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

Professional Project Services, Inc. (Pro2Serve®)
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Office of Environmental Management

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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 of 2009
ATSDR	Agency for Toxic Substances and Disease Registry
ATS	Alternative Treatment Standards
BSWTS	Big Spring Water Treatment System
CD	Critical Decision
CDR	Conceptual Design Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CMTS	Central Mercury Treatment System
CR/PC	Clinch River/Poplar Creek
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	United States Environmental Protection Agency
ESD	Explanation of Significant Differences
ETTP	East Tennessee Technology Park
EU	exposure unit
FFA	Federal Facility Agreement
FS	Feasibility Study
FY	Fiscal Year
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
NNSA	National Nuclear Security Administration
NPDES	National Pollutant Discharge Elimination System
OF200 MTF	Outfall 200 Mercury Treatment Facility
OREM	Oak Ridge Office of Environmental Management
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCCR	Phased Construction Completion Report

PIDAS	Perimeter Intrusion Detection and Assessment System
ppt	parts per trillion
QAPP	Quality Assurance Program Plan
RAO	Remedial Action Objective
RAR	Remedial Action Report
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act of 1976
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
TCLP	toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TM	Technical Memorandum
UCC	Union Carbide Corporation
UEFPC	Upper East Fork Poplar Creek
U.S.	United States
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

EXECUTIVE SUMMARY

The United States (U.S.) Department of Energy (DOE) Oak Ridge Office of Environmental Management, along with the Tennessee Department of Environment and Conservation (TDEC), and the U.S. Environmental Protection Agency (EPA), 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 (UEFPC) have not resulted in a corresponding decrease in mercury concentrations in fish. Additionally, very recent increases in surface water mercury flux leaving the site have been noted, and are attributed to storm water system cleanup activities funded under the American Recovery and Reinvestment Act of 2009. This observed, temporary increase in mercury flux raises a concern that future demolition and remediation activities are likely to increase the mercury flux at Station 17 (where UEFPC enters public waters). Therefore, it is imperative that immediate actions be taken to reduce mercury in surface waters and to put in place strategies and systems needed to control mercury releases both now and in preparation for large-scale demolition of several process facilities that historically became contaminated with radioisotopes and mercury. Demolition of these facilities, totaling approximately 1.8 million square feet, and the accompanying soil remediation activities will address removal and/or stabilization/containment of major mercury sources. Enormous quantities of waste debris and soil will be generated, of which a portion (possibly large) will require treatment prior to disposal and thus be subject to land disposal restrictions.

Future demolition/remediation projects require development and planning activities in preparation of the execution of these projects, most notably activities aimed at defining waste treatment/disposal/endstates resulting from mercury remediation. Strategic planning for mercury remediation at Y-12 includes the following actions:

- Implement near-term mercury reduction actions to achieve an immediate decrease in mercury flux in UEFPC.
- Identify, develop, and apply the best technologies to remediation of mercury contamination.
- Prepare, from regulatory and technical standpoints, for execution of large-scale demolition and remediation activities as well as for the management of resultant 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.

Remediation and mitigative activities to date have, in a few instances, resulted in unintended consequences as noted (e.g., mercury flux temporarily increased due to the storm water system cleanup). As another example, flow augmentation, implemented to improve water quality in UEFPC, is thought to cause re-suspension of creek sediments and, therefore, increase mercury flux exiting the site boundaries. Consequently, combinations of efforts are needed to effectively advance the mercury cleanup at the site.

A centrally located water treatment facility for mercury removal is proposed as a key component of this strategy. This facility will serve multiple purposes, including immediate and significant reduction of mercury flux at Station 17 (through achieving a reduction of mercury in the headwaters of UEFPC) and mercury removal from contact water generated during future demolition and remediation activities. Other near-term efforts supporting the mercury cleanup include (a) treatability studies/demonstrations to determine waste forms for contaminated soils that meet waste acceptance criteria for the on-site disposal facility, the Environmental Management Waste Management Facility, as well as regulatory land disposal restrictions and other applicable regulatory requirements, (b) on-going free mercury removal from storm sewer systems, modification of building/other drainage to redirect storm runoff away from suspected contamination areas, and targeted legacy material disposition, (c) development of required planning documents with an emphasis on producing documents that will serve multiple areas/projects, and (d) technology development efforts to reduce uncertainties and increase efficiencies in characterization, targeted removal and treatment, and waste disposition.

As a National Priorities List site, with cleanup implemented under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and governed by the Federal Facility Agreement among DOE, EPA, and TDEC, a prescriptive documentation and communication process is followed to plan, reach approval, implement, and monitor the scope at Y-12. The activities this plan addresses will mitigate mercury contamination sources, remediate soils for federally-controlled industrial use, and reduce water-borne contamination leaving the site. No single solution exists to solve the mercury contamination issue at Y-12; a multi-pronged approach is necessary in order to reach endstates that are acceptable on many levels and to all stakeholders. Given the enormity of mercury 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 the cleanup.

1. INTRODUCTION

This document presents the United States (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) that 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. Decades of precision machining experience, and earlier isotope enrichment activities, make Y-12 a production facility with capabilities unequaled nationwide, yet have left the site with a legacy of contaminated facilities requiring replacement and/or demolition, and soils and ground/surface water in need of urgent remediation mainly due to the presence of mercury. This strategy takes into account completed work regarding environmental mercury reduction and on-going 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 sources. Several key factors and goals guided the development of this mercury remediation strategy:

- Mercury contamination at Y-12 has been ranked as the greatest environmental risk at the Oak Ridge Reservation (ORR). *Goal: propose mercury reduction projects to (a) take actions to achieve immediate results in reducing the amount of mercury leaving the site and (b) plan for large-scale mercury cleanup projects in an effort to reduce risk as low as reasonably achievable.*
- Cleanup is implemented under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (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.*
- Cleanup is integrated with NNSA's ongoing missions. *Goal: coordinate mercury remediation activities with on-going 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, and (d) plan and define risk mitigation activities and opportunities.*

The Agency for Toxic Substances and Disease Registry (ATSDR) recently completed an in-depth study to determine the human health effects of mercury releases from the Y-12 site; it 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 are unaccounted for during its historical use at the site. Mercury that has persisted in the environment continues to have a great ecological impact which must be addressed, as evidenced by an increased mercury flux leaving the site in recent years, which is associated in part to remediation activities focused on source removal. While comforting to know that 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 a plan that includes completion of early action tasks to reduce mercury leaving the plant boundary from the average of 19 grams/day measured over the last six years (at the NPDES location, Station 17), identification of desirable studies in terms of data gathering/analyses and technology development/ demonstration to support building demolition and soil remediation projects, and prioritization and sequencing of these projects while considering cost efficiencies that may be implemented. A roadmap for the strategic process is given that counts risk management, technology development, regulatory considerations, and re-baselining among its steps.

Figure 1 illustrates the many issues and actions regarding mercury remediation that this strategy aims to address.

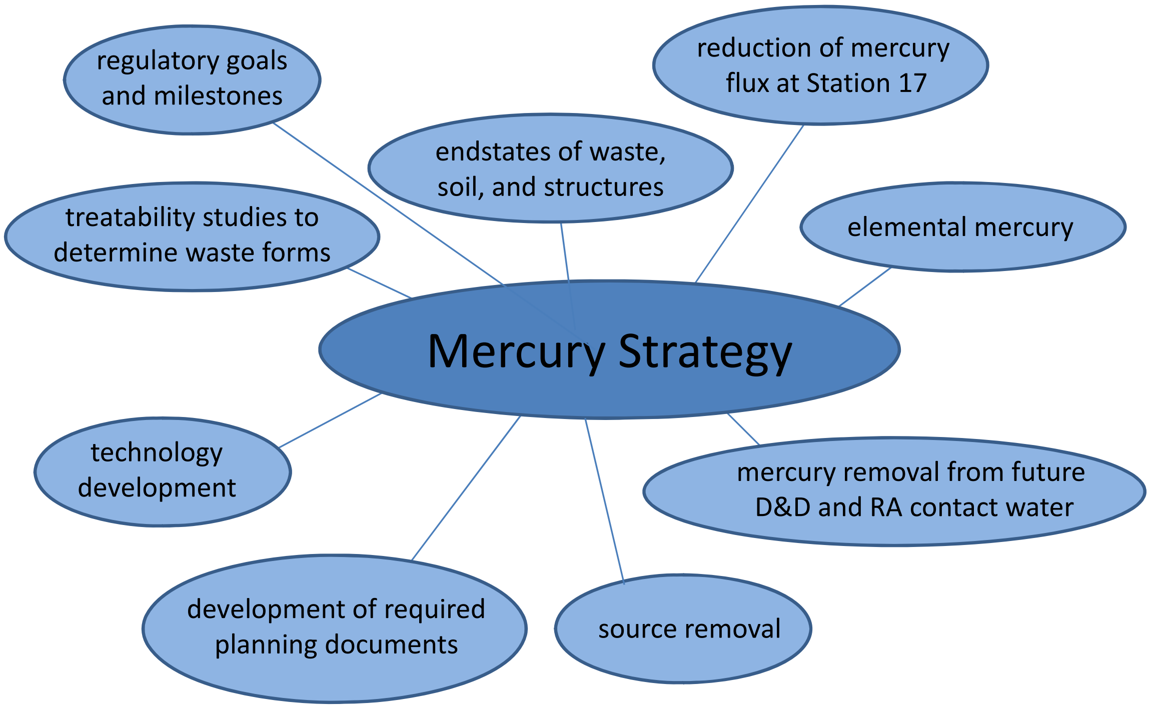


Figure 1. Issues and Actions to be Addressed by the Mercury Strategic Plan

2. BACKGROUND

2.1 Y-12 SITE HISTORY

Releases of mercury during operations at Y-12 in the 1950s and early 1960s resulted in contamination of environmental media and facilities within the complex as well as East Fork Poplar Creek (EFPC). Subsequent transport from these sources continues to threaten the creek both on-site and off-site. Remediation efforts, which began in the 1980s, have reduced waterborne mercury concentrations both within the Y-12 facility and in the EFPC ecosystem, but 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 using mercury were conducted in Buildings 9201-2 (Alpha-2), 9204-4 (Beta-4), 9201-4 (Alpha-4), and 9201-5 (Alpha-5) beginning in the 1950s and 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 facilities/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).

The EFPC can be divided into several discrete sections. The portion that occurs within the Y-12 Plant is referred to as the Upper EFPC (UEFPC, see Figure 2). The EFPC from Bear Creek Road to its confluence with Poplar Creek near the East Tennessee Technology Park (ETTP) is generally referred to as Lower EFPC (LEFPC), and it 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, is the headwaters of UEFPC. A complex underground storm water system draining the West End Mercury Area (WEMA), as shown in Figure 2, feeds Outfall 200.

