil, sediment, and groundwater discharges that contribute contamination to surface water. An Explanation of Significant Difference (ESD) to the UEFPC Phase I ROD was issued in Fiscal Year (FY) 2011 (EDI 2011). The ESD removed WEMA capping and WEMA horizontal wells from the selected remedy in the ROD because they were envisioned as the remediation for WEMA soils prior to the subsequent plan to D&D additional former mercury-use buildings in the area (introduced through the Integrated Facility Disposition Program [IFDP], see Section 2.3).

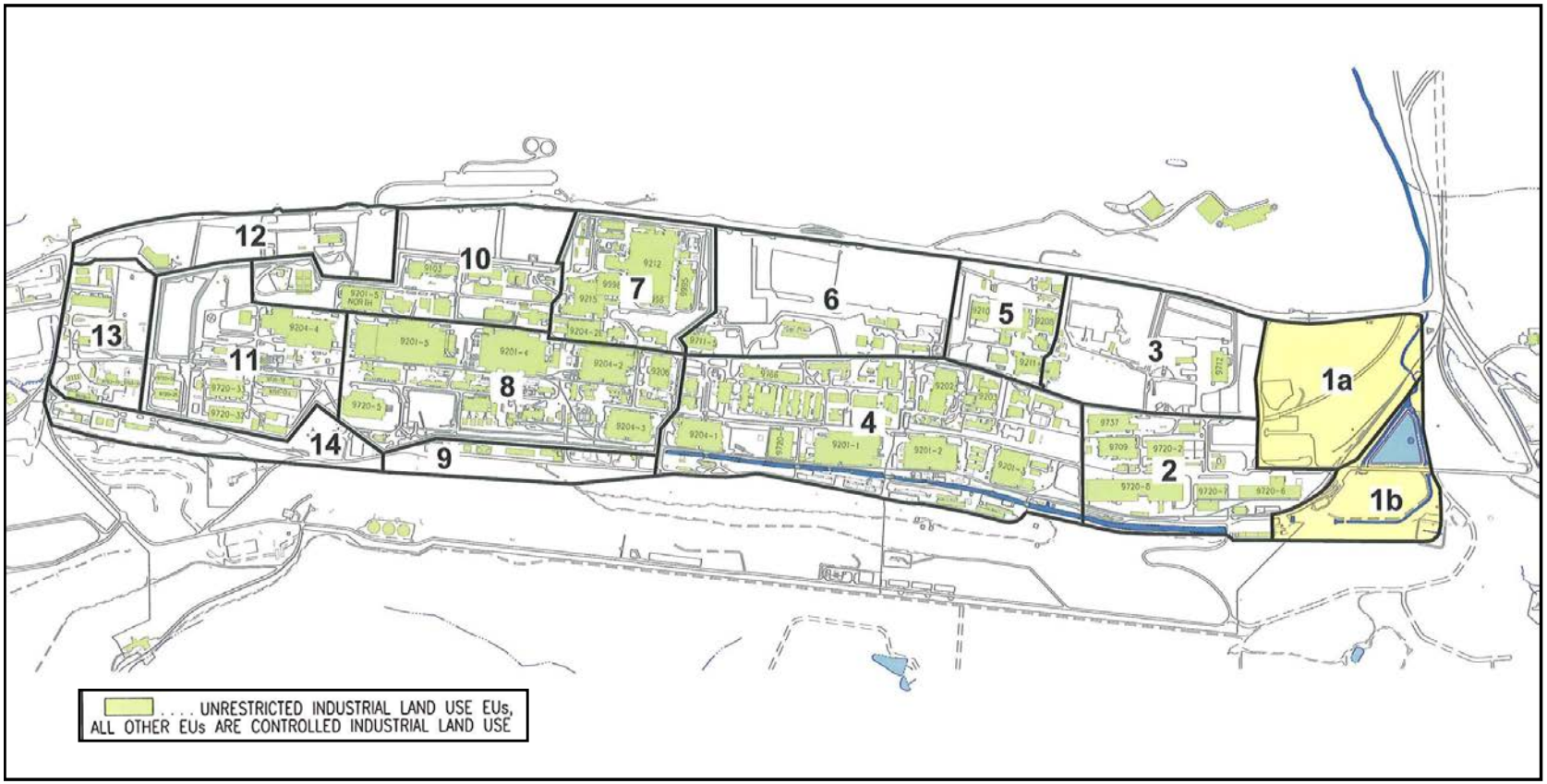


Figure 4. Exposure Units in the UEFPC Contamination Area

EU 11 and EU 8 contain three large mercury-use facilities. Beta-4 (in EU 11), and Alpha-5 and Alpha-4 (in EU 8) will be demolished as part of this mercury remediation strategy. The 81-10 Area, also a mercury-contaminated area, is located in EU 9. Alpha-2, the fourth mercury-use facility that will be demolished as part of this mercury remediation strategy, is located in EU 4. UEFPC passes through EU 4 and EU 2, as well as EU 1a and EU 1b.

Most recently, an Amendment to the Phase I ROD (DOE 2016) was approved to supplement the Phase I ROD remedial actions with a water treatment facility (the OF200 MTF); details are discussed in Section 3.4.1.1. D&D of WEMA buildings will allow access to mercury-contaminated soils beneath (Phase I ROD soils) and adjacent to the structures (soils that are addressed by the Phase II ROD).

The Phase I ROD Remedial Action Objective (RAO) is to restore surface water to human health recreational risk-based values at Station 17. An interim goal of 200 parts per trillion (ppt) mercury concentration in surface waters of UEFPC at Station 17 was identified based on achieving acceptable mercury concentrations in fish tissues for human consumption, and a waiver from the 51 ppt ambient water quality criteria (AWQC) for mercury was granted.

The Phase I ROD remedy addresses those soils and sediments that contribute to surface water contamination as principal threat waste (PTW)[4] including:

1. The WEMA (soils in the immediate vicinity, storm sewer sediments, and shallow groundwater captured by currently operating sumps).
2. Sediment in exposed portions of the UEFPC stream channel.
3. Sediment within Lake Reality.

WEMA soils were to be addressed in this Phase I ROD through capping of the WEMA area and addition of horizontal wells, which would have provided an interim solution to mobilization of PTW. However, with the removal of that action, the Phase II ROD becomes the decision document for those soils (see below).

The Phase I remedy included several actions that have since been completed:

- Alpha-2 water treatment system (Big Spring Water Treatment System [BSWTS])
- Land use controls
- WEMA storm sewer cleaning
- Short- and long-term studies (involving treatment of water/soils for mercury)

Other Phase I ROD actions that are ongoing or have yet to be completed include:

- Soil/sediment removal in UEFPC and Lake Reality
- Continued monitoring of effectiveness of remediation at various locations
- OF200 MTF construction and operation

Mercury-contaminated soils and subsurface structures that are not addressed in the Phase I ROD are addressed in the Phase II ROD, stating that "[The Phase I ROD] *addresses interim actions for remediation of principal threat waste, mercury-contaminated soils, sediments, and point*

[4] Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. (EPA 1991)

groundwater discharges that contribute contamination to surface water." and *"The focus of this second phase of remediation is interim actions for the remediation of the balance of contaminated soil, scrap, and buried materials at Y-12."*

Phase II ROD actions that have since been completed include:

- Y-12 Salvage Yard scrap removal
- Y-12 Salvage Yard soil remediation
- Land use controls (e.g., property record restrictions and notices, zoning notices, excavation/penetration permit program)

Ongoing or not completed actions in the Phase II ROD include:

- Characterization of media
- Excavation of accessible soils (in time all soils will become accessible) exceeding remediation levels, to a depth of 2 ft for controlled industrial land use (EUs 2 through 14) and a depth of 10 ft for unrestricted industrial land use (EUs 1a and 1b, see Figure 4)
- Excavation of accessible soils (in time all soils will become accessible), exceeding remediation levels for protection of groundwater and surface water, to water table or bedrock

The Phase II ROD was finalized and approved by regulators in April 2006 (BJC 2006). The focus of the second phase is remediation of the balance of contaminated soil, scrap, subsurface structures (including slabs and currently inaccessible soils under buildings), and buried materials within the Y-12 Complex.

As stated in the bullet above, this ROD addresses all soils in UEFPC, which includes those PTW soils in the WEMA area (originally addressed by interim actions in the Phase I ROD that were subsequently removed, namely WEMA capping) that are currently inaccessible but will become accessible through eventual demolition of buildings in that area.

The RAO of the Phase II ROD is to protect industrial workers from exposure to hazardous substances in the uppermost two feet of soils and protect surface water and groundwater by reducing existing contamination of the solid matrix of the site (i.e., soil, sediment, buried waste, and subsurface structures). Soil remediation levels and the calculation methods/modeling are established in the Phase II document.

A Remedial Action Work Plan (RAWP) has been completed to address soil, sediment, buried waste, and subsurface structure remediation at Y-12, based on the defined EUs (EDI 2010a). Addressing smaller, individual remediation projects, typically by EU, will thus be the regulatory strategy approach moving forward. Appendices will be added to the RAWP as the remediation strategies progress for specific EUs (characterization and remediation). A breakdown of the Y-12 site by EU is shown in Figure 4. The strategy presented in this document (Chapter 3) addresses required future CERCLA documentation.

The LEFPC ROD addressed remediation of floodplain soils, which were identified in the RI baseline risk assessment as presenting unacceptable risks – due to mercury – to human health

(e.g., hazard index exceeding 1 and/or carcinogenic risk exceeding 10^{-4}) and to ecological receptors. Per the LEFPC ROD, a mercury remediation goal of 400 mg/kg was determined to be protective, and 35,600 yd^3 floodplain soils exceeding that level were excavated in 1996-1997, resulting in 45,000 yd^3 of disposed waste soil. Groundwater and sediments were not identified as posing a risk to human health or ecological receptors; however, surface water (for all three decision documents, Phase I and II RODs and LEFPC ROD) was not considered as it is deferred to future decisions (see Section 2.2.1.3).

In both UEFPC interim RODs, soil remediation levels are noted as possibly requiring reassessment when final groundwater and surface water decisions are made. As stated in the Phase I ROD, *"This selected remedy is considered to be an interim action and will be completed, evaluated, and used as the basis for determining what, if any, additional remedial actions may be necessary to meet final goals."*, and per the Phase II ROD, *"If final land use, surface water, or groundwater decisions require additional soil remediation, it will be addressed as part of those future action(s)."* (BJC 2002, 2006)

2.2.1.2 Decisions Regarding Buildings

Building demolitions are addressed in the aforementioned EE/CA (EDI 2010b), which was subsequently followed by submission of an AM (DOE 2010b) documenting the decision regarding building demolition. Time-critical AMs addressing a limited number of buildings and a Removal Action Work Plan (RmAWP) addressing the remainder of the buildings, including those in the UEFPC watershed area, was issued (EDI 2010c). The strategy presented in this document (Chapter 3) addresses required CERCLA documentation for building D&D from this point forward.

2.2.1.3 Ground and Surface Waters in Future Decisions

A final groundwater ROD for UEFPC will be developed following the remediation of UEFPC soils, sediments, and subsurface structures. Groundwater in LEFPC was not identified as a risk in the investigations (e.g., Carmichael 1989) conducted for that OU. A final surface water decision for the EFPC (Upper and Lower) will be reached after the completion of the source control actions within the Y-12 site and will be followed by the Clinch River/Poplar Creek (CR/PC) Surface Water ROD. The CR/PC Surface Water ROD will be determined after completion of all ORR upstream source remediation and final watershed decisions at the three Oak Ridge sites (Y-12, Oak Ridge National Laboratory [ORNL], and ETTP). An ORR-wide groundwater strategy was developed recently, with the understanding that many mercury remediation actions have not yet been initiated. Mercury-associated remediation of known sources is planned under specific projects to begin in approximately FY 2025 and complete in late FY 2040's, based on current planning and funding assumptions. Both groundwater and surface water are routinely monitored through the Water Quality Program, with results being assessed and reported in the annual Remdial Effectiveness Report (RER) as part of the Water Resources Restoration Program.

2.2.2 Resource Conservation and Recovery Act

RCRA governs operations at facilities that generate, treat, store, dispose, or transport materials that meet the RCRA regulatory definition of a hazardous waste. RCRA substantive requirements when conducted under CERCLA authority are applied as ARARs. The most significant of these are the LDRs given under Title 40, Code of Federal Regulations (CFR) Part 268. Regarding mercury, LDRs specify the use of particular technologies and standards to meet before the waste (in this case mercury contaminated waste carrying the D009 waste code) may be land disposed, including Universal Treatment Standards (UTS) or optional Alternative Treatment Standards (ATS) that are specific to soil. Debris may be treated by technologies listed under Title 40, CFR Part 268.45, as shown in Table 2. As stated in the table, acceptable treatment technologies for mercury contaminated debris (hazardous waste code D009) include extraction (such as washing) and immobilization (such as macroencapsulation).

Mercury-contaminated media at Y-12 (e.g., soils, buildings, debris, etc.) were closely reviewed in 2005 for applicability of the U-151 listed waste code under RCRA. This extensive due diligence review, which considered hundreds of documents and expert testimony, concluded that Y-12 media and debris contaminated with mercury should not carry the U-151 code with the possible exception of Building 9720-26 (DOE 2005b). Those mercury-contaminated wastes that may be encountered during the Y-12 site cleanup are given in Table 2, along with the treatment or performance standards to be attained to meet LDRs.

2.2.3 Clean Water Act

Point source discharges to UEFPC are subject to the Clean Water Act of 1972 (CWA) through National Pollutant Discharge Elimination System (NPDES) permits or ARARs in CERCLA decision documents. The NPDES permit at Y-12 was renewed in October 2011 and placed considerable emphasis on reducing mercury flux in UEFPC. The permit contains activities that are consistent with modification of actions required in previous NPDES permits, while others are enforcement of CERCLA actions to address mercury reduction. In November 2011, DOE and NNSA filed an appeal to remove the performance of CERCLA actions from the permit, which were already subject to enforcement under CERCLA and the ORR FFA. As of the date of this report, this appeal is still unresolved.

CERCLA actions considered in this mercury plan will comply with all substantive requirements of Federal and state environmental laws and regulations identified as ARARs in CERCLA decision documents, or obtain waivers in accordance with CERCLA Section 121(d)(4), where needed.

Table 2. Nonwastewaters Contaminated with Mercury (D009) and Corresponding Treatment Standards and/or Performance Standards

Waste Type	Treatment Standard and/or Performance Standard
Per Title 40, CFR Part 268.40, Applicability of Treatment Standards	
Nonwastewaters that exhibit, or are expected to exhibit, the characteristic of toxicity for mercury based on the Toxicity Characteristic Leaching Procedure (TCLP) in SW846; and contain greater than or equal to 260 mg/kg total mercury that also contain organics and are not incinerator residues. (High Mercury-Organic Subcategory)	Incineration (IMERC) or Retort/ Thermal Desorption (RMERC)
Nonwastewaters that exhibit, or are expected to exhibit, the characteristic of toxicity for mercury based on the TCLP in SW846; and contain greater than or equal to 260 mg/kg total mercury that are inorganic, including incinerator residues and residues from RMERC. (High Mercury-Inorganic Subcategory)	RMERC
Nonwastewaters that exhibit, or are expected to exhibit, the characteristic of toxicity for mercury based on TCLP in SW846; and contain less than 260 mg/kg total mercury and that are residues from RMERC only. (Low Mercury Subcategory)	0.20 mg/L TCLP and meet Title 40, CFR Part 268.48, Universal treatment standards (UTS)
All other nonwastewaters that exhibit, or are expected to exhibit, the characteristic of toxicity for mercury based on TCLP in SW846; and contain less than 260 mg/kg total mercury and that are not residues from RMERC. (Low Mercury Subcategory)	0.025 mg/L TCLP and meet UTS
Elemental mercury contaminated with radioactive materials	Amalgamation (includes use of sulfur compounds)
Per Title 40, CFR Part 268.45, Treatment Standards for Hazardous Debris	
Hazardous Debris (Debris is defined in Title 40, CFR Part 268.2, as solid material exceeding a 60 mm particle size that is intended for disposal and that is: a manufactured object; or plant or animal matter; or natural geologic material. However, the following materials are not debris: lead acid batteries, cadmium batteries, and radioactive lead solids; process residuals such as smelter slag and residues from the treatment of waste, wastewater, sludges, or air emission residues; and intact containers of hazardous waste that are not ruptured and that retain at least 75 percent of their original volume.)	Extraction Technologies or Immobilization Technologies; and must meet specified performance and/or design and operating standards of Title 40, CFR Part 268.45.
Per Title 40, CFR Part 268.49, Alternative LDR Treatment Standards for Contaminated Soil	
Contaminated Soil (Soil is defined in Title 40, CFR Part 268.2, as unconsolidated earth material composing the superficial geologic strata (material overlying bedrock), consisting of clay, silt, sand, or gravel size particles as classified by the U.S. Natural Resources Conservation Service, or a mixture of such materials with liquids, sludges or solids which is inseparable by simple mechanical removal processes and is made up primarily of soil by volume based on visual inspection.)	Treatment must achieve 90 percent reduction in contaminant concentrations as measured in leachate from the treated media, tested according to TCLP, but does not have to reduce original contaminant below 10-times the UTS limits in Title 40, CFR Part 268.48.

2.3 U.S. DEPARTMENT OF ENERGY FRAMEWORK FOR CLEANUP

Scope, schedule, and budgets for the cleanup of Y-12, ORNL, and ETTP sites are addressed by DOE OREM through the development of project definitions (based on tri-party agreed upon actions, see Section 2.2) that are then assembled into an overall OREM Baseline. Much of the Y-12 and ORNL cleanup scope was introduced and received Critical Decision (CD)-0 approval, *Approve Mission Need*, on July 20, 2007 and CD-1 approval, *Approve Alternative Selection and Cost Range*, on November 17, 2008, in accordance with DOE Order (O) 413.3A *Program and Project Management for the Acquisition of Capital Assets* (DOE 2008a) under the auspices of the IFDP. This extensive cleanup scope is in the process of being added to the OREM Baseline as

discrete projects and was added to FFA-related scope and schedules in Appendices C, E, and F shortly after CD-1 approval. Further project-specific CD approvals (levels 2, 3, and 4) will be pursued in accordance with DOE O 413.3B (DOE 2010). Chapter 4 addresses the project-specific activities proposed for Y-12 in detail. Generally, these projects are organized around building complexes; for example, the Beta-4 Complex D&D Project will demolish Building 9204-4 and accompanying ancillary facilities. Remediation of currently inaccessible soils beneath the buildings will be addressed in a separate soil remediation project logically following the D&D project. The prioritization and sequencing of all these projects – multiple complexes D&D, soils remediation, etc. – is strategically based on risk and funding as discussed in Chapter 4.

2.4 INTERFACES

OREM has cleanup responsibility for the ORR National Priorites List site. Their mission at the three sites is completed under a specific budget and, while a consistent OREM mission is applied to all sites, budgets are still subject to competing site-specific needs, missions and goals, and required results. OREM is responsible for integrating the sites' competing priorities into a single, overall plan and budget based on risk, regulatory commitments, and mission needs.

Interfacing with the Y-12 site landlord, NNSA, is essential to ensuring successful execution of both entities' missions. For example, NNSA is planning and actively seeking funding for modifications to the Perimeter Intrusion Detection and Assessment System (PIDAS), which is the protective security boundary that currently encompasses three of the four major mercury-contaminated processing facilities (Beta-4, Alpha-5, and Alpha-4). Additional costs associated with executing cleanup projects within the PIDAS are not currently accounted for in facility demolition estimates for Beta-4 and Alpha-5, due to NNSA's future plans to reduce the PIDAS footprint prior to the start of demolition of these facilities.

Interfacing with regulatory entities, TDEC and EPA Region 4, is of utmost importance in executing this mercury cleanup strategy and achieving the goals set forth in the CERCLA decision documents. CERCLA remediation activities require submittal of various documents – Waste Handling Plans (WHPs), Sampling and Analysis Plans (SAPs), Remedial Design Reports, Work Plans, etc.,– that are reviewed and approved by the regulators, indicating their involvement in the decision-making process. The strategy accounts for development of these plans and regulator interactions prior to executing the actions.

Stakeholder participation and understanding is essential for DOE to achieve acceptance of its cleanup mission. Effective communication plays an important role in integrating regulators and the public into the decision-making process. Implementation of public involvement activities will be consistent with the FFA-approved *Public Involvement Plan for CERCLA Activities at the U.S. Department of Energy Oak Ridge Site* (DOE 2017b). Interactive communication will enable all parties to understand disparate views and achieve agreement on the most appropriate path(s) forward.

2.5 COMPLETED WORK

Previous and ongoing progress toward the ultimate goal of mercury remediation at Y-12 is summarized in Table 3. Funding from American Recovery and Reinvestment Act of 2009 (ARRA) enabled the completion of several activities as noted. The recent work involving removal and disposal of some COLEX equipment located outside of Alpha-4 is also listed; however, the bulk of the work remains to be completed and is addressed by this strategic plan.

