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Focused Feasibility Study for Water Management for the Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee

PRO-2-SERVE

contributed to the preparation of this document and should not be considered an eligible contractor for its review.

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Focused Feasibility Study for Water Management for the Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee

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Oak Ridge Office of Environmental Management

United Cleanup Oak Ridge LLC
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ACRONYMS

AWQC	ambient water quality criteria
ARARs	applicable or relevant and appropriate requirements
BCBG	Bear Creek Burial Grounds
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COCs	contaminants of concern
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EMDF	Environmental Management Disposal Facility
EMWMF	Environmental Management Waste Management Facility
ETTP	East Tennessee Technology Park
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FFS	Focused Feasibility Study
FR	Federal Register
HDPE	high-density polyethylene
LWTS	Landfill Wastewater Treatment System
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
OF200 MTF	Outfall 200 Mercury Treatment Facility
PRG	preliminary remediation goal
PWTC	Process Water Treatment Complex
RCRA	Resource Conservation and Recovery Act
RI/FS	Remediation Investigation/Feasibility Study
ROD	Record of Decision
TBC	to be considered
TDEC	Tennessee Department of Environment and Conservation
UEFPC	Upper East Fork Poplar Creek
WAC	waste acceptance criteria
Y-12	Y-12 National Security Complex

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EXECUTIVE SUMMARY

The purpose of this Focused Feasibility Study (FFS) is to evaluate alternatives for the management of landfill wastewater generated from the onsite disposal of Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA) waste from the Oak Ridge Reservation (ORR) and associated sites. The waste has been disposed at the Environmental Management Waste Management Facility (EMWMF) and will be disposed in the future at the proposed Environmental Management Disposal Facility (EMDF).

The D2 version of this FFS was submitted from the U.S. Department of Energy (DOE) to the U.S. Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC) in April 2016, and the document went into the formal dispute process in August 2018. The EPA Administrator issued a final decision in December 2020 resolving the dispute among EPA, TDEC, and DOE regarding the discharge to surface water of wastewaters generated during a response action under CERCLA at the ORR facility (Wheeler, A. R.).

The D3 revision to the FFS addressed the direction given in the EPA's Dispute Resolution Decision Letter. The primary revisions were made in Appendix K, Revised Discharge Limits for Landfill Wastewater; Sect. 3.2; Appendix M, EPA Administrator's Dispute Resolution Letter; and Appendix D, Applicable or Relevant and Appropriate Requirements. This D3 revision was not intended to be a comprehensive update. Additional minor revisions were made throughout the document, only to the extent required to accommodate the EPA's Dispute Resolution Decision Letter. The preliminary remediation goals (PRGs) and preliminary discharge requirements contained in the D3 FFS were developed solely for the purpose of evaluating landfill wastewater discharge alternatives. Final discharge limits were deferred to the EMWMF and EMDF project teams, to be provided in the EMWMF and EMDF Records of Decisions (RODs) and/or applicable post-ROD documents.

The D4 revision to the FFS updated the main text of the report to incorporate changes from the EPA and TDEC comments on the D3, to reflect the current proposed location for EMDF and to reflect changes made in wastewater treatment and management that have been made since the D2 and D3 versions. Additional revisions were made to the following Appendices:

- Appendix C—revised to update the data presented. All tables, graphs and descriptions were updated.
- Appendix E—restored to original, more conservative appendix in the D1/D2/D3 versions.
- Appendix J—revised/replaced per the Federal Facilities Agreement (FFA) parties agreement.
- Appendix K— the radiological section was completely revised to incorporate the development of PRGs for landfill wastewater. The non-radiological section was updated with more recent information.

The D4/R1 revision to the FFS replaces Appendix E with the original Appendix, which is more conservative and bounding, and adds Appendix N with FFA Party agreements on mercury and radiological discharge PRGs. This revision also incorporates informal EPA input and TDEC comments on the D4.

Currently, contact water from EMWMF is discharged to Bear Creek if it meets the discharge limits that are based on the fish and aquatic life criterion maximum concentration ambient water quality criteria. If the contact water does not meet the discharge limits, it is conditioned to meet the discharge limits or transferred by tanker truck to the Process Water Treatment Complex (PWTC) at the Oak Ridge National Laboratory for treatment and disposal. Leachate is transferred by tanker truck to PWTC for treatment and disposal

The alternatives evaluated are:

- Alternative 1: No Action
- Alternative 2: Managed Discharge/Treat at EMWMF/proposed EMDF site
- Alternative 3: Treat at the PWTC at the Oak Ridge National Laboratory
- Alternative 4: Treat at Outfall 200 at the Y-12 National Security Complex

All alternatives, except No Action, meet the threshold criteria of overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements. Alternative 2 can be implemented immediately at EMWMF for existing discharge limits for no additional capital cost. Capital costs are required for construction of a right-sized, adaptable landfill wastewater treatment system that will provide treatment to meet the new discharge limits with the ability to adapt to changing contaminants of concern (COCs). Since neither the PWTC nor the Outfall 200 Mercury Treatment Facility are designed to treat all the key COCs in the landfill wastewater, both alternatives require pre-treatment in order to provide long-term effectiveness. In addition, the landfill wastewater has to be transported to both sites. Therefore, the capital cost of these alternatives is greater than Alternative 2. Alternatives 2, 3, and 4 are all easy to implement because the treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easy to construct using standard equipment and techniques.

While this FFS describes the landfill wastewater management evaluation for both EMWMF and the proposed EMDF, implementation will be tailored to the current phase of the CERCLA process for each. EMWMF is currently operating and is nearing capacity, while the proposed EMDF is in the CERCLA planning process.

- Proposed EMDF. The selection and approval of a landfill wastewater management alternative was originally intended to be included in the proposed plan. However, due to the length of time for resolution of the formal dispute on the D2 FFS, the FFA parties agreed to issue the EMDF Proposed Plan for public comment in September 2018 without a recommendation for landfill wastewater management. In May 2022, DOE issued a Water Quality Protection for Bear Creek Fact Sheet for additional public comment. Public comments and responses to those comments will be documented in the Responsiveness Summary of the ROD. The EMDF ROD will document acceptance of the selected remedy. Implementation of landfill wastewater management will continue as part of the normal CERCLA process for the proposed EMDF, from design to initiation of operations.
- EMWMF. An Explanation of Significant Differences for the EMWMF ROD will be prepared to include landfill wastewater management and provided for public review and comment. Following approval, the remedial action work plan, operations plan, and the sampling and analysis plan/quality assurance project plan will be revised for implementation.

1. INTRODUCTION

1.1 PURPOSE

The purpose of this Focused Feasibility Study (FFS) is to evaluate alternatives for the management of landfill wastewater generated from the onsite disposal of Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA) waste from the Oak Ridge Reservation (ORR) and associated sites. This CERCLA waste is currently being disposed at the onsite Environmental Management Waste Management Facility (EMWMF) and will be disposed in the future at the proposed onsite Environmental Management Disposal Facility (EMDF). EMWMF is located in the Bear Creek watershed. The proposed EMDF is planned to be constructed in the same watershed.

The alternatives will provide both short-term and long-term solutions for the management of landfill wastewater generated during operation of the disposal facilities and during post-closure. This solution will supersede any previous decisions (*Addendum to Remedial Design Report for Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee* [DOE/OR/01-1873&D2/A1/R2]) for landfill wastewater management. During the planning process for the proposed EMDF, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Tennessee Department of Environment and Conservation (TDEC) agreed to evaluate the management of landfill wastewater in an FFS and then to integrate the evaluation into the decision-making documents for the proposed EMDF and EMWMF.

This is an FFS because it only addresses the management of landfill wastewater generated from EMWMF and the proposed EMDF. The evaluation from this FFS will be included in the appropriate EMWMF CERCLA decision-making documents (see Sect. 1.10, “Estimated Timeline”). The appropriate CERCLA decision-making documents are described for each alternative (Sect. 3.3, “Description of Alternatives”).

Because this FFS is focused only on landfill wastewater management from engineered facilities, the hydrogeology of the site, soils information, and ecological information is not included in this FFS. This information is contained in the *Remedial Investigation/Feasibility Study for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste* (DOE/OR/02-1637&D2 and DOE/OR/02-1637&D2/A1) and the *Remedial Investigation/Feasibility Study for Comprehensive Environmental response, Compensation, and Liability Act, Oak Ridge Reservation Waste Disposal, Oak Ridge, Tennessee* (DOE/OR/01-2535&D5).

The D2 version of this FFS was submitted from DOE to EPA and TDEC in April 2016, and the document went into the formal dispute process in August 2018. The EPA Administrator issued a final decision in December 2020 (Wheeler, A. R.) resolving the dispute among EPA, TDEC, and DOE regarding the discharge to surface water of wastewaters generated during a response action under CERCLA at the ORR facility (see Appendix M).

The D3 revision to the FFS addressed the direction given in the EPA Administrator’s Dispute Resolution Decision letter. The primary revisions were in Appendix K, Revised Discharge Limits for Landfill Wastewater; Sect. 3.2; Appendix M, EPA Administrator’s Dispute Resolution Letter; and Appendix D, Applicable or Relevant and Appropriate Requirements. The D3 version was not intended to be a comprehensive update. Additional minor revisions were made throughout the document, only to the extent required to accommodate the EPA’s Dispute Resolution Decision Letter. The preliminary remediation goals (PRGs) and preliminary discharge requirements contained in the D3 FFS were developed solely for the purpose of evaluating landfill wastewater discharge alternatives. Final discharge limits will be developed by the EMWMF and EMDF project teams, to be provided in the EMWMF and EMDF Records of Decisions (RODs) and/or applicable post-ROD documents.

The D4 revision to the FFS updates the main text of the report to reflect the current proposed location for EMDF and to reflect changes made in wastewater treatment and management that have been made since the D2 and D3 versions. Additional revisions were made to the following Appendices:

- Appendix C—revised to update the data presented. All tables, graphs and descriptions were updated.
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The D4/R1 revision to the FFS replaces the previously revised Appendix E with the original Appendix, which is more conservative and bounding. Appendix N was added with the FFA party agreements on mercury and radiological discharge PRGs. This revision also incorporates TDEC comments on the D4.

1.2 ORGANIZATION OF THE STUDY

This FFS consists of six chapters and supporting appendices.

- Chapter 1, "Introduction," describes the purpose of the study and site conditions.
- Chapter 2, "Remedial Action Objectives," presents the objectives of the study and an introduction to the applicable or relevant and appropriate requirements (ARARs).
- Chapter 3, "Development and Description of Alternatives," summarizes the assemblage of representative process options into alternatives to meet the remedial action objectives and describes each alternative.
- Chapter 4, "Analysis of Alternatives," evaluates the ability of the alternatives and no action to achieve the evaluation criteria and to meet the remedial action objectives, and summarizes the alternative evaluations as compared to no action.
- Chapter 5, "References," provides full citations for documents used in the preparation of this study and cited in the main text.

The appendices provide supporting data and additional information, including:

- Appendix A, "Bear Creek Burial Grounds Evaluation," is an evaluation of Bear Creek Burial Grounds (BCBG) as a scope element.
- Appendix B, "Contact Water and Leachate Flow Rate," describes the development of flow rates.
- Appendix C, "Explanation of How the Key Contaminants of Concern Were Developed," provides an explanation of the key contaminants of concern (COCs).
- Appendix D, "Applicable or Relevant and Appropriate Requirements," is a complete set of proposed ARARs.
- Appendix E, "Mercury Concentration in Environmental Management Disposal Facility Leachate," is a projection of mercury concentration in the proposed EMDF leachate.

- Appendix F, "Leachate and Contact Water Waste Determination," is a discussion of waste determination for leachate and contact water.
- Appendix G, "Zero Discharge," evaluates the feasibility of zero discharge of landfill wastewater.
- Appendix H, "Water Storage Requirements," develops the amount of water storage required.
- Appendix I, "Basis of Cost Estimates," presents the basis of the cost estimates.
- Appendix J, "Screening Water Sampling Results for Evaluating Compliance with ARARs."
- Appendix K, "Development of Preliminary Remediation Goals for Fish Tissue and Surface Water for Landfill Wastewater."
- Appendix L, "Proposed Sampling Approach for the Water Management FFS."
- Appendix M, "EPA Administrator's Dispute Resolution Decision Letter."
- Appendix N. "FFA Parties, Emerging Issues Team Agreements"

1.3 SITE DESCRIPTION

The approximately 33,000-acre DOE ORR is located within and adjacent to the city limits of Oak Ridge, Tennessee in Roane and Anderson counties (Fig. 1). The ORR is bounded to the east and north by the developed portion of the city of Oak Ridge. The three major industrial, research, and production facilities originally constructed as part of the World War II-era Manhattan Project and currently managed by DOE are the East Tennessee Technology Park (ETTP), the Oak Ridge National Laboratory (ORNL), and the Y-12 National Security Complex (Y-12).

Historic nuclear research and national defense-related operations on the ORR have led to the contamination of soil, surface water, sediment, groundwater, and buildings and have resulted in burial of material at various sites on the ORR. Because of these contaminant releases, ORR was placed on the EPA National Priorities List established under CERCLA (54 *Federal Register* [FR] 48184, November 21, 1989). DOE, TDEC, and EPA signed the *Federal Facility Agreement for the Oak Ridge Reservation* (DOE/OR-1014) that describes how CERCLA remediation activities are performed on the ORR.

The Bear Creek watershed (Fig. 2) contains closed and active waste disposal facilities, including EMWMF and BCBG, and is the proposed location for the proposed EMDF. Several possible onsite disposal locations were evaluated in the Remedial Investigation/Feasibility Study (RI/FS) for various siting options in Bear Creek Valley, and the proposed EMDF is in Central Bear Creek Valley at the Site 7c location. Bear Creek is classified for fish and aquatic life, recreation, livestock watering and wildlife, and irrigation uses (TDEC 0400-04-03). Bear Creek is designated by TDEC as an impacted stream for mercury, cadmium, polychlorinated biphenyls (PCBs), and nutrients (nitrate and nitrite) (TDEC 2020, *Year 2020 303(d) List*) (TDEC 2020, Gettle, J.). The *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4) establishes protectiveness and cleanup levels for the Bear Creek watershed and specifies remedial actions for the S-3 Site, the Oil Landfarm Area (Oil Landfarm Soil Containment Pad, Boneyard/Burnyard, and North Tributary-3), and the Disposal Area Remedial Action Facility.

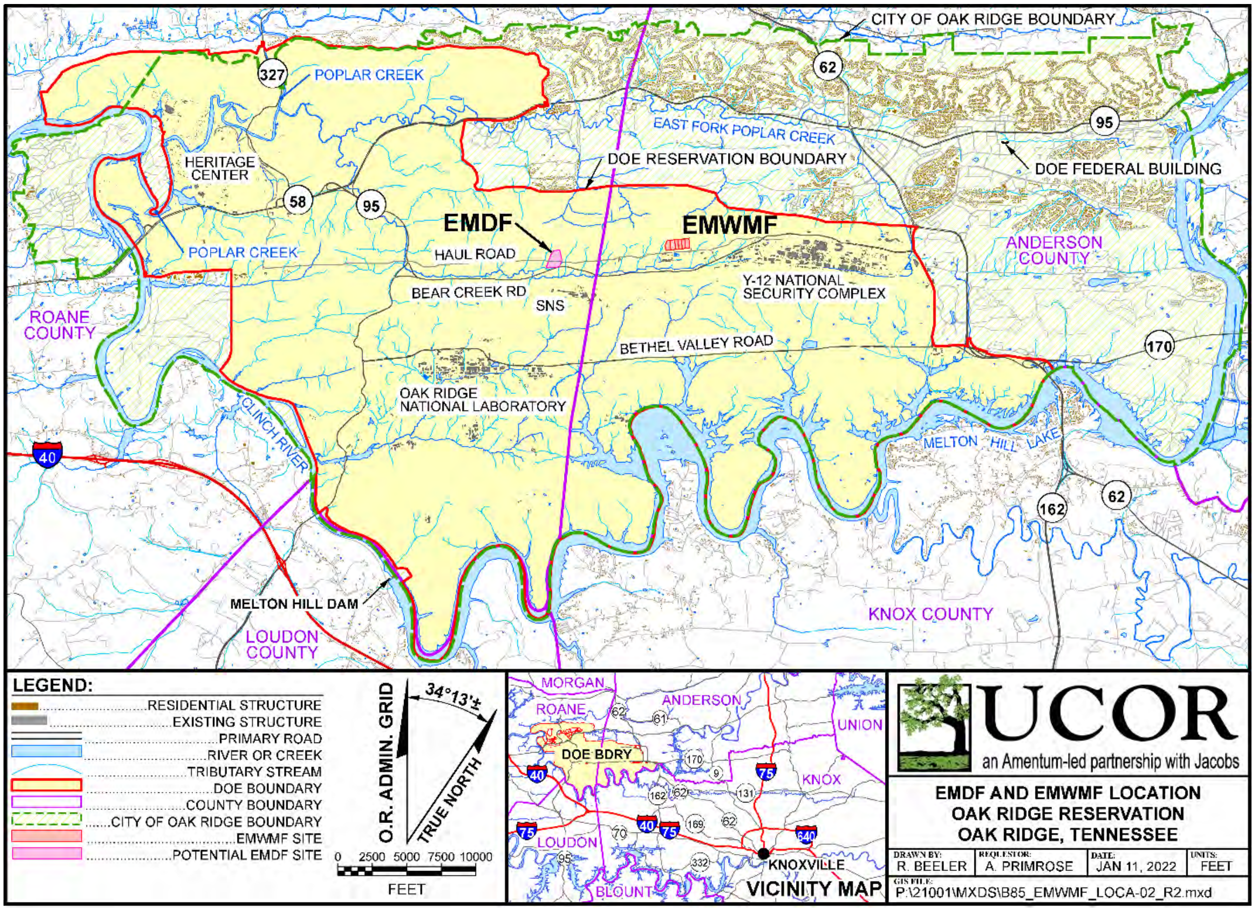

Fig. 1. Oak Ridge Reservation.

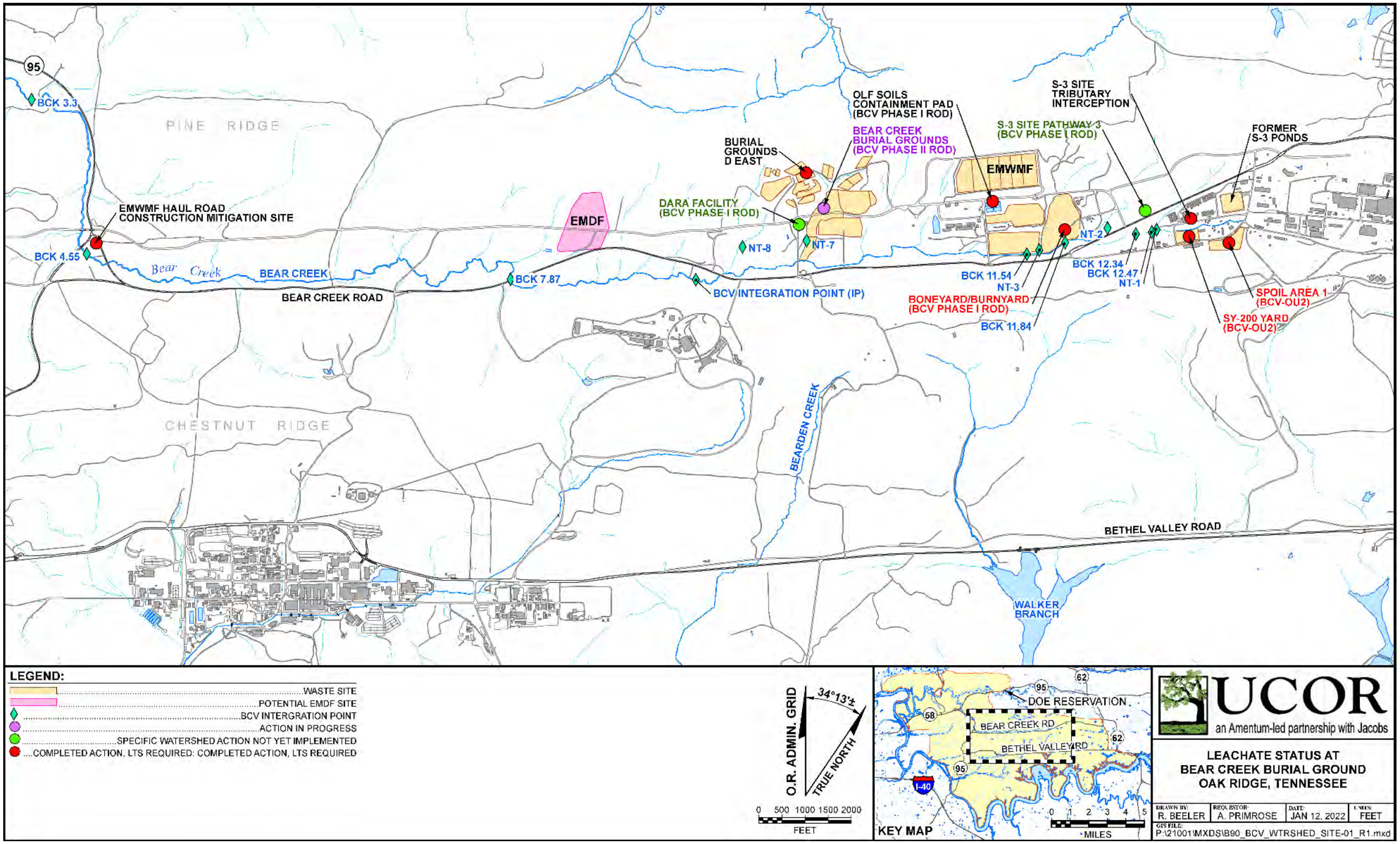

Fig. 2. Bear Creek watershed.

The *Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee* (DOE/OR/01-1791&D3) presents the selected remedy for the disposal of waste generated from CERCLA cleanup activities performed by DOE on the ORR and associated sites. This remedy is the design, construction, operation, and closure of EMWMF located in the Bear Creek watershed on the ORR. Following approval of the EMWMF ROD, three Explanations of Significant Difference were prepared to:

- Add classified waste to the description of waste approved for disposal in EMWMF (DOE/OR/01-1905&D2, *Explanation of Significant Difference from the Remedy in the Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee*)
- Construct a dedicated haul road for the transportation of waste from ETTP to EMWMF (DOE/OR/01-2194&D2, *Explanation of Significant Difference from the Remedy in the Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee*)
- Construct Cell 6 to expand EMWMF (DOE/OR/01-2426&D2, *Explanation of Significant Difference from the Remedy in the Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee*)

EMWMF began operations in 2002 and currently is receiving radioactive, hazardous, and mixed wastes from CERCLA actions on ORR and associated sites. EMWMF consists of six disposal cells with a total capacity of 2.3 million cubic yards (Fig. 3). The scope of the cleanup program has increased since the original waste estimates, and another onsite disposal facility, the proposed EMDF, is proposed to provide additional waste disposal capacity. The proposed EMDF is expected to consist of four cells with a total capacity of 2.2 million cubic yards (DOE/OR/01-2535&D4) (Fig. 4).

Fig. 3. Environmental Management Waste Management Facility.

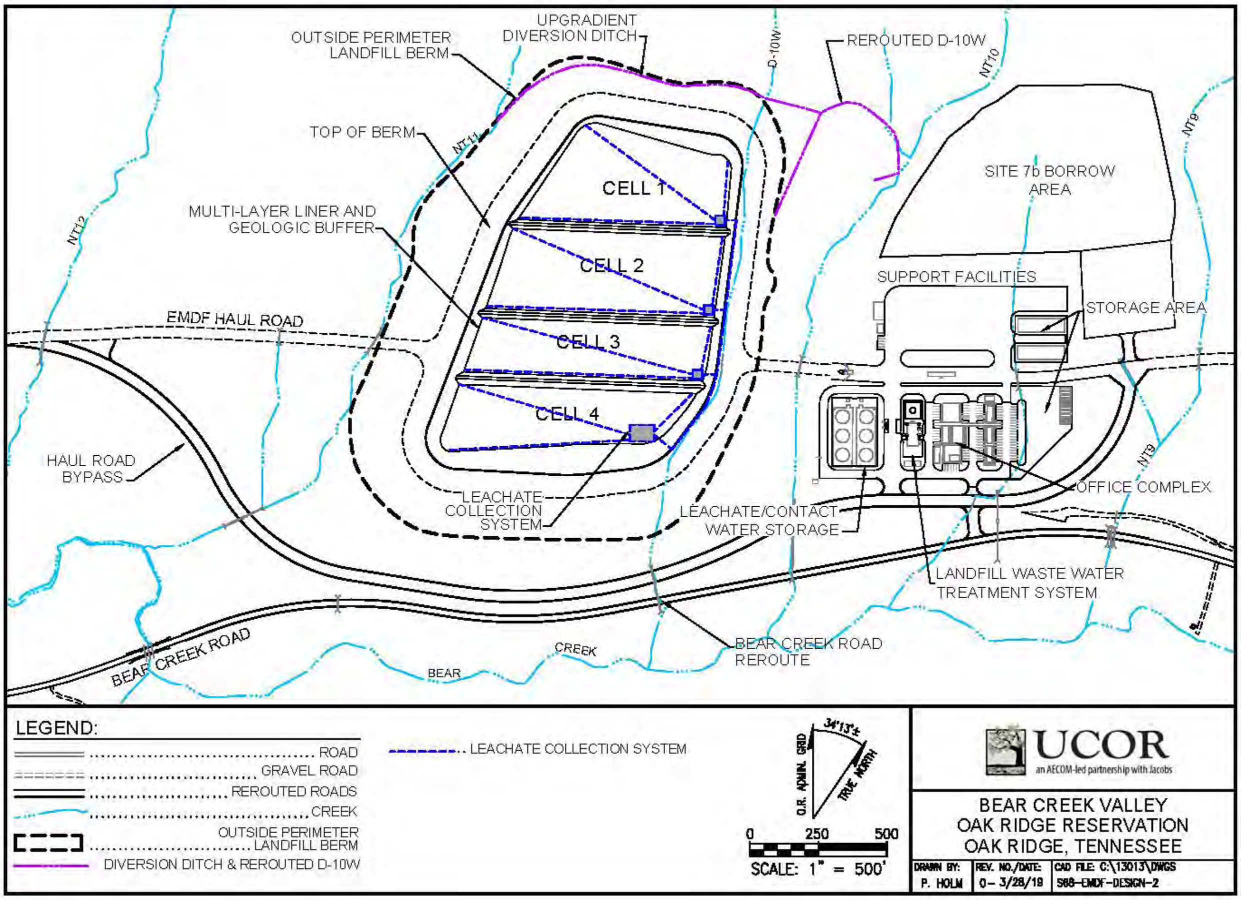

Fig. 4. Proposed Environmental Management Disposal Facility conceptual site layout.

1.4 SITE ECOLOGY

Site ecology for the EMWMF site is described in the *Remedial Investigation/Feasibility Study for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste* and the *Remedial Investigation/Feasibility Study for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge Reservation*. The area surrounding EMWMF has been strongly influenced by anthropogenic structures and industrial activities. Most of the area is covered with grass and engineered structures, such as the EMWMF disposal cells. As a result, this area provides little habitat for terrestrial vertebrates. The likelihood of the existence of federal or state-listed species in this area is low. Site ecology for the EMDF site is described in the EMDF RI/FS (DOE/OR/01-2535&D5). This site is less disturbed and there are federal and or state-listed species in this area that will require additional evaluation and/or protection.

Bear Creek and the north tributaries are the dominant aquatic features in the area. The reach of Bear Creek near EMWMF and EMDF has both gaining and losing stretches. The reach near EMWMF has periods of zero flow in the summer months. The reach of Bear Creek near the proposed EMDF maintains year-round flow.

1.5 EVALUATION OF THE BEAR CREEK BURIAL GROUNDS FOR INCLUSION IN THE FFS

BCBG was evaluated to determine if it will be feasible to include management of BCBG leachate in the scope of this FFS. BCBG is a former waste disposal area for radiologically and chemically contaminated waste generated primarily at Y-12. BCBG consists of several waste disposal units designated as BCBG Unit-A, -B, -C, -D, -E, -J, and Walk-in Pits. Each waste disposal unit consists of a series of trenches used for disposal of liquid and solid wastes. The primary wastes disposed in BCBG were uranium, potentially reactive and explosive waste, organic compounds, polychlorinated biphenyls, acids, metals, and other radionuclides.

Similar to EMWMF and the proposed EMDF, BCBG is also in the Bear Creek watershed and is close to the location of both EMWMF and the proposed EMDF (Fig. 2). Some of the BCBG leachate is collected and adequately processed for release at the Y-12 Groundwater Treatment Facility. However, other sources not currently captured have a negative impact on Bear Creek water quality. Therefore, DOE, EPA, and TDEC agreed to consider the inclusion of BCBG leachate management in this FFS.

An evaluation of historical information, documented feasibility studies, and remedial effectiveness reports indicate that BCBG leachate is not appropriate for inclusion in this FFS. Key reasons for this conclusion are:

- The flow rate of contaminated surface water nearest to BCBG seeps is far greater than what is expected for the EMWMF and proposed EMDF landfill wastewater volumes.
- The contaminants are not consistent with those at EMWMF and the proposed EMDF.
- No CERCLA remedial decision has been made for the remediation of BCBG.
- The leachate contains Resource Conservation and Recovery Act (RCRA)-listed hazardous waste.
- The larger flow rate and the different contaminants will increase the cost for EMWMF and the proposed EMDF landfill wastewater treatment alternatives. The lack of a BCBG CERCLA decision, high flow rates, and the presence of RCRA-listed hazardous waste introduce too much uncertainty to be addressed in this FFS.

Appendix A provides further details for evaluating the inclusion of BCBG leachate in the scope of this FFS.

1.6 EMWMF AND PROPOSED EMDF LANDFILL WASTEWATER MANAGEMENT OPERATIONS

The scope of this FFS is the management of EMWMF and proposed EMDF landfill wastewater. Landfill wastewater is defined in 40 *CFR* 445.2 as “all wastewater associated with, or produced by, the landfilling activities, including, but not limited to leachate, contaminated storm water, and contact wash water from washing trucks, equipment, and surface areas which have come in direct contact with waste at the facility.”

UCOR-4135/R1, *Environmental Management Waste Management Facility (EMWMF) Operation Plan, Oak Ridge, Tennessee*, describes, and Fig. 5 illustrates, how landfill wastewater from EMWMF currently is managed. The landfill wastewater types are:

- Contact water—Contact water is precipitation that falls into an active EMWMF cell, comes in direct contact with waste, is pumped to the contact water tanks from the liner, and does not infiltrate into the leachate collection system. Because contact water contacts the waste, it potentially is contaminated.

- Leachate—Leachate is precipitation that falls into an active cell, infiltrates through the waste, infiltrates through the liner, is collected by the leachate collection system, and is pumped to the leachate storage tanks. Because leachate contacts the waste, it potentially is contaminated. Leachate does not include any liquid wastes, because these are specifically prohibited in accordance with the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1909&D3).

TDEC 0400-11-01 defines leachate as “a liquid that has passed through or emerged from solid waste and contains soluble, suspended, or miscible materials removed from such waste.” RCRA (40 *CFR* 260.10) defines leachate as “any liquid, including any suspended components in the liquid that has percolated through or drained from hazardous waste.”

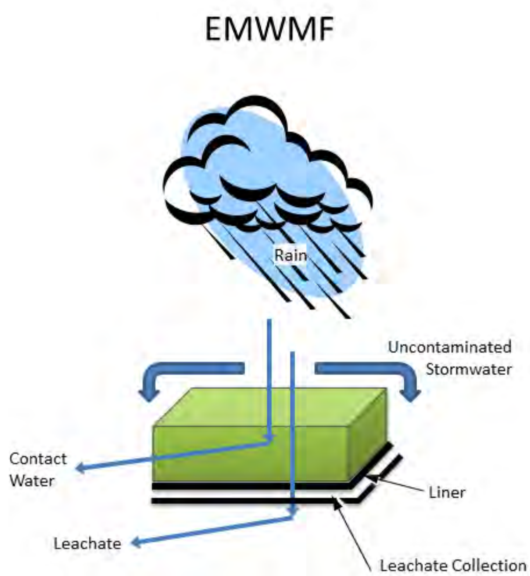

Fig. 5. Landfill wastewater management at EMWMF.

The volume of landfill wastewater is minimized by shedding and diversion of stormwater to the extent possible through landfill design and operating characteristics. Stormwater is precipitation that does not fall into an active cell, does not encounter waste, and does not become contaminated. Therefore, stormwater is not included in this FFS. Stormwater is addressed in the *Remedial Investigation/Feasibility Study for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge Reservation*.

Currently, EMWMF contact water is collected in catchments within a disposal cell and pumped to the contact water ponds and contact water tanks. The contact water is sampled and analyzed to determine if the discharge limits contained in the *Addendum to Remedial Design Report for Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee* are met. If the discharge limits are met, then the contact water is pumped into the Sediment Basin and discharged to North Tributary-5 of Bear Creek. If the discharge limits are not met, the contact water is treated to meet the discharge limits (currently performed for hexavalent chromium) or transferred by tanker truck to the onsite Process Water Treatment Complex (PWTC) at ORNL for treatment and disposal.

EMWMF leachate is collected by the leachate underdrain, pumped to the leachate storage tanks and transferred by tanker truck to the onsite PWTC for treatment and disposal. The capacities of the EMWMF contact water catchments, ponds, and tanks, and the leachate storage tanks are in Table 1.

Table 1. Contact water and leachate storage capacity at EMWMF

Location	Normal Maximum Capacity (gallons)	Subtotal (gallons)	Comments
Cell 6 catchment	2,400,000	2,400,000	
CWP #1	482,300	1,804,200	
CWP #2	492,300		
CWP #3	404,600		
CWP #4	425,000		
CWT A	235,000	940,000	
CWT B	235,000		
CWT C	235,000		
CWT D	235,000		
Leachate Storage Tanks	240,000	240,000	8 tanks
Total Storage		**5,384,200**	

CWP = contact water pond
CWT = contact water tank

As described in the *Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act, Oak Ridge Reservation Waste Disposal at the Environmental Management Disposal Facility, Oak Ridge, Tennessee*, DOE/OR/01-2794&D2 (in progress), the landfill wastewater generated at this site will be treated prior to release. Additional landfill wastewater storage capacity will be provided at EMDF, but the design for collection and storage will not be finalized until the final design.

1.7 EMWMF AND THE PROPOSED EMDF LANDFILL WASTEWATER QUALITY

DOE, EPA, and TDEC agreed to evaluate the management of landfill wastewater from EMWMF and the proposed EMDF in a FFS and to integrate the evaluation into the CERCLA decision-making documents for the proposed EMDF and, if appropriate, for EMWMF.

COCs for EMWMF were identified initially from the COCs listed for the ORR CERCLA remediation sites that were to send waste to EMWMF for disposal. Contaminants shown through calculations to be a risk were included as COCs to reduce or eliminate their exposure to humans and release to the environment. Waste acceptance criteria (WAC) for EMWMF limit the COCs and/or their concentration that may be placed in EMWMF. Additionally, a list of contaminants known to or that can potentially migrate into the environment was established for surface water and groundwater sampling on the ORR.

The COCs for EMWMF landfill wastewater were developed from the EMWMF WAC list and the list of contaminants for ORR surface water and groundwater monitoring. EMWMF COCs are contained in the *Sampling and Analysis Plan/Quality Assurance Project Plan for Environmental Monitoring at the Environmental Management Waste Management Facility* (UCOR-4156) and in Appendix C of this FFS. These COCs apply to both EMWMF and the proposed EMDF for this FFS.

The concentrations of certain contaminants in landfill wastewater from EMWMF have changed over time, particularly as the origin of the waste received changes. This is particularly noticeable for uranium isotopes and strontium (Sr) as the origin of the waste has changed from Y-12 to ORNL to ETTP. Figure 6 reflects these changes over time and indicates the potential variability in contaminants as the origin of the waste changes in the future.

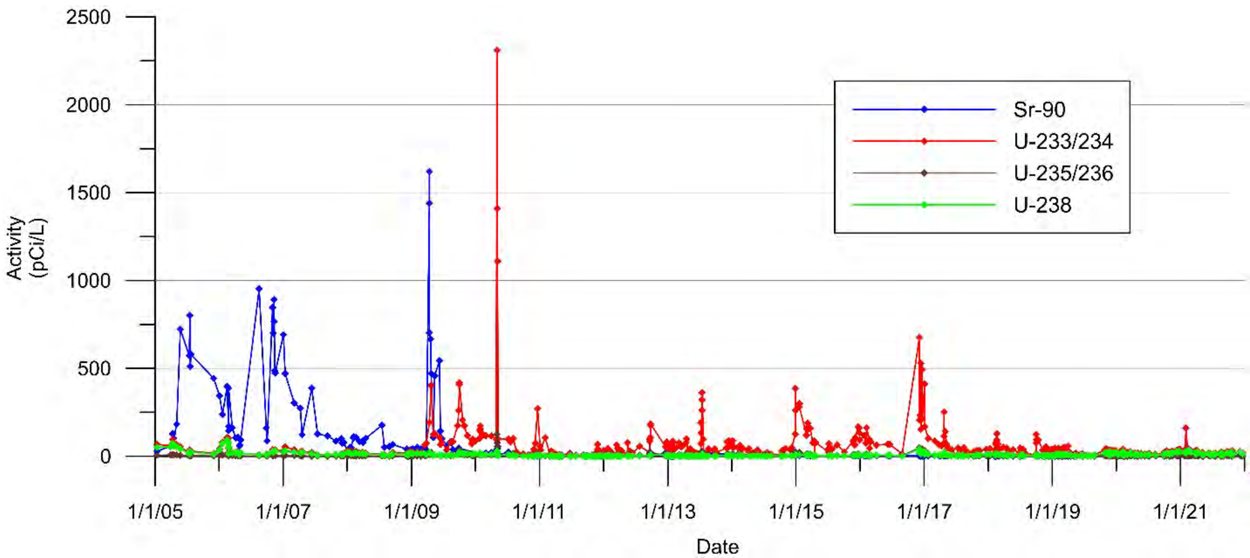

Fig. 6. Concentrations of Sr-90 and uranium isotopes in EMWMF landfill wastewater (Jan. 2005–Jan. 2022).

Because of the different contaminants at ETTP, ORNL, and Y-12, the variability in waste lots and associated waste contaminants over time, the presence of unexpected contaminants, and the mobility of the disposed contaminants, the contaminants in the EMWMF landfill wastewater have varied over time. As shown in Fig. 6 and Appendix C, at times in the past, specific contaminants have appeared for a short time, but are not currently in the landfill wastewater. It is expected that this situation will continue in the future so that both the contaminants and concentrations in the landfill wastewater will vary over time and for varying periods of time (Fig. 7). However, for EMWMF, the majority of waste placed was from the ETTP sources (now Heritage Center), and the ETTP contaminants dominate the contaminants present in EMWMF and in the contact water and leachate.

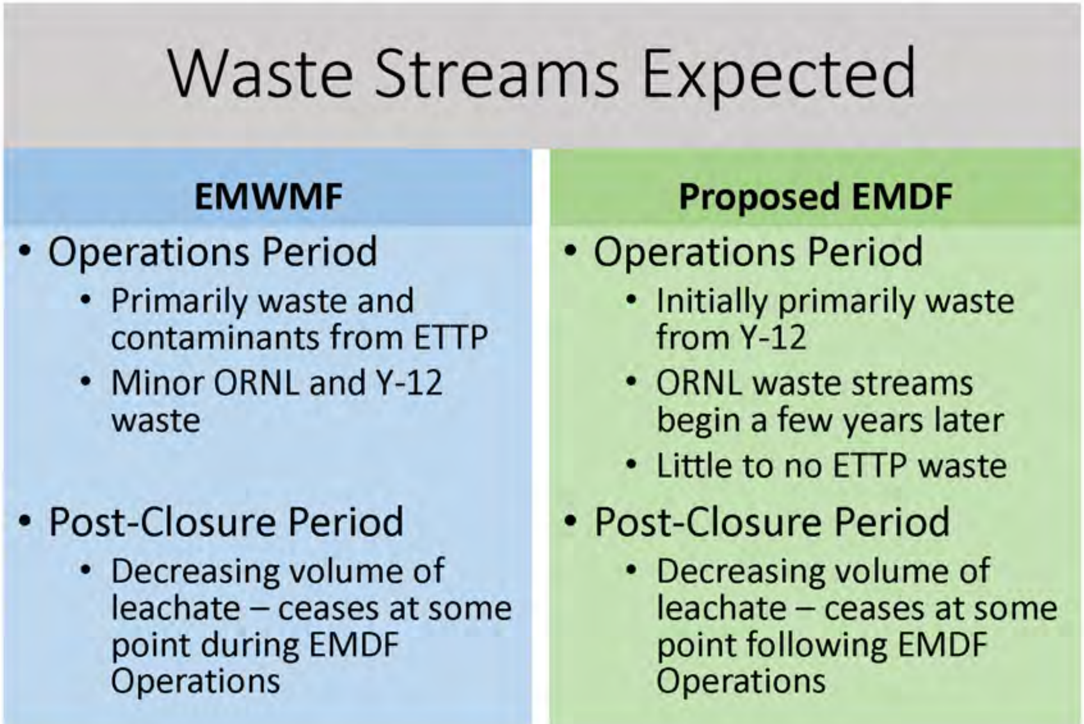

Fig. 7. Contaminants of concern requiring treatment vary over time.

However, to identify the key COCs for this FFS, all of the COCs were screened against their abundance in EMWMF waste lots, their mobility, stability, and persistence in EMWMF and the surrounding environment, and potential risk concern (Appendix C). Based on this screening, the key COCs were determined upon which this FFS is based. Table 2 lists the key COCs and their minimum, average, and maximum concentrations in leachate and contact water observed over the past two years at EMWMF. Two years of data were selected to ensure the current contaminants and concentrations are evaluated. EMWMF and the proposed EMDF will periodically evaluate the full suite of contaminants that might be present in the landfill wastewater (see Appendix L). Based on the results, COCs and/or treatment options will be adjusted accordingly, as needed. Due to the uncertainty in the contaminants to be treated over time, the ability of the alternatives in this FFS to adapt quickly and easily to changing treatment requirements will be a key criterion of the evaluation.

The concentration of mercury in the proposed EMDF landfill wastewater does not use the concentration from EMWMF, but uses a concentration derived from the analysis described in Appendix E.

The concentrations in Table 2 are used in this FFS, and their application to each alternative is discussed in Sect. 3.3. The concentrations of the key COCs in landfill wastewater will change over time due to the wide range of contaminants in debris and soil at ETTP, ORNL, and Y-12. Therefore, the ability to adapt quickly and easily to changes is an important consideration in the evaluation of alternatives.

Based on a combination of process knowledge, historical analytical data, approved EMWMF waste lots and disposal records, and physical characteristics, EMWMF landfill wastewater is shown thus far to be neither listed- nor characteristic-hazardous waste under RCRA. Appendix F provides a detailed determination. Proposed EMDF landfill wastewater is not expected to be RCRA-hazardous due to the expected concentration of mercury that is limited by an FFA party agreement not to accept mercury hazardous waste (*Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act, Oak Ridge Reservation Waste Disposal at the Environmental Management Disposal Facility, Oak Ridge, Tennessee*, DOE/OR/01-2794&D2 [in progress]). EMWMF is not operated to accept RCRA-listed hazardous waste and the proposed EMDF will not accept RCRA-listed hazardous waste.

Table 2. Key contaminants of concern concentrations (EMWMF data FY2020 to FY2021)

			Initial (used for evaluation)		FY20-FY21			
Contaminant type	**Contaminant**	**Units**	**Contact Water Mean[a]**	**Contact Water Max.**	**Contact Water Mean[a]**	**Contact Water Maximum**	**V-Weir Avg.**	**V-weir Maximum**
Metal	Arsenic*	µg/L	5	5	3.35	7.27	1.62	2.9
Metal	Cadmium**	µg/L	1	1	0.429	0.615	--	--
Metal	Total Chromium**	µg/L	30.39	309	6.09	16.9	3.47	4.94
Metal	Chromium, VI*	µg/L	30.88	250	8.43	16	--	--
Metal	Copper**	µg/L	5.24	12.8	2.84	13.4	1.47	2.72
Metal	Lead**	µg/L	3	3.63	1.4	9.09	1.4	3.93
Metal	Mercury (EMWMF)*	µg/L	0.03	0.13	0.022	0.094	0.01	0.0113
Metal	Mercury (EMDF)[b]	µg/L	1	N/A	--	--	--	--
Metal	Nickel**	µg/L	11.43	34.2	2.73	9.41	2.77	5
Metal	Uranium	µg/L	12.94	15	33.2	94.9	6.99	21
Other	Cyanide	µg/L	5	5	6.74	18.4	--	--
Pesticide	4,4'-DDD	µg/L	0.1	0.1	--	--	--	--
Pesticide	4,4'-DDE	µg/L	0.1	0.1	--	--	--	--
Pesticide	4,4'-DDT	µg/L	0.1	0.1	0.037	0.066	--	--
Pesticide	Aldrin	µg/L	0.1	0.1	0.007	0.007	--	--
Pesticide	beta-BHC	µg/L	0.1	0.1	0.017	0.046	--	--
Pesticide	Dieldrin	µg/L	0.54	1	0.036	0.036	--	--
Radiological	Iodine-129	pCi/L	1.5	2.8	0.706	0.956	1.2	1.03
Radiological	Strontium-90	pCi/L	6.85	16.1	2.23	9.17	1.2	35.5
Radiological	Technetium-99	pCi/L	627.07	3580	2247	28,500	423	8520
Radiological	Tritium	pCi/L	2104	31900	752	2300	505	680
Radiological	Uranium-233/234	pCi/L	66.52	385	24.0	124	7.2	34.1
Radiological	Uranium-235/236	pCi/L	4.92	25.1	2.39	11.5	1.24	4.06
Radiological	Uranium-238	pCi/L	3.15	21.2	11.7	32.5	1.5	9.13

[a] The arithmetic mean uses half the detection limit as proxy values for non-detects for chemicals.
[b] Mercury from EMDF landfill wastewater was estimated. See Appendix E.
[c] Observed value was not discharged.
NA = not applicable
*Criteria for these metals are expressed as dissolved.
**Criteria for these metals are expressed as dissolved and are a function of total hardness.

1.8 FLOW RATES

The quantity of landfill wastewater will vary over the EMWMF and proposed EMDF life cycle, illustrated in Fig. 8. The assumption used in the FFS evaluation was that initially, landfill wastewater will be generated from EMWMF operations, then from the combined operation of EMWMF and the proposed EMDF, then from the proposed EMDF operation, and finally following closure. In order to address this uncertain and varying flow rate, the period of time when EMWMF and the proposed EMDF operations overlap is used in this FFS because this period represents the maximum estimated flow rates. Therefore, the design flow rate for this FFS is based on relatively high anticipated flows during years 3 and 4 when EMWMF Cells 5 and 6 and the proposed EMDF Cell 1 are open. Because of the timing of the proposed EMDF, the actual flow rates are expected to consist of either the EMWMF or EMDF water volumes, not a combined water volume.

Various rainfall events were modeled to predict the flow rate of landfill wastewater, and the predictions were compared to historical data. Table 3 summarizes the flow rates from the model for the peak day, average month, wettest month, and maximum month rainfall events. A detailed description of the flow rate calculations is in Appendix B.

The assumption for the bounding condition is that both EMWMF and the proposed EMDF are operational. Therefore, for the purposes of this FFS, the average flow rate is 30 gal per minute (gpm) (average month in Table 3), and the maximum flow rate is 60 gpm (maximum month in Table 3). The landfill wastewater flow rate will vary over the life of the two facilities as rainfall varies, disposal cells are opened and closed, and during post-closure. The flow rate during post-closure will only be leachate and may be less than one gpm. Therefore, the uncertainty of flow rates and the ability to adapt to varying flow rates is considered in the evaluation of alternatives. As noted, this is a conservative approach, as it is unlikely that EMWMF and EMDF will be producing significant quantities of landfill wastewater at the same time.

Table 3. Landfill wastewater flow rates

Active cell	Active cell area (acres)	Peak day (gal per minute)	Average month (gal per minute)	Wettest month (gal per minute)	Maximum month (gal per minute)
EMWMF Cell 5	6.0	572	10	12	20
EMWMF Cell 6	5.3	501	10	11	20
Proposed EMDF Cell 1	6.2	756	10	12	20
TOTALS	17.5	1839	30	35	60

Note: This flow rate is used for evaluation purposes in the FFS.

1.9 LANDFILL WASTEWATER STORAGE

The selected location for EMDF is no longer adjacent to EMWMF and the EMWMF wastewater storage volume will no longer be expanded for EMDF. The EMDF wastewater storage volume will be obtained as part of the landfill design process and will be determined and reported in a remedial design report. The current EMWMF storage capacity is assumed to be adequate to store EMWMF landfill wastewater prior to the proposed EMDF operations. However, as the basis for the cost estimates used to compare alternatives, the water storage capacity was calculated based upon a 100-year, 24-hour design storm that occurs when three cells are open—two EMWMF cells (Cells 5 and 6) and the proposed EMDF Cell 1. The details for the water storage capacity calculations are in Appendix H.

1.10 ESTIMATED TIMELINE FOR EVALUATION AND IMPLEMENTATION

The timeline used for this FFS evaluation for the operation, closure, and post-closure periods for EMWMF and the proposed EMDF is in Fig. 8. The assumption used was that in the first two years, only EMWMF is in operation; in years 3 and 4, both EMWMF and the proposed EMDF are in operation; for the next 23 years, only the proposed EMDF is in operation and EMWMF is closed; finally, both facilities are closed. Note: EMWMF and EMDF are no longer expected to be operating at the same time. As a result, this evaluation overestimates the volume of wastewater requiring management. EMWMF and the proposed EMDF each have a 30-year period of long-term stewardship per the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA/540/G-89/004) for the purpose of this FFS. The *Remedial Investigation/Feasibility Study for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge Reservation* assumes that landfill wastewater only will be generated from the proposed EMDF for 10 years following closure, at which time the landfill will be dewatered. However, the 30-year period of long-term stewardship is still used for the purposes of this FFS.

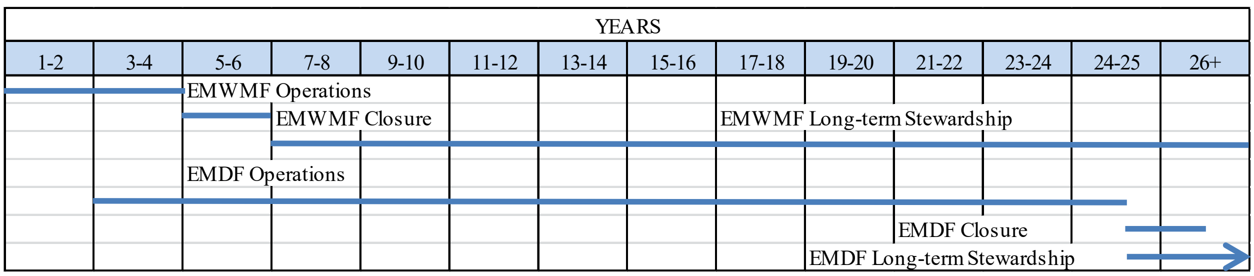

Fig. 8. Timeline used for evaluation.

EMWMF is currently operating and is nearing capacity, while the proposed EMDF is in the CERCLA planning process.

When the D2 FFS was issued in 2016, the proposed EMDF was in the RI/FS phase of the CERCLA process. A recommended approach for the proposed EMDF landfill wastewater management was intended to be provided in the Proposed Plan, based upon the evaluation in this FFS. However, the FFS was in dispute for nearly 5 years over radiological discharge limits. The EMDF CERCLA process continued during that time. The Proposed Plan was approved by the three FFA parties in 2018. The ROD will document acceptance of the wastewater management alternative developed based on this FFS. Implementation of the landfill wastewater management approach will continue as part of the normal CERCLA process from design to initiation of operations.

EMWMF has an approved CERCLA ROD (DOE/OR/01-1791&D3) and has been in operation since 2002. Therefore, the CERCLA process for implementation of this FFS for EMWMF will be as follows:

- Prepare an Explanation of Significant Differences for the EMWMF ROD (DOE/OR/01-1791&D3) based upon the evaluation described in this FFS.
- Revise the *Remedial Action Work Plan for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste* (DOE/OR/01-1874&D4/R1), the Operations Plan (UCOR-4135/R1), and the Sampling and Analysis Plan/Quality Assurance Project Plan (UCOR-4156) to incorporate the changes.
- Implement the recommended alternative.

1.11 PROBLEM SUMMARY

As discussed previously, landfill wastewater will be generated as a result of land disposal of CERCLA waste in EMWMF and the proposed EMDF that may contain concentrations of key COCs that exceed discharge limits. The problem encompasses the determination of a safe and environmentally sound approach for management of this landfill wastewater. The approach must be protective of human health and the environment, implementable, adaptable, cost effective, and meet discharge limits.

The options and alternatives identified and evaluated must have a common basis for development and comparison purposes. The following parameters define the basis for the identification, development, and evaluation of the alternatives.

- The average flow rate is 30 gpm, and the maximum flow rate is 60 gpm.
- The design storm is 100 years, 24 hours.
- Alternatives will address all key COCs, but treatment unit operations will be implemented when appropriate. Proposed EMDF landfill wastewater is not expected to be listed or characteristic RCRA hazardous waste.
- The key COCs and their current concentrations are in Table 2. The COCs and their concentrations are expected to change over time, so alternatives must be adaptable to change.

2. REMEDIAL ACTION OBJECTIVES

2.1 ANTICIPATED FUTURE LAND USE

EMWMF and the proposed EMDF are located in the Bear Creek watershed, entirely within the ORR, where public access is restricted. Because Y-12 is an active production and special nuclear materials management facility, additional security and access limitations apply.

Reasonably anticipated future uses of land are an important consideration in determining remediation levels and extent of remediation. Consistent with EPA guidance in *Land Use in the CERCLA Remedy Selection Process* (EPA 9355.7-04), DOE solicited input on potential future land use from EPA and TDEC, local land-use planning authorities, and the public during the ORR watershed-level remedial investigation and feasibility study development. The ORR Site-Specific Advisory Board (Oak Ridge Reservation End Use Working Group 1998) recommended three zones of end uses—unrestricted, recreational, and DOE-controlled industrial—for the Bear Creek watershed. The selected remedy in the *Record of Decision for the Phase I Activities in Bear Creek Valley at the Oak Ridge Y-12 Plan, Oak Ridge, Tennessee* is consistent with these anticipated future end uses and human exposure restrictions. Figure 9 provides the three end use zones, EMWMF, and the proposed EMDF site.

The land use designation for Zone 2 containing the EMDF site will change to DOE-controlled industrial as part of the EMDF ROD.

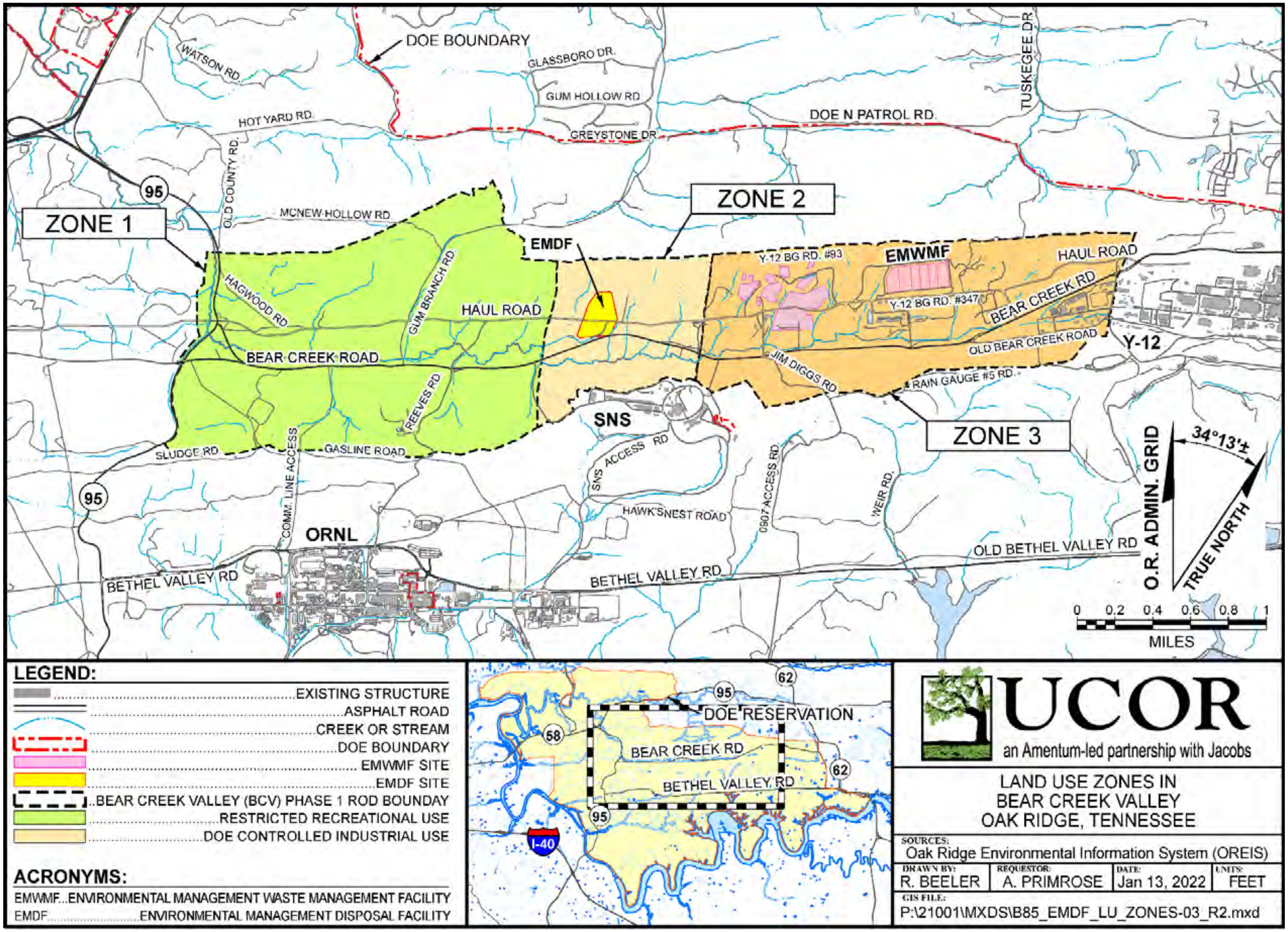

Fig. 9. Bear Creek Valley end uses and locations of the EMWMF and proposed EMDF.

2.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives are site-specific goals developed from the purpose and scope of remedial actions. CERCLA guidance defines remedial action objectives as "medium-specific or operable unit-specific goals for protecting human health and the environment" (EPA/540/G-89/004). According to the National Oil and Hazardous Substances Pollution Contingency Plan (40 *CFR* 300.430[e][2][i]), remedial action objectives should specify the media and contaminants of concern, potential exposure pathways, and remediation goals. Because EMWMF and the proposed EMDF remedial actions provide for the disposition of various waste types derived from a wide range of sources and activities, establishing specific cleanup goals is not appropriate. Instead, these goals will be developed at the project-specific level during future CERCLA remedial decisions.

Since the scope of this FFS is limited to evaluating alternatives for the management of landfill wastewater, the remedial action objective is to:

- Meet discharge limits for the key COCs to protect surface water for designated uses. This remedial action objective is consistent with the overall remedial action objectives for EMWMF and the proposed EMDF.

2.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

CERCLA Section 121 and 40 *CFR* 300.430(f)(1)(ii)(B) specify that remedial actions for cleanup of hazardous substances must attain or have waived ARARs under federal or more stringent state environmental laws. Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (40 *CFR* 300.5). Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 *CFR* 300.5). Pursuant to EPA guidance, where EPA has delegated to the State of Tennessee the authority to implement a federal program, the Tennessee regulations replace the equivalent federal requirements as the potential ARARs.

CERCLA onsite remedial response actions must comply only with the substantive requirements of a regulation and not the administrative requirements to obtain federal, state, or local permits [CERCLA Section 121(e)]. To ensure that CERCLA response actions proceed as rapidly as possible, EPA has reaffirmed this position in the final National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [55 FR 8756, March 8, 1990]. Substantive requirements pertain directly to the actions or conditions at a site, while administrative requirements facilitate their implementation (e.g., approval of or consultation with administrative bodies, documentation, permit issuance, reporting, record keeping, and enforcement).

The NCP at 40 *CFR* 300.400(e)(1) defines "onsite" as meaning "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for the implementation of the response action." CERCLA Sect. 104(d)(4) (as discussed further in the preamble to the final NCP, 55 FR 8690) states where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, these related facilities may be treated as one for the purpose of conducting response actions. Section 104(d)(4) allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit (i.e., manage as "onsite" waste). This approach was proposed and agreed to by all signatories to the

Federal Facility Agreement for the Oak Ridge Reservation for EMWMF, was acknowledged and documented in the *Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste*, and was reaffirmed in the *Record of Decision for Soil, Buried Waste, and Subsurface Structures Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee*. This agreement serves as the basis for designating waste treatment, storage, and disposal facilities on the ORR as "onsite" facilities not subject to the CERCLA Offsite Rule (40 *CFR* 300.440) when accepting wastes from CERCLA onsite response actions.

ARARs include those federal and state regulations that are designed to protect the environment. ARARs do not include occupational safety regulations. EPA requires compliance with occupational and worker protection standards in Section 300.150 of the NCP, independent of the ARARs process. Therefore, neither the regulations promulgated by the U.S. Occupational Safety and Health Agency, nor DOE Orders related to occupational safety are addressed or included as ARARs.

There are three categories of ARARs:

- Location-specific—Location-specific ARARs establish restrictions on permissible concentrations of hazardous substances or establish requirements for how activities will be conducted because they are in special locations, e.g., wetlands, floodplains, critical habitats, historic districts, or streams.
- Chemical-specific—Chemical-specific ARARs provide health- or risk-based concentration limits or discharge limitations in various environmental media, i.e., surface water, groundwater, soil, or air, for specific hazardous substances, pollutants, or contaminants.
- Action-specific—Action-specific ARARs include operation, performance, and design requirements or limitations based on waste types, media, and removal activities.

In addition to ARARs, 40 *CFR* 300.400(g)(3) states that federal or state nonpromulgated advisories or guidance may be identified as "to be considered" (TBC) guidance for contaminants, conditions, and/or actions at the site. TBC guidance includes non-promulgated criteria, advisories, guidance, and proposed standards. TBC guidance are not ARARs because they are neither promulgated nor enforceable. TBC guidance may be used to interpret ARARs and to determine remediation goals when ARARs do not exist for particular contaminants or are not sufficiently protective to develop cleanup goals.

The ARARs for this FFS are consistent with those provided with the EPA Dispute Resolution Decision (Appendix D). Those required for EMWMF may be added to the *Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee*. Those ARARs required for the proposed EMDF are included in the EMDF *Record of Decision (*DOE/OR/01-2794&D2 [in progress]).

CERCLA Section 121(d) provides that, under certain circumstances, an ARAR may be waived. The six statutory waivers are:

- Interim measures
- Equivalent standard of performance
- Greater risk to health and the environment
- Technical impracticability
- Inconsistent application of state standard
- Fund-balancing

3. DEVELOPMENT AND DESCRIPTION OF ALTERNATIVES

3.1 PURPOSE

This chapter summarizes the screening of remediation technologies and process options and the development of remedial alternatives for the management of landfill wastewater from EMWMF and the proposed EMDF. In accordance with CERCLA [40 *CFR* 300.430(1)], the goal of this FFS is to develop and evaluate remedial alternatives that eliminate, reduce, or control risks to human health and the environment. The NCP provides recommendations for developing remedial action alternatives, including:

- Use of treatment to address the principal threats posted by a site, wherever practicable.
- Use of engineering controls (e.g., containment) for waste that poses a relatively low, long-term threat for which treatment is impracticable.
- Implementation of a combination of actions, as appropriate, to achieve protection of human health and the environment. For example, in appropriate site situations, treatment of principal threats is combined with engineering and institutional controls for treatment of residuals and untreated waste.
- Use of institutional controls to supplement engineering controls for short- and long-term management to prevent or limit exposures to hazardous substances.
- Selection of an innovative technology when the technology offers the potential for comparable or better treatment performance or implementability than other technologies, fewer adverse impacts than other technologies, or lower costs than demonstrated technologies for similar levels of performance.
- Restoration of environmental media (e.g., groundwater) to their beneficial uses wherever practicable and within a reasonable time frame given the particular circumstances of the site. When restoration of groundwater to beneficial uses is not practicable, EPA expects remedial action to prevent further migration of the contaminant plume, prevent exposure to contaminated groundwater, and evaluate further risk reduction.

Because this FFS focuses on the management of landfill wastewater generated from EMWMF and the proposed EMDF, the range of alternatives is focused on water management actions. Therefore, the range of technology types and process options applicable to this study is limited to those pertinent to the management of landfill wastewater from EMWMF and the proposed EMDF. The primary problem addressed in this study is ensuring that the landfill wastewater discharge meets the PRGs for fish tissue and surface water.

3.2 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

Remedial action objectives are met through implementation of general response actions, alone or in combination. General response actions are categories of actions intended to protect human and ecological receptors from exposure to contamination in sources or environmental media, e.g., groundwater and surface water. Technology types are identified for each general response action that are appropriate for the media, contaminants, and location being considered. Next, process options are identified and evaluated to select representative process options for each technology type. Process options are broad categories of technologies that, alone or in combination, are used to satisfy the remedial action objectives. These representative process options are retained for alternative development.

As specified in EPA guidance (EPA/540/G-89/004), two screening steps typically are taken to reduce the number of technology types and process options associated with each general response action. Initially, each process option is screened for technical applicability against the following criteria:

- Applicability to the type and combination of contaminants
- Applicability to the site physical conditions

Process options that are not technically applicable to the site or to the contaminants are eliminated from further consideration. In the second screening step, the retained process options are evaluated more closely against the following criteria to select one or more options to represent each technology type.

- Effectiveness—Effectiveness considers the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the remedial action objectives; the potential impacts to human health and the environment during the construction and implementation phases; and how proven and reliable the process is with respect to the contaminants and conditions at the site.
- Implementability—Implementability encompasses both the technical and administrative feasibility of implementing a technology process. Technical implementability is an initial screen to eliminate those that are clearly ineffective or unworkable at the site. Administrative implementability considers the ability to obtain necessary permits for offsite actions; the decision-making process; the availability of treatment, storage, and disposal services (including capacity); and the availability of necessary equipment and skilled workers to implement the technology.
- Cost—Cost plays a limited role in the screening of process options. Relative capital, operations, and maintenance (O&M) costs are used rather than detailed estimates. At this stage in the process, the cost analysis is based on engineering judgment, and each process option is evaluated as to whether costs are high, low, or medium relative to other process options.

Because this is an FFS evaluating how to manage landfill wastewater, the two screening steps were combined, and the range of general response actions, technology types, and process options was limited to those pertinent to the management of landfill wastewater. The general response actions identified for management of EMWMF and the proposed EMDF landfill wastewater are:

- No action
- Monitoring
- Water treatment
- Zero discharge

The no action general response action involves the free release of untreated landfill wastewater to the environment, while other general response actions involve providing health and environmental protection from the potential impacts of contaminated landfill wastewater. Each of the general response actions was evaluated with respect to the evaluation criteria and a determination was made to either retain for further evaluation or reject from further consideration. The results of the evaluation are in Table 4.