Although 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. Dry weather loading of mercury to the UEFPC has multiple sources, including infiltration of contaminated shallow groundwater into the storm water drain network, dissolution of mercury from the contaminated pipes, advection of contaminated sediment into the surface flow, and emergence of contaminated groundwater from the karst system in springs and seeps (DOE 1994). 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).

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

Mercury Losses	Major Pathway	Mercury (pounds)	Mercury (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 lbs, when historical knowledge regarding shortage of receipts, losses to building structures, and other specific losses are taken into account. (UCC 1983)

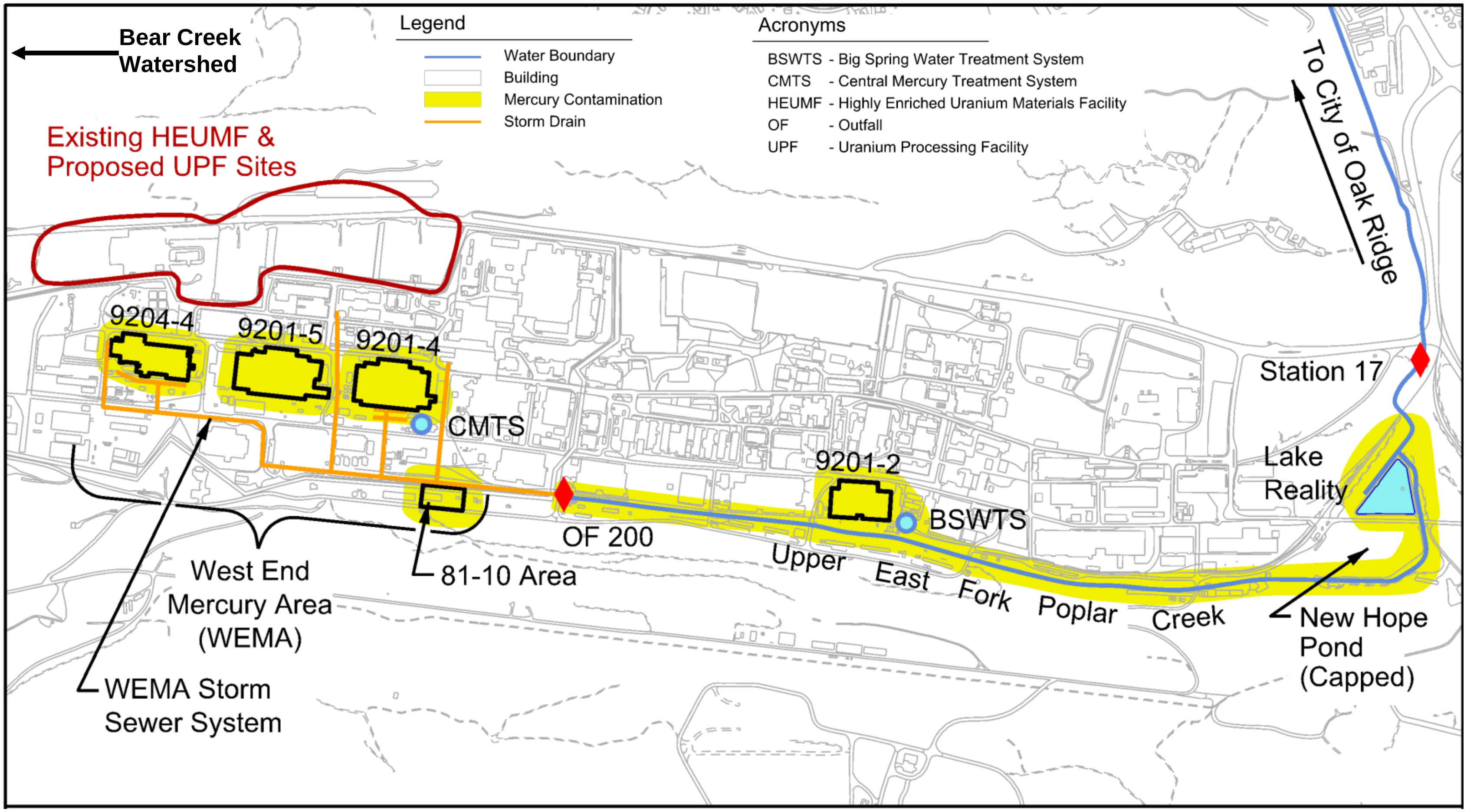


Figure 2. Y-12 Site Layout Showing Major Features in UEFPC Watershed and Expected Areas of Mercury Contamination

Figure 3. Mercury-Use Buildings at Y-12

2.2 DOE FRAMEWORK FOR CLEANUP

Scope, schedule, and budgets for the cleanup of Y-12, the Oak Ridge National Laboratory (ORNL), and ETTP sites are addressed by DOE OREM through the development of projects 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 O 413.3A *Program and Project Management for the Acquisition of Capital Assets* (DOE 2008a) under the auspices of the Integrated Facility Disposition Program (IFDP). This extensive cleanup scope is in the process of being added to the OREM Baseline as discrete projects. Further project-specific CD approvals (levels 2, 3, and 4) will be pursued in accordance with DOE O 413.3B (DOE 2010a), which replaced DOE 413.3A. 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 Deactivation and Demolition (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, and is a subject discussed in Chapter 4 as well.

2.3 REGULATORY FRAMEWORK FOR CLEANUP

The ORR was placed on the National Priorities List in 1989. The FFA, which coordinates the corrective actions under Resource Conservation and Recovery Act of 1976 (RCRA) with CERCLA response actions, became effective on January 1, 1992. Parties of 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) specified in the CERCLA decision documents, including requirements for waste characterization, treatment to meet Land Disposal Restrictions (LDRs), and waste handling, storage, and disposal.

2.3.1 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 at Y-12, Bear Creek and UEFPC. UEFPC activities are addressed in this strategy, since it is the watershed most affected by mercury contamination. Cleanup projects in the Bear Creek Watershed are addressed as part of the overall Y-12 project prioritization and sequencing discussed in Chapter 4.

Per CERCLA, a Remedial Investigation 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 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 1 Interim Record of Decision (ROD) (DOE 2002). A Focused Feasibility Study was prepared for the next phase which addressed interim actions to remediate soil contamination to protect industrial workers, groundwater, and surface water, and the site was 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 ROD was approved (DOE 2006) [see Section 2.3.1.1]. Building D&D decisions were subsequently addressed in an Engineering Evaluation/Cost Analysis (EE/CA) and Action Memorandum (AM) (see Section 2.3.1.2).

2.3.1.1 Soils, Sediments, and Subsurface Structures

Remediation of the UEFPC watershed is being conducted in stages using a phased approach under multiple CERCLA ROD documents. The primary contaminants of concern in UEFPC surface water are mercury and uranium. The Phase I ROD was signed in May 2002 (BJC 2002). Phase I addresses 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, since they were envisioned as the remediation for WEMA soils prior to the current plan to D&D additional former mercury-use buildings in the area. D&D of buildings will allow access to residual mercury contamination in soils beneath and adjacent to the structures (addressed by the Phase II ROD). The Phase I ROD Remedial Action Objective (RAO) is to achieve a concentration of 200 parts per trillion (ppt) mercury in surface waters of UEFPC at Station 17.

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.

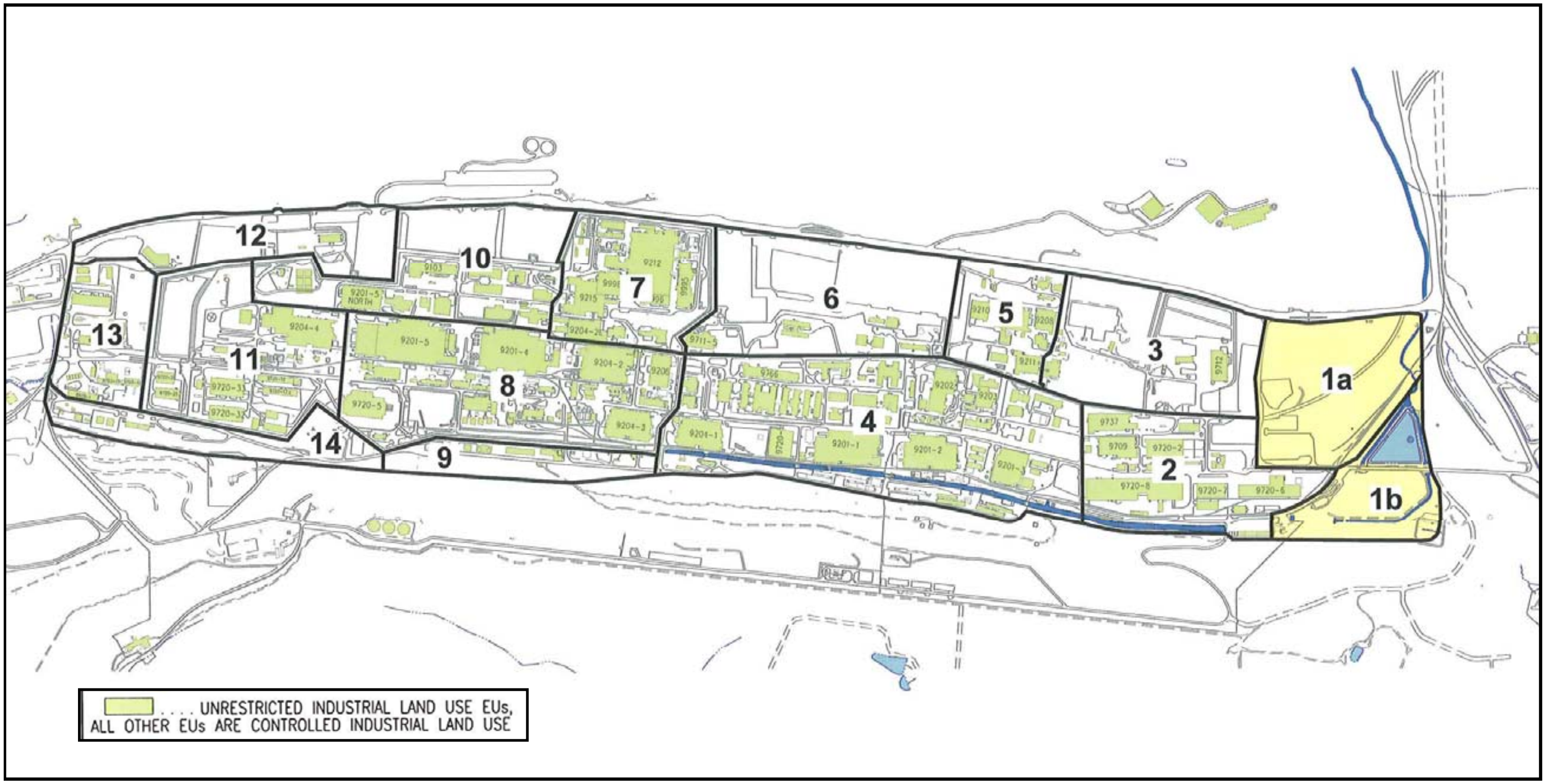


Figure 4. Exposure Units in the UEFPC Contamination Area

EU 11 and EU 8 contain the 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.