Table 3. Chronology of Significant Mercury Related Cleanup Activities

Year(s)	Project	Summary of Significant Actions	References
1985 to 1999	Building remediation activities	• Elimination of mercury sources and rerouting of process pipe in Buildings 9201-2, 9201-4, 9201-5 and 9204-4; decontamination of facilities/equipment and equipment removal; treatment of sump water in 9201-2 using activated carbon	• *Reduction of Mercury in Plant Effluents (RMPE) Program in the mid- to late 1990s* (DOE 1998g) • *Removal Action Report for Building 9201-4 Exterior Process Piping Removal at the Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/02-1650&D1
1986 to 1987	Storm drain cleaning/lining; removal of mercury-contaminated sediment	• 5,600 ft of storm sewers cleaned • 8,400 ft of storm sewers relined • 500,000 lbs of sediment removed	• RMPE Program Activity • UEFPC RI page 3-33 (SAIC 1998)
1988	Construction projects result in mercury-contaminated soil removal	• Removal and disposition of soil in high mercury-contamination areas due to construction of PIDAS	• RMPE Program Activity
1988 to 1989	New Hope Pond closure (replaced by Lake Reality)	• Located near eastern boundary of Plant • Unlined settling basin intended to remove suspended sediments from UEFPC prior to discharge from the Y-12 Plant • Constructed in 1962 • Sediments dredged in 1973 and placed in Chestnut Ridge Sediment Disposal Basin • Closed and capped in 1989	• *Removal Action Report for the Oak Ridge Y-12 Plant East End Volatile Organic Compound Plume, Oak Ridge, Tennessee,* DOE/OR/01-2297&D1 • *Post-Closure Permit for the Upper East Fork Poplar Creek Hydrogeologic Regime (New Hope Pond and Eastern S-3 Site Plume) U.S. DOE, Y-12 National Security Complex, Oak Ridge, Tennessee,* EPA ID No. TN3-89-009-0001, TN Permit No. TNHW-113 • *Closure Plan for New Hope Pond,* Y/SUB/87-86020C/3 (DOEIC = F.0603.080.0510)
1988 to 1995	Pipe rerouting: North-South Pipe replaced in 1988	• Rerouting and removal of process piping • 2,000 ft of North-South Pipe containing mercury-contaminated sediment abandoned and replaced with new pipe • North-South Pipe conveys UEFPC in western area of complex	• RMPE Program Activity • UEFPC RI Page 3-33 (SAIC 1998)

Table 3. Chronology of Significant Mercury Cleanup Activities (Continued)

Year(s)	Project	Summary of Significant Actions	References
1992	Tank remediation (removal of 30,000 lbs mercury-contaminated sediment)	• Three, concrete settling tanks (2101-U, 2104-U, 2100-U) contributed to mercury releases in UEFPC • Tanks were cleaned to remove mercury-contaminated water and sediment • Approximately 30,000 lbs of mercury-contaminated sediment removed	• *Post-Construction Report for the Mercury Tanks Interim Action at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1169&D1
1982 to 1994	Reduction of mercury in plant effluent (Lake Reality by-pass; trial treatment of Outfall 51)	• Initiated in 1982 by CWA • Two phases focused on mercury sources • Greater than 90 percent methylmercury reductions achieved • Storm sewer cleaning/relining • Rerouting process water and UEFPC • Focused water treatment	• Lake Reality by-pass project completed in 1998, which rerouted UEFPC flow around Lake Reality and reduced the flux of methyl mercury (a form more susceptible to bio-uptake) in water downstream of Lake Reality by approximately 90 percent
1996 to 2014	Flow augmentation	• Implemented to protect stream water quality per the 1995 NPDES permit • A flow of 5 million gallons per day (mgd) at Station 17 needed for protection • Flow management began in 1996 and adds approximately 4.5 mgd • Maintained by pumping water from Clinch River to Outfall 200 (North/South pipe) • Discontinued in 2014	
1996 to present	Central Mercury Treatment System operation	• NPDES Permit Compliance Program Phase 2 Action to reduce discharges at Outfall 551 • Located in Building 9623 and began operation in 1996 • Treats contaminated sump water from Buildings 9201-4 and 9201-5 • Treatment of Building 9201-5 sump halted in 2007	• *Non-significant Change to the Phase I Interim Source Control Actions in UEFPC*, April 2007
1995 to 1997	Lower EFPC floodplain soil removal	• 1994 RI/FS; 1995 ROD • Public input raised cleanup level based on mercury form (sulfide) to 400 ppm • Excavation of approximately 35,000 cubic yards of mercury-contaminated floodplain soil (45,000 cubic yards upon disposal) • Surface water decision deferred	• *Remedial Action Report on the Lower East Fork Poplar Creek Project, Oak Ridge, Tennessee*, DOE/OR/01-1680&D1
1997	Basin 9822 Remediation	• Mercury/PCB source adjacent to 81-10 Mercury Roaster • 1997 Action Memo • Basin water & sediment removed/treated • Basin demolished/filled • 81-10 sump cleanout/closure included	• *Removal Action Report for the 9822 Sediment Basin and Building 81-10 Sump at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*, DOE/OR/01-1763&D2

Table 3. Chronology of Significant Mercury Cleanup Activities (Continued)

Year(s)	Project	Summary of Significant Actions	References
1999	RI/FS completed for UEFPC		
2001	UEFPC bank stabilization	• CERCLA Treatability Study • Stabilized stream bank to reduce erosion • Reduced storm event driven releases of mercury	• *Treatability Study Report for the Upper East Fork Poplar Creek Bank Stabilization at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee,* DOE/OR/01-1890&D1
2002	Phase I ROD approved		
2005 to present	Big Spring Water Treatment System operation	• Located near Alpha-2 • Began operation in August 2005 • Removes mercury using granular activated carbon • Treats approximately 300 gallons per minute	• *Phased Construction Completion Report for the Big Spring Water Treatment System at the Y-12 National Security Complex, Oak Ridge, Tennessee,* DOE/OR/01-2218&D1
2006	Phase II ROD approved		
2008	IFDP CD-1 approved (addresses D&D of multiple buildings and remedial action sites at Y-12)		
2009 to -2013	<u>ARRA Projects</u> • WEMA Storm Sewer Project • Scrap Yard Removal • Beta-4 and Alpha-5 legacy material removal (LMR) • Alpha-5 Building characterization • Free mercury removal • Mercury secondary pathways • Mercury-contaminated soils treatability study • Disposal of five excess tanks • 81-10 characterization • OF200 MTF conceptual design	• WEMA Storm Sewer Project - Video inspection of 15,600 ft storm sewer - Cleaning of 8,100 ft of storm sewer - Relining of 1,200 ft of storm sewer - Disposition/treatment of mercury-contaminated media and wastewater • Y-12 Scrap Yard (Old Salvage Yard) characterization results show no soil treatment prior to disposal required • Completion of Alpha-5 and partial Beta-4 legacy material removal (approximately 22,000 yd^3 total removed) • Completion of Alpha-5 building characterization • Nine mercury traps installed in manholes throughout WEMA (26 lb recovered) • Drains, drainage systems, surfaces graded at Alpha-4, Alpha-5 and Beta-4 • Demonstrations by three vendors of soil treatment to meet LDRs • Dispositioned five excess tanks, two at ORR Landfills and three offsite, 650 lb of mercury disposed • 81-10 area within EU-9 characterized • OF200 MTF conceptual design and RDWP completed under ARRA funding	• *Phased Construction Completion Report for the West End Mercury Area Storm Sewer Remediation at the Y-12 National Security Complex, Oak Ridge, Tennessee,* DOE/OR/01-2526&D2 • *Phased Construction Completion Report for the Y-12 Old Salvage Yard Soil Remedial Project, Y-12 National Security Complex,* DOE/OR/01-2564&D1 • *Removal Action Report for the Removal of Legacy Material from Buildings Beta 4 (9204-4) and Alpha 5 (9201-5) at the Y-12 National Security Complex, Oak Ridge, Tennessee,* DOE/OR/01-2519&D2 • *Characterization Report for Alpha 5 Building 9201-5 at the Y-12 National Security Complex, Oak Ridge, Tennessee Volume I,* DOE/OR/01-2540&D2 • DOE 2013a, b, c • UCOR 2012b • DOE 2012a, b • DOE 2014

Table 3. Chronology of Significant Mercury Cleanup Activities (Continued)

Year(s)	Project	Summary of Significant Actions	References
May 2014	Flow augmentation discontinued	• New NPDES permit contained terms for discontinuation of augmentation. • Base flow rates at Station 17 diminished by a factor of about 2/3, from ~4,500 gpm to ~2,000 gpm.	• *2015 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation Oak Ridge, Tennessee, DOE/OR/01-2675&D2*
Ongoing	Outfall 200 Mercury Treatment Facility	• Design phase complete. • Early site preparations to begin in FY 2018.	• *2017 Final Design Report for the Outfall 200 Mercury Treatment Facility, Y-12 National Security Complex, Oak Ridge, Tennessee. UCOR-4889R1*
2017 – ongoing	COLEX equipment removal from west side, Alpha-4	• Equipment located outside at the west end of Alpha-4 is being successfully removed and disposed of offsite. Final disposition includes macroencapsulation, if necessary.	• *To be documented in a Phased Construction Completion Report at project completion*

2.6 MERCURY REMAINING IN THE ENVIRONMENT

As noted in Section 2.1, many tons of mercury have been lost to the surrounding Y-12 environment – air, soil, sediment, buildings, and water. Much of that contamination is believed to be contained in the soils surrounding and under the process buildings. A site conceptual model that identifies the major mercury sources, transport pathways, and flux was developed (ORNL 2011). Major sources delineated in the model include soils, creek sediments, buildings, and subsurface structures (storm drains, piping, sumps, and tanks). Mercury leaves the Y-12 site primarily through surface waters in UEFPC. Transport pathways are very complex, as is mercury chemistry and behavior in the environment. The amount of mercury leaving the site per a given time period (or flux) is quite variable, with the amount of rainfall the major factor impacting variability.

2.6.1 Mercury in Subsurface Soils

Mercury in the subsurface soils at Y-12 has been characterized (Rothschild et al. 1983; Miller et al. 2013) and is present in many forms (see recent Soil Treatability Study, [UCOR 2012b], for additional information). Most typically (due to its stability) the mercury II valence state versus the mercury I valence state is found, from the more soluble inorganic mercury (II) compounds (e.g., mercuric oxide, HgO) to the least soluble, mercuric sulfide (HgS, cinnabar), as well as (more sparingly) organic methylmercury compounds and, finally, a portion is present as elemental mercury. Depending on the location, any of these mercury compounds may be dominant in soils (with the exception of methylmercury, which is typically present in very low concentrations in soils, usually representing far less than 1 percent of total mercury).

Elemental mercury's unique properties of high density, surface tension, volatility, and occurrence as a liquid at room temperature lead to both challenges and advantages during its

characterization and treatment in subsurface environments. As a liquid it is perhaps the ultimate dense, non-aqueous phase liquid due to its very high density (13.5 g/cc) and relatively low solubility (60 μg/L). Its high surface tension (487 dynes/cm), highest of all common liquids at room temperature, offsets the effects of its high density and downward mobility to some degree by causing spills of the liquid to break up into small beads that stick to surfaces and retard its downward migration in porous media (e.g., soil). Elemental mercury is also relatively volatile and can reach near saturation values in stagnant air (e.g.,18 mg/m^3 at 24°C) that are hazardous to human health (the National Institiute for Occupational Safety and Health's Immediately Dangerous to Life or Heath level is 10 mg/m^3). Thus, it can migrate in the subsurface as a gas in the soil gas matrix as well as dissolve in groundwater, presenting inhalation issues during remediation. Under mildly anoxic subsurface conditions elemental mercury is thermodynamically stable; however, on exposure to air with normal oxygen content it can be oxidized to forms (HgO, HgOCl) that are far more soluble in water than the elemental form (Miller et al. 2015). One further complication arises from the observation that certain subsurface bacteria (iron reducers) are capable of reducing mercury(II) ions to elemental mercury (Barkay et al. 2009). At higher levels of mercury contamination, development and expression of the *mer* operon, a mercury-resistance gene, also facilitates mercury reduction. Thus, even where a subsurface mercury source is not initially elemental, microbial-driven processes can generate elemental mercury in the subsurface.

Total mercury concentrations in soils in the WEMA and around Alpha-2 range from a few mg/kg (ppm) to thousands of ppm. Mercury remediation of subsurface sources has been very limited, to date. The majority of this work remains planned under future actions.

2.6.2 Mercury in Water and Sediments

Considerable progress has been made in reducing the amount of mercury leaving the site through UEFPC since the 1980s demonstrated by the trend in Figure 5. However, concern was raised over the increase seen in mercury leaving the site (during the 2010 timeframe) after what appeared to be a decrease due to operation of the BSWTS beginning in 2005 (refer to Figure 6). The flux increase during 2009 to 2011 may be partially explained in terms of increased rainfall (mercury flux correlates with rainfall due to the increase in flow and turbidity, which causes mercury flux increases due to higher solids content where mercury preferentially resides). The significant increase over that period is attributed to the WEMA storm system cleanout, which resulted in disturbances of storm drain sediments, a primary mercury source. As seen in Figure 6, mercury flux has continued to drop since the cleanout, although rainfall for the three-year period has slightly increased during that time (60 inches for 2011, 62 in 2012, and almost 64 inches in 2013). Mercury flux continues to be a significant issue, and reduction of mercury leaving the site has been identified as a high environmental risk requiring near-term action. A complete discussion of mercury flux is given in the annual RER (UCOR 2017).

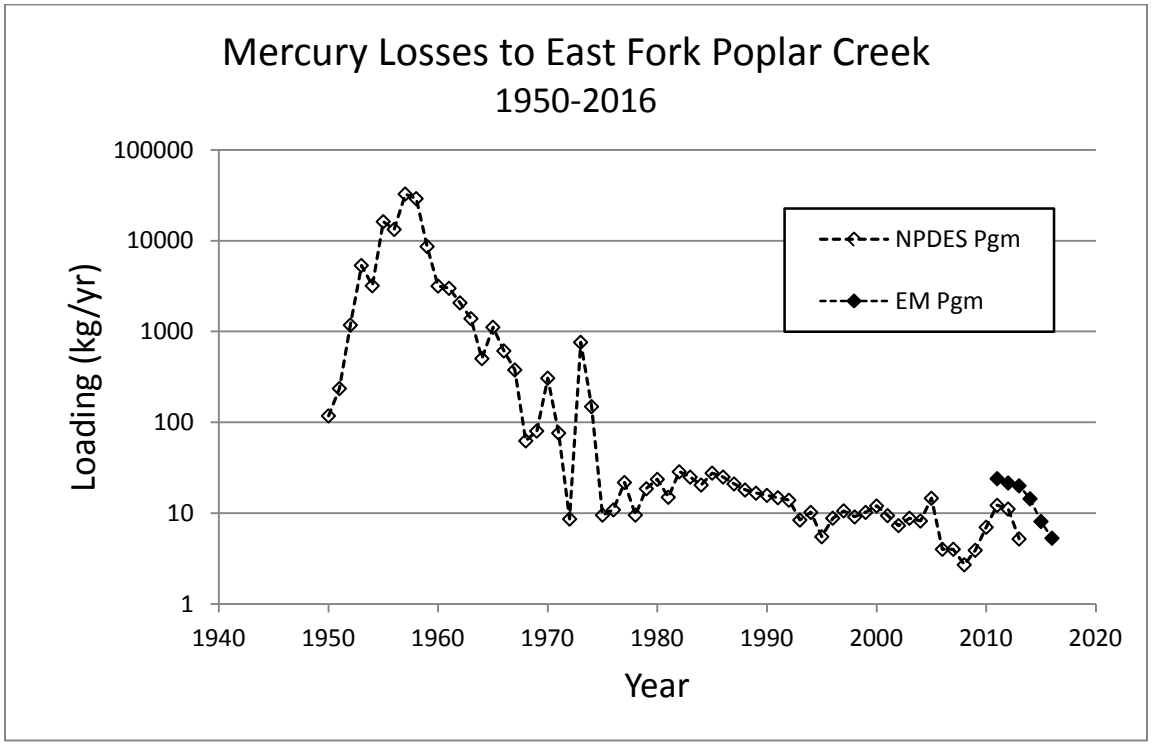


Figure 5. Station 17 Historic Mercury Loading to UEFPC

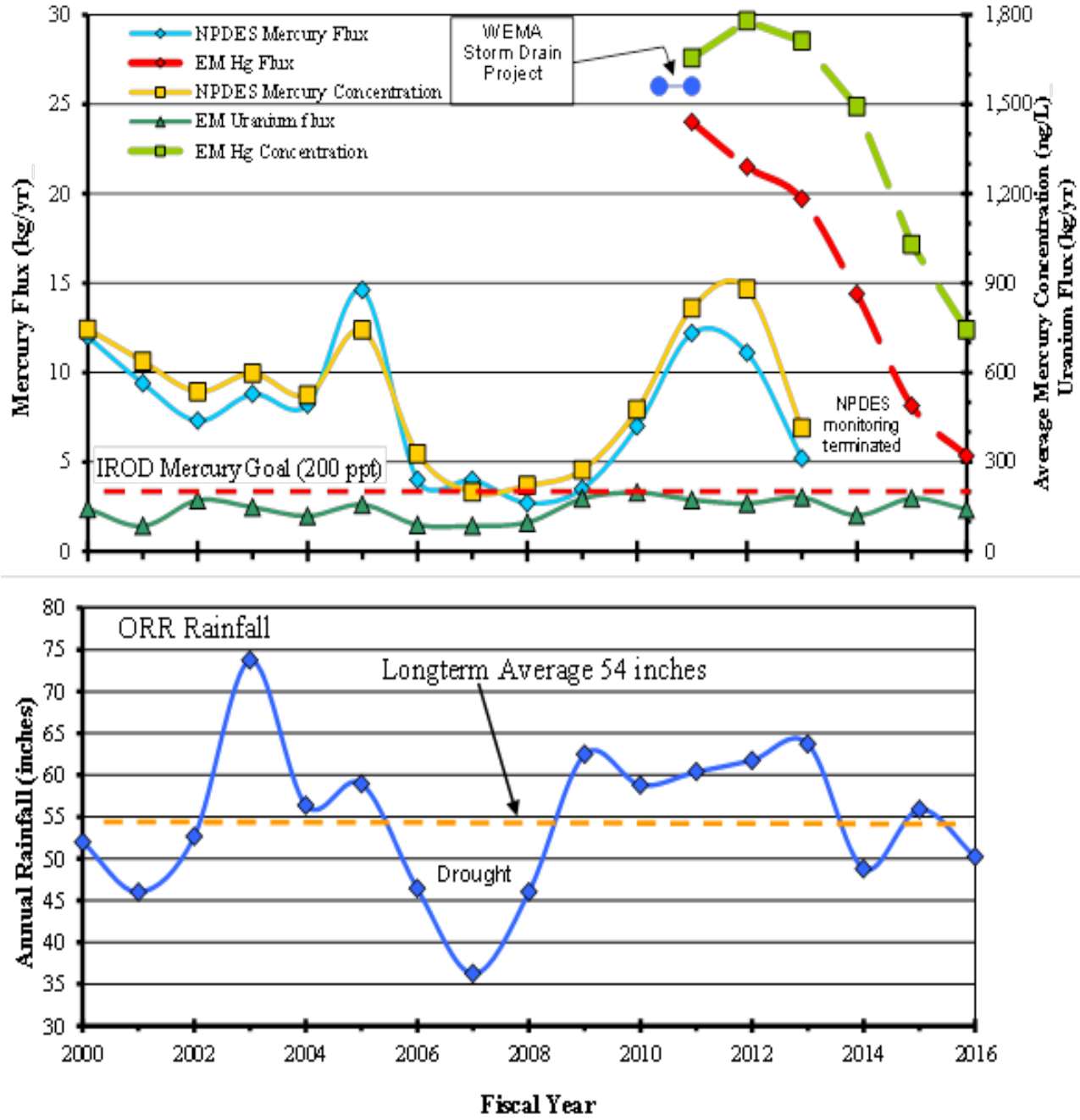


Figure 6. Annual (2000-2016) mercury and uranium fluxes at Station 17 (upper panel) and annual rainfall (lower panel)

EPA approval of the 2016 ORR Five-Year Review (FYR), (UCOR 2016) noted that the LEFPC ROD protectiveness of the environment has been deferred pending studies that indicate some terrestrial biota that are prey (spiders) for higher organisms (birds) accumulate mercury. Additionally, the Phase I ROD focus was reduction in source term contamination and was not intended to be protective for ecological receptors as presented in the FYR, based on continued high mercury flux/concentration as measured at Station 17.

Several conclusions, as shown below in italics, are drawn in the Y-12 Site Conceptual Model report (ORNL 2011) regarding mercury sources contributing to surface water contamination. Additional clarification is added in brackets.

- *Of the known mercury inputs into UEFPC, Outfall 200 (representing combined inputs from the WEMA and other upstream areas) is by far the most important current source of mercury to creek water. Depending on flow conditions, Outfall 200 represents approximately 70-80% of the flux observed at Station 17. This is a change from 10 years ago when Outfall 200 was thought to represent approximately 20% of the flux to Station 17* [when other fluxes were still present (e.g., Outfall 51 near Alpha-2)].

The dramatic increase and subsequent fall of flux measured at Station 17 during 2010 to 2012 is attributed to lingering effects of the WEMA storm sewer cleanout that has ultimately seen a more dramatic decrease. These occurrences demonstrate that resuspension of creek sediment, rainfall influences, etc., can become more significant contributors to mercury flux in the creek under some circumstances, and highlight the potentially unpredictable effects that remediation activities, soil and sediment disturbances, and other possible fluctuations can have on mercury flux in various locations throughout the flow regime.

The following observation, quoted from the Conceptual Model report, demonstrates one such influence:

- *Under base flow conditions, stream sediment provides the second most important continuing source of mercury into creek water (upstream of Outfall 109). Flow management* [augmentation of flow to UEFPC with Clinch River flow] *appears to have increased flux from this sediment source* [due to the disturbance and re-suspension of sediment caused by the introduction of the high augmentation flow. As pointed out in Table 3, flow augmentation has been terminated.].