Zero discharge was not retained because of the relatively high volume of landfill wastewater generated at EMWMF and the proposed EMDF that makes evaporation impractical. The greater volume is a result of maintaining the large working faces necessary to minimize the amount of clean fill used and provide sufficient space for the concurrent disposal of differing waste streams. Reuse of the generated landfill wastewater for dust control is confined to the working cells only. Use outside of the cells results in the potential to spread contamination. Therefore, reuse requires maintaining two separate systems for dust control and adds additional cost. Appendix G contains additional discussion of the zero-discharge general response action.

In the development and evaluation of the alternatives, an adaptive management approach is used to make a decision based on existing information, monitoring and evaluating data during operation, and modifying the landfill wastewater management system as appropriate over time (Everett and Ebert, *Production and Operations Management: Concepts, Models, and Behavior*; Holling, C. S., *Adaptive Environmental Assessment and Management*; National Research Council 2003, *Environmental Cleanup at Navy Facilities: Adaptive Site Management*; and National Research Council 2004, *Adaptive Management for Water Resources Project Planning*). This approach is a decision process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Adaptive management acknowledges uncertainty and makes use of management interventions and follow-up monitoring to promote understanding and improve decision making through an iterative process. In this case, uncertainties associated with future COCs is addressed by allowing for flexibility in construction and operations. Additional processing capability or modified operations will be implemented to address COCs that are not anticipated during initial design.

Table 4. Evaluation of process options

General response action	Technology type	Process option	Description	Technical applicability	Effectiveness	Implementability	Cost	Retained
No action	None	None	No additional action	Not applicable	Not effective	Easy to implement	No incremental cost	Retained as required by the National Contingency Plan
Monitoring	Monitoring	Managed discharge	Discharge if discharge limits met	Not applicable	Not effective; not adaptable	Easy to implement	Low	Not retained; discharge limits not met at all times; not adaptable
Water treatment	Treat in situ	Constructed wetlands	Construct wetlands to treat water	Partly applicable; will convert mercury to methyl mercury	Not certain if discharge limits met; perhaps useful for polishing; not adaptable	Will convert mercury to methyl mercury; will have to be constructed	Low	Not retained; conversion of mercury to methyl mercury; uncertainty in meeting discharge limits; not adaptable

Table 4. Evaluation of process options (cont.)

General response action	Technology type	Process option	Description	Technical applicability	Effectiveness	Implementability	Cost	Retained
Water treatment	Treat at EMWMF/EMDF site	Landfill wastewater treatment system	Construct new landfill wastewater treatment system	Applicable	Effective; proven treatment technology; meets discharge limits; adaptable	Easy to implement; standard treatment processes; cannot be implemented immediately	Medium	Not retained; cannot be implemented immediately; redundant with following process option; meets discharge limits; proven treatment technology; adaptable
	Monitoring/Treat at EMWMF/EMDF sites	Managed discharge / landfill wastewater treatment system	Discharge if discharge limits met; construct new landfill wastewater treatment system.	Applicable	Effective; proven treatment technology; meets discharge limits; adaptable	Manage discharge easy to implement; Standard treatment processes requires design and construction time.	Medium	Retained; Managed discharge can be implemented immediately; meets discharge limits; New landfill wastewater treatment using proven treatment technology; adaptable
	Treat elsewhere on ORR	ORNL PWTC	Transport to ORNL PWTC for treatment by truck or pipeline	Partly applicable; WAC do not accept mercury; radiological treatment system does not have capacity	Effective	WAC does not allow mercury, so WAC will have to be revised; harder to implement due to trucking or pipeline; may need expansion of storage facilities and future modification of treatment processes for additional COCs; radiological treatment processes limited; past useful life of PWTC; adaptable	Medium	Retained; mercury WAC required; upgrade being planned to extend operating life

Table 4. Evaluation of process options (cont.)

General response action	Technology type	Process option	Description	Technical applicability	Effectiveness	Implementability	Cost	Retained
		Y-12 WETF	Transport to Y-12 WETF for treatment by truck or pipeline	Applicable	Effective	Meets WAC; harder to implement due to trucking or pipeline and work in Y-12; significant treatment plant expansion required; adaptable	Medium	Not retained; trucking/pipeline construction; significant expansion; construction required in Y-12
		Outfall 200 treatment system	Transport to Outfall 200 treatment system by truck or pipeline	Partly applicable; addresses only mercury	Effective for mercury; will require modification for other key COCs	Easy to implement; treatment system proposed but not built; discharges into another watershed; ROD revision; adaptable	Medium	Retained; addresses mercury; adaptable
	Treat offsite	Existing facility	Use an existing offsite treatment facility and transport by truck or pipeline	Applicable	Not effective	No facility available	Not applicable	Not retained; no facility available
		New facility	Construct a new offsite treatment facility and transport by truck or pipeline	Applicable	Effective	Difficult due to new construction and transporting to new facility	High	Not retained; construction of offsite facility; high cost
Zero discharge	Reuse of water	Reuse of water	Reuse landfill wastewater	Applicable	Not effective	Use of contaminated water unacceptable; treatment prior to reuse is not cost effective	High	Not retained; use of contaminated water unacceptable; treatment prior to reuse is not cost effective

Table 4. Evaluation of process options (cont.)

General response action	Technology type	Process option	Description	Technical applicability	Effectiveness	Implementability	Cost	Retained
	Evaporation	Evaporation	Evaporate landfill wastewater	Applicable	Not effective due to inadequate evaporation rate	Easy to implement	Low	Not retained; inadequate evaporation rate

ROD = record of decision
WETF = West End Treatment Facility

The general response actions, technology types, and representative process options retained for alternative development are in Table 5.

Table 5. Retained representative process options

General response action	Technology type	Representative process option (s)
No action	None	No action
Water treatment	Monitoring/Treat at EMWMF/EMDF site	Managed discharge/landfill wastewater treatment system
	Treat elsewhere on ORR	ORNL PWTC
		Outfall 200

The specific treatment unit operations assumed in this FFS might change during design, but they will be substantively equivalent for the treatment of the key COCs.

3.3 DESCRIPTION OF ALTERNATIVES

3.3.1 Introduction

This section presents the description of the alternatives to manage the landfill wastewater from EMWMF and the proposed EMDF. The general response actions and representative process options selected in the preceding section were used to develop a range of alternatives. The purpose of a range of alternatives is to present the decision makers with technical and economic options for implementation. While the representative process options provide a basis for developing alternatives, the specific process options used to implement the action can change and may not be selected until the design phase. The following four alternatives were assembled from the retained representative process options:

- Alternative 1: No Action. In Alternative 1, EMDF is not built. Current operations continue at EMWMF. Landfill wastewater is discharged to Bear Creek or trucked to PWTC at ORNL.
- Alternative 2: Managed Discharge/Treat. In Alternative 2, landfill wastewater initially is discharged to Bear Creek in accordance with current discharge limits. Following EMDF construction, wastewater is treated at the Landfill Wastewater Treatment System (LWTS) located at the proposed EMDF site prior to discharge to Bear Creek in accordance with revised discharge limits.
- Alternative 3: Treat at PWTC. In Alternative 3, landfill wastewater is transported by truck or pipeline to the onsite PWTC at ORNL.
- Alternative 4: Treat at Outfall 200 Mercury Treatment Facility (OF200 MTF). In Alternative 4, the landfill wastewater is transported by truck or pipeline to the planned, onsite OF200 MTF at Y-12.

Following are descriptions of the alternatives in sufficient detail to support their analysis in Chap. 4. Specific treatment unit operations, other than those described here, may be substituted once the alternative is selected and subsequent detailed design is underway.

3.3.2 Alternative 1: No Action

Summary: In Alternative 1, EMDF is not built. At EMWMF, current operations continue. Landfill wastewater is discharged to Bear Creek if it meets the current discharge limits. Landfill wastewater that does not meet the current discharge limits is trucked to PWTC at ORNL. As required by the NCP, the No Action alternative provides a comparative baseline against which other alternatives are evaluated. The No Action alternative does not initiate any new remedial action, normally assumes that present security measures and land use controls to limit access and use are not maintained and eliminates short- and long-term monitoring. The landfill wastewater will not be expected to meet discharge limits at all times. No implementation is required and there are no additional costs associated with this alternative.

Time frame for implementation: This alternative can be implemented immediately.

3.3.3 Alternative 2: Managed Discharge/Treat

Summary: In Alternative 2, EMWMF landfill wastewater initially is discharged to Bear Creek in accordance with current discharge limits (Table 6) and subsequently is treated at the LWTS located at the proposed EMDF site prior to discharge to Bear Creek in accordance with revised discharge limits (Table 6). Because the proposed EMDF is not constructed adjacent to EMWMF, the landfill wastewater from EMWMF will be transported by either a pipeline or truck to the proposed EMDF site, assumed to be located at Site 7c in Central Bear Creek (Fig. 9). The LWTS is built in accordance with a compliance schedule negotiated per the *Federal Facility Agreement for the Oak Ridge Reservation*, but for estimating purposes, the assumption is LWTS is built when EMDF is built. Prior to construction and operation of LWTS, landfill wastewater that exceeds current discharge limits is treated, or will be transported by truck to the onsite PWTC.

Figure 10 illustrates the process flow diagram for this alternative.

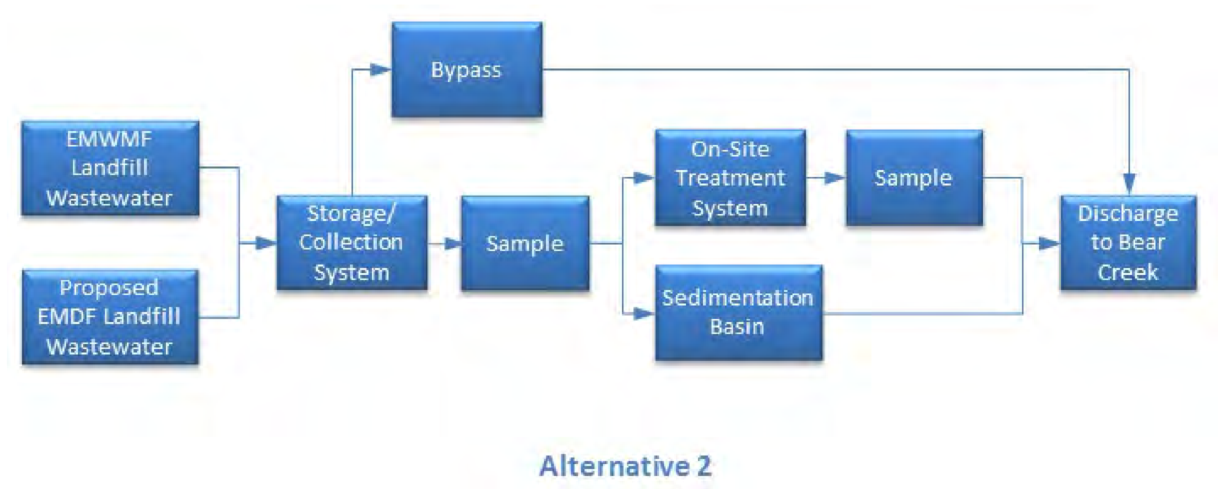

Fig. 10. Alternative 2: process flow diagram.

Details: Landfill wastewater is collected in existing and new ponds and tanks. From these storage facilities, the landfill wastewater passes through a flow proportional sampler that collects representative samples and measures flow rates. The design flow is 60 gpm. If storm flow above the design storm rate occurs that exceeds the storage capacity, the stormwater is released through a bypass pipeline without active management, per Rule 0400-40-05-.07(2)(l), to prevent damage to LWTS and to protect the workers. The existing EMWMF layout is in Fig. 3, and proposed EMDF site layout with landfill wastewater management features is in Fig. 11.

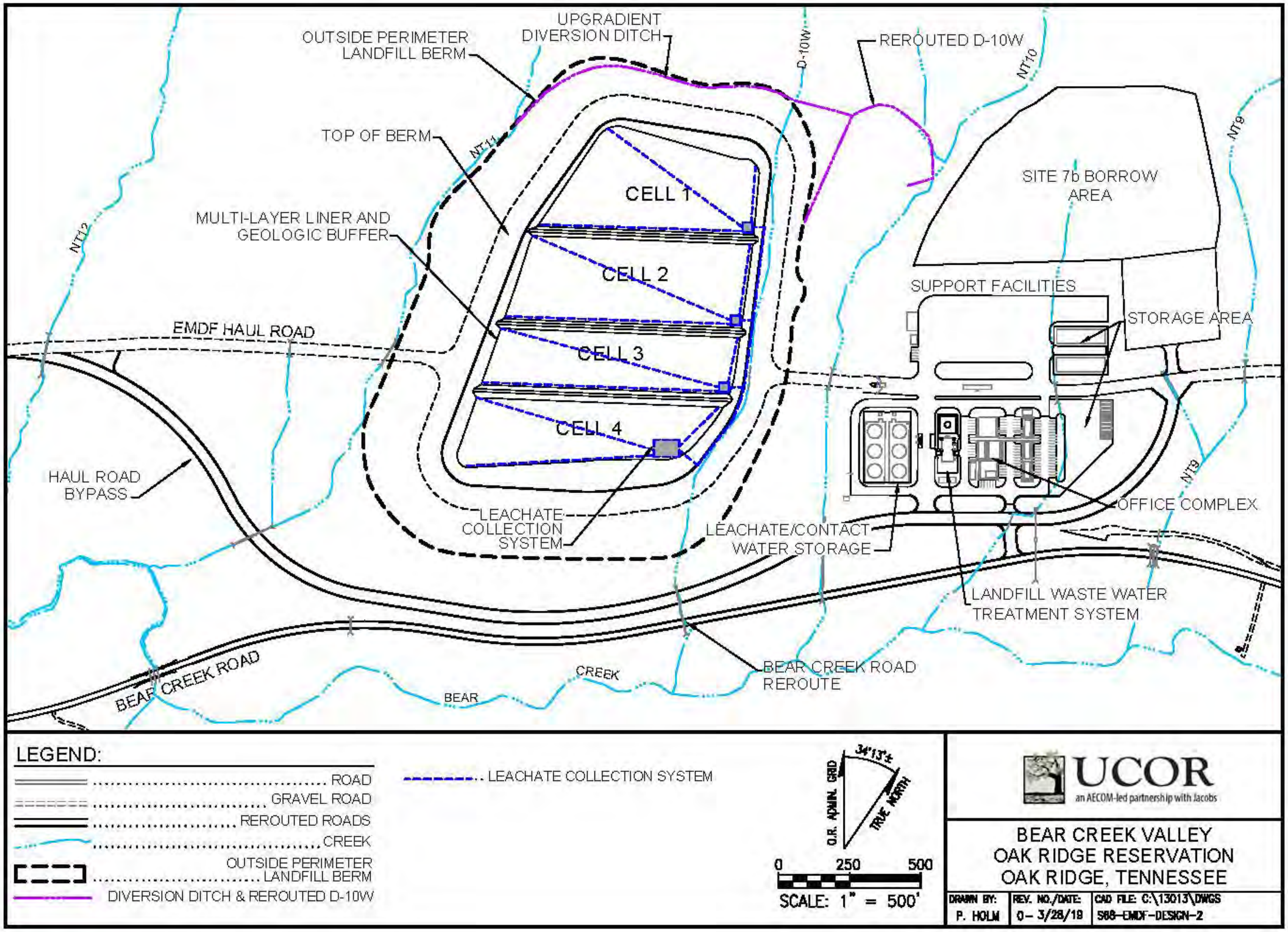

Fig. 11. Alternative 2: site plan.

The proposed EMDF was previously assumed to be located adjacent to EMWMF. The proposed EMDF is now planned to be at Site 7c, and the landfill wastewater from EMWMF will be transported by either a pipeline or truck to the proposed EMDF site, assumed to be in Central Bear Creek (Fig. 9).

Ultimately, the discharge limits (Table 6 used for this evaluation, and Appendix K) for landfill wastewater must be protective of human health and the environment and meet ARARs and are developed as follows:

- Non-radiological key COCs—Discharge limits are based on the lowest ambient water quality criteria (AWQC) (TDEC 0400-40-03-.03) and the anti-degradation requirements (TDEC 0400-40-03-.06).
- Radionuclides and uranium metal—AWQC are not available for radionuclides and uranium metal, so risk-based PRGs for fish tissue and surface water are calculated using the EPA Radionuclide Preliminary Remediation Goal calculator under a recreational scenario for a recreational fisher for the purpose of this evaluation and in accordance with the EPA Administrator's Decision letter (Wheeler, A. R). Radiological discharge limits for both EMWMF and EMDF will be finalized and included in the respective RODs or post-ROD decision documents.

Details on development of these screening level radiological discharge limits are in Appendix K.

Landfill wastewater initially is discharged to Bear Creek in accordance with current discharge limits (Table 6) and points of compliance. Subsequently, landfill wastewater is treated at LWTS, located at the proposed EMDF site, prior to discharge to Bear Creek in accordance with revised discharge limits (Table 6 used for this evaluation, and Appendix K). The point of compliance will be the discharge pipe from LWTS. LWTS is built in accordance with a compliance schedule negotiated per the *Federal Facility Agreement for the Oak Ridge Reservation*.

Prior to construction and operation of LWTS during Managed Discharge, landfill wastewater that exceeds current discharge limits will be treated, such as is done currently for chromium, or will be transported by truck to the onsite PWTC. Construction of LWTS at the proposed EMDF site provides the treatment capability to remove key COCs that exceed the revised discharge limits (Table 6). LWTS occupies an area of approximately 3100 square feet, located east of EMDF (Fig. 11). LWTS consists of manufactured units housed in a structure to provide weather protection. Preliminary process equipment is selected based on key COC characteristics (Tables 2 and 6) and best available technology to meet the revised PRGs for fish tissue and surface water. The assumed LWTS process flow diagram is in Fig. 12. A treatability study is included in this alternative to ensure the appropriate process equipment is identified and installed.

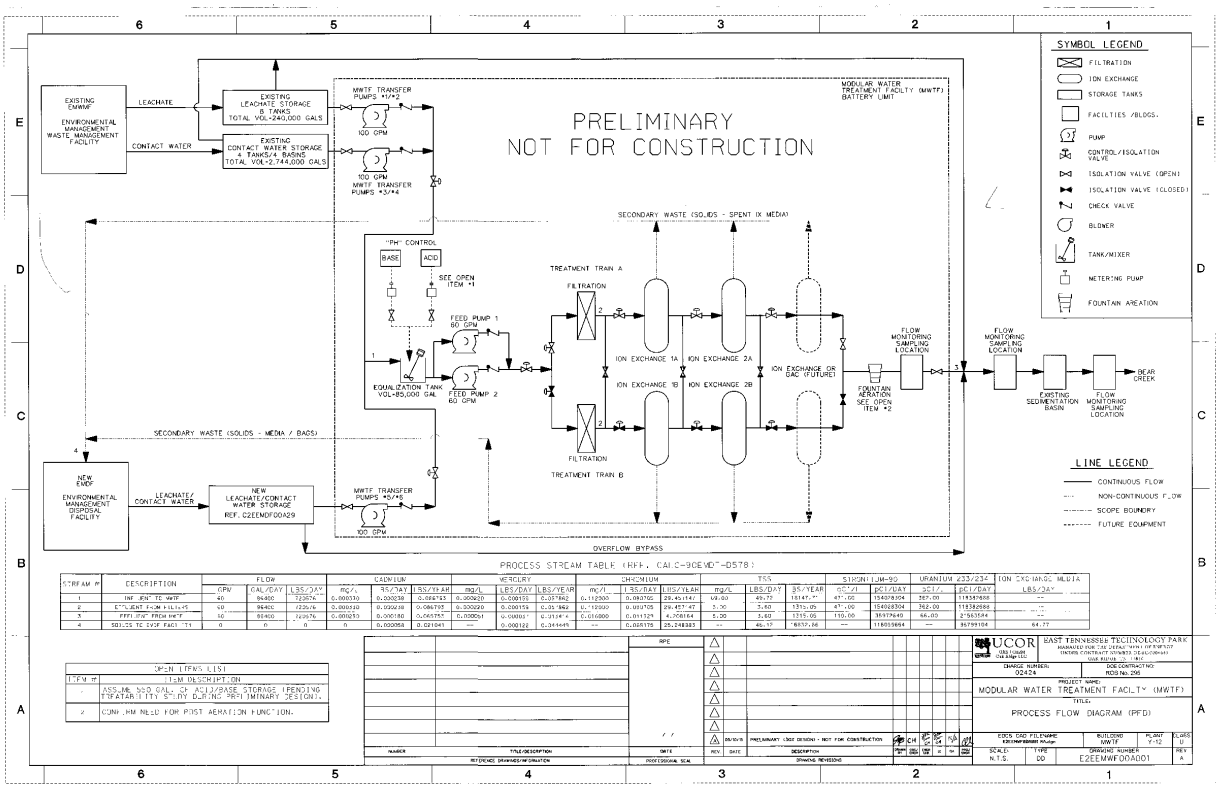

Fig. 12. Alternative 2. Landfill wastewater treatment system process flow diagram.

Managed Discharge is operated on a batch basis. LWTS can be operated on either a batch or continuous basis. Samples will be collected from a continuous, flow proportional sampler prior to release.

Secondary waste may include spent cartridge filters, spent granular carbon, clarifier settled solids (blowdown), carbon column backwash, and liquid from spent carbon dewatering. The spent filters and carbon are dewatered, packaged, and placed in EMWMF or proposed EMDF. The blowdown, backwash return, and dewatering liquid is transferred to the existing contact water ponds where suspended solids will settle until dredging of the basin is necessary to maintain design capacity. The solids from dredging are dewatered, packaged, and placed in EMWMF or the proposed EMDF.

Table 6. Alternative 2 screening level data and discharge limits/PRGs used for evaluating alternatives

Contaminant Type	Contaminant	Units	Average[a]	Maximum	Discharge Limits - Managed Discharge[b]	Discharge Limits/Discharge PRGs – LWTS[b]
Metal	Arsenic*	ug/L	5	5	340	10
Metal	Cadmium**	ug/L	1	1	2.2	0.27
Metal	Total Chromium**	ug/L	30.39	309	625	81
Metal	Chromium, VI*	ug/L	30.88	250	16	11
Metal	Copper**	ug/L	5.24	12.8	15	9.9

Table 6. Alternative 2 screening level data and discharge limits/PRGs used for evaluating alternatives (cont.)

Contaminant Type	Contaminant	Units	Average[a]	Maximum	Discharge Limits - Managed Discharge[b]	Discharge Limits/Discharge PRGs – LWTS[b]
Metal	Lead**	ug/L	3	3.63	73	2.8
Metal	Mercury (EMWMF lower detection limit)[c*]	ug/L	0.03	0.13	1.4	0.051
Metal	Mercury (EMDF)[d]	ug/L	1	NA	NA	0.051
Metal	Nickel**	ug/L	11.43	34.2	515	57
Metal	Uranium	ug/L	12.94	15	NA	24
Other	Cyanide	ug/L	5	5	22	5.2
Pesticide	4,4'-DDD	ug/L	0.1	0.1	NA	0.1
Pesticide	4,4'-DDE	ug/L	0.1	0.1	NA	0.1
Pesticide	4,4'-DDT	ug/L	0.1	0.1	1.1	0.1
Pesticide	Aldrin	ug/L	0.1	0.1	3	0.5
Pesticide	beta-BHC	ug/L	0.1	0.1	NA	0.17
Pesticide	Dieldrin	ug/L	0.54	1	0.24	0.05
						Surface Water PRG
Radiological	Iodine-129	pCi/L	1.5	2.8	83	10.2
Radiological	Strontium-90	pCi/L	6.85	16.1	275	47.9
Radiological	Technetium-99	pCi/L	627.07	3580	5238	1,000
Radiological	Tritium	pCi/L	2104	31900	215000	465,000
Radiological	Uranium-233/234	pCi/L	66.52	385	170	317
Radiological	Uranium-235/236	pCi/L	4.92	25.1	180	455
Radiological	Uranium-238	pCi/L	3.15	21.2	188	210

[a]Non-detects are replaced by the reporting limit.
[c]The detection limit was lowered for appropriate comparison to the ambient water quality criteria.
[b]See Appendix K for the development of these discharge limits.
[d]Mercury from EMDF landfill wastewater was estimated. See Appendix E.

NA = not applicable
*Criteria for these metals are expressed as dissolved.
**Criteria for these metals are expressed as dissolved and are a function of total hardness.

The landfill wastewater is also analyzed for the indicator parameters, e.g., nutrients, dissolved solids, total suspended solids, and total organic carbon. Total organic carbon is used as an indicator of organic compounds. An increasing trend triggers additional evaluation of the potential for increased organic compounds in the landfill wastewater. The indicator parameters are not EMWMF or proposed EMDF key COCs but are used to ensure the landfill wastewater can be discharged without additional impairment of Bear Creek.

Support Activities: No additional support facilities are required to implement Managed Discharge. Managed Discharge of EMWMF landfill wastewater is performed with the existing EMWMF landfill wastewater management staff. No additional resources are needed.

LWTS is constructed near EMDF. Site preparation for LWTS requires minor excavation for the weather structure. The footprint includes 750 square feet of free space to add additional process equipment, if needed, per the adaptive management approach. Utility requirements include electrical power for pumping systems, an air compressor, mechanical equipment, lighting, and instrumentation, and potable water for fire protection and cleaning.

Support activities include constructing the weather structure and providing connection between the alarm systems and emergency transponders for high-level alarms and similar alerts. Operating LWTS requires trained chemical operators and an operations supervisor to oversee the processing activities. The EMWMF/proposed EMDF operating contractor provides support functions (operations management, engineering, health and safety, environmental management, human resources, payroll, accounting, etc.) Sanitary services and change facilities are available in the existing EMWMF office complex, although additional sanitary services and change facilities will be provided at the EMDF site.

Monitoring and Land Use Controls: EMWMF and the proposed EMDF are expected to remain within the control of DOE indefinitely with existing access restrictions and land use controls.

For Managed Discharge, landfill wastewater is sampled, and the results compared to the current discharge limits (Table 6) prior to batch discharge. LWTS effluent is sampled at the flow proportional sampler at the LWTS discharge pipe and compared to the revised discharge limits (Table 6). The details of current EMWMF monitoring are described in the *Sampling and Analysis Plan/Quality Assurance Project Plan for Environmental Monitoring at the Environmental Management Waste Management Facility*. This document requires revision for this alternative. Appendix L provides details on sampling landfill wastewater to determine compliance with discharge limits. One sample per week is collected for the indicator parameters using the flow proportional sampler.

Monitoring will continue following closure of EMWMF and the proposed EMDF. Landfill wastewater volume will be reduced following closure and construction of the final covers. LWTS will be operated on a batch basis when sufficient landfill wastewater has accumulated to justify operating LWTS. The sampling frequency will be reduced to one sample a month. New flow proportional samplers are installed at completion of the final covers to ensure representative samples are collected.

Time frame for implementation: Managed Discharge can be implemented immediately. LWTS is built in accordance with a compliance schedule negotiated per the *Federal Facility Agreement for the Oak Ridge Reservation*. Construction of LWTS is assumed to be concurrent with EMDF construction, with operations planned to begin in 2028-2029.

Uncertainties: There is uncertainty in the future concentrations of the key COCs in landfill wastewater over time because of the different contaminants at ETTP, ORNL, and Y-12; the variability in waste lots and associated contaminants over time; the presence of unexpected contaminants; and the mobility of the disposed contaminants. As shown in Appendix C, at times in the past, specific contaminants have required treatment for a short time, but do not currently require treatment. It is expected that this situation will continue in the future so that the contaminants requiring treatment will vary over time and for varying periods of time. There also is uncertainty in the flow rate due to rainfall variation, the number of open disposal cells, and the number of closed cells (cells under enhanced operational cover or equivalent). Therefore, LWTS is constructed using a modular design that can be modified, as needed. The adaptive management approach is used with likely additional contaminants identified, and potential additional processing capability is identified in advance of need based on waste and wastewater data. The ability to adapt to changes in key COCs, COC concentrations, and fluctuating flow rate is considered in the subsequent evaluation of this alternative. Although current concentrations of key COCs in Table 2 indicate Managed Discharge will be successful for EMWMF landfill wastewater, there is the potential for increases in the EMWMF key COCs above existing discharge limits that could require extensive trucking to PWTC. The PWTC is expected to remain operational during the time period that EMWMF is operating.

The indicator parameters also may change based on potential changes in waste characteristics, changes in field measurements, or total organic carbon indicating a change in the landfill wastewater characteristics and/or the results of the biennial sampling results. The nutrient loading, total suspended solids, and/or total dissolved solids sample results may require additional management controls to reduce these to acceptable levels. These management controls, if required, are implemented at EMWMF/proposed EMDF site and will not require transport for treatment elsewhere on the ORR or additional treatment unit operations.

Documents: To implement this alternative, the EMWMF ROD and implementing documents, including the sampling and analysis plan (UCOR-4156) and remedial action work plan (DOE/OR/01-1874&D4/R4), will have to be revised. The proposed EMDF ROD will be developed to include this remedy and be approved. A remedial action work plan/remedial design report will be completed that include the specific design for LWTS, and a remedial action work plan for operations will be completed. A completion report will be required to document the as-built conditions. Operations details will be included in the annual report.

3.3.4 Alternative 3: Treat at Process Waste Treatment Complex

3.3.4.1 Common Components

Summary: In Alternative 3, landfill wastewater is transported by pipeline (Alternative 3a) or truck (Alternative 3b) to the onsite PWTC. Figure 13 illustrates the process flow diagram for this alternative.

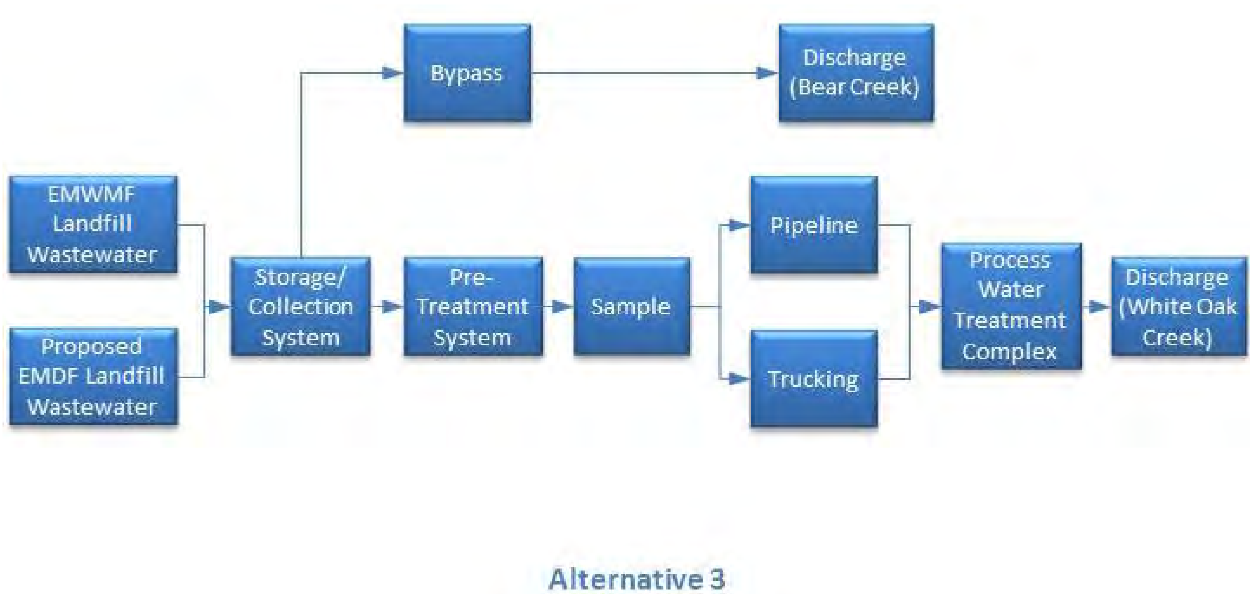

Fig. 13. Alternative 3: process flow diagram.

Background: The entire ORR is on the CERCLA National Priorities List due to legacy contamination. The ORNL PWTC is located on the ORR and is an onsite treatment facility primarily used to treat waters arising from the ORNL facilities and environmental management actions. PWTC treats the existing EMWMF landfill wastewater that does not meet the current EMWMF discharge limits (DOE/OR/01-1873&D2/A1/R2). This landfill wastewater is currently trucked to the ORNL PWTC.

The NCP at 40 *CFR* 300.400(e)(1) defines "onsite" as meaning "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for the implementation of the response action." CERCLA Sect. 104(d)(4) (as discussed further in the preamble to the final NCP, 55 FR 8690) states where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, these related facilities may be treated as one for the purpose of conducting response actions. Section 104(d)(4) allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit (i.e., manage as "onsite" waste).

This approach was proposed and agreed to by all signatories to the *Federal Facility Agreement for the Oak Ridge Reservation* for EMWMF, was acknowledged and documented in the EMWMF ROD (DOE/OR/01-1791&D3) and was reaffirmed in the ETTP Zone 2 ROD (DOE/OR-01-2161&D2). This agreement serves as the basis for designating waste treatment, storage, and disposal facilities on the ORR as "onsite" facilities not subject to the CERCLA Offsite Rule (40 *CFR* 300.440) when accepting wastes from CERCLA onsite response actions.

Details: Landfill wastewater is collected in storage tanks and then transferred to PWTC. The average flow rate is 30 gpm. The maximum flow rate is 60 gpm. Figure 4 illustrates the existing EMWMF and proposed EMDF site layout with water management features.

PWTC was recently upgraded to extend the life of PWTC. However, this extension of the design life does not consider EMWMF contact water and proposed EMDF landfill wastewater as an influent, so the ability to treat mercury and radionuclides, and possibly other key COCs, and to manage the increased flow is limited. Therefore, pre-treatment of EMWMF and proposed EMDF landfill wastewater are required for the long-term viability of this alternative. The pre-treatment system is equivalent to the LWTS in Alternative 2 and is located at the proposed EMDF site due to a lack of space at PWTC.

From the water storage locations, the landfill wastewater is pretreated and then pumped through a pipeline or to a truck for transport to the ORNL PWTC. Following pre-treatment, the landfill wastewater flows through a flow proportional sampler at which the flow is measured, and samples are collected for analysis and verification that the PWTC WAC (Table 7) are met. If storm flow above the design storm rate occurs that exceeds the storage capacity, the stormwater is released through a bypass pipeline without active management, per Rule 0400-40-05-.07(2)(l) to prevent damage to the pre-treatment system and to protect the workers. The storage capacity design is based on a 100-year, 24-hour storm. Water storage is constructed or upgraded to be RCRA-compliant.

Based on the design flow of 60 gpm from EMWMF and the proposed EMDF, there is sufficient capacity at PWTC to accommodate the landfill wastewater in the non-radiological treatment system, but not in the radiological treatment system.

Table 7. Alternative 3: landfill wastewater characteristics and PWTC waste acceptance criteria

Contaminant type	Contaminant	Units	Average[a]	Maximum	PWTC WAC[b] (Bldg. 3544-radiological)	PWTC WAC[b] (Bldg. 3608-non-radiological)
Metal	Arsenic*	ug/L	5	5	4000	4000
Metal	Cadmium**	ug/L	1	1	300	10
Metal	Chromium, III**	ug/L	30.39	309	NA	NA
Metal	Chromium, VI*	ug/L	30.88	250	NA	NA
Metal	Copper**	ug/L	5.24	12.8	2500	100
Metal	Lead**	ug/L	3	3.63	30,000	30,000
Metal	Mercury (EMWMF lower detection limit)[c]*	ug/L	0.03	0.13	0[d]	0[d]
Metal	Mercury (EMDF)[e]	ug/L	1	NA	0[d]	0[d]
Metal	Nickel**	ug/L	11.43	34.2	65,000	11,000
Metal	Uranium	ug/L	12.94	15	NA	NA
Other	Cyanide	ug/L	5	5	200	200
Pesticide	4,4'-DDD	ug/L	0.1	0.1	NA	NA
Pesticide	4,4'-DDE	ug/L	0.1	0.1	NA	NA
Pesticide	4,4'-DDT	ug/L	0.1	0.1	NA	NA
Pesticide	Aldrin	ug/L	0.1	0.1	NA	NA
Pesticide	beta-BHC	ug/L	0.1	0.1	NA	NA
Pesticide	Dieldrin	ug/L	0.54	1	NA	NA
Radiological	Iodine-129[b]	pCi/L	1.5	2.8	NA	NA
Radiological	Strontium-90[b]	pCi/L	6.85	16.1	10,000B q/L	NA
Radiological	Technetium-99[b]	pCi/L	627.07	3580	NA	NA
Radiological	Tritium[b]	pCi/L	2104	31900	NA	NA
Radiological	Uranium-233/234[b]	pCi/L	66.52	385	NA	NA
Radiological	Uranium-235/236[b]	pCi/L	4.92	25.1	NA	NA
Radiological	Uranium-238[d]	pCi/L	3.15	21.2	NA	NA

Table 7. Alternative 3: landfill wastewater characteristics and PWTC waste acceptance criteria (cont.)

[a]Non-detects are replaced by the reporting limit.
[b]*Waste Acceptance Criteria for Liquid Waste Systems Operated by Liquid and Gaseous Waste Operations at Oak Ridge National Laboratory*, WM-LWS-WAC, *Rev. 9.*
[c]The detection limit was lowered for appropriate comparison to the ambient water quality criteria.
[d]Waiver to WAC required.
[e]Mercury from EMDF landfill wastewater was estimated. See Appendix E.

NA = not applicable
*Criteria for these metals are expressed as dissolved.
**Criteria for these metals are expressed as dissolved and are a function of total hardness.

The evaluated process flow diagram for PWTC is illustrated in Fig. 14. Following treatment, the treated effluent is discharged into White Oak Creek under a National Pollutant Discharge Elimination System (NPDES) permit.

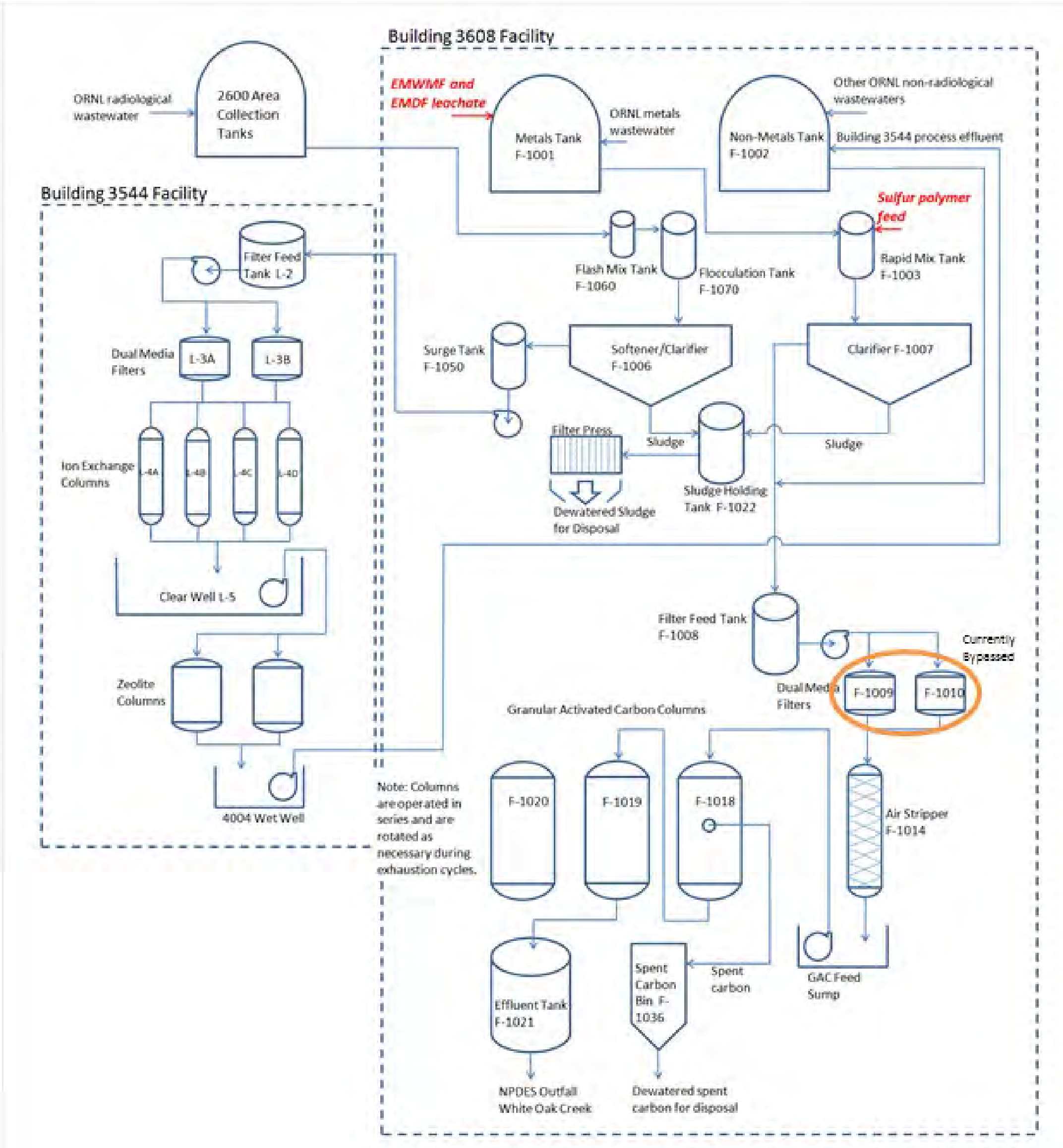

Fig. 14. Alternative 3: PWTC process flow diagram.

Prior to accepting new wastewater for treatment at PWTC, the waste generator must ensure the wastewater meets the WAC (WM-LWS-WAC/R9, *Waste Acceptance Criteria for Liquid Waste Systems Operated by Liquid and Gaseous Waste Operations at Oak Ridge National Laboratory*). In limited situations, wastewaters containing mercury can be accepted at the PWTC, but even then, only with an approved variance request. Therefore, a variance request will have to be issued and approved to allow for the treatment of mercury-containing landfill wastewater. Longer-term treatment of mercury-containing landfill wastewater will require a NPDES permit modification, as will the planned addition of increased, long-term landfill wastewater flow from the EMWMF and proposed EMDF.

Support activities: Landfill wastewater is transferred to PWTC by either pipeline (Alternative 3a) or truck (Alternative 3b). Support activities are needed to construct additional loading and unloading stations, connect to utilities, construct the pre-treatment facility, and provide connection between the alarm systems and emergency transponders for high-level alarms and similar alerts. Operation of the PWTC will use the existing trained and qualified chemical operators, but operation of the pre-treatment facility located at EMWMF/proposed EMDF site will require additional operators.

Monitoring and land use controls: EMWMF, proposed EMDF, and PWTC are expected to remain within the control of DOE indefinitely with existing access restrictions and land use controls.

One sample is collected using a flow proportional sampler for every 140,000 gal to ensure compliance with PWTC WAC (Table 7). The number of samples is estimated at 72 per year, based on current and projected landfill wastewater generation rates.

Monitoring continues following completion of the EMWMF and proposed EMDF final covers. Landfill wastewater volume is reduced, and the sampling frequency is reduced to one sample a month. New flow proportional samplers are installed at completion of the final covers to ensure representative samples continue to be collected.

Effluent from PWTC is monitored in accordance with the NPDES permit.

Time frame for implementation: Construction of the pre-treatment facility also must be complete at the start of proposed EMDF operations. Additionally, the PWTC NPDES permit and WAC need to be renegotiated prior to long-term acceptance of landfill wastewater. Construction of the pipeline, if selected, will be concurrent with EMDF construction, with operations planned to begin in 2028–2029.

Uncertainties: There is uncertainty in the future concentrations of the key COCs in landfill wastewater over time because of the different contaminants at ETTP, ORNL, and Y-12; the variability in waste lots and associated contaminants over time; the presence of unexpected contaminants; and the mobility of the disposed contaminants. As shown in Appendix C, at times in the past, specific contaminants have required treatment for a short time, but do not currently require treatment. It is expected that this situation will continue in the future so that the contaminants requiring treatment will vary over time and for varying periods.

Since the concentration of mercury in EMDF landfill water is estimated and uncertain, the actual concentration may exceed the ability of the PWTC to reduce it sufficiently to meet the discharge permit limits. If the mercury levels are sustained at high levels, and/or are projected to result in effluent that exceeds the NPDES permit, then this water cannot be treated at the PWTC without pre-treatment. Therefore, construction of the pre-treatment facility must be complete prior to receipt of landfill wastewater. Because of space limitations at PWTC, pre-treatment is expected to take place at the EMWMF/proposed EMDF site.

There also is uncertainty in the flow rate due to rainfall variation, the number of open disposal cells, and the number of closed cells. The combined flow from the proposed EMDF and EMWMF, the ability to adapt to changes in key COCs, COC concentrations, and fluctuating flow rate are considered in the subsequent evaluation of this alternative.

There are no unit operations for uranium removal at PWTC, so landfill wastewater with uranium isotopes cannot be accepted at this time. Pre-treatment facilities are needed at the EMWMF/proposed EMDF site if high levels of uranium or other radionuclides in landfill wastewater are encountered in the future.

The PWTC 3608 processing system was recently upgraded. However, when the evaluation was performed, the PWTC was constructed in 1989 and shows signs of deterioration from 25 years of operation. The dual media filters F-1009 and F-1010 had experienced corrosion problems and had been removed from service. The sulfuric acid feed tank was also replaced because of corrosion. Routine maintenance and component replacement will continue, as necessary, to continue operations, although an extension of PWTC life has now been completed.

Documents: To implement this alternative, the proposed EMDF ROD will be developed to include this remedy and be approved. The EMDF remedial action work plan/remedial design report will be completed that include the specific design, and a completion report will be required to document the as-built conditions.

The PWTC NPDES permit and WAC require modification to include EMWMF contact water and the proposed EMDF wastewater.

The EMWMF ROD and implementing documents, including the Sampling and Analysis Plan/Quality Assurance Project Plan (UCOR-4156) and the remedial action work plan (DOE/OR/01-1874&D4/R4), will have to be revised.

3.3.4.2 Alternative 3a: Pipeline Transport to PWTC

Summary: A pipeline is constructed to transport landfill wastewater from EMWMF/proposed EMDF to PWTC. This pipeline consists of double-walled, welded, high-density polyethylene (HDPE) piping and follows existing disturbed areas, such as Haul Road and the power line easement, where possible.

Details: Approximately 4.8 miles of pressurized pipe is installed between EMWMF/proposed EMDF and PWTC. The pipeline is double-walled 4-in. (SDR 11) HDPE pipe with a single lift station and leak-detection sensors in the annular space. The primary pipe is contained within a secondary HDPE pipe with leak-detection sensors. The leak-detection sensors are electronic low-point leak-detection stations set approximately 5000 feet apart that communicate wirelessly to a main receiver. The pipeline lift station receives landfill wastewater from the water storage facilities currently provided at EMWMF and the additional tanks provided for the proposed EMDF, at the EMDF location. As shown, on Fig. 15, the change in the EMDF location does not substantially change this option because the pipeline route as planned runs across the EMDF location at Site 7c.

The pipeline follows the existing Haul Road west from EMWMF, turns south at Reeves Road, and joins the power line easement that crosses over Chestnut Ridge (Fig. 15). The pipeline exits the power line easement alongside Bethel Valley Road, then turns south at First Street, turning east near the 2600 tanks. The pipeline follows First Street within ORNL to avoid the congestion of utilities that typically exists within the ORNL main campus footprint. This route is anticipated to have minimal impact to the environment or ORNL operations. There are two pipeline crossings for Bear Creek and White Oak Creek. The creek crossings utilize the existing bridges at these locations.

The pump station is located at the beginning of the pipeline near to the existing EMWMF contact water storage areas. The pump station consists of a prefabricated metal structure over a wet well with a primary transfer pump and secondary back-up pump. The pumps are sized based on the design flow rate of 60 gal per minute and the required head to overcome elevation changes to clear Chestnut Ridge and friction losses along the entire length of the pipeline. Power runs from existing infrastructure at the EMWMF/proposed EMDF site, and an emergency generator is provided to maintain operations during prolonged power outages.

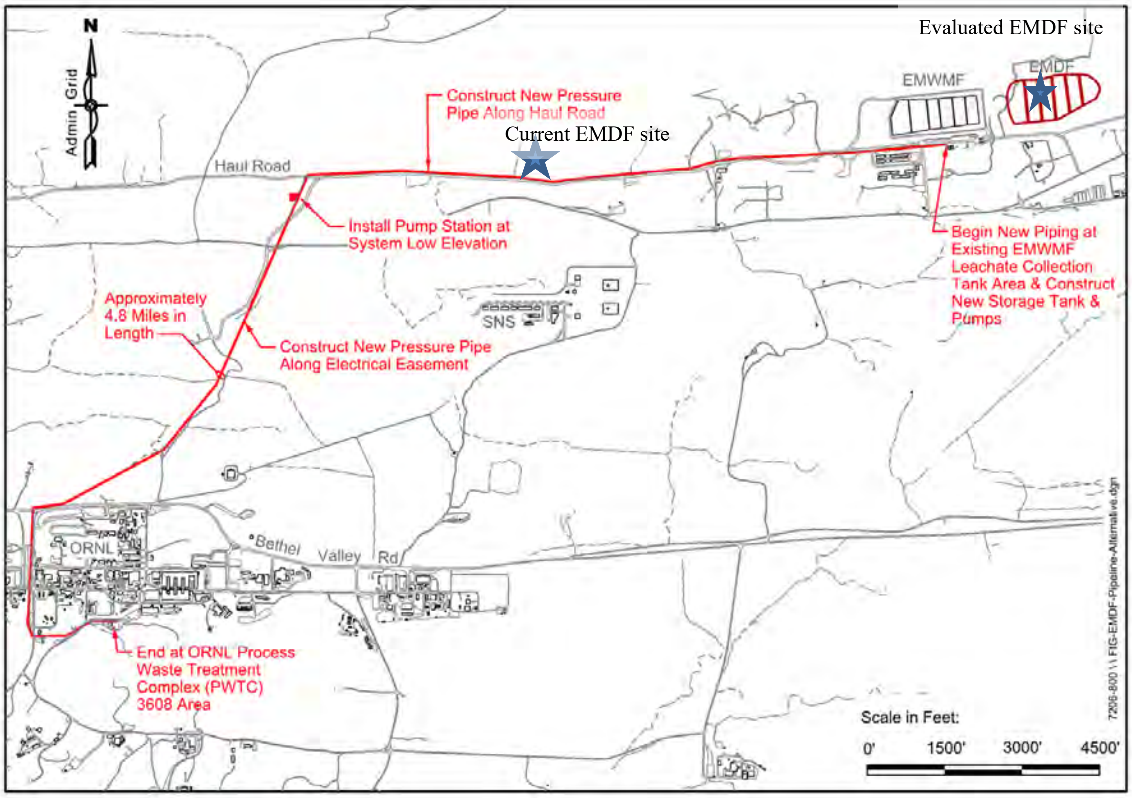

Fig. 15. Alternative 3a: route of pipeline to PWTC.

Support activities: Additional utility support is required at ORNL to ensure utilities and structures are identified, moved, or protected during construction activities. Electrical power is required to the pump stations. Leak-detection alarms are required, along with telemetry to alert operators of potential alarms or leaks. Additional storage is required for the landfill wastewater at the EMWMF/proposed EMDF site to retain the design stormwater and to provide a consistent flow of water to the lift station.

Monitoring and land use controls: The ORR remains within the control of DOE indefinitely with existing access restrictions and land use controls. Additional monitoring of the pipeline is performed to verify safe and efficient operating conditions.

Time frame for implementation: Construction of the pipeline is concurrent with the proposed EMDF construction, with operations planned to begin in 2028–2029.

Uncertainties: The following uncertainties are associated with the pipeline:

- Potential route deviations within ORNL due to structures, utilities, or similar obstructions that cannot be moved or avoided
- Potential route deviations outside of ORNL due to potential ecological impacts
- Construction delays within the ORNL main campus due to conflicts with the existing operations
- Construction delays within the power line easement due to the proximity to electrical lines
- Additional lift stations may be required if the planned lift station cannot be placed at the planned location
- Potential soil contamination along the pipeline route may cause delays and increased cost for disposal

Documents: An environmental survey of the pipeline route is required.

3.3.4.3 Alternative 3b: Truck transport to PWTC

Summary: The landfill wastewater is trucked to PWTC using the existing fleet of government-furnished, 5000-gal capacity tanker trailers and tractors, plus an additional two tankers. The route is the same as the current route taken by EMWMF tanker trucks and is shown in Fig 16.

Details: The trucks typically haul 4500 gal per load. For the higher precipitation season of approximately three months, trucks haul landfill wastewater seven days per week for a regular 10-hour day shift. During the remaining nine months of the year, trucks are expected to haul landfill wastewater four days per week, day shift only, as is the current practice. However, if higher precipitation volumes occur during winter, then the seven-day-per-week schedule may need to be extended for up to six months to empty the storage system.

The two existing EMWMF loading stations are required to process up to 20 shipments per 10-hour shift and a third loading station is required, as a contingency, should additional landfill wastewater require offsite treatment. The existing 4-in. portable pumps are used to transfer the landfill wastewater to the loading station. Connections exist for the portable pump to each tank, and hoses connect the pump discharge to the loading arm pipe at the new loading station.

The new loading station, located centrally to the contact water tanks or at the EMDF site, includes a pull-through spill containment slab similar to that at the current West Loading Station, but with both long sides curbed. The containment slab is 60-ft long with a sump for collection of rainwater and spill/leaks. The sump has an automatic submersible pump that pumps back to any of the four tanks via a new underground pipe network.

The existing West Loading Station is refurbished to add a loading platform and new articulating loading arm of similar design to the existing East Loading Station. The only change to the East Loading Station is an upgrade to a higher capacity leachate transfer/loading pump.

A second, accessible tanker unloading station or bay is required at PWTC to allow two tankers to be simultaneously unloaded. The unloading station consists of a pull-through concrete containment slab with a sump to collect and transfer rainwater or spills into the treatment system and a gravity discharge pipe header to allow for emptying the tanker into the main collection sump. To create space for the new unloading station, a long retaining wall is demolished, and excavation into a hillside with potentially contaminated soil is performed. The retaining wall is re-constructed. The excavated soil requires characterization to determine the appropriate disposal pathway, expected to be the ORR landfill.

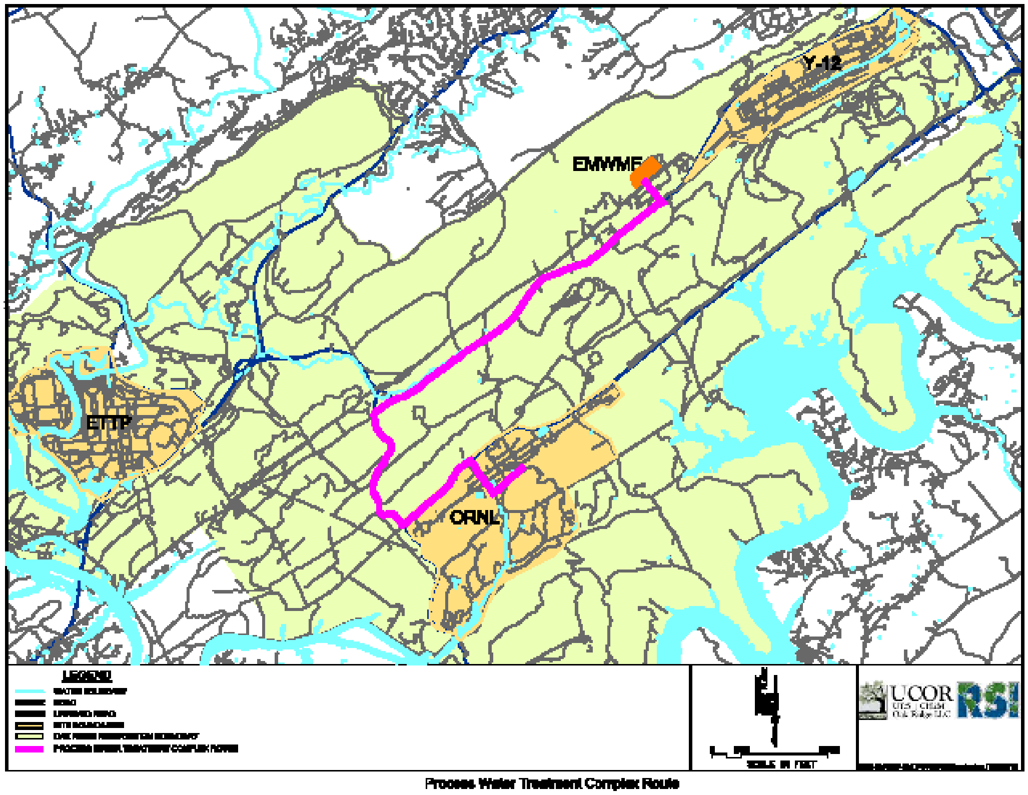

Fig. 16. Alternative 3b: truck route to PWTC.

Support activities: Piping is required to connect the proposed EMDF storage tanks and load-out pump to the new loading station near the existing ModuTanks®[1] at EMWMF. Additional support activities are required to procure two additional tankers, train drivers, and maintain the ORR roadways. Tractors to transport the leachate tankers are leased. The changed location for the EMDF site would require trucks to transport landfill wastewater down Haul Road to Reeves Road, then follow the same route. No other changes are required.

PWTC personnel are required to support a seven-days/week shipping schedule for up to six months per year. In addition, a second tanker unloading station or bay is required at PWTC.

Monitoring and land use controls: ORR remains within the control of DOE indefinitely with existing access restrictions and land use controls. No additional monitoring is required over what is required for Alternative 3.

Time frame for implementation: Construction of the additional support structures is concurrent with the proposed EMDF construction, with operations planned to begin in 2028 to 2029.

Uncertainties: Low levels of contamination are present in the soil that must be removed to undertake the infrastructure modifications at PWTC. While this soil is expected to be suitable for disposition at the ORR landfill, if higher levels of contamination are found, additional worker protection may be needed. In

[1]Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

addition, more stringent packaging and handling may be necessary for waste disposal at an alternate location. The future cost and availability of fuel may be a factor in the execution of this alternative.

The truck route to PWTC (Fig. 16) may be altered due to safety and security issues, as has occurred recently. This change may result in significant inefficiencies and cost increases.

Documents: No additional documentation is required in addition to the Alternative 4 documents.

3.3.5 Alternative 4: Treat at Outfall 200 Mercury Treatment Facility

3.3.5.1 Common Components

Summary: In Alternative 4, the landfill wastewater is transported by truck or pipeline to the planned, onsite OF200 MTF at Y-12. Figure 17 illustrates the process flow diagram for this alternative.

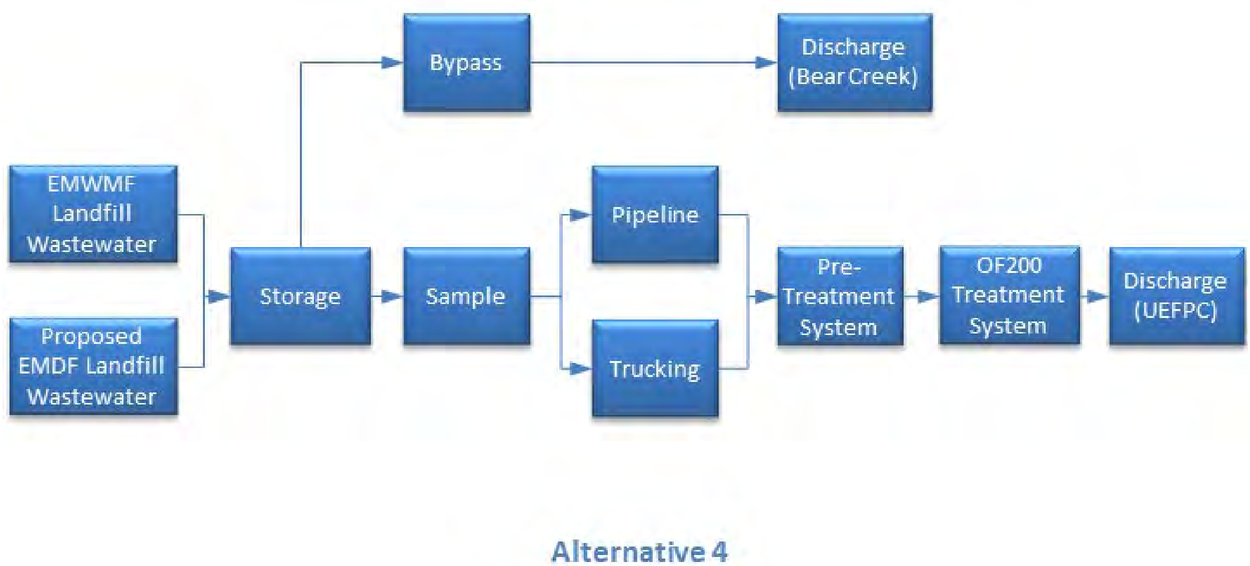

Fig. 17. Alternative 4: process flow diagram.

Background: The proposed OF200 MTF will be an onsite water treatment facility located on the Y-12 footprint of the ORR. OF200 MTF is currently being designed as an onsite water treatment facility to remove mercury from Upper East Fork Poplar Creek (UEFPC) surface water. While not yet in place, this treatment facility is being designed as a CERCLA action to reduce the amount of mercury discharged into UEFPC.

CERCLA remedial actions conducted onsite, as defined by 40 *CFR* 300.5, must comply with the ARARs, but not procedural or administrative requirements. The NCP at 40 *CFR* 300.400(e)(1) defines "onsite" as meaning "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for the implementation of the response action." CERCLA Sect. 104(d)(4) (as discussed further in the preamble to the final NCP, 55 FR 8690) states where two or more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, these related facilities may be treated as one for the purpose of conducting response actions.

Section 104(d)(4) allows the lead agency to manage waste transferred between such noncontiguous facilities without having to obtain a permit (i.e., manage as "onsite" waste). This approach was proposed and agreed to by all signatories to the *Federal Facility Agreement for the Oak Ridge Reservation* for EMWMF, was acknowledged and documented in DOE/OR/01-1791&D3 and was reaffirmed in DOE/OR-01-2161&D2. This agreement serves as the basis for designating waste treatment, storage, and disposal facilities on the ORR as "onsite" facilities not subject to the CERCLA Offsite Rule (40 *CFR* 300.440) when accepting wastes from CERCLA onsite response actions.

Details: The landfill wastewater from EMWMF and the proposed EMDF is pumped to sumps, tanks, and/or basins for storage. The average flow rate is 30 gpm, and the peak flow rate is 60 gpm. From storage, the water is pumped through a pipeline (Alternative 4a) or to a truck (Alternative 4b) for transport to OF200 MTF. The landfill wastewater will flow through a flow proportional sampler at which the flow will be measured, and samples will be collected for analysis. If storm flow above the design storm rate occurs that exceeds the storage capacity, the stormwater is released through a bypass pipeline without active management, per Rule 0400-40-05-.07(2)(l), to prevent damage to LWTS and to protect the workers. Storage capacity design will be based on a 100-year, 24-hour storm. Water storage is constructed or upgraded to be RCRA-compliant.

OF200 MTF is being designed to remove mercury from UEFPC surface water. While the OF200 MTF design may be effective for removal of other COCs in addition to mercury, treatment system performance for other contaminants has not been evaluated to date. Therefore, pre-treatment is provided for the other key COCs. The pre-treatment system is equivalent to the LWTS in Alternative 2 and is located at the OF200 MTF. The proposed OF200 MTF will be capable of treating 3000 gpm of UEFPC surface water (95th percentile of the projected UEFPC stream flow) with a goal of treating to an effluent concentration < 51 ppt mercury. Storage capacity for the landfill wastewater is provided at the EMWMF/proposed EMDF site until these waters are transferred to the proposed OF200 MTF.

A treatability study is performed as part of this alternative to determine whether contaminants other than mercury, such as cadmium and radionuclides, are removed by the proposed OF200 MTF. The treatability study will evaluate removal of the key COCs requiring treatment. The results of the treatability study will be used to develop the criteria to determine whether landfill wastewater can be accepted at OF200 MTF or require pre-treatment.

The *Proposed Plan for Water Treatment at Outfall 200 Under the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-2661&D2) describes the water treatment facility planned to reduce the release of mercury from OF200 into UEFPC at Y-12. The *Amendment to the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee, Water Treatment at Outfall 200* (DOE/OR/01-2697&D2) was approved by the regulatory agencies in 2016.

The OF200 MTF headworks will be constructed near Outfall 200, and the treatment plant will be constructed approximately 3000 feet east (Fig. 18).

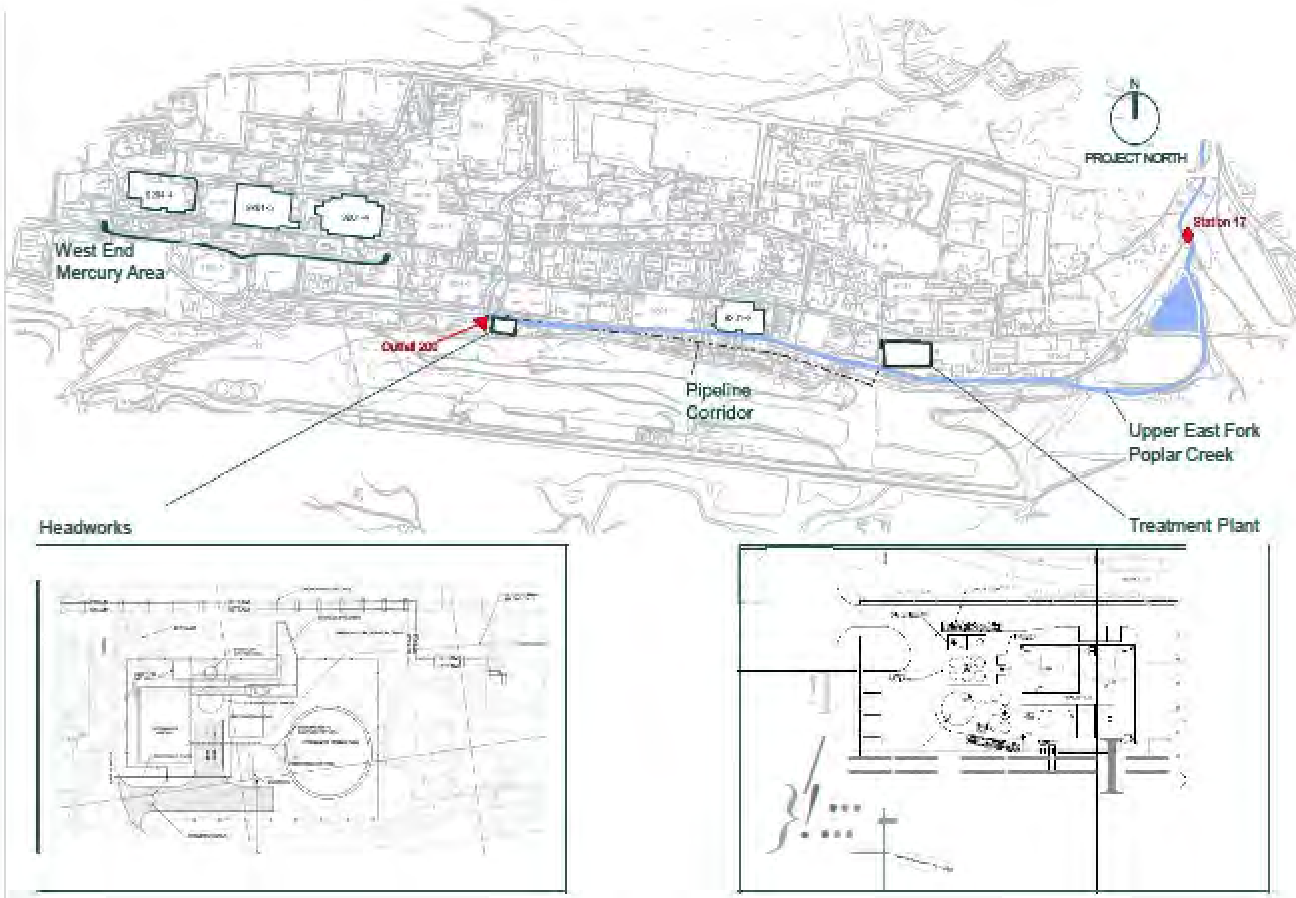

Fig. 18. Location of the Outfall 200 MTF.