The RAO of the Phase II ROD is to protect industrial workers from exposure to hazardous substances 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 are established in the document.

A Remedial Action Work Plan (RAWP) has been completed to address soil, sediment, buried waste, and subsurface structure remediation, 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 CERCLA documentation for media from this point forward.

2.3.1.2 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 addressing the remainder of the buildings including those in the UEFPC watershed area were issued (EDI 2010c). The strategy presented in this document (Chapter 3) addresses required CERCLA documentation for building D&D from this point forward.

2.3.1.3 Surface and Ground Waters

A final groundwater ROD for UEFPC will be developed following the remediation of UEFPC soils, sediments, and subsurface structures. 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, ORNL, and ETTP).

2.3.2 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. The ORR currently has a RCRA operating permit and Hazardous and Solid Waste Amendments corrective action permit covering all such facilities located within the ORR boundaries. RCRA also includes certain requirements that may be applicable whether the remedial activities are conducted under RCRA or CERCLA authority. The most significant of these are the LDRs given under 40 Code of Federal Regulations Part 268 (40 Code of Federal Regulations [CFR] § 268). Regarding mercury, LDRs specify the use of particular technologies and standards to meet, including Universal Treatment Standards (UTS) or optional Alternative Treatment Standards (ATS) that are specific to soil that must be attained before the waste may be land disposed. Those mercury-contaminated wastes that may be applicable to the Y-12 site cleanup are given in Table 2, along with the treatment standard to be attained to meet LDRs.

2.3.3 Clean Water Act

Point source discharges to UEFPC are subject to the Clean Water Act of 1972 through NPDES permits; the NPDES permit at Y-12 was recently renewed (October 2011) and places considerable emphasis on reducing mercury flux in UEFPC. The newly-issued 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 in process.

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)(D), where needed.

Table 2. Nonwastewaters Contaminated with Mercury and Corresponding RCRA LDR UTS or ATS

Waste Type	Treatment Standard and/or Technology
Per 40 CFR § 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 40 CFR§ 268.48 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 40 CFR § 268.45 Treatment Standards for Hazardous Debris	
Hazardous Debris	Extraction Technologies or Immobilization Technologies; and must meet specified performance and/or design and operating standards of 40 CFR§268.45
Per 40 CFR § 268.49 Alternative LDR Treatment Standards for Contaminated Soil	
Contaminated Soil	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 40 CFR§ 268.48.

ATS = Alternative Treatment Standard; Hg = mercury; TCLP = Toxicity Characteristic Leaching Procedure; UTS = Universal Treatment Standard

2.4 INTERFACES

OREM has cleanup responsibility for the entire ORR. Their mission at the three sites is completed under a single 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 three site drivers into a single, overall plan and budget based on priorities involving 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 plans to modify 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). Therefore, 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.

Interfacing with regulatory entities, TDEC and EPA Region 4, is of utmost importance in executing this mercury cleanup strategy and achieving the remediation goals set forth in the CERCLA decision documents. CERCLA remediation activities require submittals of various documents – Waste Handling Plans (WHP), Sampling and Analysis Plans, Remedial Design Reports, Work Plans, etc. – that are reviewed and approved by the regulators, showing 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 Reservation* (DOE 2011) and DOE P 141.2, *Public Participation and Community Relations* (DOE 2003). Interactive communication will enable all parties to understand disparate views and to achieve agreement for the most appropriate path forward.

2.5 COMPLETED WORK

Previous and on-going progress toward the ultimate goal of mercury remediation at Y-12 is summarized in Table 3. Most recently, funding from American Recovery and Reinvestment Act of 2009 (ARRA) enabled the completion of several activities as noted at the end of the table; however, the bulk of the work remains to be completed and is addressed by this strategic plan.

2.6 CURRENT Y-12 CONCEPTUAL MODEL

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 has been 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 UEFPC. Transport pathways are very complex as is the mercury chemistry and behavior in the environment. The amount of mercury leaving the site per a given time period (or flux) is quite variable.

Considerable progress has been made in reducing the amount of mercury leaving the site through UEFPC since the 1980s as shown in the trends of Figure 5. However, EPA evaluates mercury levels in fish tissue as an indication of the "health" of a water body, and these levels have not seen a corresponding decrease within the fish of UEFPC as shown in the figure. Additionally, concern has been raised over the increase seen in mercury leaving the site in the last several years (refer to Figure 6) which, from 2008 to 2010, 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 in 2011 is attributed to the WEMA storm system cleanout, which resulted in disturbances of storm drain sediments, a primary mercury source. As seen in 2012 (Figure 6), the flux has dropped very slightly (33 to 32 g/d or 12.2 to 11.1 kg/yr), although rainfall for the year is slightly higher (62 inches for 2012 compared to 60 for 2011). 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 Remedial Effectiveness Report (UCOR 2012a).

Table 3. Chronology of Significant Mercury Cleanup Activities

Year(s)	Project	Summary of Significant Actions
1985 to 1995	Building remediation activities	• Elimination of mercury sources and rerouting of process pipe in Bldgs. 9201-2, 9201-4, 9201-5 and 9204-4; decon of facilities/equipment and equipment removal; treatment of sump water in 9201-2 using activated carbon
1986 to 1987	Storm drain cleaning/lining; removal of mercury-contaminated sediment	• 5,600 LF of storm sewers cleaned • 8,400 LF of storm sewers relined • 500,000 lbs of sediment removed
1988	Construction projects result in mercury-contaminated soil removal	• Removal and disposition of soil in high mercury-contamination areas due to construction of PIDAS
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
1988 to 1995	Pipe rerouting: North-South Pipe replaced in 1988	• Rerouting and removal of process piping • 2000 ft of North-South Pipe containing mercury-contaminated sediment abandoned & replaced with new pipe • North-South Pipe conveys UEFPC in western area of complex
1992	Tank remediation (removal of 30,000 lb mercury-contaminated sediment)	• 3 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 • ~ 30,000 lbs of mercury-contaminated sediment were removed
1982 to 1994	Reduction of mercury in plant effluent (Lake Reality by-pass; trial treatment of Outfall 51)	• Initiated in 1982 by Clean Water Act • Two phases focused on mercury sources • >90 percent mercury reductions achieved • Storm sewer cleaning/relining • Rerouting process water & UEFPC • Focused water treatment
1996 to present	Flow augmentation	• Implemented to protect stream water quality per the 1995 NPDES permit • A flow of 5 M 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; added at Outfall 200 (North/South pipe)

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

Year(s)	Project	Summary of Significant Actions
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 Bldgs. 9201-4 and 9201-5
1996 to 1997	EFPC floodplain soil removal	• 1995 ROD • Public input raised cleanup level based on mercury form (sulfide) • Excavation of ~35,000 cubic yards of mercury-contaminated floodplain soil • Surface water decision deferred
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
1999	Remedial Investigation and Feasibility Study completed for UEFPC	
2001	UEFPC Bank Stabilization	• CERCLA Treatability Study • Stabilized stream bank to reduce erosion • Reduced storm event driven releases of mercury
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 ~300 gal/min
2006	Phase II ROD approved	
2008	IFDP CD-1 approved (addresses D&D of >100 buildings and multiple remedial action sites at Y-12)	
2009 to present	ARRA Projects (WEMA Storm Sewer Project; Scrap Yard Removal; Beta-4 and Alpha-5 Legacy Material Removal; Alpha-5 Building Characterization) see Section 3.4.1 for new near-term actions for mercury remediation	• 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 - Mercury treatment cost savings achieved • Completion of Alpha-5 and partial Beta-4 legacy material disposition • Completion of Alpha-5 building characterization

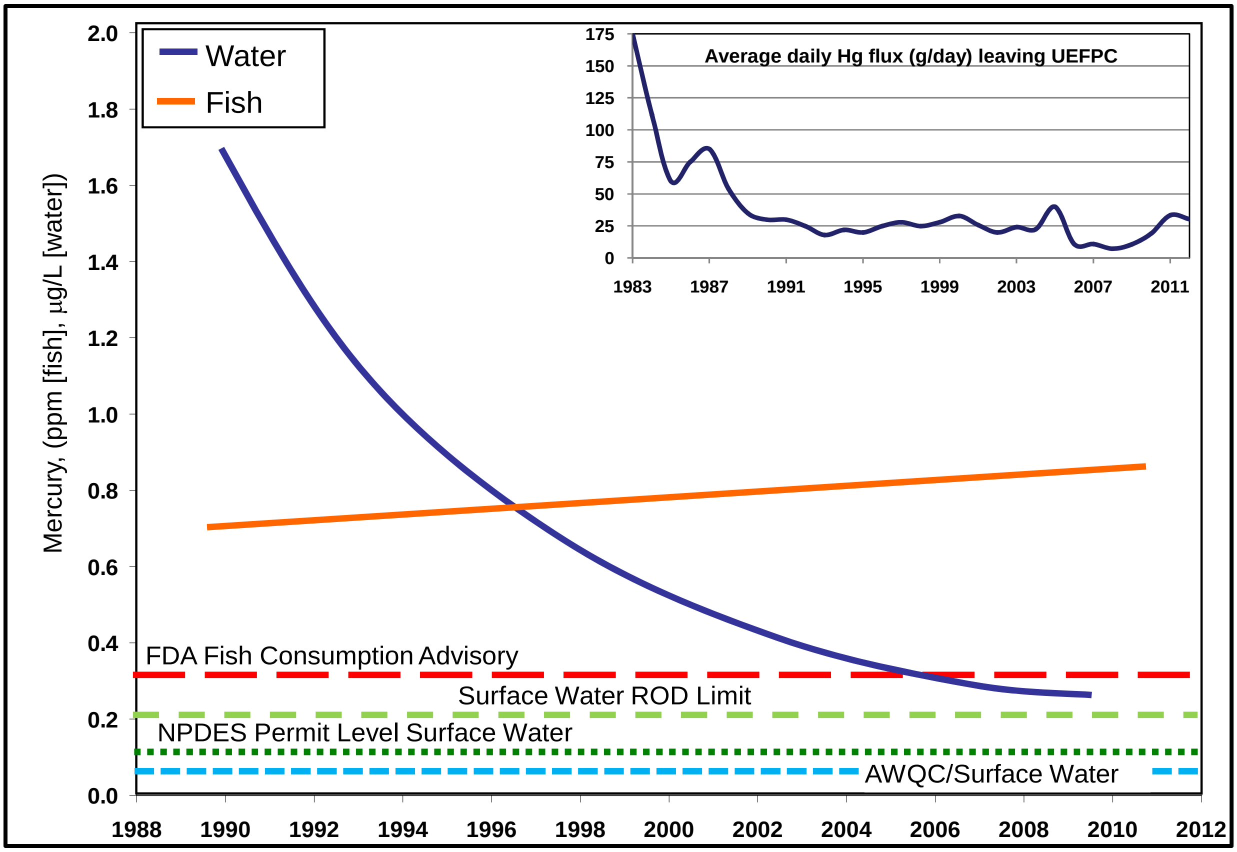


Figure 5. Station 17 Historic Mercury Loading to UEFPC (Water and Fish) and Current Standards