Other conclusions drawn from the report include:

- *Sediments in UEFPC may* [also] *act as a sink for mercury under dry-weather conditions* [especially in the absence of flow augmentation] *with sediments and suspended solids moving downstream and contributing to high flux numbers during extremely high flow conditions (Southworth et al. 2009, Southworth et al. 2010). Mercury flux monitoring at Station 17 is affected both by large changes in water flow volumes and by impacts to mercury concentration from short-term spikes of particle-associated mercury (DOE 2011). Ungauged flux downstream of Outfall 109 to Station 17 represents a very uncertain and*

poorly-understood contribution to the UEFPC mass balance during wet-weather periods. Further complicating the downstream mass balance is the fact that year-to-year variation in export estimates at Station 17 is very large and dependent on the sources and handling of data used to generate the estimate (e.g., grab samples vs. composites, inclusion or exclusion of very high spikes, and averaging methods).

- *Shallow groundwater near Big Spring is known to be a substantial mercury source that highlights the need for continued operation of Big Spring Water Treatment System (BSWTS). The primary groundwater sources to the BSWTS, whether originating from 81-10, the WEMA area, or the Alpha-2 area, are not well understood.*
- *BSWTS has been successful at removing approximately 2–3 g/d of mercury that entered UEFPC prior to BSWTS start-up, as well as substantially reducing the average mercury concentration in the creek. Over much of its operation, BSWTS has removed a much higher amount of mercury from groundwater than was anticipated.*

The behavior of mercury in UEPFC between Outfall 200 and Station 17 is complex. As noted already the mercury mass balance for this reach is dynamic and controlled in large part by timing and duration of dry weather and storm flows. The reach effectively stores significant amounts of the mercury discharged during dry weather flow in bed sediments and then releases all or portions of it during storm flow. The reach provides trapping of particle-associated mercury (including free-phase mercury) between storm events as well as opportunities for solution-phase (dissolved) mercury to partition to bed sediments and suspended particles. The latter behavior is illustrated by the observation that dissolved mercury at Outfall 200 accounts for more than 80 percent of total mercury under dry weather flow conditions and 66-72 percent of total mercury under all flow conditions. In contrast, the dissolved percentage for all flows at Station 17 is 5 percent, with dry weather flow conditions characterized by somewhat higher dissolved percentage. Some solution-phase mercury is also lost from the creek due to reduction of ionic mercury to the volatile elemental form and evasion[5] from creek water. These processes make calculation of short-term mass balances, which do not include storage and evasion terms, meaningless. The relevance of this behavior to remediation strategies is that it makes assessment of the effectiveness of any applied remedy more difficult, or at least requires that only long-term observations be used. Capture of base and storm flow by the OF200 MTF headworks (EFPC headwaters below Outfall 200) and subsequent transfer of that flow through piping through this reach of creek, to the MTF (a distance of approximately 3100 ft) will provide an opportunity to access some interim remediation/treatment demonstration steps.

Cessation of flow augmentation significantly altered the partitioning behavior (K_d) of mercury to suspended matter throughout LEFPC. Measured distribution coefficients[6] for mercury decreased by up to 10-fold after flow augmentation was halted (Peterson et al. 2017).

[5]Evasion is the physical transfer of a dissolved substance (in this case elemental mercury) from water to air. Note that this process was evaluated (Southworth 1997, Southworth et al. 2009) during field testing of the chemical reduction-air stripping concept and found to be minor.

[6] Kd, or distribution coefficient, is defined as the ratio of the solid to dissolved phase masses of a compound and reflects the affinity of a compound for the solid phase, with higher values indicating higher affinity.

While the explanation for this change is uncertain it is thought to be related more to a change in the composition of suspended matter than to the concentration of suspended matter in creek water (Peterson et al. 2017).

Clearly, the effectiveness of remedies applied upstream of Outfall 200 should be much less difficult to assess at Outfall 200, while those applied at (e.g., proposed mercury treatment facility) or downstream of Outfall 200 and assessed at Station 17 will require careful consideration of this complex environment.

2.6.3 Mercury in Fish

Taken as a whole, these and previous discussed observations – decreases in mercury flux have not resulted in corresponding fish mercury level declines; cleanup of storm sewer systems seem to have triggered temporary increases in mercury flux; flow augmentation, introduced as a response to improve water quality, is thought to have resulted in increased mercury flux at Station 17 while its absence changed how mercury behaves in the creek; a significant 75 percent decrease in mercury flux at Outfall 200 was noted from 2011 to 2012 after storm sewer cleanup, but not followed by a corresponding decrease in mercury flux at Station 17 – all demonstrate the uncertainty and variability in environmental mercury response when cleanup steps are initiated or the hydrology of the system is altered. Ultimately, source removal will lead to reduced mercury levels in the environment, in the meantime, however, interim cleanup actions can influence mercury transport in a sometimes uncertain, and even negative, manner.

The USEPA evaluates mercury levels in fish tissue as an indication of the "health" of a water body. These tissue levels have not seen a corresponding decrease within the fish of EFPC as shown in Figure 7. The relationship of mercury in fish tissue to mercury in water is complex and not well understood in spite of many years of monitoring both water and fish, during which time mercury in water has been significantly decreasing as already described (e.g., see Figure 6 for Station 17). The relationship is non-linear as seen in recent data from both EFPC and other streams on the ORR (Figure 7). In the 1980s when mercury concentrations in UEFPC were considerably higher but decreasing, it appeared that a linear relationship existed between water and fish tissue, at least in the upper reach of EFPC. Based on that relationship, it was anticipated that reducing mercury in water to <200 ppt would result in fish tissue values decreasing to less than 0.4 mg/kg, the tissue standard of that time period and the basis for the interim ROD for UEFPC. Mathews et al. (2013) published a detailed summary of the history of efforts to reduce mercury concentrations at Station 17 and the responses in fish tissue concentrations at several downstream locations that followed these efforts. These authors also examined the relationship between water and fish concentration in White Oak Creek as it has evolved during similar efforts to reduce mercury concentrations in water at the ORNL facility. Results for both streams support this non-linear relationship between mercury water concentrations and fish concentrations. Both the Mathews et al. paper, and another recent ORNL publication (Southworth et al. 2013) mention that fish tissue concentrations in LEFPC are not being entirely controlled by waterborne mercury from the plant site. They note that more than 80 percent of the mercury loading from the EFPC watershed (at confluence with Poplar Creek) is derived from floodplain soils and downstream creek sediments due to storm flow erosion of bed sediments and bank soils. The most recent

(2016) longitudinal pattern of mercury in fish in EFPC (Figure 8) shows that mercury in fish is relatively constant with distance from Station 17, although historical data trends have shown both decreases with distance downstream, indicative of point source dilution, and increases with distance downstream, suggestive of instream sources (sediments and floodplain soils). This latter pattern is very similar to that for another river (South River, Virginia; Flanders et al. 2010) with floodplain soil mercury contamination similar to LEFPC but without significant point source loading from the facility that originally released the mercury. Research on both rivers is pointing to eroding stream banks as the main source of mercury in fish in the downstream reaches of these rivers.

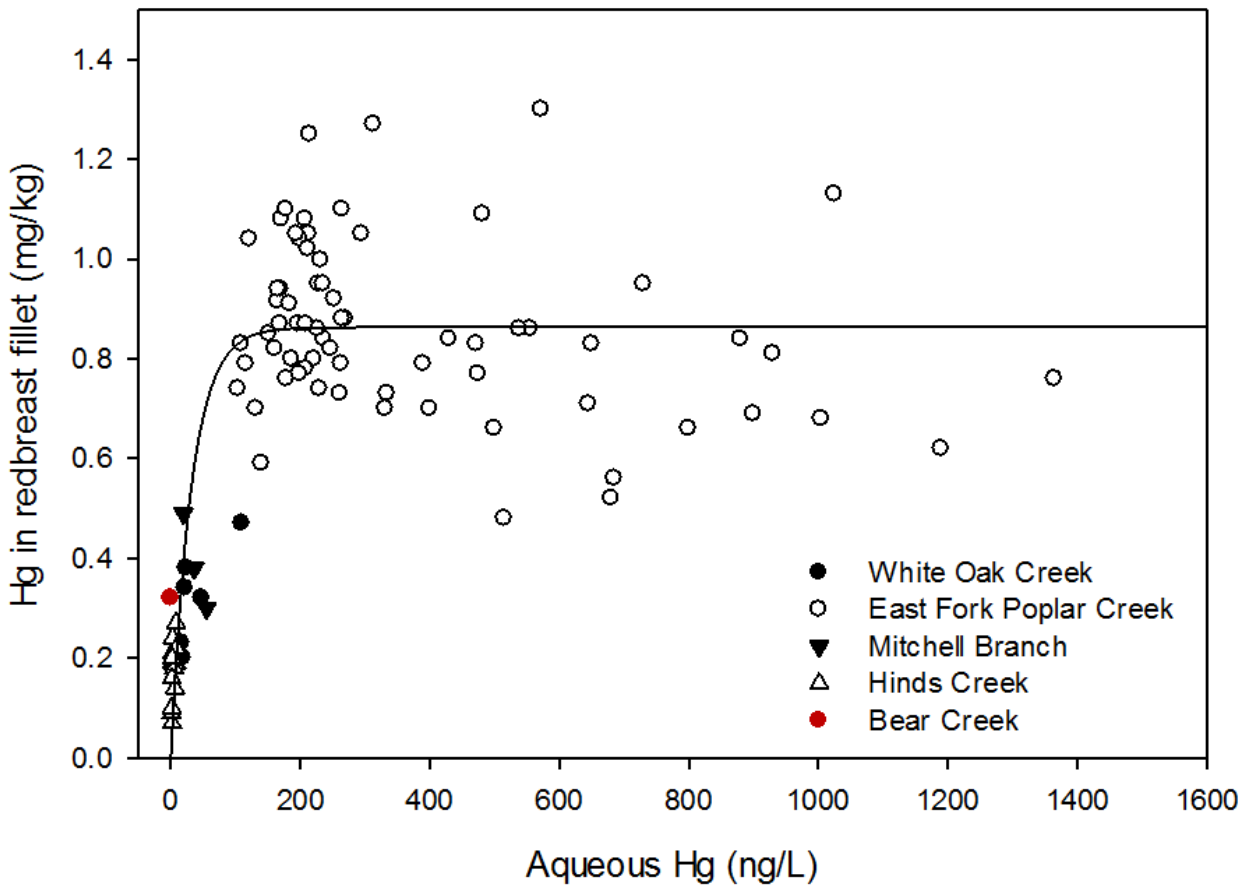


Figure 7. Mercury Concentrations in Water and Redbreast Sunfish Collected on the ORR, 1997-2012

Each data point represents the mean total mercury concentration in six redbreast sunfish at each sampling season and the mean aqueous concentration for the previous season. An exponential model fit is shown by the line in the graph (from Mathews et al. 2013).

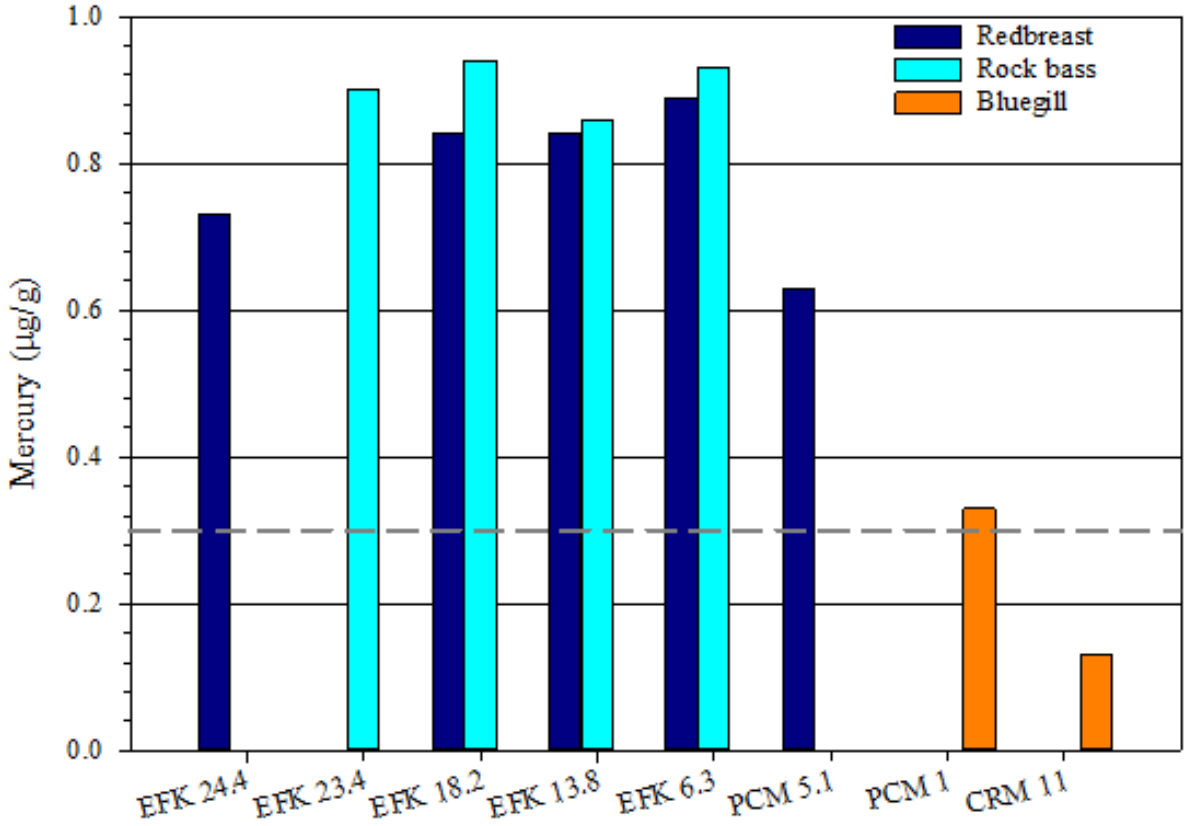


Figure 8. East Fork Poplar Creek Mercury in Fish, Spatial Trends

Average seasonal mercury concentrations in fish in EFPC as noted (from Peterson 2013); dashed line indicates EPA recommended AWQC for mercury (0.3 µg/g in fish)

3.0 PATH FORWARD – STRATEGIC PLANNING

Based on the observations and issues regarding mercury in the environment on the Y-12 site and downstream in LEFPC as measured to date, namely that mercury levels in fish tissue are not declining as anticipated and mercury flux remains elevated, several significant measures were implemented as previously recommended by this 2014 Strategic Plan (Rev 0). Future actions will be consistent with the adaptive approach to introduce additional actions based on results of these staged measures.

This chapter lays out the strategy to complete the Y-12 mercury-related cleanup. Section 3.1 groups the strategies to conduct the mercury cleanup into general categories. An overall strategy roadmap is presented in Section 3.2 based on those categories, and Section 3.3 defines the endstates that are anticipated. Section 3.4 develops the detailed implementation of the strategy, generally following the first four categories, and the fifth category, technology development, is discussed in Section 3.5. The regulatory strategy is given in Section 3.6, and risks and opportunities introduced through the strategy are covered in Section 3.7.

Research supported at ORNL under both the Environmental Management Applied Research and Technology Development (ARTD) Program and the Office of Science's (SC) Science Focus Area (SFA) will continue to address the underlying mechanisms and controls on those mechanisms driving mercury uptake by fish in EFPC. Completed and proposed studies in this area are outlined further in this document (see Section 3.4.1.2), with the expectation that any necessary additional remediation activities on LEFPC can be identified and applied soon after upstream sources are controlled.

Effectively addressing the mercury sources is, ultimately, the goal of the mercury cleanup efforts at Y-12, while the efficacy of the cleanup will be measured in terms of fish tissue methylmercury concentrations. Source removal/stabilization – that is, demolition/removal of mercury-use building debris and excavation/stabilization/disposal of soils and sediments – is very costly and time-consuming. Therefore, as only one of many urgent missions that OREM is responsible for completing on the Reservation, it will be undertaken as soon as current, committed missions are completed and funding becomes available. Prior to initiating the large source removal projects, a plan for managing treatment and disposal of the expected soil and debris waste must be in place to allow for seamless removal, staging as needed, treatment, and final disposal. Typically, this information is contained in the RmAWP, RAWP, and WHP. A pertinent study has been completed that considers the regulatory path and approvals, treatment methods and facilities, disposal locations, and costs associated with management of mercury-contaminated soil, *Treatment Study Report for Y-12 Site Mercury Contaminated Soil, Oak Ridge* (UCOR 2012b). A similar study for mercury-contaminated debris has now also been completed (UCOR 2016).

Two significant measures have been completed or are planned, termination of flow augmentationand OF 200 MTF, that will reduce mercury loading to UEFPC and thus mercury contamination leaving the site. Based on an adaptive approach, ongoing field and laboratory evaluations and modeling efforts (action plans are given in Attachment A) – to refine mercury

source contributions, methylation and bioaccumulation processes, and reduce uncertainties regarding protectiveness of efforts taken to date as well as future efforts – may dictate the need for further actions (see Section 3.4.2.2 for more details). Also in Section 3.4.2.2 is a list of proposed studies to examine other possible actions that might be implemented following the OF 200 MTF startup. A CERCLA Alternatives Evaluation is proposed that will summarize results of studies/efforts in the FY 2021 time frame, and propose future actions that might be deemed necessary. Within this plan, any further actions are not currently accounted for in terms of the planned funding profile and schedule. Therefore, implementation of additional actions outside of this plan will necessarily result in extension of the proposed schedule for planned source remediation (e.g., building demolition and soil/sediment remediation). A combination of actions, large and small, thus makes up the strategy for mercury cleanup at the Y-12 Complex, which under current planning assumptions is projected to be completed in FY 2039.

3.1 STRATEGIES TO CONTROL MERCURY RELEASES

Activities to control and/or reduce mercury concentrations (and loading) in Y-12 Plant groundwater and surface water have been grouped into five generic strategies:

- Water Management
- Capture and Treat
- Source Removal
- Source Isolation
- Technology Development

Figure 9 shows a high-level organization of these generic strategies and summarizes recently completed scope and future work to be accomplished under the mercury strategy presented here and discussed in subsequent sections.

Water Management encompasses the concept of "clean water through clean conduits." Historically, water management has played a major role in reducing losses of mercury into the plant drainage network by identifying alternate paths for clean water flow around conduits known to be contaminated with mercury. Redirecting roof drainage and cooling systems condensate away from building sumps represent good examples of effective water management for contaminant mass transport control.

Operation of building sumps has consequences to contaminant mass transport control. These sumps and their pumps were installed to maintain dry basements in buildings such as 9201-4 and 9201-5 (9201-5 sumps are currently not being used due to the potential for accumulation of methanol in sump water, rendering it not amenable to treatment in the current system; see Table 3). They at least partially regulate water table elevations in their proximity, and thus may limit contact of groundwater with mercury-contaminated soil and building materials. This connection with mercury loading to UEFPC has been recognized and evaluated previously (e.g., at Alpha-2).

Additionally, water management encompasses the future routing of clean stormwater around active building demolition, as possible, as well as around other (soil) remediation activities (e.g., through the use of tents, straw bales, sand bags, etc.).

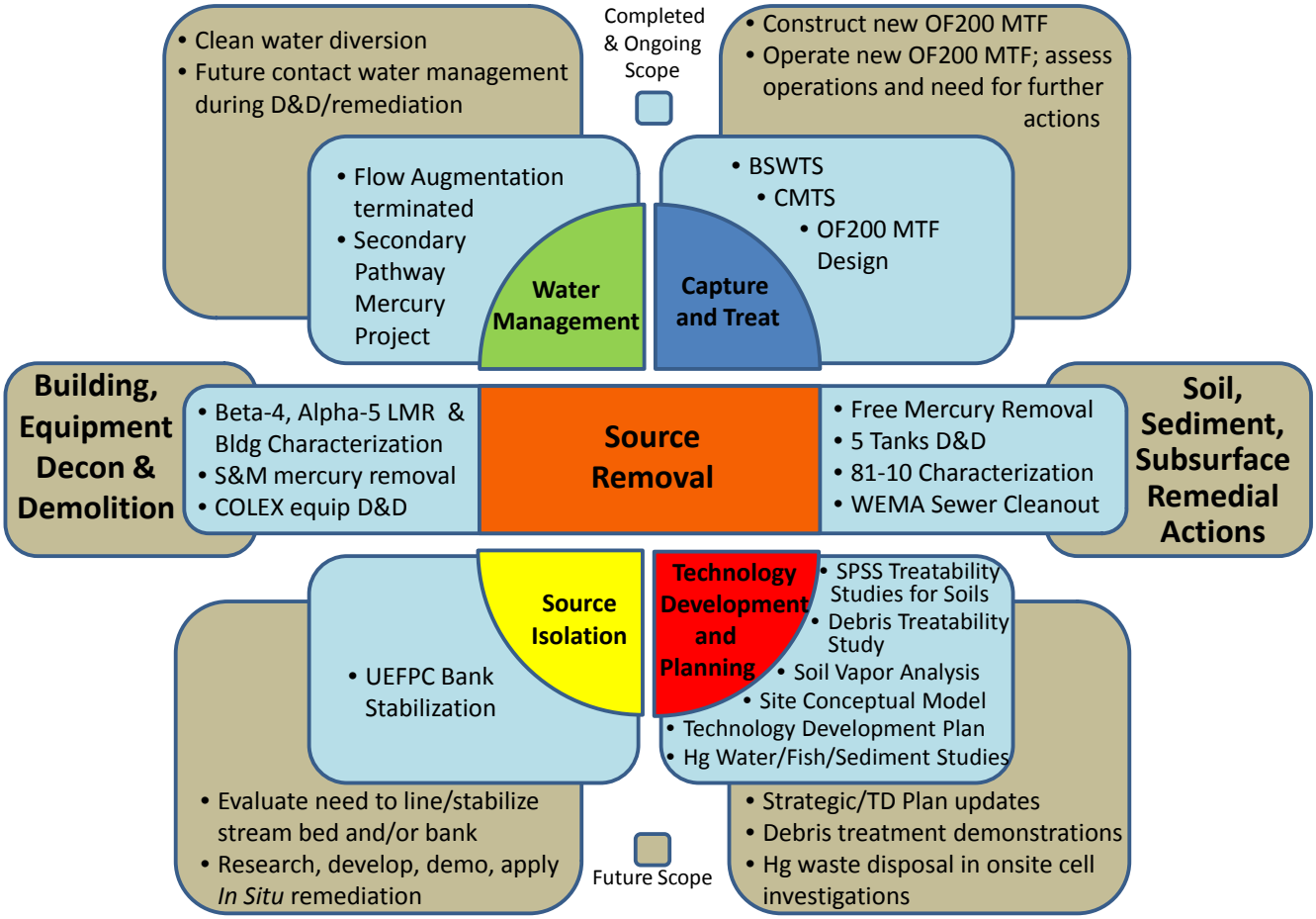


Figure 9. Multi-layered Approach to Mercury Remediation – Completed Scope (blue) and Future Scope (brown)

Capture and Treat is the proposed action to achieve reduction of mercury in UEFPC. It has been practiced very successfully at Y-12 but at considerable cost. Both distributed (BSWTS) and centralized (Central Mercury Treatment System [CMTS]) systems have been installed at Y-12, and planning for an additional system is ongoing (OF200 MTF). Selection of cost-effective treatment is important, as is siting (i.e., design capacity can be reduced if location of capture is situated as close to an undiluted source as practical). Modular and scalable design and construction of water treatment systems, as is planned for the OF200 MTF, can allow for flexibility in terms of plant efficiency and capacity.