As described in the Proposed Plan, water flowing from Outfall 200 will be diverted into the inlet channel of the headworks through an intake structure grit removal and pump station. Water that has completed the grit removal process will be sent to either stormwater storage at the headworks or an equalization tank at the treatment plant. OF200 MTF will include the following sequential unit operations:

- Headworks/intake structure overflow diversion to UEFPC.
- Grit removal and grit classifier for solid waste separation.
- Inclined plate clarifiers for solids removal.
- Multimedia filtration—liquid effluent from the clarifiers will go to multi-media filters for additional solids removal prior to discharge of the treated effluent back to UEFPC.
- Sludge thickening and dewatering—sludge from the clarifiers will go to a sludge thickening tank and then to a filter press for dewatering. The resulting filter cake will be sent for disposal, while the filtrate will be recycled back into the treatment stream.

The OF200 MTF process flow diagram is in Fig. 19.

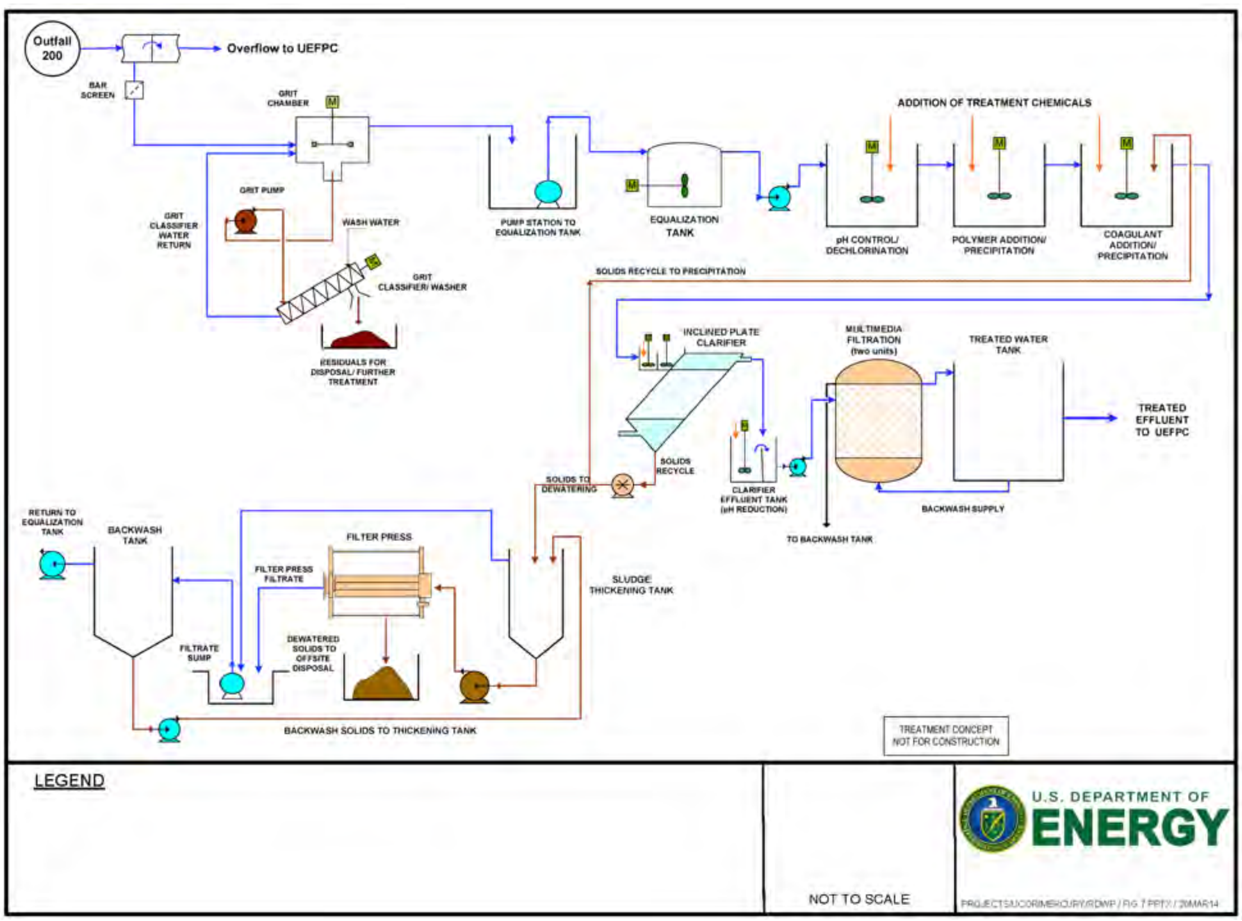

Fig. 19. Outfall 200 MTF process flow diagram.

OF200 MTF is only planned to accept the influent from UEFPC. If the OF200 MTF alternative is selected, design modifications are required to convey the landfill wastewater to OF200 MTF by either pipeline (Alternative 4a) or trucking (Alternative 4b).

Operation of the OF200 MTF will continue until mercury source areas at the West End Mercury Area have been remediated and mercury levels in discharges from Outfall 200 have declined to levels that no longer require treatment, estimated at 30 years.

Support activities: Landfill wastewater is transferred to OF200 MTF by either pipeline (Alternative 4a) or truck (Alternative 4b). Support activities are needed to construct additional loading and unloading stations, connect to utilities, and provide connection between the alarm systems and emergency transponders for high-level alarms and similar alerts. The additional 60 gpm of wastewater will not be expected to require any additional trained and qualified chemical operators over what is already estimated (DOE/OR/01-2599&D2). Pre-treatment will be needed to enhance the treatment effectiveness and/or minimize impacts to the OF200 facility operations. Pre-treatment is expected to increase the operating costs for this facility.

The predominant solid waste streams generated by the proposed OF200 MTF treatment operations are estimated to include grit material from the grit removal system (estimated at 1,300,000 lb/year), filter cake from the filter press (estimated at 440,000 lb/year), and spent media from the multi-media filters (estimated at 44,000 lb/year) (DOE/OR/01-2660&D3, *Focused Feasibility Study for Supplemental Mercury Abatement Actions Under the Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee*). All wastes will be sent for appropriate onsite or offsite disposal as sanitary/industrial waste, RCRA-regulated hazardous waste, low-level radioactive waste, or mixed waste, as suitable (DOE/OR/01-2599&D2, *Remedial Design Work Plan for the Outfall 200 Mercury Treatment Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee*).

Monitoring and land use controls: EMWMF, the proposed EMDF, and OF200 MTF are expected to remain within the control of DOE indefinitely with existing access restrictions and land use controls.

Time frame for implementation: The current schedule for the proposed OF200 MTF is for the treatment system to be operational in 2022. This time frame will result in the ability to treat the proposed EMDF landfill wastewater when this begins to be generated in 2028 to 2029. However, OF200 MTF will not be available to treat EMWMF landfill wastewater until it is fully operational and a pretreatment facility is constructed.

Uncertainties: There is uncertainty in the future concentrations of the key COCs in landfill wastewater over time because of the different contaminants at ETTP, ORNL, and Y-12; the variability in waste lots and associated contaminants over time; the presence of unexpected contaminants; and the mobility of the disposed contaminants. As shown in Appendix C, at times in the past, specific contaminants have required treatment for a short time, but do not currently require treatment. It is expected that this situation will continue in the future so that the contaminants requiring treatment will vary over time and for varying periods. There also is uncertainty in the flow rate due to rainfall variation, the number of open disposal cells, and the number of closed cells.

OF200 MTF is being designed to treat mercury in UEFPC surface water. While other waters may be effectively treated and other contaminants potentially may be removed, no evaluation has been conducted to determine if additional contaminant removal will be successful. Therefore, pre-treatment for the key COCs other than mercury is included in this alternative. Treatability studies will be conducted for this alternative to determine effectiveness at removing additional EMWMF/proposed EMDF contaminants.

OF200 MTF is currently in design and planned to be operational in 2025. If landfill wastewater requires treatment during this time frame, an alternative treatment system will be necessary. In addition, delays in completion of OF200 MTF will increase the potential that an alternative treatment system will be required prior to availability of OF200 MTF.

Operation of the OF200 MTF will continue until mercury source areas at the West End Mercury Area have been remediated and mercury levels in discharges from Outfall 200 have declined to levels that no longer require treatment, estimated at 30 years. This duration may be incompatible with the time needed to treat landfill wastewater.

Documents: To implement this alternative, the ROD for the proposed EMDF has to be developed to include this remedy and approved, and the proposed OF200 MTF CERCLA documents must be revised and approved to include the proposed EMDF/EMWMF landfill wastewater as a treatment stream. A remedial action work plan/remedial design report will be completed that include the specific design for conveyance support. A completion report will be required to document the as-built conditions. EMWMF ROD and implementing documents, including the sampling and analysis plan (UCOR-4156), may have to be revised. The division of scope between EMWMF, the proposed EMDF, and OF200 MTF CERCLA documents will have to be determined.

3.3.5.2 Alternative 4a: Pipeline transport to Outfall 200 MTF

Summary: A pipeline is constructed to transport landfill wastewater from EMWMF/proposed EMDF to OF200 MTF. This pipeline consists of welded HDPE piping and follows existing disturbed areas, such as Haul Road, where possible.

Details: Approximately 4400 ft of pressurized pipe is installed between the EMWMF/proposed EMDF site and OF200 MTF. The pipeline is 4-in. (SDR 11) HDPE pipe with a single lift station and leak-detection sensors. This primary pipe is contained within a secondary HDPE pipe with leak-detection sensors. The leak-detection sensors are electronic low-point leak-detection stations set approximately 2000 ft apart that communicate wirelessly to a main receiver.

For ease of installation, the pipeline route follows Haul Road and Bear Creek Road as much as possible (Fig. 20). An additional pipeline segment will be constructed between the EMDF Site (7c) and EMWMF. This pipeline will follow Haul Road.

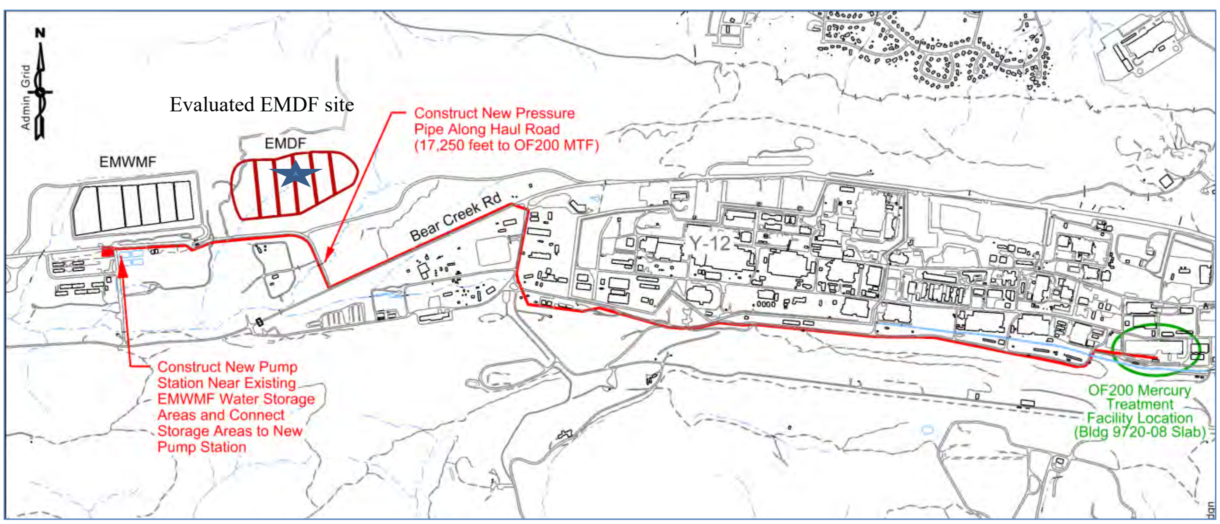

Fig. 20. Alternative 4a: route of pipeline to Outfall 200 MTF.

No additional storage is included in this alternative, but additional storage is required for the proposed EMDF construction.

The pipeline is pressurized with a pump station located near the EMWMF contact water storage tanks and ponds. A pressurized system eliminates the need for large, deep excavations required for a gravity flow system over the varying terrain. Locating the pump station at the beginning of the pipeline near the EMWMF contact water storage areas and making the entire system pressure driven allows for more flexibility when installing the pipe. Minimizing the working footprint along Haul Road lessens the impact to hauling operations, including the Uranium Processing Facility construction traffic.

No bridges are crossed, but North Tributary-2 and North Tributary-3 are crossed. For tributary crossings, the pipeline is buried next to or in the shoulder of Haul Road, while still maintaining the required burial depth when crossing culverts.

Support activities: Additional utility support is required at Y-12 to ensure utilities and structures are identified, moved, or protected during construction activities. Electrical power is required to the pump stations. Leak-detection alarms are required, along with telemetry to alert operators of potential leaks. Additional storage is required for the landfill wastewater at the EMWMF/proposed EMDF site to retain the design stormwater and to provide a consistent flow of water for the pipeline.

Monitoring and land use controls: EMWMF, the proposed EMDF, and OF200 MTF are expected to remain within the control of DOE indefinitely with existing access restrictions and land use controls.

Additional monitoring of the pipeline is performed to verify operating conditions.

Time frame for implementation: Construction of the pipeline is concurrent with the proposed EMDF construction, with operations planned to begin in 2028 to 2029.

Uncertainties: The following uncertainties are associated with the pipeline:

- Potential route deviations within Y-12 because of ecological concerns, structures, utilities, or similar items that cannot be moved or avoided.
- Slower construction rate than planned within Y-12 because of potential conflicts with the existing infrastructure.
- Slower construction rate within Y-12 due to the increased security requirements.
- Additional lift stations may be required if the lift station cannot be placed as planned.

Documents: An environmental survey of the pipeline route is required.

3.3.5.3 Alternative 4b. Truck transport to OF200 MTF

Summary: The landfill wastewater is trucked to OF200 MTF using the existing fleet of government-furnished, 5000-gal capacity tanker trailers and tractors, plus an additional two tankers. The route is along Haul Road to Bear Creek Road (Fig. 21). Similar to Alternative 4a, the tankers discharge to a holding tank. An additional route segment will use Haul Road to transport wastewater from the EMDF Site (7c) to EMWMF.

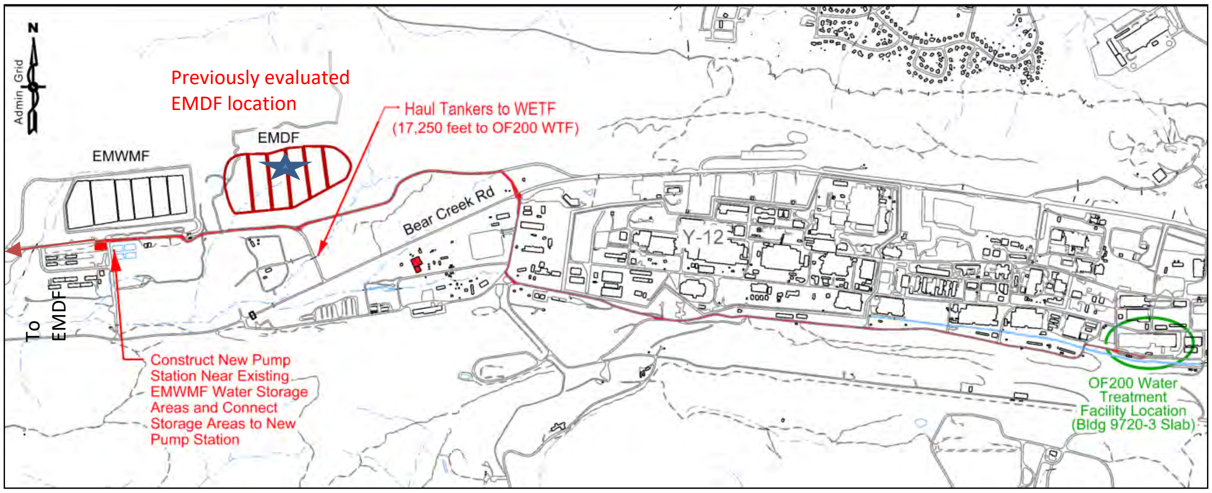

Fig. 21. Alternative 4b: truck route to Outfall 200 MTF.

Details: The existing 5000-gal capacity tanker trucks typically haul 4500 gal per load. For the higher precipitation season of approximately three months, trucks haul landfill wastewater seven days per week during a regular day shift. During the remaining nine months of the year, trucks haul landfill wastewater four days per week, day shift only, as is the current practice.

Two efficient loading stations are required to process up to 20 shipments per 10-hour shift. A new loading station is required at the EMWMF contact water tanks (the four ModuTanks®) to ship the EMWMF contact water. The existing 4-in. Wacker portable pumps are used to transfer the contact water to the loading station. Hook-ups exist for the hose connection of a portable pump to each ModuTank®, and hoses are used to connect the pump discharge to the loading arm pipe at the new station.

The new station includes a pull-through spill containment slab similar to that at the current West Loading Station, but with both long sides curbed. The containment slab will be 60-ft long with a sump for collection of rainwater and spill/leaks. The sump has an automatic submersible pump that pumps back to any of the four ModuTanks® via new 2-in. underground pipe network.

The existing West Loading Station is refurbished to add a SafeRack® loading platform and new articulating loading arm of similar design to the existing East Loading Station. The only change to the East Loading Station is an upgrade to a higher capacity leachate transfer/loading pump.

No new landfill wastewater storage is required at OF200 MTF. Landfill wastewater storage is maintained at the EMWMF/proposed EMDF location due to the proximity to OF200 MTF.

Support activities: Piping is required to connect the proposed EMDF storage tanks and load-out pump to the new loading station. Additional support activities are required to procure an additional tanker, train drivers, and maintain the ORR roadways.

Additional landfill wastewater storage is required at the EMWMF/proposed EMDF location to provide a consistent flow of water for the trucking operation. Operations staff provides sufficient workers to ship from two stations at the same time.

Monitoring and land use controls: EMWMF, the proposed EMDF, and OF200 MTF are expected to remain within the control of DOE indefinitely with existing access restrictions and land use controls. No additional monitoring is required over what is required for Alternative 4.

Time frame for implementation: Construction of the additional support structures is concurrent with the proposed EMDF construction, with operations planned to begin in 2028 to 2029.

Uncertainties: The space for additional tanker unloading stations is limited and soil may have low levels of contamination that must be removed prior to construction. The future cost and availability of fuel may be a factor in the execution of this alternative.

The schedule impacts caused by entering and exiting the Y-12 security portal are not determined but have been significant in the past.

The truck route to OF200 MTF (Fig. 21) may be altered due to safety and security issues. This change may result in significant inefficiencies and cost increases.

Documents: No additional documentation is required in addition to the Alternative 4 documents.

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4. ANALYSIS OF ALTERNATIVES

4.1 INTRODUCTION

This chapter presents the detailed analyses of the alternatives for the management of landfill wastewater generated from EMWMF and the proposed EMDF. The analysis of alternatives provides the basis for subsequently recommending an alternative in the EMDF proposed plan and modifying the EMWMF ROD. Section 4.2 describes the evaluation criteria, Sect. 4.3 is an in-depth analysis for each alternative that provides the basis of alternative selection, and Sect. 4.4 is a comparative analysis of the alternatives.

4.2 EVALUATION CRITERIA

CERCLA, Section 121, as amended, specifies statutory requirements for remedial actions. These requirements include protection of human health and the environment, compliance with ARARs, a preference for permanent solutions that incorporate treatment as a principal element to the maximum extent practicable, and cost effectiveness. To assess whether alternatives meet these requirements, the following nine criteria (EPA/540/G-89/004**)** are identified in the NCP (40 *CFR* 300.430) that must be evaluated for each alternative [Section 300.430(e)(9)(iii)].

- Threshold Criteria
  - — Overall Protection of Human Health and the Environment
  - — Compliance with ARARs
- Balancing Criteria
  - — Long-Term Effectiveness and Permanence
  - — Reduction of Toxicity, Mobility, or Volume Through Treatment
  - — Short-Term Effectiveness
  - — Implementability
  - — Cost
- Modifying Criteria
  - — State Acceptance
  - — Community Acceptance

The first two criteria are the threshold criteria that relate directly to statutory findings that must be documented in the ROD. The next five criteria, the primary balancing criteria, address the performance of the alternative and verify that the alternative is realistic. The last two modifying criteria are not addressed in the current analyses because they rely on stakeholder participation and feedback on the recommended alternative.

In addition to these evaluation criteria prescribed under CERCLA, DOE policy directs that the substantive elements of analysis required under the National Environmental Policy Act (NEPA) be incorporated into CERCLA decision documents (DOE 1994, *Secretarial Policy Statement on National Environmental Policy Act*). Elements common to both CERCLA and NEPA include protectiveness, compliance with ARARs, long-term effectiveness and permanence, short-term effectiveness, and cost. Additional NEPA values that are not specifically included in the CERCLA criteria include socioeconomic impacts, environmental justice, irreversible and irretrievable commitment of resources, and cumulative impacts.

Additionally, current EPA policy (EPA/542-R-12-002, *Methodology for Understanding and Reducing a Project's Environmental Footprint*) is to incorporate sustainability principles into the remedial decision-making process by considering all environmental effects of remedy implementation and incorporating options to maximize net environmental benefit of cleanup actions. The processes used for remediation also use a lot of water and energy and can create problems with emissions to air and water. To limit such collateral damage from remediation, EPA is adopting and promoting greener remediation practices. The core elements to be considered are energy requirements for treatment technologies, air emissions, water requirements and impacts, land and ecosystem impacts, material consumption and waste generation, and long-term stewardship.

Because both the landfill wastewater flow and potential COCs are expected to be variable over time, the adaptability of each alternative to address these uncertainties is included in the implementability criterion.

Below are summaries of the factors that comprise the nine CERCLA criteria and a brief discussion on the integration of NEPA and green remediation with the CERCLA analysis.

- **Criterion 1: Overall Protection of Human Health and the Environment.** This evaluation criterion assesses whether the alternative achieves and maintains adequate protection of human health and the environment in accordance with the remedial action objectives. Because the scope of this criterion is broad, it also reflects the discussions of the subsequent criteria, including long-term effectiveness and permanence and short-term effectiveness. This criterion evaluates how site risks associated with each exposure pathway will be eliminated, reduced, or mitigated through treatment, engineering controls, or land use controls. This criterion also evaluates impacts to the site environment resulting from the action itself.
- **Criterion 2: Compliance with ARARs.** This evaluation criterion addresses compliance with promulgated federal and state environmental requirements that are legally applicable or relevant and appropriate. If an alternative cannot meet a requirement, a waiver under CERCLA might be appropriate and a basis for justifying the waiver is presented. ARARs consist of two sets of requirements—those that are applicable and those that are relevant and appropriate. If there are no standards that address the proposed action or COCs, nonpromulgated advisories, criteria, or guidance developed by EPA, other federal agencies, or states may be designated as TBC guidance.

  The ARARs for this FFS that may be added to the *Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee* are in Appendix D. Those ARARs required for the proposed EMDF will be included in the *Remedial Investigation/Feasibility Study for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge, Tennessee* and subsequent CERCLA decision documents.
- **Criterion 3: Long-Term Effectiveness and Permanence.** This evaluation criterion evaluates the extent to which an alternative achieves an overall reduction in risk to human health and the environment after the remedial action objectives are met. The criterion also considers the degree to which the alternative provides sufficient long-term controls and reliability to prevent exposures that exceed protective levels for human and environmental receptors. The principal factors addressed by this criterion include the magnitude of residual risk, the adequacy and reliability of controls to address such risk, and the uncertainties associated with these factors. This criterion also evaluates the potential long-term environmental effects of the alternative. The evaluation of adequacy and reliability of controls assesses the effectiveness of any treatment, containment, or land use controls that are part of the alternative. Factors considered include performance characteristics, maintenance requirements, and expected durability. Information and data from past performance and similar technology applications

may be appropriately incorporated into the evaluation. Land use controls are considered if they potentially improve the effectiveness of engineering controls.

- **Criterion 4: Reduction of Toxicity, Mobility, or Volume Through Treatment.** This evaluation criterion reflects the statutory preference that remedial alternatives contain a principal component that substantially reduces toxicity, mobility, or volume of hazardous substances through treatment. The evaluation of alternatives against this criterion considers the extent to which alternative technologies can effectively and permanently fix, transform, immobilize, or reduce the volume of contaminants.

- **Criterion 5: Short-Term Effectiveness.** This evaluation criterion addresses the effects on human health and the environment posed by the construction and implementation of the alternative. Both the potential impacts and associated mitigative measures are examined for protectiveness of the community, remediation workers, and environmental receptors during remedial activities. Potential short-term risks to the public include inhalation of contaminants that might be released during construction and implementation of the alternative. Potential short-term risks to workers include direct contact and exposure during construction, waste handling, and transportation; physical injury or death during construction and transportation activities; and airborne contamination during soil removal. Alternative analyses also include a description of mitigative measures, such as engineering and land use controls, expected to minimize potential risks to the public and workers. This criterion also evaluates impacts on environmental media and potentially sensitive resources. Short-term environmental effects and mitigation measures are qualitatively assessed.

- **Criterion 6: Implementability.** This evaluation criterion examines the technical and administrative factors affecting implementation of an alternative and considers the availability of services and materials required during implementation. Technical factors to be assessed include the ease and reliability of construction and operations, the prospects for implementing any needed future actions, and the adequacy of monitoring systems to detect failures. Administrative factors include permitting and coordination requirements between the lead agency (DOE) and regulatory agencies (EPA and TDEC). Service and material considerations include treatment, storage, or disposal capacities; equipment and operator availability; and applicability or development requirements for prospective technologies.

  Technical feasibility considers the performance history of the technologies in direct applications or the expected performance for similar applications. Also addressed are uncertainties associated with construction, operation, and performance monitoring.

  The evaluation of administrative feasibility addresses actions required to coordinate with regulatory agencies in establishing the framework for compliance with substantive technical requirements. The NCP requires that the evaluation of the relative administrative feasibility of each alternative include "…activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for offsite actions). CERCLA, Sect. 121(e), stipulates that no federal, state, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site." An action must satisfy the substantive requirements of any permits that would otherwise be required. The availability of services and materials is addressed by analyzing the material components of the proposed technologies and then determining the locations and quantities of those materials. Process operations are reviewed to identify any special services, operator skills, or training needed for ready implementation of the process.

  There is uncertainty in the future concentrations of the key COCs in landfill wastewater over time because of the different contaminants at ETTP, ORNL, and Y-12; the variability in waste lots and associated contaminants over time; the presence of unexpected contaminants; and the mobility of the disposed contaminants. As shown in Appendix C, at times in the past, specific contaminants have required treatment for a short time, but do not currently require treatment. This situation is expected to occur in the future with contaminants requiring treatment that will vary over time and for varying periods. There also is uncertainty in the flow rate due to rainfall variation, the number of open disposal cells, and the number of closed cells (such as under enhanced operational cover). Therefore, a key factor in evaluating the alternatives is the ability to adapt to changes in key COCs, concentrations, and flow rate.

- **Criterion 7: Cost.** A cost estimate is included for each alternative. The estimate is based on feasibility-level scoping and is intended to facilitate evaluation of the alternative. The estimate has an expected accuracy of +50 to -30 percent for the scope of action. All estimates have been escalated using DOE-approved annual rates and a schedule for the various activities based on similar project experience. Typical cost estimating contingencies are not included in the estimate.

  The cost estimate is divided into capital and O&M costs. Capital costs are defined as those expenditures required to initiate and install an alternative. These are short-term costs and exclude costs required to maintain the action throughout the project's lifetime. O&M costs are long-term costs required to maintain the action throughout the project's lifetime. These costs occur after construction and installation are completed.

  Appendix H contains additional information on the cost estimates and the major assumptions used to develop those estimates.

- **Criterion 8: State Acceptance.** State acceptance of alternatives will be evaluated in the proposed plan issued for public comment. Therefore, this criterion is not necessary for this FFS.

- **Criterion 9: Community Acceptance.** Community acceptance of alternatives will be evaluated when the proposed plan is issued for public comment. Therefore, this criterion is not necessary for this FFS.

- **NEPA Considerations.** DOE policy (DOE 1994) directs that the substantive elements of analysis required under NEPA be incorporated into CERCLA decision documents. This process provides decision makers with a wider range of environmental and social concerns than those specifically delineated under CERCLA. The CERCLA evaluation criteria are directly applicable to the consideration of environmental and social impacts, as listed below:

  — Compliance with ARARs addresses the NEPA requirement for consideration of applicable laws and guidelines, including cultural and historical resources

  — Long-term effectiveness and permanence address the NEPA requirement for consideration of long-term impacts on human health and the environment, including emissions to air and water

  — Short-term effectiveness addresses the NEPA requirement for consideration of short-term impacts on human health and the environment, noise, air, transportation, and short-term emissions to air and water

  — Cost is a consideration under both NEPA and CERCLA

Other NEPA values not normally considered in a CERCLA FFS include the following:

- Aesthetic effects
- Socioeconomic impacts
- Environmental justice
- Irreversible and irretrievable commitments of resources
- Cumulative impacts

These values are not key differentiators among the alternatives, except for the irreversible and irretrievable commitments of resources.

- **Green remediation considerations.** EPA policy (EPA/542-R-12-002; EPA/542-R-08-002, *Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites*) is to incorporate sustainability principles into the remedial decision-making process. The CERCLA evaluation criteria are directly applicable to the following core elements, as listed below:
  - Overall protection of human health and the environment addresses the core element of land and ecosystem impacts.
  - Implementability addresses the core element of long-term stewardship by evaluating the impacts of the alternatives on operations and maintenance. Implementability also addresses the core element of air emissions in the evaluation of the trucking option.
  - Compliance with ARARs addresses the core element of water impacts by evaluating compliance with AWQC.
  - The discussion of process options (Sect. 3.2) already addresses water requirements in terms of reusing water.

The core values not normally considered in a CERCLA feasibility study are the following:

- Energy required
- Material consumption and waste generation

These are similar to the irreversible and irretrievable commitment of resources discussed above with the NEPA values, so another criterion against which each alternative is evaluated is the irreversible and irretrievable commitment of resources.

4.3 INDIVIDUAL ANALYSIS OF ALTERNATIVES

4.3.1 Alternative 1: No Action

Evaluation of the No Action alternative is required under CERCLA [40 *CFR* 300.430(e)(6)] to provide a baseline for comparison with the action alternatives. Under the No Action alternative, the proposed EMDF is not built. Current operations continue at EMWMF. Landfill wastewater is discharged to Bear Creek or trucked to PWTC at ORNL. The landfill wastewater will not be expected to meet the current discharge limits at all times. No implementation is required and there are no additional costs associated with this alternative.

Overall Protection of Human Health and the Environment (Alternative 1)

The No Action alternative will not be protective of human health and the environment, will not meet the remedial action objective to meet current discharge limits for the key COCs to protect surface water for designated uses, and will not be effective. No action will be taken to attain AWQC in surface water, and contaminant releases in excess of current discharge limits are possible.

Compliance with ARARs (Alternative 1)

Compliance with ARARs applies only to actions taken under CERCLA authority. Since the No Action alternative includes no response actions to manage landfill wastewater, there are no ARARs associated with this alternative.

Long-Term Effectiveness and Permanence (1)

The No Action alternative will not be effective in the long-term and is unacceptable since no remedial action will be taken to mitigate contaminant releases from the landfill wastewater. Contaminant releases to surface water and groundwater will continue.

Reduction of Toxicity, Mobility, or Volume through Treatment (Alternative 1)

Implementation of the No Action alternative will not meet the CERCLA preference for treatment to reduce toxicity, mobility, or volume of contaminants.

Short-Term Effectiveness (Alternative 1)

Since the No Action alternative involves no construction, there will be no short-term risks to workers or the community and no short-term environmental impacts.

Implementability (Alternative 1)

No implementation activities will be required for the No Action alternative. Therefore, this alternative is inherently implementable. However, it may be difficult to obtain acceptance from the regulators and the public. Since no action is being taken to manage the discharge of landfill wastewater, the No Action alternative does not address fluctuating flows and varying COCs.

Cost (Alternative 1)

Capital Cost. There is no capital cost for Alternative 1.

O&M Cost. There is no incremental annual O&M cost for Alternative 1.

Present Worth. The present worth of Alternative 1 is zero.

The basis for the cost estimate is in Appendix I.

The No Action alternative can result in fines under the Clean Water Act if AWQC are not maintained.

Irretrievable Commitment of Resources (Alternative 1)

There will be no additional commitment of resources under the No Action alternative. However, the release of contaminants will continue to degrade the water quality of Bear Creek.

4.3.2 Alternative 2: Managed Discharge/Treat

In Alternative 2, landfill wastewater initially is discharged to Bear Creek in accordance with current discharge limits and subsequently is treated at LWTS, located at the proposed EMDF site, prior to discharge to Bear Creek in accordance with revised discharge limits. Because the proposed EMDF is not constructed adjacent to EMWMF, LWTS will be constructed at EMDF, and EMWMF landfill wastewater will be transported by truck or pipeline to LWTS.

Overall Protection of Human Health and the Environment (Alternative 2)

Protection of Human Health and the Environment. This alternative will be protective of human health and the environment because landfill wastewater will meet discharge limits prior to discharge. The discharge limits for both managed discharge and treatment were developed considering the anti-degradation requirements (Appendix K). Since discharge limits will be met prior to discharge, Bear Creek will not be further degraded.

Treatment technologies for removal of the key COCs are best available technology, well demonstrated, reliable, effective, readily available, and easily implemented. If the landfill wastewater composition changes and additional contaminants must be addressed, LWTS can be modified easily, due to its modular design, to include the necessary unit operations. Sampling treatment system influent and effluent verifies performance and identifies changes in the characteristics of the landfill wastewater.

The contingent pipeline or trucking to transport landfill wastewater from EMWMF to the proposed EMDF at the Central Bear Creek location is protective of human health and the environment. The pipeline is an engineered system with secondary containment, instrumentation, controls, and leak-detection capability. The utilization of pipelines is a well-established technology with standards codes and specifications for designing, constructing, and testing a pipeline system. As with any pipeline, there will be inherent minor risk associated with pipeline failure from a manmade event or natural phenomena, e.g., fire, earthquake, freeze damage. Environmental surveys are required prior to construction to evaluate impacts to wetlands and rare and endangered species. Trucking has been practiced for EMWMF landfill wastewater for many years without incident

Effectiveness. This alternative will be effective for the discharge of landfill wastewater because the concentrations of the key COCs will meet discharge limits prior to discharge. The discharge limits for both managed discharge and treatment were developed considering the anti-degradation requirements. Since discharge limits will be met prior to discharge, Bear Creek will not be further degraded. Treatment technologies for removal of key COCs are best available technology, well demonstrated, reliable, effective, readily available, and easily implemented. If the landfill wastewater composition changes and additional contaminants must be addressed, LWTS can be modified easily to include the necessary unit operations.

Impacts to Site Environment. Alternative 2 has minimal impact to the site environment. Managed Discharge will have no impact to the site environment because there will be no new construction. Existing facilities and equipment will be used, and no upgrade will be necessary. Even though LWTS will be constructed at the proposed EMDF, the site previously has been impacted by waste disposal operations, and site preparation will require only minor excavation. If the proposed EMDF is constructed at the Central Bear Creek location, then there will be some impact to the site environment by developing an area for waste disposal that has not been previously developed, and the construction of the pipeline.

Compliance with ARARs (Alternative 2)

Compliance with ARARs. Alternative 2 will comply with all chemical-specific, location-specific, and action-specific ARARs. Key COCs concentrations will meet discharge limits prior to discharge. Treatment technologies for removal of the key COCs are best available technology, well demonstrated, reliable, readily available, and easily implemented. Sampling treatment system effluent verifies performance and identifies changes in the characteristics of landfill wastewater. If landfill wastewater composition changes and additional contaminants must be addressed, LWTS can be modified easily, due to its modular design, to include the necessary unit operations. Anti-degradation will be met because discharge limits were developed considering anti-degradation, the discharge limits will be met prior to discharge, the treatment is best available technology, and periodic toxicity testing will be performed.

ARAR Waivers. No ARAR waivers are required.

Long-Term Effectiveness and Permanence (Alternative 2)

Effectiveness. Alternative 2 will be effective for the long-term. Landfill wastewater will meet discharge limits prior to discharge. LWTS will provide processing equipment with a design life that matches the anticipated landfill operations schedule with continued post-closure operations until landfill wastewater no longer requires treatment or is no longer generated. Since treatment technologies for removal of the key COCs are best available technology, well demonstrated, reliable, effective, readily available, and easily implemented, LWTS can be maintained, and components can be replaced with normal procedures. Sampling LWTS influent and effluent will verify performance and identify changes in the characteristics of the landfill wastewater. If landfill wastewater composition changes, and additional contaminants must be addressed, LWTS can be modified easily, due to its modular design, to include the necessary unit operations.

Permanence. The EMWMF and proposed EMDF sites are expected to remain within the control of DOE indefinitely with existing access restrictions and land use controls. There is uncertainty associated with the quality of the landfill wastewater in the future, as remediation continues at ORNL and Y-12 with different COCs and as contaminants continue to leach in unpredictable concentrations. Since treatment technologies for removal of the key COCs are best available technology, well demonstrated, reliable, effective, readily available, and easily implemented, LWTS can be maintained, and components can be replaced with normal procedures. Sampling LWTS influent and effluent will verify performance and identify changes in the characteristics of the landfill wastewater. If landfill wastewater composition changes, and additional contaminants must be addressed, LWTS can be modified easily, due to its modular design, to include the necessary unit operations.

Reduction of Toxicity, Mobility, or Volume Through Treatment (Alternative 2)

Alternative 2 will meet the CERCLA preference for treatment to reduce toxicity, mobility, or volume of contaminants. LWTS will reduce the concentrations of key COCs to acceptable levels through treatment of landfill wastewater prior to discharge to Bear Creek, if needed.

Short-Term Effectiveness (Alternative 2)

Since Managed Discharge involves no construction, there will be no short-term risk to workers, the community, and the environment. The treatment of landfill wastewater will require construction activities with the associated risk of industrial accidents. DOE safety policies, procedures, and worker training reduce the potential for and mitigate the consequences of such incidents. This alternative will have minimal short-term impacts to the surrounding community and the environment.

The operation of LWTS will have minimal short-term impacts to remediation workers, the surrounding community, and the environment.

Implementability (Alternative 2)

Technical Feasibility. Alternative 2 will be technically feasible and simple to implement. For Managed Discharge, existing facilities and equipment will be used and no upgrade will be necessary. LWTS will be technically easy to implement because the treatment technologies for removal of the key COCs are well demonstrated, reliable, effective, readily available, and easy to construct using standard equipment and techniques. DOE has implemented similar projects at ORNL, Y-12, and ETTP and has access to experienced engineering and project management resources for landfill wastewater treatment projects. LWTS will be designed for ease of expansion if additional COCs are encountered. The time required to respond to additional COCs will be minimized through monitoring of landfill wastewater and through contingency planning that includes evaluation of waste planned for disposal

Administrative Feasibility. Alternative 2 will be administratively easy to implement. The remedial investigation/feasibility study, proposed plan, and ROD for the proposed EMDF will have to be approved. A remedial action work plan/remedial design report that include the specific LWTS design and a completion document that contains the as-built conditions will be required. The EMWMF ROD and implementing documents will be revised to include appropriate ARARs for the discharge of landfill wastewater into Bear Creek. All of these documents are conventional CERCLA documents for which DOE has extensive experience. A compliance schedule will be developed in accordance with the *Federal Facility Agreement for the Oak Ridge Reservation*.

Availability of Services and Materials. The services and materials for Alternative 2 are readily available. The treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easy to construct using standard equipment and techniques. DOE has implemented similar projects at ORNL, Y-12, and ETTP and has access to experienced engineering and project management resources for landfill wastewater treatment projects. Construction of LWTS will use conventional construction techniques.

Adaptability. Alternative 2 is adaptable. LWTS will be designed to quickly implement different treatment units, if required by changes in COCs above or below discharge limits or due to long-term changes in flow rates. If higher flow rates are continuous, then the treatment system will be easily expanded. Lower flow rates normally will be treated in batches, requiring no changes to the treatment system. If lower flow rates are continuous, then the treatment system will be easily reduced in size.

Cost (Alternative 2)

Capital Cost. The capital cost is approximately $14 million.

O&M Cost. The annual O&M cost for Alternative 2 is estimated at approximately $1.5 million during operation and closure and approximately $0.3 million during post-closure. Offsetting this annual O&M cost is the current annual cost of approximately $500,000 to transport EMWMF leachate to PWTC for treatment.

Present Worth. The present worth of Alternative 2 is estimated at approximately $48 million.

The basis for the cost estimate is in Appendix I.

Irretrievable Commitment of Resources (Alternative 2)

In Alternative 2, there will be minimal irretrievable commitment of resources. The footprint of LWTS is in an area not previously developed but associated with the EMDF. There will be environmental impacts that will need to be minimized/mitigated.

4.3.3 Alternative 3: Treat at PWTC

In Alternative 3, the landfill wastewater will be transferred by truck or pipeline to the onsite PWTC at ORNL for treatment prior to discharge into White Oak Creek. The PWTC was recently upgraded and the design life extended. This extension does not include EMWMF contact water/proposed EMDF landfill wastewater. Also, PWTC currently cannot accept mercury, and the radiological treatment processes are limited. Therefore, the pre-treatment is necessary for the long-term viability of Alternative 3.

Overall Protection of Human Health and the Environment (Alternative 3)

Protection of Human Health and the Environment. Alternative 3 is protective of human health and the environment because the remedial action objective for landfill wastewater from EMWMF and the proposed EMDF will be met by treatment at PWTC prior to discharge to White Oak Creek. The treatment technologies used at PWTC and at the pre-treatment facility are effective for the landfill wastewater. Sampling the landfill wastewater prior to shipping to PWTC will verify compliance with WAC and identify changes in the characteristics of the landfill wastewater. The need to construct the pre-treatment facility will require time to obtain additional funds and to design, construct, and deploy the additional processing equipment. If the landfill wastewater is transported by truck to PWTC, then there will be risk to the drivers and the public associated with the potential for roadway transport incidents.

The pipeline option is protective of human health and the environment because it will transfer landfill wastewater in an engineered system with secondary containment, instrumentation, controls, and leak-detection capability. The utilization of pipelines is a well-established technology with standards codes and specifications for designing, constructing, and testing a pipeline system. As with any pipeline, there will be inherent minor risk associated with pipeline failure from a manmade event or natural phenomena, e.g., fire, earthquake, freeze damage. Since the pipeline route will follow the existing Haul Road and power line easement, there will be minimal additional environmental impacts. Environmental surveys will be required prior to construction to evaluate impacts to wetlands and rare and endangered species.

This alternative will reduce the flow of water into Bear Creek that may be detrimental to aquatic life. On rare occasions that storm events necessitate the bypass of untreated landfill wastewater directly into Bear Creek, the overall impact to protection of human health and the environment will be minimal because the flux of contaminants should be small.

Effectiveness. The treatment technologies used at PWTC and the pre-treatment facility will be effective for the landfill wastewater. Sampling the landfill wastewater prior to transferring to PWTC will verify compliance with WAC and identify changes in the characteristics of the landfill wastewater. The pre-treatment is necessary for the long-term effectiveness of this alternative. This project will require time to obtain additional funds, design, and deploy the new equipment.

Either transporting the landfill water by truck or transferring by pipeline will be effective for moving landfill wastewater to PWTC for treatment. Both methods have some level of inherent risk associated with potential spills.

Truck transportation of landfill wastewater has been performed successfully for twenty years. However, due to the increased quantity of landfill wastewater to be transported, there is uncertainty in the availability of trucks, the availability of drivers, and the travel time during bad weather. Increased truck transportation will also require additional PWTC support for unloading tankers.

Impacts to Site Environment. Alternative 3 will have minimal impacts to the site environment. Since the pipeline route follows the existing Haul Road and power line easement for most of the route, minimal additional environmental impacts are anticipated. However, an environmental survey will be required prior to construction. This alternative will reduce the flow of water in Bear Creek and may be detrimental to aquatic life. On the rare occasions that untreated landfill water bypasses the treatment system and is discharged directly into Bear Creek, the overall protection of human health and the environment will be minimal. In order to install the additional landfill wastewater offloading stations at PWTC, soil will have to be excavated that has low levels of contamination.

Compliance with ARARs (Alternative 3)

Compliance with ARARs. Alternative 3 will comply with all chemical-specific, location-specific, and action-specific ARARs. Treatment of landfill wastewater at PWTC and the pre-treatment facility is compliant with ARARs. The WAC and the NPDES permit will have to be revised. The treatment technologies used at PWTC and the pre-treatment facility are effective for the landfill wastewater. Sampling landfill wastewater prior to transporting it to PWTC will verify compliance with WAC and identify changes in the characteristics of the landfill wastewater. The pipeline will be constructed to appropriate engineering standards and will have secondary containment and leak-detection capability.

ARAR Waivers. No ARAR waivers are required.

Long-Term Effectiveness and Permanence (Alternative 3)

Effectiveness. Alternative 3 will be effective in the long-term. Treatment of landfill wastewater at PWTC will be effective for long-term operation and compliant performance when the design life is extended and the pre-treatment facility is operational. Sampling landfill wastewater prior to transporting it to PWTC will verify compliance with WAC and identify changes in the characteristics of the landfill wastewater due to the differing predominant contaminants at ETTP, ORNL, and Y-12. If additional contaminants are introduced into the landfill wastewater, PWTC modifications can be performed, as necessary, to meet processing needs. Significant PWTC modifications can result in impaired treatment effectiveness and performance for the time necessary to provide the required treatment capability.

Transporting the landfill wastewater by tanker truck to PWTC will not be an effective long-term option. The utilization of trucks has been practiced successfully for twenty years. However, the expected increase and fluctuation in landfill wastewater flow will introduce uncertainty in the availability of trucks and drivers and increase the potential for transport incidents.

The pipeline will be effective because it will provide an engineered, automated, and well-contained system for transferring landfill water to the PWTC. Piping has a long service life and can be designed and installed to last well beyond the period of performance for EMWMF and the proposed EMDF.

Permanence. The EMWMF and proposed EMDF sites and ORNL are expected to remain within the control of DOE indefinitely with existing access restrictions and land use controls. Additionally, pre-treatment is required for mercury and radionuclides and possibly other COCs. If additional contaminants are introduced into the landfill wastewater, PWTC modifications can be performed, as necessary, to meet processing needs

Transporting the landfill wastewater by tanker truck to PWTC will not be an effective long-term option. The utilization of trucks has been practiced successfully for twenty years. However, the fluctuation in landfill wastewater flow will introduce uncertainty in the availability of trucks and drivers and increase the potential for transport incidents. The pipeline will be effective because it will provide an engineered, automated, and well-contained system for transferring landfill wastewater to PWTC. Piping has a long service life and can be designed and installed to last well beyond the period of performance for EMWMF and EMDF.

Reduction of Toxicity, Mobility, or Volume Through Treatment (Alternative 3)

Alternative 3 will reduce the concentrations of key COCs to acceptable levels through treatment of landfill wastewater prior to discharge to White Oak Creek.

Short-Term Effectiveness (Alternative 3)

The operation of PWTC will have minimal short-term impacts to remediation workers, the surrounding community, and the environment. The PWTC currently accepts and processes EMWMF leachate effectively and safely. Truck transport is currently used to deliver the leachate to PWTC for treatment and is being performed effectively and safely. Construction of the pipeline will have short-term environmental impacts, but by following Haul Road and power line easement, the impacts are minimized. DOE safety policies, procedures, and worker training reduce the potential for and mitigate the consequences of such incidents. Alternative 3 will reduce the flow of water in Bear Creek and may be detrimental to aquatic life. In order to install the additional landfill wastewater offloading stations at PWTC, soil will have to be excavated that has low levels of contamination that will require additional worker protection.

Implementability (Alternative 3)

Technical Feasibility. Alternative 3 will be technically feasible and simple to implement. Upgrades at PWTC to install the additional landfill water offloading stations are easy to construct, and the slightly contaminated soil should be disposed at the ORR landfill. However, implementability during construction of pre-treatment will be impaired by the need to obtain additional funds, complete design activities, and perform construction, while maintaining operational capability for continued landfill wastewater processing.

The construction activities required to install pre-treatment to accept the landfill wastewater are common, and the additional risk of a construction accident is not significant. Operational risk for landfill wastewater treatment is no greater than what is currently experienced during PWTC ongoing operations.

Construction of the pipeline will use conventional construction techniques. However, there is likely to be interference from existing underground utilities and potentially contaminated soil that will complicate construction of the pipeline. The utilization of trucks has been practiced successfully twenty years. However, the expected fluctuation in landfill wastewater flow will introduce uncertainty in the availability of trucks and drivers and increase the potential for transport incidents.

Administrative Feasibility. Alternative 3 will be administratively easy to implement. The ROD for the proposed EMDF will have to be developed to include this remedy and approved. A remedial action work plan/remedial design report that include the specific pre-treatment facility design and a completion document that contains the as-built conditions will be required. The EMWMF ROD and implementation documents will have to be revised. All of these documents are conventional CERCLA documents for which DOE has extensive experience. The WAC and NPDES permit will have to be revised. If additional contaminants appear in the landfill wastewater in the future, then the WAC will require further revision before the new contaminants can be accepted on a permanent basis.

Availability of Services and Materials. Construction of the pre-treatment system to receive the landfill wastewater and construction of the pipeline will use conventional construction techniques. The additional trucks and drivers that will be needed are available, but the varying demand complicates access to them.

Adaptability. The current PWTC is not readily adaptable to changing flow rates and COCs, but PWTC with the pre-treatment system should be more adaptable.

Cost (Alternative 3)

- Trucking Option (Alternative 3a):
  - **Capital Cost.** The capital cost of Alternative 3a is estimated at approximately $17 million.

— **O&M Cost.** The annual O&M cost of Alternative 3a is estimated at approximately $4 million during operation and closure and $0.4 million during post-closure.

— **Present Worth.** The present worth of Alternative 3a is estimated at approximately $110 million. The basis for the cost estimate is in Appendix I.

- Pipeline Option (Alternative 3b):

— **Capital Cost.** The capital cost of Alternative 3b is estimated at approximately $20 million.

— **O&M Cost.** The annual O&M cost of Alternative 3b is estimated at approximately $1.8 million during operations and closure and $0.3 million during post-closure.

— **Present Worth.** The present worth of Alternative 3b is estimated at approximately $61 million.

The basis for the cost estimate is in Appendix I.

Irretrievable Commitment of Resources (Alternative 3)

In Alternative 3, there will be minimal irretrievable commitment of resources. PWTC is an existing facility, and the additional flow is minimal. Therefore, the incremental energy and chemical requirements for treatment will be minimal, even following construction of the pre-treatment facility. The route of the pipeline is in an area already used as a haul road and power line easement, so there will be minimal environmental impacts. Transporting landfill wastewater by truck will consume more energy in fuel than the pipeline option.

4.3.4 Alternative 4: Treat at Outfall 200 MTF

In Alternative 4, the landfill wastewater will be transferred by truck or pipeline to the planned, onsite treatment facility at Outfall 200 at Y-12 for treatment prior to discharge into UEFPC. Pre-treatment of landfill wastewater is required for key COCs other than mercury.

Overall Protection of Human Health and the Environment (Alternative 4)

Protection of Human Health and the Environment. Alternative 4 will be protective of human health and the environment because the remedial action objective for landfill wastewater from EMWMF and the proposed EMDF will be met by pre-treatment and treatment at OF200 MTF prior to discharge to UEFPC. The treatment technologies planned at OF200 MTF and additional pre-treatment are effective for key COCs. Treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easily implemented. If the landfill wastewater composition changes and additional contaminants must be addressed, the pre-treatment system can be modified easily, due to its modular design, to include the necessary unit operations. Sampling the landfill wastewater prior to shipping to OF200 MTF will verify compatibility with OF200 MTF and pre-treatment capability and identify changes in the characteristics of the landfill wastewater. If the landfill wastewater becomes contaminated with COCs other than key COCs, the adaptability of OF200 MTF and pre-treatment is adequate. Treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easily implemented. If the landfill water composition changes and additional contaminants must be addressed, the pre-treatment system can be modified easily, due to its modular design, to include the necessary unit operations. Until treatability studies are performed, the ability to treat other COCs is not known. The pre-treatment facility will be constructed and operated at the OF200 MTF site. This alternative will reduce the flow of water into Bear Creek that may be detrimental to aquatic life, and at peak, EMDF flow is less than a 5% increase to the average flow rate in East Fork Poplar Creek at OF200.

If the landfill wastewater is transported by truck to OF200 MTF, there will be risk to the drivers and the public associated with the potential for roadway transport incidents. Existing tankers are a proven technology currently used for EMWMF landfill wastewater transport.

The pipeline option is protective of human health and the environment because it will transfer landfill wastewater in an engineered system with secondary containment, instrumentation, controls, and leak-detection capability. The utilization of pipelines is a well-established technology with standards, codes, and specifications for designing, constructing, and testing a pipeline system. As with any pipeline, there will be inherent minor risk associated with pipeline failure from a manmade event or natural phenomena, e.g., fire, earthquake, freeze damage. Since the pipeline route will follow the existing Haul Road, there will be minimal additional environmental impacts. Environmental surveys will be required prior to construction to evaluate impacts to wetlands and rare and endangered species.

On the rare occasions that storm events necessitate the bypass of untreated landfill wastewater directly into Bear Creek, the overall impact to protection of human health and the environment will be minimal because Bear Creek will be at high flow conditions.

Effectiveness. OF200 MTF and pre-treatment will be effective for the landfill wastewater key COCs. Treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easily implemented. If the landfill water composition changes and additional contaminants must be addressed, the pre-treatment system can be modified easily, due to its modular design, to include the necessary unit operations. Until treatability studies are performed, the ability of OF200 MTF to treat other COCs is not known. Sampling the landfill wastewater prior to transferring to OF200 MTF and pre-treatment will verify compatibility with OF200 MTF and pre-treatment capability and identify changes in the characteristics of the landfill wastewater. If the landfill wastewater becomes contaminated with other key COCs, the adaptability of OF200 MTF and pre-treatment are adequate.

Either transporting the landfill wastewater by truck or transferring by pipeline will be effective for moving landfill wastewater to OF200 MTF. Both methods have some level of inherent risk associated with potential spills.

The utilization of trucks has been practiced successfully for twenty years. However, due to the increased quantity of landfill wastewater to be transported, there is uncertainty in the availability of trucks, the availability of drivers, and the travel time during bad weather.

Impacts to Site Environment. Alternative 4 will have minimal impacts to the site environment. An environmental survey will be required prior to construction of the pipeline. This alternative will reduce the flow of water in Bear Creek and may be detrimental to aquatic life. On the rare occasions that untreated landfill wastewater bypasses the treatment facility and is discharged directly into Bear Creek, the increased contaminant mass will be minimal.

Compliance with ARARs (Alternative 4)

Compliance with ARARs. Alternative 4 will comply with all chemical-specific, location-specific, and action-specific ARARs. The treatment technologies used at Outfall 200 MTF and pre-treatment are effective for the landfill wastewater key COCs. Until the treatability studies are performed, the ability of OF200 MTF to treat other COCs is not known. Sampling landfill wastewater prior to transporting it to Outfall 200 and pre-treatment will verify compatibility with OF200 MTF and pre-treatment capability and identify changes in the characteristics of the landfill wastewater. The pipeline will be constructed to appropriate engineering standards and will have secondary containment and leak-detection capability.

ARAR Waivers. No ARAR waivers are required.

Long-Term Effectiveness and Permanence (Alternative 4)

Effectiveness. Alternative 4 will be effective in the long-term. Treatment of landfill wastewater at OF200 MTF and pre-treatment will be effective for long-term operation and compliant performance. Treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easily implemented. If the landfill wastewater composition changes and additional contaminants must be addressed, the pre-treatment system can be modified easily, due to its modular design, to include the necessary unit operations. Sampling landfill wastewater prior to transporting it to Outfall 200 MTF and pre-treatment will verify compatibility with OF200 MTF and pre-treatment capability and identify changes in the characteristics of the landfill wastewater due to the differing predominant contaminants at ETTP, ORNL, and Y-12. If additional contaminants are introduced into the landfill wastewater, OF200 MTF and pre-treatment modifications can be performed, as necessary, to meet processing needs. Significant OF200 MTF and pre-treatment modifications can result in impaired treatment effectiveness and performance for the time necessary to provide the required treatment capability.

Transporting the landfill wastewater by tanker truck to OF200 MTF and pre-treatment will not be an effective long-term option. The utilization of trucks has been practiced successfully for twenty years. However, the expected increase and fluctuation in landfill wastewater flow will introduce uncertainty in the availability of trucks and drivers and increase the potential for transport incidents.

The pipeline will be effective because it will provide an engineered, automated, and well-contained system for transferring landfill wastewater to OF200 MTF and pre-treatment. Piping has a long service life and can be designed and installed to last well beyond the period of performance for EMWMF and the proposed EMDF.

Permanence. The EMWMF and proposed EMDF sites and Y-12 are expected to remain within the control of DOE indefinitely with existing access restrictions and land use controls. Treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easily implemented. If the landfill wastewater composition changes and additional contaminants must be addressed, the pre-treatment system can be modified easily, due to its modular design, to include the necessary unit operations.

Transporting the landfill wastewater by tanker truck to OF200 MTF and pre-treatment will not be an effective long-term option. The utilization of trucks has been practiced successfully for twenty years. However, the fluctuation in landfill wastewater flow will introduce uncertainty in the availability of trucks and drivers and increase the potential for transport incidents. The pipeline will be effective because it will provide an engineered, automated, and well-contained system for transferring landfill wastewater to OF200 MTF and pre-treatment. Piping has a long service life and can be designed and installed to last well beyond the period of performance for EMWMF and the proposed EMDF.

Reduction of Toxicity, Mobility, or Volume Through Treatment (Alternative 4)

Alternative 4 will reduce the concentrations of key COCs through treatment of landfill wastewater prior to discharge to UEFPC. Until the treatability studies are performed, the ability of OF200 MTF to treat other COCs will not be known.

Short-Term Effectiveness (Alternative 4)

The operation of OF200 MTF and pre-treatment will have minimal short-term impacts to remediation workers, the surrounding community, and the environment. Truck transport is currently used to deliver the leachate to PWTC for treatment and is being performed effectively and safely. Construction of the pipeline and pre-treatment will have short-term environmental impacts. DOE safety policies, procedures, and worker training reduce the potential for and mitigate the consequences of such incidents. Alternative 4 will reduce the flow of water in Bear Creek and may be detrimental to aquatic life, and at peak, EMDF flow is less than a 5% increase to the average East Fork Poplar Creek flow at OF200.

Implementability (Alternative 4)

Technical Feasibility. Alternative 4 will be technically feasible because treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easily implemented. If the landfill wastewater composition changes and additional contaminants must be addressed, the pre-treatment system can be modified easily, due to its modular design, to include the necessary unit operations. Upgrades at Outfall 200 MTF to install the additional landfill wastewater offloading stations and pre-treatment processes are easy to construct. Treatability studies are simple to perform, and construction of the pre-treatment facility is technically feasible and simple to implement. If the landfill wastewater becomes contaminated with constituents other than those treated at OF200 MTF and pre-treatment, implementability may be impaired temporarily.

Construction of the pipeline will use conventional construction techniques. However, there is likely to be interference from existing underground utilities and potentially contaminated soil that will complicate construction of the pipeline. The utilization of trucks has been practiced successfully for twenty years. However, the expected fluctuation in landfill wastewater flow will introduce uncertainty in the availability of trucks and drivers and increase the potential for transport incidents.

Administrative Feasibility. Alternative 4 will be administratively easy to implement. The ROD for the proposed EMDF will have to be developed to include this remedy and approved,, and the OF200 MTF CERCLA documents must be revised and approved to include the EMWMF/proposed EMDF landfill wastewater as a treatment stream. A remedial action work plan/remedial design report that includes the specific design and a completion document that contains the as-built conditions will be required. The EMWMF ROD and implementing documents will require revision. All of these documents are conventional CERCLA documents for which DOE has extensive experience. The separation of scope among EMWMF, the proposed EMDF, and OF200 MTF CERCLA documents will have to be determined.

Availability of Services and Materials. The services and materials for Alternative 4 are readily available. The treatment technologies for removal of key COCs are well demonstrated, reliable, effective, readily available, and easy to construct using standard equipment and techniques. DOE has implemented similar projects at ORNL, Y-12, and ETTP and has access to experienced engineering and project management resources for landfill water treatment projects.

Expansion of the facilities to receive and pre-treat the landfill wastewater and construction of the pipeline will use conventional construction techniques. The additional trucks and drivers that will be needed are available, but the varying demand complicates access to them.

Adaptability. The pre-treatment system will be designed to quickly implement different treatment units, if required by changes in COCs above or below discharge limits or due to long-term changes in flow rates. Flow rates above the design flow rate during storms will bypass the treatment system. If higher flow rates are continuous, then the pre-treatment system will be easily expanded. Lower flow rates normally will be treated in batches, requiring no changes to the pre-treatment system. If lower flow rates are continuous, then the pre-treatment system will be easily reduced in size.

Cost (Alternative 4)

- Trucking Option (Alternative 4a):
  - — **Capital Cost.** The capital cost of Alternative 4a is estimated at approximately $17 million.
  - — **O&M Cost.** The annual O&M cost of Alternative 4a is estimated at approximately $4 million during the operation and closure and $0.4 million during post-closure.
  - — **Present Worth.** The present worth of Alternative 4a is estimated at approximately $110 million.
- Pipeline Option (Alternative 4b):
  - — **Capital Cost.** The capital cost of Alternative 4b is estimated at approximately $22 million.
  - — **O&M Cost.** The annual O&M cost of Alternative 4b is estimated at approximately $1.8 million during the operations and closure and $0.3 million during post-closure.
  - — **Present Worth.** The present worth of Alternative 4b is estimated at approximately $63 million.

The basis for the cost estimate is in Appendix I.

Irretrievable Commitment of Resources (Alternative 4)

In Alternative 4, there will be minimal irretrievable commitment of resources. OF200 MTF is a planned facility for a much larger flow, and the additional flow is minimal. Therefore, the incremental energy and chemical requirements for treatment will be minimal. There will be minimal environmental impacts. Transporting leachate and contact water by truck will consume more energy in fuel than the pipeline option.

4.4 COMPARATIVE ANALYSIS OF ALTERNATIVES

4.4.1 Introduction

A comparative analysis was performed for the alternatives to develop the basis for selecting a recommended alternative. Both threshold criteria and the primary balancing criteria were considered in the analysis. The following threshold criteria reflect key statutory mandates of CERCLA that must be satisfied by an alternative for it to be eligible for selection.

- Overall Protection of Human Health and the Environment
- Compliance with ARARs

The following primary balancing criteria were used to compare the relative advantages and disadvantages of the alternatives to determine the most appropriate remedy.

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Adaptability
- Cost

A comparison of these six criteria forms the basis of the comparative analysis. The first three balancing criteria address the statutory preference for treatment as a principal element of the remedy. Together with the last three criteria, these form the basis for determining the general feasibility of each alternative and for determining whether costs are proportional to the overall effectiveness.

The two modifying criteria—state acceptance and community acceptance—will not be evaluated until the public has had the opportunity to comment on the proposed plan. Therefore, these criteria were not formally evaluated in this FFS.

Finally, irreversible and irretrievable commitment of resources was evaluated.

4.4.2 Threshold Criteria

4.4.2.1 Introduction

The threshold criteria consist of two of the nine criteria that must be satisfied by the selected alternative. These criteria are important because they reflect the key statutory mandates of CERCLA. If an alternative does not satisfy both of these criteria, it is not eligible to be selected as a remedy. CERCLA Sect.121(d) provides that, under certain circumstances, an ARAR may be waived. The following includes a discussion of the degree to which the four alternatives satisfy the two threshold criteria.

4.4.2.2 Overall Protection of Human Health and the Environment

The No Action alternative will not protect human health and the environment because no action will be taken to manage the release of key COCs into Bear Creek in the landfill wastewater.

Alternatives 2 through 4 will protect human health and the environment. Alternatives 2 through 4 will involve treatment of the landfill wastewater and can accommodate changes to COC concentrations in the future. However, Alternatives 3 and 4 require pre-treatment for them to be viable alternatives. Alternative 3 WAC does not allow mercury and the PWTC does not include the additional EMWMF/proposed EMDF landfill wastewater volumes. Alternative 4 currently does not address any COC, except mercury. Until the treatability studies are completed, the ability of Alternative 4 to treat other COCs will not be known. Alternatives 3 and 4 will require the landfill wastewater to be transported to PWTC and OF200, respectively, by either truck or pipeline. Both of these transportation methods will be effective, but involve risk associated with the potential for transport incident or pipeline failure. In addition, Alternatives 3 and 4 will divert water flow from Bear Creek, which may be detrimental to aquatic life in Bear Creek. The pipeline will be effective and will be protective due to the double containment and leak detection.

4.4.2.3 Compliance with ARARs

Since Alternative 1 is No Action for the management of landfill wastewater, there are no ARARs.

Alternatives 2 through 4 will meet the action-specific, chemical-specific, and location-specific ARARs. Alternative 2, Managed Discharge/Treat, will be compliant with ARARs because it allows only landfill wastewater that meets discharge limits to be released into Bear Creek. In Alternative 3, landfill wastewater is treated at the onsite PWTC, and the discharge will meet the NPDES permit. In Alternative 3, the PWTC WAC do not accept mercury-contaminated landfill wastewater, so pre-treatment will be required. The WAC will have to be revised or a waiver approved to be able to accept the landfill wastewater, and a revision to the NPDES permit may be required. In Alternative 4, the OF200 MTF is designed to treat only mercury, so pre-treatment is required. Alternatives 2 through 4 will accommodate changes to COC concentrations and the need to provide additional treatment processes and continue compliance with ARARs. Alternative 2 will be the easiest to modify to address additional treatment because it will be designed in a modular fashion with expansion in mind. PWTC and OF200 are slightly more difficult.

4.4.2.4 Summary

The No Action alternative will not meet the threshold criteria and cannot be considered for selection. Therefore Alternative 1, No Action will be included in the comparative analysis against the balancing criteria in Section 4.4.3.

Alternative 2, Managed Discharge/Treat, will satisfy both criteria because it only allows landfill wastewater that meets the discharge limits to be released to Bear Creek. The treatment system will be the easiest to modify because it is designed in a modular fashion with expansion in mind.

Alternative3, Treatment at PWTC, will satisfy both criteria because with pre-treatment it can treat all key COCs.

Alternative 4, Treatment at OF200 MTF, will satisfy both criteria, because with pre-treatment it can treat all key COCs.

Alternatives 2 through 4 can adapt to changing COCs. Therefore, Alternatives 2 through 4 meet the threshold criteria, can be considered for selection, and are included in the comparative analysis against the balancing criteria in Sect. 4.4.3.