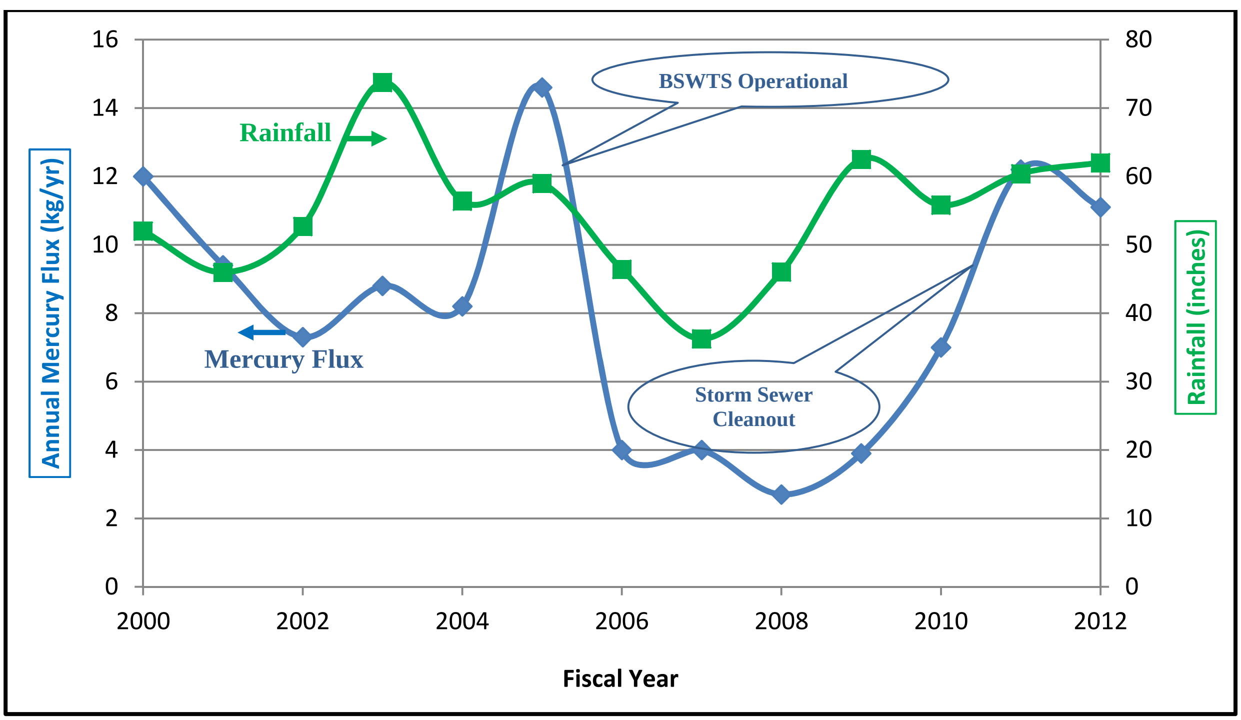


Figure 6. Annual Mercury Flux at Station 17

Several conclusions are drawn in the Y-12 Site Conceptual Model report (ORNL 2011) regarding mercury sources, a few of which are quoted here in italics. 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)].

Data collected during the last year (2012) shows a significant decrease in the Outfall 200 average mercury flux from 31 g/day in 2011 to 7 g/day. Conversely, the Station 17 average mercury flux decreased by only 3 g/day, from 33 to 30 g/day, during the same time frame. This phenomenon may be attributed to the WEMA storm sewer cleanout conducted in the previous year. Recent efforts to remove elemental mercury from WEMA (see the Free Mercury Removal project discussed in Section 3.4.1) also may be contributing to the reduction in the Outfall 200 flux. Given more time, the Station 17 flux may also ultimately decrease. These occurrences demonstrate that creek sediment, rainfall influences, etc., can become more weighty contributors to mercury presence in the creek under some circumstances, and highlights the unforeseen effects remediation, soil and sediment disturbances, and possible other 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.]

Other conclusions drawn from the report include:

- *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.*

Taken as a whole, these and previous discussed observations – decreases in mercury flux have not resulted in corresponding fish mercury level drops; 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 result in increased mercury flux at Station 17; a significant 75% 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. Ultimately, source removal will lead to reduced mercury levels in the environment, but in the meantime, interim cleanup actions can influence mercury transport in an uncertain, and even negative, manner.

3. PATH FORWARD – STRATEGIC PLANNING

Based on the observations and issues presented in the previous section, several significant measures are being implemented to address mercury flux in UEFPC. For one, NNSA recently submitted plans to relocate and/or reduce raw water addition to UEFPC based on previous studies that showed a reduction in flow augmentation can achieve a corresponding reduction in mercury flux in UEFPC (ORNL 2009). In response to those plans, TDEC recently submitted a letter to NNSA directing them to shut down flow augmentation. Additionally, OREM has proposed and completed the conceptual design for a surface water treatment facility, the Outfall 200 Mercury Treatment Facility (OF200 MTF) to be located at Outfall 200. This facility will provide effective relief regarding mercury loading to UEFPC. In terms of future operation, the OF200 MTF will provide the capability to remove mercury from surface waters generated during major, planned source removal actions such as building demolition. In order to meet fluctuating inputs and goals, the facility will be designed with modular, scalable features (see Section 3.4.2 for a more detailed description of the facility).

Effectively addressing the mercury sources is, ultimately, the goal of the mercury cleanup efforts at Y-12. Source removal/stabilization – that is, demolition/removal of mercury-use building debris and excavation/stabilization/disposal of soils and sediments – is costly. 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 WHP. A pertinent study has been recently 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 may be advantageous.

In the meantime, the two significant measures, flow augmentation relocation, or even cessation, and the OF200 MTF will reduce mercury loading to UEFPC and thus mercury contamination leaving the site. Several smaller-scale initiatives (e.g., mercury traps in storm sewers) have also been implemented and are discussed further in Section 3.4.1. A combination of actions, large and small, thus makes up the strategy for mercury cleanup at the Y-12 complex.

3.1 STRATEGIES TO CONTROL MERCURY RELEASES

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

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

Figure 7 shows a high level organization of these generic strategies and summaries of 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). 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).

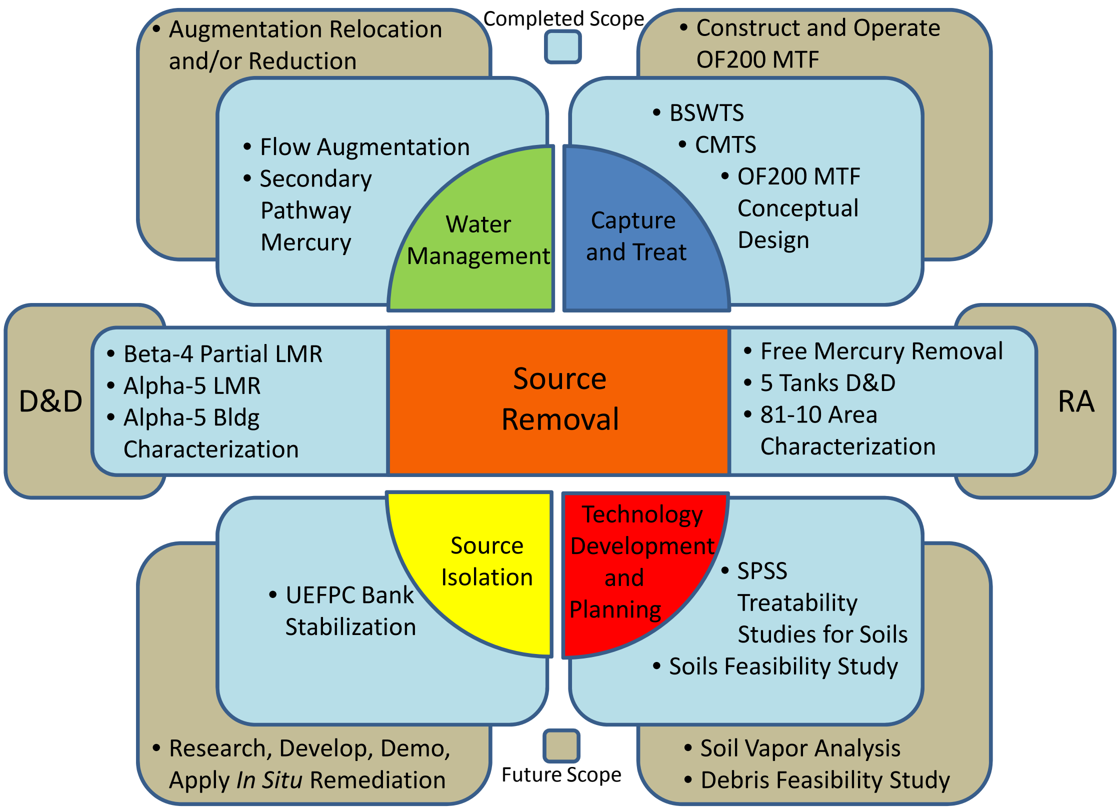


Figure 7. Summary of Mercury Remediation Strategy, Completed Scope, and Future Scope

Capture and Treat is the proposed interim 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 scalar 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.

Source Containment/Isolation is achieved by construction of physical barriers around soil/waste such that water cannot enter the containment area. It may entail surface capping and/or impermeable wall installation, as was completed in the UEFPC bank stabilization effort some years ago. 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 or chemical methods with the goal of reducing solubility/leaching of contaminants.

Source Removal involves activities such as soil/debris excavation, storm sewer sediment cleanout, building demolition, and elemental Hg trapping/removal from plumbing. 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% reduction of mercury in soils does not guarantee a 95% reduction in water-borne mercury concentrations or loading). In the long term the goal should still be to remove as much source inventory as practical and any early opportunities to remove sources regardless of flow path consideration should be taken. As seen in the strategy figure, source removal encompasses D&D of the four large process building complexes as well as remediation of the associated soils. Sediments are addressed in out-years.

Technology Development is an overarching strategy supporting effective implementation of the four strategies above. Technologies exist for mercury-contaminated media treatment that can be considered “off-the-shelf,” including retorting, amalgamation, and excavation with relocation to Schedule D 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. As indicated previously, this work has been initiated for soil treatment.

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. These and other technology development initiatives are ongoing and may be applied to mercury remediation at Y-12. They 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
- Cost
- Schedule
- Mitigation strategies to address risks and issues
- Implementation strategies for identified opportunities
- Monitoring of remediation effectiveness

Figure 8 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 on- and off-site through implementation of organized projects and the fifth –

technology development – which includes activities and studies that support the other four physical strategies. Support activities (e.g., regulatory documentation and DOE capital project submittals) are also noted.