Capture and Treat methods will be used during future demolition projects to manage expected contact water. Existing facilities (CMTS, BSWTS) may be used during demolition and remediation work to treat contaminated-groundwater or contact water as might be encountered, and as may be planned for operation of the OF200 MTF. It should be noted that these treatment systems are designed to accommodate certain contaminants and function under specific conditions (e.g., flowrates), and the addition of new streams (e.g., those resulting from demolition activities) may require setting waste acceptance criteria (WAC) and exploring the ability of the systems to handle other contaminants along with possible modifications that may be required.

Source Containment/Isolation is achieved by construction of physical barriers around soil/waste such that water cannot enter the containment area. This may entail surface capping and/or impermeable wall installation, as was completed in the past UEFPC bank stabilization effort. To be effective in some cases it may need to be combined with Water Management or Capture and Treat strategies. This category may also include *in situ* stabilization wherein soil or waste is modified in place using physical (e.g., grouting to reduce hydraulic conductivity) or chemical methods with the goal of reducing solubility/leaching of contaminants.

Source Removal includes activities such as soil/debris excavation, storm sewer sediment cleanout, building demolition, and elemental mercury trapping/removal from plumbing and equipment and even in situ extraction of contaminants like elemental mercury that can be recovered by thermally-enhanced vapor extraction. Targeting removal actions within known or suspected flow paths of water is critical to assure success in reducing concentrations in the receiving stream. Flow paths may vary temporally as well as spatially, and thus sources may not always be within a flow path. It is also important to recognize that a given percent reduction in source inventory of mercury (mass) does not usually translate into a similar percent reduction in water-borne mercury concentrations (i.e., achieving a 95 percent reduction of mercury in soils does not guarantee a 95 percent reduction in water-borne mercury concentrations or loading). As seen in Figure 9, source removal encompasses pre-demolition work and D&D of the four large process building complexes as well as remediation of the associated substructures (e.g., slabs) and soils. Sediments will be addressed in out-years.

Technology Development is an overarching strategy supporting effective implementation of the four strategies above as well as evaluating non-traditional strategies addressing pollution prevention (e.g. selection of dechlorination chemicals which do not enhance dissolution and mobility of mercury in storm drains) and techniques to limit bioaccumulation of mercury in fish

and wildlife downstream of sources. Technologies exist for mercury-contaminated media treatment that can be considered "off-the-shelf," including retorting, amalgamation, and excavation with relocation to appropriate landfills (if treatment standard limits are met). The proven technologies of retorting and amalgamation have high-energy demand and are not cost effective or practical for the potentially large volumes of waste anticipated during source removal. Several commercial vendors have proven technologies for treating high concentration, mercury-contaminated soils. Likewise, macroencapsulation of debris is acceptable as a treatment step. Exploratory treatment is necessary to establish remedial effectiveness, expected costs, and regulatory agreement. Studies examining treatment for soils have been initiated (UCOR 2012b).

Mercury presents unique challenges in both characterization and treatment but offers opportunities for innovation, which take advantage of its chemistry. Since elemental mercury has a significant vapor pressure at room temperature, it can often be located by air sampling, including in the subsurface (soil gas), affording real-time delineation of this form of mercury in soil and building spaces.

Ongoing studies looking at fish-mercury relationships in the EFPC system are aimed at supplying information to better understand methylation and bioaccumulation processes and further examine mercury source contributions in the ecosystem to quantitatively refine the site conceptual model and help direct remediation more accurately. These and other technology development initiatives (see Section 3.5 for a full discussion of technology development initiatives) are ongoing or planned, and may be applied to mercury remediation at Y-12 and LEFPC. Additionally, several proposed studies, some in the technology development arena, are presented in the strategy (Section 3.4.1.2) that may lead to significant future actions aimed at mercury flux and fish/surface water mercury concentration reductions. These offer opportunities to reduce cost and increase effectiveness of remediation.

3.2 STRATEGIC ROADMAP

Strategic management of remediation projects/activities involving mercury-contaminated media – soil and sediments, subsurface structures, water, and buildings – is essential to OREM reaching an acceptable endstate at the site in an orderly, integrated, timely, compliant, and cost-effective manner. The strategy considers all the support aspects/activities of physical cleanup, including:

- Regulatory approach/submittals and defined endstates
- DOE-required project scope/funding request submittals and approvals
- Technology development evaluations in support of cleanup efforts
- Project prioritization and sequencing
- Scope and method of accomplishment
- Schedule and cost
- Mitigation strategies to address risks and issues
- Implementation strategies for identified opportunities
- Monitoring of remediation effectiveness

Figure 10 is a high-level overall schedule communicating the strategic roadmap for mercury remediation at Y-12. On the left of the strategic schedule, activities are grouped by the five generic strategies: four (water management, capture and treatment, source isolation, and source removal) that physically control mercury releases both onsite and offsite through implementation of organized projects (addressed further in Section 3.4) and the fifth – technology development – which includes activities and studies that support the other four physical strategies (addressed further in Section 3.5). Support activities (e.g., regulatory documentation and DOE capital project submittals) are also noted. This schedule is referred to throughout the subsequent sections.

Understanding the desired endstates for waste, buildings, soils/sediments, and water is necessary to fully address building demolition and media remediation. Eendstates are discussed in Section 3.3.

3.3 ENDSTATES

Successfully completing the mercury cleanup at Y-12 relies heavily on achieving tri-party approved, affordable, and environmentally protective endstate criteria for soil and sediment as determined by land use expectations and endstates (e.g., acceptable disposition) for remediation and building demolition waste. Building/debris waste "endstates" are described in the AM; soil, sediment, and surface water interim remediation goals/states are defined in the UEFPC Phase I and II RODs. Land use expectations do not determine groundwater and surface water resource classifications and, therefore, final goals. Final decisions for groundwater and surface water, which could potentially include reclassification of surface water or groundwater resources, have yet to be determined (TBD) and will be addressed in future RODs.

3.3.1 Media Interim and Final Endstates

Table 4 summarizes interim and final endstates for groundwater, surface water, soils, sediments, buildings, and waste contaminated with mercury – for the Y-12 site (WEMA) and Upper and Lower EFPC. Subsurface soils containing mercury that will remain in place (following interim actions) per agreements in the Phase I and II RODs may be addressed by future groundwater and surface water RODs, and so are noted by TBD in the final endstate column of Table 4 (note, TBD applies if *in situ* treatment is applied) along with groundwater and surface water final endstates. Future determinations for water quality criteria may be made based on meeting the criterion of 0.3 mg methylmercury/kg in fish tissue.

Of particular note is the interim goal of 200 ppt mercury in UEFPC surface water. As discussed in the tri-party workshop of August 13, 2013, the AWQC of 51 ppt mercury is the applicable ARAR (whereas the 200 ppt is a waiver to that goal, presented in the Phase I ROD) and as such is the ultimate in-stream goal; however, it is recognized by all parties that achieving this goal will take time, and a phased approach that implements several varied actions will be required.

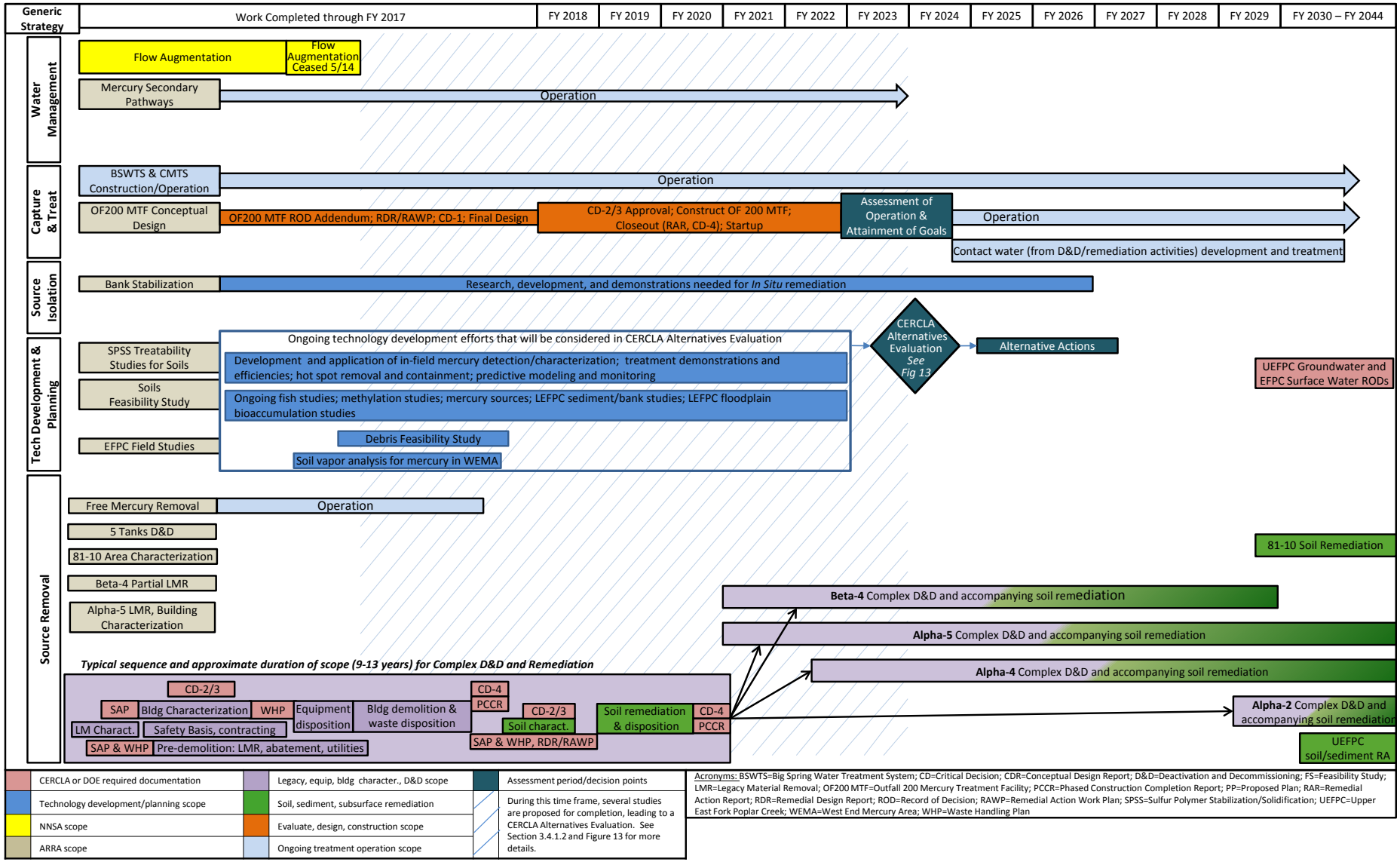


Figure 10. Strategic Schedule for Mercury Cleanup at Y-12

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Table 4. Media and Waste Interim and Endstates for Mercury Remediation

Media	Interim state/Goal	Final Endstate/Goal	Decision Document(s)
UEFPC groundwater (except Outfall 51)	• Treatment by CMTS (ongoing) • Land Use Controls (LUCs) (ongoing) • Monitoring near deep soil excavation for minimum of five years	• TBD	• Phase I ROD • Phase II ROD • Future final UEFPC groundwater ROD
UEFPC groundwater discharge at Outfall 51 and Alpha-2 sumps (treated by BSWTS)	• 200 ppt mercury (ongoing)	• TBD	• Phase I ROD • Future final UEFPC groundwater ROD
UEFPC surface water	• LUCs (ongoing) • 200 ppt mercury as measured at Station 17 (not yet achieved) • Monitoring (at Station 17, midpoint of UEFPC channel, at storm sewer system outfalls, at treatment system effluents) • Monitoring to assess reduction of mercury in fish and effectiveness of actions (ongoing)	• 51 ppt mercury • TBD, to be based on fish tissue 0.3 mg/kg mercury	• Phase I ROD • Phase II ROD (App. C risk calculation for GW and SW impacts from soil) • Future final EFPC surface water ROD
LEFPC groundwater	• Does not present risk	• NA	• LEFPC ROD
LEFPC surface water	• LUCs • Monitoring	• 51 ppt mercury • TBD, to be based on fish tissue 0.3 mg/kg mercury	• LEFPC ROD • Future final EFPC surface water ROD
Fish	• Controls per 1983 TDEC advisory signs (ongoing)	• 0.3 mg/kg mercury in tissue	
LEFPC soil (floodplain)	• NA	• Remove soils exceeding 400 ppm mercury	• LEFPC ROD
LEFPC sediment	• Does not present risk	• NA	• LEFPC ROD
UEFPC soil	• LUCs (ongoing) • Remove soil to 2 ft in EUs 2-14 and to 10 ft in EUs 1a and 1b that exceed mercury remediation levels (model derived)	• TBD	• Phase II ROD • Future final EFPC surface water ROD
UEFPC soil affecting groundwater and surface water	• LUCs (ongoing) • Remove to water table or bedrock to protect against unacceptable releases to groundwater or surface water (as determined by model)	• TBD	• Phase II ROD • Future final EFPC surface water ROD
UEFPC sediment	• Remove streambed sediments to bedrock, 1-6 ft; remove soil from banks	• TBD	• Phase I ROD • Future final EFPC surface water ROD
UEFPC Lake Reality sediment remaining	• Remove lake bed sediment to 1 ft depth	• TBD	• Phase I ROD • Future final EFPC surface water ROD
WEMA soils	• Originally addressed in Phase I ROD through WEMA capping; default to Phase II ROD through statements in Phase II ROD saying all “soils that are inaccessible and become accessible” are included in Phase II ROD	• TBD	• Phase I/II ROD • Phase II ROD • Future final EFPC surface water ROD
WEMA storm sewer sediment	• Flush sediment from piping/reline sewers (completed) • Treat sediment if necessary to meet LDRs (completed) • Meet waste acceptance criteria (WAC) of disposal site and dispose of sediment (completed)	• TBD	• Phase I ROD
Removed soil/sediment waste (all sources)	• NA	• Treat if necessary to meet LDRs • Meet WAC of disposal site and dispose	• Phase I ROD • Phase II ROD
Buildings	• NA	• Demolish to on-grade slab	• AMs and RmAWP for building demolition
Building slabs	• To be defined in building D&D design and documented in future addenda to the building RmAWP	• TBD	• Future addenda to building RmAWP
Demolition/remediation contact water	• NA	• Treatment by OF200 MTF, CMTS, and/or other systems with modifications as needed	• Future addenda to building RmAWP
Debris waste (building/equipment/legacy waste)	• NA	• Treat if necessary to meet LDRs • Meet WAC of disposal site & dispose	• AMs and RmAWP for building demolition or other decision documents for equipment and/or legacy • WHPs

NA = not applicable; TBD = to be determined.

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3.3.2 Remediation Waste Endstates

Endstates for waste debris and soil resulting from demolition and remediation are discussed in terms of the waste's disposition: onsite, offsite, and treatment, if needed.

3.3.2.1 Onsite Disposal

As the most cost effective measure available, this strategy assumes the majority of the low-level waste (LLW) and mixed (LLW and hazardous) waste resulting from future demolition and remediation activities will be dispositioned at the onsite CERCLA facility, the Environmental Management Waste Management Facility (EMWMF) located in Bear Creek Valley (BCV), as specified in RODs and AM, provided facility waste acceptance criteria (WAC) are met. The EMWMF is projected to reach capacity in the mid-2020s, after which time a future replacement CERCLA facility is assumed to be available (currently also proposed to be located in BCV). Its availability is scheduled to overlap the closure of EMWMF, and thus consistently provide an approved onsite disposal location for ORR cleanup waste. This future onsite disposal facility is currently being proposed through the CERCLA process, and is to be fully planned in CERCLA documentation and addressed in subsequent milestones (DOE 2017c). It has been included in the OREM baseline, and is included in Chapter 4 of this document. For purposes of this strategy, the onsite CERCLA disposal facilities – current and future – are referred to only as the EMWMF.

Non-hazardous, non-radioactive waste generated during demolition and remediation activities is disposed of at onsite ORR Industrial Landfills (ORR Landfills), which are assumed to have sufficient capacity throughout the Y-12 cleanup efforts. ORR Landfills are the preferred disposal alternative for wastes (debris and soil) that do not require treatment, are not LLW and/or RCRA/TSCA hazardous, and meet the ORR Landfills' WAC.

All mercury-contaminated waste planned for disposal in CERCLA disposal facilities in BCV will comply with ARARs specified in decision documents for those facilities. In general, those ARARs provide protection of human health and the environment from multiple perspectives:

- Design of the landfill (e.g., liner and caps), along with assessment of the design (including defining WAC) and all appropriate approvals of that design to achieve protectiveness assurance.
- Treatment of the waste to assure containment within the landfill, most notably the LDRs.
- Protection of human health and the environment through release restrictions, (e.g., managed through treatment of landfill wastewater as necessary to meet discharge limits for Bear Creek).
- Containment assurances through proper closure, as well as post-closure maintenance.
- Institutional controls and monitoring during operation, closure, and post-closure. These processes help assure the containment of the waste and interception of exposure pathways. Ongoing monitoring (e.g., groundwater monitoring) to indicate any unexpected deviations early-on provides assurance that issues that may develop are dealt with in a timely manner.

Implementation of a future CERCLA disposal facility should include consideration of integrating treatment with disposal for mercury-contaminated debris through application of the RCRA Corrective Action Management Unit (CAMU) regulations found at Title 40, CFR Part 264.552. These regulations allow treatment (in this case macroencapsulation) of mercury-contaminated debris to be completed in-place within the disposal cell. In-cell macroencapsulation provides advantages in terms of safety and cost, and has the potential to minimize the disposal capacity utilized over methods that would complete macroencapsulation outside of the disposal unit. Treatment external to the disposal unit necessitates moving large waste forms from the treatment location to the disposal unit for final placement/disposal, introducing more risk (from a safety perspective as well as containment perspective). A study completed by UCOR (UCOR 2015) considered various options for treatment of mercury-contaminated debris, including in-cell macroencapsulation. The report points out significant benefits afforded by in-cell macroencapsulation both in terms of safety and cost.