4.4.3 Balancing Criteria

4.4.3.1 Long-Term Effectiveness and Permanence

Alternatives 2 through 4 will all be effective in the long-term because treatment systems will be provided that are designed and maintained for long-term operation. Alternative 2 only allows landfill wastewater that meets the discharge limits to be released to Bear Creek and will be the easiest to modify to accommodate changes in the concentrations of COCs in the future because it will be designed in a modular fashion with modification in mind. PWTC in Alternative 3 does not allow mercury and is limited in accepting radiological contaminants. Therefore, PWTC must have pre-treatment for long-term effectiveness and permanence. OF200 MTF in Alternative 4 is designed only for mercury, so pre-treatment facilities will have to be constructed. Alternatives 2 through 4 are sited at locations fully under the control of the DOE Environmental Management Program, and there are no competing priorities for the utilization of the sites.

4.4.3.2 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 2 through 4 will all satisfy this criterion because they include treatment, thus reducing toxicity of the landfill wastewater.

4.4.3.3 Short-Term Effectiveness

Alternatives 2 through 4 will satisfy the short-term effectiveness criterion. Alternative 2, Managed Discharge/Treat, will be immediately effective for landfill wastewater that meets discharge limits and can be discharged without treatment and then later when the LWTS is built. Alternative 4, Treatment at OF200 MTF, will involve construction of treatment and pre-treatment facilities, but will be effective upon treatment system startup. Alternative 3, Treatment at the PWTC, will be effective immediately on a temporary basis for landfill wastewater because it is a current, ongoing process, and permanently when pre-treatment is completed.

4.4.3.4 Implementability

Alternatives 2 through 4 will be technically feasible to implement and will be performed using standard construction equipment and techniques. Services and materials required for implementation of all action alternatives will be readily available. Alternative 2, Managed Discharge/Treat, will be the easiest to implement because existing facilities will be used initially, a treatment system will not be required immediately. Alternatives 3 and 4 will be more difficult to implement. Alternative 4 will require construction of the OF200 MTF and pre-treatment facilities, as well as trucking or construction of a pipeline to move the landfill wastewater to the site. Alternative 3 will utilize the existing PWTC with pre-treatment but will also require continued trucking or construction of a pipeline to move the landfill wastewater to the site. If additional contaminants appear in the landfill wastewater in the future, Alternative 2 will have the greatest flexibility to implement additional processing capability.

Alternatives 2 through 4 will satisfy the need for administrative implementability. All of the required documents are conventional CERCLA documents with which DOE has extensive experience. All alternatives will require approval of the EMDF ROD and implementing documents and revision of the EMWMF ROD and implementing documents. Alternative 3 will require additional revisions for the facility WAC and NPDES permit. Alternative 4 will require revisions to the UEFPC ROD and OF200 MTF implementing documents.

Alternatives 2 through 4 will be adaptable. Alternative 2 will have the most flexibility to address uncertainties in flow and future COCs through use of a modular approach for treatment to allow treatment units to be added, modified, or removed as the landfill wastewater contaminants change. Alternatives 3 and 4 are less adaptable; however, the pre-treatment facilities will be modular, which will facilitate modifications. Based on future treatability studies, the ability of Alternatives 3 and 4 to treat other COCs may be determined, which will also facilitate modifications.

4.4.3.5 Cost

Cost estimates are used in the CERCLA evaluation process to eliminate alternatives that are significantly more expensive than competing alternatives without offering commensurate increases in performance or overall protection of human health and the environment. The cost estimates are preliminary estimates with an intended accuracy range of +50 to -30 percent. Final costs will depend on actual labor and material costs, actual site conditions, productivity, competitive market conditions, final scope, final schedule, final engineering design, and other variables. Table 8 presents the estimated capital, annual O&M, and total present value costs for each alternative. Alternatives 3 and 4 with trucking will be the most expensive alternatives with present values of approximately $110 million. Alternative 2 will be the least expensive alternative with a present value of approximately $14 million.

4.4.4 Irreversible and Irretrievable Commitment of Resources

None of the action alternatives will have significant irreversible and irretrievable commitment of resources. Alternative 2, Managed Discharge/Treat, will have the least because there will be no treatment system involved initially. However, the LWTS may require mitigation of sensitive resources. Alternatives 3 and 4 will be similar because they will require landfill wastewater treatment systems for the entire time and associated energy requirements. The use of trucks or pipelines to transport the landfill wastewater for Alternatives 3 and 4 will increase energy requirements. Alternatives 3 and 4 will remove the landfill wastewater from Bear Creek with possible impacts to aquatic organisms in Bear Creek.

4.4.5 Comparative Analysis Summary

Results of the comparative analysis of alternatives are summarized in Table 8. Each of the alternatives is assigned a numeric rating for each of the criteria evaluated to assist the comparative analysis. Numeric ratings are semi-quantitative in that, while based on objective factors and data, they incorporate some degree of subjectivity as to the relative impact of the factors and data. The ratings are:

- 0—Not Applicable
- 1—Worst/Least
- 2—Worse/Less
- 3—Average/Neutral
- 4—Better/More
- 5—Best/Most

Table 8. Comparative analysis of alternatives

Criteria	Alternative 1: No Action	Alternative 2: Managed Discharge/Treat	Alternative 3: Treat at ORNL PWTC		Alternative 4: Treat at Outfall 200 MTF	
			Alternative 3a: Pipeline	Alternative 3b: Truck	Alternative 4a: Pipeline	Alternative 4b: Truck
Overall Protection of Human Health and the Environment	Not protective	Protective of human health and the environment; discharge limits met; easily adaptable to future COC changes	Protective of human health and the environment; COCs are treated after pre-treatment; adaptable to future COC changes; minimal risk due to the potential for pipeline failure; potential impact to Bear Creek aquatic life	Protective of human health and the environment; COCs are treated after pre-treatment; adaptable to future COC changes; minor risk due to potential for trucking incidents; potential impact to Bear Creek aquatic life	Protective of human health and the environment; COCs are treated with pre-treatment; adaptable to future COC changes; minimal risk due to the potential for pipeline failure; potential impact to Bear Creek aquatic life	Protective of human health and the environment; COCs are treated with pre-treatment; adaptable to future COC changes; minor risk due to the potential for trucking incidents; potential impact to Bear Creek aquatic life
Rating	1	5	3	3	4	4
Compliance with ARARs	Not applicable	Meets all ARARs	Meets all ARARs; PWTC WAC and NPDES permit will have to be revised to accept mercury and landfill wastewater, respectively	Meets all ARARs; PWTC WAC and NPDES permit will have to be revised to accept mercury and landfill wastewater, respectively	Meets all ARARs; UEFPC ROD will require revision	Meets all ARARs; UEFPC ROD will require revision
Rating	0	5	4	4	3	3
Long-Term Effectiveness and Permanence	Not applicable because threshold criteria not met	Effective	Effective with pre-treatment; minimal risk from long-term use of pipeline; adaptable to future COC changes	Effective with pre-treatment; long-term use of trucking involves risk; adaptable to future COC changes	Effective with pre-treatment; minimal risk from long-term use of pipeline; adaptable to future COC changes	Effective with pre-treatment; long-term use of trucks involves risk; adaptable to future COC changes
Rating	0	5	3	3	4	4

Table 8. Comparative analysis of alternatives (cont.)

Criteria	Alternative 1: No Action	Alternative 2: Managed Discharge/Treat	Alternative 3: Treat at ORNL PWTC		Alternative 4: Treat at Outfall 200	
			Alternative 3a: Pipeline	Alternative 3b: Truck	Alternative 4a: Pipeline	Alternative 4b: Truck
Reduction of Toxicity, Mobility, or Volume Through Treatment	Not applicable because threshold criteria not met	Reduction of toxicity through treatment	Reduction of toxicity through treatment; requires pre-treatment	Reduction of toxicity through treatment; requires pre-treatment	Reduction of toxicity through treatment; requires pre-treatment	Reduction of toxicity through treatment; requires pre-treatment
Rating	0	5	3	3	4	4
Short-Term Effectiveness	Not applicable because threshold criteria not met	Minor short-term impacts due to construction activities; uses existing facilities initially; standard construction risks to workers	Minor short-term impacts due to construction activities; plant expansion in heavily industrialized area; pipeline construction; standard construction risks to workers	Minor short-term impacts due to construction activities; plant expansion in heavily industrialized area; standard construction risks to workers	Minor short-term impacts due to construction activities; pipeline construction; standard construction risks to workers	Minor short-term impacts due to construction activities; standard construction risks to workers
Rating	0	5	3	3	3	3
Implementability	Not applicable because threshold criteria not met	Technically and administratively feasible; materials and services available; uses existing facilities; EMWMF and proposed EMDF CERCLA documents; easily adaptable to future COC changes	Technically and administratively feasible; materials and services available; pre-treatment required to implement; WAC and NPDES permit will have to be revised; inherent risk associated with pipeline construction and operation; adaptable to future COC changes; EMWMF/proposed EMDF CERCLA documents	Technically and administratively feasible; materials and services available; pre-treatment required to implement; WAC and NPDES permit will have to be revised; inherent risk associated with trucking; adaptable to future COC changes; EMWMF/proposed EMDF CERCLA documents	Technically and administratively feasible; materials and services available; pre-treatment required to implement; inherent risk associated with pipeline construction and operation; adaptable to future COC changes; EMWMF/proposed EMDF and OF200 MTF CERCLA documents	Technically and administratively feasible; materials and services available; pre-treatment required to implement; inherent risk associated with trucking; adaptable to future COC changes; EMWMF/proposed EMDF and OF200 MTF CERCLA documents
Rating	0	5	3	3	4	4

Table 8. Comparative analysis of alternatives (cont.)

Criteria	Alternative 1: No Action	Alternative 2: Managed Discharge/Treat	Alternative 3: Treat at ORNL PWTC		Alternative 4: Treat at Outfall 200	
			Alternative 3a: Pipeline	Alternative 3b: Truck	Alternative 4a: Pipeline	Alternative 4b: Truck
Cost ($million)	Not applicable because threshold criteria not met	Capital = $14 O&M = $1.5/year during operation and closure O&M = $0.3/year during post-closure Present Value = $48	Capital = $20 O&M = $1.8/year during operation and closure O&M = $0.3/year during post-closure Present Value = $61	Capital = $17 O&M = $4/year during operation and closure O&M = $0.4/year during post-closure Present Value = $110	Capital = $22 O&M = $1.8/year during operation and closure O&M = $0.3/year during post-closure Present Value = $63	Capital = $17 O&M = $4/year during operation and closure O&M = $0.4/year during post-closure Present Value = $110
Rating	0	5 = Capital 5 = O&M 5 = Present Value	3 = Capital 3 = O&M 3 = Present Value	4 = Capital 1 = O&M 1 = Present Value	1 = Capital 3 = O&M 3 = Present Value	4 = Capital 1 = O&M 1 = Present Value
Irreversible and Irretrievable Commitment of Resources	Not applicable because threshold criteria not met	Minor energy requirements associated with and sensitive resource impacts for LWTS construction and operation	Minor energy requirements associated with PWTC pre-treatment facility construction and operation; moderate construction and energy requirements for pipeline; removes water from Bear Creek	Minor energy requirements associated with PWTC pre-treatment facility construction and operation; moderate energy requirements for trucking; removes water from Bear Creek	Minor energy requirements associated with pre-treatment facility construction and operation; moderate energy requirements for pipeline; removes water from Bear Creek	Minor energy requirements associated with pre-treatment facility construction and operation; moderate energy requirements for trucking; removes water from Bear Creek
Rating	0	5	1	3	3	2

This FFS assumes that landfill wastewater quality and quantity will vary over time. Therefore, adaptability to manage these changes is the key criterion in determining the recommended alternative. Alternatives 3b and 4b are eliminated from further comparison because they are difficult to implement and have high present values. Table 9 provides a comparison of the remaining alternatives for adaptability, along with the major assumptions and cost.

Table 9. Analysis of alternatives for future water quality changes

Alternative	Summary evaluation	Capital cost/present value ($million)
2 - Managed Discharge/Treat	Alternative can be implemented immediately; meets discharge limits; easy to adapt to changing COCs.	$14/$48
3a - Treat at PWTC, transport by pipeline	Immediate capital costs required for the pipeline, pre-treatment; less adaptable than Alternative 2	$20/$61
4a - Treat at OF200 MTF, transport by pipeline	Immediate capital costs required for the pipeline and pre-treatment; less adaptable than Alternative 2	$22/$63

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APPENDIX A.
BEAR CREEK BURIAL GROUNDS EVALUATION

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BEAR CREEK BURIAL GROUNDS ANALYSIS

A feasibility study is being conducted to determine the optimum approach for managing wastewater generated as a consequence of hazardous/radioactive landfill operations located on the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) west of the Y-12 National Security Complex (Y-12). There are several major landfills currently located or planned for this area. The Environmental Management Waste Management Facility (EMWMF) is currently operating to provide disposal services for contaminated waste materials being generated as a consequence of ORR demolition and remediation projects. An additional facility to be constructed adjacent to EMWMF for the same purpose, the Environmental Management Disposal Facility (EMDF), will also require water management capability. The Bear Creek Burial Grounds (BCBG) is a disposal area that is no longer operating, but has been used in the past to dispose of hazardous and radioactive materials, and currently generates leachate for collection and treatment. There are additional uncontrolled releases of dissolved uranium from BCBG that must be considered for collection and treatment. This analysis is being performed to evaluate the feasibility of a combined solution that addresses all wastewater sources from EMWMF, future EMDF, and BCBG.

EMDF will be located in the same vicinity as the existing EMWMF and is expected to produce leachate that is similar in composition to EMWMF, with the notable exception of mercury that will be present at higher concentration in EMDF leachate. The proximity of EMDF will be close enough to allow for shared infrastructure for leachate collection and management. Consequently, a combined wastewater management solution for these two facilities is considered feasible and appropriate. EMWMF currently transports leachate to the Oak Ridge National Laboratory Process Waste Treatment Complex by tanker where it is combined with other wastewaters for processing and discharge to White Oak Creek via an existing permitted outfall. Contact water, generated separately at EMWMF and consisting of stormwater that comes into contact with waste materials at the working face of the landfill, is collected and analyzed to verify discharge criteria are met prior to release to a stormwater retention basin. Contact water exceeding discharge criteria is transported to the PWTC for treatment and discharge

BCBG is located west of EMWMF at a distance of roughly 3000 ft (Fig. A.1) and was historically used for disposal of radiologically and chemically contaminated wastes generated primarily by Y-12 operations. The source and type of waste materials disposed at BCBG are significantly different from those being disposed or planned for disposal at EMWMF and EMDF. BCBG consist of several principal waste disposal units designated as BCBG Unit-A, -B, -C, -D, -E, -J, and Walk-in Pits. Each waste disposal unit consists of a series of trenches used for disposal of liquid and solid wastes. Contamination in these disposal units include depleted uranium, shock-sensitive acids (e.g., picric acid), chromic acid, various organic solvents, polychlorinated biphenyls (PCBs), beryllium, chromium, thorium, and other radionuclides (DOE/OR/01-2382&D1, *Focused Feasibility Study for the Bear Creek Burial Grounds at the Y-12 National Security Complex*).

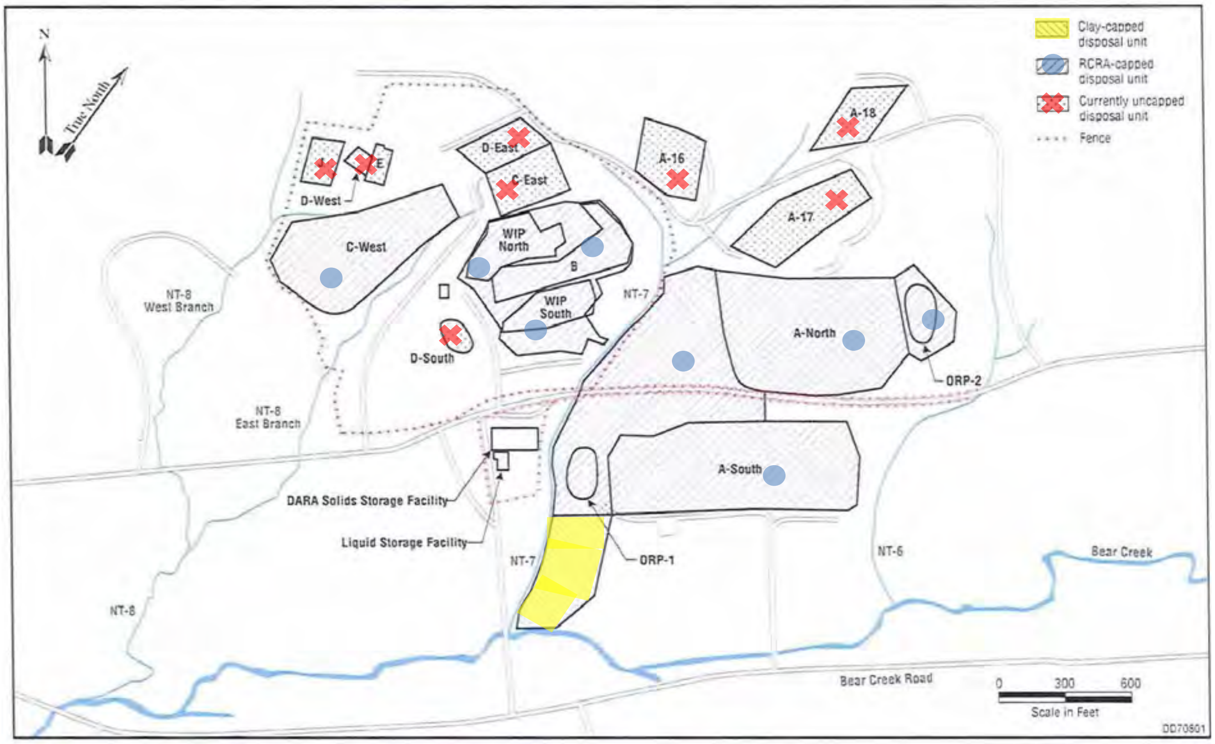

Fig. A.1. BCBG Waste Disposal Unit locations.

Disposal activities at BCBG ended in 1993, and several of the BCBG waste units have been closed under requirements of the Resource Conservation and Recovery Act (RCRA), including construction of multilayer caps. In 1989, a leachate collection system was installed in the North Tributary (NT)-7 catchment to intercept seepage from Unit A-North. A second leachate collection system was installed in the NT-8 catchment in 1993 to collect water from several seeps in this area. These leachate collection systems and associated storage comprise the Leachate Storage Facility (LSF). Collected leachate at the LSF is currently transported by tanker to the Y-12 Groundwater Treatment Facility (GWTF) for treatment and discharge through a permitted outfall. It has been determined; however, that there are additional uncontrolled releases of contaminated water from BCBG that contribute significant releases of dissolved uranium and other contaminants to surface water at NT-8 (DOE/OR/01-2638, *2014 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*).

As seen in the figure, several BCBG disposal units have not yet been remediated or capped. A Focused Feasibility Study (FFS) was written in 2008 (DOE/OR/01-2382&D1) to address remediation of these BCBG disposal units under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A future Record of Decision (ROD) is planned to develop a tri-party agreement regarding the approach for remediation of this area. Due to current issues associated with water-borne uranium being released from BCBG into NT-8, this analysis considers the feasibility of incorporating the management of BCBG-contaminated water along with EMWMF/EMDF wastewater.

Existing BCBG Leachate

The existing BCBG water collection and storage system for contaminated groundwater, the LSF, (see Fig. A.2) was built as part of the RCRA closure activities at BCBG. Leachate is collected from two locations at BCBG:

- BCBG NT-7: The leachate gravity flows from the burial grounds north of Tributary 7 into a holding tank and is pumped into the LSF.
- BCBG NT-8: The leachate gravity flows from underground Seeps 3 and 4 of C-West Burial Ground, Seep 2 of C-East Burial Ground, and the underground slope of C-West into a holding tank and is pumped into the LSF.

The LSF provides a gravity separator and storage tanks. The leachate collected from Tributary 7 area is primarily contaminated with depleted uranium, PCBs, VOCs, and iron whereas Tributary 8 area leachate contains depleted uranium, PCBs, volatile organic compounds (VOCs), lithium, iron, and moderately high sediment levels. The leachate carries the RCRA Hazard Code F039 waste (Y/ER-188, *Focused Feasibility Study Report for the Bear Creek Burial Grounds Leachate Collection System Project at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*).

Fig. A.2. Leachate Storage Facility.

GWTF (see Fig. A.3) receives tanker trucks from the LSF and also receives wastewater from the East Chestnut Ridge Waste Pile in 300-gal bulk containers for processing. Other contaminated groundwater seeps or other wastewaters appropriate to this treatment system may also be treated at this facility. After treatment, the water is discharged to Upper East Fork Poplar Creek through a National Pollution Discharge System permit. The facility operates 4 days a week, 10 hours per day. Contaminants of concern (COCs) include uranium-235 and -238, technetium-99, PCBs, VOCs, and beryllium. Unit operations include air stripping and activated carbon columns to remove contaminants. It operates at a nominal 25 gal per minute (gal/min) and an average of 2.1 million (M) gallons is treated annually, depending on rainfall. A continuous treatment of this volume would result in an average of 3 to 4 gal/min flow rate.

Fig. A.3. GWTF located in Bldg. 9616-7.

Bear Creek Uranium Flux Issue

Uranium contamination is a primary concern in Bear Creek. Uranium migration continues to be an issue, as noted in a review of past Remedial Effectiveness Reports (RERs), and specifically, the most recent RER (DOE/OR/01-2638). See Table A.1 for a summary of uranium flux in Bear Creek over time as given in the 2014 RER. More recently (2009 and later), the flux has increased more dramatically. The uranium measured at Bear Creek Kilometer (BCK) 9.2 in Zone 2 (see Fig. A.5) currently exceeds the ROD goal of 34 kg/year by about a factor of four. As shown in Fig. A.1, three tributaries (NT-6, NT-7, and NT-8) drain the BCBG area and flow into Bear Creek. NT-8 contributes heavily to the uranium flux migrating into Zone 2, at up to approximately half the total flux passing BCK 9.2. As noted in the RER, the NT-7 uranium flux of 1 to 2 kg per year in recent years has not been very significant, and NT-6 is not mentioned as a notable contributing factor to the contaminant load of Bear Creek. This information is corroborated by the fact that NT-7 is now mostly an engineered ditch with an existing groundwater seepage collection system, and that groundwater flow tends to flow towards the southwest and away from NT-6.

Table A.1. Uranium flux at flow-paced monitoring locations in BCV watershed (Table 4.7 from 2014 RER)

Fiscal year	BCK 9.2	SS-6	NT-8	BCK 11.54	NT-3	BCK 12.34	Average rainfall (in.)
2001	88.7	17.2	--	--	79.9	24.5	45.9
2002	**120.2**	13.1	--	158.2	**62.8**	25.4	52.7
2003	**165.4**	12.3	--	87.0	**4.6**	**44.3**	73.7
2004	**115.0**	9.5	--	45.8	1.2	**27.3**	56.4
2005	**115.4**	11.1	--	39.8	4.1	**40.3**	58.9
2006	**68.5**	--	--	25.2	1.7	21.3	46.4
2007	**59.5**	--	--	12.6	--[a]	15.8	36.8
2008	**73.2**	--	27.9	15.9	--[a]	23.0	49.3
2009	**147.7**	11.6	43.3[b]	27.2	--[a]	**32.9**	62.5
2010	**118.9**	9.9	61.0	32.5	**14.5**	**33.9**	55.8
2011	**108.7**	9.1	40	36.7	**16.3**	**37.8**	59.2
2012	**114.9**	9.2	43.3	45.4	**13.6**	**32.9**	61.75
2013	**122.3**	9.5	64.0	47.6	**22.3**	**40.3**	63.73
ROD Goals:	*34*				*4.3*	*27.2*	

Bold values indicate the *Record of Decision for the Phase 1 Activities in Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (DOE/OR/01-1750&D4) goal for uranium flux has not been met**.**

[a] Goal attained; flux monitoring discontinued in FY2007 and reinstituted in FY2010.

[b] Uranium isotope mass balancing at BCK 9.2 suggests NT-8 contributed about 60 kg in FY2009. Approximately 17 kg infiltrated into karst seepage pathways upstream of the NT-8 flume.

BCK = Bear Creek kilometer
BCV = Bear Creek Valley
FY = fiscal year
kg = kilograms
NT = North Tributary
ROD = Record of Decision
SS = surface spring

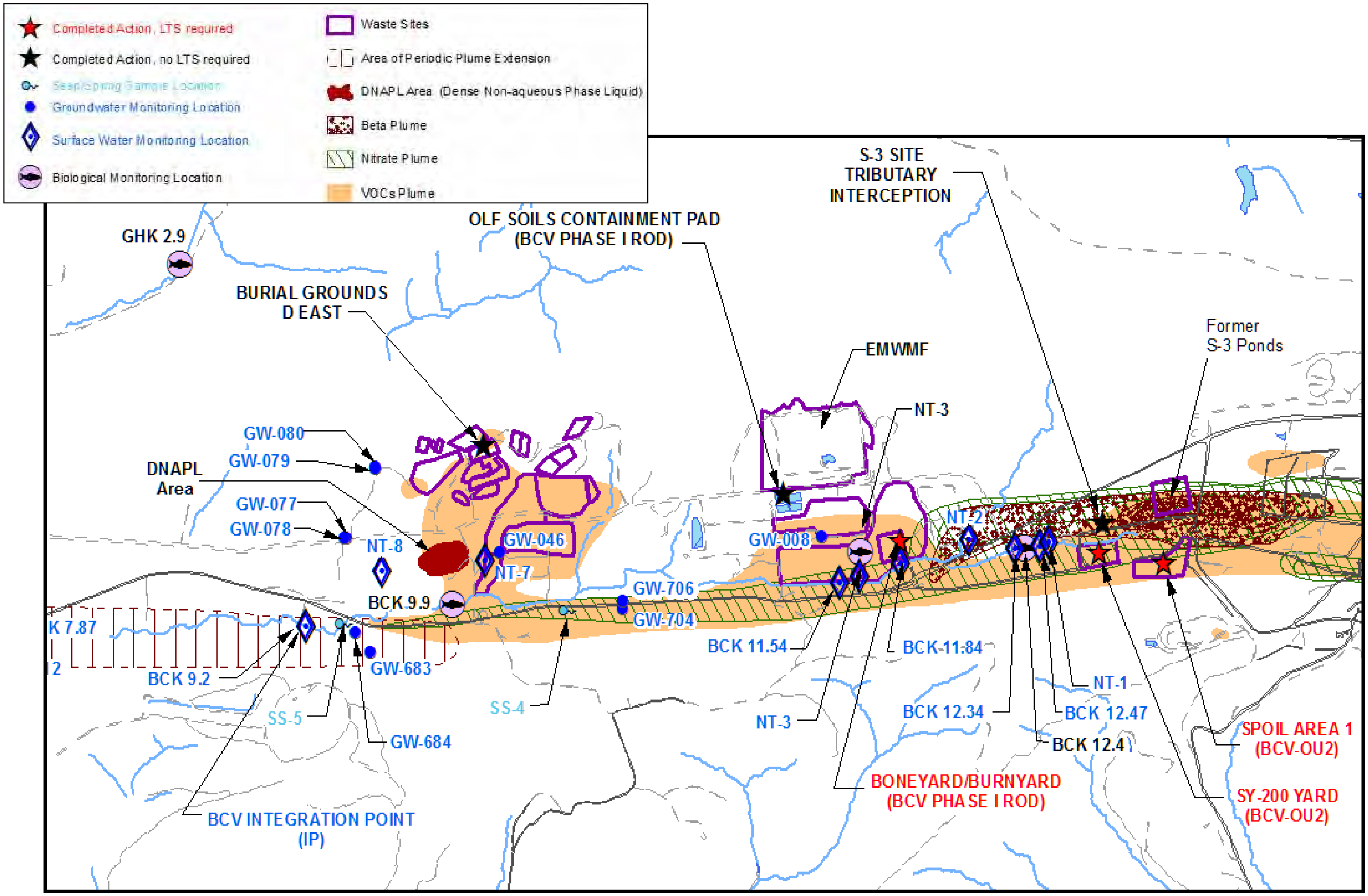

Fig. A.4. Bear Creek Valley points of interest in Zones 2 and 3—integration point BCK 9.2 and BCK 11.84; NT-3; NT-8 (portion of Fig 4.1 from 2014 RER).

Per the 2008 BCBG FFS, tributaries NT-6, -7, and -8 are usually dry during the periods in the late summer and early fall. Base flow in each stream reaches a maximum between December and April, and peak storm flow for each tributary ranges from 900 to 27,000 gal/min. A more recent examination of flow in NT-8 alone indicates a wet season base flow of about 10 gal/min.[2] Figure A.5 provides graphics of current NT-8 maximum and base flows. The NT-8 flow is measured from the RER monitoring flume just past the point in NT-8 where east and west branches merge to form a single stream channel. Figure A.5 demonstrates the highly variable flow rates that occur at the NT-8 flume. As seen in the top graph of Fig. A.5, flow rates have exceeded 1000 gpm, with rates over 5000 gpm on record. The bottom graph in Fig. A.5 clearly demonstrates that the creek is often dry during summer months. If NT-8 was targeted for treatment to reduce the Bear Creek uranium flux, a complex collection system and large equalization tanks would be required to provide a constant flow for processing. To reduce the flow to a more manageable rate, further investigation of the source of the existing contaminant issues at BCBG was completed and is discussed in the following section.

Proposed Collection of Additional BCBG Wastewater

As described above, NT-8 appears to contribute a significant portion of the uranium flux in Bear Creek. Additional sampling data and field investigation has been performed at the BCBG area since the issuance of the 2008 BCBG FFS. The fiscal year (FY)2008 RER identified the need to install a continuous flow monitoring station in NT-8, since the ungauged uranium input at BCK 9.2 was increasing and uranium flux attributable to NT-8 had not been quantified since the Bear Creek Valley Remedial Investigation (DOE/OR/01-1455/V1–V4&D1, *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*). The FY2009 RER reported that a new monitoring station demonstrated that NT-8 was contributing high levels of uranium to the watershed. As part of the FY2011 RER, a recommended action was identified to document the discharge of contaminants along NT-8 in order to determine where contaminants were entering the stream. Uranium, VOCs, and PCBs were listed as being of greatest concern. A secondary recommendation of the FY2011 RER was to review the engineering design, operational records, and system performance of the existing non-CERCLA groundwater seepage collection system in the NT-8 headwaters (associated with BCBG D-West). The secondary recommendation was deferred, but the investigation of NT-8 surface water was carried out and the results discussed in the FY2012 RER. Ten transects were examined along NT-8, starting from the NT-8 RER monitoring flume and moving north towards the buried waste. It was determined that the eastern branch of NT-8 was the principal source of uranium, with the highest concentrations occurring near the intersection of the fence line and the eastern branch of NT-8 (near C-West). Historical data collected from the area indicated dissolved uranium-238 concentrations at this location were as high as 1230 pCi/L. The eastern branch of NT-8 was also determined to be a significant source of PCBs. VOCs were highest near the confluence of the eastern and western branches of NT-8.

Knowledgeable subject matter experts have suggested that an interceptor trench located perpendicular to NT-8 East branch (see Fig. A.6) along the fence line could capture groundwater that likely contains some of the highest uranium concentrations, prior to its combining with surface water in NT-8. This interceptor trench would be 8- to 10-ft deep and entail a French drain collection system with a downgradient slurry wall barrier along the fence line next to C-West. The trench would include a cap to shed stormwater and would connect with the existing LSF collection system.

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[2]Data for BCK 9.2 and NT-8 flow, taken from Oak Ridge Environmental Information System (OREIS), April 2014.

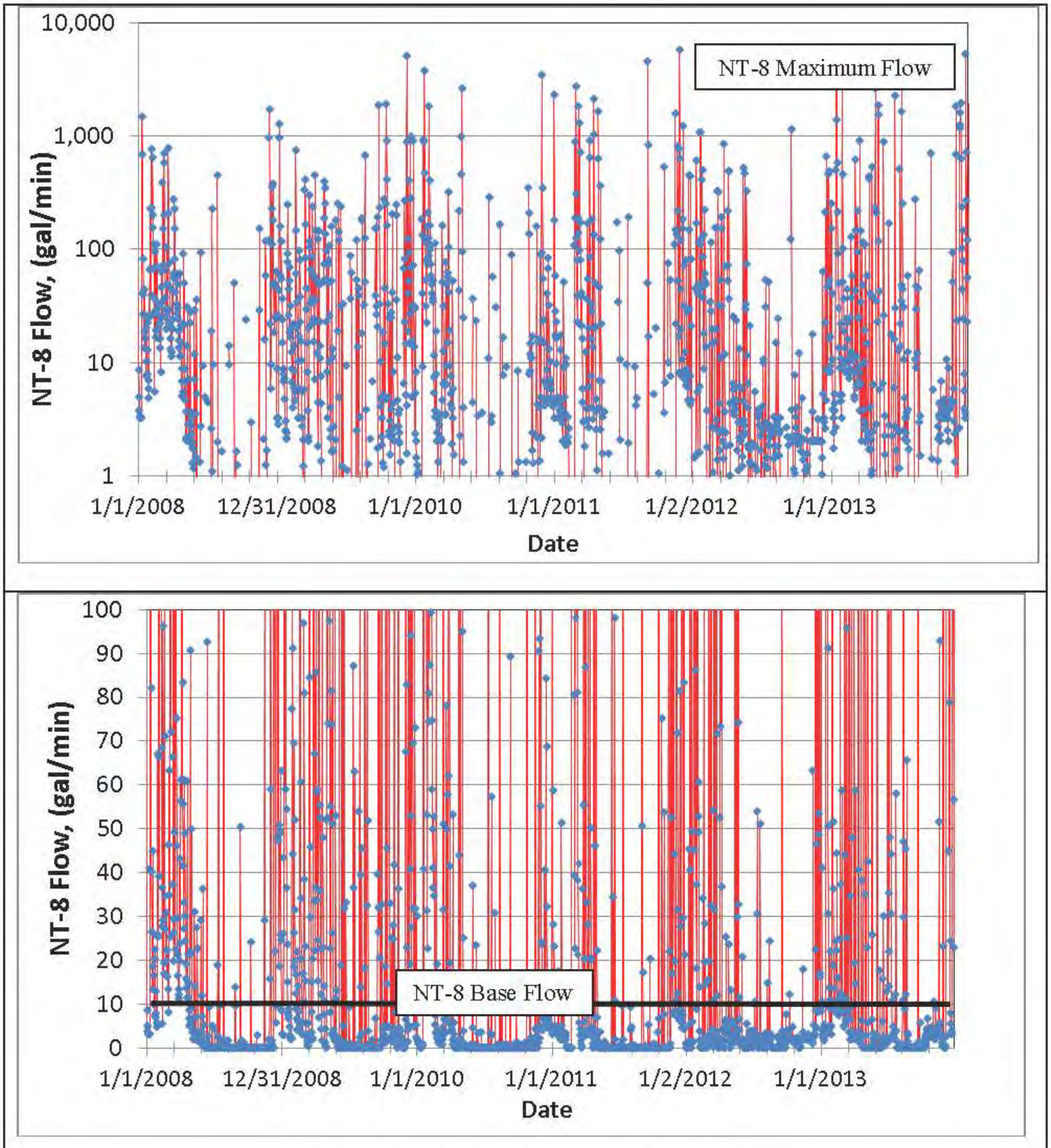


Fig. A.5. OREIS sampling location BC-NT8 (NT-8 continuous flow monitoring flume)—maximum and base flows.

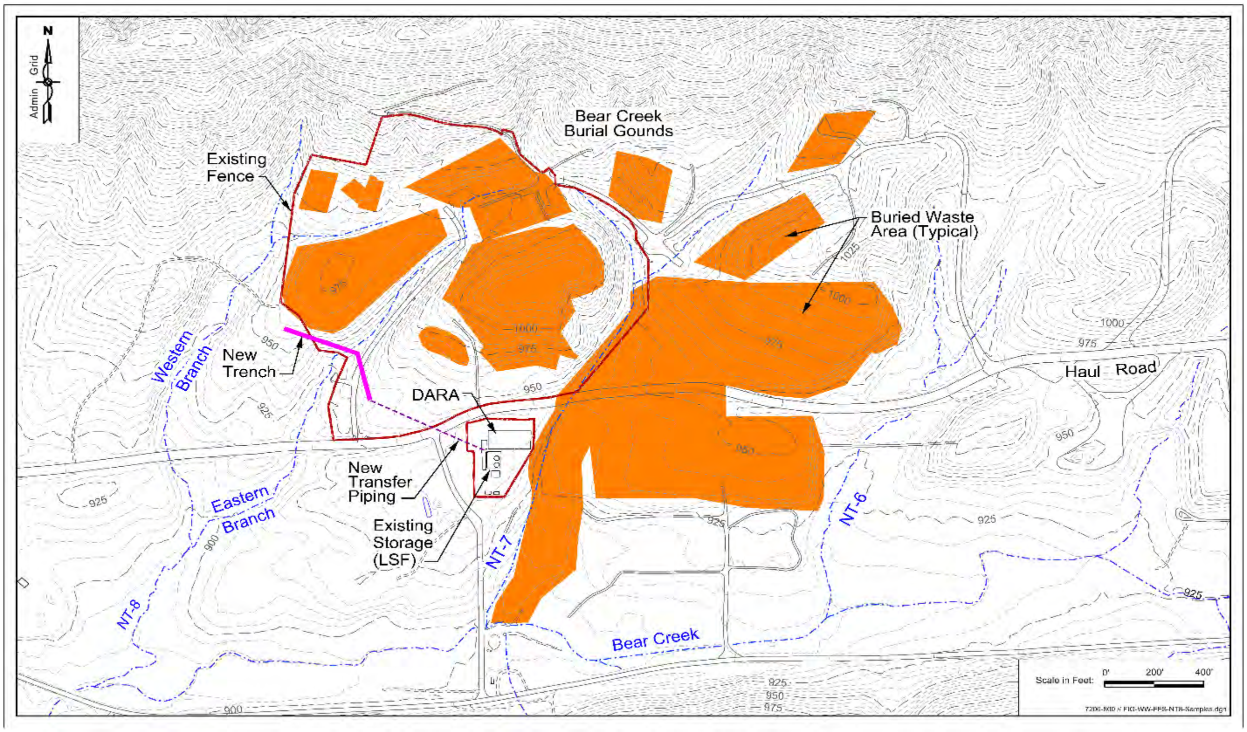


Fig. A.5. Proposed interceptor trench at BCBG.

This approach to collecting BCBG wastewater for treatment, however, would require additional data and engineering to evaluate the feasibility and cost. Data gaps include information that would require somewhat extensive investigation, for example:

- Depth to bedrock in order to determine collection trench size
- Flow information to determine collection trench dimensions, collection pipe size, the need for a booter pump, and storage needs
- Potential modifications to the existing GWTF to manage higher volumes of water
- More specific contaminant information (e.g., dissolved versus particle-bound contaminants)

Management of Additional BCBG Wastewater

Collecting the intercepted groundwater prior to combining with surface water would greatly reduce the volume of water to be treated and the associated cost of water management systems. Based on an anticipated continuous flow of less than 10 gal/min, this intercepted groundwater flow could be managed by incorporating it with the existing LSF collection system. It could be transferred to and treated at the GWTF along with the current BCBG leachate or could be stored at the LSF and considered for incorporation into the EMWMF/EMDF water management FFS alternatives.

Connecting this intercepted groundwater flow to the existing LSF collection system would be straight forward. Transfer (currently trucking) to the existing GWTF and frequency of batch treatment operations would increase, but the combined flow would not likely exceed the current system treatment capacity. The COCs are the same as those currently managed by the GWTF. Considering drainage areas and speaking with subject matter experts, the NT-8 interceptor trench would probably double the flow that is currently being collected at the LSF. The current system focuses on collection of seeps instead of a continuous trench that would be required for protecting the eastern branch of NT-8. However, as previously discussed, the design flow of the GWTF is nearly a factor of ten higher than the current average flow processed by the system. Treating the additional flow would result in more frequent trucking/transfer and batch treatment campaigns.

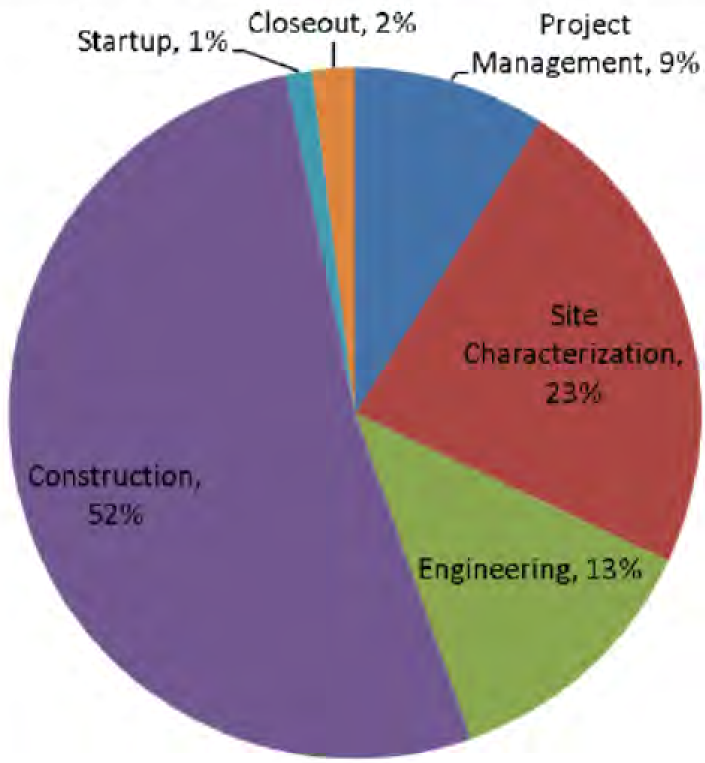
Although the anticipated flow collected by this trench system would be manageable within an EMWMF/EMDF wastewater analysis, contaminants must also be considered, and would necessarily need to be a subset of those contaminants that will be managed under the EMWMF/EMDF water management alternative. PCBs, F039-listed solvents, and uranium are the main COCs for BCBG. Uranium is also an expected COC for the EMWMF/EMDF; however, PCBs and F039-listed solvents have not been identified as COCs. Treatment of PCBs and F039-listed solvents would require additional RCRA considerations (requirements in terms of design and construction) and would greatly increase the cost of secondary waste disposal. Due to the F039-listed components, the secondary wastes from the EMWMF/EMDF leachate treatment system would also be listed with this constituent. Consequently, the secondary wastes would require additional processing and disposal at an offsite disposal facility as a mixed RCRA/radioactive waste material and could not be considered for return to either disposal facility since neither facility accepts listed wastes. The existing GWTF currently manages these constituents and there would be no need to alter current disposal practices. It would therefore be advantageous to collect, transfer, and treat the NT-8 intercept trench water along with the current BCBG leachate stream at the GWTF.

Rough order-of-magnitude costs for the management of BCBG wastewater as proposed, via an interceptor trench, incorporating a slurry wall and cap, have been determined. These costs are summarized in Table A.2. Additional costs have not been delineated but are noted as applicable.

Table A.2. Cost of proposed methods for capture of BCBG contaminated water management

Proposed method	ROM cost	Issues
Interceptor trench, slurry wall, cap, collect and treat with existing BCBG leachate stream at GWTF	• $1.4 M (interceptor trench, slurry wall, cap) • Additional cost to tie into existing BCBG leachate collection at LSF • Additional transfer/operations costs at GWTF	• Data gaps remain
Interceptor trench, slurry wall, cap, collect and manage with EMWMF/EMDF stream	• $1.4 M (interceptor trench, slurry wall, cap) • Additional cost to tie into existing BCBG leachate collection at LSF • Additional cost to transfer/tie into EMWMF/EMDF treatment • Additional capital costs for increased design flow and COC treatment • Additional permitting and operating costs for management of combined wastewater as F039-listed waste (projected to be a high cost)	• Data gaps remain • COCs outside of envelope of those to be treated for EMWMF/EMDF

As shown in Table A.2, treatment by the currently utilized method (e.g., collection within the LSF system, trucking to the GWTF for treatment) would be a more cost-effective solution as opposed to combining the management of the waters with EMWMF/EMDF waters. Details of the cost estimate for the interceptor trench, slurry wall, and cap are given in Fig. A.7.



WBS	WBS Description	Cost
1.1	Project Management	$110,959.68
1.2	Site Characterization	$284,472.00
1.3	Engineering	$155,218.73
1.4	Construction	$645,117.33
1.5	Startup	$14,923.81
1.6	Closeout	$24,816.35
	Subtotal	$1,235,507.90
	Contingency - 30% of construction	$132,913.67
	Total Estimated Cost	$1,368,421.57

Fig. A.6. Detailed cost information for interceptor trench, slurry wall, and cap for BCBG.

Conclusions

This analysis indicates that the solution to address wastewater sources from EMWMF, future EMDF, and BCBG involves combined processing of EMWMF and EMDF wastewaters and treatment of BCBG wastewater separately. While the projected volume of BCBG wastewater to be treated would be capable of being managed within a future EMWMF/EMDF alternative, the list of COCs for BCBG wastewater precludes treatment with the EMWMF/EMDF wastewater. Listed F039 solvents and PCBs are not contaminants identified as requiring treatment for the EMWMF/EMDF wastewater. Additional equipment and operating costs to treat BCBG wastewater in combination with EMWMF/EMDF wastewater are projected to be much greater than the cost of processing BCBG wastewater at GWTF. Additionally, the wastewater would require transport by truck (or pipeline) from the LSF to a location for incorporation into a "new" EMWMF/EMDF option. Negative impacts, such as increased capital cost, increased complexity in terms of contaminants requiring treatment, and increased waste disposal costs are identified by incorporating a BCBG leachate waste stream into the EMWMF/EMDF wastewater management analysis.

A preferred solution would involve constructing an additional trench at BCBG to intercept contaminated groundwater entering NT-8 and transfer it to the existing LSF. The flow of the collected water would be within the existing capacity of the GWTF that currently processes leachate collected at the LSF. Additionally, the COCs to be addressed are the same as those currently managed by GWTF.

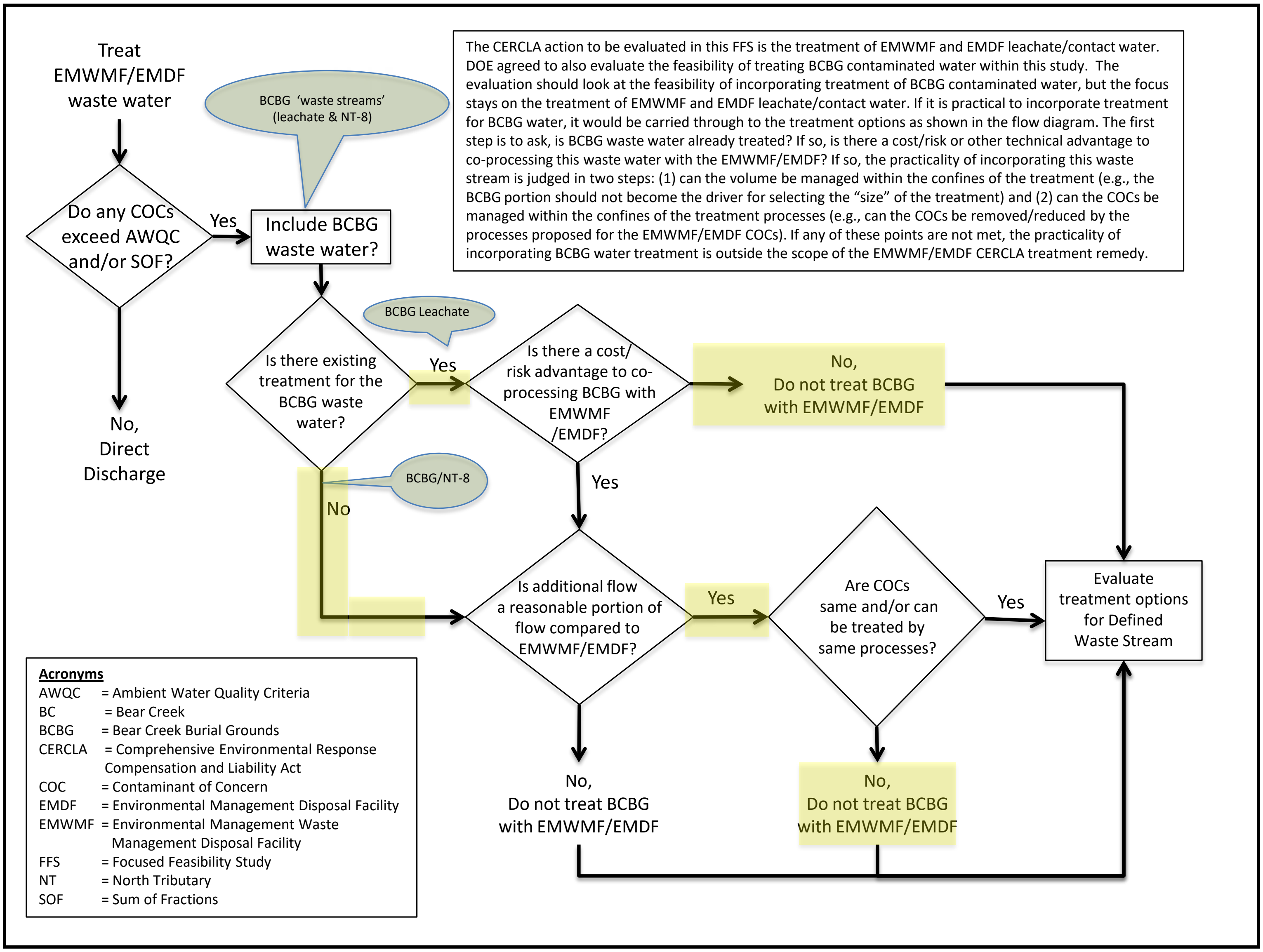


Fig. A.7. Flow sheet for determining the scope of the EMWMF/EMDF FFS.

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APPENDIX B.
CONTACT WATER AND LEACHATE FLOW RATE

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B.1 General Approach

The flow rates used in the focused feasibility study (FFS) were calculated with input from the Environmental Management Waste Management Facility (EMWMF) HELP model, the historical flow rate data, and the existing water balance that takes into account interim storage in tanks and ponds and the effect of varying water transfer rates. The historical data and HELP model output are useful in pointing to a range of values that are worth considering, but do not provide the precision required to calculate the future processing rates. Therefore, the water input was determined from a combination of HELP and historical data. The water balance was then used to evaluate the impact from changing storage volumes, transfer rates, and storm recurrence intervals to evaluate the risk of spillage from the system of storage units. The water storage requirement is provided in Appendix H.

B.2 Considerations When Using HELP Model Analysis Validated Against Historical Data to Establish Water Processing Rates

<u>HELP Model Limitations:</u>

It is difficult to model all variations in cover conditions that are possible during active cell operations. The enhanced operational cover and large areas with compacted, low permeability clay above waste that still shed water into the active cells likely result in more rainfall becoming contact water than HELP would forecast.

HELP modeling does not usually attempt to account for the large, multi-day, storm events that generated a tremendous amount of water. A good example is the 8.66 inches of rain that fell over the Labor Day weekend in 2011. That storm exceeded the 100-year, 24-hour storm by 2.16 inches. Another example is the 9.54 inches of rain that fell between February 14–16, 2003, exceeding the 100-year, 24-hour storm by slightly over 3 inches.

HELP does not account for storage of stormwater runoff (i.e., contact water) nor does it accurately account for the delay/damping of the peak leachate generation as the water percolates through the waste mass and into the collection system.

Comparison of HELP model predictions of leachate and contact water quantities to the measured volumes provides inconclusive results. Leachate predictions are generally more accurate than contact water and typically are higher than actual quantities. Contact water appears to be under-predicted by HELP, except for the larger storms (such as the 100-year, 24-hour storm) where the model significantly over-predicts the volume.

The EMWMF HELP modeling scenarios assume that as cells reach their final waste placement grades, the cells are quickly placed into a cover situation that diverts most of the precipitation out of the cell to the stormwater collection system. Although progress is being made, EMWMF has not been able to fully establish this cover to match the model’s aggressive assumptions, resulting in contact water volumes that typically exceed the model-predicted values.

<u>Actual Data Limitations</u>:

Actual data can be misleading because measured values are only recorded when someone is onsite to do so. Thus, amounts of rainfall and leachate generated often represent the net total for a 3-day period (or more if a holiday weekend is involved).

When comparing to predicted quantities of leachate or contact water, the actual values are substantially influenced by storage and infrequent closures of the Leachate Collection System valves. This has the effect of reducing or damping the daily volumes to levels the existing water management system can accommodate.

Water inputs and outputs to leachate storage tanks, contact water ponds, and contact water tanks are monitored daily with good precision; however, the water level changes in the catchments is only monitored weekly or subsequent to large storm events. While there is no true daily record of contact water input to the catchments, the measured output from the catchments is recorded. The output volume is essentially equal to the input volume minus the fraction that evaporates or infiltrates the leachate system. As a result and as shown in Table B.1, leachate volumes are lower than the HELP model predicts, and contact water volumes are higher than the HELP model predicts.

Table B.1. Actual vs. HELP model leachate quantities (2004–2009)

Peak day generation rate	
Actual volume (gal/day)	56,300
Projected volume - rainfall adjusted (gal/day)	62,532
Percentage of actual to projected (%)	90
Average month generation rate	
Actual volume (gal/mon)	166,294
Projected volume - rainfall adjusted (gal/mon)	320,698
Percentage of actual to projected (%)	52
Wettest month generation rate	
Actual volume (gal/mon)	412,600
Projected volume (gal/mon)	549,300
Percentage of actual to projected (%)	75

Table B.2. Actual vs. HELP model contact water quantities (2004–2009)
(Note: In this analysis all stormwater runoff is included with contact water.)

Peak day generation rate	
Actual volume (gal/day)	490,000
Projected volume - rainfall adjusted (gal/day)	1,516,859
Percentage of actual to projected (%)	32
Average month generation rate	
Actual volume (gal/mon)	593,409
Projected volume - rainfall adjusted (gal/mon)	837,200
Percentage of actual to projected (%)	71
Wettest month generation rate	
Actual volume (gal/mon)	2,101,400
Projected volume (gal/mon)	995,000
Percentage of actual to projected (%)	211

Flow Rate Estimates

The following likely situations were evaluated for the Cell 6 Remedial Design Report and are used in the FFS flow rate calculations.

Table B.3. Landfill situation descriptions used in Cell 6 RDR HELP model calculation

Situation	Landfill layer descriptions
A—New cell	New cell with minimum waste plus water catchment
B1—Working face with 10-ft layer of waste	10-ft waste at K = 5.0 × 10E-4 cm/s
B2—Working face with 30-ft layer of waste	30-ft waste at K = 5.0 × 10E-4 cm/s
C1—Operational cover with 40-ft layer of waste	0.25-in. Posi-shell cover at K = 5.8 × 10E-6 cm/s 1-ft operational cover at K = 5.0 × 10E-6 cm/s 40 ft of waste at K = 5.0 × 10E-4 cm/s
C2—Operational cover with 70-ft layer of waste	0.25-in. Posi-shell cover at K = 5.8 × 10E-6 cm/s 1-ft operational cover at K = 5.0 × 10E-6 cm/s 70 ft of waste at K = 5.0 × 10E-4 cm/s

The EMWMF Help model was then used with the above scenarios to develop leachate and contact water generation rates.

Table B.4. Leachate and contact water generation rates from EMWMF HELP Model average for Cells 1–6 from prior analyses (Cell 6 RDR HELP calculation)

Cell	Peak day (CF/Ac/day)		Average month (CF/Ac/day)		Wettest month (CF/Ac/day)		Max month (CF/Ac/day)	
Situation	Leachate	CW	Leachate	CW	Leachate	CW	Leachate	CW
A	1,198	22,311	44	255	78	288	127	473
B1	1,235	17,175	212	76	305	76	501	125
B2	1,234	17,175	212	76	313	76	514	125
C1	480	22,719	14	328	44	374	72	615
C2	487	22,719	14	328	44	374	72	615

Peak day data based on 100-yr, 24-hr storm of 6.5 in.
Average month data based on 100 years of HELP model synthetically generated data
Wettest month data based on 5.72-in. rain
Max month data based on 9.39 in. of rain (avg. of highest single month rain over period)
Ac = acre
CF = cubic feet
CW = contact water

These data were then used to simulate the conditions where EMWMF Cells 5 and 6 were open concurrently with Environmental Management Disposal Facility Cell 1, the base case for the FFS evaluations.

Table B.5. Base case modeling scenario

	Cell area	Peak day (CF/day)		Average month (CF/day)		Wettest month (CF/day)		Max month (CF/day)	
Active cells/condition	(acres)	Leachate	CW	Leachate	CW	Leachate	CW	Leachate	CW
EMWMF Cell 5 Situation B2	6.0	7,404	103,050	1,272	456	1,878	456	3,084	750
EMWMF Cell 6 Situation B2	5.3	6,479	90,169	1,113	399	1,643	399	2,699	656
EMDF Cell 1 Situation A	6.2	7,440	138,551	273	1,584	484	1,788	789	2,937
Totals	17.5	21,322	331,770	2,658	2,439	4,006	2,643	6,571	4,344
Converting to gal/day		159,489	2,481,640	19,884	18,240	29,962	19,773	49,152	32,490
Converting to gal/min		111	1,723	14	13	21	14	34	23
leachate + CW gal/min			**1,834**		**26**		**35**		**57**

CF = cubic feet
CW = contact water

The resulting flow rates were then used in the FFS as follows:

- Average flow rate was rounded to 30 gpm

Maximum month flow rate was rounded to 60 gpm and was used as the design basis in the FFS as a conservative measure, given the uncertainty in the flow rates.

APPENDIX C.
EXPLANATION OF HOW THE KEY CONTAMINANTS OF CONCERN WERE DEVELOPED

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C.1 METHODOLOGY

The Environmental Management Waste Management Facility (EMWMF) approach taken was to first compile the available data, then to qualitatively evaluate these for abundance in the waste lots, mobility, stability, and persistence in EMWMF and the surrounding environment, and potential risk concern. Following compilation and initial evaluation, the key contaminants of concern (COCs) were selected.

For the last several years, almost all of the waste disposed at EMWMF consists of waste lots from the East Tennessee Technology Park (ETTP—now known as the Heritage Center) site, with similar contaminants. Waste lots from the Heritage Center are expected to continue for several years as remediation activities are completed. Therefore, the last two years of data were analyzed to determine which of the current analytes would require treatment if a system was installed at this time.

As remediation activities increase at the Y-12 National Security Complex (Y-12) and the Oak Ridge National Laboratory (ORNL) sites, contaminants in the associated waste lots are expected to change and the key COCs may change. Additional evaluation was performed on the key COCs to determine trends and evaluate which COCs may require treatment at a future date as facilities with different characteristics are demolished. A process was also identified and will be documented in the EMWMF Sampling and Analysis Plan (SAP)/Quality Assurance Program Plan (QAPP) for ready evaluation of key COCs.

The following information was considered as part of this process:

- Free liquids are not allowed to be disposed at EMWMF.
- No listed waste has been or is projected to be disposed at EMWMF. Therefore, no degreasers/solvents are expected, such as trichloroethene and tetrachloroethene. Instead, these materials are present as a result of intended use associated with the facilities that have been demolished and disposed at EMWMF, or as residual amounts in soil or debris from previously remediated leaks or spills. Therefore, these materials may be present in minor amounts, rather than as primary contaminants.
- Wastes disposed at EMWMF must meet land disposal restrictions, minimizing the concentrations available to potentially leach into water.
- Metals typically require a low pH environment to dissolve and be transported in water. Both the geologic environment and the disposed waste (primarily building debris) at EMWMF are carbonate-rich with historically higher pH levels. Therefore, many metals are not expected to dissolve and be transported in either the surface or groundwater.

C.2 DATA COMPILATION

The EMWMF V-weir (outfall from the Sediment Basin, including contact water discharges), leachate and contact water analytical data were compiled from the start of calendar year 2005 to the end of fiscal year 2021, over 16 years of data. The data set selected included the most sensitive detection limits and analytical methods. These analytical data included COCs, and additional analytical data obtained by analyzing EMWMF wastewater for analytical suites instead of for COCs identified in the waste lots. The V-weir water analytical data are in Attachment 1, contact water analytical data are in Attachment 2 to this appendix, and the leachate data are in Attachment 3. As shown in these attachments, the number of analytes routinely detected is much less than the analytes that are analyzed. These data were considered in the preliminary design of the Environmental Management Disposal Facility (EMDF) Landfill Wastewater Treatment System (LWTS).

C.3 DATA EVALUATION

Following data compilation, the analytes were reviewed to evaluate abundance in the waste lots disposed at EMWMF, the contaminant mobility in water, the regulatory concern and/or risk, and other factors.

C.3.1 Analyte Abundance in EMWMF Waste

To determine the abundance in the waste, the number of waste lots with each analyte was compared against the number of waste lots where the analyte was detected during characterization. This comparison also determined that EMWMF was analyzing for many analytes not characterized in the waste. The abundance is provided per analyte in Attachment 4, the COC winnowing table. Analytes not characterized in the waste are indicated with a dash in the abundance table.

There have been 181 waste lots disposed to date at EMWMF. Analytes detected in waste in 0–50 waste lots were designated as low abundance. Analytes detected in 50–100 waste lots were designated as moderate abundance. Analytes detected in over 100 of the waste lots were designated as high abundance.

C.3.2 Mobility, Stability, and Persistence

Analytes were next evaluated for mobility in water, stability, and persistence. As a conservative approach, stability and persistence were assumed to be remain constant, and mobility in the landfill environment was expected to predict whether a contaminant could be present in the landfill water. The mobility class for the common organic analytes was derived from Applied Hydrogeology (Fetter, C. W., 1994, *Applied Hydrogeology,* Prentice-Hall, Upper Saddle River, New Jersey). The analytes specifically listed are highlighted in Attachment 4. For the remaining analytes not listed in Fetter, the following mobility class was assigned based upon the chemical properties:

Table C.1. Assigned mobility class for analyte families

Suffix	Assigned mobility class	Suffix	Assigned mobility class
-hexane	L	-nitrile	H
-ketone	M	-phenol	H
-benzene	H	-chlor	L
-ethene	M	-naphthalene	L
-ethane	H	-amine	L
-chloride	H		

H = high
L = low
M = moderate

Asbestos has not been seen in leachate or contact water and was assigned a low mobility due to its physical properties.

Several metals are not expected to be mobile within the landfill or within the geologic setting because of the concrete disposed in the landfill and the carbonate-rich geologic environment. However, metals such as barium and cadmium are mobile in the environment and are designated as such. Chromium has a dual mobility designation. Chrome III has a low mobility, but Chrome VI is highly mobile.

C.3.3 Potential Risk Concern

Several analytes are of greater concern because of their carcinogenic risk and/or an underlying potential risk concern. These analytes were assigned a low, moderate, or high rating based on the level of concern.

Mercury, cadmium, and nitrogen compounds (including ammonia) are of high concern because of the potential harm to the ecosystem. Pesticides are also of high concern because of the potential harm to the ecosystem. In addition, certain mobile radionuclides are of high concern because of the mobility combined with the persistence in the environment and the potential harm to the ecosystem.

Volatile organic compounds are of low concern because these are a relatively small component of the contamination associated with the waste. No free liquids or listed waste is allowed in EMWMF, limiting the amount to residual amounts in soil or debris from previously remediated leaks or spills. Therefore, these are a low-risk concern.

The assigned ratings are found in Attachment 3.

C.4 SELECTION OF KEY COCS

Based upon the preceding evaluation, the key COCs were identified (Table C.2) as analytes that are present in the wastewater and are abundant in the waste, mobile in the local environment, and of high potential risk concern. Additional water quality parameters will be monitored based on the Tennessee Department of Environment and Conservation (TDEC) Water Pollution Control experience in assessing industrial wastewater and recognizing reasonable potential impacts to streams in this geographical region. For example, Total Organic Carbon (TOC) will be monitored to indicate the presence of volatile organic compounds and semivolatile organic compounds. Additional analyses would be triggered if a significant increasing trend is seen.

Details on the key COCs monitoring are included in the EMWMF SAP/QAPP and will be included in the EMDF SAP/QAPP when developed.