Understanding the desired endstates for waste, buildings, and soils/sediments is a primary data point needed to fully address building demolition and media remediation. To that end, endstates are discussed in Section 3.3, followed by strategy implementation in Section 3.4; technology development in Section 3.5; regulatory strategy is presented in Section 3.6; and risks/opportunities follow in Section 3.7.

3.3 ENDSTATES

Successfully completing the mercury cleanup at Y-12 relies heavily on achieving three Party approved, affordable, and environmentally protective endstate criteria for soil, sediment, and subsurface remediation and building demolition waste. Final endstates, those for groundwater and surface water, have yet to be determined, and will be addressed in future RODs.

3.3.1 On-Site 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 on-site CERCLA facility, the Environmental Management Waste Management Facility (EMWMF), as specified in the RODs and AM, provided EMWMF waste acceptance criteria (WAC) are met. The EMWMF is projected to reach capacity in FY 2020-2021, after which time a future replacement CERCLA facility is assumed to be available. Its availability is scheduled to overlap the closure of EMWMF, and thus consistently provide an approved, on-site disposal location. This planned, future on-site disposal facility is currently being proposed through the CERCLA process (DOE 2012a). It has been included in the OREM baseline as discussed in Chapter 4 of this document. For purposes of this strategy, the on-site CERCLA disposal facilities – current and future – are referred to only as the EMWMF.

Non-hazardous, non-radioactive waste generated during future demolition and remediation activities will be disposed of at 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 mercury-contaminated wastes (debris and soil) that have been treated to meet LDRs, are not LLW, and meet the ORR Landfills WAC.

3.3.2 Off-Site Disposal

Off-site disposal is available for mercury-contaminated LLW (mixed waste) provided the waste has been treated to meet LDRs and meets facility WAC. For example, the Nevada National Security Site can accept treated mixed waste that meet the WAC, and commercial facilities can provide the treatment as well as, in some cases, disposal for mixed wastes. However, the future volumes of debris and soils projected to be generated at Y-12 may be impractical to send off-site from a cost perspective. Therefore, it is of value to investigate providing treatment on-site for mercury-contaminated waste, to avoid the transportation to and from commercial off-site treatment facilities. Until on-site facilities for treatment are provided and approved, commercial facilities are the only treatment option available.

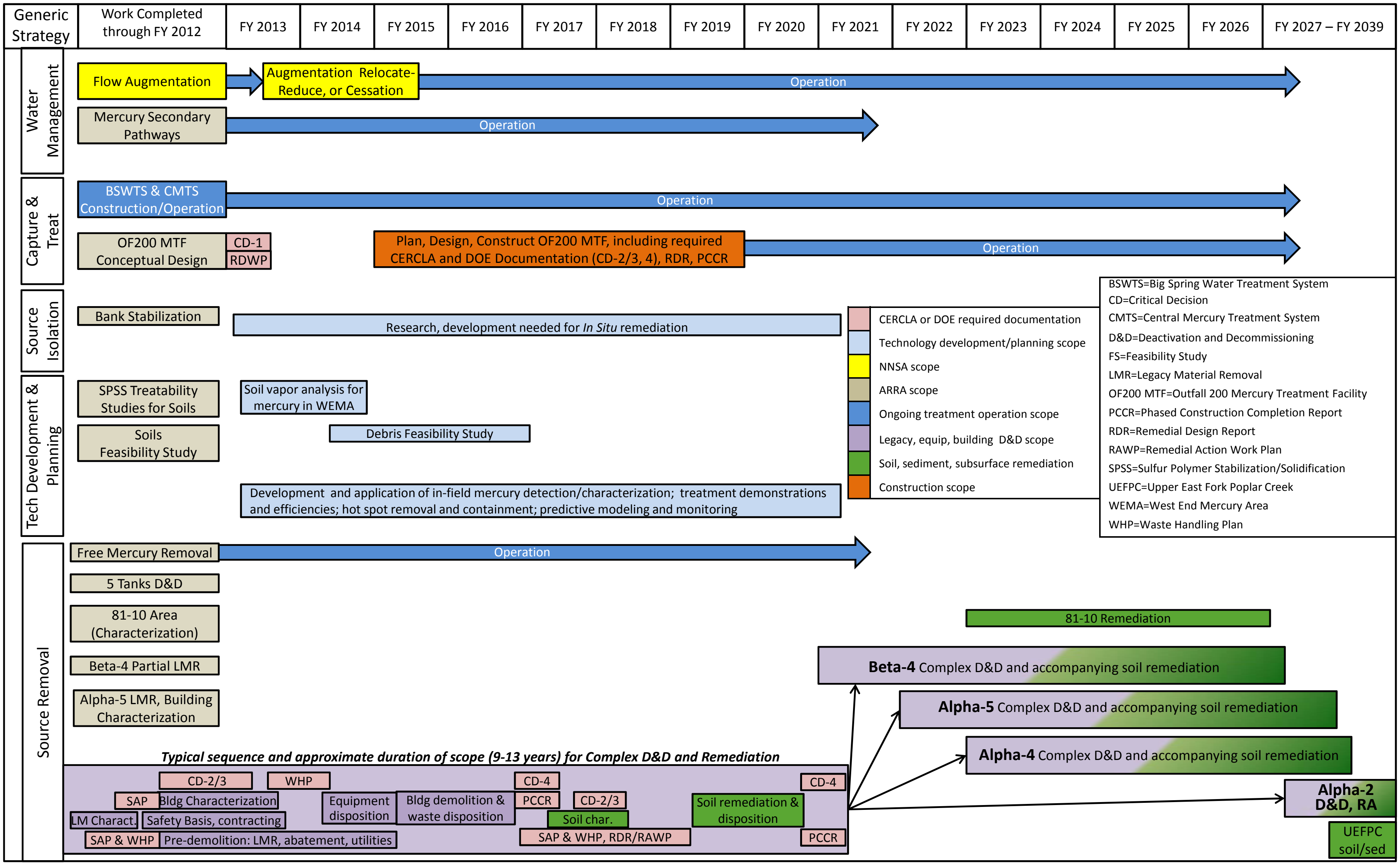


Figure 8. Strategic Schedule for Mercury Cleanup at Y-12

3.3.3 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 on-site disposition path (EMWMF) 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 (40 CFR § 268). A logic diagram summarizing the treatment options and standards that must be met, per LDRs, for wastes containing mercury is given in Figure 9. This diagram assumes that the waste is also LLW and is thus ultimately disposed at EMWMF (ORR Landfills may be substituted for EMWMF if waste meets ORR Landfill WAC). Additionally, it is assumed that, if present, other contaminants are treated to meet LDRs if need be prior to entering this flowchart, or are managed along with the mercury (e.g., lead would be stabilized along with mercury in macroencapsulation).

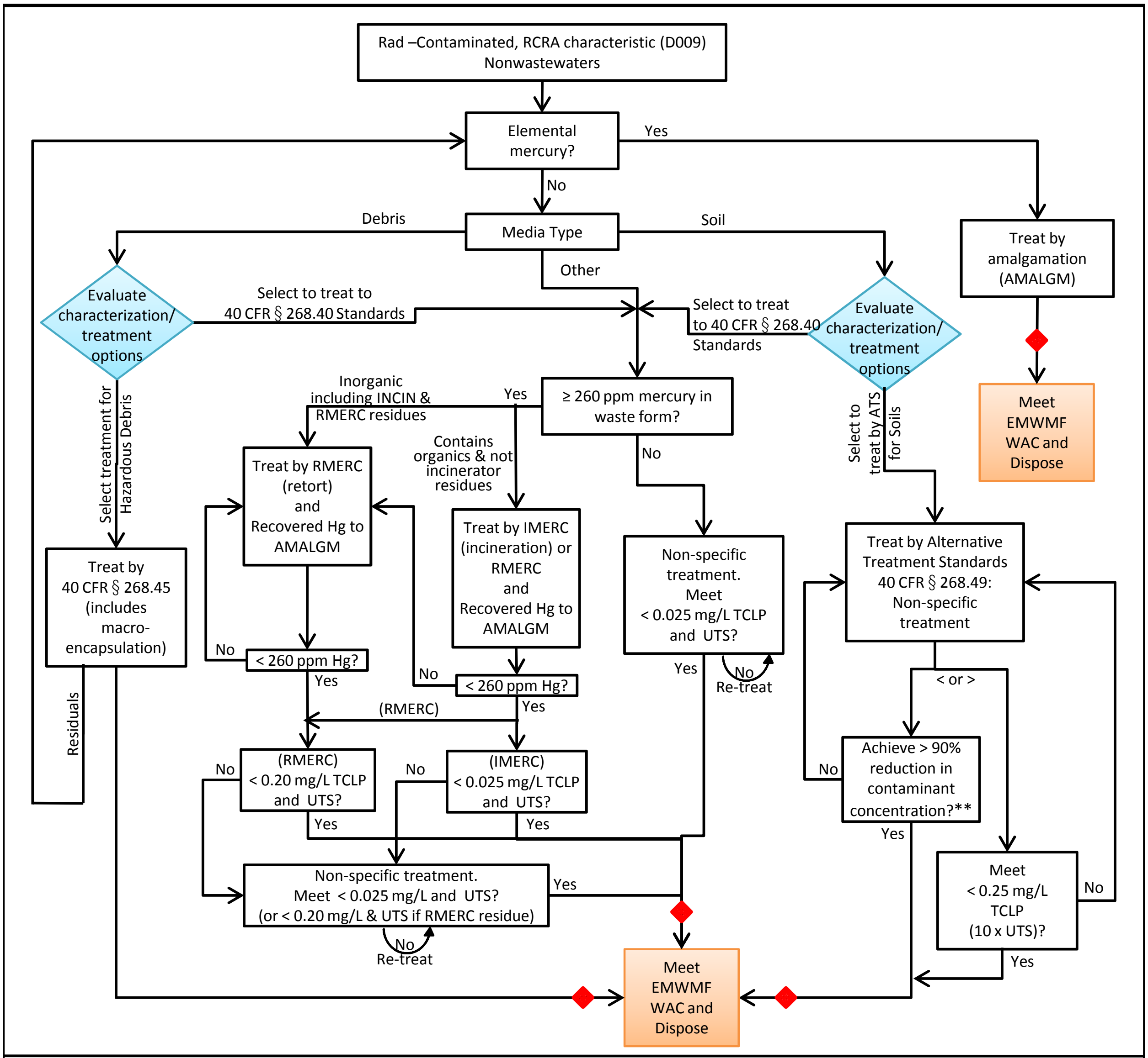
To the extent that waste characteristics are known at this time, several technologies to treat the wastes and meet LDRs exist; however, difficulties and uncertainties may emerge because of the large volumes of waste that could possibly require treatment, resulting in higher costs, and possible unknowns 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 on-site (requires construction of facilities, consideration of executing time frames, regulatory framework required) or off-site (vendor location, requires transportation considerations), and where to dispose of the waste must be made. Decisions will require supporting evidence for their selection – 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 feasibility study addresses this type of information for soil (UCOR 2012b). A similar study, as previously mentioned, is desirable for debris. The current, assumed disposition path for mercury-contaminated, LLW debris is macroencapsulation (per 40 CFR 248.45) and disposal in EMWMF. As characterization data become available, refinements to these studies may be made to serve as useful tools in planning building demolition and remediation.