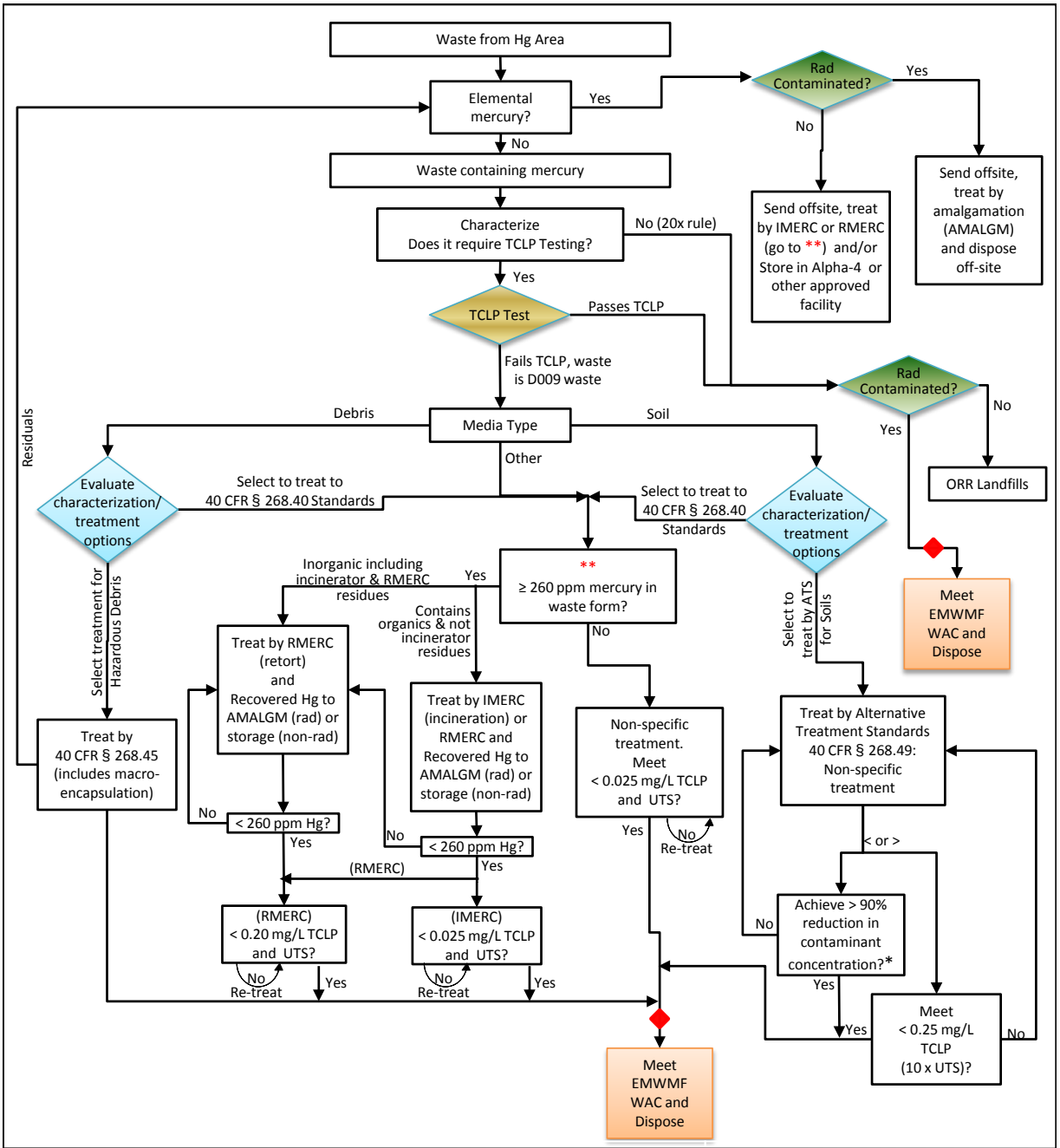
3.3.2.2 Offsite Disposal

Offsite disposal is available for mercury-contaminated LLW (mixed waste) or hazardous-only waste but is not the preferred method of disposal given the high cost and greater risk as compared with onsite disposal (DOE 2017c). Offsite disposal facilities that could potentially be used must meet CERCLA requirements under the offsite rule (Title 300, CFR Part 440). Such available facilities include the Nevada National Security Site and commercial facilities such as Energy Solutions (or Clean Harbors for hazardous waste) in Clive, Utah. Some commercial facilities can provide treatment as well as disposal for mixed wastes. However, the future volumes of debris and soils projected to be generated at Y-12 may be impractical to send offsite from a risk and cost perspective. Therefore, it is of value to investigate providing treatment onsite for mercury-contaminated waste to avoid the transportation involved with using these facilities. Unless onsite capabilities for treatment are provided and approved, commercial facilities are the only treatment option currently available.

3.3.2.3 Land Disposal Restrictions

Meeting LDRs for disposal of mercury-contaminated media poses a significant challenge when considering the large volumes, and thus high projected costs.

The onsite disposition path (EMWMF) for mercury-contaminated hazardous waste is subject to ARARs (e.g., LDRs) summarized in the appropriate decision documents. Meeting LDRs will be accomplished by applying appropriate treatment technologies as presented in the regulations (Title 40, CFR Part 268). A logic diagram summarizing the treatment options and standards that must be met, per LDRs, for wastes containing mercury is given in Figure 11. Additionally, it is assumed that, if present, other, underlying hazardous constituents (UHC) present at concentrations above their respective UTS limits are treated to meet LDRs as needed, prior to entering this flowchart, or are managed along with the mercury (e.g., lead and other characteristically hazardous metals would be stabilized along with mercury in macroencapsulation).



Acronyms
AMALGM=Amalgamation
ATS=Alternative Treatment Standards
EMWMF=Environmental Management Waste Management Facility
IMERC = Incineration
LDR=Land Disposal Restrictions
ppm=parts per million
RCRA=Resource Conservation and Recovery Act
RMERC=Retort
TCLP=Toxicity Characteristic Leaching Procedure
UTS=Universal Treatment Standards (in 40 CFR§268.48)
WAC=Waste Acceptance Criteria

◆ = Regulatory approval via Waste Handling Plan required to dispose of waste forms at EMWMF.

* See *Guidance on Demonstrating Compliance with the Land Disposal Restrictions (LDR) Alternative Soil Treatment Standards*, EPA530-R-02-003, July 2002.

NOTE: This flowsheet assumes disposal of waste in onsite facilities. Offsite disposal facilities are alternative disposal options, provided the facility's WAC are met.

Figure 11. Logic Diagram for Treatment of Mercury Waste

To the extent that waste characteristics are known at this time, several technologies to treat the wastes and meet LDRs for mercury exist; however, difficulties and uncertainties may emerge because of the large volumes of waste that could possibly require treatment, resulting in higher costs, and possible unknowns that have yet to be uncovered. The logic diagram includes "blue" decision diamonds where, for debris and soil, decisions must be made as to what treatment will be used and which standards met. For debris and soil, alternative treatments offer more flexibility and potential cost savings than the traditional treatments, retort (e.g., thermal treatment to vaporize mercury) and incineration.

Decisions regarding what treatment to use, whether to perform treatment onsite (requires construction of facilities, consideration of execution time frames, regulatory framework required) or offsite (vendor location, requires transportation considerations), and where to dispose of the waste must be made.

Decisions will require supporting evidence for their selection, including treatability studies showing appropriate treatment standards have been met, possible pilot demonstrations, and evaluations particularly of the costs involved for the various options. The completed soils treatability study addresses some of this information for mercury treatment of soil and UHCs (UCOR 2012b); a summary of the study is given in Section 3.4.4.1. A similar study was recently completed for debris that, while it did not include actual treatability studies, did examine the literature and lessons learned at other facilities that dealt with major D&D of mercury structures and remediation of media and presented some cost analyses for debris treatment alternatives (UCOR 2015).

The current, assumed disposition path for mercury-contaminated debris that meets the threshold for hazardous wastes and may or may not be radiologically contaminated is macroencapsulation (per Title 40, CFR Part 248.45) and disposal in the existing EMWMF. For a future CERCLA disposal facililty, the addition of ARARs (in the appropriate decision document[s]) designating the facility as a CAMU would allow for macroencapsulation to be completed integral with disposal within the disposal unit. As described in the debris study report (UCOR 2015) this in-cell macroencapsulation would provide additional cost savings over treatment provided prior to disposal under LDRs while also providing a safer alternative to "out-of-cell" treatment.

As characterization data become available, refinements to these studies may be made and actual demonstrations completed to serve as useful tools and provide valuable lessons learned for future building demolition and remediation.

WHPs will address the selected treatment path and ability to meet treatment standards and are required if waste is dispositioned onsite at EMWMF as noted by the red diamonds in the figure. Regulatory interaction and acceptability of the waste at EMWMF are provided through their review and approval of the WHPs. Once a decision is made regarding treatment paths for debris and soil, and fully evolved through demonstrations/scale-up etc., selected treatment paths must be integrated into the disposal facilities' future plans. These activities have not been completed yet, and until they are, the only option available once a mercury-contaminated waste has been generated is offsite commercial treatment. To be considered cost-effective, onsite treatment for

mixed waste soil, sediment, and debris is likely to be dependent upon generating a moderate to large quantity of mixed waste at a sustained level over an extended period of time (five or more years). Provisions for onsite treatment of *intermittent and/or low quantities* of mixed waste soil and sediment may not be cost-effective.

Making decisions will require consideration of the data along with appropriate studies to weigh and determine the best value to the government and tax payers, so as to propose the most suitable endstate that will meet regulatory requirements and disposal facility WAC. This whole process – characterization, treatability studies/demonstrations, engineering/alternative studies, and regulatory involvement in the decision process – to ultimately determine the endstates for the waste streams (debris and soils) will require coordination and interfacing of many parties. Documentation of these key steps and FFA tri-party concurrence are part of the regulatory process, which is described in Section 3.6.

Such studies/efforts have been initiated under a near-term project looking at treatment of soils, discussed in Section 3.4.1, and documented in *Treatment Study Report for Y-12 Site Mercury Contaminated Soil, Oak Ridge* (UCOR 2012b). Long-term storage or hold-up of these waste streams has not been considered an option throughout this planning process; therefore, strategies for managing the waste should be in place prior to executing the mercury-use building demolitions, which will begin the generation of these waste streams. While waste endstates were briefly described in Table 4, more detail on those endstates, possible issues, and strategy approaches are given in Table 5.

3.4 STRATEGY IMPLEMENTATION

Initial submittal of this strategy document (in 2014) presented several high level activities to pursue in the near-term, most of which were subsequently initiated under a new OREM Mercury Technology Development program. Below is a summary of those efforts as well as the strategy going forward for those activities in Section 3.4.1. Future strategies for D&D efforts are given in Section 3.4.2 and strategies for soils remediation are summarized in Section 3.4.3.

3.4.1 Control of Mercury Releases to EFPC

The most pressing issue regarding mercury remediation centers around the pathway mercury travels to human receptors, that is, through fish consumption. Mercury, in its most toxic form, methylmercury, bioaccumulates in fish and in turn may be ingested by humans. It is unclear exactly what mercury form(s) contributes to methylmercury in EFPC – whether it is dissolved (filter-passing) mercury in water, various mercury forms attached to particles suspended in water, forms of mercury in the sediment matrix, or all of the above.

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Table 5. Endstates for Mercury-Contaminated Waste

Waste	Current Defined Endstate	Endstate Achievable?	Strategy*
Building D&D Waste			
LM and Waste	Mercury-contaminated LM has been treated and disposed of offsite through commercial facilities.	Endstate disposal in approved offsite waste disposal facilities has been demonstrated.	Continue with removal and disposal as demonstrated. LM remains in Alpha-2, Alpha-4, and portions of Beta-4. As funding is available, some LM removal may be completed prior to pre-demolition scope.
Process Equipment and Piping	Requires venting, purging, draining (VPD) and/or recovery of source material. Source material managed as per LM above, or as elemental mercury per below. Equipment remaining as mercury-contaminated may be managed as per debris below.	Large-scale equipment demolition/disposal has not yet been demonstrated for mercury-use facilities, but has been demonstrated for other facilities on the Reservation. VPD of mercury-use equipment has been performed successfully in past.	VPD and decontamination of equipment and piping as needed to meet onsite disposal facility WAC. As possible, complete equipment removal and disposition activities for all facilities consecutively to reduce costs.
Deactivation Waste (e.g., asbestos-containing material, universal waste, beryllium waste)	If deactivation wastes meet EPA Title 40, CFR Part 268, definition of debris, may be managed per debris entry below. If not, must be treated offsite.	See debris below or LM above.	Continue with removal and disposal as demonstrated. As possible, consider completing pre-demolition waste removal and disposition activities for all facilities consecutively to reduce costs. See debris strategy below.
Debris and Rubble	Debris must meet LDRs for disposal at EMWMF. See logic diagram (Figure 11). Current baseline plan is to macroencapsulate mercury-contaminated debris at EMWMF.	Current defined endstate is macroencapsulation and disposal at EMWMF. Needs regulatory approval. Needs coordination with EMWMF.	Need to define volumes better and demonstrate production quantities achievable at EMWMF. May require demonstration/documentation to show macroencapsulation/ stabilization meets performance standards. Forecast of waste volumes destined for EMWMF needs to be clarified for planning purposes (e.g., macro-encapsulation of debris at EMWMF requires preplanning regarding placement in cell). May be desirable to develop a debris feasibility study.
Liquid (Elemental Mercury)	Treated to produce solid stable form (e.g., amalgamation or stabilization with sulfur polymer solidification/stabilization [SPSS]). Elemental Hg is sent to commercial facilities for treatment by amalgamation and offsite disposal.	Amalgamation is proven technology, but requires offsite treatment and disposal. Stabilization using SPSS technology achieved and variance granted to Brookhaven National Lab (EPA 1998) for use on elemental mercury.	Offsite amalgamation is proven and acceptable. Elemental mercury volumes are not expected to be large enough to make onsite treatment and disposal economically necessary or feasible.
Building Slab (Interim endstate following building demolition and prior to remediation)			
Building Slab Interim State	The state that building slab is left in, the interim state between building demolition being completed and subsequent soils/subsurface structure remediation, must be defined. Questions to address: Fill the basement/wind tunnels with clean fill dirt? Cover the slab? Control stormwater infiltration into the wind tunnels? When to characterize remaining soil and subsurface structure?	There are no technology issues with achieving an endstate for the slab; however, the selected endstate may create additional waste depending on the approach. Are slabs to be used as laydown areas for subsequent work? Approach needs to be integrated with demolition and with subsequent soil/subsurface remediation.	The building slab intermediate state determination is a difficult question, and needs to be defined early in the process since the decision will affect so many aspects of both demolition and remediation, and can have a significant consequence to future work scope. The building sumps should be maintained and ability to treat in-leakage/groundwater in wind tunnels continued by appropriate treatment facilities. State of the slab should be defined in demolition "design," and documented in appropriate CERCLA documentation. Thought should be given and documented as to how to proceed with subsurface/surrounding soil characterization and remediation.
Soils, Sediments, Subsurface Structures			
Excavated Soil and Sediment Waste	Soil must meet LDRs for disposal at EMWMF. See logic diagram (Figure 11). Current baseline assumption is to treat an assumed portion of soil by low temperature thermal desorption. Needs further exploration as this is a very costly alternative.	Treatment per LDRs for soils is achievable; however, quantities of soil and sediment that require treatment may be excessive and expensive. Typical treatment is retort. Microencapsulation via SPSS has been demonstrated. Other stabilization treatment options exist as well.	Explore options (characterization to allow segregation) to minimize quantities requiring treatment. SPSS has been successfully demonstrated with Y-12 soils. Soils Feasibility Study explores options for onsite versus offsite treatment and disposition.
Excavated Subsurface Structure Waste	Same as building debris above.	See debris above.	See debris above.
In-situ Treated Soils and Sediments	*In situ* stabilization to prevent migration of mercury and other contaminants in surface or groundwater. Not currently defined as an endstate for any areas. Needs to be explored. May be very cost effective. If *in situ* treatment is used, performance monitoring/endstates must be defined.	Needs to be demonstrated in small and large-scale within the Y-12 site, preferably where performance can be effectively monitored and any unintended consequences mitigated, e.g., Alpha-2 basement or 81-10 Area. Approach and endstates would require regulatory approval.	Identify best available treatment technology through Technology Development component of strategy and conduct demonstration/pilot at Alpha-2 (See previous technology assessment for this area, BJC 1999b) or elsewhere. This technology has been successful in other locations, for other contaminants. Does present the possibility of significant cost savings.

*Regulatory concurrence is required at the various stages of these activities from characterization through assessment, decision, design, implementation, and final closeout, and is documented and submitted in appropriate plans and reports.

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Many environmental/water-specific attributes, both chemical and biological, also play a role in methylmercury production: pH, suspended solids, dissolved organic matter, flow rate, anionic content, sediment-related biological attributes/interactions, etc. Once produced, methylmercury is taken up by organisms lower on the food chains (e.g., bacteria, algae, benthic invertebrates) and then magnified at each step in the food chain leading to fish and other higher organisms. Direct uptake of either inorganic mercury or methylmercury by fish is much less important than uptake via food. It is obvious that there is no silver bullet to reduce fish mercury concentrations for every water body, and likely, none for a single water body. With that in mind, an adaptive management approach is proposed, and remediation of EFPC begins with targeting a lower mercury concentration in UEFPC (to be initiated through construction of the OF200 MTF) and continuing through research into mercury-environment interactions, followed by subsequent actions as needed and elucidated through these studies.

3.4.1.1 Outfall 200 Mercury Treatment Facility

In 2012, an ARRA-funded project provided conceptual design of the OF200 MTF. Since that time, a ROD Amendment was approved adding the facility as a CERCLA interim action. Final design is complete, and construction is scheduled to start by the end of CY 2017. The MTF treatment parameters include: 40,000 gpm stormwater capture rate, 3,000 gpm treatment capacity and 2 million gallons of stormwater storage. Storm flow in excess of 40,000 gpm will by-pass the facility. Reduction of mercury concentration in the effluent will be achieved by this facility, and will provide significant progress toward achieving the Phase I ROD RAO, “to restore surface water to human health recreational risk-based values at Station 17.” Achieving the recreational AWQC of 51 ppt mercury in-stream (at Station 17) may have to be attained through a series of steps under the adaptive management approach as discussed below. The approach includes possible actions aimed at reducing mercury concentrations in fish as well as in water.

Design

Conceptual design of the OF200 MTF included an alternatives analysis to explore various treatment options for removal of mercury from water (e.g.,reverse osmosis, chemical precipitation, granular activated carbon [GAC], ion exchange, and various combinations thereof). Grit removal and chemical precipitation/flocculation followed by filtration was selected on the basis of implementability, cost, and performance. In terms of performance, bench-scale testing using the selected process has demonstrated the ability to attain less than 51 ppt mercury in the effluent, but this efficiency has not been proven at full-scale. Based on modeling using historical data from a year with greater than normal rainfall (2003), it is estimated that the treatment system might remove 65 percent of the total mercury flux, and treat 69 percent of an average annual flow through Outfall 200.

In addition, the effluent discharge from the facility is currently designed (and will be confirmed in final design) to be reintroduced to UEFPC approximately 3,000 ft downstream of the outfall, thus bypassing a good portion of the creek bed that contains mercury-contaminated sediment that might otherwise be resuspended by the plant discharge.

Adaptive Management Approach for OF200 MTF

Treating WEMA base flow and stormwater is a challenging prospect due to the wide variation in flows (as little as hundreds of gpm during dry weather and in excess of 100,000 gpm during heavy storm events) and the extremely low mercury concentration target . Predicting operation of a full-scale system is difficult, so it is recognized that, while bench-scale studies have demonstrated successfule mercury removal under a variety of conditions to below 51 ppt, mercury removal performance has not yet been demonstrated at the full-scale under various operating conditions. In the adaptive management approach, system performance will be monitored for the first two years of operation to evaluate the full scale MTF performance against the ROD Amendment goal of 51 ppt. Monitoring will ensure that a sufficient data set is collected to support future decisions. At the end of the two-year monitoring period, an adaptive management decision will be made after evaluating MTF performance, the potential need for an additional polishing step, and other potential remedial/mitigative actions (as discussed in the next section) to support a tri-party decision regarding a path forward. An additional polishing step could include GAC, membrane (ultra-filtration), or other technology (e.g., air stripping) , including, as necessary, any pilot studies to support evaluation of the polishing technology. DOE's current cleanup baseline (in terms of proposed projects with estimated costs) accounts only for treatment facility construction and operation i.e., without addition of a polishing step. Should additional actions need to be implemented per tri-party agreement following the evaluation, source demolition and/or remediation delays due to limited budgets may result.

The CD-1 submittal documented the Conceptual Design Report, per DOE requirements (CH2MHill, 2013). Completed CERCLA documents include the Remedial Design Work Plan (RDWP) (DOE 2014), the Focused Feasibility Study/Proposed Plan, and Amendment to the UEFPC Phase I ROD (DOE 2016). The Remedial Design Report and RAWP were submitted as an FFA Appendix E milestone September 12, 2017. The Final Design Report (UCOR 2017) was approved July 2017. A CD-2/3 approval under DOE O 413.3B for the project baseline and construction start is planned for summer 2018. The construction and startup of the MTF will be executed as a capital project in accordance with DOE O 413.3B, ending with submittal and approval of CD-4. A final PCCR will document completion of the system construction under CERCLA.

3.4.1.2 Additional Interim Actions to Control Mercury Releases to East Fork Poplar Creek

It is recognized that the final in-stream goal for EFPC is the recreational AWQC, 51 ppt mercury. The adaptive management approach presented in this document will work toward achieving that goal. As discussed above, the OF200 MTF construction/operation constitutes a major action toward obtaining that goal; however, additional interim actions may be necessary to achieve 51 ppt mercury in-stream. Several further investigations proposed in the original strategy were aimed at reducing mercury concentrations in fish, as opposed to focusing on lowering the water mercury concentrations.

Fish mercury levels are a concern in both Upper and Lower EFPC, and field/laboratory studies addressing greater understanding of fish-mercury relationships, methylation, and mercury source contributions, as well as evaluations of potential beneficial interventions, are ongoing under

OREM's technology development work . The goal of these studies is to provide viable alternatives that will contribute to goals of reducing mercury levels in fish, mercury flux, and/or mercury water concentrations. A tri-party decision point is planned to evaluate results from these studies as well as system performance of the OF200 MTF, so as to reach agreement on any additional actions that might be necessary in attaining these goals. Figure 12 is an illustration of the adaptive management approach to completing the OF200 MTF activities, the ongoing EFPC field studies, and other relevant actions that will contribute to a final CERCLA Alternatives Evaluation to define future actions.

Soil and Groundwater Source Control

Legacy mercury contamination in creek banks, floodplain soils, and stream sediments accounts for the majority of the annual export of mercury to the EFPC watershed (Watson et al. 2016). As legacy mercury leaches or erodes from bank soils, it contributes to concentrations in the water column and sediments and provides a source for in-stream production of methylmercury. Recent studies that coupled measurements of bank erosion with soil mercury concentrations pointed to the importance of high-mercury historical release deposits in the upper section of LEFPC. In addition, groundwater can contribute to mercury leaching caused by infiltration through contaminated soils and subsequent discharge by groundwater into LEFPC. Early studies have found that methylmercury production in groundwater can be significant, especially during the summer.