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Table C.2. Key COCs and summary statistics for Calendar Year 2019–2021

Analysis type	Analyte	No. of analyses/ Detects	Units	Detected min.	Detected average	Detected max.	Min detection limit	Max detection limit	Project quantitation limit (MDA)	CMC AWQC TDEC Fish and Aquatic Life (batch)	CCC AWQC TDEC Fish and Aquatic Life (continuous)	TDEC AWQC recreation Water & organism/ organism only	24% of the DCGs	Max above FAL CMC (batch) ?	Max above CCC FAL (cont.) ?	Max above recreation ?	Max above DCGs?
EMWMF V-Weir																	
METAL	Arsenic, Tot + Diss	14/24	ug/L	0.71	1.62	2.9	0.33	5	5	340	150	10		No	No	No	-
METAL	Cadmium, Tot + Diss	0 / 25	ug/L	--	--	--	0.083	1	0.25 & 1	2.2*	0.27*	-		No	-	-	-
METAL	Chromium, Tot + Diss	6/24	ug/L	1.81	3.47	4.94	0.5	2.4	5	625*	81*	-		No	No	-	-
METAL	Chromium, hexavalent	0 / 0	ug/L	--	--	--	6	6	6	16	11			No	No	-	-
METAL	Copper, Tot + Diss	7/24	ug/L	0.52	1.47	2.72	0.18	9.4	2	15*	9.9*	-		No	No	-	-
METAL	Lead, Tot + Diss	8/24	ug/L	0.65	1.4	3.93	0.18	3.3	1	73*	2.8*	-		No	Yes (1)	-	-
METAL	Mercury, Tot + Diss	3/9	ug/L	0.00468	0.01	0.0113	0.0002	0.067	0.02 & 0.09	1.4	0.77	0.051		No	No	-	-
METAL	Nickel, Tot + Diss	4/24	ug/L	0.39	2.77	5	0.3	2.4	5	515*	57*	610 / 4600		No	No	No	-
METAL	Uranium	18/18	ug/L	1.6	6.99	21	--	--	5	-	-	-		-	-	-	-
Other	Cyanide	0 / 3	ug/L	--	--	--	1.67	1.67	5	22	5.2	140		No	No	No	-
Other	Dissolved Solids	17/18	mg/L	76	155	170	3.4	20	2.5	-	-	-		-	-	-	-
Other	Suspended Solids	76/83	mg/L	1.1	46	72	0.57	5.7	2.5	-	-	-		-	-	-	-
Other	Total Organic Carbon (TOC)	3/3	mg/L	4.6	6.5	7.5	0.3	0.3	1	-	-	-		-	-	-	-
PPCB	4,4'-DDD	0 / 3	ug/L	--	--	--	0.01	0.1	0.1	-	-	0.0031		-	-	-	-
PPCB	4,4'-DDE	0 / 3	ug/L	--	--	--	0.01	0.01	0.1	-	-	0.0022		-	-	-	-
PPCB	4,4'-DDT	0 / 9	ug/L	--	--	--	0.01	0.01	0.1 & 0.05	1.1	0.001	0.0022		-	-	-	-
PPCB	Aldrin	0 / 9	ug/L	--	--	--	0.007	0.007	0.1 & 0.05	3	-	0.0005		-	-	-	-
PPCB	beta-BHC	0 / 3	ug/L	--	--	--	0.007	0.007	0.1	-	-	0.091 / 0.17		-	-	-	-
PPCB	Dieldrin	0 / 9	ug/L	--	--	--	0.01	0.01	0.1 & 0.24	0.24	0.056	0.00054		-	-	-	-
RAD	Iodine-129	8/195	pCi/L	0.782	1.2	1.03	0.317	1.33	1	0	0	0	120	-	-	-	No
RAD	Strontium-90	151 / 207	pCi/L	0.386	1.2	35.5	0.518	0.788	4 & 2	0	0	0	240	-	-	-	No
RAD	Technetium-99	210 / 210	pCi/L	8.8	423	8520	2.03	--	10 & 5	5	0	0	24,000	-	-	-	No
RAD	Tritium	74 / 195	pCi/L	162	505	680	239	372	300	0	0	0	4.8E+05	-	-	-	No
RAD	Uranium-233/234	210 / 210	pCi/L	1.53	7.2	34.1	--	--	1 & 0.5	0	0	0	120	-	-	-	No
RAD	Uranium-235/236	210 / 155	pCi/L	0.14	1.24	4.06	0.278	1.14	1 & 0.5	0	0	0	120	-	-	-	No
RAD	Uranium-238	210 / 210	pCi/L	0.536	1.5	9.13	--	--	1 & 0.5	0	0	0	144	-	-	-	No
Contact Water (Ponds and Tanks)																	
METAL	Arsenic, Tot + Diss	173 / 179	µg/L	2.06	3.35	7.27	2	2	5	340	150	10		No	No		-
METAL	Cadmium, Tot + Diss	6 / 179	µg/L	0.301	0.429	0.615	0.3	0.3	1	2.2*	0.27*	-		No	Yes		-
METAL	Chromium, Tot + Diss	173 / 179	µg/L	1.05	6.09	16.9	1	1	5	625*	81*	-		No	No		-
METAL	Chromium, hexavalent	59 / 179	µg/L	6	8.43	16	6	6	6	16	11			No	Yes		-
METAL	Copper, Tot + Diss	178 / 179	µg/L	0.574	2.84	13.4	0.3	0.3	5	15*	9.9*	-		No	Yes		-
METAL	Lead, Tot + Diss	135 / 179	µg/L	0.5	1.4	9.09	0.5	0.5	3	73*	2.8*	-		No	Yes		-
METAL	Mercury, Tot + Diss	190 / 190	µg/L	0.002	0.022	0.094	--	--	0.02	1.4	0.77	0.051		No	No	Yes	-
METAL	Nickel, Tot + Diss	91 / 179	µg/L	1.5	2.73	9.41	1.5	1.5	10	515*	57*	4600		No	No	No	-
METAL	Uranium	179 / 179	µg/L	3.44	33.2	94.9			15	-	-	-		-	-		-

Analysis type	Analyte	No. of analyses	Units	Detected Min.	Detected Mean	Detected Max.	Min Detection Limit	Max Detectio n Limit	Project quantitation limit (MDA)	CMC AWQC TDEC Fish and Aquatic Life (batch)	CCC AWQC TDEC Fish and Aquatic Life (continuous)	TDEC AWQC recreation Water & organism / organism only	96% of the DCGs	Max above FAL CMC (batch) ?	Max above CCC FAL (cont) ?	Max above recreation ?	Max above DCGs?
Other	Cyanide	4 / 179	µg/L	1.86	6.74	18.4	1.67	1.67	5	22	5.2	140		No	Yes		-
Other	Dissolved Solids	177 / 177	mg/L	154	381	923	--	--	2.5	-	-	-		-	-		-
Other	Suspended Solids	182 / 187	mg/L	1.04	14.4	77.9	582	1390	2.5	-	-	-		-	-	-	-
Other	Total Organic Carbon (TOC)	177 / 177	mg/L	2.4	6.9	17.4	--	--	1	-	-	-		-	-		-
PPCB	4,4'-DDD	0 / 179	µg/L	--	--	--	0.009	0.02	0.1	-	-	0.0031		-	-		-
PPCB	4,4'-DDE	0 / 179	µg/L	--	--	--	0.009	0.02	0.1	-	-	0.0022					-
PPCB	4,4'-DDT	4 / 179	µg/L	0.02	0.037	0.066	0.009	0.02	0.05	1.1	0.001	0.0022					-
PPCB	Aldrin	1 / 179	µg/L	0.007	0.007	0.007	0.006	0.013	0.05	3	-	0.0005					-
PPCB	beta-BHC	6 / 179	µg/L	0.009	0.017	0.046	0.006	0.013	0.05	-	-	0.17					-
PPCB	Dieldrin	1 / 179	µg/L	0.036	0.036	0.036	0.009	0.02	0.24	0.24	0.056	0.00054					No
RAD	Iodine-129	4 / 179	pCi/L	0.534	0.706	0.956	0.459	1.62	5	0	0	0	480				No
RAD	Strontium-90	159 / 179	pCi/L	0.463	2.23	9.17	0.606	0.966	2	0	0	0	960				No
RAD	Technetium-99	179 / 179	pCi/L	142	2247	28,500	--	--	5	0	0	0	96,000				No
RAD	Tritium	75 / 179	pCi/L	257	752	2300	238	363	300	0	0	0	1.9E+06				No
RAD	Uranium-233/234	179 / 179	pCi/L	4.58	24.0	124	--	--	0.5	0	0	0	480				No
RAD	Uranium-235/236	175 / 177	pCi/L	0.373	2.39	11.5	0.731	2.02	0.5	0	0	0	480				No
RAD	Uranium-238	179 / 179	pCi/L	1.45	11.7	32.5	--	--	0.5	0	0	0	576				No

* Hardness adjusted value

Additional Water Quality Parameters

Other	Hardness, as CaCO3, mg/l
Other	Nitrogen, Nitrate total (as N)
Other	Nitrogen, total (as N)
Other	Phosphorus, total (as P)
Other	TDS or conductivity
Other	Total Organic Carbon
Other	TSS
Other	Whole effluent toxicity, both acute and chronic
Other	Ammonia Nitrogen, Total as N
Other	Stream flow
Other	Wastewater Flow

AWQC = ambient water quality criteria
CCC = criterion continuous concentration
CMC = criterion maximum concentration
DCG = derived concentration guidelines
FAL = fish and aquatic life
MDA = minimum detectable activity
PPCB = pesticides and polychlorinated biphenyls
RAD = radiological
TDS = total dissolved solids
TSS = total suspended solids

Additional Analysis

Each of the key COCs was evaluated over the EMWMF operating history to determine the trends. The data range from 2005 to 2014 was selected as the most complete, representative data set to evaluate and provides ten years of data. Contact water and leachate are graphed separately for each analyte, with the same axes for each analyte to facilitate the comparison between leachate and contact water. The following data were not filtered to show only the water released. Instead, all available analyses were used, including those from water that were treated. These graphs also indicate the changes in the analytical reporting limits over time, particularly for the analytes with minimal detects.

The Table C.3 and Fig. C.1 show the water volumes that have been treated since 2004. As shown, no contact water has been shipped for treatment since April 2011.

Table C.3. EMWMF contact water volume shipped by year (2005 to present)

Year		
2005	Jan–Mar	660,262
2006	Sep–Dec	831,187
2007	April	274,621
2009	April–May October	724,056 121,823
2010	May–June	1,191,035
2011	March–April	1,187,119
Total (2005–2021)		4,990,103

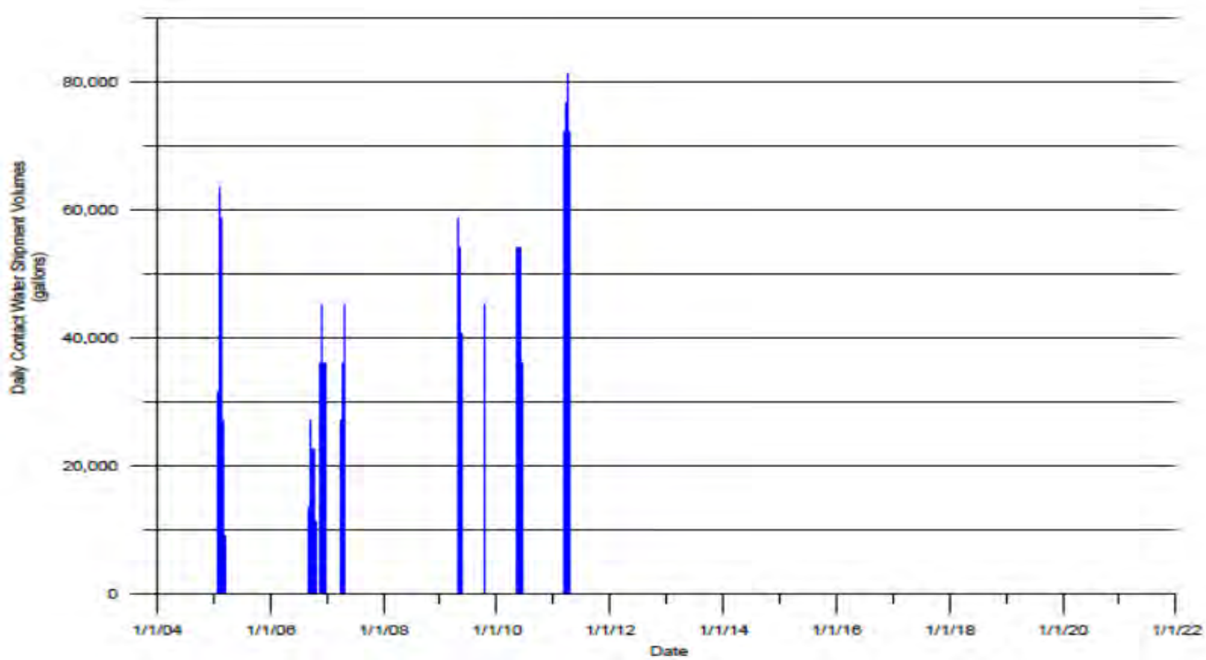
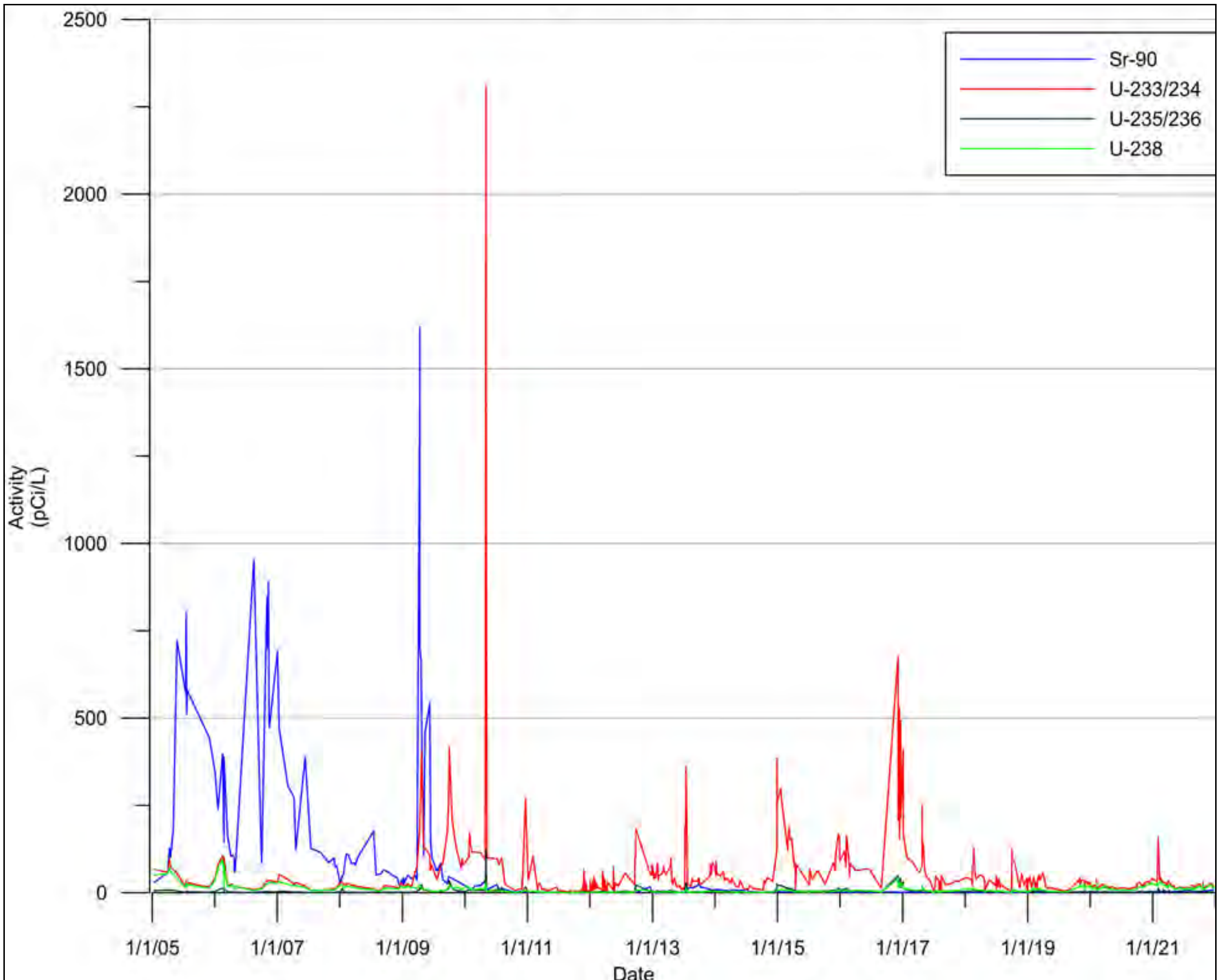


Fig. C.1. Contact water shipped for treatment 2004 to December 2021.

As shown in the following sections, concentrations of certain contaminants in contact water have changed over time, particularly as the origin of the waste received has changed. This is particularly noticeable in uranium (U) isotopes and strontium (Sr) as the origin of the waste has changed from Y-12 to ORNL to

ETTP. The following figure reflects these changes over time and indicates the changes expected to be seen as the origin of the waste changes in the future.



	2002–2006	2007–2010	2011–2021
Y-12	Boneyard/Burnyard		Old Salvage Yard, Biology Complex, Alpha 5
ORNL	Melton Valley closure soil and sediment, main plant surface impoundments	University of Tennessee-Battelle Bldg. 3026, 2000 complex	2000 complex, including slabs and soils
ETTP	K1070A burial ground, main facilities	K-25, Zone 1 and 2, Poplar Creek process facilities	K-33, K-25, ETTP/Heritage Center facilities, and soil remediation projects
Other	David Witherspoon 901	David Witherspoon 1630	

Fig. C.2. Activity of Sr-90 and uranium isotopes I EMWMF contact water—Jan. 2005 to Dec. 2021.

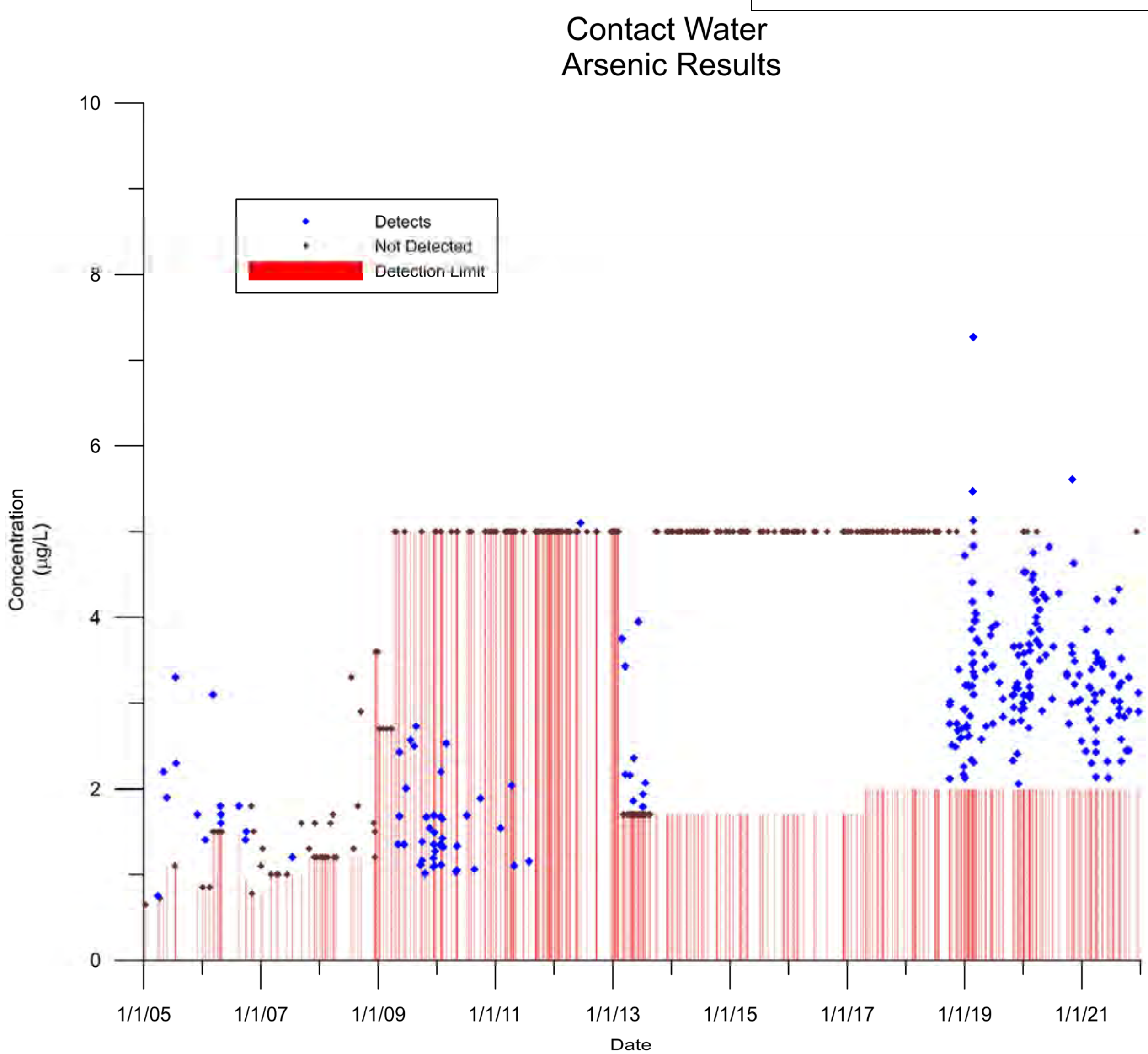
As shown above, prior to 2010, strontium was more prevalent in the contact water, representing the waste streams from Y-12 and ORNL. After 2010, U-233/234 is the prevalent radionuclide, representing a change in waste streams to primarily those originating at ETTP. U-235/236 is also more common in contact water prior to 2007, representing the portion of waste received from Y-12 and the Boneyard/Burnyard.

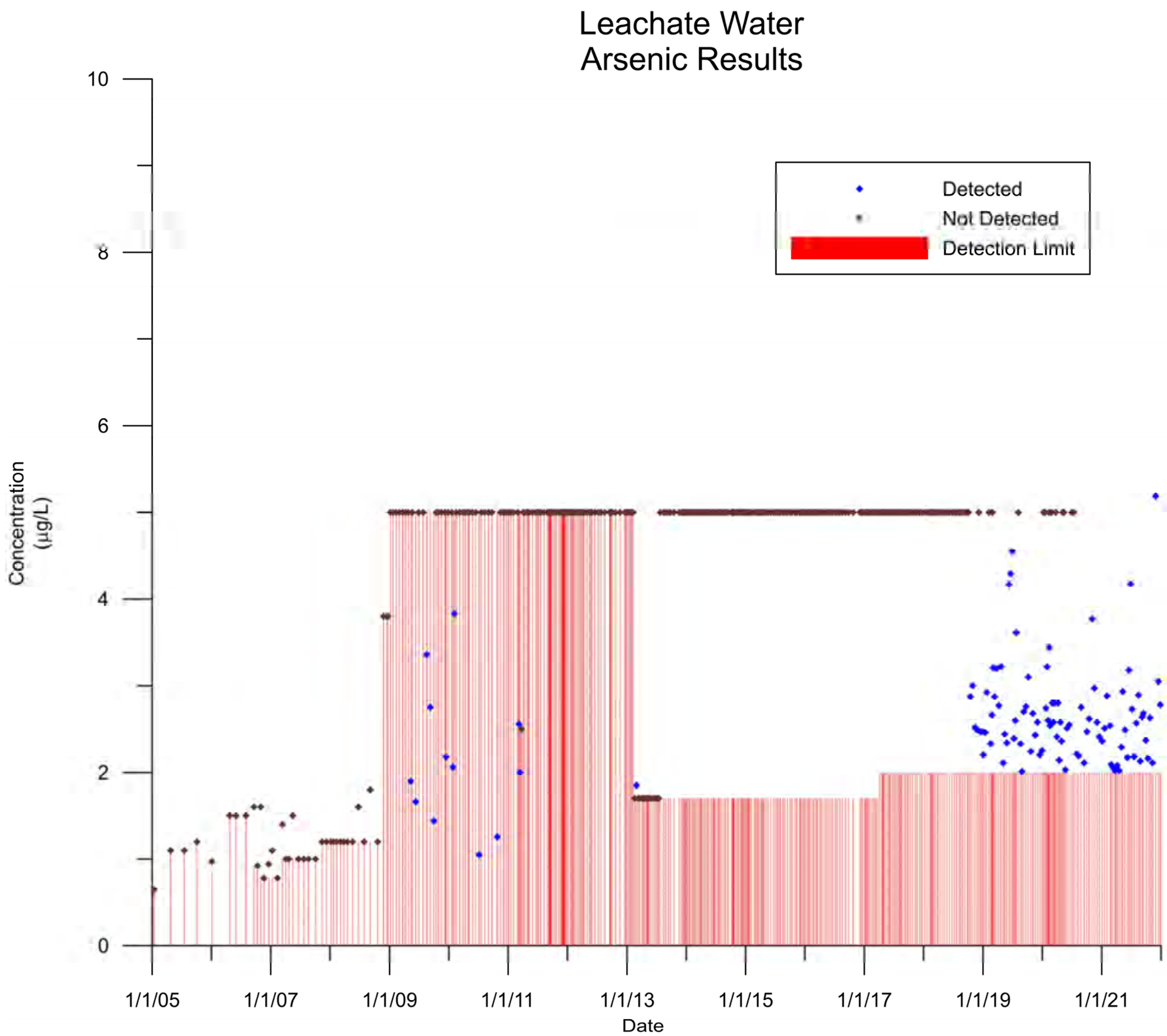
Following completion of the ETTP remedial actions, changes in the overall landfill wastewater concentrations are anticipated as Y-12 and ORNL waste again become the major waste lots received. Specifically, increases in mercury and strontium concentrations are anticipated.

Arsenic

Low levels of arsenic are detected in both the contact water and leachate. Arsenic was detected above the detection limit in 30% of the V-weir results, 61% of contact water results, and 26% of the leachate results. When detected, arsenic is generally below the project quantitation level (PQL) of 5 ug/L. Arsenic is not expected to require treatment.

Recreational ambient water quality criteria (AWQC) – 10 ug/L Criterion maximum concentration (CMC) – 340 ug/L Criterion continuous concentration (CCC) – 150 ug/L





Leachate Water
Arsenic Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
10
8
6
4
2
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Cadmium

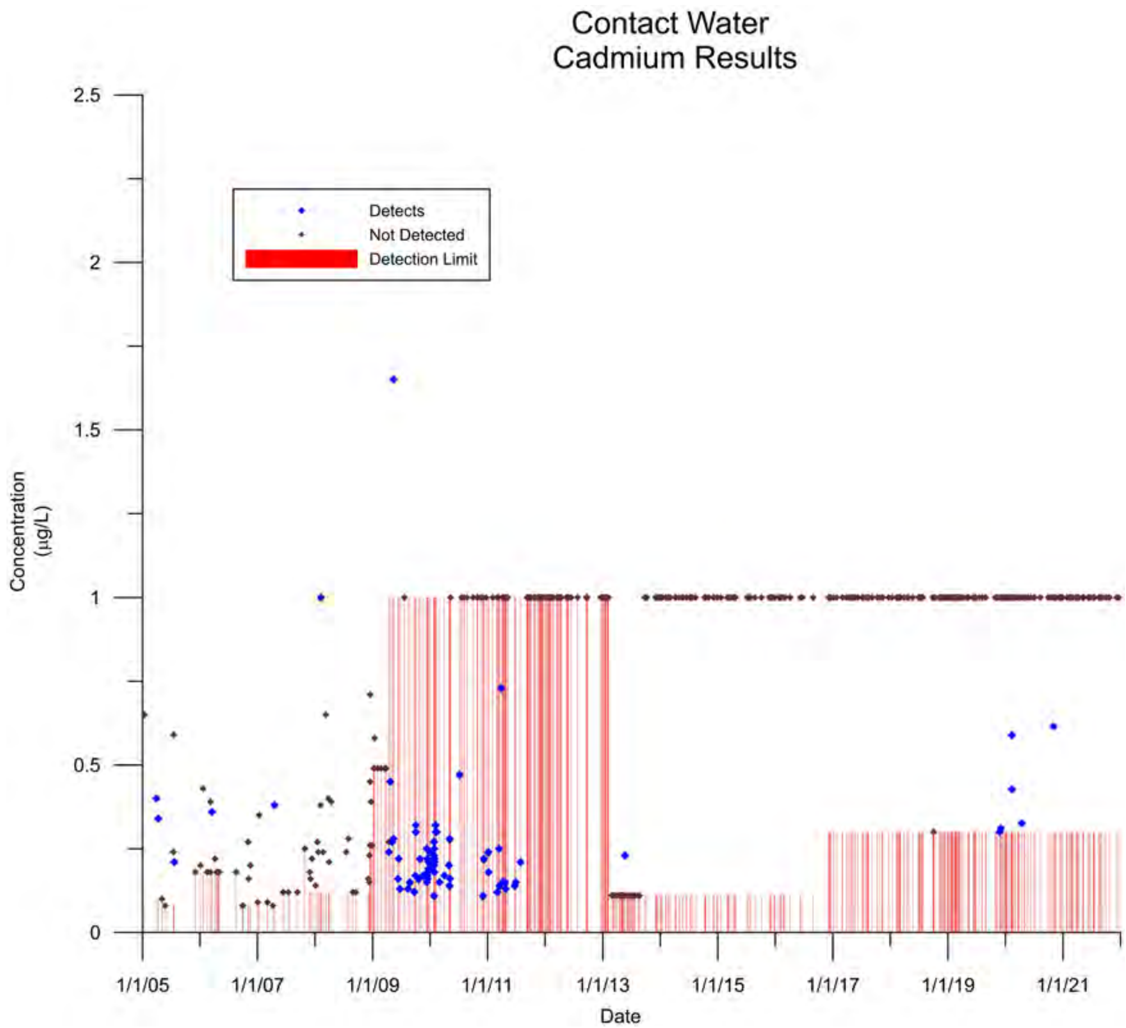
Cadmium was detected in about 20% of the contact water, 8% of the leachate results, and 9% of the results from the V-weir. Leachate typically contains lower cadmium than contact water. There have been no results higher than the CMC, but there are several instances, particularly in 2009, when results were higher than the CCC. The PQL is somewhat higher than the CCC; results occasionally exceed this value. Continuous discharge is not planned for EMWMF. Cadmium treatment is expected if continuous discharge is implemented at EMDF.

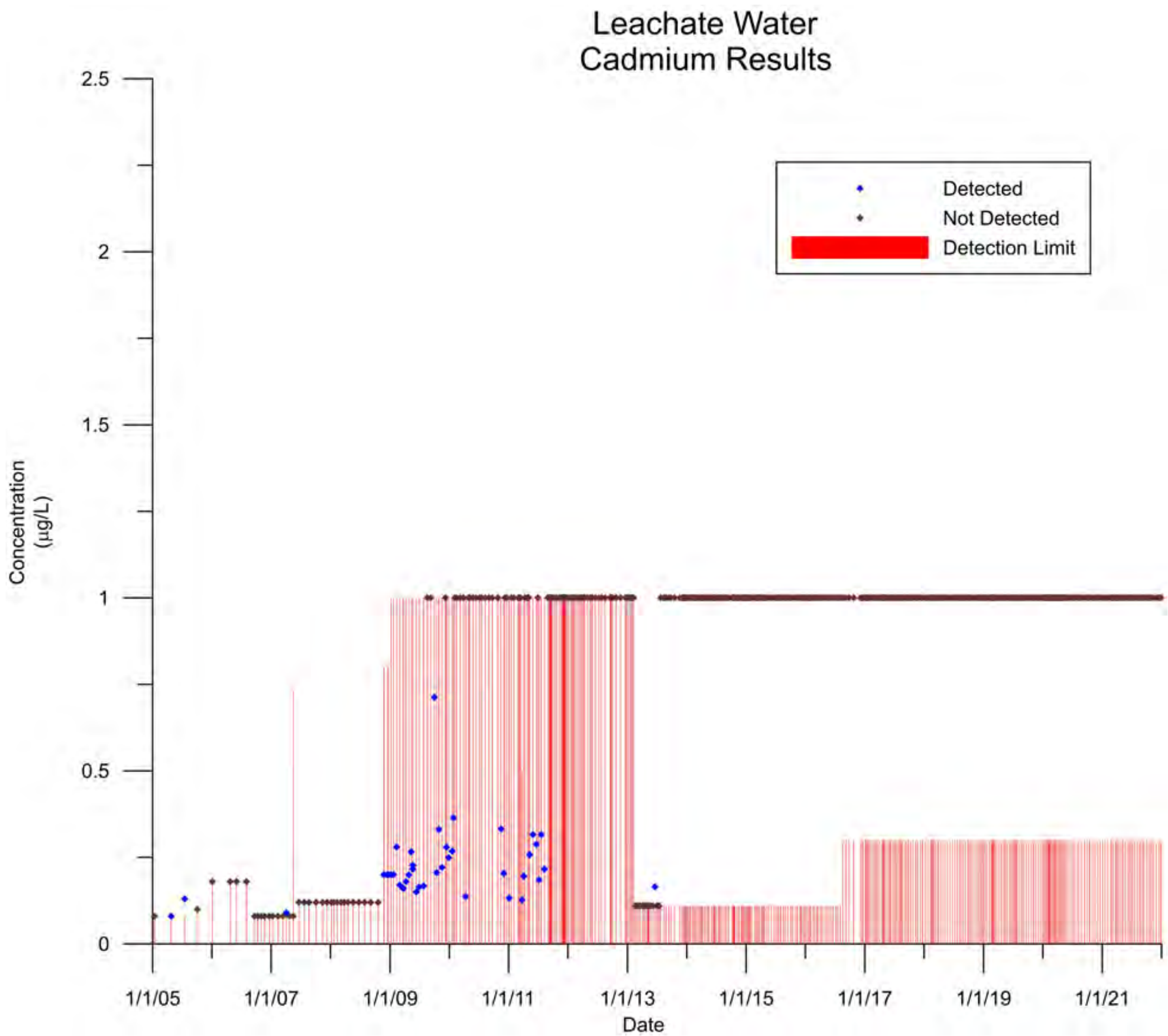
Recreational AWQC – n/a
Hardness corrected CMC – 2.2 ug/L
Hardness corrected CCC – 0.27 ug/L

Cadmium CW summary	No. samples	Detected	Min. detect (ug/L)	Max. detect (ug/L)
Total (unfiltered)	380	73	0.08	1
Dissolved (filtered)	233	36	0.105	1.65
Total	613	109		

CW = contact water

The highest value of 1.65 ug/L was a filtered sample collected on 5/13/2009 from Contact Water Pond (CWP) 2. However, this sample may not be representative of the actual water quality. The next highest sample result was 1.0 ug/L from an unfiltered sample collected from CWP 1 on 2/8/2008, again indicating that the highest result may not be representative of the actual water quality but resulted from suspended sediment in the sample. The filtered sample collected from CWP 2 had a result of 0.28 ug/L. The comparison of filtered vs. unfiltered results does not show a consistent trend. For some pairs, filtered and unfiltered results are the same; for others, the filtered results are slightly higher; and for others, the unfiltered results are slightly higher. However, almost all are in the 0.1 to 0.2 ug/L range.


Contact Water
Cadmium Results
Concentration (µg/L)
Date
Detects
Not Detected
Detection Limit
2.5
2
1.5
1
0.5
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21

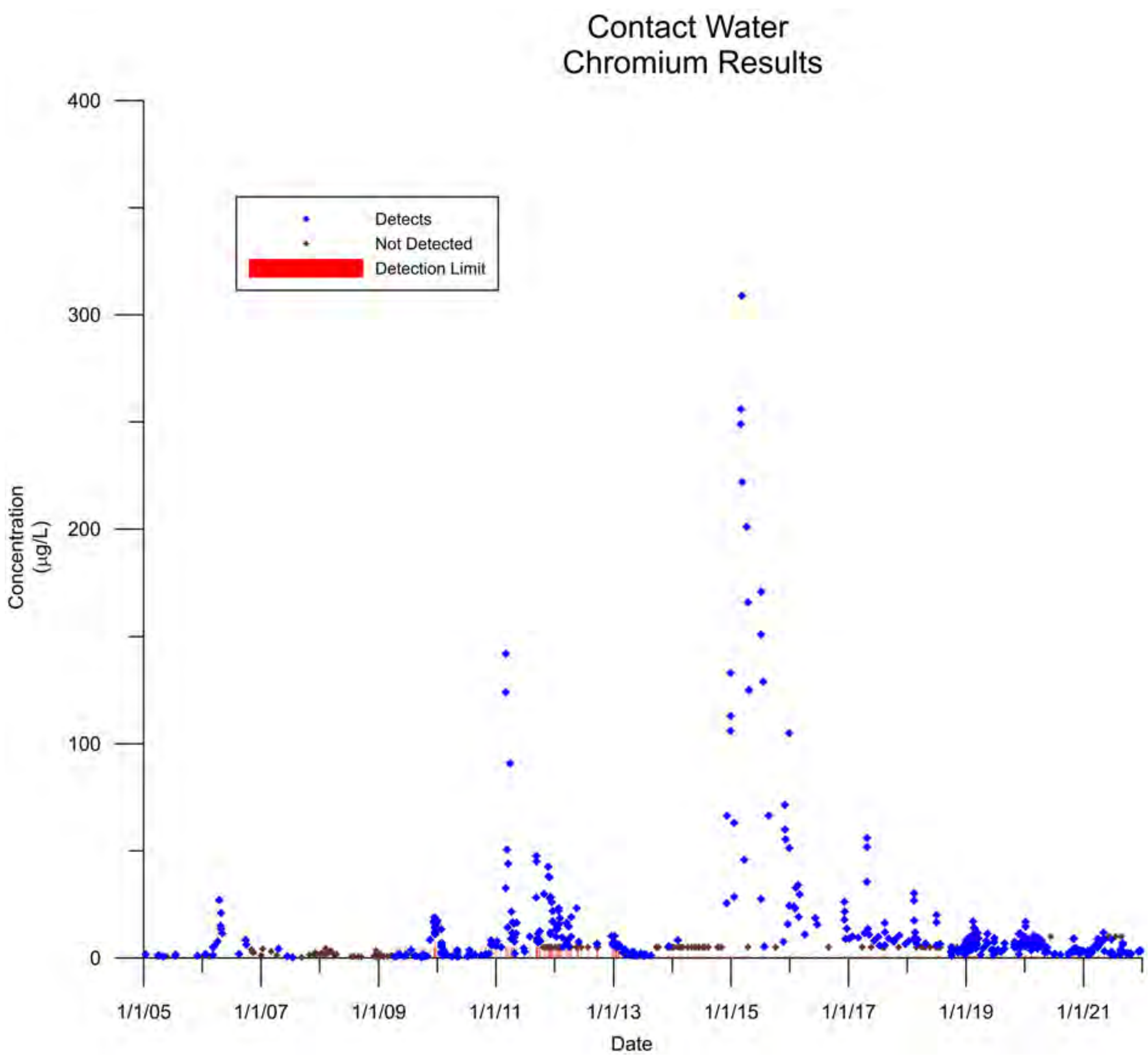


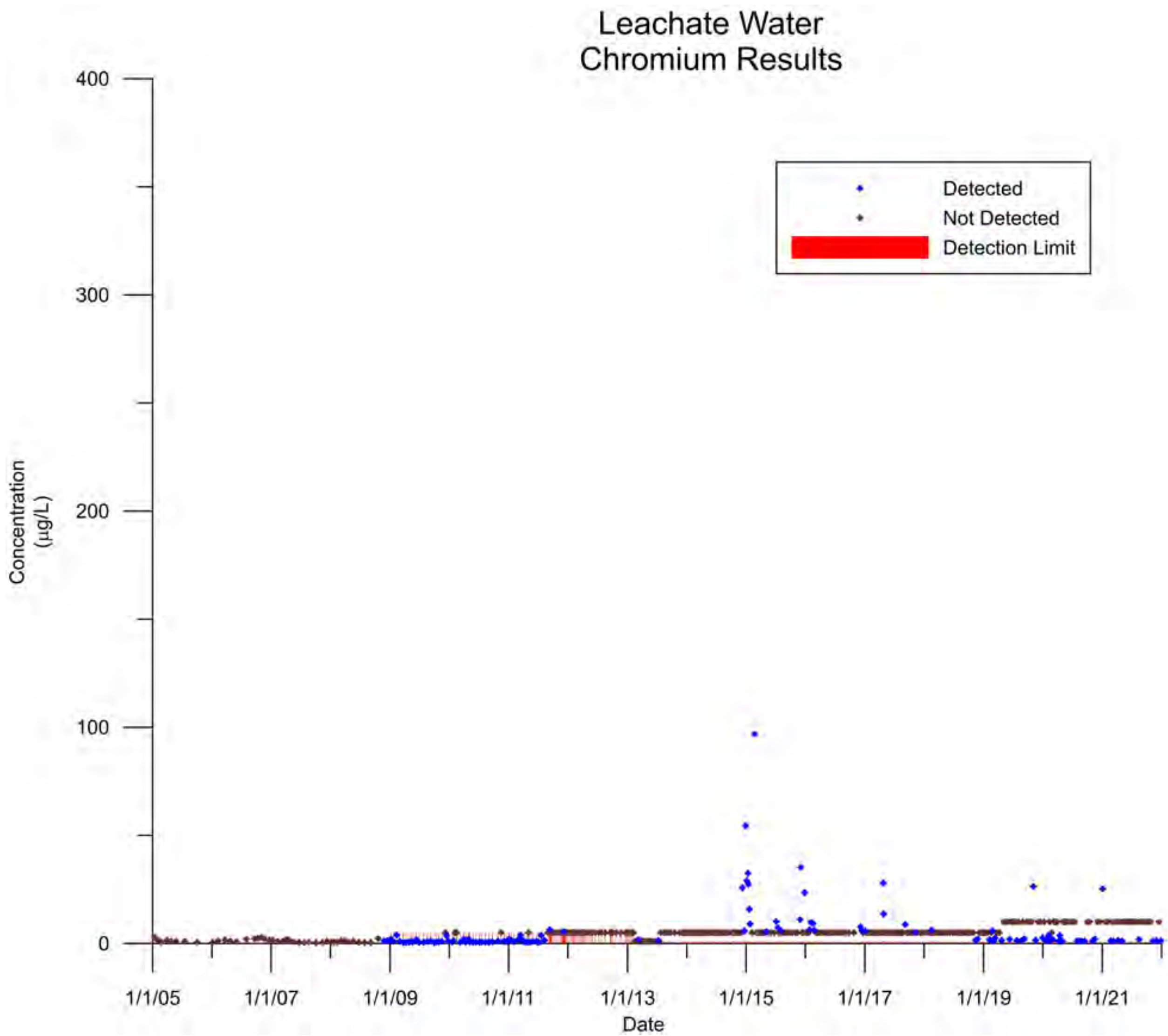
Leachate Water
Cadmium Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
2.5
2
1.5
1
0.5
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Chromium (total)

Historically, about 39% of the V-weir results, 91% of the contact water, and 27% of the leachate results have been detects. Total chrome has not been above the hardness corrected CMC but exceeded the hardness corrected CCC 3 times in March 2011 and 15 times between December 2014 and December 2015.

Recreational AWQC – n/a Hardness corrected CMC – 625 ug/L Hardness corrected CCC – 81 ug/L




Leachate Water
Chromium Results
400
300
200
100
0
Concentration
(µg/L)
Detected
Not Detected
Detection Limit
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

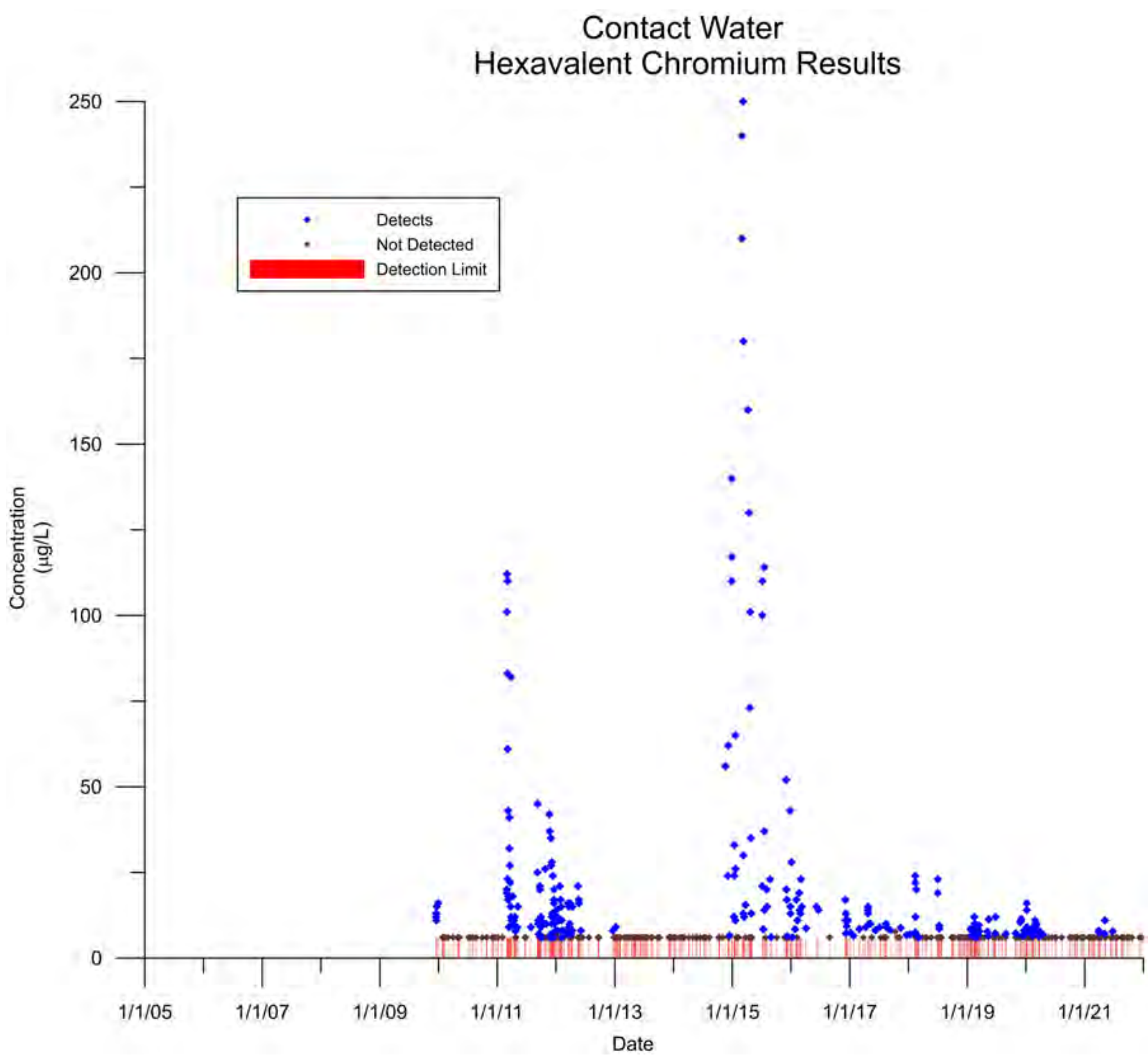
Hexavalent Chrome

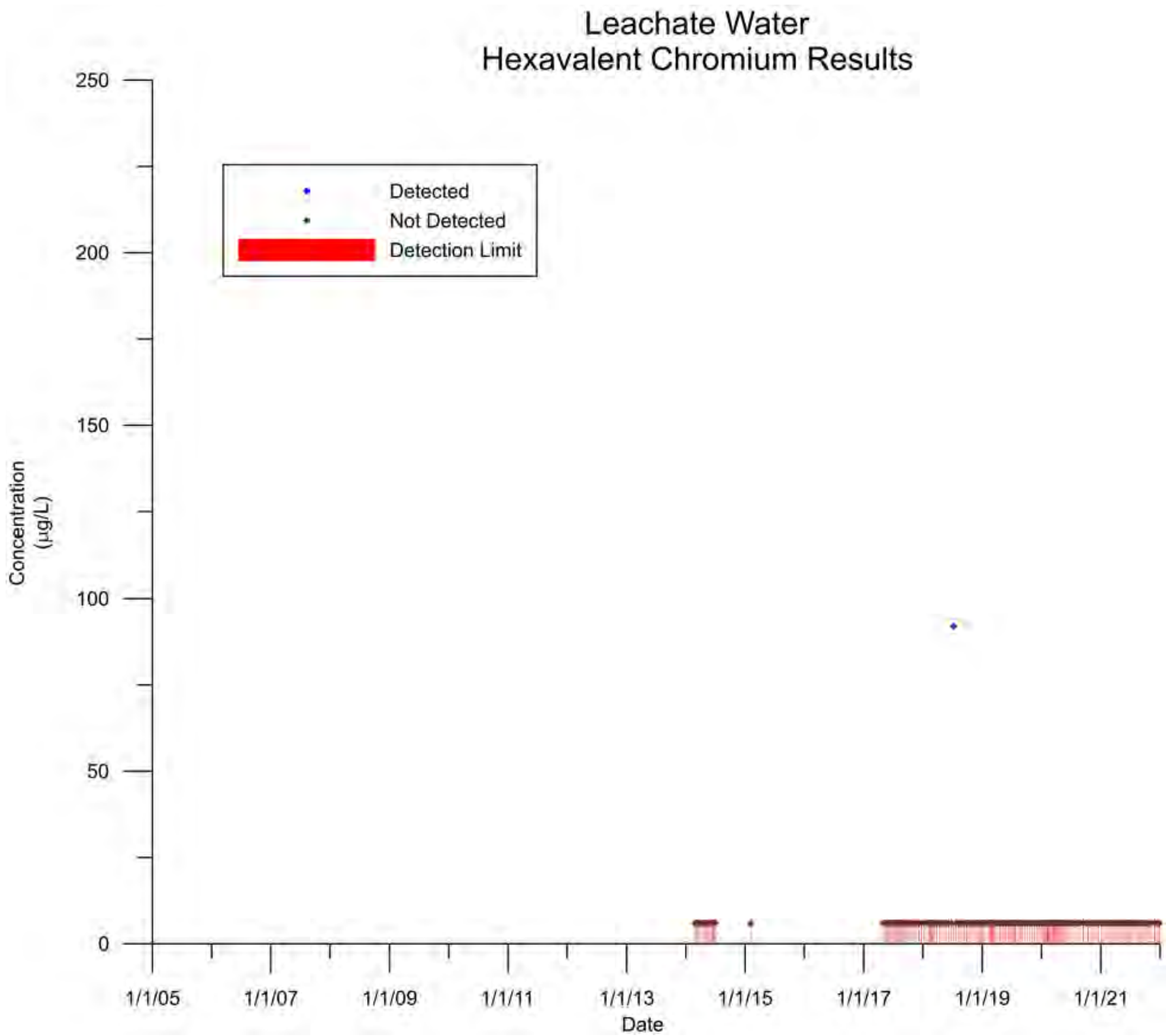
Recreational AWQC – n/a CMC – 16 ug/L CMC – 11

Historically, about 42% of the results have been detects for contact water. Contact water is analyzed for hexavalent chrome (Cr-VI). There are very few analyses from the V-weir or leachate samples, primarily because it is not needed to prove compliance with the Liquid and Gaseous Waste Operations/Process Waste Treatment Complex waste acceptance criteria. V-weir and leachate results, when available, show little to no hexavalent chromium, as anticipated.

As shown in the graph below, hexavalent chrome was an issue in contact water from March 2011 through May 2012, November 2014 through December 2016, and February 2018 through July 2018. Water with Cr-VI results higher than the AWQC of 16 ug/L were retained in the CWPs and tanks; however, the Cr-VI was reduced to levels at or below 16 ug/L prior to release. Additional samples were collected to monitor the reduction and verify water was acceptable for release, resulting in the stair-step pattern on the graph.

The Cr-VI was thought to result from disposal of gaseous diffusion facility debris at EMWMF during this time frame, particularly from cooling tower associated debris. However, the EMWMF operations staff places similar debris in areas that are not impacted by accumulations of contact water to minimize hexavalent chromium impacts, and maintains the capacity to reduce contact water when required.





Leachate Water
Hexavalent Chromium Results
Detected
Not Detected
Detection Limit
Concentration (µg/L)
250
200
150
100
50
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Copper

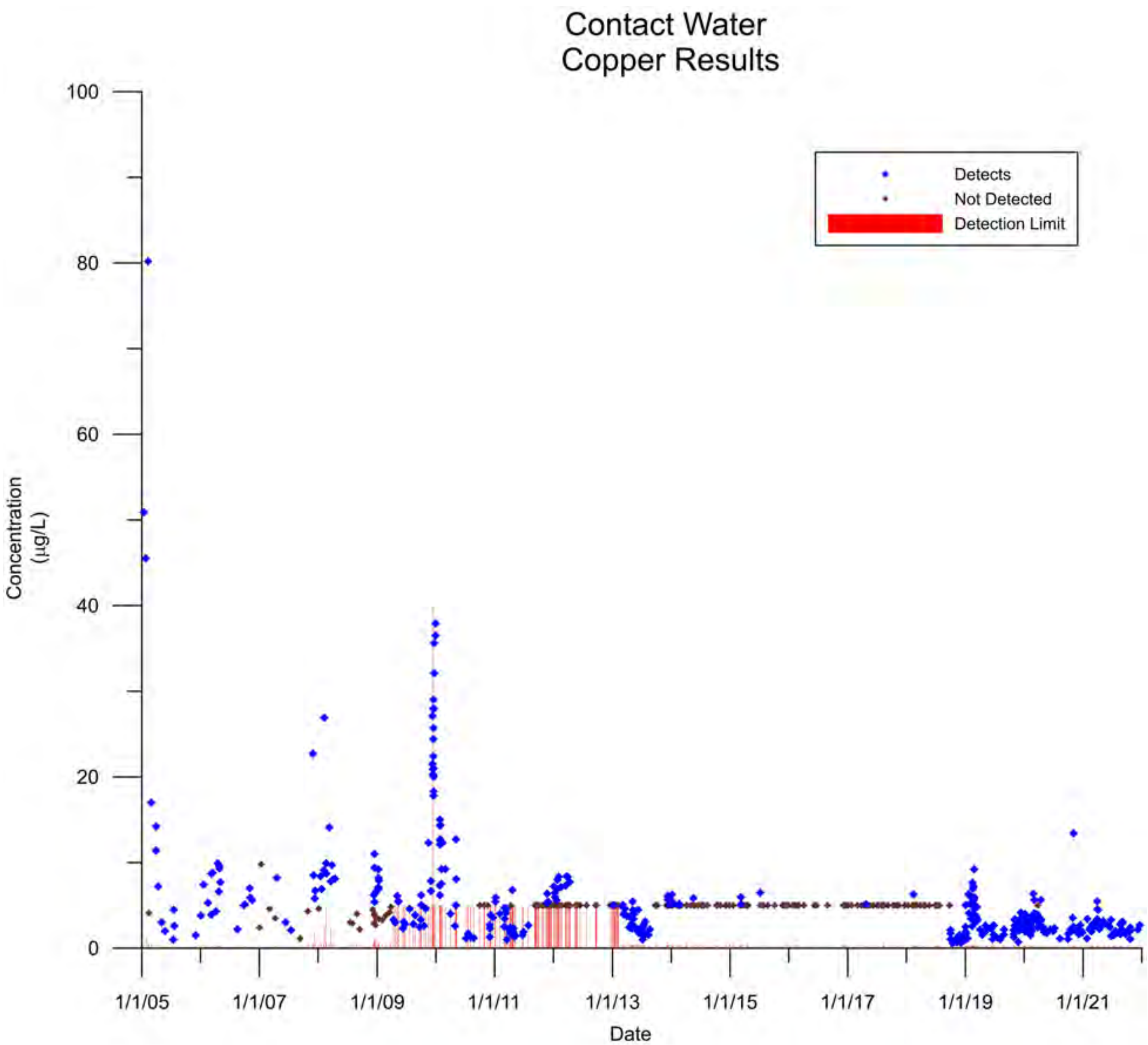
Historically, about 32% of V-weir results and 70% of contact water results, and 48%% of the leachate results in both contact water and leachate have been detects. Higher copper contact water results were more prevalent in the past, with results above the CMC in January to March 2005, November 2007, February 2008, and December 2009. Since that time, there have been no results above the CMC.

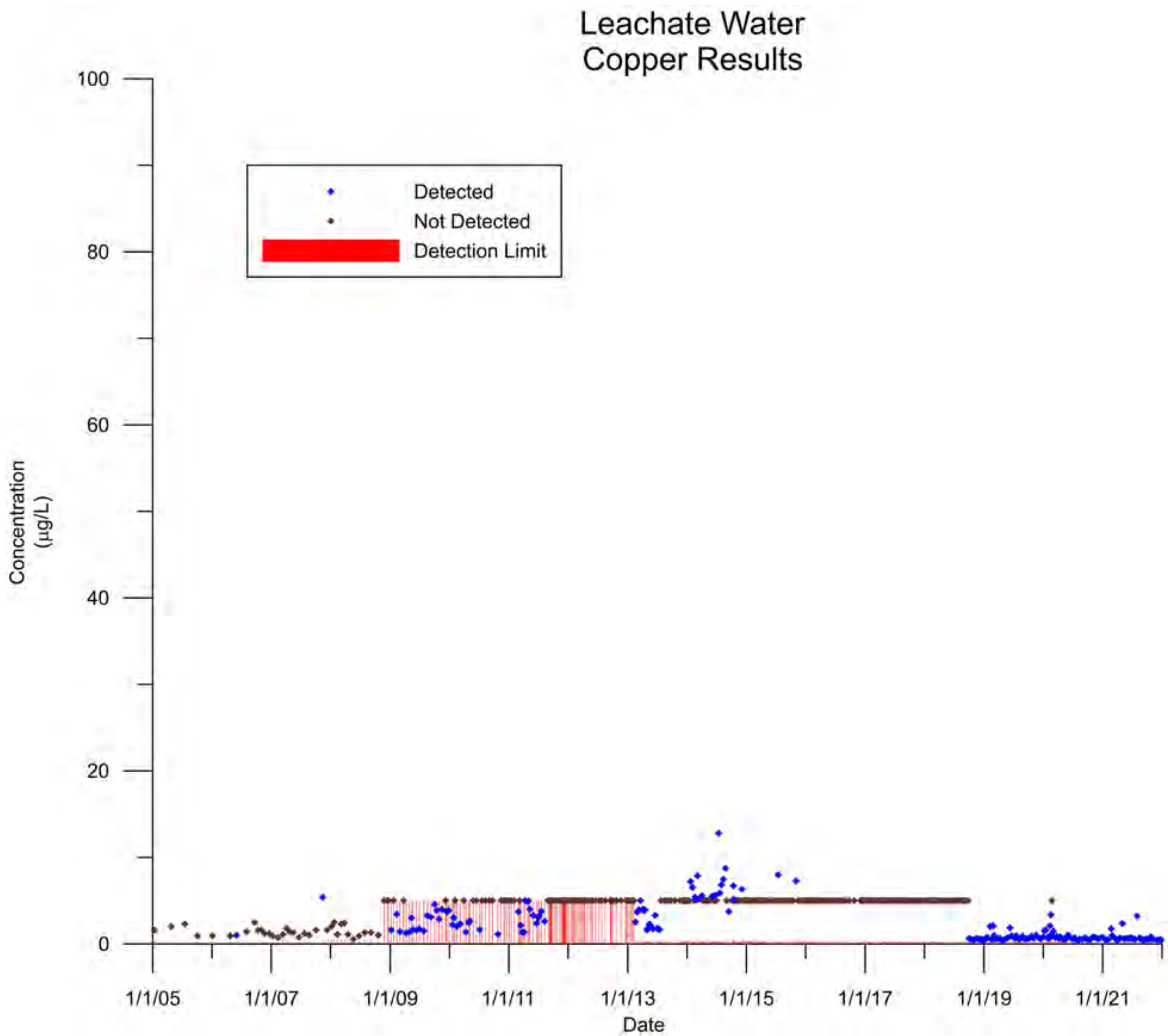
Recreational AWQC – n/a
Hardness corrected CMC – 15 ug/L
Hardness corrected CCC – 9.9 ug/L

Copper CW Summary	No. Samples	Detected	Min. detect (ug/L)	Max. detect (ug/L)
Total (unfiltered)	431	303	0.57	80.2
Dissolved (filtered)	236	121	1	36.5
Total	667	424		

CW = contact water

Leachate contains lower concentrations of copper than contact water. The highest result was 12.8 on July 14, 2014. This value was below the CMC, but exceeded the CCC. There was no corresponding increase in contact water. Potential copper treatment was considered for the EMDF LWTS preliminary design.



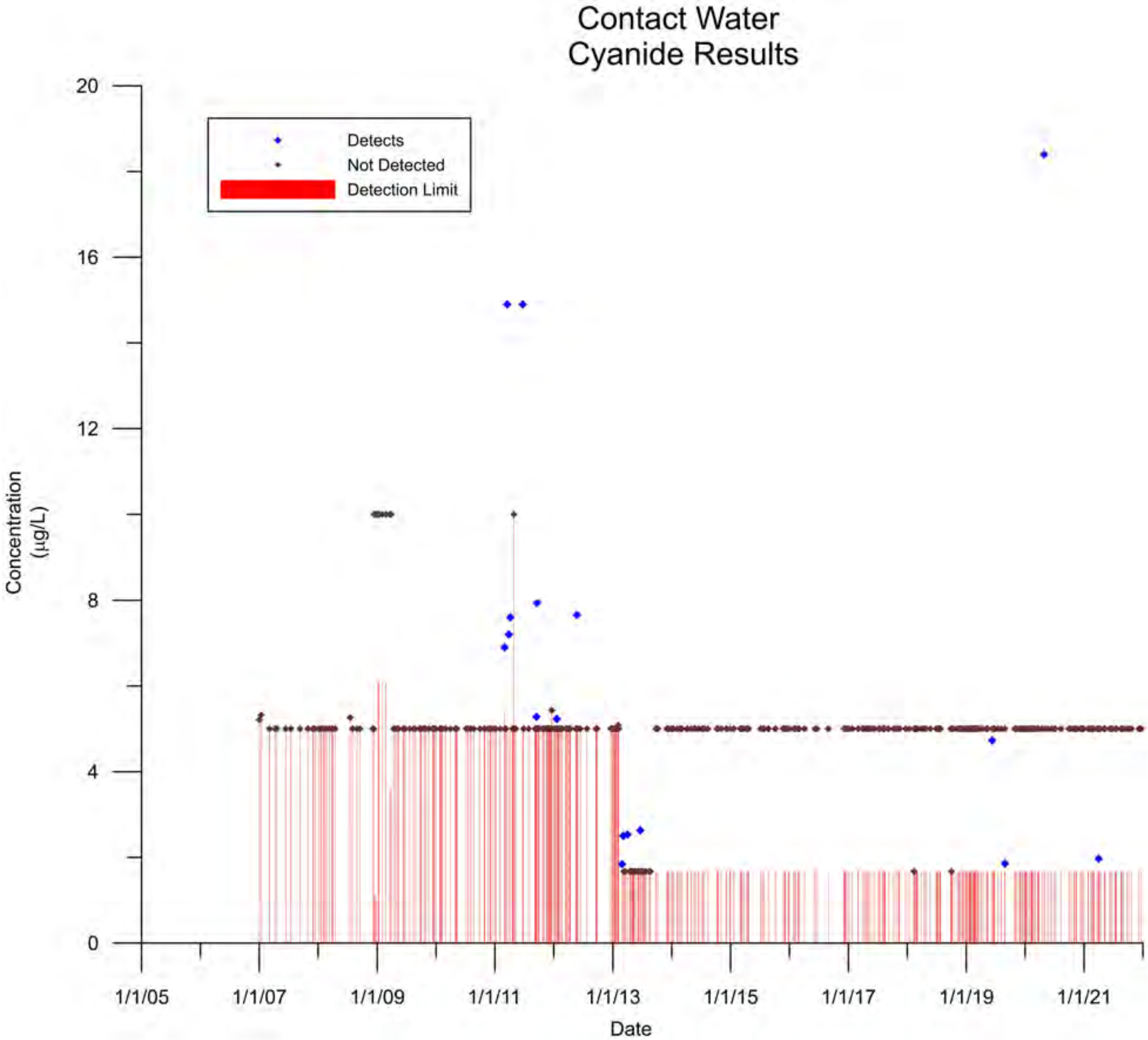


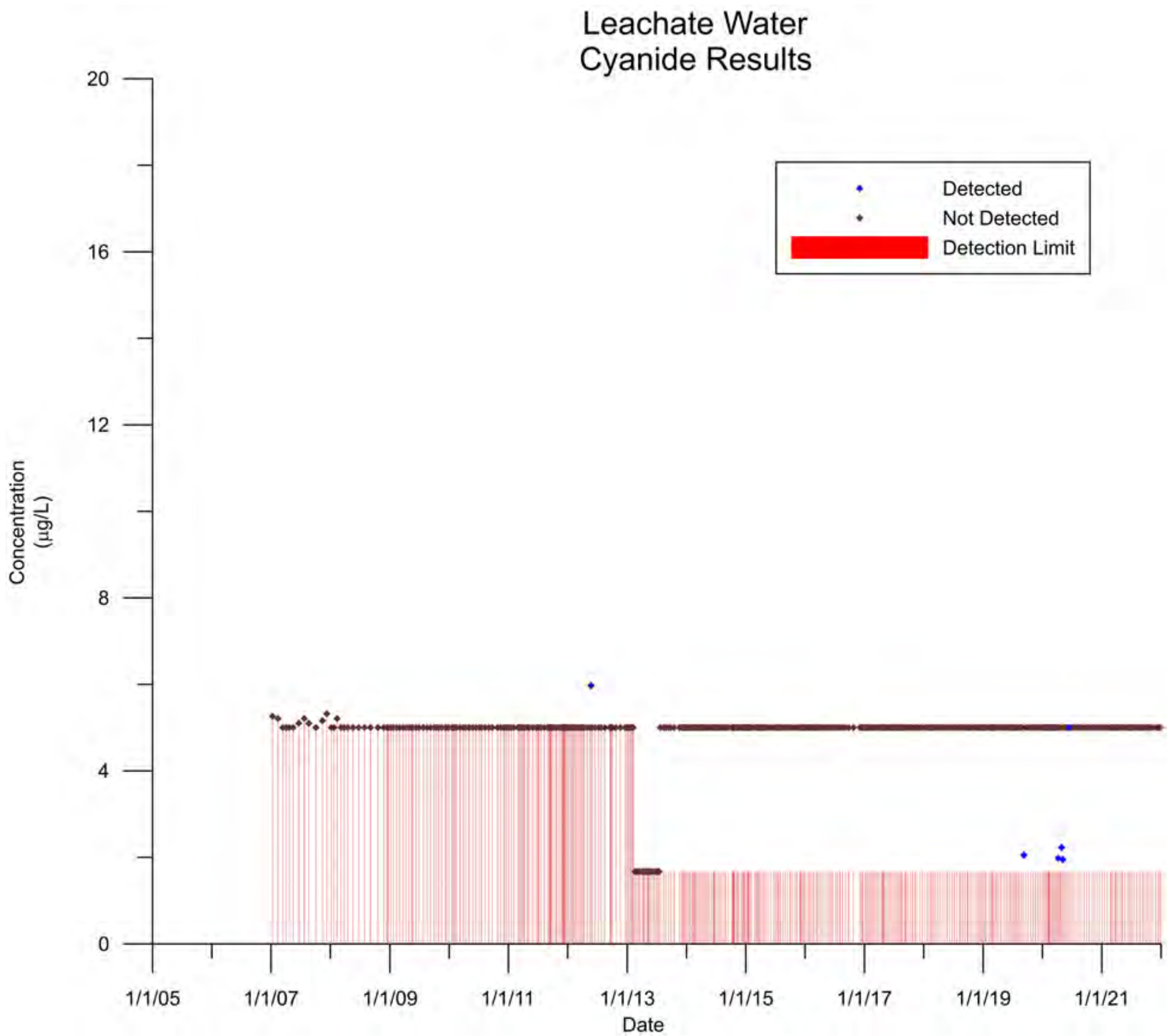
Leachate Water
Copper Results
100
80
60
40
20
0
Concentration
(µg/L)
Detected
Not Detected
Detection Limit
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Cyanide

Historically, about 1 to 3% of the results in contact water and leachate have been detects. Results are well below the CMC. Most results have been below detection limits, but there several results above the CCC during the period March 2011 to September 2011. One additional result exceeded the CCC in May 2012. The potential for cyanide treatment was considered for the EMDF LWTS if continuous discharge is implemented.