WHPs will address the selected treatment path and ability to meet treatment standards, and are required if waste is dispositioned on-site at EMWMF as noted by the red diamonds in the figure. Regulatory interaction and acceptability 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 off-site commercial treatment. To be considered cost-effective, on-site 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 (5 or more years); provisions for on-site treatment of *intermittent and/or a low quantities* of mixed waste soil and sediment may not be cost-effective.

3.3.4 *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. Variance requests to regulators addressing waste form endstates need to be investigated/applied for depending on results of these efforts. Very little work has been done to date exploring options for *in situ* treatment of mercury, 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, while *in situ* treatments are not technologically advanced enough to be implemented currently, advancements may yet be made, and it should remain a consideration in future analyses.



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.

Figure 9. LDR Logic Diagram for Treatment of Radioactive Waste Contaminated with Mercury

3.3.5 Decision Making

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, and 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.

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. Currently defined endstates for various waste streams, possible issues, and strategy approaches are given in Table 4.

3.4 STRATEGY IMPLEMENTATION

3.4.1 Near-Term Control of Mercury Releases

Several projects to control mercury releases to UEFPC were recently completed. These projects were funded with remaining ARRA funds in late 2012 and early 2013, and are listed in the strategy Figure 8 under the FY 2012 column and described further in Table 5. Regulatory documentation and the generic strategy category are noted in the table for each activity. These projects were recently completed with the exception of the OF200 MTF. This activity included only development of the conceptual design of the facility and some sampling/analysis at the Outfall. Full design, construction, startup, and operation are addressed as a project to begin execution in FY 2015 as discussed in the next section.

3.4.2 Outfall 200 Mercury Treatment Facility

A near-term ARRA-funded project has recently provided the conceptual design of the OF200 MTF. The conceptual design of the OF200 MTF is based on a design criteria of 1500 gpm base flow and obtaining a mercury concentration in the effluent of at most 200 ppt (per goal identified in the UEFPC Phase I ROD). The facility is scalable and designed to allow for future expansion/addition of unit operations if needed; the 200 ppt effluent goal may be revisited with the stakeholders in the future based on actual performance of the OF200 MTF. Further investigations into mercury concentration during storm events and refinement of contributors to the base flow (possible diversion/interception modifications) will be considered in the final design.

Conceptual design included an alternatives analysis to explore various treatment options for removal of mercury from water (e.g., the current treatment using granular activated carbon such as is employed at BSWTS and CMTS versus filtration only). These and other options were examined and compared on several levels. The CD-1 submittal will document the conceptual design report (CDR) per DOE requirements, and an enforceable FFA milestone documenting the CDR is scheduled for June 30, 2013.

Full system design is expected to proceed following the conceptual design and result in a CD-2/3 submittal to fulfill DOE requirements and obtain construction start approval, in accordance with DOE O 413.3B. The remainder of this scope, construction of the treatment system, will be executed as a capital project in accordance with DOE O 413.3B, ending with submittal and approval of CD-4.

Table 4. Endstates for Mercury-Contaminated Media

Media	Current Defined Endstate	Endstate Achievable?	Strategy
Building D&D Waste			
Legacy Material (LM) and Waste	Mercury-contaminated LM has been treated and disposed of off-site through commercial facilities.	Endstate disposal in approved off-site 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 on-site 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 40 CFR 268 definition of debris, may be managed per debris entry below. If not, must be treated off-site.	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 9). 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 to show macroencapsulation/stabilization meets performance standards. Forecast of waste destined for EMWMF needs to be clarified for planning purposes. (e.g., macro-encapsulation of debris at EMWMF requires preplanning re: 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 off-site disposal.	Amalgamation is proven technology, but requires off-site treatment and disposal. Stabilization using SPSS technology achieved and variance granted to Brookhaven National Lab (EPA 1998).	Off-site amalgamation is proven and acceptable. Elemental mercury volumes are not expected to be large enough to make on-site treatment and disposal economically necessary or feasible.
Building Slab (Interim endstate following building demolition and prior to remediation)			
Building Slab Interim Endstate	The state that building slab is left in, the endstate 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 storm water 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 endstate 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 inleakage/groundwater in wind tunnels continued by appropriate treatment facilities.
Soils, Sediments, Subsurface Structures			
Excavated Soil and Sediment Waste	Soil must meet LDRs for disposal at EMWMF. See logic diagram (Figure 9). 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 on-site versus off-site 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 ground water. 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.
Water			
Surface water	UEFPC Phase 1 ROD defines the surface water at Station 17 goal as human health recreational risk-based value for mercury of 200 ppt.	Operating treatment facilities and future OF200 MTF treat to 200 ppt mercury or below.	Maintain focus and emphasis on need to reduce loading of mercury from Outfall 200 by construction of a facility to treat this loading. Facility will be designed to enable expansion in terms of capacity and treatment efficiency.
Groundwater	Not currently defined beyond generic standards. Future ROD will address groundwater.	To be determined (TBD)	TBD

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Table 5. Near-Term Activities to Reduce Mercury Releases

Activity	Generic Strategy	Regulatory/DOE Submittal(s)
Outfall 200 Mercury Treatment Facility. Under ARRA funding, the conceptual design for a water treatment system to reduce mercury concentration in UEFPC has been developed. Outfall 200 is the integration point of many surface water and groundwater sources with a total base flow of ~1,500 gpm that can vary substantially based on weather conditions. The conceptual design included an alternatives analysis that explored various treatment options and configurations. Options were examined and compared based on criteria (such as complexity, secondary waste generation, technology readiness level, reliability, and cost). DOE-required documentation is being developed to support the capital project to construct and startup the facility. A remedial design work plan will be submitted to regulators in the latter half of FY 2013.	Capture and Treat	Amendment to UEFPC Phase I ROD CDR and Remedial Design Work Plan CD-1
Free Mercury Removal. This project removes free mercury from accessible areas of major storm drains at the site by having installed nine mercury traps at locations upstream from outfalls to UEFPC. These mercury traps, installed in manholes throughout the WEMA area, remove mercury through settling and separating mercury, which deposits in traps as the flow moves through the sewer system. A total of approximately 26 lbs of elemental mercury was recovered from major storm drain areas during 2012. Elemental mercury will continue to be collected and removed from the traps.	Source Removal	Removal Action Report
Mercury Secondary Pathways. The purpose of the Secondary Pathways project is to identify and correct potential water infiltration and mercury migration points at the three large former mercury-contaminated process buildings (Alpha-4, Alpha-5, and Beta-4). Secondary water infiltration around the three facilities was mitigated by modifying drains, drainage systems, and installing graded surfaces to ensure surface water runoff is appropriately routed to storm drains thereby reducing water percolation through mercury-contaminated soil. Resulting waste soils were packaged and will be shipped for treatment and/or disposal.	Water Management	Phased Construction Completion Report (PCCR)
Mercury-Contaminated Soils Treatability Study. This subproject evaluates technologies and capabilities to stabilize mercury-contaminated soil to meet LDRs. Three vendors received excavated mercury-contaminated soils from Y-12 and successfully completed demonstrations for treating the materials using sulfur polymerization solidification/stabilization. All three treatability studies were successful in meeting the 40 CFR, Part 268.49 “Alternative Treatment Standard for Contaminated Soils” by achieving the required TCLP concentration of <0.2 mg/L for mercury. One additional technology which did not receive a soil sample for demonstration was recommended for further evaluation.	Technology Development	Treatability Study Report
Disposal of Five Excess Tanks. The project has dispositioned five excess tanks from the Y-12 site. Characterization was completed; two tanks were disposed at the ORR Landfills and three have been sent to an off-site vendor for disposal. About 650 pounds of elemental mercury were removed and disposed from these tanks.	Source Removal	PCCR Addendum
81-10 Characterization. Characterization of a limited area (known as the 81-10 Area) within EU 9 was completed. An area was designated for future excavation due to mercury contamination.	Source Removal	Remedial Design Report

3.4.3 Building D&D

At the Y-12 site, building D&D encompasses the demolition of approximately 100 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:

- 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 8) includes executing these four D&D projects. Components of building D&D projects include development of regulatory and DOE documentation as noted in the schedule, as well as the activities described in the following three subsections.

3.4.3.1 Legacy Material Removal and Characterization

Legacy material characterization and legacy material removal/disposition (LMR) is the first step in preparation of demolition. Legacy material encompasses any material, waste, or equipment 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). Legacy material requires characterization to determine the disposition pathway and development of a WHP should waste be sent to the on-site disposal facility, EMWMF, along with accompanying closeout reports as noted. To date, a significant amount of legacy material has been successfully disposed (see Figure 8, all LMR for Alpha-5 has been completed; Beta-4, second floor LMR has been completed and first floor and basement still remain). The remaining LMR scope for the facilities is expected to be accomplished using the same or similar methods.

Building characterization is completed once all legacy materials have 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 completely characterized with the exception of the basement/wind tunnels (ORISE 2012). The process of characterizing Alpha-5 (including development and approvals of Data Quality Objectives (DQOs), Sampling and Analysis Plan (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 scabbling or other separation/extraction techniques, if used, can provide a benefit by decreasing volumes of debris requiring treatment. A gap analysis is being prepared for characterization of the remaining mercury-use facilities. A WHP(s) for the building(s) is then developed prior to demolition.

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 8) shows CD-2 initiating well before demolition.

3.4.3.2 Pre-Demolition

Pre-demolition work – or deactivation – consists of venting, purging, 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 prior to demolition; beryllium is stabilized with a fixative prior to invasive work; radioactive contamination is sometimes managed with a fixative spray); and possibly removal/disposal of some process equipment. Deactivation requires entrance to the building, and can pose problems when a building is allowed to deteriorate. A single WHP is typically completed for pre-demolition and demolition waste.

3.4.3.3 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 3.4.3.1. CD-3 approval, *Start of Construction*, will signal the start of demolition. Building demolition includes activities such as:

- Mobilization/demobilization
- Removal/disposition of hot spots (segregation of waste) [alternatively this may be completed under pre-demolition]
- Removal/disposition of non-friable asbestos (e.g., transite siding)
- Removal/disposition of interior process equipment and structures
- Demolition of exterior structures and disposition of resulting debris
- 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 storm water and mercury-contaminated decontamination water/dust suppression water during demolition activities may be required, and would be provided by the OF200 MTF, currently projected to be operational prior to the start of demolition. Suppression of the groundwater table during demolition may need to be considered.