A review of historical and recently-collected LEFPC bank soil and groundwater data, coupled with a literature review of potential remedial technologies that might be applicable in EFPC, was was completed in 2015. The pros and cons of various remedial approaches, as well as the research and TD needs, were identified. For example, stabilization of bank soils in EFPC might be achieved through the use of plants, trees, rocks, and/or man-made materials (liners – possibly impregnated with chemicals targeting mercury binding) and by slowing/redirecting flow. South River work in Virginia provides some good examples of bank stabilization methods used to reduce mercury flux. The use of sorbents to bind mercury, perhaps in conjunction with bank stabilization and engineering options, is a major area of investigation as part of the OREM TD program. Ongoing LEFPC studies will provide a better understanding of the primary soil areas where remediation may be the most effective. Results would be used to provide input to the CERCLA Alternatives Evaluation.

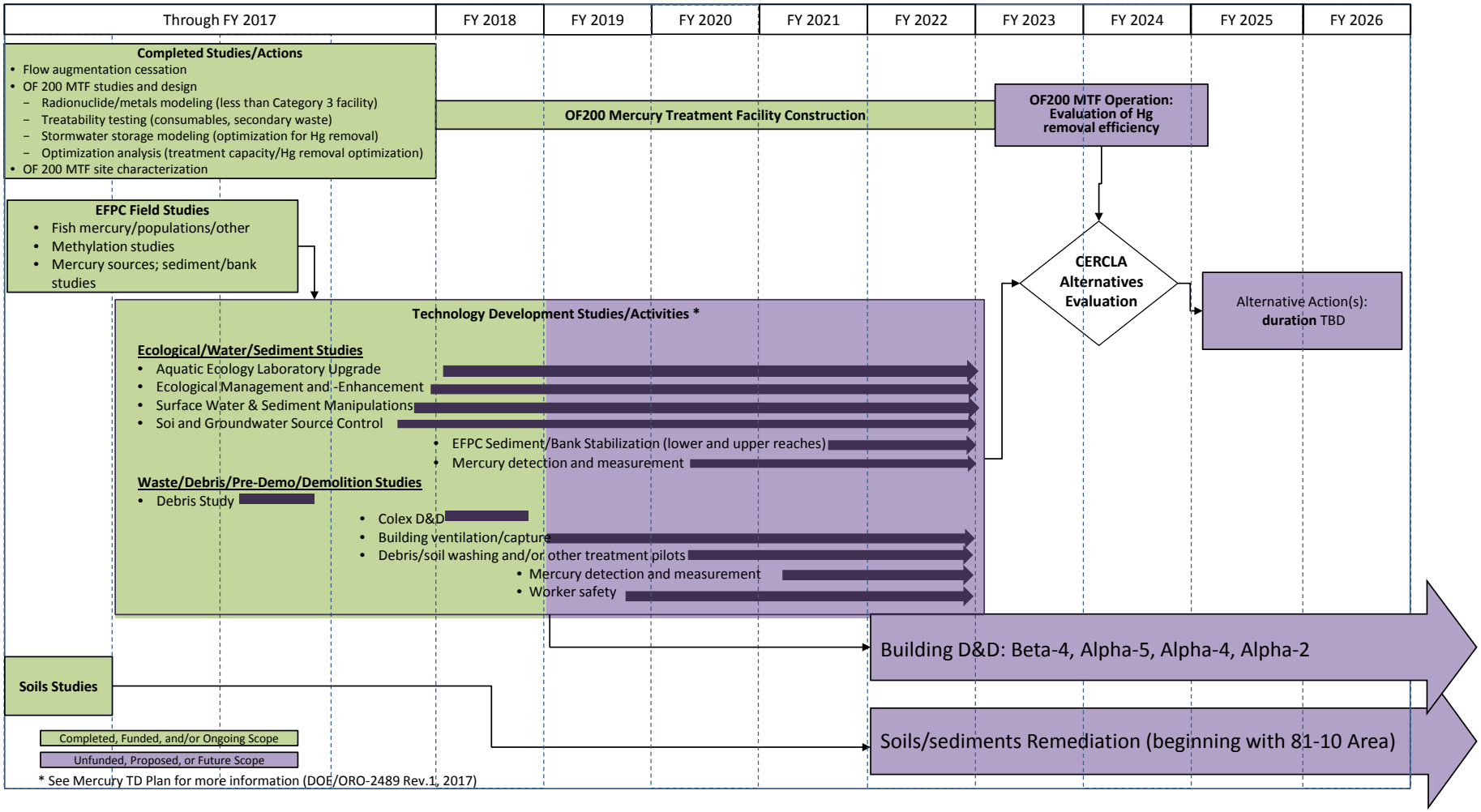

Figure 12. Ongoing Actions and Studies to Achieve Reductions in Fish and Water Mercury Concentrations and Mercury Flux in EFPC

Surface Water and Sediment Manipulation

Water chemistry can affect the speciation, transformation, and transport of mercury and methylmercury, but there remain significant knowledge gaps, particularly in freshwater stream systems. These knowledge gaps limit the ability to make informed remediation decisions for EFPC. As part of the OREM TD program, flow and water chemistry guages were established in EFPC providing, for the first time, a watershed understanding of instream chemistry that can affect mercury flux and methylation. Investigations (1) examined the role of chemicals present in UEFPC water due to ongoing plant operations on the flux and forms of mercury present and mercury methylation processes, (2) estimated mercury flux at several locations along EFPC, and (3) characterized streambed sediments along the length of EFPC. These efforts are ongoing and will provide a solid knowledge base upon which the effects of in-stream manipulations can be evaluated.

Amendment of EFPC surface water chemistry may provide an opportunity to reduce the bioavailability of mercury/methylmercury, thus reducing those levels in fish tissue and lowering human health risks posed by consumption of fish. Some relevant work with tracers in various surface waters has recently been completed by scientists at ORNL, with promising results that suggest differences in water chemistry can affect the behavior of both inorganic and methylmercury in water, which in turn affects the bioavailability and bioaccumulation of mercury. Further studies have pointed to the importance of periphyton on mercury methylation, and the role of bioturbation (which increases at night). Research is being done to examine the potential for sorbent use to reduce mercury flux and methylation from sediments, as well as the use of alternative treatment chemicals at Y-12 that might decrease mercury flux. Results will provide input to the CERCLA Alternatives Evaluation.

Ecological Management and Enhancement

Mercury (especially in its organic form, methylmercury) biomagnifies, or becomes increasingly concentrated as it is transferred through aquatic food chains, leading to elevated concentrations of this toxin in fish. Because the primary exposure route for mercury in humans and other wildlife is through the consumption of contaminated fish, national guidelines for the protection of human and ecological health include a fish tissue concentration (0.3 ppm methylmercury in fish fillet), which is considered to be a more consistent indicator of exposure and risk than aqueous guidelines. Because of this, remediation actions and research efforts for the surface water environment may include mitigating mercury bioaccumulation in EFPC fish.

Ecological management and enhancement approaches, including modifications of fish and plant communities and water quality, have been successfully used to decrease human health risks and enhance natural resources. This approach is particularly attractive in downstream water bodies where contaminated sediment or soil is difficult or costly to remediate by conventional means. This could be achieved, for example, through the addition or removal of key species that can change mercury transfer in the food chain (e.g., introduction of less bioaccumulating fish, mussel addition to change mercury surface water flux), or through the manipulation of physical factors (e.g., nutrients, light) that may favor less mercury transformation. There is precedent on the ORR

for the proposed mitigation strategy as ecological manipulations have been implemented previously to mitigate contaminant bioaccumulation, obtaining positive results at a fraction of the cost of traditional remediation methods (e.g., Peterson et al. 2015).

Recent studies have quantified methylmercury concentrations in a variety of invertebrate and fish species in EFPC, and demonstrate that methylmercury is a lower percentage of total mercury near Y-12. Thus fish in upper EFPC have less of the more toxic methyl mercury form in their tissues. Modeling is being conducted using the recent data to simulate how changes in the food chain may impact mercury uptake and risk. Investigations have also determined that periphyton (algae on rocks) is an important bioaccumulation step in the transfer of mercury in the food chain. This may lead to solutions that involved changing nutrient loading or light to impact algae.

Aquatic Ecology Laboratory Upgrade

Facility investments are needed to support controlled testing of new technologies and remedial strategies that will address mercury contamination in LEFPC. This approach advances the scale of testing beyond field studies and bench scale, allowing for greater certainty that a technology may be successful upon stream deployment. A Field Research Station (FRS) was initially proposed to be located near the Horizon Center site and adjacent to LEFPC to address this TD need. The FRS would have served as a near-stream research facility for mercury research, and design would have allowed LEFPC water to be brought into the facility for flow-through rapid testing and/or water chemistry manipulation and study. However, concerns about where to site the facility resulted in the FRS concept being replaced with an upgrade to the existing ORNL Environmental Sciences Division's Aquatic Ecology Laboratory. The proposed upgrade could provide many of the features and conveniences of the FRS. The basic premise is that EFPC water will be brought to an outside storage tank where the EFPC water will be run into test vessels or systems, then treated by the ORNL Process Water Treatment Complex prior to discharge. Study plans include soil and sediment column tests of various sorbents or chemical manipulations, and modifying water chemisty or ecology in stream mesososms and fish tanks to evaluate changes in mercury concentrations or uptake.

Evaluation of UEFPC

Previous studies have pointed to the importance of the Y-12 facility and UEFPC relative to mercury flux (Peterson 2011, Watson 2016). The 2011 conceptual model for Y-12 and UEFPC identified Outfall 200 as the major conduit of mercury into the creek, highlighting the importance and prioritization of the OF200 MTF construction. Other investigations led to another storm drain cleanout in WEMA and ending flow augmentation. These actions have had measurable impacts on downstream mercury concentrations and transformations. Other studies have found high mercury deposits in some sediments in UEFPC that could be targeted in the future. The role of potential mercury sources downstream of Outfall 200 is not well understood. Further, this section of stream could change dramatically once the OF200 MTF becomes operational. There remains a need to better understand the UEFPC system and update the conceptual model to include recent changes in flux and chemistry thereby helping predict changes that may occur after OF200 MTF is operational.

Reclassification of UEFPC

Reclassification of UEFPC, from Outfall 200 to Station 17, would involve removing recreational and possibly other use classifications of this stretch of the creek. Effects of reclassification would be analyzed to help inform a decision by the state and EPA regarding reclassification. The advantages of reclassification could be significant. UEFPC flow is comprised of industrial discharges, groundwater discharges, runoff from precipitation, and flow augmentation. Cessation of flow augmentation has likely affected the habitat in this area of the creek, and might further support reclassification. Additionally, operation of the OF 200 MTFOF200 MTF, with its effluent currently planned to by-pass approximately 3,000 linear ft portion of the creek, may also have a significant effect.

3.4.2 Building Deactivation and Demolition

At the Y-12 site, building D&D encompasses the demolition of numerous facilities that have been grouped into multiple distinct projects. Based on the facilities' historical uses, four of those projects are considered to be part of the mercury strategy (see Appendix B):

- Building 9201-4 (Alpha-4) Complex D&D
- Building 9201-5 (Alpha-5) Complex D&D
- Building 9204-4 (Beta-4) Complex D&D
- Building 9201-2 (Alpha-2) Complex D&D

The strategic schedule (Figure 10) includes executing these four D&D projects. Components of building D&D include development of regulatory and DOE documentation and approvals, as noted in the schedule, as well as the activities described in the following three (3) subsections.

3.4.2.1 Legacy Material Removal and Characterization

Legacy material characterization and legacy material removal/disposition (LMR*)* is the first step in preparation for demolition. LM encompasses any material, waste, or equipment contained within the excess facility that is physically easy to remove (e.g., is not large or fastened to flooring, walls, ceiling, etc., such that it would require tools to remove). LM requires characterization to determine the disposition pathway and development of a WHP should waste be sent to the onsite disposal facility, EMWMF, along with accompanying closeout reports as noted. To date, a significant amount of LM has been successfully disposed (see Figure 10, extensive LMR for Alpha-5 was completed; likewise Beta-4, second floor LMR has been completed, and first floor/basement LMR is ongoing by NNSA). Note that waste not destined for EMWMF is generally documented in waste management plans prior to disposal and summarized in closeout reports (e.g., PCCR).

Building characterization is completed once all LM has been removed, thus leaving a facility accessible for characterization of walls, floors, remaining process equipment (e.g., piping, large items), roof, etc. Alpha-5 has been characterized with the exception of the basement/wind tunnels (DOE 2012a). The process of characterizing Alpha-5 (including development and approvals of data quality objectives [DQOs], SAP, and Technical Memorandum [TM]) provides

a sound basis for other facility (Alpha-4, Alpha-2, and Beta-4) planning and characterization, and the results are believed to be bounding since Alpha-5 historically suffered the most mercury-loss incidents. Characterization showed distinct hot spots within the facility that can guide limited segregation of higher-concentration debris prior to demolition. Additionally, concrete sampling demonstrated that mercury does not penetrate past the top 1-2 inches, which suggests that scabbling or other separation/extraction techniques, if used, can provide a benefit by decreasing volumes of debris requiring treatment. A gap analysis was prepared for characterization of the remaining mercury-use facilities to aid in focusing future characterization efforts and avoid unnecessary sampling (ORISE 2013). A WHP(s) for the building(s) is then developed and must be approved by regulators prior to demolition. The RmAWP for building demolition at Y-12 has been completed and approved (EDI 2010c).

In order to commence with building demolition, which is capital work scope, CD-2/3 *Approve Project Baseline* and *Approve Start of Construction*, documentation must be developed and approved per DOE O 413.3B. A reasonably sound engineering approach to demolition and waste management should be defined to develop a defensible baseline and request funding approval. Typically, development and approval of CD-2 information could take six months to a year for the large-scale demolition projects proposed. In addition, funding requests for capital work are made two years in advance, thus a large lead time (minimum two years) for CD-2/3 preparations are noted. The strategic schedule (Figure 10) shows CD-2 initiating well before demolition.

3.4.2.2 Pre-Demolition

Pre-demolition work – or deactivation – consists of venting, purging, and draining equipment; deactivation of utilities; hazard abatement (removal/disposition of asbestos-containing material, universal waste, etc.); surface stabilization of contaminants (mercury in walls may require stabilization or passive extraction[7] prior to demolition, beryllium is stabilized with a fixative prior to invasive work, and radioactive contamination is sometimes managed with a fixative spray); and removal/disposal of some process equipment. Deactivation requires entrance to the building, which can pose problems when a building is allowed to deteriorate. A single WHP is typically completed and approved for pre-demolition and demolition waste.

Removal of COLEX equipment from the west end of Alpha-4 is ongoing. This effort is being performed under the Excess Facilities initiative and has proven valuable in demonstrating the extensive work involved in pre-demolition of equipment that contained mercury. Venting, purging, and cleaning piping has taken efforts well in excess of those anticipated, due to extensive holdup in piping (piping materials, generally carbon steel, have corroded over time).

Protection of workers from mercury vapors (personal protective equipment, testing, ventilation, monitoring), preparation of the site (e.g., protection of ground surface with impeneratrable coatings and access to equipment via platforms, preparations for heavy equipment, working in the limited area of Y-12, engineering controls), preparations for waste (packaging, handling), and

[7] Passive extraction could include use of sprayable coatings that extract mercury into the coating (e.g., InnoSense 2016) which is then stripped from the wall or floor, as well as long-term active ventilation, possibly at elevated temperature, and capture of mercury vapor in chilled condensers or activated carbon canisters. The latter approach has potential given long lead time before demolition begins.

utility isolations/avoidance are all significant, labor intensive, and time-consuming activities that must be planned, documented, and performed. The PCCR resulting from the COLEX D&D work will contain extensive information on lessons learned. This work is a step toward future, much larger scale mercury remediation, and it provides a good basis from which to plan work and estimate future costs and schedules and needs for future emphasis and technology development. Building Demolition

Building demolition, waste treatment/disposal, and project closeout will be accomplished as a capital project. As a capital project, building demolition must be preceded by development and approval of CD-2/3 baseline submittals as introduced above in Section 3.4.4.1. CD-3 approval, *Start of Construction*, will signal the start of demolition. Regulatory involvement will proceed through the WHPs. Building demolition includes activities such as:

- Mobilization/demobilization
- Worker and environmental safety, monitoring, and protection equipment and plans
- Preparation of facilities to allow for worker and equipment access
- Removal/disposition of hot spots (segregation of waste) [alternatively this may be completed under pre-demolition]
- Waste segregation and packaging preparations and equipment
- Beryllium containment throughout D&D, packaging, and disposal considerations
- Removal/disposition of non-friable asbestos (e.g., transite siding)
- Removal/disposition of interior process equipment and structures
- Preparations for decontamination, dust suppression, and stormwater runoff and containment
- Preparations and protection of surrounding environmental media during building demolition (e.g., protection of soils from releases of mercury during building demolition)
- Capture/storage and treatment of contaminated contact water (e.g., decontamination fluids, stormwater contacting waste/debris that becomes contaminated, etc.)
- Demolition of exterior structures and disposition of resulting debris
- Decontamination/stabilization of remaining building slabs

Opportunities exist to reduce the cost and/or risk presented by building demolition. Careful planning and execution to minimize the generation of mercury-contaminated waste through selective treatment/hot spot removal and/or concrete scabbling and the application of fixatives (e.g., for mercury vapor control during demolition) will be completed. Management/treatment of stormwater, mercury-contaminated decontamination water, and dust suppression water during demolition activities may be required, and could be provided by the OF200 MTF and/or other systems. Suppression of the groundwater table during demolition may need to be considered. As with the COLEX pre-demolition work discussed above, demolition of these facilities will be long, complex, and labor-intensive. Complications due to other contaminants (e.g., beryllium, PCBs, etc.) must be considered. For example, while the treatment and disposal of mercury-contaminated COLEX debris at offsite facilities has been achievable because PCB levels have been below 50 ppm, if PCB levels above 50 ppm were to be encountered, current offsite disposal facilities would no longer be an option. In this case, it is even more imperative that onsite

disposal capacity be available since the existing and proposed CERCLA disposal facilities are (will be) RCRA and TSCA mixed waste compliant.

The original Strategy Plan recommended a debris study be completed; this was completed by in 2015 to aid in decision making regarding future D&D.

As discussed in Section 3.3, endstate definitions for waste and the remaining building slab will require significant preplanning and approvals. Removal of the buildings will give access to the subsurface structures and soils beneath the buildings.

3.4.3 Soil, Sediment, Subsurface Structure Remediation

Soils under buildings are presently not well characterized. While some data exist (Rothschild et al. 1983, BJC 1999b; Watson et al. 2014), depth and areal extent of mercury contamination under and around buildings (basements) remains largely unknown, and may be altered by demolition work. Conjecture based on masses of mercury lost to the environment (see Section 2.1), and specifically to the ground, lead to the belief that contaminated soil volumes may be excessive. A technology development project to look at soil concentrations in the WEMA area via mercury vapor analysis was completed (Watson, et al. 2014). The analysis indicated soil vapor analysis is useful in rapidly and inexpensively identifying specific areas contaminated with Hg(0) within much larger areas, and as expected, hot spots exist in soils in WEMA, with indications in limited areas above 1,000 ppm. In conjunction with the effort to show the usefulness of soil vapor analysis, work was completed to help understand the speciation and makeup of mercury soil beads (Miller et al. 2013), which should be useful in developing treatment methods for mercury-contaminated soils both *in situ* and *ex situ*.

Ultimately, ongoing/current releases of mercury to UEFPC are mainly sourced in soil, sediments, and subsurface structures although all mercury in these media is not necessarily subject to mass transport to UEFPC under current conditions. Identification of mercury sources that are currently within transport pathways has been, and continues to be, a priority activity to achieve near-term reductions in releases.

Upon characterization, soil that exceeds the risk-based levels outlined in the Phase II ROD must be managed as waste. Only two generic options beyond capture and treatment of contaminated water contained in soil/sediment are available to deal with these sources: removal or isolation (including *in situ* stabilization).

The treatment and disposal options for excavated mercury-contaminated soils are fully discussed in the *Treatment Study Report for Y-12 Site Mercury Contaminated Soil, Oak Ridge* (UCOR 2012b), as summarized in the subsection below. Those options include onsite treatment with SPSS and onsite disposal at EMWMF as well as other commercial treatment options with onsite and offsite disposal options. Isolation technologies may offer comparable environmental protection and at lower cost; however, they are not technologically mature and require further research and development before application can be considered (See Section 3.4.3.2). The current planned treatment for soil is defined (in the Phase II ROD and assumed in the CD-1 baseline) as removal up to 2 ft depth for EU 2 through EU 14 (includes WEMA) and 10 ft depth

for EUs 1a and 1b to meet land use and groundwater protection criteria. Additionally, remediation of soil surrounding and beneath each mercury-use facility is sequenced to immediately follow demolition of that building.

If excavation is undertaken, care should be taken to avoid contact and accumulation of stormwater with excavated areas (e.g., filling in areas as soon as possible). Seepage of groundwater and any collected stormwater in excavated areas would require sampling for mercury contamination and management of the water as necessary depending on results.