Recreational AWQC – 140 ug/L
CMC – 22 ug/L
CCC – 5.2 ug/L



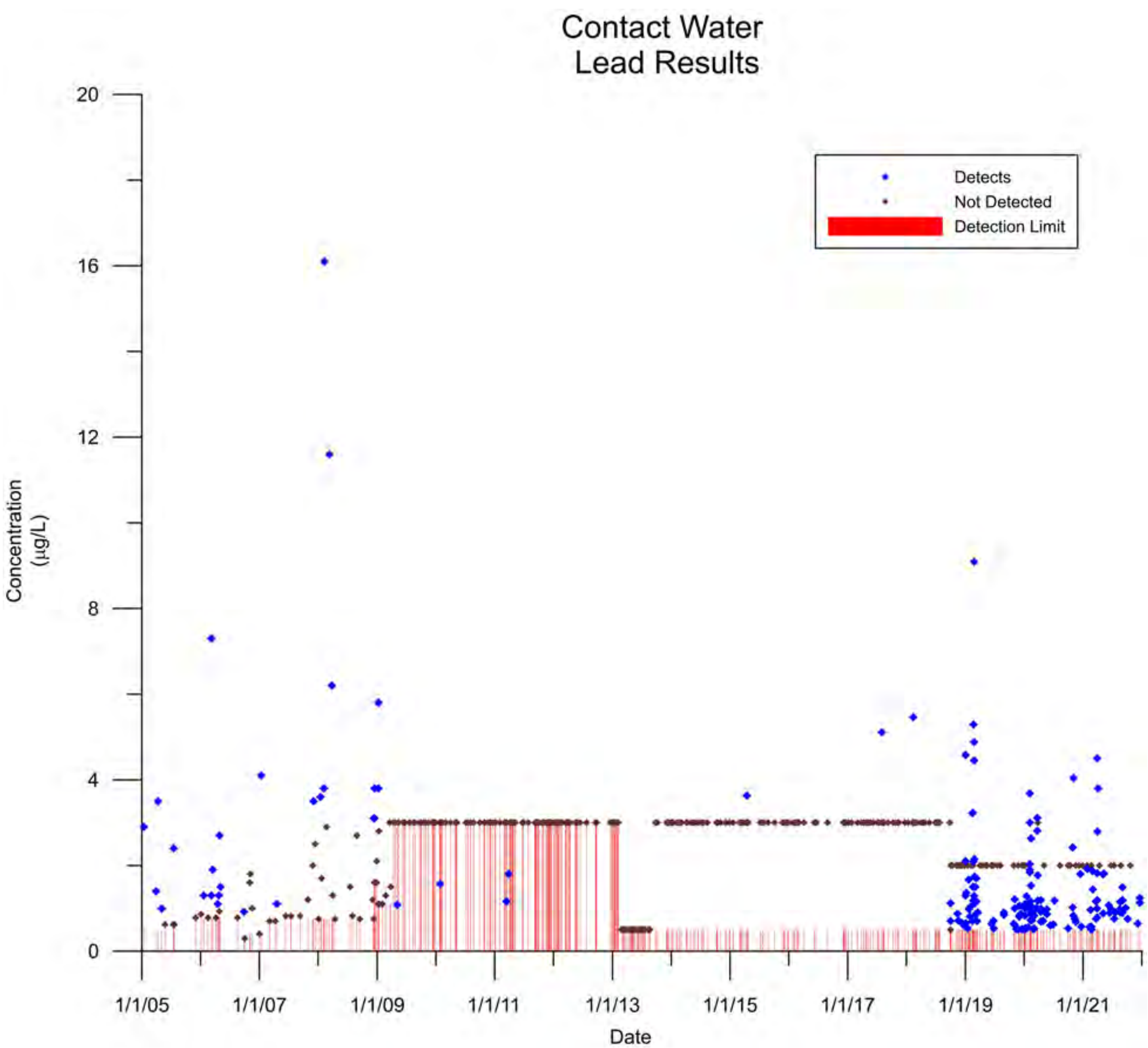

Leachate Water
Cyanide Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
20
16
12
8
4
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

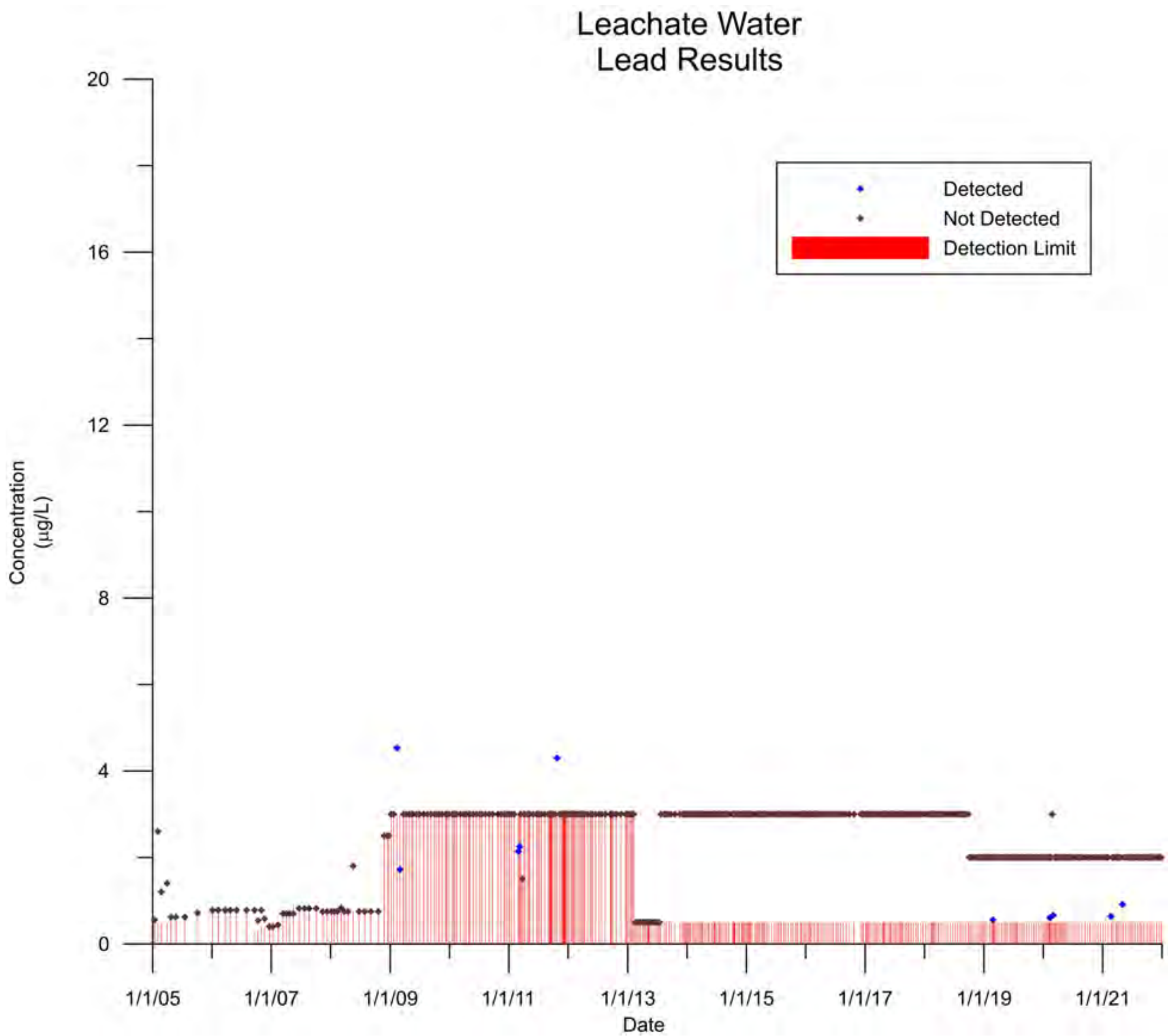
Lead

Historically, about 30% of the results at the V-weir, 51% of contact water, and 5% of leachate have been detects. Results are below the CMC, but several have been above the CCC in the past. The highest contact water results were in February and March 2008.

Recreational AWQC – n/a
Hardness corrected CMC – 73 ug/L
Hardness corrected CCC – 2.8 ug/L

Since March 2009, no detected result has been above the CCC, although the detection limit was usually set at 3 ug/l. However, the lack of results above 3 ug/L and lack of results above the lower detection limits in early 2013 demonstrate that recent contact water met the hardness corrected CCC. The highest leachate value was 4.53 in February 2009, which is above the CCC. The potential for lead treatment was considered for the EMDF LWTS if continuous discharge is implemented.





Leachate Water
Lead Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
20
16
12
8
4
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Mercury

Historically, about 11% of the results at the V-weir, 59% of contact water, and 27% of leachate have been detects. Results are below the CMC, but several have been above the CCC in the past. The highest contact water results were in February and March 2008.

Recreational AWQC – 0.051 ug/L
CMC – 1.4 ug/L
CCC – 0.77 ug/L

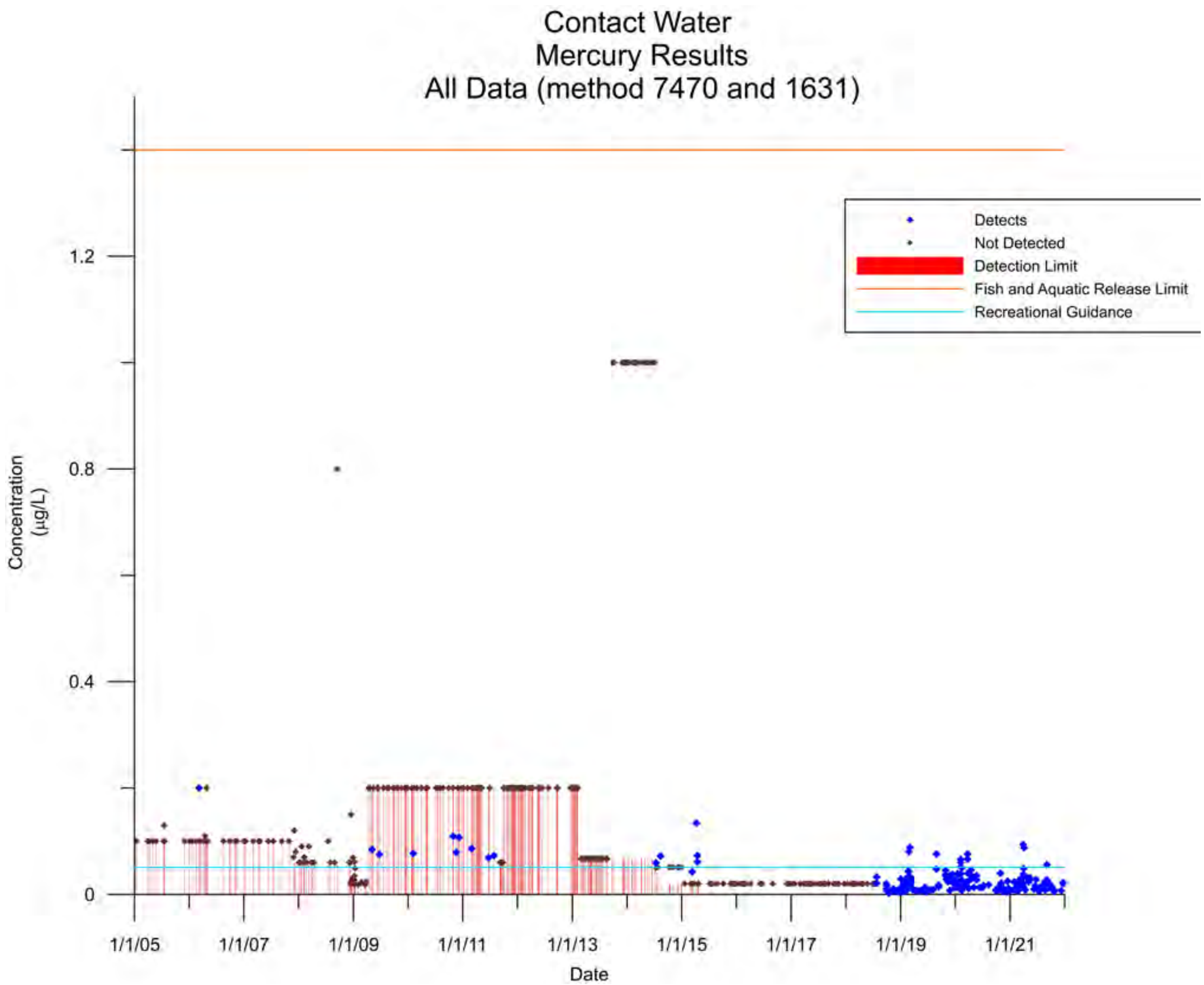
Mercury CW Summary	No. Samples	Detected	Min. detect (ug/L)	Max. detect (ug/L)
Total (unfiltered)	399	234	0.002	0.8
Dissolved (filtered)	218	11	0.02	0.109
Total	617	245		

CW = contact water

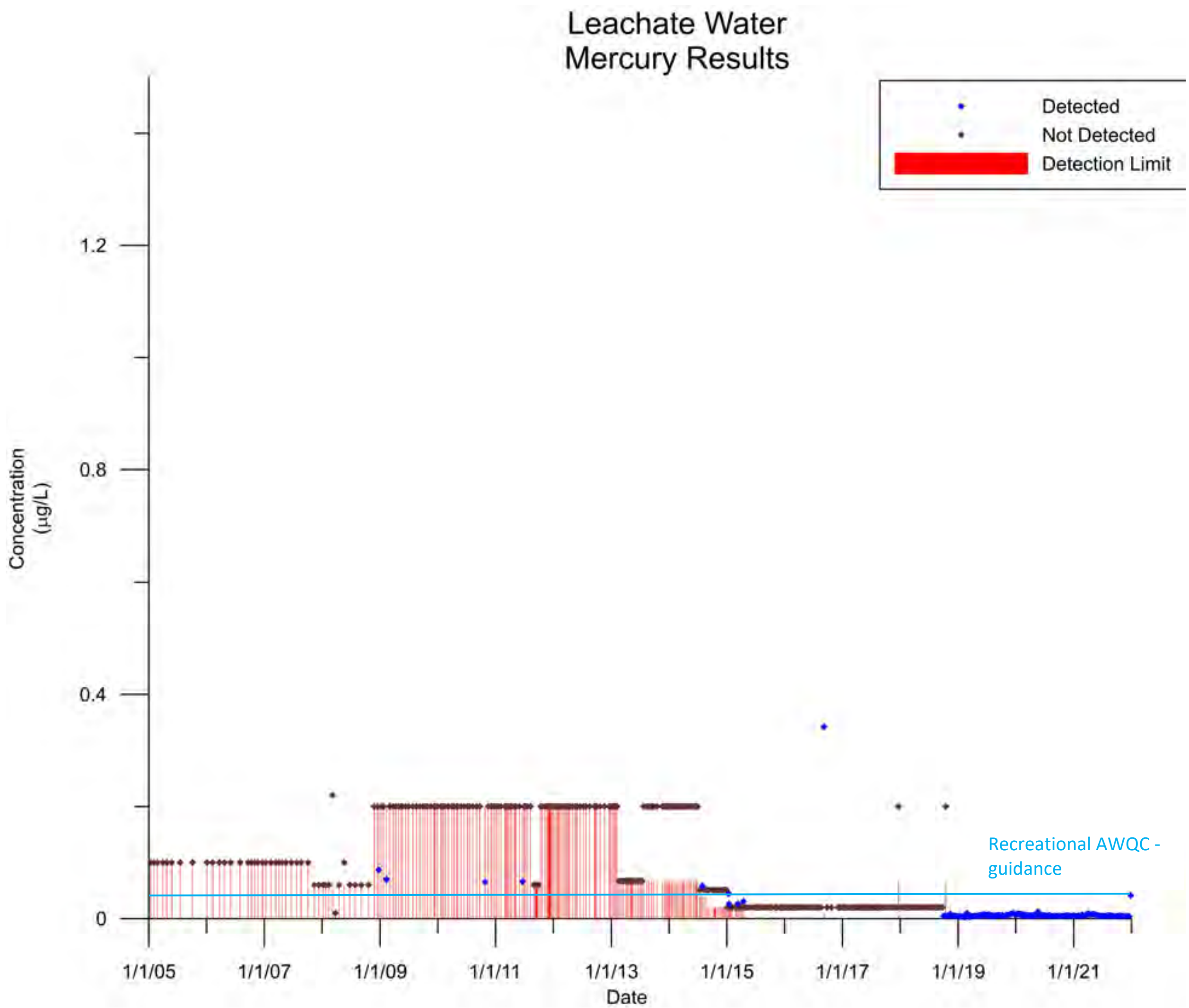
Because the recreational AWQC was not a discharge criterion, prior to 2015, the detection limit was not low enough to determine if the recreational AWQC was met. As shown on the graphs below, the detection limit for contact water was lowered beginning around 2015. Since the detection limit was lowered, results demonstrate that the recreational AWQC is typically achieved. The percent detected has increased as the detection limit was lowered, as expected.

The highest detected result was 0.8 on Sept 15, 2008. This result was BN qualified, indicating mercury was found in both the blank and the sample (B), and that the matrix spike recovery was not within control limits (N). The result may not be accurate. While reporting limits were set at 1 ug/L from September 2009 through July 2014, mercury was not detected at its detection limit of 0.067 ug/L during this time period.

The results from filtered and unfiltered pairs show filtered sample results are generally slightly less than the total sample results. This indicates that mercury is present in both the dissolved and undissolved state. Mercury treatment is expected to be required because of the low recreational AWQC and because the EMDF is expected to receive more mercury-contaminated waste.



Contact Water
Mercury Results
All Data (method 7470 and 1631)
Detects
Not Detected
Detection Limit
Fish and Aquatic Release Limit
Recreational Guidance
1.2
0.8
0.4
0
Concentration (µg/L)
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

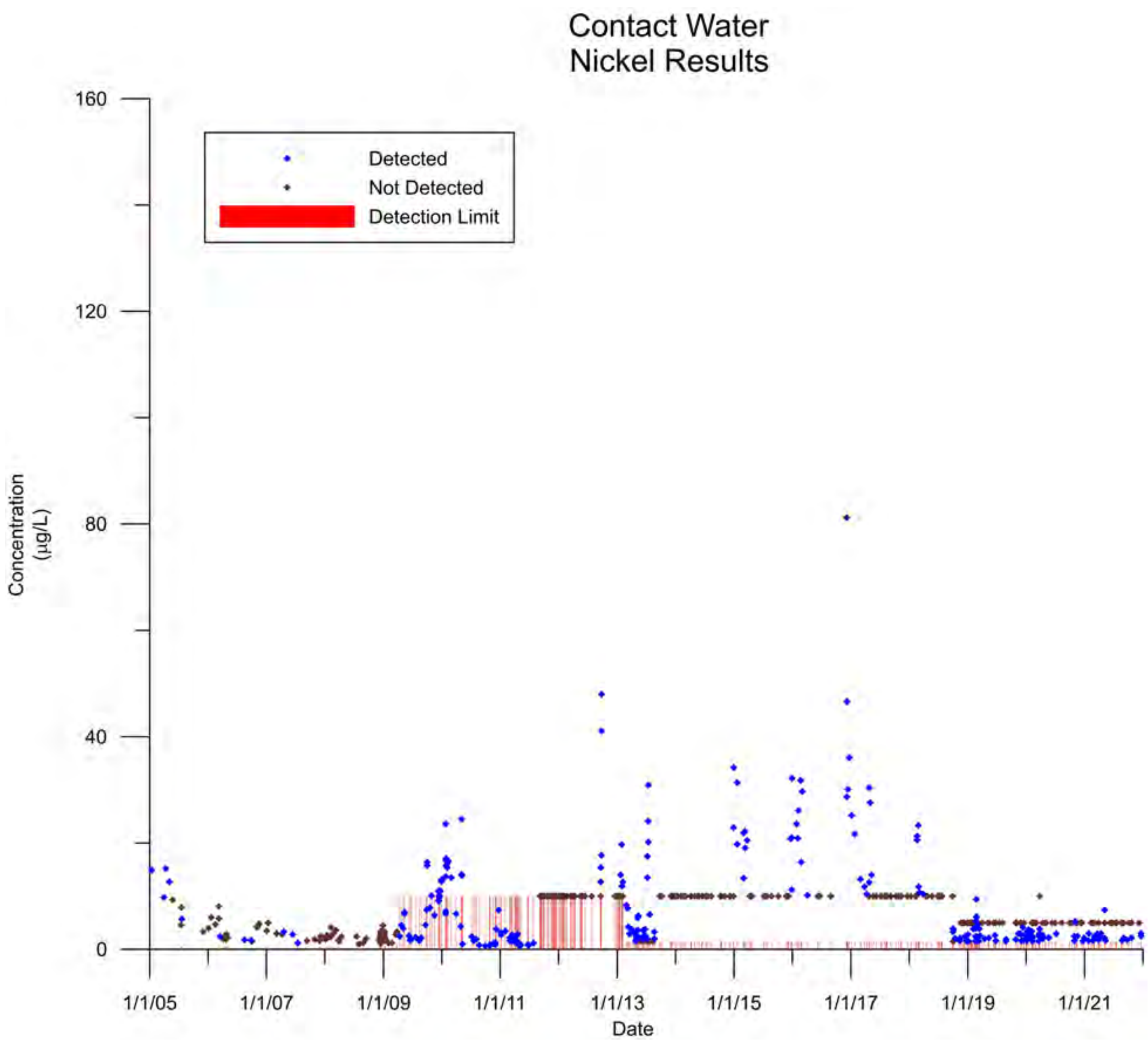


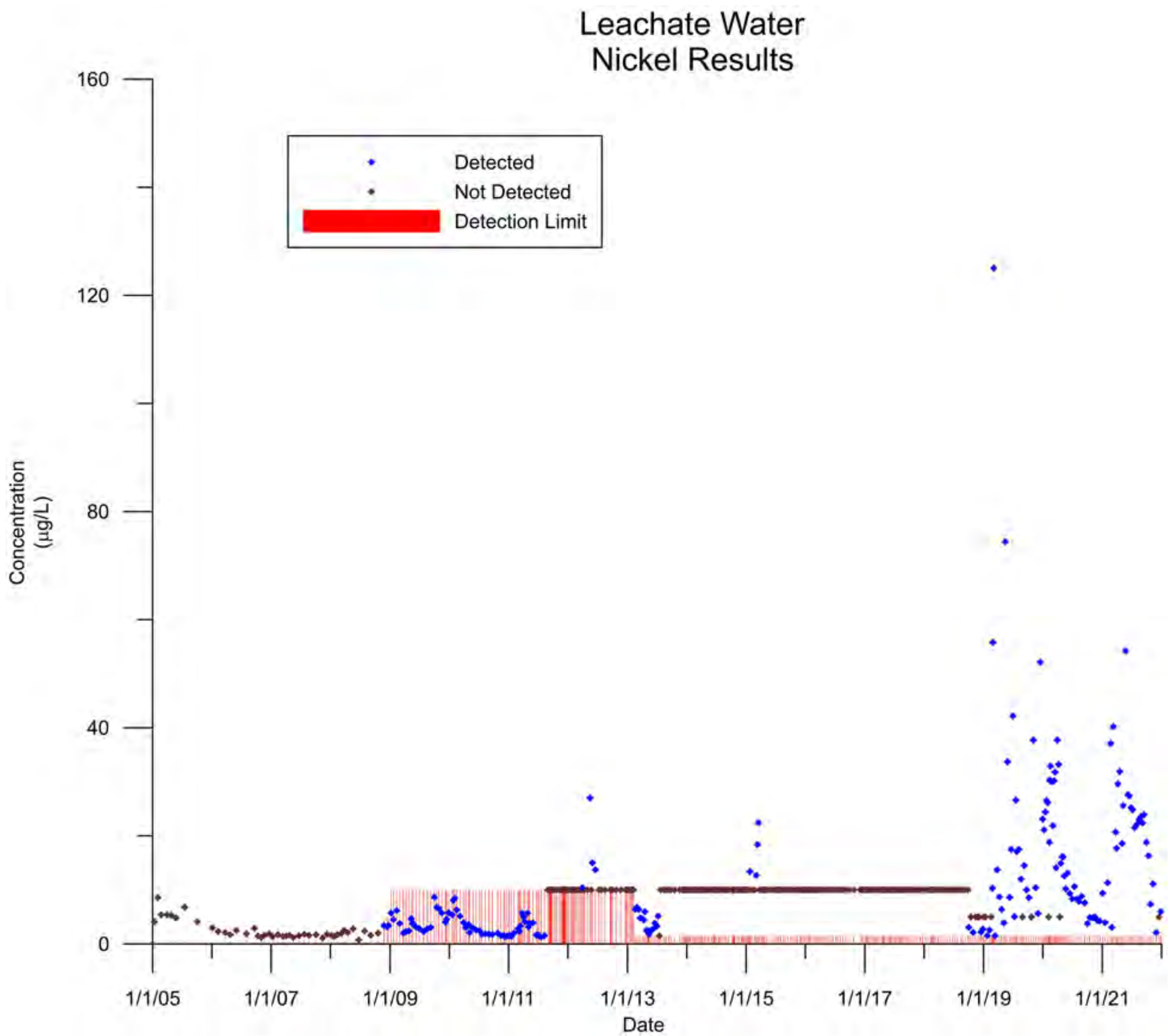
Leachate Water
Mercury Results
Detected
Not Detected
Detection Limit
Concentration (µg/L)
1.2
0.8
0.4
0
Recreational AWQC - guidance
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Nickel

Historically, about 36% of the V-weir results, 60% of the contact water results, and 48% of the leachate results have been detects. Results are well below the CMC and CCC. The highest result in contact water (81 ug/L) was on December 5, 2016. No other contact water results exceeded the CCC. There we two results in leachate above the CCC—125 ug/L (3/5/2019) and 74 ug/L (5/15/2019).

Recreational AWQC – 4600 ug/L
Hardness corrected CMC – 515 ug/L
Hardness corrected CCC – 57 ug/L

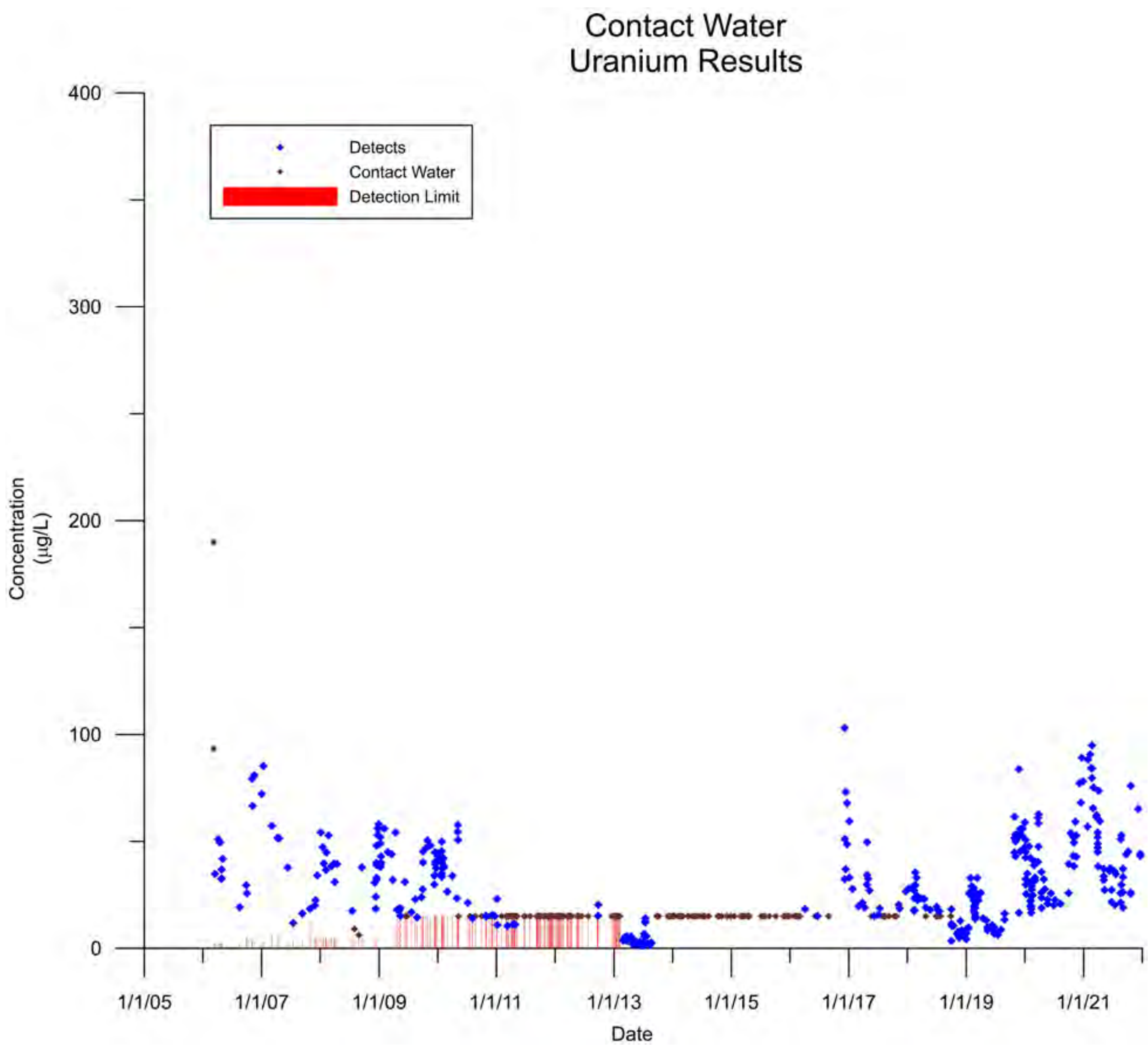


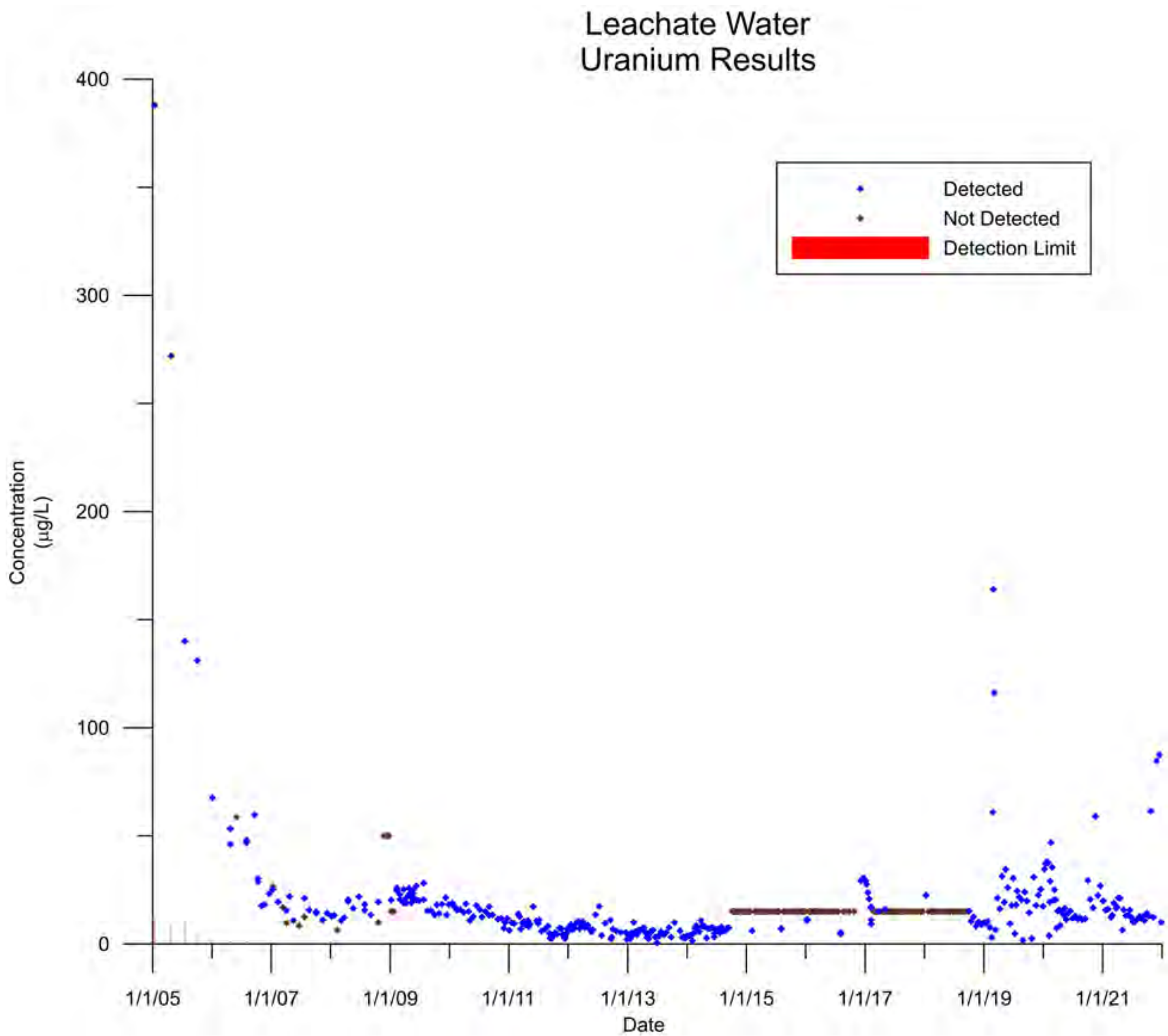


Leachate Water
Nickel Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
160
120
80
40
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Uranium

Release criteria are established for the uranium radionuclides present within EMWMF waste, but not for uranium as a metal. Total uranium is monitored in conjunction with the radionuclide analyses to show trends. There were higher levels of total uranium in the leachate early in the EMWMF history, followed by a declining trend with lower results from 2007 to 2017, then another increasing trend. A similar trend can be observed in the contact water data. Total uranium concentrations in leachate and contact water are expected to decline again now that decontamination and demolition of the ETTP/Heritage Center buildings is nearly complete.



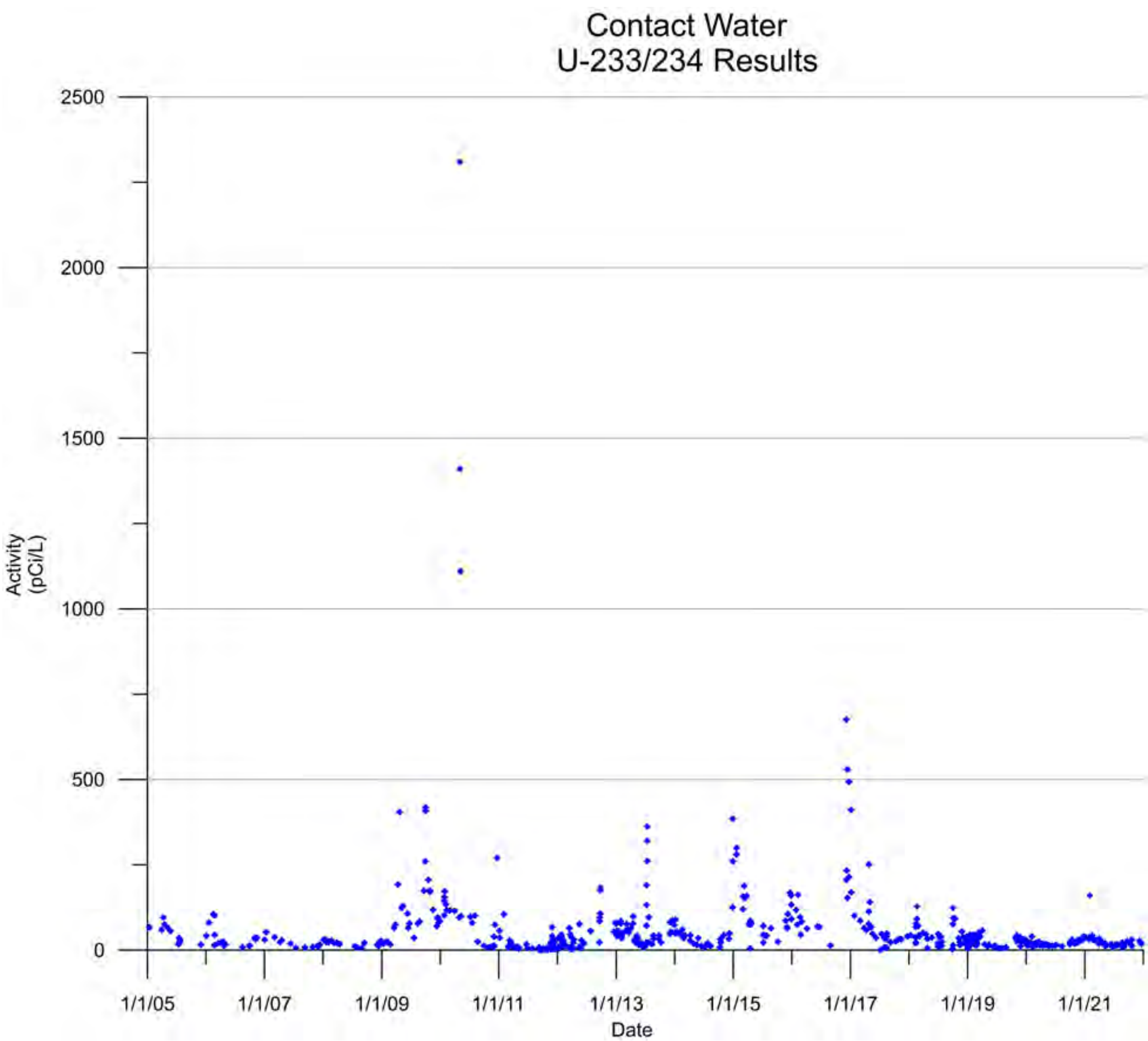

Leachate Water
Uranium Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
400
300
200
100
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

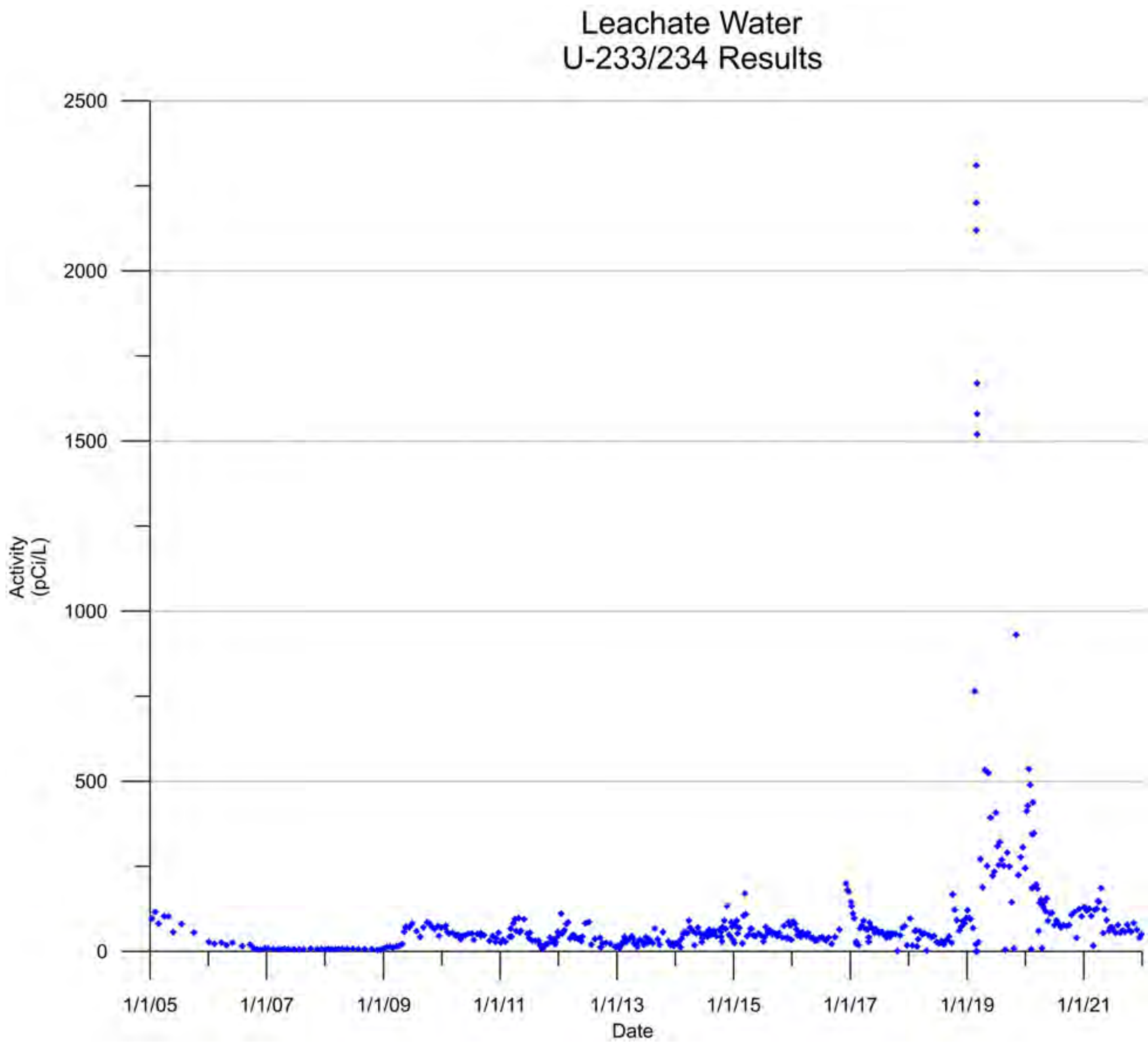
U-233/234

U-233/234 is detected in almost all samples from the V-weir, contact water, and leachate. There was one result above the criterion at the V-weir in January 2017. There were 6 results above the release decision criterion in contact water and 8 above the release decision criterion in leachate. The spike in leachate concentrations in the winter of 2019 was immediately investigated and mitigated.

Current criterion – 480 pCi/L for contact water release decisions 120 pCi/L at the V-weir based on a trailing annual average

The potential for U-233/234 treatment was considered for the EMDF LWTS.



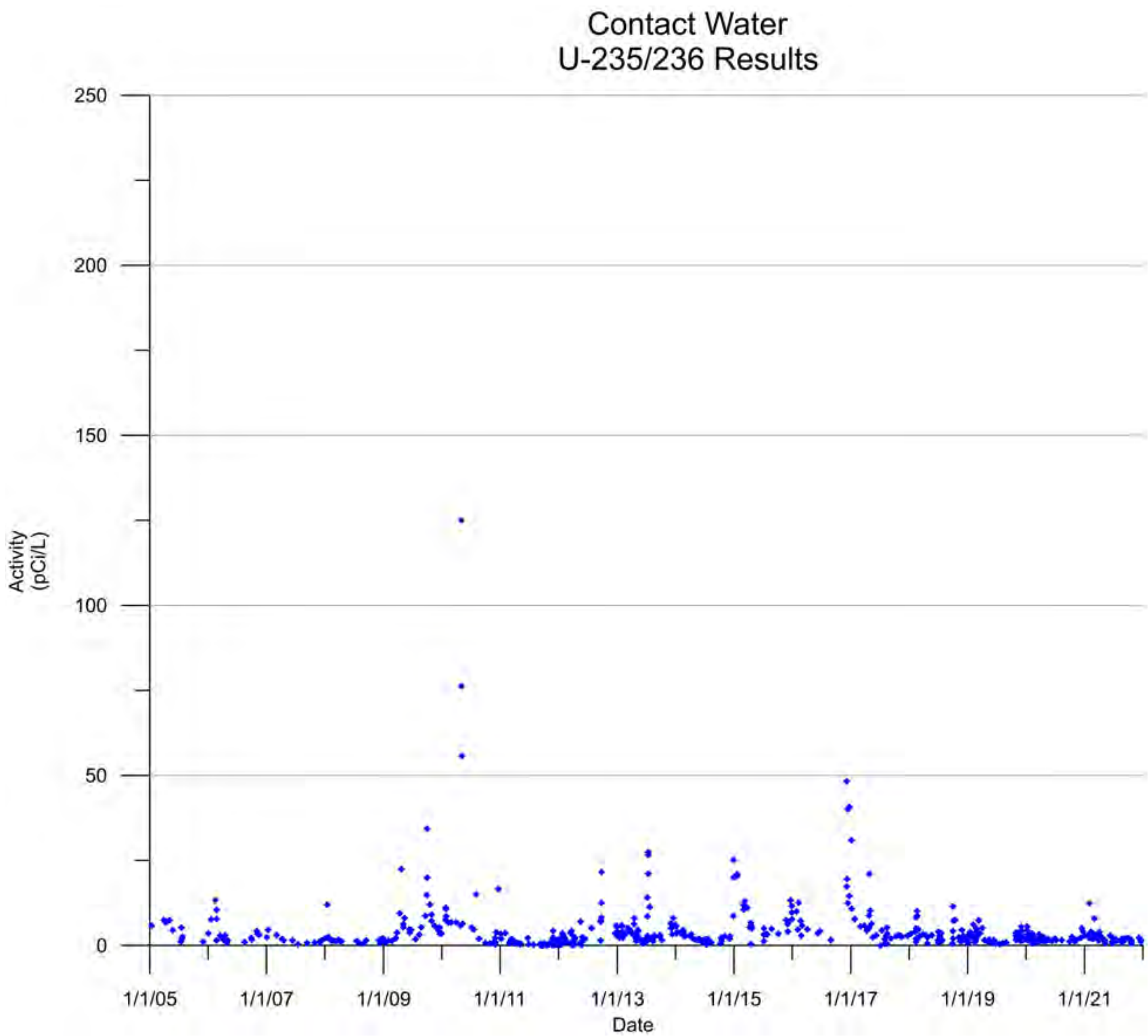


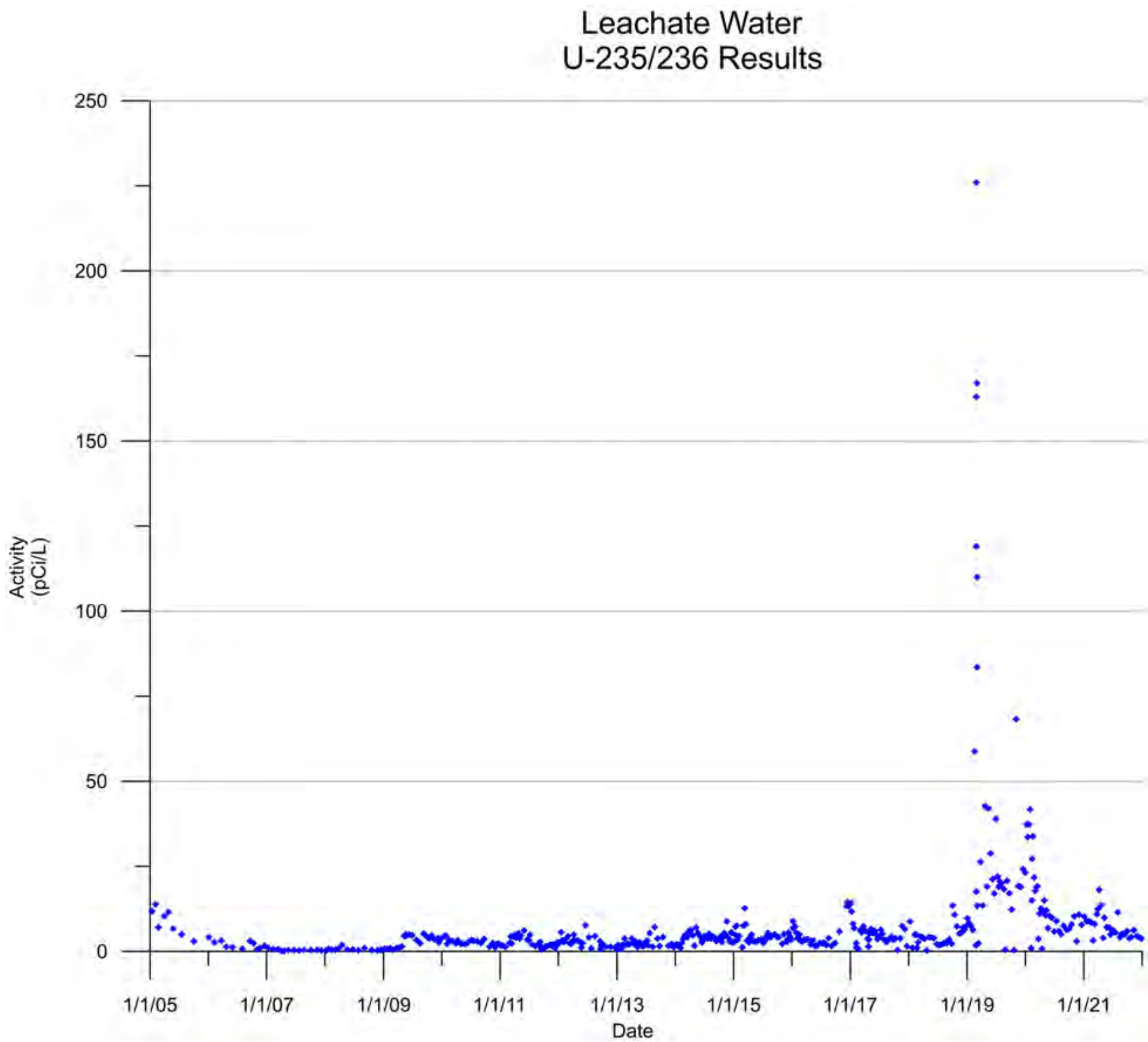
Leachate Water
U-233/234 Results
2500
2000
1500
1000
500
0
Activity
(pCi/L)
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

U-235/236

U-235/236 is detected in about 74% of the V-weir samples and in almost all samples from the contact water and leachate. There were no results above the criterion at the V-weir. There have been no results above the release decision criterion in contact water or leachate. As with the U-233/234 leachate results, the spike in leachate concentrations in the winter of 2019 was immediately investigated and mitigated.

Current criterion –
480 pCi/L for contact water release decisions
120 pCi/L at the V-weir based on a trailing annual average



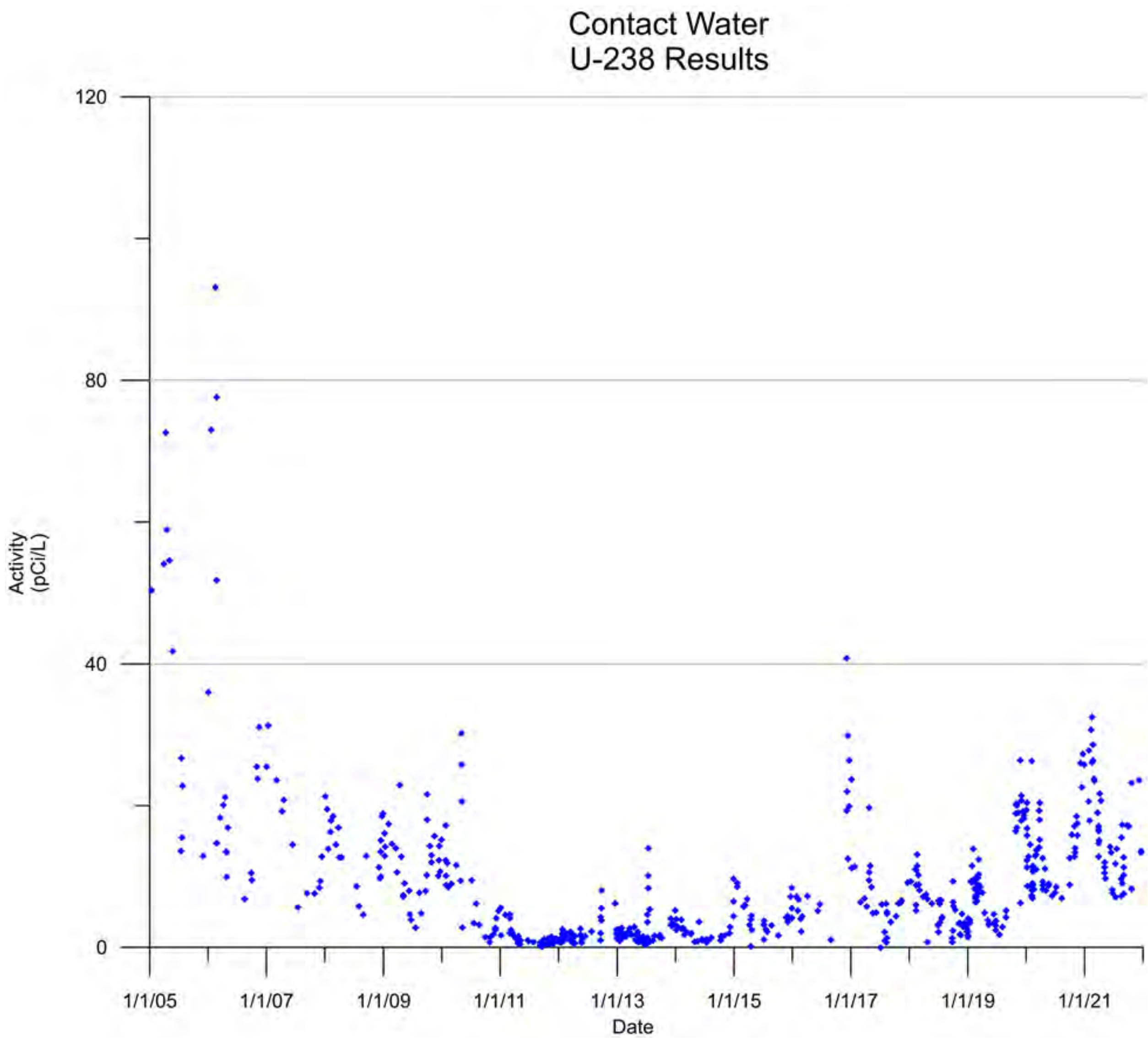


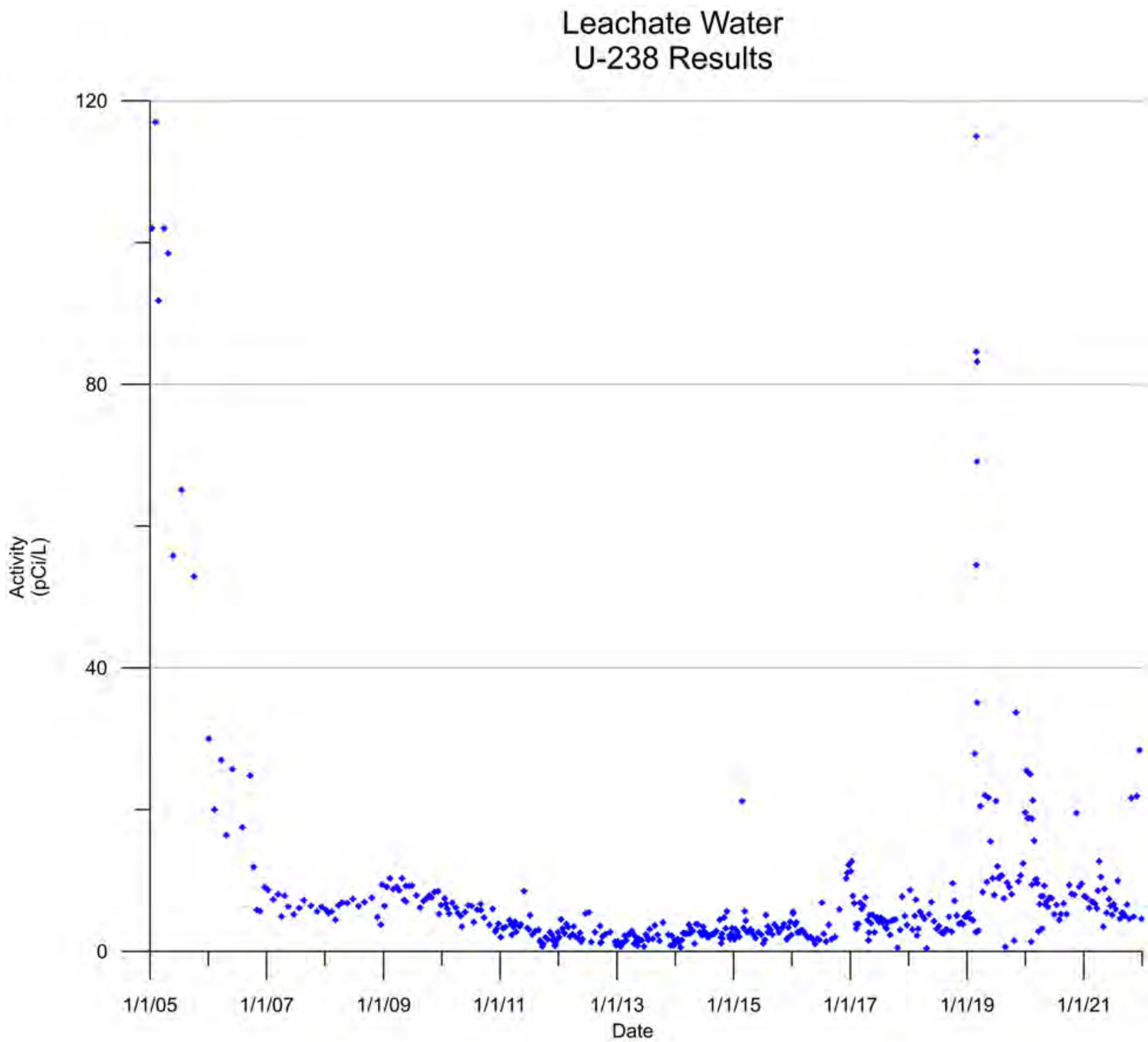
Leachate Water
U-235/236 Results
Activity
(pCi/L)
250
200
150
100
50
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

U-238

U-238 is detected in about 74% of the V-weir samples and in almost all samples from the contact water and leachate. There were no results above the criterion at the V-weir. There have been no results above the release decision criterion in contact water or leachate. The leachate and contact water trends for total uranium and U-238 are very similar, indicating U-238 is likely the basis of the total uranium results.

Current criterion –
576 pCi/L for contact water release decisions
144 pCi/L at the V-weir based on a trailing annual average



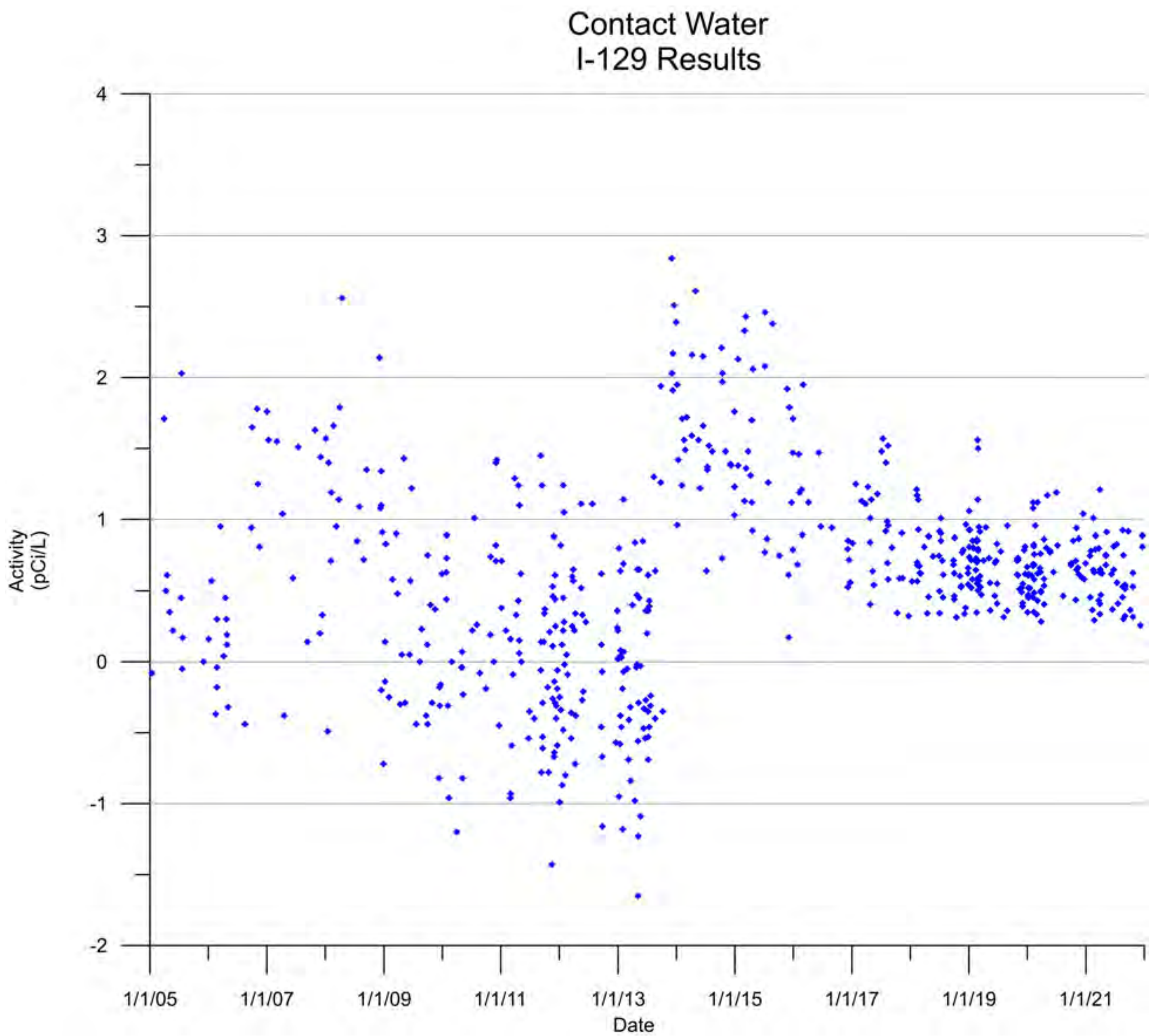


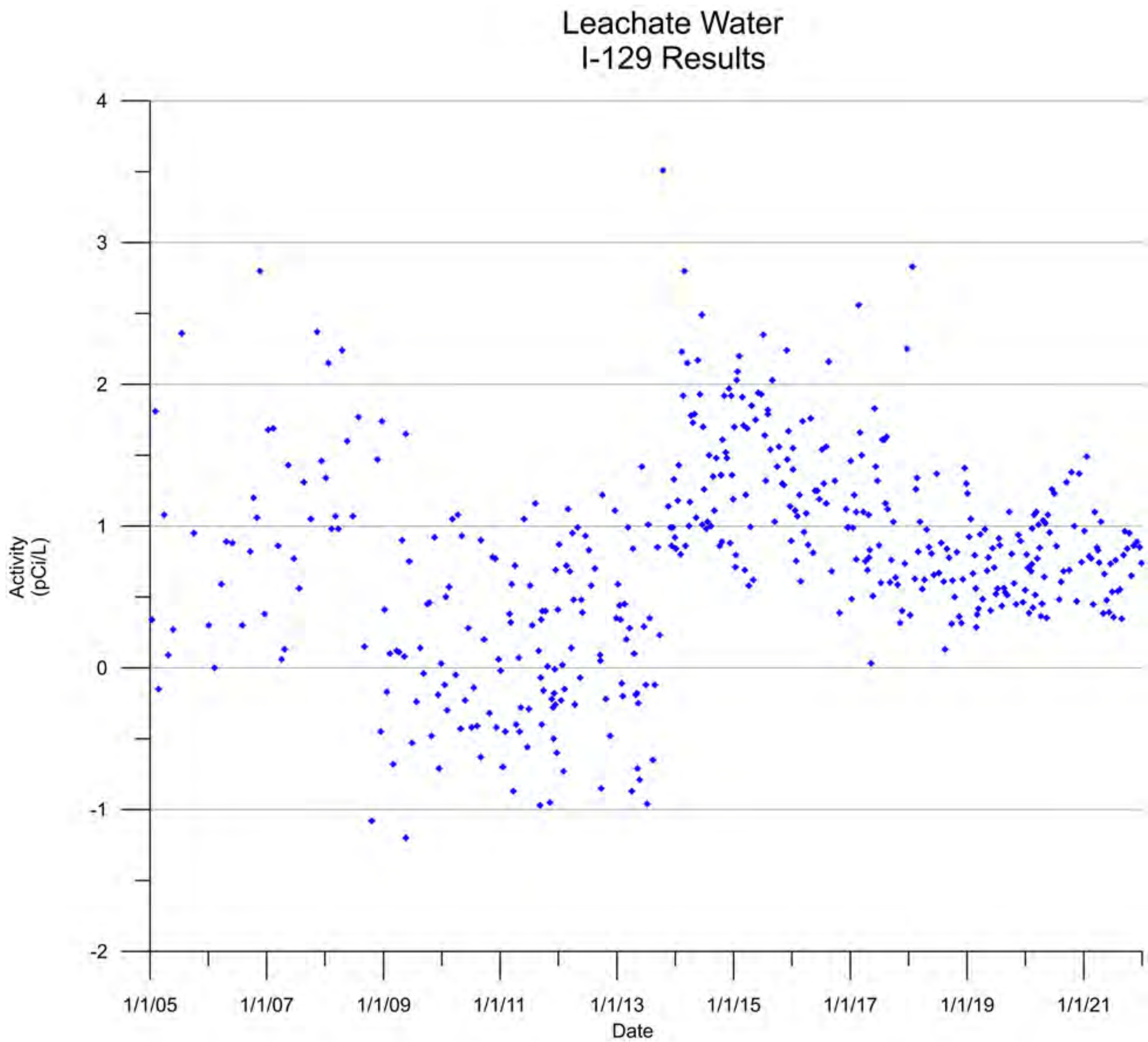
Leachate Water
U-238 Results
120
80
40
0
Activity
(pCi/L)
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Iodine (I)-129

I-129 is detected in about 14% of the V-weir samples, in 5% of contact water samples, and in 16% of leachate samples. There were no results above the criterion at the V-weir. There have been no results above the release decision criterion in contact water or leachate. Neither contact water nor leachate results have been above 5 pCi/L in the evaluated timeframe (sixteen years).