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

3.4.4 Soil, Sediment, Subsurface Structure Remediation

Soils under buildings are presently not well characterized. Some data exist (BJC 1999b); however, 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 has been proposed for FY 2013 and should give some indication regarding contamination levels and extent of contamination.

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 interim RODs 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 identified in Section 3.4.1. Those options include on-site treatment with SPSS and on-site disposal at EMWMF as well as other commercial treatment options with on-site and off-site disposal options. Isolation technologies may offer comparable environmental protection and at lower cost, but are not technologically mature and require further research and development before application can be considered. The current default treatment for these media 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 EU 1a&b to meet land use and groundwater protection criteria. Additionally, remediation of soil surrounding and beneath each mercury-use facility is sequenced to follow demolition of that building,

Some storm sewer sediments have already been removed (in 2011) using ARRA funding. Sediments in UEFPC will need to be removed or contained at some point. 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. 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.

3.5 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 Office of Science (SC) and applied technology activities conducted under DOE EM. 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 Science Focus Area (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.

Within the Environmental Management Program, the Applied Research and Technology Development 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.

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:

- **Mercury Source Identification and Measurement:** Improvements can be made in identifying mercury sources in building materials and near facilities, monitoring the form and concentration of mercury in surface and groundwater systems; and field screening soils. For example, supplemental characterization of mercury contamination in surface and subsurface sediments and near facilities within WEMA is planned. This activity will support refining the estimated amount of mercury-contaminated environmental media that will need to undergo treatment and disposal. The characterization involves using real-time, vapor-phase measurements.
- **Treatment of Mercury-Contaminated Debris, Soil, 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 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 on-going, 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 define achievable alternative end states.

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 8. The benefit of the 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. Furthermore, technology development activities will also:

- Reduce the overall project schedule by increasing the technical maturity of unproven approaches and technologies.
- Reduce the uncertainty associated with implementation of these approaches and technologies.
- 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

Planning and sequencing of Y-12 OREM projects for the CD-1 baseline was completed based on a regulatory strategy that is 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) was part of CD-1 conceptual design and planning, and is consistent with this strategy plan and baseline information presented herein. Table 6 summarizes the CERLCA documents required for project activities. The strategic schedule (Figure 8) appropriately schedules the CERCLA and DOE documents expected to be required prior to the execution of the specified projects.

Table 6. Summary of Required CERCLA Documentation and DOE-Required Documentation Needed to Proceed with Mercury Source Removal Projects

Activity/Project	Required CERCLA Documentation and Approvals[a]	Required DOE Documentation and Approvals[b]
Legacy Material	• DQOs • RAWP* • WHP*/ SAP/Quality Assurance Program Plan (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) • PCCR*	• CD-2 Approve Performance Baseline • CD-3 Approve Start of Execution • CD-4 Project Closeout
All Building Complexes Demolition	• Remedial Action Report (RAR)*	• NA
Soils/Subsurface Characterization	• DQOs • WHP*/SAP/QAPP (one for whole EU remediation) • Nature and Extent Characterization	• See footnote c
Subsurface Remediation	• DQOs • WHP*/SAP/QAPP • TM • PCCR*	• CD-2 Approve Performance Baseline • CD-3 Approve Start of Execution • CD-4 Project Closeout
Soils Remediation	• DQOs • RAWP Addendum* • WHP*/SAP/QAPP • TM • PCCR*	• CD-2 Approve Performance Baseline • CD-3 Approve Start of Execution • CD-4 Project Closeout
Sediment Characterization	• DQOs • RAWP* • WHP*/SAP/QAPP • Nature and Extent Characterization	• See footnote c
Sediment Remediation	• 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	• RAR*	• 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 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.
[c]These activities are typically completed prior to CD-3. However, much of the documentation required is similar (e.g., Work Plans, Safety Basis, Environmental, Safety, and Health Plan, etc.)
*These documents are primary FFA documents.

3.7 RISKS AND OPPORTUNITIES

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

- **Off-site release of mercury –** mercury concentrations in fish continue to be elevated and have not responded to earlier actions to reduce creek concentrations and loading. The relationship between effluent concentrations and mercury in fish is non-linear.
- **Mercury leach testing protocol –** TCLP protocol is being examined by EPA and may be modified. This may 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.
- **Funding availability –** Funding availability is driven by economic mechanisms that can negatively affect the schedule for remediation of Y-12.

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. Therefore, a final evaluation of efforts that may be needed to influence fish tissue mercury concentrations cannot be made until after source removal is completed. In the interim, reduction of mercury flux will be addressed through construction and operation of the OF200 MTF and flow augmentation modification. Recent ARRA-funded activities, installation of mercury traps and secondary pathways modifications, have and will continue to result in mercury reductions in pathways.

Mercury remediation projects have risk management plans and associated contingencies. The remaining risks identified here, TCLP protocol modifications and funding availability, as well as other risks not addressed here, are captured and managed within the baseline.

Opportunities associated with mercury remediation at Y-12 currently being implemented, or to be implemented in the future, include:

- **Targeted hot spot removal of mercury-contamination –** targeted removal of mercury-contaminated debris and soil “hot spots” (identified through nature and extent characterization) will allow for reduced treatment costs.
- **Consolidation of CERCLA/DOE documentation –** the existing RAWP for UEFPC soils (EDI 2010a) has been written to encompass all EUs that will require remediation, with the idea that addendums may be added to address the individual areas as the work becomes more defined. Consolidation of other CERCLA and DOE documentation in a likewise manner, where possible, will be pursued.
- **Gap analysis of building characterization –** an ongoing assessment of the mercury-use facility complexes considers existing structural characterization and historical documentation to identify outstanding data gaps. Results of the analysis will help target and minimize needed future building characterization.
- **Optimization of OF200 MTF design** – continue to refine conceptual design of the treatment system by gaining an understanding of the storm flow mercury concentrations and further investigation of contributors to the base flow (possible diversion/interception modifications).

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4. 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. A total of 41 projects have been defined to complete the cleanup of Y-12, of which 12 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 BASELINE PROJECTS

Forty-one projects are defined in the OREM baseline to accomplish the cleanup at Y-12. Figure 10 lists 38 of those projects, arranged by the overarching CERCLA decision documents. The remaining three projects not shown in the figure include ongoing and future Surveillance and Maintenance (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; two projects to design, construct, and operate the OF200 MTF; and two projects to develop UEFPC RODs.

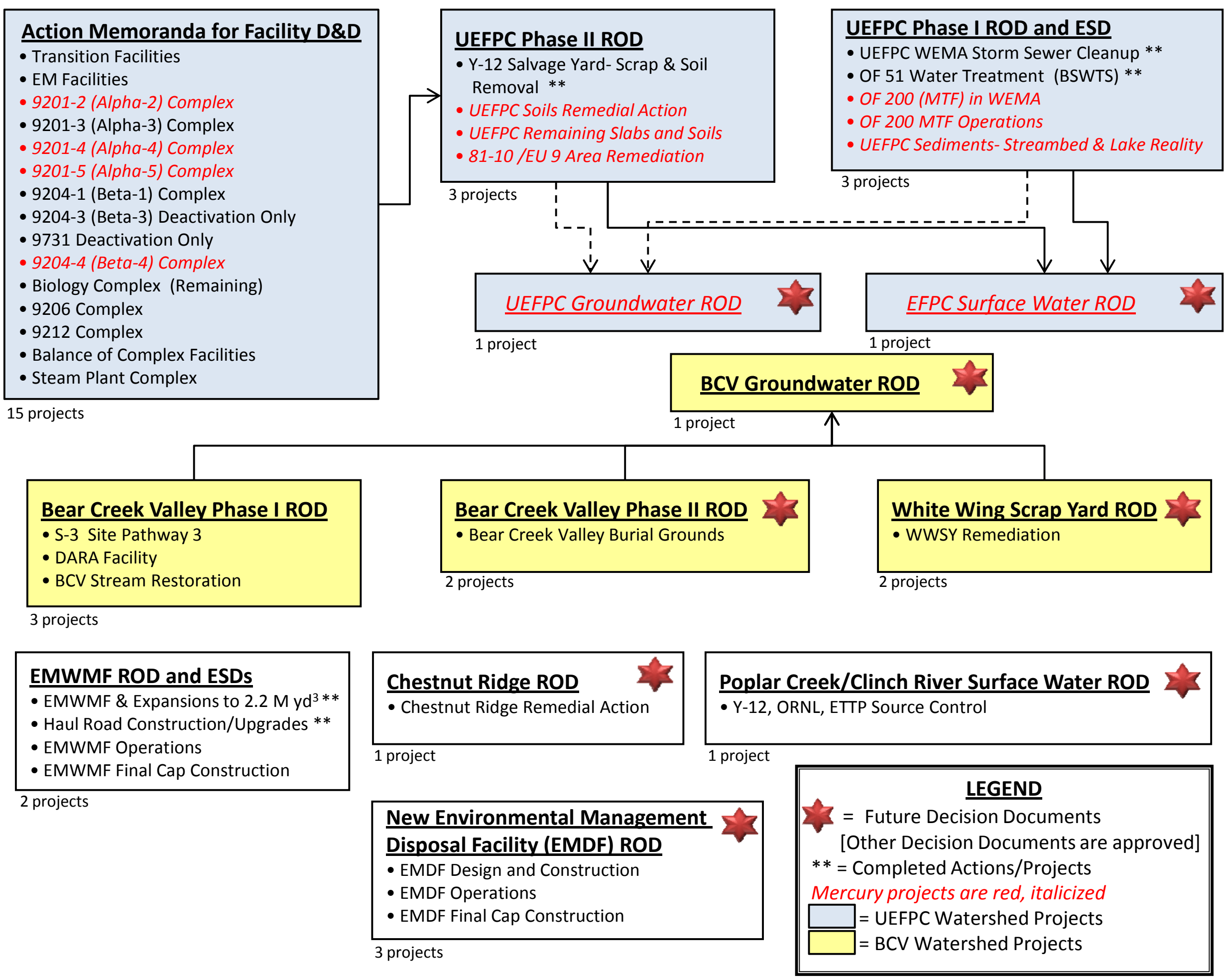

Figure 10. Project Summary for Y-12, Grouped by CERCLA Decision Document

A detailed list of the Y-12 projects is given in Attachment A along with a list of all facilities in the 15 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). Annual funding levels subsequently drive the time-phased sequencing of the OREM program projects to create the OREM baseline.