Some storm sewer (WEMA) sediments have already been removed (in 2011) using ARRA funding. Mercury contaminated sediments in UEFPC will need to be removed or contained at some point as per the ROD. Although the current strategy is to conduct creek sediment remediation after all upstream remediation is complete, in order to avoid the possibility of re-contaminating cleaned creek beds, ongoing assessments may require that actions be taken earlier. For example, future containment of Outfall 200 flow at the headworks of the OF200 MTF and subsequent piping along the creek bed to the MTF plant downstream may provide access to sediment for containment and/or treatment demonstrations, pilot studies, and/or remediation. Again, isolation or *in situ* technologies such as creek bed hydraulic barriers offer cost and remedial effectiveness but require a significant amount of development before their feasibility is proven (see Section 3.4.3.2).

As with demolition, soil and sediment remedial actions will require the same regulatory interactions and approvals in the treatment decision making process, development of WHPs, and "design" parameters to be documented through attachment submittals to the UEFPC Soils RAWP (EDI 2010a).

3.4.3.1 Soils Treatability Study

Briefly summarized, this study (UCOR 2012b) provided Y-12 soils to three vendors to perform mercury treatability studies of their stabilization technologies. All three successfully demonstrated their stabilization methods by achieving <0.2 mg/L TCLP mercury for the treated waste forms, thus indicating the ability to meet LDRs for mercury. All vendors indicated that underlying hazardous constituents could be addressed, but some, organics in particular, would likely require supplemental treatment.

Soils samples contained mercury contamination; however, to ensure a representative and bounding test, the soils were further inoculated with elemental mercury up to 2,000 mg/kg and second samples to 10,000 mg/kg prior to delivery and testing by vendors. A fourth vendor had previously demonstrated stabilization of mercury-contaminated waste, but entered the study at a later date and, therefore, did not participate; however, the recommendation was made to further investigate that vendor's treatment.

While LDR attainment was proven by the tests, the study did recommend further assessment of the long-term stability of treated waste forms under representative disposal conditions. An assessment was made of possible treatment and disposal scenarios as well.

3.4.3.2 *In Situ* Treatment Options

In situ treatment of mercury-contaminated soils/sediments or substructures may be determined to be an option in some cases. If *in situ* treatment is applied, the treated media is not subject to LDRs under EPA's Area of Contamination Policy (EPA 1989) provided it is managed within the defined Area of Contamination and as long as the waste is not placed in containers, tanks or non-land based units. Variance requests to regulators addressing waste form endstates need to be investigated/applied for depending on results of these efforts.

Treatment of subsurface elemental mercury, beyond excavation with *ex situ* treatment and disposal, is an emerging science. *In situ* immobilization and *in situ* extraction using heat or chemicals represent two lines of research and development in this field and are practiced by very few vendors (BJC 1999b; Cabrejo 2010; He et al. 2015). Thermal desorption coupled with vacuum extraction was identified as likely to be effective for basement soils in Building 9201-2 (Cabrejo 2010). As shown by Svensson et al. (2006), materials such as elemental sulfur, FeS and FeS_2 can be reacted under certain geochemical conditions with elemental mercury to produce highly insoluble HgS. For an *in situ* application of any of these methods some technical challenges exist, especially the means to deliver and mix the reactants in the subsurface.

Recent nanotechnology research with iron sulfide nanoparticles (e.g., Bower et al. 2008; Gong et al. 2012) has shown promise in overcoming the deployment challenge. As well, scientists at Savannah River National Laboratory have identified a method of targeting mercury for sequestration in contaminated soil zones by use of sulfur-vapor heated gas (SRNL 2012). Innovative technical approaches for *in situ* soil mercury stabilization (SRNL 2012; Kalb and Milian 2008), or *in situ* vapor extraction followed by *in situ* stabilization (Jackson et al. 2016), have been developed at DOE National Laboratories. At one Swedish site (Hg-cell chloralkali plant), enhanced *in situ* thermal recovery of mercury from soil at relative low temperatures (50° C) was tested and showed promise as a means of recovering at least the more volatile forms of mercury (Torin et al. 2016). The low temperatures employed in this study would likely only be effective in removing elemental mercury and require a relatively long period (months) of heating. He et al. (2015) provided a comprehensive review of all *in situ* technologies for mercury in soil, including recent progress in the application of nano technology to *in situ* stabilization of mercury. Many of the *in situ* technologies show promise but require additional development and pilot testing.

The continuing emergence and field demonstration of innovative tools for remediation of elemental mercury in subsurface environments should make it possible in the near future to successfully identify and treat this form of mercury in even the most challenging locations at the Y-12 site. Work completed to date exploring options for *in situ* treatment of mercury has been limited, but it could conceivably provide significant savings in terms of transport, treatment, and disposal costs and should continue to be explored as an option for remediation of soils, sediments, and subsurface structures contaminated with mercury. Subsurface remediation at Y-12 is far enough in the future that advancements may yet be made, demonstration options are more than feasible, and it should remain a consideration in future analyses.

3.5 DOE-WIDE TECHNOLOGY DEVELOPMENT

DOE technology development activities related to the mercury cleanup at Y-12 are conducted under a two-pronged approach: basic, fundamental studies conducted under the DOE SC and applied technology activities conducted under DOE Office of Environmental Management (around the DOE complex as well as locally in Oak Ridge). Integration of these two approaches is an ongoing responsibility of both Offices. Focusing integration of technology development into strategic planning is addressed in this section of the document.

A mercury-related SFA under DOE SC is aimed at enhancing a fundamental understanding of the environmental behavior (physical and chemical) of mercury, particularly in the LEFPC area. This mercury SFA is a multi-scale, multi-disciplinary, and multi-institutional research program led by researchers at ORNL that integrates geochemistry, microbiology, molecular biology, and molecular simulations to understand mercury behavior in the field. Current efforts are aimed at identification of mercury source areas, mercury transport, storm flow impacts, methylation, and other factors that affect bioaccumulation. An objective of this effort is to draw conclusions/ support theories that can be applied to guide and target future remedial actions.

Within the Environmental Management Program, the ARTD Program, whose mission is to transform science and innovation into practical solutions for environmental cleanup, conducts the Remediation of Mercury and Industrial Contaminants Applied Field Research Initiative (AFRI) at ORNL, whose purpose is to leverage field investigations and treatability testing involving mercury remediation of environmental media into practical solutions. Additionally, the AFRI provides the framework for leveraging and translating DOE SC investments (such as the SFA activity mentioned in the previous paragraph) into knowledge and technologies that can be used to address the Y-12 mercury challenge. Some of the proposed studies outlined in Section 3.4.1.2 would be accomplished under the auspices of the ARTD Program.

Remediation of the Y-12 site and EFPC ecosystem poses a long-term cleanup challenge. A number of previous efforts and reviews have identified science and technology needs relevant to the mercury cleanup challenge. These key knowledge and technology needs include the following activities:

- **Mercury Source Identification and Measurement** – Historically, the distribution of subsurface mercury at Y-12 has been characterized by conventional drilling techniques that employed direct-push sampling technology (Shelby tubes) in the soil overburden to minimize redistribution of the mercury due to drilling (e.g., Rothschild et al. 1984). As reported in the Rothschild study, only about 2 percent of the estimated losses by spills were located by this method. Subsequently various vendors have promoted the use of remote sensing using geophysical methods to identify subsurface accumulations of liquid mercury, but none of these has proved very useful so far at Y-12 or elsewhere. More recent characterization technology involves soil gas sampling (Watson et al. 2014; Miller et al. 2013).

  This technology is divided into two approaches: (1) passive sampling using sorbents installed in, and recovered from, borings (e.g., CH2M Hill 2012) and (2) active sampling/ measurement in real time during drilling wherein either soil gas is extracted (enhanced by heating the probe, see Jackson 2011) and brought to a mercury vapor analyzer on the surface,

or a "direct-push" electrical sensor provides selective response to presence of elemental mercury (SRNL 2011).

Supplemental characterization of mercury contamination in surface and subsurface sediments and near facilities within WEMA was completed. This activity supports refining the estimated amount of mercury-contaminated environmental media that will need to undergo treatment and disposal. The characterization involves using this real-time, vapor-phase measurement technique (Watson 2014). Combining these results with results from other subsurface studies and overlaying these with assigned risk values as "layers" in modeling (a systems analysis approach) could potentially help better define the problem, indicate areas of concern, and help direct future efforts (see last bullet).

- **Treatment of Mercury-Contaminated Debris, Soil, Sediment, Water –** Less costly and more effective treatment, recovery, containment, and stabilization techniques are needed for mercury-contaminated media (debris from demolition, soil and sediment, and water). *In-situ* treatment approaches that immobilize mercury in contaminated soils and sediments represent an opportunity for considerable savings in comparison to excavation/treatment/ disposal methods.
- **Hot Spot Stabilization/Containment/Removal –** Considerable cost savings may be gained with the application of reactive caps/barriers to line the creek banks/beds as an alternative to excavation/treatment/disposal methods. Additionally, techniques that remove or isolate mercury surface contamination in concrete or soils would also greatly reduce volumes and/or simplify handling of debris requiring treatment.
- **Predictive Modeling and Monitoring** – Development of a systems-based understanding of the impact of D&D activities on subsurface flow paths and mercury release is ongoing and can help understand and predict the long-term effectiveness of remedial alternatives on mercury flux reduction. This knowledge provides information needed to better design remediation strategies and long-term stewardship methods, as well as to define achievable alternative endstates.

Some of the above activities have been structured into tasks to be completed over the next several years, and are integrated into this Mercury Strategy Plan as *Technology Development and Planning* activities, shown in the strategic schedule, Figure 10. Proposed studies aimed at addressing water and fish mercury levels (Section 4.3.2.2) to be performed are also included in the figure. The benefit of activities being performed as part of the Mercury AFRI can result in cost savings by reducing the amount of mercury-contaminated material requiring treatment and disposal. For example, investments in the characterization of mercury sources near and around facilities—specifically the form, chemical speciation, and range of concentrations—will enable a refined cost estimate for cleanup and allow for more surgical treatment in place as an alternative to the baseline technology, excavation. Recent examples of Mercury AFRI-supported work are found in publications by Miller et al. (2015) which characterized formation of soluble mercury oxide coatings on elemental mercury beads and by Donovan et al. (2014) which employed measurement of stable isotopes of mercury to identify multiple mercury sources to stream sediments. Very recent advancements in mercury methylation discoveries by ORNL researchers under fundamental research in the SFA include identification of the genes cluster (*hgcAB*)

responsible for mercury methylation (Parks et al. 2013) and development of a broad-range qualitative and semi-quantitative method for identifying these genes within organisms (Christensen et al. 2016). Technology development activities will:

- Reduce the overall project schedule by increasing the technical maturity of unproven approaches and technologies.
- Reduce uncertainty associated with implementation of these approaches and technologies.
- Reduce costs by narrowing and targeting remediation approaches.
- Increase the likelihood of success for alternative approaches and technologies that can revolutionize and reduce cost during the cleanup project execution phase.

3.6 REGULATORY STRATEGY

The process of addressing cleanup under CERCLA involves prescriptive documentation/ regulatory approval procedures as outlined and maintained/statused within the FFA. Planning and sequencing of Y-12 OREM projects for the CD-1 baseline was completed based on a regulatory strategy that is essentially unchanged in this strategy (DOE 2008b).

Consideration of time and resources required for preparation of regulatory documents (CERCLA and National Historic Preservation Act documentation, permits and permit modifications, public comment periods, and regulatory review and approval) within the OREM planning baseline is consistent with this strategy plan and planning baseline information presented herein.

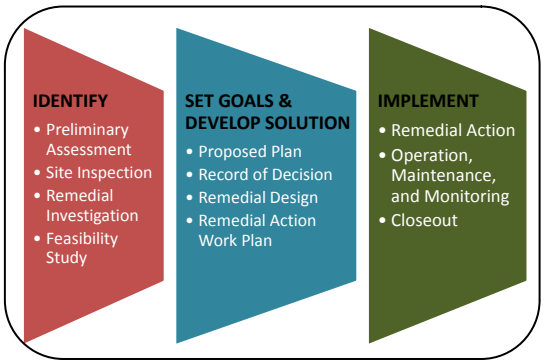

Figure 13. CERCLA Process

Figure 13 is a schematic of the steps undertaken in the CERCLA remediation process, where each bullet or step approximately applies to a study/evaluation that is performed, documented, and approved by all parties. For most of the actions addressed in this strategy, the process is in the middle stage, Set Goals and Develop Solution, where detailed information regarding implementation planning occurs (e.g., design, design reports, design characterization SAP/Quality Assurance Program Plans [QAPPs], and WHP for EMWMF waste).

Table 6 summarizes the CERLCA documents required for project activities currently envisioned. Some of the listed documents have been completed while others remain to be prepared and approved. Activities involving approaches that deviate significantly from those envisioned (e.g., *in situ* treatment of soils) may require further/different documentation and approvals from those specified in the table. The strategic schedule (Figure 10) appropriately schedules the CERCLA and DOE documents expected to be required prior to the execution of the specified projects.

Table 6. Examples of Required CERCLA and DOE Documentation in Support of Mercury Remediation Projects

Activity/Project	Required CERCLA Documentation and Approvals[a,b]	Required DOE Documentation and Approvals[b]
Legacy Material	• DQOs • RAWP*[d] • WHP*/SAP/QAPP • PCCR*	• See footnote c
Building Characterization	• DQOs • WHP*/SAP/QAPP (for characterization waste)	• See footnote c
Building Pre-Demolition	• WHP*/SAP/QAPP (single plan for pre-demolition and demolition waste) • PCCR*	• See footnote c
Building Demolition	• WHP*/SAP/QAPP (single plan for pre-demolition and demolition waste) • RmAWP[d] • PCCR*	• CD-2 Approve Performance Baseline • CD-3 Approve Start of Execution • CD-4 Project Closeout
All Building Complexes Demolition	• Removal Action Report*	• NA
Soils/Subsurface Characterization	• RAWP[e] and attachment* • DQOs • WHP*/SAP/QAPP (one for whole EU remediation)	• See footnote c
Soils/Subsurface Remediation	• RAWP[e], and attachment* • DQOs • WHP*/SAP/QAPP • TM/PCCR*	• CD-2 Approve Performance Baseline • CD-3 Approve Start of Execution • CD-4 Project Closeout
Sediment Characterization	• RAWP[e] and attachment* • DQOs • WHP*/SAP/QAPP • Nature and Extent Characterization	• See footnote c
Sediment Remediation	• RAWP* • DQOs • WHP*/SAP/QAPP • TM/PCCR*	• CD-2 Approve Performance Baseline • CD-3 Approve Start of Execution • CD-4 Project Closeout
All Soil/Sediment/ Subsurface Remediation	• Remedial Action Report*	• NA

[a] The documents/approvals listed here are those required after decision documents have been approved (see Section 2.3). In some cases, these documents may be addenda or appendices to existing documents. Some of these documents may be combined, for example, the WHP for pre-demolition and demolition waste may be able to be submitted as a single plan, and for multiple facilities.

[b] This list is not meant to be exhaustive. Various documents are required, for example the facility safety basis documents must be up-to-date and modified to include all projected activities to be completed under the given work scope. As another example, the RmAWP for building demolition states that other project-specific plans, such as verification plans, monitoring plans, and water management plans may be required.

[c] These activities are typically completed outside of the Critical Decision process. However, much of the documentation required is similar (e.g., Work Plans; Safety Basis; Environmental, Safety, and Health Plan; etc.)

[d] The RmAWP for Y-12 building demolition is an existing document (EDI 2010c). Project-specific plans will be developed (e.g., Verification Plans, Monitoring Plans, Water Management Plans) but are not submitted for regulatory approvals.

[e] The RAWP for UEFPC soils is an existing, approved document (EDI 2010a).

*These documents are primary FFA documents and require regulatory approvals.

3.7 RISKS AND OPPORTUNITIES

Specific risks associated with mercury remediation at Y-12 include:

- **Mercury in fish continues to be elevated –** Mercury concentrations in fish continue to be elevated and do not respond to actions to reduce creek concentrations and loading. The relationship between effluent concentrations and mercury in fish is non-linear.
- **Final surface water and groundwater decisions may require reassessment of soil/sediment remediation levels** – This risk is low, but has significant consequences**.**
- **Mercury leach testing protocol –** Potential revision/replacement of the TCLP protocol was highlighted in the 2014 edition of the Mercury Strategic Plan as a risk because any change in this protocol could affect applicability of past characterization data in meeting LDRs, could result in increased volumes of waste requiring disposal, and may affect implementation of treatment options. However, an inquiry to EPA received an answer stating there were no plans to replace or revise this protocol (see Appendix A).
- **Funding availability –** Funding availability is driven by economic mechanisms that can negatively affect the schedule for remediation of Y-12.
- **Regulatory approval of alternative treatment/disposal methods for mercury waste –** gaining this approval for in cell macroencapsulation and/or in situ soil remediation is needed to implement these treatment/disposal methods.

The relationship between water and fish concentrations is clearly non-linear and not well understood. During source removal efforts, the mercury water concentrations will likely fluctuate, and completion of source removal is expected to result in a final picture of the mercury conceptual model that is significantly different from that of today. Although efforts will be directed at reducing fish tissue mercury concentrations throughout this strategy with parallel monitoring/assessment of those concentrations, it is conceivable that a final evaluation of effort needed to influence fish tissue mercury concentrations will not be possible until after source removal is completed. The adaptive management approach put forth in this strategy is to respond to those fluctuations by revising, as necessary and as allowed within constraints (e.g., budgets, timing), approaches utilized to best address those as yet unforeseen ecological responses to cleanup actions. In the interim, reduction of mercury flux will be addressed through construction and operation of the OF200 MTF. New efforts under the Excess Facilities work (e.g., COLEX equipment D&D) will continue to advance the cleanup efforts within Y-12.

Mercury remediation projects have risk management plans and associated contingencies. The risks identified above: offsite release of mercury and a expectation to see further decreases in mercury levels in surface water, and funding availability, as well as other risks not addressed here, are captured and managed within the baseline. A comprehensive risk management process is used to ensure that project activities incorporate appropriate, efficient, and cost-effective methods to identify, manage, and mitigate the impact of project-related risks. Project contingencies are calculated utilizing Monte Carlo methodology; simulation runs are conducted to provide technical and programmatic risk cost and schedule impacts. Contingency is thus

calculated at 50 percent and 80 percent confidence levels, and incorporated in project baseline projections. Opportunities associated with mercury remediation at Y-12, currently being implemented or to be implemented in the future, include the following:

- **Targeted Hot Spot Segregation and Remediation of Mercury Contamination –** As a form of volume reduction, targeted, localized determination of the extent of mercury-contaminated areas in buildings and identification of soil "hot spots" (identified through characterization efforts) will allow for reduced treatment costs. For example, Alpha-5 characterization shows localized areas of the building that have much higher mercury concentrations. These areas may be strategically demolished and segregated from the bulk of the building debris to reduce treatment and disposal costs. This approach will be documented and approved through WHPs or other appropriate documents. *In situ* remediation of soils may provide many advantages in cost, safety, reduced waste volumes, and more. Advancement of this technology is needed to improve delivery systems and examine efficiencies.
- **Consolidation of Required Documentation –** The existing RAWP for UEFPC soils (EDI 2010a) and the Y-12 facility D&D RmAWP have been written to encompass all EUs and facilities that will require remediation and includes common information to all areas, with the idea that appendices may be added to address the individual areas as the work becomes more defined, rather than developing multiple, repetitive RAWP/RmAWPs. These appendices will address the specific scope and schedule response action planning and completion reporting. Consolidation of other CERCLA documentation in a likewise manner, where possible, will be pursued, as well as separate consolidation of DOE-required documentation in a similar manner, as applicable (e.g., as was completed for a single CD-1, which captured multiple projects in the IFDP).
- **Continue "progressive" demolition work** – As is being accomplished under the Excess Facilities effort, the removal of COLEX equipment is a step toward the more signficant large-scale building demolition. Lessons learned under this and future, near-term "progressive" work will help reduce risk and uncertainty to future large-scale remediation work, help train a work force, and identify areas (planning, work execution) in need of development.
- **In-cell macroencapsulation –** This method of disposal that combines treatment (macroencapsulation) of mercury-contaminated debris within the land disposal facility provides for increased safety (e.g., reducing the movement by heavy equipment of large waset forms, decreasing needed handling of debris/equipment) and reduced cost (enabling larger waste forms to be managed in-place, within the land disposal unit). Under this scenario, a future CERCLA onsite landfill would have to obtain a CAMU designation in the appropriate documentation through EPA.

4.0 PROJECT SUMMARY AND TIME-PHASED PLAN

The current and future OREM work scope discussed in this strategy has involved only those projects associated with mercury-contamination in UEFPC. However, Y-12 cleanup scope includes many more projects than have been presented thus far, and a discussion of the time-phased execution of Y-12 projects cannot be isolated from the rest of the OREM baseline and ORR priorities. Multiple projects have been defined to complete the cleanup of Y-12, of which 14 projects are related to the mercury-cleanup. The prioritization and sequencing of all Y-12 cleanup projects are discussed further in sections that follow.

4.1 Y-12 NATIONAL SECURITY COMPLEX BASELINE PROJECTS

Multiple projects are defined in the OREM baseline to accomplish the cleanup at Y-12. Figure 14 lists many of those projects, arranged by the overarching CERCLA decision documents. The remaining projects not shown in the figure include ongoing and future S&M/Environmental Monitoring and Reservation Management Projects. The mercury remediation projects, all in the UEFPC watershed area, are given as red text and italicized in the figure. They include the four mercury-use facility complexes D&D; four subsurface, soil, and sediment remediation projects; three projects to design, construct, operate, and ultimately D&D the OF200 MTF; and two projects to develop UEFPC RODs.

A detailed list of the Y-12 projects is given in Attachment B along with a list of all facilities in the D&D projects.