Current criterion – 480 pCi/L for contact water release decisions 120 pCi/L at the V-weir based on a trailing annual average

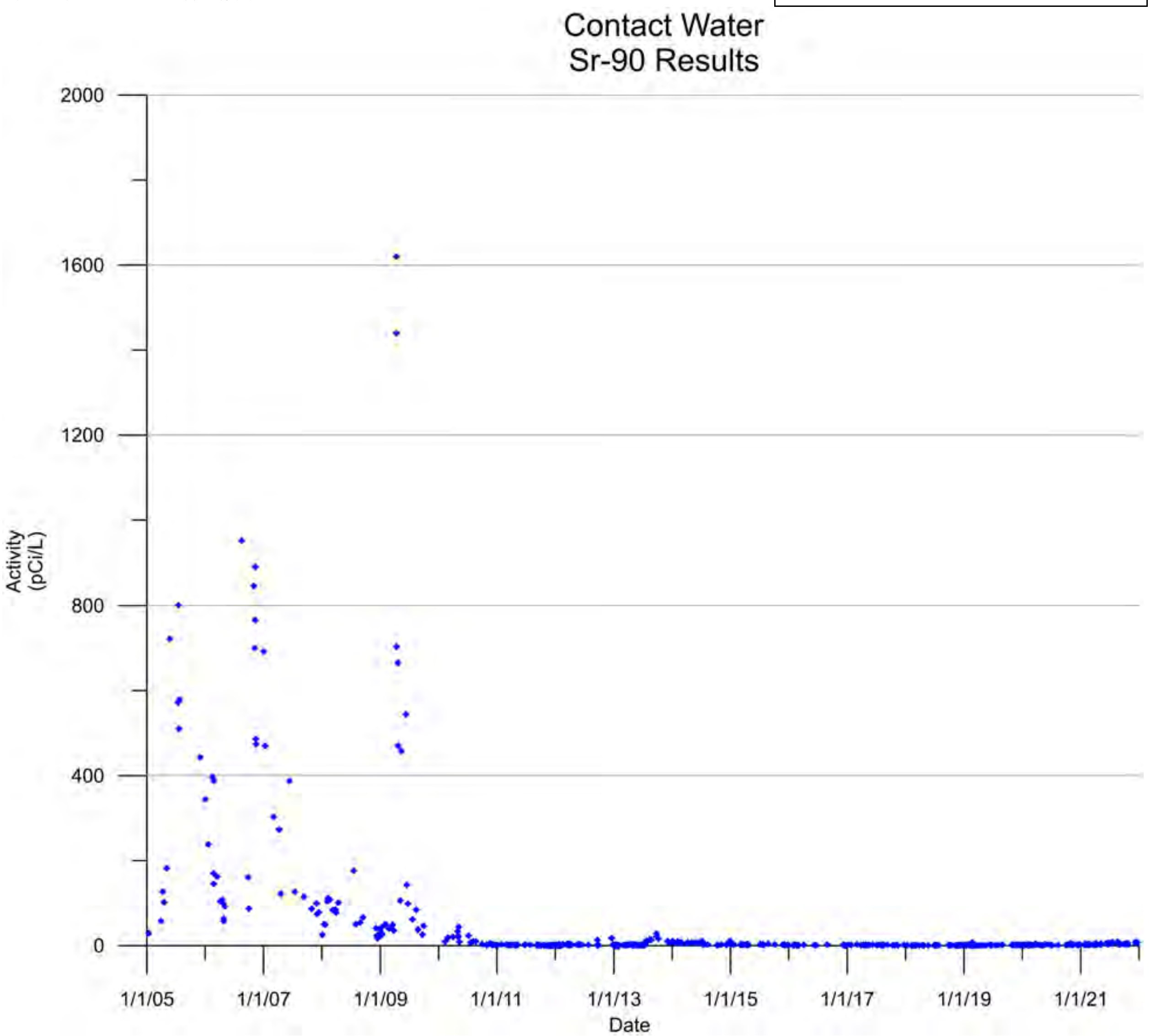


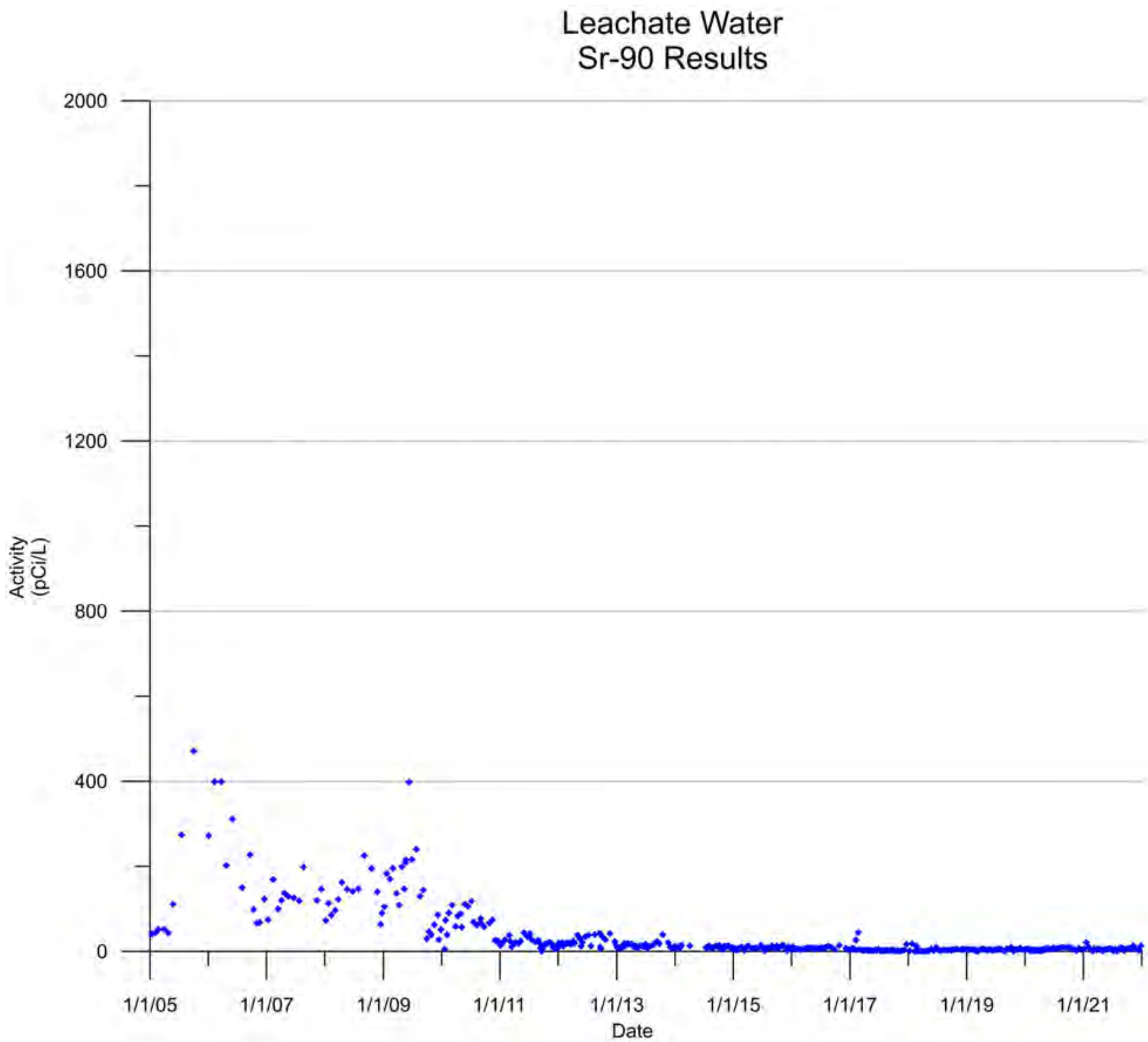

Leachate Water
I-129 Results
Activity (pCi/L)
4
3
2
1
0
-1
-2
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

Sr-90

Current criterion – 960 pCi/L for contact water release decisions 240 pCi/L at the V-weir based on a trailing annual average

Sr-90 is detected in about 71% of the V-weir samples, in 75% of contact water samples, and in 96% of leachate samples. There were 8 results above the criterion at the V-weir from 2005 to 2007. There were two results above the release decision criterion in contact water in April 2009 (1440 and 1620 pCi/L). No leachate results have approached the release decision criterion. Since 2009, Sr-90 activities in landfill wastewater have been very low. Because of the higher activities in the past, the potential for Sr-90 treatment was considered for the EMDF LWTS. .



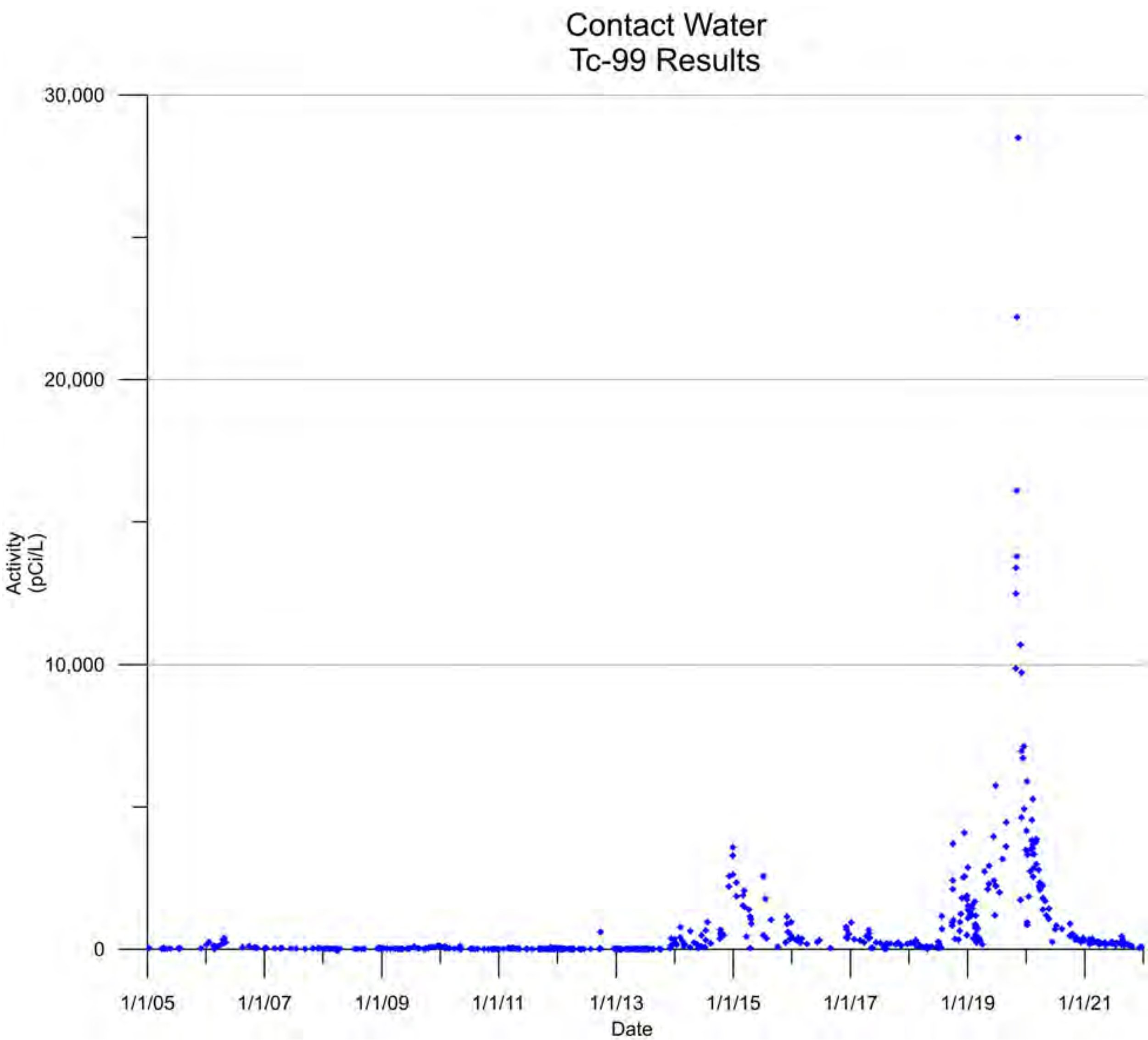

Leachate Water
Sr-90 Results
Activity (pCi/L)
2000
1600
1200
800
400
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

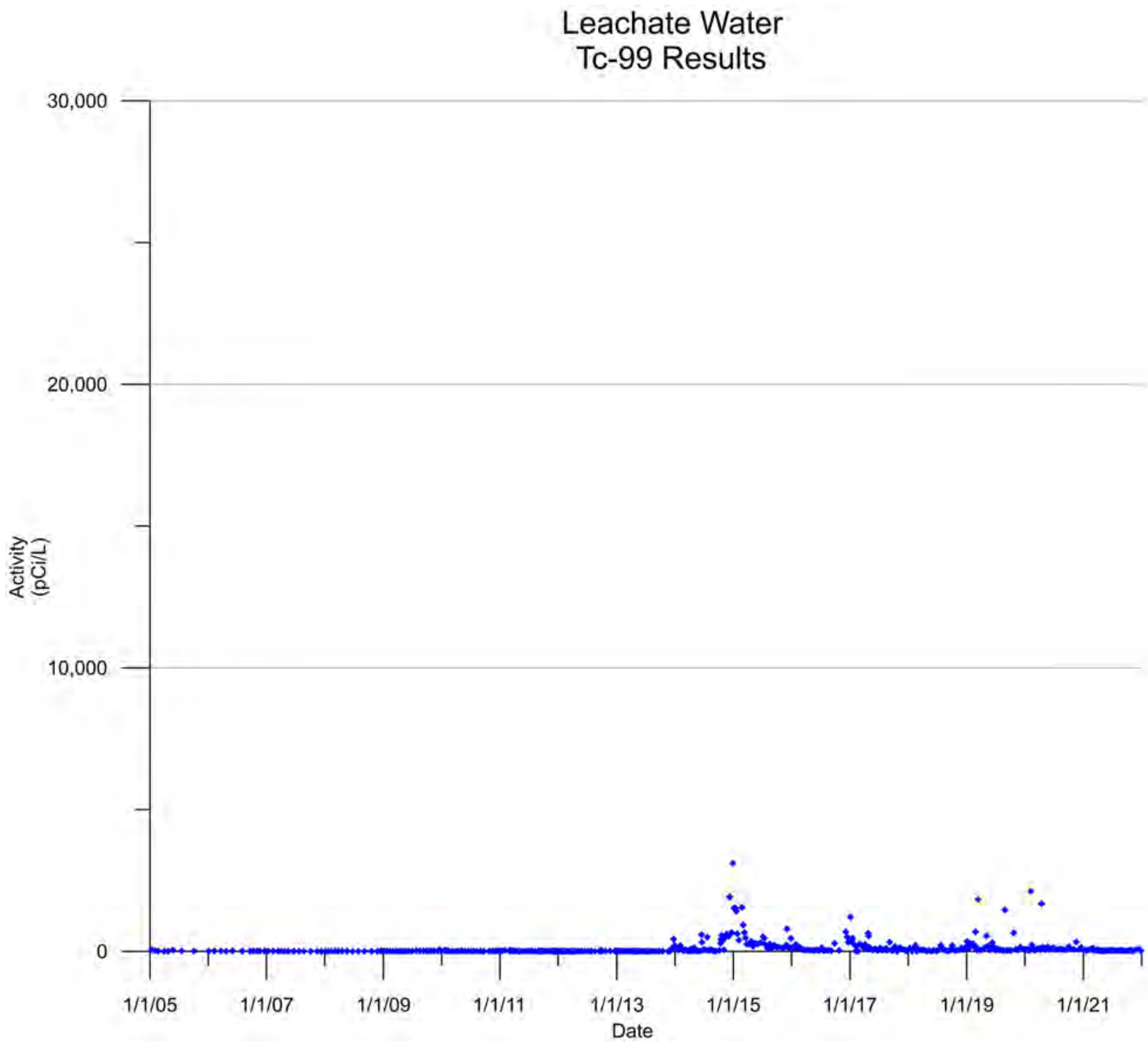
Technetium (Tc)-99

Tc-99 is detected in about 78% of the V-weir samples, in 98% of contact water samples, and in 95% of leachate samples. There were no results above the criterion at the V-weir. There have been no results above the release decision criterion in contact water or leachate. Of note, leachate has consistently lower concentrations than contact water.

Current criterion – 96,000 pCi/L for contact water release decisions 24,000 pCi/L at the V-weir based on a trailing annual average

The results show the impact of the demolition debris disposal at EMWMF from the ETTP/Heritage Center gaseous diffusion facilities on both the contact water and leachate. This demolition/disposal campaign is complete.



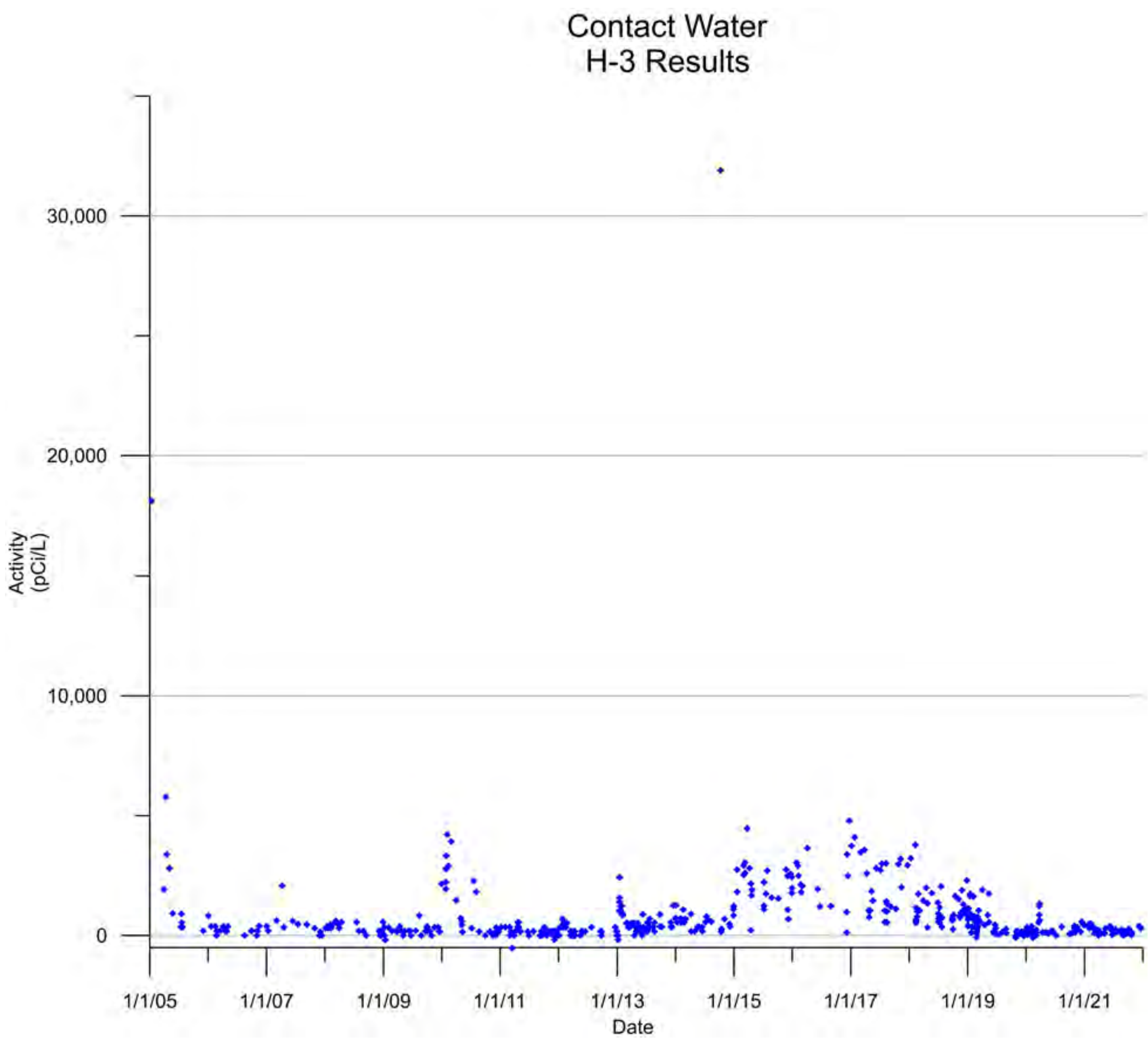

Leachate Water
Tc-99 Results
30,000
20,000
10,000
0
Activity
(pCi/L)
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

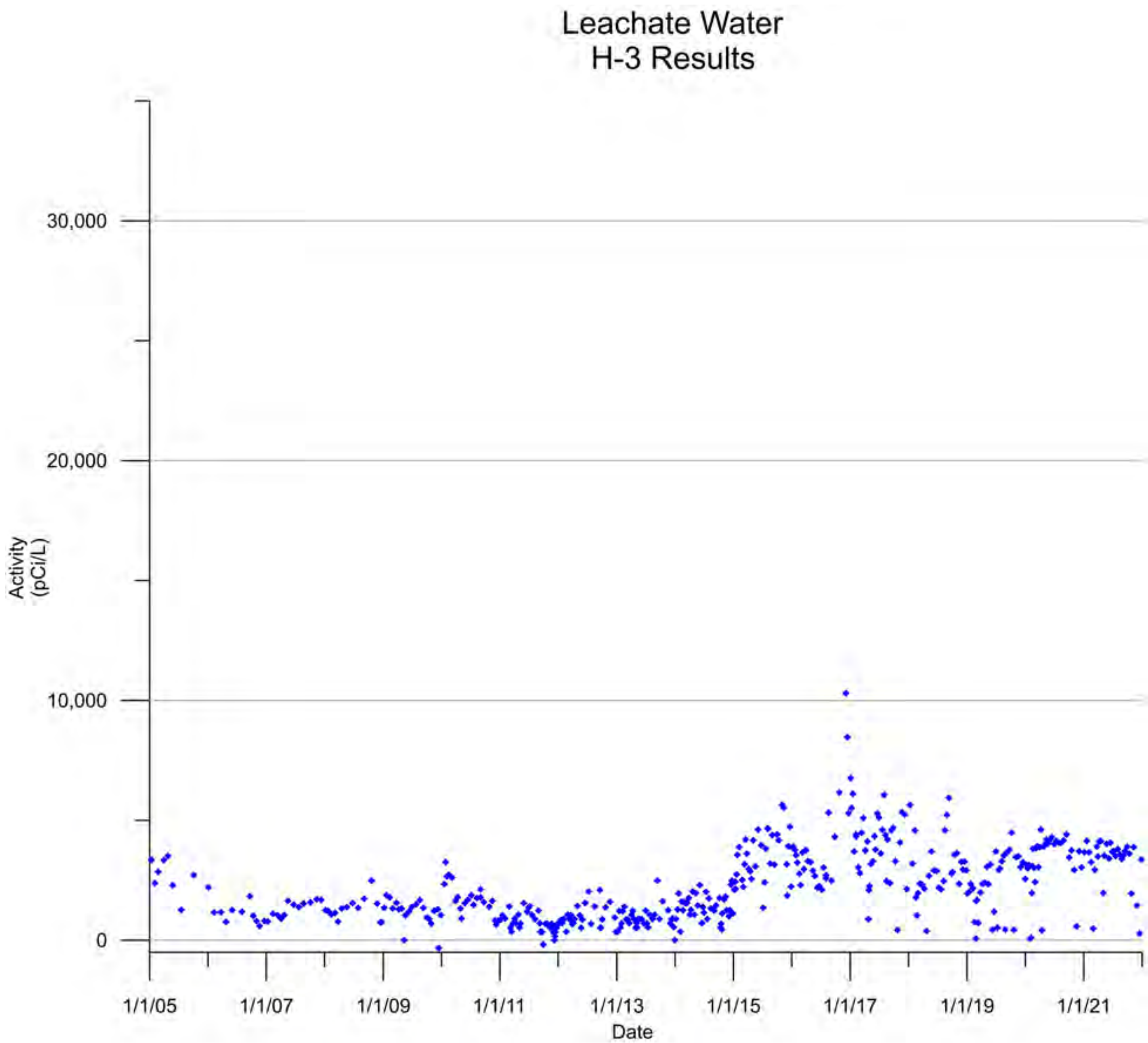
Tritium

Tritium is detected in about 46% of the V-weir samples, in 57% of contact water samples, and in 98% of leachate samples. There were no results above the criterion at the V-weir. There have been no results above the release decision criterion in contact water or leachate.

One contact water result in October 2014 was approximately 32,000 pCi/L. However, this result is questionable because the results immediately before this result was below 1000 pCi/L and the result four days later was below 200 pCi/L. Because tritium behaves like water, a high spike in concentration, followed immediately by a decline, is extremely unlikely.

Current criterion – 1,920,000 pCi/L for contact water release decisions 480,000 pCi/L at the V-weir based on a trailing annual average




Leachate Water
H-3 Results
30,000
20,000
10,000
0
Activity
(pCi/L)
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

C.4.2 Pesticides

The proposed AWQC for EMWMF include the following pesticides:

4,4'-DDD
4,4'-DDE
4,4'-DDT
Aldrin
beta-BHC
Dieldrin

Significant quantities of these materials were not present in incoming waste lots disposed at EMWMF and were not identified as site-related contaminants. Instead, these materials are present as a result of intended use associated with the facilities that have been demolished and disposed at EMWMF, or as residual amounts in soil or debris from previously remediated leaks or spills.

The contact water and leachate have been tested for these compounds at the detection limits, at or below the TDEC Rule 1200-04-03-.05-required method detection limits (RDLs). These results were lower than the applicable TDEC Fish and Aquatic Life discharge limits required for EMWMF. Almost all results have been non-detects (see summary table below). Most of the variations in the specific graphs below are the result of changes in detection limits. Based on the presence of only residual amounts of these compounds in the waste, and that none of these were principal contaminants in the disposed waste, the required reporting limits are acceptable detection limits for these compounds.

Summary of Pesticide Analyses for Contact Water

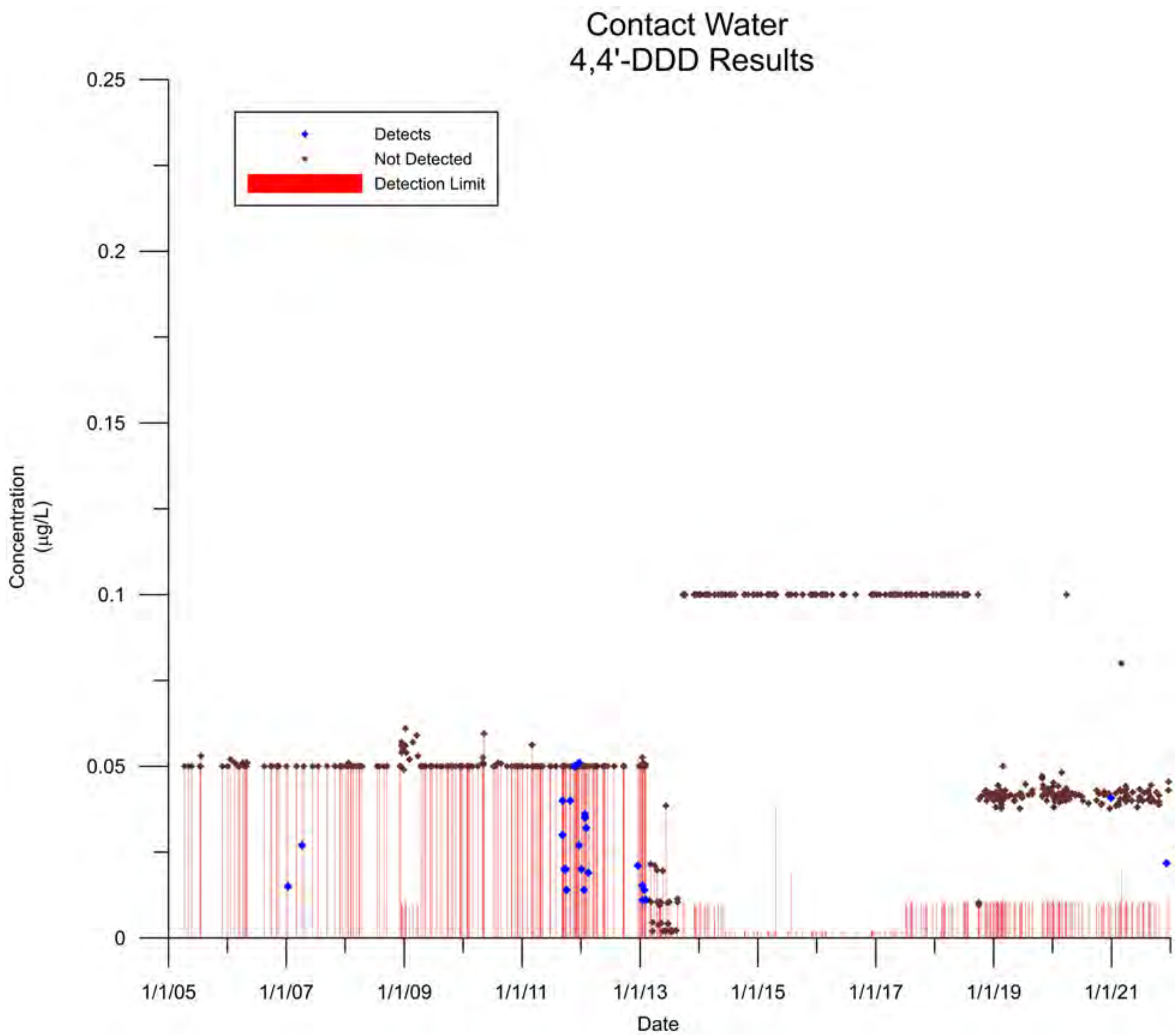
Chemical	Detection Frequency	Percent Detected	Unit	Min detection limit	Max detection limit	Min Detected	Max Detected
4,4'-DDD	24 / 587	4.09	ug/L	0.0019	0.0595	0.011	0.051
4,4'-DDE	28 / 587	4.77	ug/L	0.0019	0.0595	0.01	2.11
4,4'-DDT	9 / 577	1.56	ug/L	0.0019	0.0595	0.013	0.066
Aldrin	21 / 562	3.74	ug/L	0.0013	0.0595	0.0074	0.044
beta-BHC	106 / 577	18.4	ug/L	0.0013	0.0595	0.011	0.045
Dieldrin	12 / 589	2.04	ug/L	0.001	0.5	0.011	0.0364

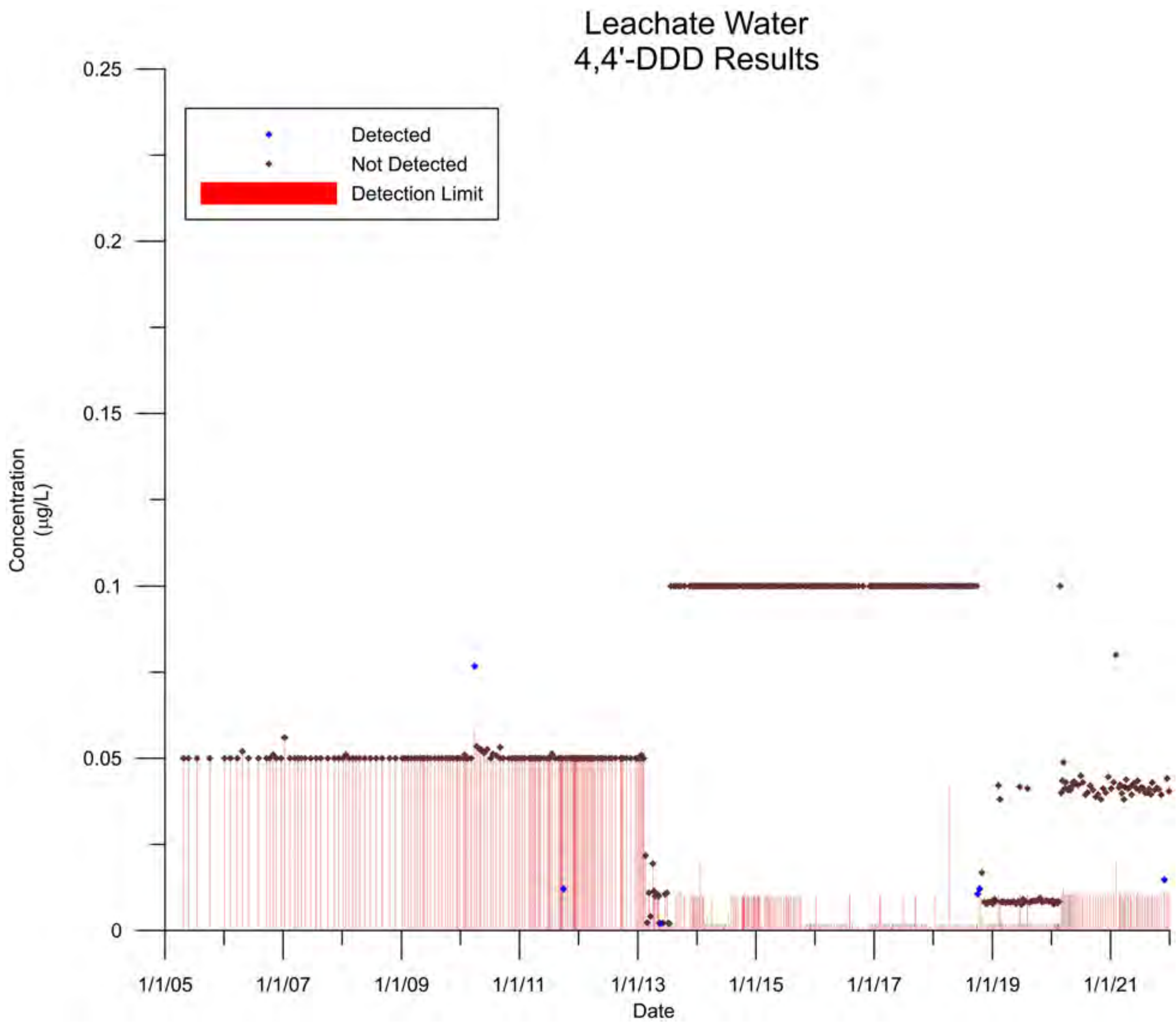
4,4-DDD

Recreational AWQC – 0.0031 ug/L CMC – n/a CMC – n/a RDL – 0.1 ug/L

4,4-DDD was detected in about 2.5% of the V-weir samples, in 4% of contact water samples, and in 1% of leachate samples. There were no detected results above the RDL at the V-weir, contact water, or leachate.

The mean concentration was calculated using the detected results and non-detects. Because of the few detects, the mean is 0.028 ug/L at the V-weir, 0.0119 ug/L for contact water, and 0.0252 ug/L for leachate.





Leachate Water
4,4'-DDD Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
0.25
0.2
0.15
0.1
0.05
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

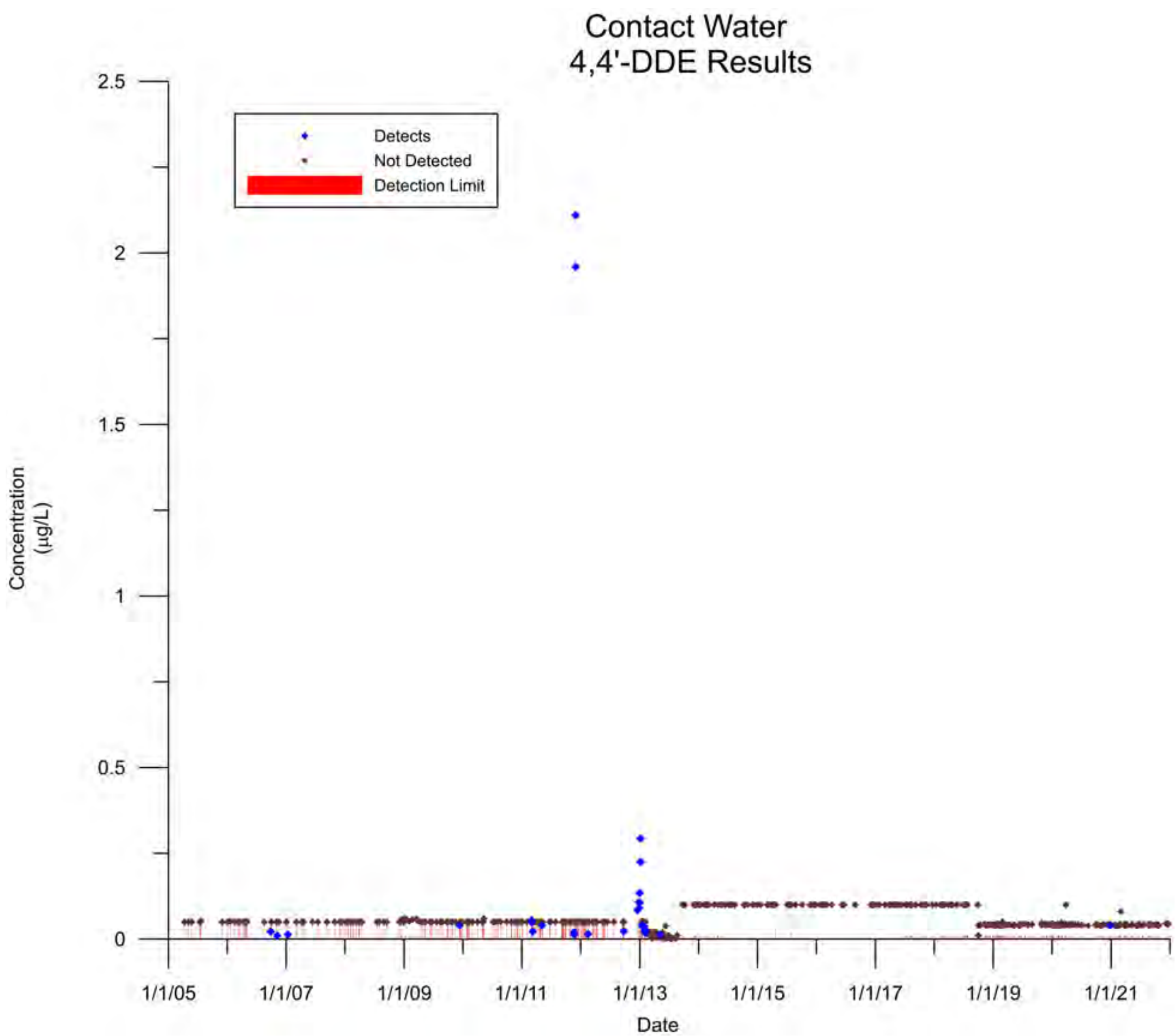
4,4-DDE

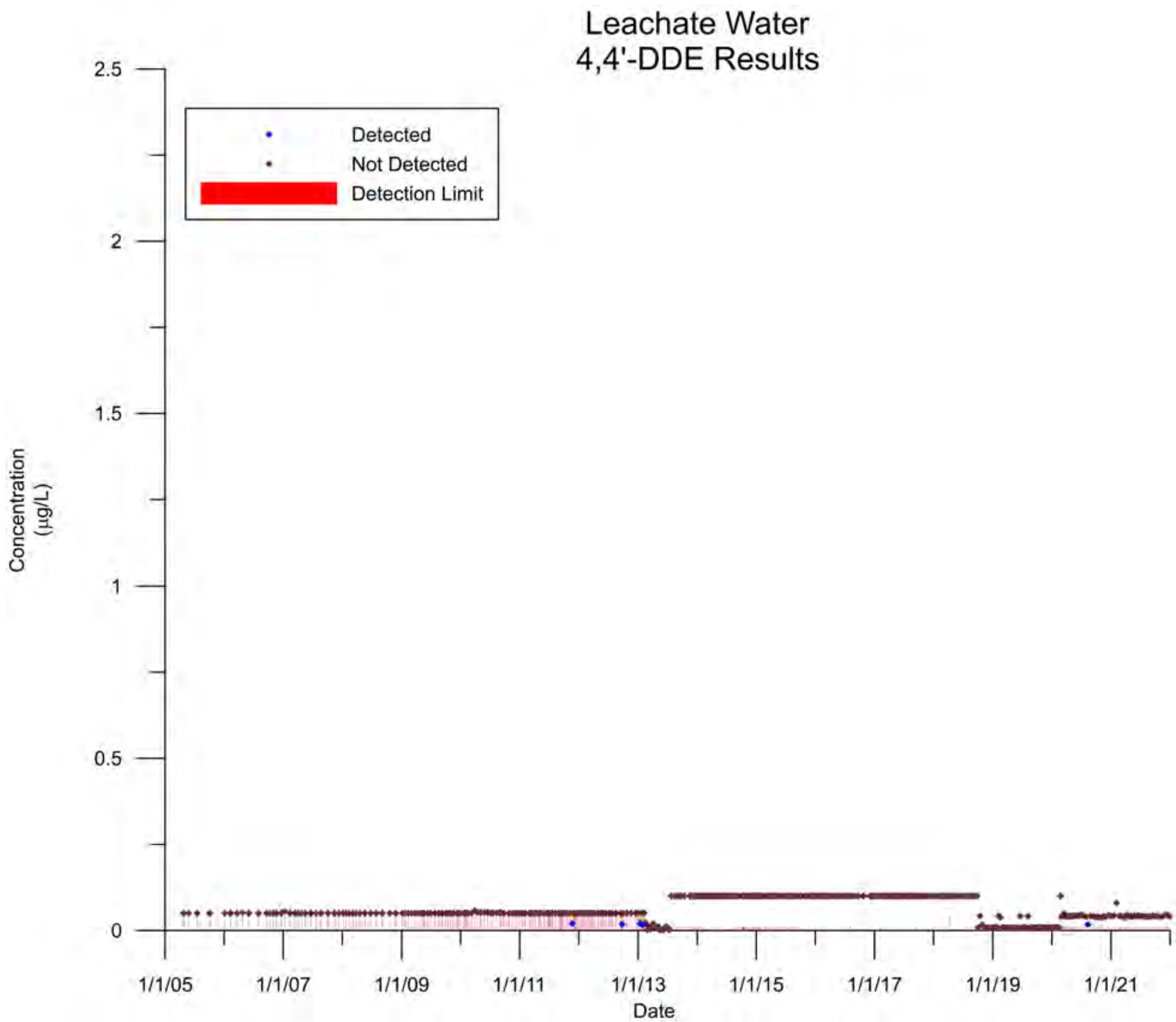
Recreational AWQC – 0.0022 ug/L CMC – n/a CMC – n/a RDL – 0.1 ug/L

4,4-DDE was detected in about 3.8% of the V-weir samples, in 4.8% of contact water samples, and in 1.4% of leachate samples. There were no detected results above the RDL at the V-weir, or leachate.

Contact water results from December 2011 and January 2012 were mostly non-detects at the detection limit of 0.05. However, two samples had results of 2.11 and 1.96 ug/L. These results are suspect as these are orders of magnitude higher than the other, concurrent results. These samples were above the RDL.

The mean concentration was calculated using the detected results and non-detects. Because of the few detects, the mean is 0.021 ug/L at the V-weir, 0.017 ug/L for contact water, and 0.01 ug/L for leachate—all below the RDL



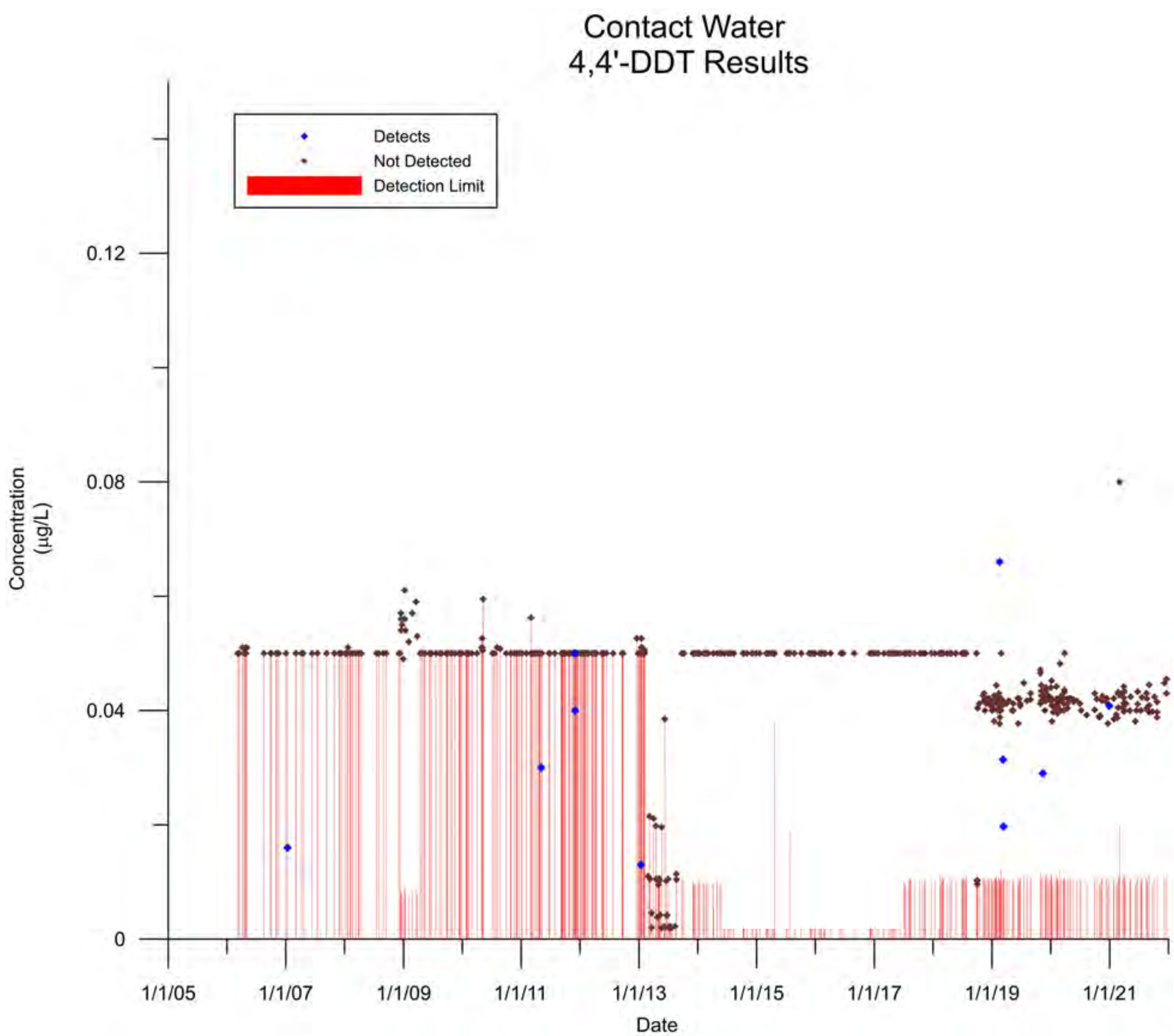

Leachate Water
4,4'-DDE Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
2.5
2
1.5
1
0.5
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

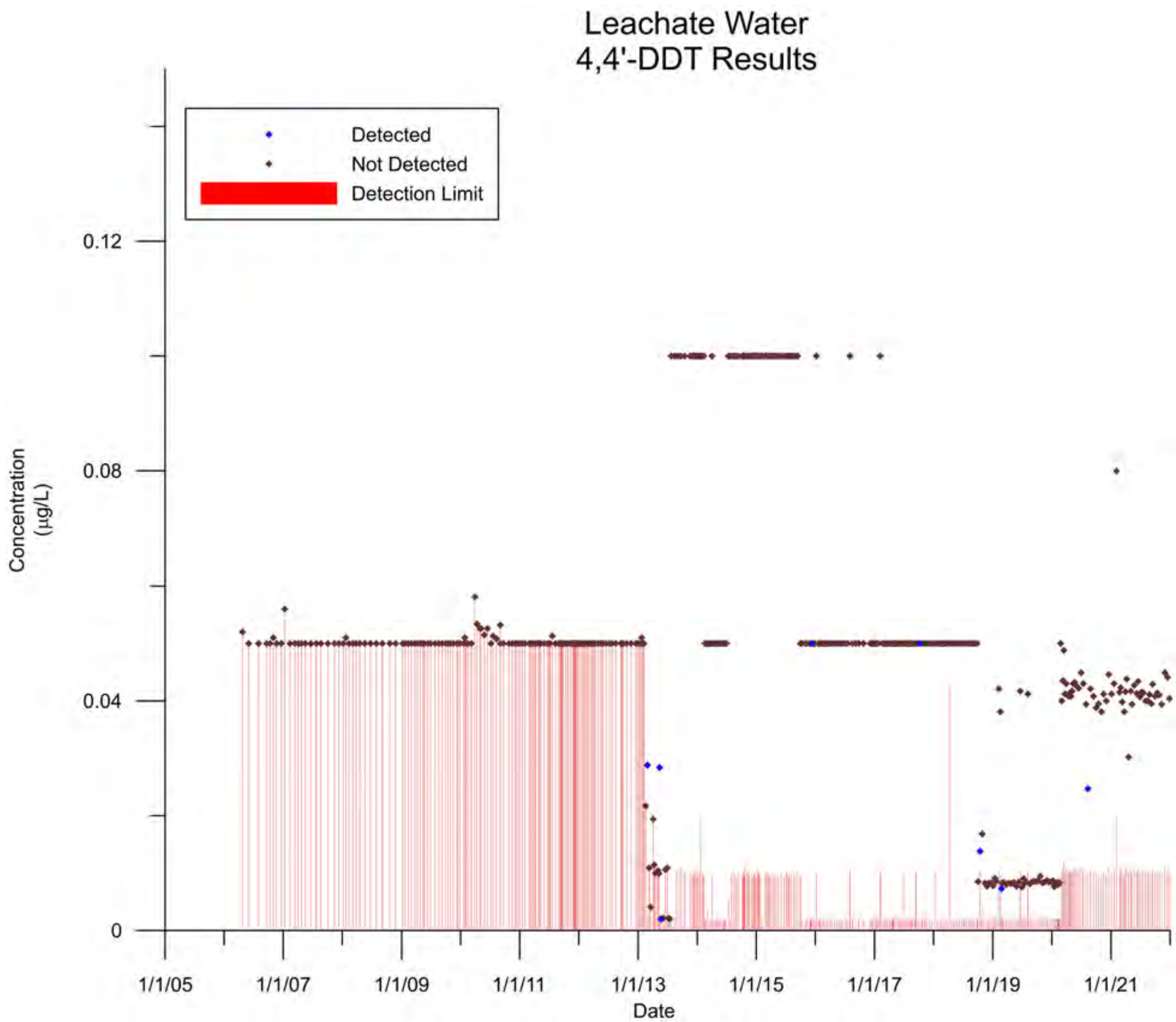
4,4-DDT

Recreational AWQC – 0.0022 ug/L
CMC – 1.1 ug/L
CMC – 0.001 ug/L
RDL – 0.1 ug/L

4,4-DDT was detected in about 1% of the V-weir samples, in 1.6% of contact water samples, and in 1.4% of leachate samples. There were no detected results above the RDL at the V-weir, in contact water, or in leachate.

The mean concentration was calculated using the detected results and non-detects. Because of the few detects, the mean is 0.017 ug/L at the V-weir, 0.0052 ug/L for contact water, and 0.0102 ug/L for leachate.





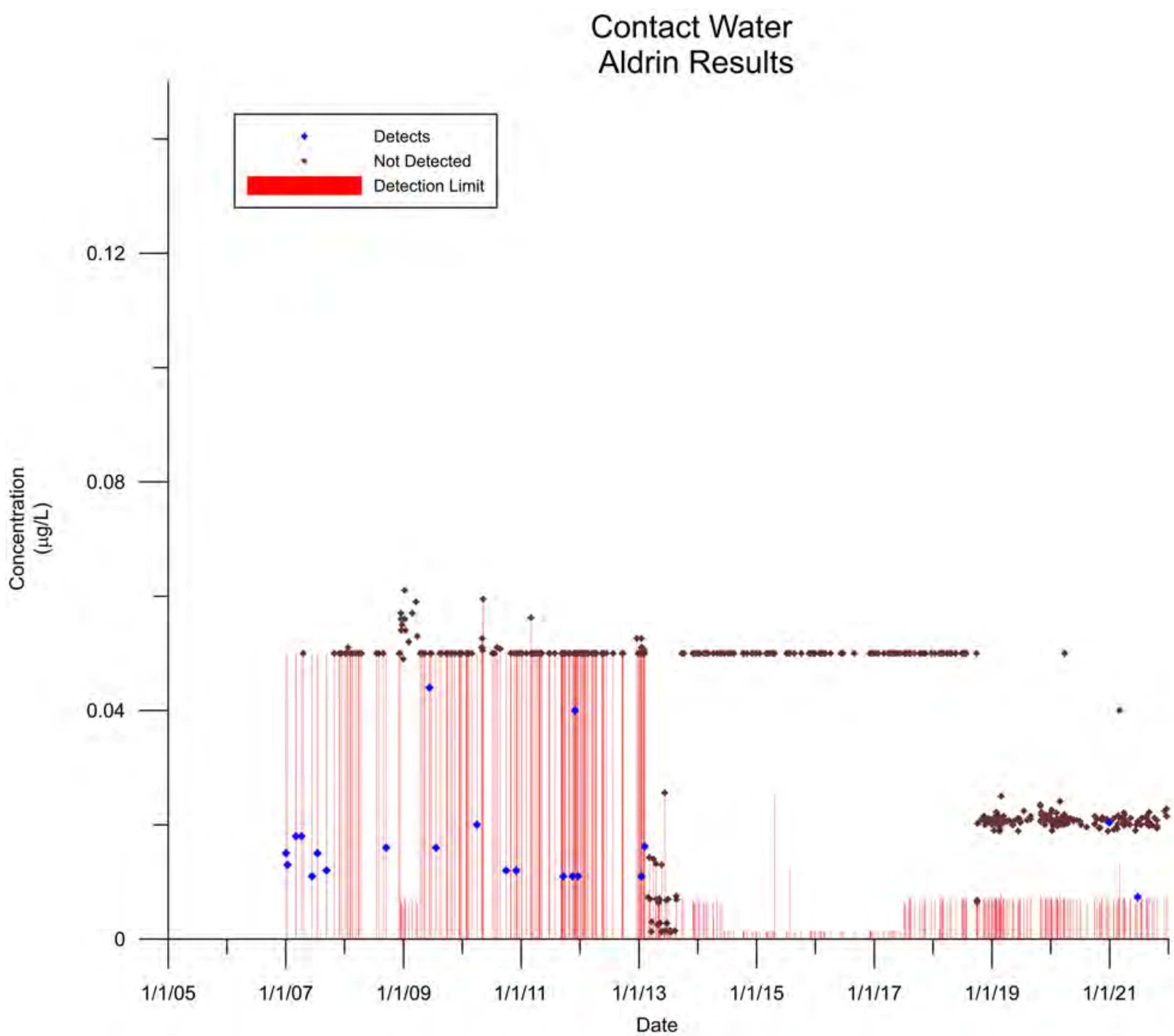
Leachate Water
4,4'-DDT Results
Detected
Not Detected
Detection Limit
Concentration (µg/L)
0.12
0.08
0.04
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

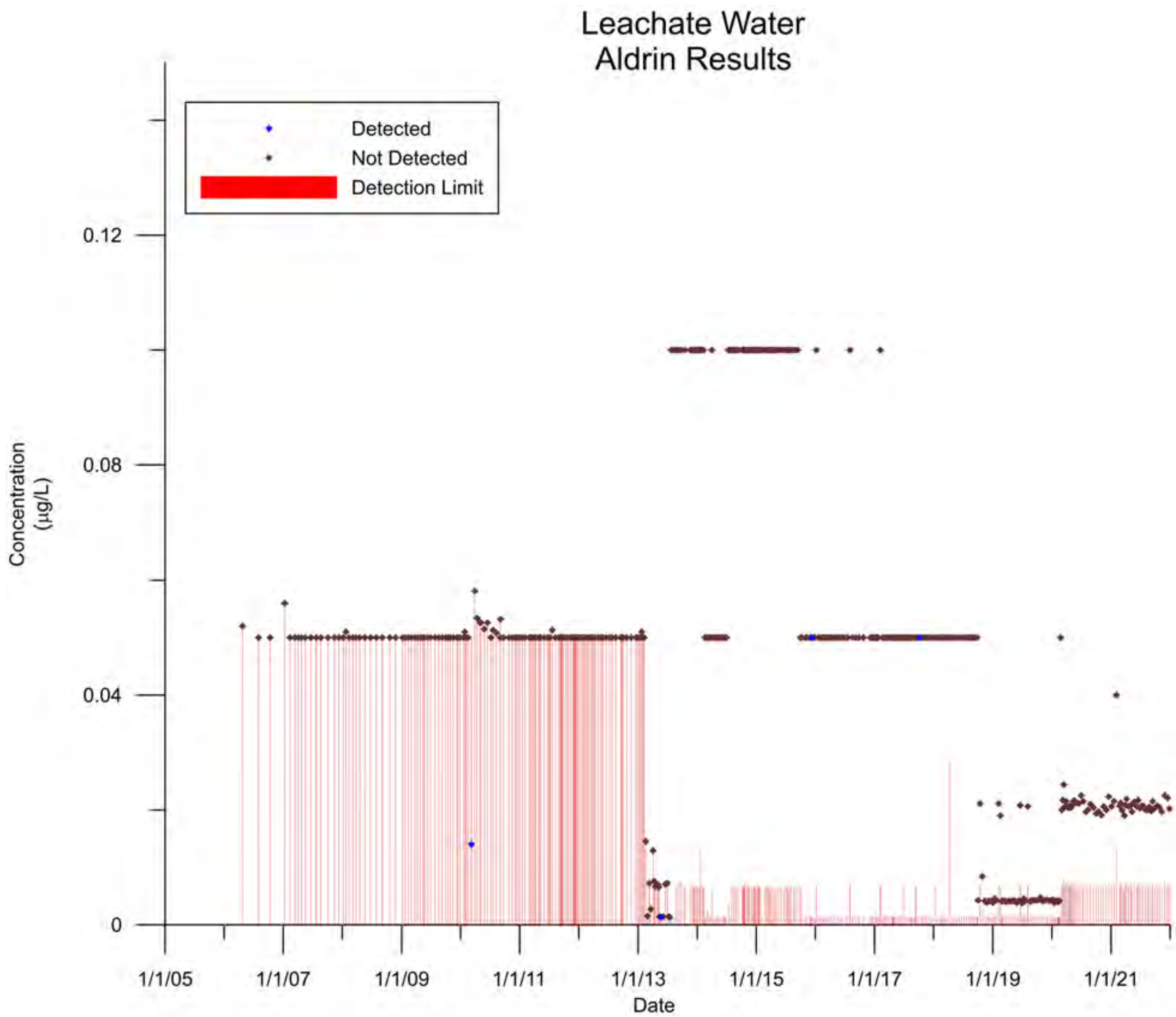
Aldrin

Recreational AWQC – 0.0005 ug/L CMC – 3 ug/L CMC – 0.001 ug/L RDL – 0.5 ug/L

Aldrin was detected in about 5% of the V-weir samples, in 3.7% of contact water samples, and in 0.2% of leachate samples. There were no detected results above the RDL at the V-weir, in contact water, or in leachate.

The mean concentration was calculated using the detected results and non-detects. Because of the few detects, the mean is 0.017 ug/L at the V-weir, 0.01 ug/L for contact water, and 0.01 ug/L for leachate.




Leachate Water
Aldrin Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
0.12
0.08
0.04
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

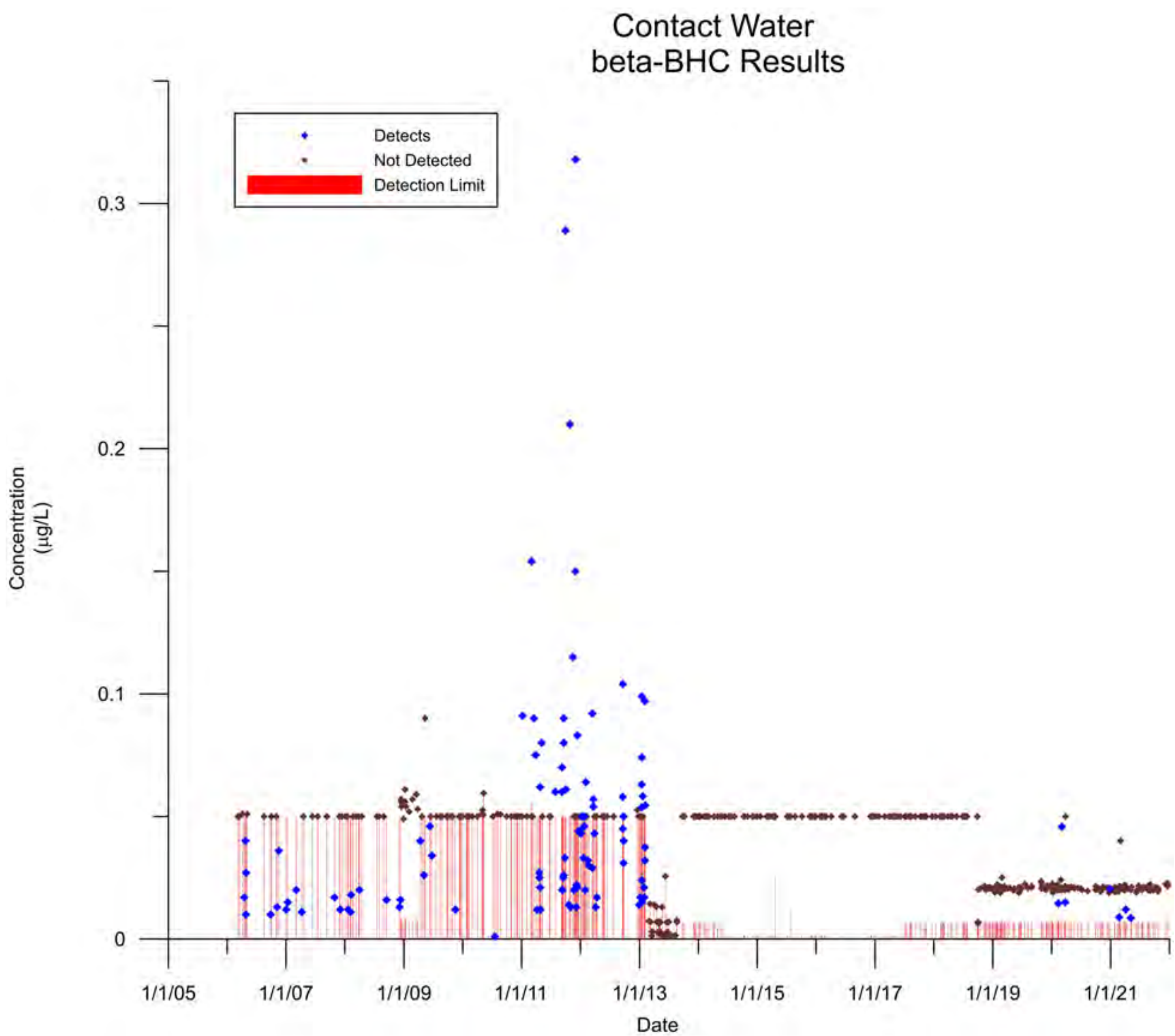
Beta BHC

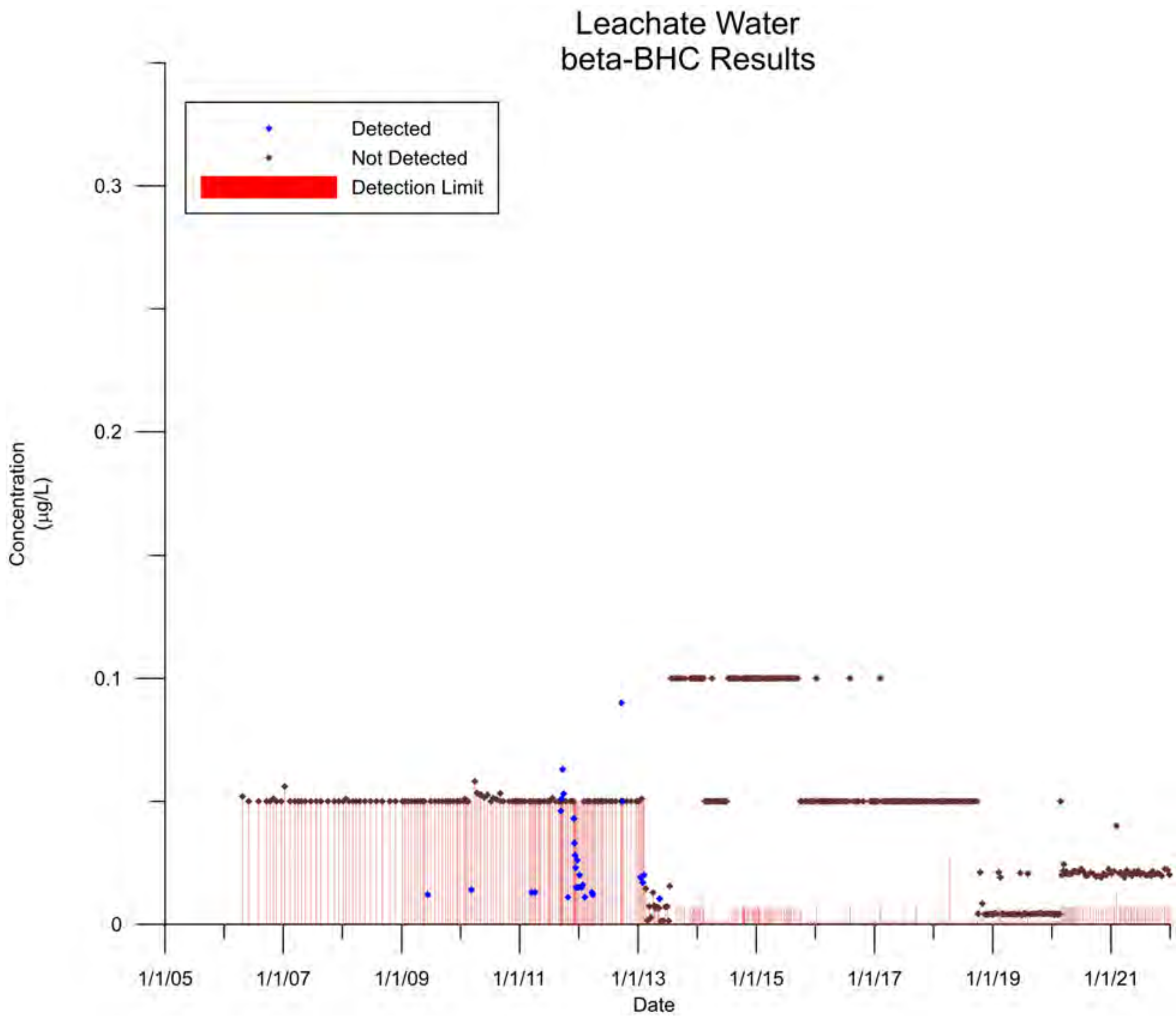
Recreational AWQC – 0.17 ug/L CMC – n/a CMC – n/a RDL – 0.5 ug/L (gamma BHC)

Beta BHC was detected in about 15.4% of the V-weir samples, in 18.4% of contact water samples, and in 6.9% of leachate samples. There were no detected results above the RDL at the V-weir or leachate.

There were three instances between 2005 and 2016 when results were higher than the recreational AWQC: September 29, 2011 (0.289 ug/L); October 26, 2011 (2.1 ug/L); and December 1, 2011 (0.318 ug/L). All other results are below the recreational AWQC and are mostly non-detects.

The mean concentration was calculated using the detected results and non-detects. Because of the few detects, the mean is 0.014 ug/L at the V-weir, 0.015 ug/L for contact water, and 0.006 ug/L for leachate





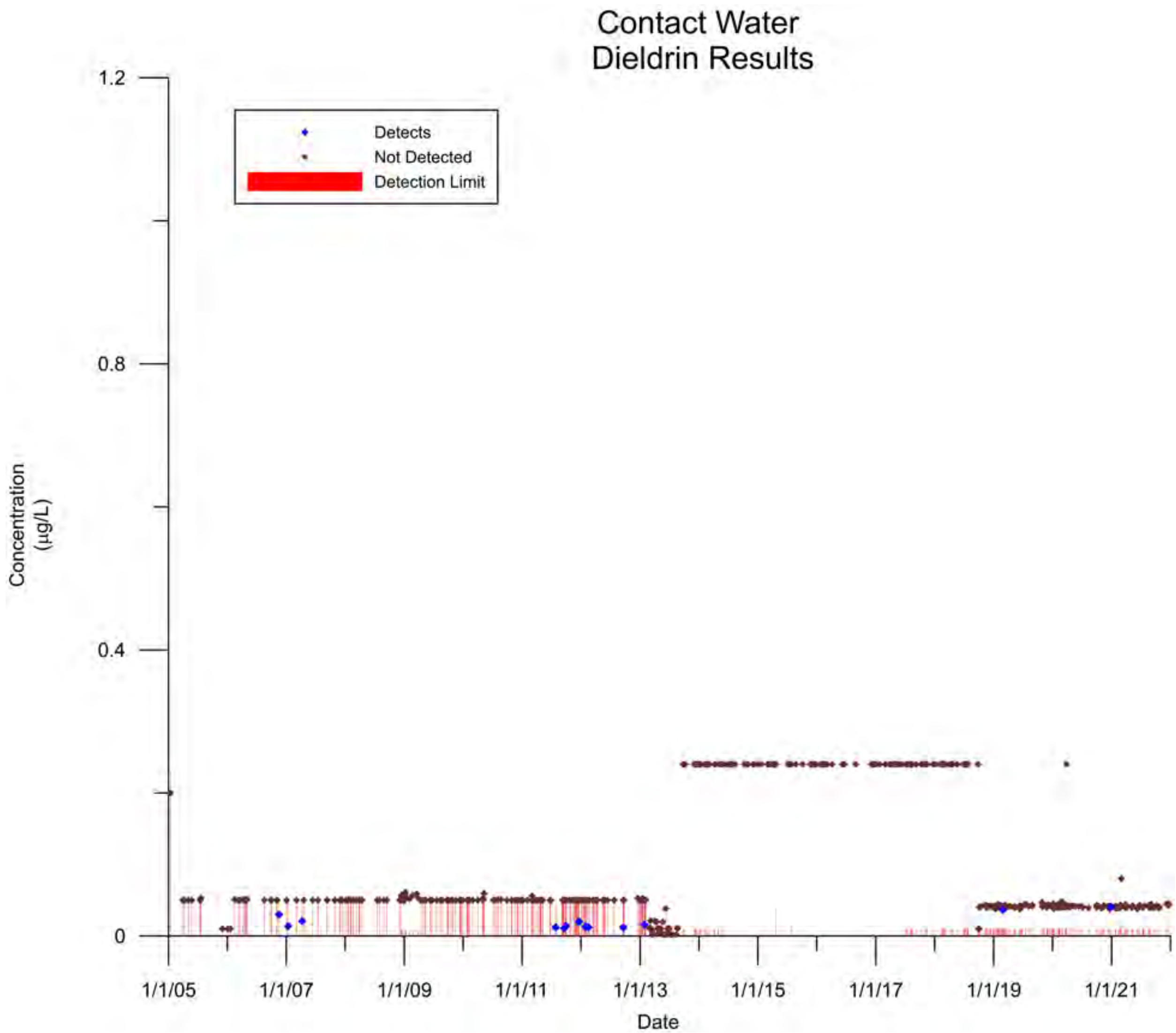
Leachate Water
beta-BHC Results
Detected
Not Detected
Detection Limit
Concentration
(µg/L)
0.3
0.2
0.1
0
1/1/05
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
1/1/19
1/1/21
Date

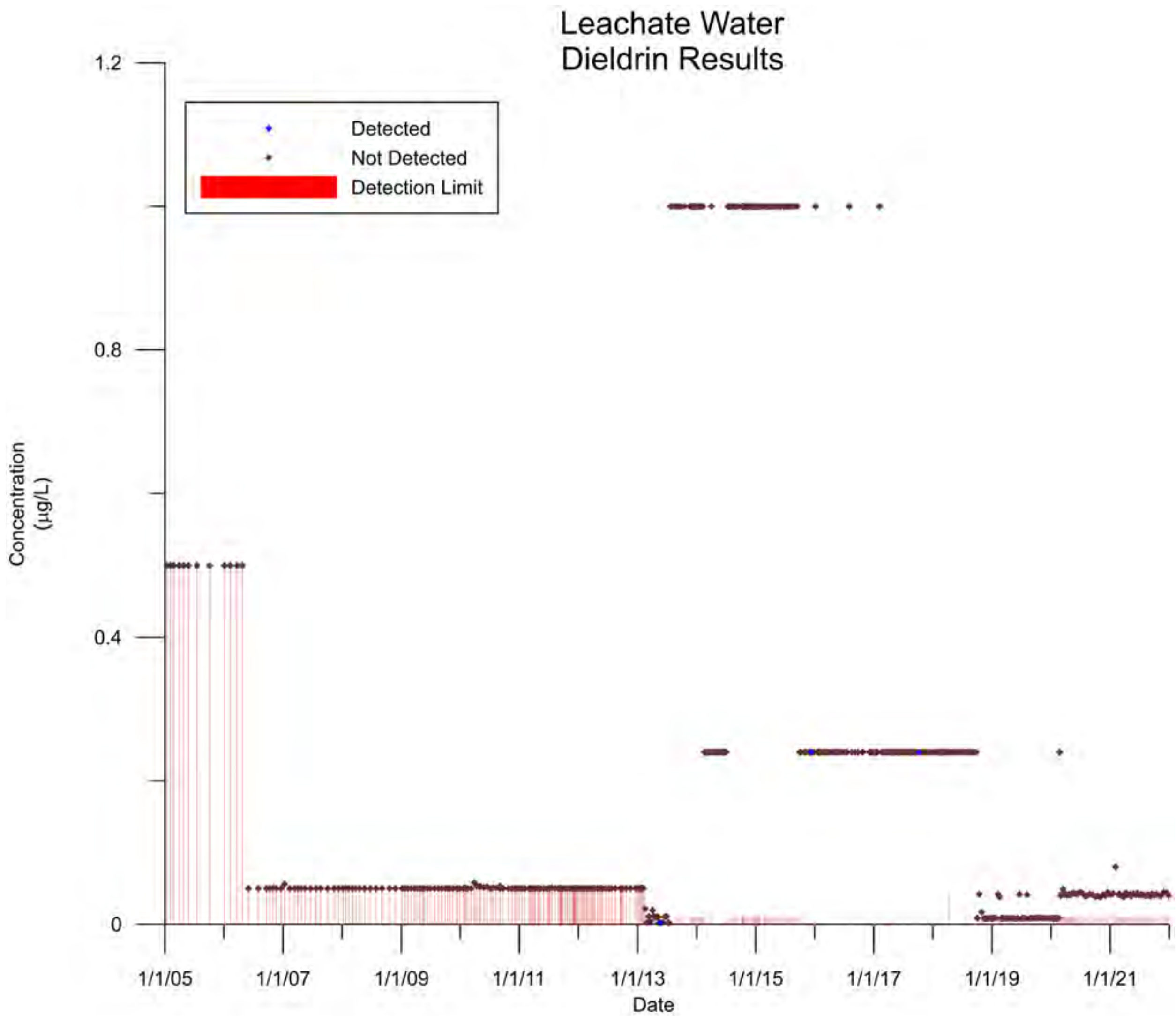
Dieldrin

Dieldrin was detected in about 1% of the V-weir samples, in 2% of contact water samples, and in 0% of leachate samples. There were no detected results above the RDL at the V-weir or leachate.