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 prioritized goals are to:

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

Based on these goals, Y-12 projects have been prioritized with mercury remediation being the 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 – to provide immediate reduction of mercury leaving site and to be in place and operational to provide mercury removal capabilities during demolition activities.
- Beta-4 – 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, and is addressed in an ESD to the Phase I ROD (EDI 2011); working west to east will minimize the possibility of re-contaminating cleaned areas.
- Soils cleanup is being completed by EU where possible, and 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 and from an EU by EU perspective. Soil remediation for each mercury-use facility will follow the demolition of that facility.
- Alpha-5 – the building has been characterized and all legacy material has been removed; facility is beginning to deteriorate; delays in gaining entrance for deactivation activities may add costs needed for reinforcement of structure in the future and increase S&M costs. Soil remediation is sequenced to follow after the complex demolition.
- Alpha-4 – building is to the east of Alpha-5, and is therefore sequenced to follow Alpha-5 demolition.
- Remediation of 81-10 Area 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 2023, it may be possible to pull the project forward if funding becomes available.
- Alpha-2 – building demolition is prioritized lower and sequenced later since the building and surrounding area is served by the BSWTS for mercury treatment of building basement inleakage 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 right after 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, thus minimizing the period of "vulnerability" would be desirable and (2) if the approach is to fill in the subsurface structure with flowable fill in order to avoid the previously mentioned issue, more waste is/may be generated during remediation and increase cost.

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 11. Appendix A 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% of forecasted cost (including operation of the OF200 MTF), all other D&D/remediation accounts for 25%, and the remaining 50% 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 in the range of $7.5 to 8.4 B, and is expected to take 34 more years to complete at the level of funding currently projected for that period.

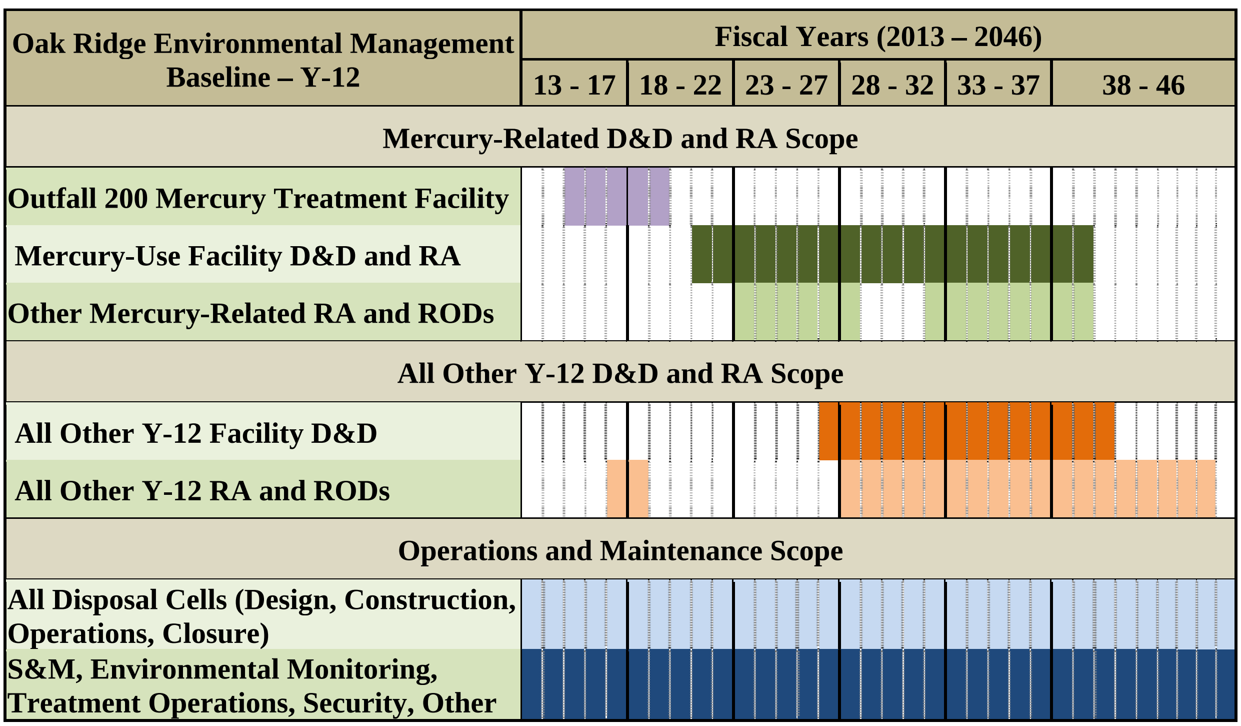

Figure 11. Y-12 EM Cleanup Project Summary Schedule

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5. 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 where surface water mercury concentrations are concerned (e.g., WEMA storm sewer cleanout increased mercury flux), and future demolition activities are expected to generate runoff requiring treatment for mercury. Recent ARRA-funded actions that have advanced mercury remediation efforts at the site include:

- Cleanout of mercury-contaminated sediment from the WEMA storm sewer system has resulted in a significant decrease in mercury flux measured at Outfall 200.
- Three recent demonstrations of SPSS for the treatment of mercury-contaminated Y-12 soils were successfully completed. A follow-on study summarizes the regulatory path and approvals, treatment methods and facilities, disposal locations, and costs associated with management of mercury-contaminated soil.
- Legacy material has been removed from Alpha-5 and portions of Beta-4 in anticipation of future demolition.
- Characterization of the Alpha-5 building has been completed and will serve as the basis of a WHP for the building debris disposition.
- Re-routing building and terrain runoff (Mercury Secondary Pathways Project) and installing mercury traps in WEMA pipelines (Free Mercury Removal) are small-scale methods to reduce mercury input to UEFPC with potentially large paybacks (e.g., 26 pounds of elemental mercury removed to date through the mercury traps).

Mercury has been identified as the largest environmental risk on the ORR stemming from on-going releases of mercury in UEFPC to off-site, 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 near-term 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 necessary treatment for future demolition/remediation-generated contact storm water and decontamination water. Optimization of the facility design in terms of treatment method, secondary waste generation, through-put versus cost, and mercury removal efficiency will be considered, as will be methods to reduce the volume of base flow and storm water sewer contributions going to Outfall 200, to ultimately reduce the volume of water requiring treatment at the OF200 MTF.
- Flow augmentation will be modified/relocated or eliminated and is expected to result in a reduction of mercury flux at Station 17.
- 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 managing the expected waste debris and soil. A significant step toward identifying the soil management path has been addressed through the soils feasibility study (UCOR 2012). A similar debris study may be desirable, based on the current plan to macroencapsulate mercury-contaminated debris at the EMWMF. Working with regulators, the path forward on managing the expected mercury-contaminated soils and debris will be defined and approved prior to the actual execution of these projects. Advance planning will allow efficiencies and cost reductions 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.

The on-going and future mercury remediation at Y-12 is an extremely large and complex problem from all perspectives: chemical, geological, ecological, physical, regulatory, and monetary. Efforts are being made daily by multiple contractors, regulators, and DOE officials to define, develop, and implement solutions to the issues. This strategic plan helps to organize and focus 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.

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ATTACHMENT A:
Y-12 PROJECT INFORMATION

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Y-12 OREM Baseline Projects

(Summary Level)	Mercury-Related D&D and Remediation Scope
(Summary Level)	Outfall 200 Mercury Treatment Facility, Design, Construction, Operation
• (Project level) – note, ongoing projects are **BOLDED**	• Outfall 200 Water Treatment Facility
	• Outfall 200 Water Treatment Facility Operations
	Mercury-Use Facility D&D and Associated Soils
	• Alpha-2 Complex
	• Beta-4 Complex
	• Alpha-4 Complex
	• Alpha-5 Complex
	Other Mercury-Related Soil/Sediment Remediation and RODs
	• UEFPC Soils Remedial Action
	• UEFPC Remaining Slabs and Soils
	• UEFPC Soils 81-10 Area
	• UEFPC Sediments - Streambed and Lake Reality
	• UEFPC Groundwater Record of Decision
	• EFPC Surface Water Record of Decision
	All Other Y-12 D&D and Remediation Scope
	• Alpha-3 Complex
	• Beta-1 Complex
	• Beta-3 Prep for Historical Preservation
	• Remaining Biology Complex
	• 9206 Complex
	• 9212 Complex
	• Steam Plant Complex
	• Balance of Facilities Complex
	• Transition Facilities
	• Y-12 EM Facilities
	• 9731 Prep for Historical Preservation
	• BCV Burial Grounds Record of Decision
	• BCV S-3 Ponds Pathway 3
	• BCV DARA Facility
	• BCV Stream Restoration
	• BCV Burial Grounds Remedial Action
	• BCV White Wing Scrap Yard Record of Decision
	• BCV White Wing Scrap Yard Remedial Action
	• BCV Groundwater Record of Decision
	• Chestnut Ridge Record of Decision and Remedial Action
	• Clinch River/Poplar Creek Surface Water Record of Decision
	Y-12 Operations Scope
	S&M/Environmental Monitoring and Reservation Management
	• **Y-12 S&M/Environmental Monitoring**
	• Y-12 S&M/Environmental Monitoring New
	• Reservation Management
	Disposal Cells (Planning, Construction, Operations, and Closure)
	• **EMWMF and ORR Landfills Operations**
	• EMWMF Final Cap Construction
	• EMDF Design and Construction
	• EMDF Operations
	• EMDF Final Cap Construction

Demolition Projects, Facility Program Owners, and Gross Square Footage

(Mercury-Use Complexes are Highlighted)

D&D Project	No. of Facilities to be Demolished Total	Demolition Gross sq ft	Deactivation Only Gross sq ft	Program Owner	No. of Facilities by Program	Demolition Gross sq ft by Program
Alpha-2 Complex	4	332,595		NNSA	2	7,667
				SC	2	324,928
Alpha-3 Complex	3	196,870		NNSA	3	196,870
Alpha-4 Complex	4	513,374		EM	1	510,218
				NNSA	3	3,156
Alpha-5 Complex	15	662,541		NNSA	15	657,575
Beta-1 Complex	3	213,162		NNSA	1	N/A
				SC	2	213,162
9731 Prep for Historical Preservation (sq ft and facility count not included in totals)	0	N/A	37,159	NNSA	1	0
Beta-3 Prep for Historical Preservation (sq ft and facility count not included in totals)	0	small	0	NNSA	1	small
		N/A	255,656	NE	1	0
Beta-4 Complex	10	347,132		NNSA	10	347,132
Remaining Biology Complex	8	346,278		SC	8	346,278
9206 Complex	5	75,650		NNSA	5	75,650
9212 Complex	26	548,709		NNSA	26	548,709
Balance of Facilities	6	2,097		EM	3	701
				NNSA	2	716
				SC	1	680
Steam Plant Complex	6	68,951		NNSA	6	68,951
Transition Facilities	2	37,308		EM	2	37,308
Y-12 EM Facilities	7	54,313		EM	7	54,313
TOTALS	**99**	**3,398,980**	**292,815**	**EM**	**13**	**602,540 sq ft**
				NNSA	**73 ***	**1,911,392 sq ft**
				SC	**13**	**885,048 sq ft**
				NE	**1 Building, Deactivation Only**	

EM=Office of Environmental Management; N/A = not applicable; NE=Office of Nuclear Energy; NNSA=National Nuclear Security Administration; SC=Office of Science; sq ft=square feet.
* In addition to the 73 buildings, NNSA owns two facilities that will be deactivated only.