Once defined, the site's projects are prioritized. Following prioritization, Y-12 projects are integrated into the overall OREM program and project prioritization (which includes ETTP and ORNL projects). Enforceable milestones are established based on consensus priorities and aligned to the overall pace of cleanup and projected funding. Annual funding levels, both projected and allocated, affect the time-phased sequencing of the OREM program projects and thus the OREM baseline.

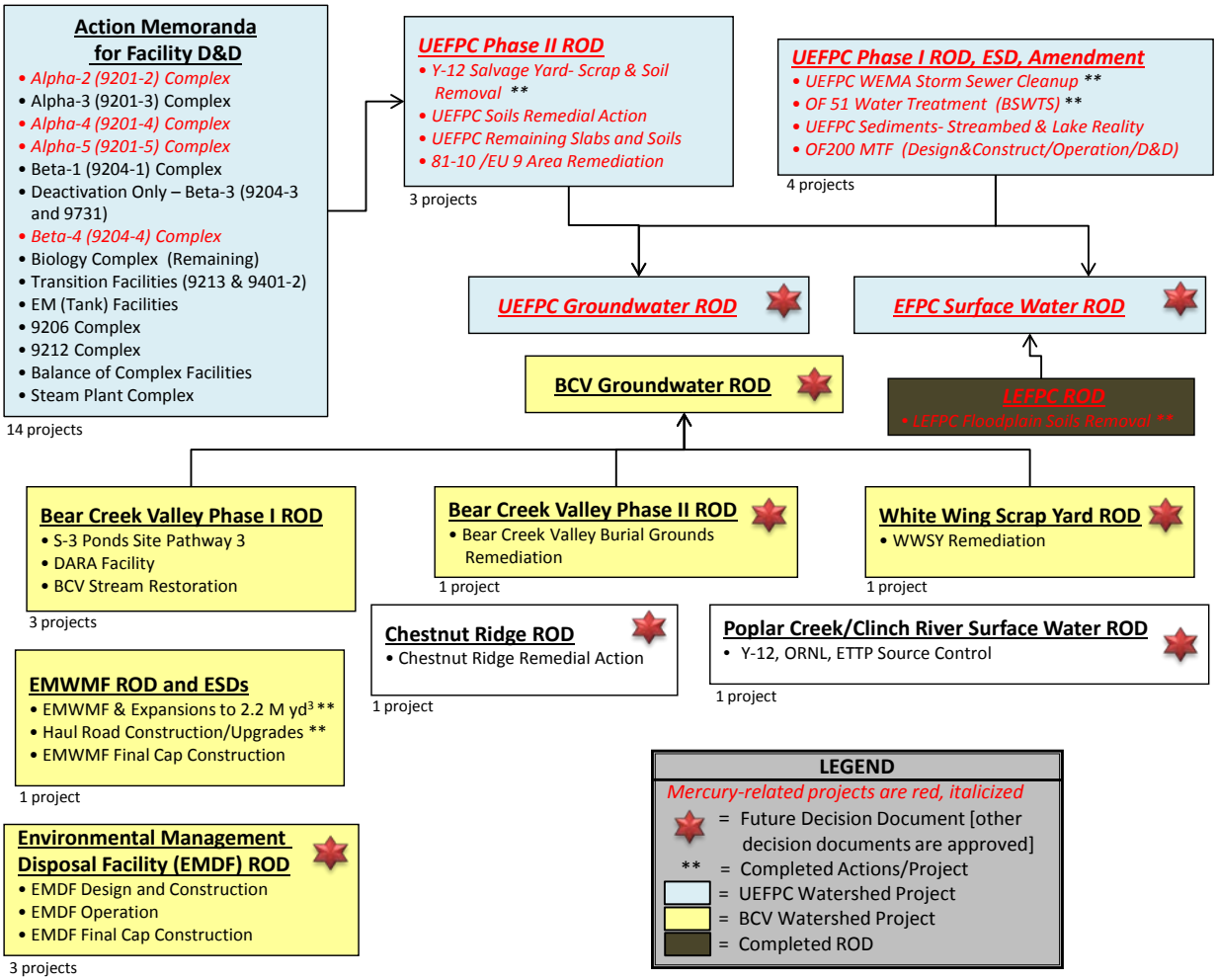

Figure 14. Project Summary for Y-12, Grouped by CERCLA Decision Document

4.2 PROJECT PRIORITIZATION

The Oak Ridge cleanup strategy employs a risk-based approach that focuses first on those contaminant sources that are the greatest contributors to risk. To further refine the overall cleanup strategy, a prioritization system has been developed to help guide decisions where investments should be made. DOE OREM Program risk-based prioritized goals are to:

- Mitigate immediate offsite risks.
- Reduce migration of contaminants offsite.
- Control ongoing sources of onsite contamination.
- Demolish excess facilities.
- Address remaining media (soil, surface water, and groundwater).

Other factors affecting prioritization include stakeholder interests, regulatory commitments, funding availability, and mission support. The OREM Program Plan discusses the prioritization of Reservation cleanup (DOE 2015). Based on these goals, Y-12 projects have been prioritized, with mercury remediation being the site's highest priority. Other prioritization considerations include construction logic (for example, building D&D allows access to underlying contaminated environmental media), building utility relationships, prevention of recontamination, opportunities for reduction of S&M costs, and release of strategic real estate to support site missions. The prioritization for the mercury remediation projects is:

- **OF200 MTF Design/Construction** – to provide immediate reduction of mercury leaving the site and to be in place and operational to provide mercury removal capabilities during demolition activities. Use of the MTF for D&D contact water may require some additional work at the facility and/or by the project creating the waste, to determine acceptance of the waste water, for example, or if some type of pre-treatment were to be necessary.
- **Beta-4 Complex Demolition** – the first complex accessible from the west and has the most available surrounding area that can be used for staging/laydown; therefore, it is logical to begin demolition at this facility. In addition, a west to east approach has been adopted since it is the direction of groundwater flow, as addressed in an ESD to the Phase I ROD (EDI 2011); therefore, working west to east will minimize the possibility of re-contaminating cleaned areas.
- **Soils Cleanup** – is being completed by EU where possible, based on the west to east approach. Western EU 11 scrap yard soils were remediated by ARRA in FY 2011-2012; Beta-4 is contained in EU 11 and is a logical next cleanup target in that EU, from an EU by EU perspective. Soil remediation for each mercury-use facility will follow demolition of that facility.
- **Alpha-5 Complex Demolition** – the building has been characterized (DOE 2012a) and all legacy material has been removed. The facility is beginning to deteriorate; therefore, delays in gaining entrance for deactivation activities may add costs needed for reinforcement of the structure in the future and increase S&M costs. Soil remediation is sequenced to immediately follow after the complex demolition.

- **Alpha-4 Complex Demolition** – the building is to the east of Alpha-5 and is, therefore, sequenced to follow Alpha-5 demolition. Soil remediation is sequenced to immediately follow after the complex demolition. COLEX equipment at the west end (outside) of this building is being removed and disposed of, to reduce risks to the environment. This work will alsoprovide experience in conducting these kinds of activities.
- **81-10 Area Remediation** – soil (EU 9) is prioritized following building demolition starts. However, characterization has been completed and, while it is currently sequenced to be remediated beginning in FY 2032, it may be possible to pull the project forward if funding becomes available.
- **Alpha-2 Complex Demolition** – building demolition is prioritized lower and sequenced later because the building and surrounding area is served by the BSWTS for mercury treatment of shallow groundwater inleakage to the basement and adjacent Outfall 51, Big Spring. Additionally, the building is located in the eastern portion of the site, so from a west to east approach, it is prioritized lower as well.

Soil remediation (in relation to building demolition) is assumed to occur following after each individual (large) building demolition as opposed to completing multiple complex demolitions followed by large or multiple area soil remediations. This is considered to be a logical sequence for the scope execution for several reasons: (1) once a building has been demolished, the slab and/or subsurface (hole in the ground/basement/wind tunnels) may create an issue with contaminant movement and/or treatment of inleakage, making minimizing the period of "vulnerability" in between D&D and remediation work desirable; (2) if the approach is to fill in the subsurface structure with flowable fill in order to avoid the previously mentioned issue, more waste may be generated during remediation and increase cost; and (3) soil waste can act as void fill for the onsite disposal facility(appropriately sequencing soil remediation interspersed with demolition accomplishes savings by reducing clean fill purchase/use in the disposal facility and conserving disposal capacity).

4.3 BASELINE SEQUENCE

All OREM projects (ETTP, ORNL, and Y-12) are sequenced in time based on a given annual funding constraint for the remaining baseline as well as logic ties within each site. This sequencing results in the schedule for Y-12 cleanup, as seen in Figure 15. Appendix B contains a listing of projects that are included in each summary level presented in the figure. In developing the baseline, the cost of each project is estimated, Monte Carlo risk analyses are completed to define contingencies, and cost ranges developed and escalated as necessary. Mercury-related projects account for ~25 percent of forecasted cost (including operation of the OF200 MTF), all other D&D/remediation accounts for ~25 percent, and the remaining 50 percent of the forecasted cost covers S&M, environmental monitoring, security, and operations, as well as all disposal cell planning, construction, operation, and closure. Funding needed to complete the Y-12 cleanup is estimated at approximately $8.7 Billion, and is expected to take 33 more years to complete at the level of funding currently projected for that period.

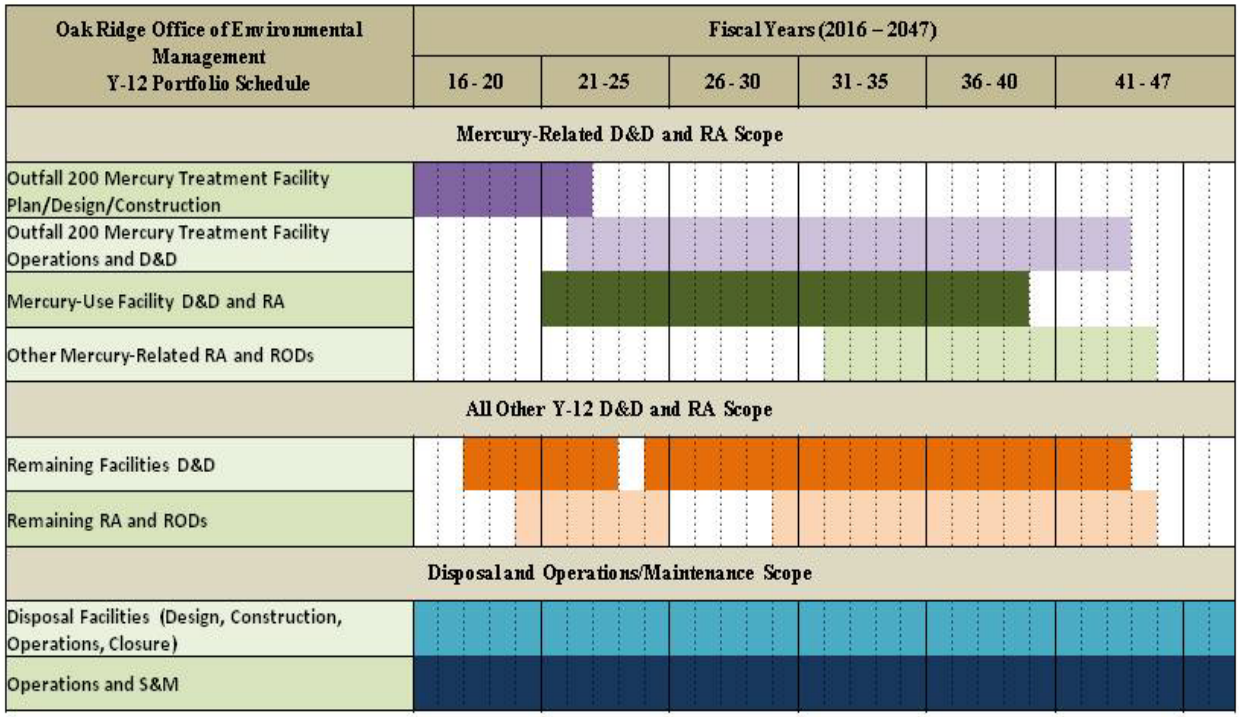

Figure 15. Y-12 EM Cleanup Project Summary Schedule

5.0 CONCLUSIONS

Cleanup of mercury contamination and sources at Y-12 presents a complex, multi-faceted problem that requires an equally multi-layered remediation approach. Remediation actions to date have had some opposing reactions (expected to be short-term only) where surface water mercury concentrations are concerned (e.g., WEMA storm sewer cleanout increased mercury flux) as future demolition activities are expected to generate contact water requiring treatment for mercury.

Mercury has been identified as the largest environmental risk on the ORR stemming from ongoing releases of mercury in UEFPC to offsite, public waters and due to a lack of response in fish mercury concentrations to overall reductions of mercury in UEFPC from pre-1980 highs. This strategy responds to that risk with the following elements:

- Construction of the OF200 MTF to reduce mercury loading in UEFPC will be completed, thereby reducing the amount/flux of mercury leaving the site at Station 17, as well as providing treatment for future demolition/remediation-generated contact stormwater and decontamination water.
- The CERCLA Alternatives Evaluation in the FY 2023/2024 time frame will be the basis for agreement on any additional actions to be implemented in UEFPC or LEFPC if necessary, with input from the OF200 MTF operation evaluation.

- Large-scale, future mercury source removals (building demolitions followed by soil remediation) have been planned through a project-based approach. The approach involves many planning and pre-demolition activities prior to demolition and remediation. Key to the success of these large-scale demolition and remediation projects is a well-defined path for mitigating increased Hg migration during and following WEMA demolition efforts and managing the expected waste debris and soil treatment and/or disposal. Significant steps toward identifying the soil and debris management paths have been addressed through the soils treatment feasibility study (UCOR 2012). Working with regulators, the path forward on managing the expected mercury-contaminated soils and debris will be defined and approved through WHPs prior to the actual execution of these projects. Advance planning will allow efficiencies and cost-benefit analyses to be more successfully considered and implemented prior to, and in parallel, with the work.
- Building demolition and soil remediation have been sequenced in the OREM baseline to proceed west to east, to allow for ease of access in completing demolition and to reduce or eliminate issues of recontamination associated with groundwater flow that exhibits a west to east flow. Remediation of soil will follow directly after demolition for each facility.
- Treatment and disposal of future mercury contaminated waste (debris and soil) in onsite facilities (and *in situ* in the case of soils) should be considered and the regulatory path forward to accomplish these goals must be defined and negotiated.
- A workshop to provide an open forum to researchers, vendors, contractors, and subject matter experts involved with all aspects of mercury remediation should be held, to facilitate the future Y-12 cleanup scope.

The ongoing and future mercury remediation at Y-12 is an extremely large and complex problem from all perspectives: chemical, geological, ecological, physical, regulatory, and financial. Efforts are being made daily by DOE contractors, regulators, and DOE officials to define, develop, and implement solutions to the issues. This strategic plan has been written as a source to guide future mercury remediation activities and support processes. Changes to schedules will likely occur over the extensive time frame encompassed by this plan. Hopefully, many advancements and achievements in mercury remediation will be forthcoming, but some unexpected setbacks will undoubtedly be encountered. This plan will be updated through tri-party agreement, as necessary, to remain effective in organizing and focusing those efforts to define the work, reduce costs and increase efficiencies where possible, and to ultimately achieve the goal of cleaning up mercury from the Y-12 site and EFPC.

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ATTACHMENT A.

RESPONSE FROM EPA REGARDING CHANGES TO TCLP PROTOCOL

From: orcrSW846 [mailto:orcrSW846@epa.gov]
Sent: Thursday, May 18, 2017 10:20 AM
To: Ralph R Turner
Subject: RE: Form submission from: Hazardous Waste Test Methods / SW-846 Contact Us About Hazardous Waste Test Methods form

Ralph,

You have been added to the SW-846 mailing list.

At present, there are no plans to replace TCLP/Method 1311 with the LEAF leaching methods. The LEAF methods will be added to SW-846 in addition to Method 1311, and the regulatory requirements to use Method 1311 for toxicity characteristic testing will not change.

The LEAF methods (Methods 1313, 1314, 1315, and 1316) are currently available on the SW-846 Validated Methods webpage at https://www.epa.gov/hw-sw846/validated-test-methods-recommended-waste-testin
g. These methods will be officially incorporated into the SW-846 compendium as part of Update VI, Phase 4, which will also include the LEAF User Guide.
Update VI, Phase 4 is slated to be released for public comment in June or July of 2017, and updated information can be found at https://www.epa.gov/hw-sw846/sw-846-update-vi-announcements.

Thank you,
The RCRA Methods Team

ATTACHMENT B.

Y-12 NATIONAL SECURITY COMPLEX PROJECT INFORMATION

Project Summaries
Mercury-Related D&D and RA *
Outfall 200 Mercury Treatment Facility
• Outfall 200 Mercury Treatment Facility (Design/Construction)
• Outfall 200 Mercury Treatment Facility Operations and Maintenance
• Outfall 200 Mercury Treatment Facility D&D
Mercury-use Facility D&D and RA *
• Alpha-2 Complex D&D
• Alpha-4 Complex D&D
• Alpha-5 Complex D&D
• Beta-4 Complex D&D
• UEFPC Remaining Slabs and Soils
o Alpha-2 Complex Remedial Action
o Alpha-4 Complex Remedial Action
o Alpha-5 Complex Remedial Action
o Beta-4 Complex Remedial Action
Other Mercury-Related RA and RODs
• UEFPC Soils 81-10 Area Remediation
• UEFPC Soils Remedial Action
• UEFPC Streambed & Lake Reality
• EFPC SW ROD
All Other Y-12 D&D
All Other Y-12 Facility D&D
• 9206 Complex D&D
• 9212 Complex D&D
• 9213 / 9401-2 D&D
• 9731 Deactivation Only and Beta-3 Deactivation Only
• Alpha-3 Complex D&D
• Balance of Facilities Complex D&D
• Beta-1 Complex D&D
• Biology Complex D&D
• Steam Plant Complex D&D
• Tank Facilities D&D
All Other Y-12 RA
• UEFPC Remaining Slabs and Soils *(continued from above)*
o 9206 Complex Remedial Action
o 9212 Complex Remedial Action
o 9213/9401-2 Complex Remedial Action
o Alpha-3 Complex Remedial Action

Project Summaries
o Balance of Facilities Remedial Action
o Beta-1 Complex Remedial Action
o Biology Complex RA
o Steam Plant Complex Remedial Action
o Tank Facilities Remedial Action
• BCV Burial Grounds Remedial Action
• BCV S-3 Ponds (Pathway 3)
• BCV Stream Restoration
• BCV White Wing Scrap Yard RA
• BCV White Wing Scrap Yard ROD
• Chestnut Ridge ROD and RA
• BCV DARA Facility
• BCV Burial Ground (Phase II) ROD
• BCV Groundwater ROD
• Clinch River/Pop Creek SW ROD
• UEFPC Groundwater ROD
Operations and Maintenance Scope
All Disposal Cells (Design, Construction, Operations, Closure)
• EMWMF Final Cap Construction
• EMDF (OR On-site Disposal Facility) Design/Construction
• EMDF (OR On-site Disposal Facility) Final Cap Construction
• CERCLA Cell and ORR Landfill and ORR Operations
Excess Facilities/Risk Reduction
• Excess Facilities Risk Reduction
S&M and Environmental Monitoring
• Ground Water Investigation
• Y-12 Surveillance & Maintenance / Environmental Monitoring
• Y-12 WQP and WRRP
• Technology Development Activities
Landlord and Security Operations
• Infrastructure and General Program Activities
• DOE Direct

* D&D and RA are two (2) separate projects

Demolition Projects, Facility Program Owners, and Gross Square Footage

(Mercury-use complexes are highlighted)

D&D Project	Number of Facilities to be Demolished	Demolition (gross ft^2)	Deactivation Only (gross ft^2)	Current Program Owner	Number of Facilities by Program	Demolition (gross ft^2) by Program
Alpha-2 Complex	3	332,595		NNSA	1	7,667
				SC	2	324,928
Alpha-3 Complex	3	196,870		NNSA	3	196,870
Alpha-4 Complex	3	513,374		EM	1	510,218
				NNSA	2	3,156
Alpha-5 Complex*	13	646,613		NNSA	13	646,613
Beta-1 Complex	2	213,162		SC	2	213,162
Deactivation Only Complex (Beta-3 and 9731 Prep for Historical Preservation - sq ft and facility count not included in totals)	0	NA	37,159	NNSA	1	0
	0	NA	255,656	NE	1	0
Beta-4 Complex	8	345,532		NNSA	8	345,532
Biology Complex	8	346,278		SC	8	346,278
9206 Complex	3	63,369		NNSA	3	63,369
9212 Complex	20	536,372		NNSA	20	536,372
Balance of Facilities	5	1,417		EM	3	701
				NNSA	2	716
Steam Plant Complex	6	68,951		NNSA	6	68,951
Transition Facilities	2	37,308		EM	2	37,308
EM (Tank) Facilities	2	3,216		EM	2	3,216
TOTALS	**78**	**3,305,057**	**292,815**	**EM**	**8**	**551,443 ft^2**
				NNSA	**59****	**1,869,246 ft^2**
				SC	**12**	**884,368 ft^2**
				NE	**1**	**(deactivation)**

EM = Environmental Management; NA = not applicable; NE = Office of Nuclear Energy; NNSA = National Nuclear Security Administration; SC = Office of Science.

* Alpha-5 Complex currently does not include Alpha-5W (Building 9201-5W), which belongs to NNSA. It shares a wall with Alpha-5, and is expected to be included in this Complex demolition project in the future.

** One (1) of the 59 buildings NNSA owns will be deactivated only.

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