Recreational AWQC – 0.00054 ug/L
CMC – 0.2 ug/L
CMC – 0.056 ug/L
RDL – 0.05 ug/L

The mean concentration was calculated using the detected results and non-detects. Because of the few detects, the mean is 0.017 ug/L at the V-weir, 0.018 ug/L for contact water, and 0.017 ug/L for leachate.





C.5 SUMMARY

Based on the evaluation of the 2019 to 2021 data, the COCs considered to require treatment for the Focused Feasibility Study (FFS) are mercury and cadmium if future operations rely on continuous release of wastewater to Bear Creek. Neither COC is currently expected to require treatment if there is batch release of landfill wastewater to Bear Creek, based on concentrations below the applicable CMC AWQC.

Additional COCs that would have required treatment in the past under the FFS AWQC are:

Copper
Cyanide
Lead
U-238
Sr-90

The potential that treatment may be required for these additional COCs will be considered during evaluation of the alternatives to determine if these could be effectively treated with minimal changes/upgrades.

Hexavalent chrome is anticipated to be reduced in the contact water ponds/tanks when this occurs.

As stated in Sect. C.4.2, pesticides are present in the waste because of their intended use at the facilities disposed at EMWMF. These are present in minor concentrations in the contact water and leachate. Therefore, the RDL will be used as the future detection limit. Concentrations are anticipated to be below these levels.

APPENDIX C.
ATTACHMENT 1—EMWMF V-WEIR WATER DATA

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Attachment 1. EMWMF summary statistics and comparison to AWQC for Unfiltered Surface Water from EMW-VWEIR 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	24% of DCG[f]	Freq. > 24% of DCG[f]
Unfiltered Surface Water from EMW-VWEIR 2005-2021																				
Physical																				
Depth	1 / 1	100	ft	--	--	0.14	0.14	0.14	0.14	0.14	0.14	0.14	--	--	--	--	--	--	--	--
Dissolved Oxygen	1 / 1	100	mg/L	--	--	7.1	7.1	7.1	7.1	7.1	7.1	7.1	--	--	--	--	--	--	--	--
Flow	1 / 1	100	L/min	--	--	32.4	32.4	32.4	32.4	32.4	32.4	32.4	--	--	--	--	--	--	--	--
Oxidation-Reduction Potential	1 / 1	100	mV	--	--	76.6	76.6	76.6	76.6	76.6	76.6	76.6	--	--	--	--	--	--	--	--
Specific Conductivity (PIP)	89 / 89	100	umhos/cm	--	--	124	350	329	1040	124	350	1040	--	--	--	--	--	--	--	--
Temperature	1 / 1	100	deg C	--	--	18.7	18.7	18.7	18.7	18.7	18.7	18.7	--	--	--	--	--	--	--	--
pH	166 / 166	100	Std Unit	--	--	6.8	7.861	7.8	9.34	6.8	7.861	9.34	6.5 to 9	**3 / 166**	6.5 to 9	**3 / 166**	6 to 9	**3 / 166**	--	--
Metals																				
Aluminum	119 / 130	91.5	ug/L	15	100	7.5	1656	474	27,100	36	1806	27,100	--	--	--	--	--	--	--	--
Antimony	21 / 130	16.2	ug/L	0.049	6	0.0245	1.2	1.5	3	0.06	0.279	1.1	--	--	--	--	640	0 / 130	--	--
Arsenic	50 / 166	30.1	ug/L	0.46	5.4	0.23	2.421	2	14.6	0.71	3.542	14.6	150	0 / 166	340	0 / 166	10	**3 / 166**	--	--
Barium	130 / 130	100	ug/L	--	--	7.7	69.8	62.4	282	7.7	69.8	282	--	--	--	--	--	--	--	--
Beryllium	5 / 128	3.91	ug/L	0.02	1.1	0.01	0.0614	0.04	1.12	0.04	0.3488	1.12	--	--	--	--	--	--	--	--
Boron	115 / 130	88.5	ug/L	1.2	36	0.6	124	58	801	10.3	138	801	--	--	--	--	--	--	--	--
Cadmium	16 / 171	9.36	ug/L	0.062	1	0.031	0.1563	0.065	0.529	0.069	0.1835	0.529	0.25	**3 / 171**	2.014	0 / 171	--	--	--	--
Calcium	164 / 164	100	ug/L	--	--	15,700	46,937	41,350	173,000	15,700	46,937	173,000	--	--	--	--	--	--	--	--
Chromium	68 / 176	38.6	ug/L	0.5	5	0.25	3.151	1.7	35.2	0.61	5.714	35.2	74	0 / 176	570	0 / 176	--	--	--	--
Chromium, hexavalent	0 / 6	0	ug/L	6	6	3	3	3	3	--	--	--	11	0 / 6	16	0 / 6	--	--	--	--
Cobalt	23 / 128	18.0	ug/L	0.19	5	0.095	0.822	0.43	11.8	0.13	2.389	11.8	--	--	--	--	--	--	--	--
Copper	55 / 171	32.2	ug/L	0.3	9.4	0.15	2.53	1.5	24	0.52	4.774	24	9	**6 / 171**	13	**6 / 171**	--	--	--	--
Hafnium	0 / 22	0	ug/L	3	50	1.5	11.5	1.5	25	--	--	--	--	--	--	--	--	--	--	--
Iron	129 / 130	99.2	ug/L	44	44	22	1814	518	35,500	44	1827	35,500	--	--	--	--	--	--	--	--
Lead	53 / 176	30.1	ug/L	0.18	5	0.09	2.038	1	35.2	0.77	4.899	35.2	2.5	**21 / 176**	64.6	0 / 176	--	--	--	--
Lithium	47 / 130	36.2	ug/L	0.32	10	0.16	6.855	4.6	194	1.4	11.5	194	--	--	--	--	--	--	--	--
Magnesium	164 / 164	100	ug/L	--	--	4900	7859	7535	15,000	4900	7859	15,000	--	--	--	--	--	--	--	--
Manganese	130 / 130	100	ug/L	--	--	5.7	87.1	45	671	5.7	87.1	671	--	--	--	--	--	--	--	--
Mercury	10 / 89	11.2	ug/L	2.0E-04	0.2	1.0E-04	0.0434	0.0335	0.1	0.0021	0.0235	0.096	0.77	0 / 89	1.4	0 / 89	0.051	**2 / 89**	--	--
Molybdenum	33 / 40	82.5	ug/L	0.165	5	0.0825	4.862	4.09	14.8	1.2	5.332	14.8	--	--	--	--	--	--	--	--
Nickel	63 / 176	35.8	ug/L	0.32	10	0.16	2.974	1.79	34.4	0.39	4.854	34.4	52	0 / 176	468	0 / 176	4600	0 / 176	--	--
Phosphorus	31 / 33	93.9	ug/L	60	60	22.2	79.5	51.1	414	22.2	81.9	414	--	--	--	--	--	--	--	--
Potassium	130 / 130	100	ug/L	--	--	870	4911	4480	17,000	870	4911	17,000	--	--	--	--	--	--	--	--
Selenium	18 / 172	10.5	ug/L	0.18	6	0.09	0.4851	0.31	7	0.28	1.338	7	5	**1 / 172**	20	0 / 172	--	--	--	--
Silicon	70 / 70	100	ug/L	--	--	150	2136	1800	10,000	150	2136	10,000	--	--	--	--	--	--	--	--
Silver	9 / 167	5.39	ug/L	0.023	5	0.0115	0.6307	0.25	2.5	0.02	0.0404	0.1	--	--	3.217	0 / 167	--	--	--	--
Sodium	130 / 130	100	ug/L	--	--	990	8946	6890	61,000	990	8946	61,000	--	--	--	--	--	--	--	--
Strontium	130 / 130	100	ug/L	--	--	50.4	179	130	775	50.4	179	775	--	--	--	--	--	--	--	--
Thallium	6 / 128	4.69	ug/L	0.0041	40	0.0021	0.8157	0.5	20	0.01	0.04	0.08	--	--	--	--	0.47	0 / 128	--	--
Tin	2 / 42	4.76	ug/L	0.9	50	0.45	3.146	1.25	25	0.62	0.91	1.2	--	--	--	--	--	--	--	--
Titanium	32 / 37	86.5	ug/L	1	5	0.5	34.6	12	200	1.7	39.4	200	--	--	--	--	--	--	--	--
Uranium	86 / 127	67.7	ug/L	0	15	0	4.484	2.8	61.2	0.96	5.61	61.2	--	--	--	--	--	--	480	0 / 127
Vanadium	34 / 130	26.2	ug/L	0.15	10	0.075	3.583	0.72	49.6	0.46	9.479	49.6	--	--	--	--	--	--	--	--
Zinc	129 / 172	75	ug/L	0.12	10	0.06	17.6	11	129	1.1	22.3	129	120	**1 / 172**	117	**1 / 172**	--	--	--	--
Zirconium	6 / 24	25	ug/L	0.66	50	0.33	7.357	0.685	25	1.04	3.768	11.1	--	--	--	--	--	--	--	--
Dioxins/Furans																				
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1 / 31	3.23	ug/L	4.2E-07	7.2E-06	2.1E-07	1.2E-06	1.3E-06	3.6E-06	1.1E-06	1.1E-06	1.1E-06	--	--	--	--	--	--	--	--
Herbicides																				
Silvex	0 / 28	0	ug/L	0.079	0.515	0.0395	0.1613	0.25	0.2575	--	--	--	--	--	--	--	--	--	--	--
Pesticides																				
4,4'-DDD	2 / 79	2.53	ug/L	0.0019	0.0551	9.7E-04	0.0208	0.025	0.0276	0.013	0.0165	0.02	--	--	--	--	0.0031	**2 / 79**	--	--
4,4'-DDE	3 / 79	3.8	ug/L	0.0019	0.0551	9.7E-04	0.0207	0.025	0.0276	0.011	0.0163	0.026	--	--	--	--	0.0022	**3 / 79**	--	--
4,4'-DDT	1 / 116	0.86	ug/L	0.001	0.0551	5.0E-04	0.0169	0.025	0.0276	0.01	0.01	0.01	0.001	**1 / 116**	1.1	0 / 116	0.0022	**1 / 116**	--	--
Aldrin	5 / 101	4.95	ug/L	0.0013	0.0551	6.5E-04	0.0158	0.025	0.0276	0.012	0.016	0.02	--	--	3	0 / 101	5.0E-04	**5 / 101**	--	--
Chlordane	0 / 1	0	ug/L	0.1	0.1	0.05	0.05	0.05	0.05	--	--	--	0.0043	0 / 1	2.4	0 / 1	0.0081	0 / 1	--	--
Dieldrin	1 / 120	0.83	ug/L	0.001	0.5	5.0E-04	0.0249	0.025	0.25	0.017	0.017	0.017	0.056	0 / 120	0.24	0 / 120	5.4E-04	**1 / 120**	--	--
Endosulfan I	0 / 97	0	ug/L	0.0013	0.0551	6.5E-04	0.0168	0.025	0.0276	--	--	--	0.056	0 / 97	0.22	0 / 97	89	0 / 97	--	--
Endosulfan II	0 / 112	0	ug/L	0.001	0.0551	5.0E-04	0.0175	0.025	0.0276	--	--	--	0.056	0 / 112	0.22	0 / 112	89	0 / 112	--	--
Endosulfan sulfate	0 / 56	0	ug/L	0.0019	0.0551	9.7E-04	0.0208	0.025	0.0276	--	--	--	--	--	--	--	89	0 / 56	--	--
Endrin	1 / 112	0.89	ug/L	0.001	0.0551	5.0E-04	0.0174	0.025	0.0276	0.01	0.01	0.01	0.036	0 / 112	0.086	0 / 112	0.06	0 / 112	--	--

Attachment 1. EMWMF summary statistics and comparison to AWQC for Unfiltered Surface Water from EMW-VWEIR 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Mean	Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	24% of DCG[f]	Freq. > 24% of DCG[f]
Endrin aldehyde	0 / 75	0	ug/L	0.0013	0.0551	6.5E-04	0.0217	0.025	0.0276	--	--	--	--	--	--	--	0.3	0 / 75	--	--
Endrin ketone	0 / 28	0	ug/L	0.0019	0.0551	9.7E-04	0.0166	0.025	0.0276	--	--	--	--	--	--	--	--	--	--	--
Heptachlor	0 / 74	0	ug/L	0.0013	0.0551	6.5E-04	0.0142	0.016	0.0276	--	--	--	0.0038	0 / 74	0.52	0 / 74	7.9E-04	0 / 74	--	--
Heptachlor epoxide	2 / 112	1.79	ug/L	0.001	0.0551	5.0E-04	0.0102	0.001	0.814	0.017	0.4155	0.814	0.0038	**2 / 112**	0.52	**1 / 112**	3.9E-04	**2 / 112**	--	--
Lindane	0 / 29	0	ug/L	0.0013	0.0139	6.5E-04	0.0034	0.0034	0.007	--	--	--	--	--	0.95	0 / 29	1.8	0 / 29	--	--
Methoxychlor	2 / 51	3.92	ug/L	0.0097	0.104	0.0049	0.025	0.025	0.052	0.011	0.018	0.025	0.001	**2 / 51**	--	--	--	--	--	--
alpha-BHC	1 / 57	1.75	ug/L	0.0013	0.0551	6.5E-04	0.0205	0.025	0.0276	0.022	0.022	0.022	--	--	--	--	0.049	0 / 57	--	--
alpha-Chlordane	0 / 126	0	ug/L	0.001	0.0551	5.0E-04	0.0179	0.025	0.0276	--	--	--	--	--	--	--	--	--	--	--
beta-BHC	10 / 65	15.4	ug/L	0.0013	0.0551	6.5E-04	0.014	0.011	0.095	0.01	0.0225	0.095	--	--	--	--	0.17	0 / 65	--	--
delta-BHC	0 / 57	0	ug/L	0.0013	0.0551	6.5E-04	0.0205	0.025	0.0276	--	--	--	--	--	--	--	--	--	--	--
gamma-Chlordane	1 / 126	0.79	ug/L	0.001	0.0551	5.0E-04	0.0178	0.025	0.0276	0.012	0.012	0.012	--	--	--	--	--	--	--	--
Polychlorinated Biphenyls																				
PCB-1016	0 / 254	0	ug/L	0.0311	0.532	0.0156	0.1151	0.075	0.266	--	--	--	--	--	0.5	0 / 254	6.4E-04	0 / 254	--	--
PCB-1221	0 / 254	0	ug/L	0.0311	0.532	0.0156	0.1155	0.085	0.266	--	--	--	--	--	0.5	0 / 254	6.4E-04	0 / 254	--	--
PCB-1232	0 / 254	0	ug/L	0.0311	0.532	0.0156	0.1152	0.0775	0.266	--	--	--	--	--	0.5	0 / 254	6.4E-04	0 / 254	--	--
PCB-1242	0 / 259	0	ug/L	0.0311	0.532	0.0156	0.1154	0.1	0.266	--	--	--	--	--	0.5	0 / 259	6.4E-04	0 / 259	--	--
PCB-1248	0 / 254	0	ug/L	0.0311	0.532	0.0156	0.1148	0.0625	0.266	--	--	--	--	--	0.5	0 / 254	6.4E-04	0 / 254	--	--
PCB-1254	0 / 259	0	ug/L	0.0311	0.532	0.0156	0.1162	0.1	0.266	--	--	--	--	--	0.5	0 / 259	6.4E-04	0 / 259	--	--
PCB-1260	0 / 259	0	ug/L	0.0311	0.532	0.0156	0.1155	0.1	0.266	--	--	--	--	--	0.5	0 / 259	6.4E-04	0 / 259	--	--
PCB-1262	0 / 241	0	ug/L	0.0311	0.532	0.0156	0.1099	0.049	0.266	--	--	--	--	--	0.5	0 / 241	6.4E-04	0 / 241	--	--
PCB-1268	0 / 241	0	ug/L	0.0311	0.532	0.0156	0.1106	0.065	0.266	--	--	--	--	--	0.5	0 / 241	6.4E-04	0 / 241	--	--
Polychlorinated biphenyl	0 / 8	0	ug/L	0.15	0.18	0.075	0.0819	0.08	0.09	--	--	--	0.014	0 / 8	--	--	6.4E-04	0 / 8	--	--
Semivolatile Organics																				
1,2,4-Trichlorobenzene	0 / 60	0	ug/L	0.5	11.2	0.25	2.381	0.78	5.6	--	--	--	--	--	--	--	70	0 / 60	--	--
1,2-Dichlorobenzene	0 / 60	0	ug/L	0.5	11.2	0.25	2.381	0.78	5.6	--	--	--	--	--	--	--	1300	0 / 60	--	--
1,3-Dichlorobenzene	0 / 60	0	ug/L	0.5	11.2	0.25	2.381	0.78	5.6	--	--	--	--	--	--	--	960	0 / 60	--	--
1,4-Dichlorobenzene	0 / 60	0	ug/L	0.5	11.2	0.25	2.381	0.78	5.6	--	--	--	--	--	--	--	190	0 / 60	--	--
2,3,4,6-Tetrachlorophenol	0 / 69	0	ug/L	1.42	11.2	0.71	4.237	5	5.6	--	--	--	--	--	--	--	--	--	--	--
2,4-Dimethylphenol	0 / 37	0	ug/L	1.42	11.2	0.71	3.577	5	5.6	--	--	--	--	--	--	--	850	0 / 37	--	--
2,4-Dinitrophenol	0 / 37	0	ug/L	2.36	28	1.18	8.919	12.5	14	--	--	--	--	--	--	--	5300	0 / 37	--	--
2-Methylnaphthalene	0 / 74	0	ug/L	0.142	11.2	0.071	4.177	5	5.6	--	--	--	--	--	--	--	--	--	--	--
2-Methylphenol	0 / 37	0	ug/L	1.42	11.2	0.71	3.577	5	5.6	--	--	--	--	--	--	--	--	--	--	--
3- and 4- Methylphenol	0 / 48	0	ug/L	5	11.2	2.5	4.963	5	5.6	--	--	--	--	--	--	--	--	--	--	--
4-Chloro-3-methylphenol	0 / 40	0	ug/L	1.42	20	0.71	3.871	5	10	--	--	--	--	--	--	--	--	--	--	--
4-Methylphenol	0 / 11	0	ug/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Acenaphthene	0 / 41	0	ug/L	0.142	11.2	0.071	3.052	5	5.6	--	--	--	--	--	--	--	990	0 / 41	--	--
Acenaphthylene	0 / 40	0	ug/L	0.142	11.2	0.071	3.54	5	5.6	--	--	--	--	--	--	--	--	--	--	--
Acetophenone	0 / 60	0	ug/L	1.42	11.2	0.71	4.123	5	5.6	--	--	--	--	--	--	--	--	--	--	--
Anthracene	0 / 37	0	ug/L	0.142	11.2	0.071	3.354	5	5.6	--	--	--	--	--	--	--	40,000	0 / 37	--	--
Benz(a)anthracene	0 / 37	0	ug/L	0.142	0.556	0.071	0.1946	0.25	0.278	--	--	--	--	--	--	--	0.18	0 / 37	--	--
Benzenemethanol	0 / 40	0	ug/L	1.42	20	0.71	4.746	5	10	--	--	--	--	--	--	--	--	--	--	--
Benzidine	0 / 28	0	ug/L	1.5	56.1	0.75	14.8	25	28.1	--	--	--	--	--	--	--	0.002	0 / 28	--	--
Benzo(a)pyrene	0 / 37	0	ug/L	0.142	0.556	0.071	0.1965	0.25	0.278	--	--	--	--	--	--	--	0.18	0 / 37	--	--
Benzo(b)fluoranthene	0 / 37	0	ug/L	0.142	0.556	0.071	0.1946	0.25	0.278	--	--	--	--	--	--	--	0.18	0 / 37	--	--
Benzo(ghi)perylene	0 / 37	0	ug/L	0.142	0.556	0.071	0.1946	0.25	0.278	--	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	1 / 37	2.7	ug/L	0.142	0.556	0.071	0.2014	0.25	0.5	0.5	0.5	0.5	--	--	--	--	0.18	**1 / 37**	--	--
Benzoic acid	6 / 73	8.22	ug/L	2.83	51	0.5	16.2	25	25.5	0.5	1.267	3	--	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	2 / 37	5.41	ug/L	1.42	10	0.71	2.028	2.5	5	2	2.91	3.82	--	--	--	--	22	0 / 37	--	--
Butyl benzyl phthalate	0 / 37	0	ug/L	1.42	11.2	0.71	3.577	5	5.6	--	--	--	--	--	--	--	1900	0 / 37	--	--
Carbazole	0 / 40	0	ug/L	0.142	5.61	0.071	1.557	2.5	2.805	--	--	--	--	--	--	--	--	--	--	--
Chrysene	0 / 37	0	ug/L	0.142	11.2	0.071	3.354	5	5.6	--	--	--	--	--	--	--	0.18	0 / 37	--	--
Di-n-butyl phthalate	3 / 41	7.32	ug/L	1	11.2	0.5	3.155	5	5.6	0.5	1.833	3	--	--	--	--	4500	0 / 41	--	--
Di-n-octylphthalate	0 / 37	0	ug/L	1.42	11.2	0.71	3.577	5	5.6	--	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	0 / 37	0	ug/L	0.142	0.556	0.071	0.1946	0.25	0.278	--	--	--	--	--	--	--	0.18	0 / 37	--	--
Dibenzofuran	0 / 37	0	ug/L	1.42	11.2	0.71	3.577	5	5.6	--	--	--	--	--	--	--	--	--	--	--
Diethyl phthalate	0 / 37	0	ug/L	1.42	11.2	0.71	3.577	5	5.6	--	--	--	--	--	--	--	44,000	0 / 37	--	--
Dimethyl phthalate	2 / 37	5.41	ug/L	1.42	11.2	0.71	3.45	5	5.6	2.53	2.695	2.86	--	--	--	--	1.1E+06	0 / 37	--	--
Diphenylamine	0 / 12	0	ug/L	1.42	1.67	0.71	0.7625	0.75	0.835	--	--	--	--	--	--	--	--	--	--	--
Fluoranthene	0 / 37	0	ug/L	0.142	11.2	0.071	3.354	5	5.6	--	--	--	--	--	--	--	140	0 / 37	--	--
Fluorene	0 / 37	0	ug/L	0.142	11.2	0.071	3.354	5	5.6	--	--	--	--	--	--	--	5300	0 / 37	--	--

Attachment 1. EMWMF summary statistics and comparison to AWQC for Unfiltered Surface Water from EMW-VWEIR 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	24% of DCG[f]	Freq. > 24% of DCG[f]
Hexachlorobenzene	0 / 22	0	ug/L	1.42	11.2	0.71	2.716	0.835	5.6	--	--	--	--	--	--	--	0.0029	0 / 22	--	--
Hexachlorobutadiene	0 / 40	0	ug/L	1.42	11.2	0.71	3.746	5	5.6	--	--	--	--	--	--	--	180	0 / 40	--	--
Hexachloroethane	0 / 3	0	ug/L	10	10	5	5	5	5	--	--	--	--	--	--	--	33	0 / 3	--	--
Indeno(1,2,3-cd)pyrene	1 / 37	2.7	ug/L	0.142	0.556	0.071	0.2041	0.25	0.6	0.6	0.6	0.6	--	--	--	--	0.18	**1 / 37**	--	--
Isophorone	0 / 37	0	ug/L	1.5	11.2	0.75	3.611	5	5.6	--	--	--	--	--	--	--	9600	0 / 37	--	--
Naphthalene	0 / 41	0	ug/L	0.142	11.2	0.071	3.052	5	5.6	--	--	--	--	--	--	--	--	--	--	--
Pentachlorophenol	0 / 88	0	ug/L	0.0476	25	0.0238	2.115	1.5	12.5	--	--	--	15	0 / 88	19	0 / 88	30	0 / 88	--	--
Phenanthrene	0 / 37	0	ug/L	0.142	11.2	0.071	3.354	5	5.6	--	--	--	--	--	--	--	--	--	--	--
Phenol	0 / 69	0	ug/L	1.42	11.2	0.71	4.237	5	5.6	--	--	--	--	--	--	--	1.7E+06	0 / 69	--	--
Pyrene	0 / 37	0	ug/L	0.142	11.2	0.071	3.354	5	5.6	--	--	--	--	--	--	--	4000	0 / 37	--	--
m+p Methylphenol	0 / 15	0	ug/L	1.5	10	0.75	1.728	0.925	5	--	--	--	--	--	--	--	--	--	--	--
Volatile Organics																				
(1,1-Dimethylethyl)benzene	0 / 31	0	ug/L	0.3	5	0.15	1.591	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
(1-Methylpropyl)benzene	0 / 31	0	ug/L	0.3	5	0.15	1.591	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	0 / 203	0	ug/L	0.3	5	0.15	0.7358	0.1665	2.5	--	--	--	--	--	--	--	--	--	--	--
1,1,2,2-Tetrachloroethane	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	40	0 / 194	--	--
1,1,2-Trichloroethane	0 / 198	0	ug/L	0.3	5	0.15	0.6913	0.1665	2.5	--	--	--	--	--	--	--	160	0 / 198	--	--
1,1-Dichloroethane	0 / 203	0	ug/L	0.3	5	0.15	0.7358	0.1665	2.5	--	--	--	--	--	--	--	--	--	--	--
1,1-Dichloroethene	0 / 199	0	ug/L	0.3	5	0.15	0.7079	0.1665	2.5	--	--	--	--	--	--	--	7100	0 / 199	--	--
1,2,3-Trimethylbenzene	0 / 18	0	ug/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,2,4-Trichlorobenzene	0 / 17	0	ug/L	1	1	0.5	0.5	0.5	0.5	--	--	--	--	--	--	--	70	0 / 17	--	--
1,2,4-Trimethylbenzene	0 / 32	0	ug/L	0.3	5	0.15	1.62	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,2-Dichlorobenzene	0 / 148	0	ug/L	0.3	5	0.15	0.5891	0.1665	2.5	--	--	--	--	--	--	--	1300	0 / 148	--	--
1,2-Dichloroethane	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	370	0 / 194	--	--
1,2-Dichloropropane	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	150	0 / 194	--	--
1,2-Dimethylbenzene	0 / 60	0	ug/L	0.3	5	0.15	2.031	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	0 / 32	0	ug/L	0.3	5	0.15	1.63	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,3-Dichlorobenzene	0 / 148	0	ug/L	0.3	5	0.15	0.5891	0.1665	2.5	--	--	--	--	--	--	--	960	0 / 148	--	--
1,4-Dichlorobenzene	0 / 148	0	ug/L	0.3	5	0.15	0.5891	0.1665	2.5	--	--	--	--	--	--	--	190	0 / 148	--	--
1-Methyl-4-(1-methylethyl)benzene	0 / 31	0	ug/L	0.3	5	0.15	1.591	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
2-Butanone	1 / 59	1.69	ug/L	1.5	10	0.75	4.109	5	5	2	2	2	--	--	--	--	--	--	--	--
2-Chloroethyl vinyl ether	0 / 194	0	ug/L	0.5	5	0.25	1.126	0.835	2.5	--	--	--	--	--	--	--	--	--	--	--
2-Hexanone	0 / 60	0	ug/L	1.5	10	0.75	4.182	5	5	--	--	--	--	--	--	--	--	--	--	--
4-Methyl-2-pentanone	0 / 76	0	ug/L	1.5	10	0.75	4.331	5	5	--	--	--	--	--	--	--	--	--	--	--
Acetone	7 / 76	9.21	ug/L	1.5	10	0.75	4.255	5	5	3	3.806	5	--	--	--	--	--	--	--	--
Acrylonitrile	0 / 22	0	ug/L	1.5	20	0.75	4.962	0.835	10	--	--	--	--	--	--	--	2.5	0 / 22	--	--
Benzene	0 / 76	0	ug/L	0.3	5	0.15	2.129	2.5	2.5	--	--	--	--	--	--	--	510	0 / 76	--	--
Bromodichloromethane	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	170	0 / 194	--	--
Bromoform	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	1400	0 / 194	--	--
Bromomethane	0 / 194	0	ug/L	0.3	5	0.15	0.6546	0.1685	2.5	--	--	--	--	--	--	--	1500	0 / 194	--	--
Carbon disulfide	0 / 59	0	ug/L	1.5	5	0.75	2.147	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Carbon tetrachloride	0 / 206	0	ug/L	0.3	5	0.15	0.7567	0.1665	2.5	--	--	--	--	--	--	--	16	0 / 206	--	--
Chlorobenzene	0 / 206	0	ug/L	0.3	5	0.15	0.7615	0.1665	2.5	--	--	--	--	--	--	--	1600	0 / 206	--	--
Chloroethane	0 / 203	0	ug/L	0.3	5	0.15	0.7358	0.1665	2.5	--	--	--	--	--	--	--	--	--	--	--
Chloroform	1 / 206	0.49	ug/L	0.3	5	0.15	0.7622	0.1665	2.63	2.63	2.63	2.63	--	--	--	--	4700	0 / 206	--	--
Chloromethane	1 / 194	0.52	ug/L	0.3	5	0.15	0.6589	0.1665	2.5	1.2	1.2	1.2	--	--	--	--	--	--	--	--
Cumene	0 / 60	0	ug/L	0.3	5	0.15	2.031	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Dibromochloromethane	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	170	0 / 194	--	--
Dichlorodifluoromethane	0 / 194	0	ug/L	0.3	5	0.15	0.6575	0.1775	2.5	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	0 / 60	0	ug/L	0.3	5	0.15	2.031	2.5	2.5	--	--	--	--	--	--	--	2100	0 / 60	--	--
Hexane	0 / 29	0	ug/L	1.67	5	0.835	1.872	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
M + P Xylene	0 / 24	0	ug/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Methanol	0 / 21	0	ug/L	250	5000	125	1143	125	2500	--	--	--	--	--	--	--	--	--	--	--
Methylcyclohexane	0 / 76	0	ug/L	0.3	5	0.15	2.129	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Methylene chloride	2 / 205	0.98	ug/L	0.5	5	0.25	1.019	0.835	2.5	2.02	2.05	2.08	--	--	--	--	5900	0 / 205	--	--
Propylbenzene	0 / 31	0	ug/L	0.3	5	0.15	1.591	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Propylene glycol	0 / 22	0	ug/L	3000	20,000	1500	5636	4500	10,000	--	--	--	--	--	--	--	--	--	--	--
Styrene	0 / 29	0	ug/L	0.3	5	0.15	1.529	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Tetrachloroethene	0 / 206	0	ug/L	0.3	5	0.15	0.7615	0.1665	2.5	--	--	--	--	--	--	--	33	0 / 206	--	--
Toluene	2 / 76	2.63	ug/L	0.3	5	0.15	2.07	2.5	2.5	0.2	0.25	0.3	--	--	--	--	15,000	0 / 76	--	--

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Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	24% of DCG[f]	Freq. > 24% of DCG[f]
Total Xylene	0 / 76	0	ug/L	0.3	5	0.15	2.138	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Trichloroethene	0 / 206	0	ug/L	0.3	5	0.15	0.7615	0.1665	2.5	--	--	--	--	--	--	--	300	0 / 206	--	--
Trichlorofluoromethane	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	--	--	--	--
Trimethylbenzene	0 / 12	0	ug/L	0.3	0.33	0.15	0.1525	0.15	0.165	--	--	--	--	--	--	--	--	--	--	--
Vinyl chloride	0 / 203	0	ug/L	0.3	5	0.15	0.7358	0.1665	2.5	--	--	--	--	--	--	--	24	0 / 203	--	--
cis-1,2-Dichloroethene	0 / 35	0	ug/L	0.3	5	0.15	1.695	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
cis-1,3-Dichloropropene	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	--	--	--	--
trans-1,2-Dichloroethene	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	10,000	0 / 194	--	--
trans-1,3-Dichloropropene	0 / 194	0	ug/L	0.3	5	0.15	0.654	0.1665	2.5	--	--	--	--	--	--	--	--	--	--	--
Other Organics																				
Extractable Petroleum Hydrocarbons	2 / 9	22.2	ug/L	1100	5000	550	2393	1100	9700	3000	6350	9700	--	--	--	--	--	--	--	--
Oil and Grease	3 / 24	12.5	ug/L	1100	3800	550	919	723	1900	1300	1503	1650	--	--	--	--	--	--	--	--
Radionuclides																				
Actinium-227	87 / 730	11.9	pCi/L	0.05	2.67	-0.176	0.1226	0.09	3.64	0.14	0.3636	3.64	--	--	--	--	--	--	2.4	0 / 730
Alpha activity	126 / 132	95.5	pCi/L	1.81	3.84	0.3	15.3	8.57	132	1.51	15.9	132	--	--	--	--	--	--	--	--
Aluminum-26	7 / 608	1.15	pCi/L	1.81	14.9	-5.23	0.2582	0.16	6.22	1.91	3.4	5.46	--	--	--	--	--	--	2400	0 / 608
Americium-241	21 / 908	2.31	pCi/L	0.0383	1.3	-0.17	0.0667	0.0511	0.832	0.133	0.3055	0.832	--	--	--	--	--	--	7.2	0 / 908
Americium-243	65 / 698	9.31	pCi/L	0.07	4.93	-0.12	0.1203	0.0919	1.02	0.12	0.3433	1.02	--	--	--	--	--	--	7.2	0 / 698
Beta activity	132 / 132	100	pCi/L	--	--	5.96	94.3	34.2	1240	5.96	94.3	1240	--	--	--	--	--	--	--	--
Californium-252	1 / 682	0.15	pCi/L	0.0434	1.19	-0.75	0.0099	0	0.418	0.27	0.27	0.27	--	--	--	--	--	--	24	0 / 682
Carbon-14	29 / 912	3.18	pCi/L	1.47	68.3	-20.7	2.683	3.66	33.4	8.08	19.7	33.4	--	--	--	--	--	--	16,800	0 / 912
Cesium-137	19 / 933	2.04	pCi/L	2.48	16	-6.24	0.9316	0.72	13	2.98	6.223	13	--	--	--	--	--	--	720	0 / 933
Chlorine-36	170 / 912	18.6	pCi/L	0.7	5.33	-2.85	1.798	1.03	76.3	1.91	5.987	76.3	--	--	--	--	--	--	12,000	0 / 912
Cobalt-60	4 / 911	0.44	pCi/L	2.2	13	-6.18	0.8279	0.679	7.76	3.45	5.48	6.62	--	--	--	--	--	--	1200	0 / 911
Curium-242	1 / 705	0.14	pCi/L	0.0434	1.19	-0.75	0.0104	0	0.418	0.27	0.27	0.27	--	--	--	--	--	--	240	0 / 705
Curium-243/244	19 / 700	2.71	pCi/L	0.046	1.39	-0.77	0.0567	0.0395	0.65	0.146	0.3607	0.65	--	--	--	--	--	--	12	0 / 700
Curium-245	118 / 876	13.5	pCi/L	0.08	7.44	-0.172	0.1439	0.11	1.7	0.12	0.3869	1.7	--	--	--	--	--	--	7.2	0 / 876
Curium-246	118 / 876	13.5	pCi/L	0.08	7.44	-0.172	0.1438	0.11	1.7	0.12	0.3869	1.7	--	--	--	--	--	--	7.2	0 / 876
Curium-247	17 / 874	1.95	pCi/L	0.04	5.63	-0.437	0.0541	0.03	1.53	0.18	0.4128	1.27	--	--	--	--	--	--	7.2	0 / 874
Curium-248	31 / 726	4.27	pCi/L	0.06	5.35	-0.081	0.0482	0.03	0.85	0.12	0.2763	0.85	--	--	--	--	--	--	1.92	0 / 726
Europium-152	3 / 887	0.34	pCi/L	5.83	69.2	-36	0.8208	0.504	62.8	22.6	37.8	62.8	--	--	--	--	--	--	4,800	0 / 887
Europium-154	8 / 885	0.9	pCi/L	3.02	29.4	-15.8	0.719	0.8	18.8	7.65	12.2	18.8	--	--	--	--	--	--	4,800	0 / 885
Europium-155	4 / 703	0.57	pCi/L	3.75	28.6	-40.6	-0.4537	0.198	33.9	6.74	12.0	16.2	--	--	--	--	--	--	24,000	0 / 703
Europium-156	0 / 1	0	pCi/L	27	27	7.61	7.61	7.61	7.61	--	--	--	--	--	--	--	--	--	--	--
Iodine-129	129 / 912	14.1	pCi/L	0.317	3.53	-2.02	0.7606	0.8485	6.79	0.58	1.534	6.79	--	--	--	--	--	--	120	0 / 912
Lead-210	206 / 771	26.7	pCi/L	0.0721	1.89	-1.07	0.5435	0.5	6	0.35	1.082	6	--	--	--	--	--	--	7.2	0 / 771
Neptunium-237	41 / 911	4.5	pCi/L	0.04	1.6	-0.16	0.0492	0.03	2.91	0.12	0.3579	2.91	--	--	--	--	--	--	7.2	0 / 911
Neptunium-239	0 / 1	0	pCi/L	0.09	0.09	0.03	0.03	0.03	0.03	--	--	--	--	--	--	--	--	--	--	--
Nickel-63	85 / 857	9.92	pCi/L	0.04	91	-88.9	7.493	4.02	206	15.3	47.8	206	--	--	--	--	--	--	72,000	0 / 857
Plutonium-236	5 / 704	0.71	pCi/L	0.07	0.943	-0.19	0.0171	0.0082	0.975	0.19	0.467	0.975	--	--	--	--	--	--	24	0 / 704
Plutonium-238	2 / 884	0.23	pCi/L	0.08	1.17	-0.213	0.0254	0.0189	0.48	0.15	0.315	0.48	--	--	--	--	--	--	9.6	0 / 884
Plutonium-239/240	19 / 910	2.09	pCi/L	0.04	1.23	-0.199	0.0327	0.02	0.43	0.07	0.2524	0.43	--	--	--	--	--	--	7.2	0 / 910
Plutonium-241	9 / 861	1.05	pCi/L	8.52	90.7	-164	0.4979	0	69	15.1	40.2	69	--	--	--	--	--	--	480	0 / 861
Plutonium-242	69 / 883	7.81	pCi/L	0.06	0.741	-2.9	0.075	0.0654	2.63	0.1	0.2756	1	--	--	--	--	--	--	7.2	0 / 883
Plutonium-244	61 / 702	8.69	pCi/L	0.04	0.912	-0.137	0.0969	0.05	3.18	0.106	0.486	3.18	--	--	--	--	--	--	7.2	0 / 702
Potassium-40	69 / 910	7.58	pCi/L	5.94	208	-72.4	24.5	24.3	170	27.8	59.6	170	--	--	--	--	--	--	1680	0 / 910
Protactinium-234m	869 / 912	95.3	pCi/L	0.25	1.81	-0.0368	2.438	1.31	55.2	0.26	2.546	55.2	--	--	--	--	--	--	16,800	0 / 912
Radioactive Strontium (Total)	42 / 42	100	pCi/L	--	--	1.24	54.8	28.7	450	1.24	54.8	450	--	--	--	--	--	--	--	--
Radium-226	150 / 904	16.6	pCi/L	0.08	1.35	-0.217	0.2222	0.184	1.43	0.1	0.5307	1.43	--	--	--	--	--	--	24	0 / 904
Radium-228	176 / 912	19.3	pCi/L	0.07	2.38	-0.88	0.4308	0.35	3.19	0.35	1.142	3.19	--	--	--	--	--	--	24	0 / 912
Strontium-90	639 / 894	71.5	pCi/L	0.372	3.71	-1.29	13.2	1.8	729	0.22	18.2	729	--	--	--	--	--	--	240	0 / 894
Technetium-99	727 / 933	77.9	pCi/L	0.01	12.1	-5.55	119	15.2	8520	2.72	152	8520	--	--	--	--	--	--	24,000	0 / 933
Thorium-227	80 / 705	11.3	pCi/L	0.05	2.67	-0.176	0.1214	0.09	3.64	0.14	0.3674	3.64	--	--	--	--	--	--	960	0 / 705
Thorium-228	93 / 912	10.2	pCi/L	0.07	1.64	-0.339	0.0927	0.0637	1.26	0.12	0.3395	1.26	--	--	--	--	--	--	96	0 / 912
Thorium-229	25 / 832	3.0	pCi/L	0.04	1.33	-4.3	0.0462	0.02	6.68	0.06	0.6111	6.68	--	--	--	--	--	--	9.6	0 / 832
Thorium-230	512 / 909	56.3	pCi/L	0.07	1.34	-0.133	0.3107	0.25	4.1	0.09	0.4163	4.1	--	--	--	--	--	--	72	0 / 909
Thorium-232	126 / 909	13.9	pCi/L	0.04	1.13	-0.209	0.0954	0.07	1.1	0.117	0.2977	1.1	--	--	--	--	--	--	12	0 / 909
Thorium-234	844 / 887	95.2	pCi/L	0.25	1.81	-0.0368	2.261	1.3	25.4	0.26	2.363	25.4	--	--	--	--	--	--	2400	0 / 887
Tritium	417 / 912	45.7	pCi/L	177	703	-419	372	208	4510	147	697	4510	--	--	--	--	--	--	4.8E+05	0 / 912
Uranium-232	62 / 684	9.06	pCi/L	0.04	0.94	-0.283	0.1134	0.08	1.47	0.22	0.4459	1.47	--	--	--	--	--	--	24	0 / 684

Attachment 1. EMWMF summary statistics and comparison to AWQC for Unfiltered Surface Water from EMW-VWEIR 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	24% of DCG[f]	Freq. > 24% of DCG[f]
Uranium-233/234	932 / 933	99.9	pCi/L	0.49	0.49	0.37	12.5	7.07	155	0.37	12.6	155	--	--	--	--	--	--	120	0 / 933
Uranium-234	1 / 1	100	pCi/L	--	--	0.334	0.334	0.334	0.334	0.334	0.334	0.334	--	--	--	--	--	--	120	0 / 1
Uranium-235	4 / 11	36.4	pCi/L	0.11	0.41	-0.0089	0.2846	0.28	0.59	0.37	0.49	0.59	--	--	--	--	--	--	144	0 / 11
Uranium-235/236	686 / 928	73.9	pCi/L	0.0847	2.04	-0.08	1.064	0.6735	15.6	0.157	1.351	15.6	--	--	--	--	--	--	120	0 / 928
Uranium-236	1 / 9	11.1	pCi/L	0.15	0.67	0	0.1456	0.11	0.34	0.34	0.34	0.34	--	--	--	--	--	--	120	0 / 9
Uranium-238	891 / 933	95.5	pCi/L	0.25	1.81	-0.0368	2.429	1.31	55.2	0.178	2.53	55.2	--	--	--	--	--	--	144	0 / 933
Yttrium-90	623 / 887	70.2	pCi/L	0.454	3.71	-1.29	12.4	1.8	526	0.22	17.4	526	--	--	--	--	--	--	2400	0 / 887
Wet Chemistry																				
Ammonia	12 / 17	70.6	ug/L	17	17	8.5	114	128	192	103	141	192	--	--	--	--	--	--	--	--
Ammonia as Nitrogen	7 / 16	43.8	ug/L	100	100	50	144	100	420	120	200	420	--	--	--	--	--	--	--	--
Biochemical Oxygen Demand (BOD)	20 / 33	60.6	ug/L	1000	3000	500	2503	1520	8980	1000	3278	8980	--	--	--	--	--	--	--	--
Conductivity	49 / 49	100	umhos/cm	--	--	110	397	373	926	110	397	926	--	--	--	--	--	--	--	--
Cyanide	0 / 58	0	ug/L	1.1	6.1	0.55	1.82	2.5	3.05	--	--	--	5.2	0 / 58	22	0 / 58	140	0 / 58	--	--
Dissolved Solids	97 / 98	99.0	mg/L	4.7	4.7	2.35	284	210	6100	68	287	6100	--	--	--	--	--	--	--	--
Residue, Non-filterable (TSS)	10 / 10	100	ug/L	--	--	5000	116,800	42,000	700,000	5000	116,800	700,000	--	--	--	--	--	--	--	--
Settleable Solids	0 / 4	0	ml/L	0.5	0.5	0.25	0.25	0.25	0.25	--	--	--	--	--	--	--	--	--	--	--
Silica	10 / 10	100	ug/L	--	--	1440	5207	4050	10,300	1440	5207	10,300	--	--	--	--	--	--	--	--
Suspended Solids	422 / 459	91.9	ug/L	570	5000	285	38,305	19,300	832,000	1100	41,446	832,000	--	--	--	--	--	--	--	--
Total Organic Carbon Average	4 / 4	100	ug/L	--	--	2930	5275	5355	7460	2930	5275	7460	--	--	--	--	--	--	--	--
Turbidity	1 / 1	100	NTU	--	--	16.9	16.9	16.9	16.9	16.9	16.9	16.9	--	--	--	--	--	--	--	--

[a] One half of the detection limits shown are used as proxy values for chemicals for non-detects except where there is sufficient detected data to calculate Kaplan-Meier summary statistics.

[b] This summary statistic is calculated using both detects and non-detects. Kaplan-Meier is used where there is sufficient detected data for chemicals.

[c] CCC = Tennessee Department of Environment and Conservation chapter 0400-40-03 fish and aquatic life Criterion Continuous Concentration general water quality criteria September 2019.

[d] CMC = Tennessee Department of Environment and Conservation chapter 0400-40-03 fish and aquatic life Criterion Maximum Concentration general water quality criteria September 2019.

[e] Rec. OOC = Tennessee Department of Environment and Conservation chapter 0400-40-03 recreation Organisms Only Criteria general water quality criteria September 2019.

[f] DCG = U.S. Environmental Protection Agency derived concentration guideline for radionuclides.

Dist. = distribution. Distribution flags are defined as:

D = The distribution could not be determined with fewer than 6 samples and 3 detects. The UCL95 was calculated using the nonparametric Chebyshev inequality method with at least 2 detects and 3 samples.

L = lognormal. UCL95 was calculated using Land's statistic, Chebyshev minimum variance unbiased estimator, or nonparametric Chebyshev inequality method.

N = normal. UCL95 was calculated using t statistic.

O = no detected results to calculate some summary statistics.

X = neither normal, lognormal nor gamma. UCL95 was calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.

mg/L = milligrams per liter.

µg/L = micrograms per liter.

pCi/L = picocuries per liter.

S.D. = standard deviation.

UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.

UTL95/95 = upper tolerance limit on individual concentrations with 95% confidence and 95% coverage. A nonparametric UTL95/95 requires at least 59 samples.

UTL95/95 values shown in italic font have less than 95% confidence with 95% coverage because there are either fewer than 59 samples for nonparametric or non-detects have higher concentrations than detects.

-- = Not applicable, not available or insufficient data to calculate the statistic.

* The mean, median, standard deviation and UCL95 were calculated using the Kaplan-Meier method for organics and inorganics. UTL95/95 used Kaplan-Meier for parametric distributions for organics and inorganics.

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APPENDIX C.
ATTACHMENT 2—CONTACT WATER DATA

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Attachment 2. EMWMF summary statistics and comparison to AWQC for Unfiltered Contact Water 2005-2021

Chemical	CAS Number	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	UTL 95/95[b]	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
Unfiltered Surface Water from tanks and ponds 2005-2021																										
Metals																										
Aluminum	7429905	141 / 149	94.6	µg/L	15	50	7.5	284	188	2490	343	16.2	298	2490	349	L*	349	1168	--	--	--	--	--	--	--	--
Antimony	7440360	37 / 151	24.5	µg/L	0.55	6	0.275	1.298	0.88	3.1	1.002	0.78	1.449	3.1	0.5072	X	1.654	2	--	--	--	--	640	0 / 151	--	--
Arsenic	7440382	231 / 380	60.8	µg/L	0.65	5	0.325	2.709	2.91	7.27	1.109	0.75	2.972	7.27	0.9708	X*	3.006	4.5	150	0 / 380	340	0 / 380	10	0 / 380	--	--
Barium	7440393	151 / 151	100	µg/L	--	--	20.4	47.2	44.3	109	15.2	20.4	47.2	109	15.2	L	52.3	79.2	--	--	--	--	--	--	--	--
Beryllium	7440417	21 / 151	13.9	µg/L	0.02	1	0.01	0.1713	0.1	0.5	0.1801	0.02	0.1052	0.29	0.0894	X	0.2352	0.24	--	--	--	--	--	--	--	--
Boron	7440428	150 / 150	100	µg/L	--	--	16.9	573	305	2860	598	16.9	573	2860	598	L	710	2381	--	--	--	--	--	--	--	--
Cadmium	7440439	73 / 380	19.2	µg/L	0.08	1	0.04	0.2407	0.21	1	0.1489	0.08	0.291	1	0.1675	X*	0.3053	0.4	0.25	**35 / 380**	2.014	0 / 380	--	--	--	--
Calcium	7440702	150 / 150	100	µg/L	--	--	18,500	111,521	104,500	266,000	53,542	18,500	111,521	266,000	53,542	N	118,756	211,636	--	--	--	--	--	--	--	--
Chromium	7440473	347 / 382	90.8	µg/L	0.25	5	0.125	13.1	5.41	309	34.0	0.3	14.2	309	35.5	X*	20.7	105	74	**12 / 382**	570	0 / 382	--	--	--	--
Chromium, hexavalent	18540299	250 / 589	42.4	µg/L	6	6	3	13.4	6	250	24.8	6	23.5	250	35.8	X*	17.9	62	11	**127 / 589**	16	**78 / 589**	--	--	--	--
Cobalt	7440484	44 / 137	32.1	µg/L	0.2	5	0.1	0.4392	0.34	3.7	0.4672	0.13	0.5732	3.7	0.5897	X*	0.6761	1.12	--	--	--	--	--	--	--	--
Copper	7440508	303 / 431	70.3	µg/L	0.3	5	0.15	4.432	2.9	80.2	6.322	0.574	5.21	80.2	7.388	X*	5.769	15	9	**31 / 431**	13	**19 / 431**	--	--	--	--
Hafnium	7440586	0 / 55	0	µg/L	3	50	1.5	3.722	1.5	25	6.796	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Iron	7439896	146 / 149	98.0	µg/L	30	50	5.42	437	345	3790	454	5.42	446	3790	456	G*	506	1339	--	--	--	--	--	--	--	--
Lead	7439921	193 / 380	50.8	µg/L	0.3	3	0.15	1.415	1.01	16.1	1.417	0.5	1.802	16.1	1.845	X*	1.749	4.5	2.5	**39 / 380**	64.6	0 / 380	--	--	--	--
Lithium	7439932	98 / 149	65.8	µg/L	2	15	1	39.5	9.1	898	109	2.76	56.4	898	131	X*	78.4	498	--	--	--	--	--	--	--	--
Magnesium	7439954	150 / 150	100	µg/L	--	--	4370	10,162	9225	33,200	4587	4370	10,162	33,200	4587	L	11,546	19,338	--	--	--	--	--	--	--	--
Manganese	7439965	148 / 150	98.7	µg/L	1	5	0.5	134	84.6	1270	157	10.2	135	1270	158	L*	160	519	--	--	--	--	--	--	--	--
Mercury	7439976	234 / 399	58.6	µg/L	2.0E-04	0.2	1.0E-04	0.0263	0.016	0.8	0.0471	0.0022	0.0337	0.8	0.0591	X*	0.0369	0.0938	0.77	**1 / 399**	1.4	0 / 399	0.051	**37 / 399**	--	--
Molybdenum	7439987	137 / 139	98.6	µg/L	0.165	5	0.0825	13.1	11.4	30.6	6.221	1.5	13.2	30.6	6.18	G*	14.1	27.4	--	--	--	--	--	--	--	--
Nickel	7440020	228 / 380	60	µg/L	1.5	10	0.75	5.179	2.57	81.2	7.499	0.98	6.868	81.2	9.268	X*	6.873	25.2	52	**1 / 380**	468	0 / 380	4600	0 / 380	--	--
Phosphorus	7723140	87 / 97	89.7	µg/L	15	60	7.5	35.3	27.4	346	35.4	8.26	37.5	346	36.8	L*	37.7	84.4	--	--	--	--	--	--	--	--
Potassium	7440097	149 / 149	100	µg/L	--	--	938	8717	5500	34,300	6800	938	8717	34,300	6800	X	11,146	28,000	--	--	--	--	--	--	--	--
Selenium	7782492	45 / 360	12.5	µg/L	0.9	10	0.45	1.578	1.25	5	0.9757	0.96	1.926	4.2	0.678	X	1.802	2.1	5	0 / 360	20	0 / 360	--	--	--	--
Silver	7440224	3 / 149	2.01	µg/L	0.1	1	0.05	0.2115	0.125	0.5	0.163	0.22	0.3267	0.47	0.129	X	0.2698	0.22	--	--	3.217	0 / 149	--	--	--	--
Sodium	7440235	149 / 149	100	µg/L	--	--	2890	29,541	24,100	77,600	16,694	2890	29,541	77,600	16,694	L	32,655	74,986	--	--	--	--	--	--	--	--
Strontium	7440246	148 / 149	99.3	µg/L	50	50	25	458	348	1540	306	77.8	461	1540	306	L*	521	1367	--	--	--	--	--	--	--	--
Thallium	7440280	7 / 151	4.64	µg/L	0.45	4.1	0.225	0.902	0.829	5	0.5661	0.56	2.533	5	1.895	X*	1.459	4.2	--	--	--	--	0.47	**7 / 151**	--	--
Tin	7440315	7 / 149	4.7	µg/L	0.7	50	0.312	5.37	0.75	25	9.513	0.312	2.874	8.81	3.322	X	8.767	3.4	--	--	--	--	--	--	--	--
Titanium	7440326	85 / 127	66.9	µg/L	0.25	5	0.125	5.073	2.64	39.5	6.334	0.19	6.626	39.5	7.242	X*	7.568	27.4	--	--	--	--	--	--	--	--
Uranium	7440611	311 / 371	83.8	µg/L	0.067	15	0.0335	30.9	26	190	22.1	3.44	35.1	190	21.7	X*	35.9	80.9	--	--	--	--	--	--	--	--
Vanadium	7440622	74 / 149	49.7	µg/L	0.15	20	0.075	1.9	0.72	11.1	2.417	0.18	2.486	11.1	2.572	X*	2.963	9.92	--	--	--	--	--	--	--	--
Zinc	7440666	129 / 154	83.8	µg/L	3.3	10	0.88	28.9	14.4	213	33.8	0.88	33.4	213	35.4	L*	36.0	125	120	**5 / 154**	117	**5 / 154**	--	--	--	--
Zirconium	7440677	4 / 55	7.27	µg/L	0.66	50	0.33	0.9323	0.33	25	3.328	0.736	0.7935	0.866	0.054	X	2.889	*0.866*	--	--	--	--	--	--	--	--
Other Inorganics																										
Asbestos	1332214	0 / 291	0	MFL	--	--	0.1	0.1013	0.1	0.49	0.0229	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Dioxins/Furans																										
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	19408743	0 / 2	0	µg/L	2.5E-05	2.5E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746016	1 / 47	2.13	µg/L	4.6E-08	5.1E-06	2.3E-08	7.2E-07	5.0E-07	2.6E-06	6.5E-07	1.4E-07	1.4E-07	1.4E-07	--	D	--	*1.4E-07*	--	--	--	--	--	--	--	--
Herbicides																										
Silvex	93721	3 / 22	13.6	µg/L	0.011	0.5	0.0055	0.101	0.0293	0.25	0.116	0.016	0.0277	0.05	0.0193	L	0.517	0.0816	--	--	--	--	--	--	--	--
Pesticides																										
4,4'-DDD	72548	24 / 587	4.09	µg/L	0.0019	0.0595	9.5E-04	0.0119	0.0053	0.051	0.0106	0.011	0.0264	0.051	0.0127	X	0.0138	0.014	--	--	--	--	0.0031	**24 / 587**	--	--
4,4'-DDE	72559	28 / 587	4.77	µg/L	0.0019	0.0595	9.5E-04	0.0166	0.0019	2.11	0.1198	0.01	0.2005	2.11	0.5227	X*	0.0392	0.022	--	--	--	--	0.0022	**28 / 587**	--	--
4,4'-DDT	50293	9 / 577	1.56	µg/L	0.0019	0.0595	9.5E-04	0.0052	0.0019	0.066	0.0089	0.013	0.0328	0.066	0.017	X*	0.0105	0.013	0.001	**9 / 577**	1.1	0 / 577	0.0022	**9 / 577**	--	--
Aldrin	309002	21 / 562	3.74	µg/L	0.0013	0.0595	6.3E-04	0.01	0.0035	0.044	0.0104	0.0074	0.0163	0.044	0.0091	X	0.0119	0.011	--	--	3	0 / 562	5.0E-04	**21 / 562**	--	--
Chlordane	57749	0 / 303	0	µg/L	0.0144	0.294	0.0072	0.0408	0.05	0.147	0.0266	--	--	--	--	O	--	--	0.0043	0 / 303	2.4	0 / 303	0.0081	0 / 303	--	--
Dieldrin	60571	12 / 589	2.04	µg/L	0.0019	0.2	9.5E-04	0.0118	0.0053	0.1	0.0107	0.011	0.0176	0.0364	0.008	X	0.0137	0.011	0.056	0 / 589	0.24	0 / 589	5.4E-04	**12 / 589**	--	--
Endosulfan I	959988	12 / 331	3.63	µg/L	0.0013	0.0595	6.3E-04	0.0149	0.025	0.0298	0.0114	0.011	0.0183	0.026	0.0049	X	0.0176	0.014	0.056	0 / 331	0.22	0 / 331	89	0 / 331	--	--
Endosulfan II	33213659	6 / 346	1.73	µg/L	0.0019	0.0595	9.5E-04	0.0158	0.025	0.0298	0.011	0.011	0.0159	0.028	0.0063	X	0.0184	0.011	0.056	0 / 346	0.22	0 / 346	89	0 / 346	--	--
Endosulfan sulfate	1031078	7 / 336	2.08	µg/L	0.0019	0.0595	9.5E-04	0.0044	0.0019	0.126	0.0087	0.01	0.0316	0.126	0.0423	X*	0.009	0.01	--	--	--	--	89	0 / 336	--	--
Endrin	72208	3 / 346	0.87	µg/L	0.0019	0.0595	9.5E-04	0.0159	0.025	0.0298	0.011	0.015	0.0207	0.027	0.006	X	0.0185	0.015	0.036	0 / 346	0.086	0 / 346	0.06	0 / 346	--	--
Endrin aldehyde	7421934	1 / 356	0.28	µg/L	0.0013	0.0595	6.3E-04	0.0158	0.025	0.0298	0.0114	0.012	0.012	0.012	--	D	--	0.012	--	--	--	--	0.3	0 / 356	--	--
Endrin ketone	53494705	0 / 304	0	µg/L	0.0019	0.1	9.5E-04	0.0148	0.025	0.05	0.0114	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Heptachlor	76448	7 / 304	2.3	µg/L	0.0013	0.0595	6.3E-04	0.014	0.025	0.0298	0.0115	0.011	0.0124	0.015	0.0014	X	0.0168	0.011	0.0038	**7 / 304**	0.52	0 / 304	7.9E-04	**7 / 304**	--	--
Heptachlor epoxide	1024573	8 / 346	2.31	µg/L	0.0013	0.0595	6.3E-04	0.0154	0.025	0.0298	0.0114	0.011	0.016	0.0241	0.0051	X	0.0181	0.011	0.0038	**8 / 346**	0.52	0 / 346	3.9E-04	**8 / 346**	--	--
Lindane	58899	0 / 131	0	µg/L	0.0013	0.0256	6.3E-04	0.0019	7.0E-04	0.0128	0.0021	--	--	--	--	O	--	--	--	--	0.95	0 / 131	1.8	0 / 131	--	--
Methoxychlor	72435	22 / 330	6.67	µg/L	0.0094	0.192	0.0047	0.0208	0.025	0.096	0.0115	0.011	0.0247	0.05	0.0098	X	0.0235	0.026	0.001	**22 / 330**	--	--	--	--	--	--

Attachment 2. EMWMF summary statistics and comparison to AWQC for Unfiltered Contact Water 2005-2021

Chemical	CAS Number	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	UTL 95/95[b]	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
alpha-BHC	319846	2 / 336	0.6	µg/L	0.0013	0.0595	6.3E-04	0.0152	0.025	0.0298	0.0115	0.011	0.0155	0.02	0.0064	D	0.0179	0.011	--	--	--	--	0.049	0 / 336	--	--
alpha-Chlordane	5103719	3 / 356	0.84	µg/L	0.0013	0.0595	6.3E-04	0.0158	0.025	0.0298	0.0114	0.01	0.0167	0.023	0.0065	X	0.0184	0.01	--	--	--	--	--	--	--	--
beta-BHC	319857	106 / 577	18.4	µg/L	0.0013	0.0595	6.3E-04	0.0152	0.011	0.318	0.0273	0.001	0.0465	0.318	0.0499	X*	0.0209	0.064	--	--	--	--	0.17	**3 / 577**	--	--
delta-BHC	319868	4 / 336	1.19	µg/L	0.0013	0.0595	6.3E-04	0.0153	0.025	0.0372	0.0115	0.013	0.0226	0.0372	0.0103	X	0.0181	0.013	--	--	--	--	--	--	--	--
gamma-Chlordane	5103742	11 / 356	3.09	µg/L	0.0013	0.0595	6.3E-04	0.0159	0.025	0.045	0.0115	0.011	0.024	0.045	0.0109	X	0.0185	0.011	--	--	--	--	--	--	--	--
Polychlorinated Biphenyls																										
PCB-1016	12674112	0 / 360	0	µg/L	0.0314	0.476	0.0157	0.1285	0.2	0.238	0.0886	--	--	--	--	O	--	--	--	--	0.5	0 / 360	6.4E-04	0 / 360	--	--
PCB-1221	11104282	0 / 360	0	µg/L	0.0314	0.476	0.0157	0.1289	0.2	0.238	0.0884	--	--	--	--	O	--	--	--	--	0.5	0 / 360	6.4E-04	0 / 360	--	--
PCB-1232	11141165	0 / 360	0	µg/L	0.0314	0.476	0.0157	0.1286	0.2	0.238	0.0885	--	--	--	--	O	--	--	--	--	0.5	0 / 360	6.4E-04	0 / 360	--	--
PCB-1242	53469219	0 / 360	0	µg/L	0.0314	0.476	0.0157	0.1278	0.2	0.238	0.0891	--	--	--	--	O	--	--	--	--	0.5	0 / 360	6.4E-04	0 / 360	--	--
PCB-1248	12672296	1 / 360	0.28	µg/L	0.0314	0.476	0.0157	0.1284	0.2	0.238	0.0887	0.111	0.111	0.111	--	D	--	0.111	--	--	0.5	0 / 360	6.4E-04	**1 / 360**	--	--
PCB-1254	11097691	9 / 360	2.5	µg/L	0.0314	0.476	0.0157	0.1275	0.2	0.238	0.0879	0.0435	0.1066	0.23	0.058	X	0.1477	0.0435	--	--	0.5	0 / 360	6.4E-04	**9 / 360**	--	--
PCB-1260	11096825	1 / 360	0.28	µg/L	0.0314	0.476	0.0157	0.1278	0.2	0.238	0.0889	0.14	0.14	0.14	--	D	--	0.14	--	--	0.5	0 / 360	6.4E-04	**1 / 360**	--	--
PCB-1262	37324235	0 / 346	0	µg/L	0.0314	0.476	0.0157	0.1272	0.2	0.285	0.0901	--	--	--	--	O	--	--	--	--	0.5	0 / 346	6.4E-04	0 / 346	--	--
PCB-1268	11100144	0 / 348	0	µg/L	0.0314	0.476	0.0157	0.1261	0.2	0.238	0.089	--	--	--	--	O	--	--	--	--	0.5	0 / 348	6.4E-04	0 / 348	--	--
Polychlorinated biphenyl	1336363	0 / 12	0	µg/L	0.14	0.18	0.07	0.0808	0.08	0.09	0.0051	--	--	--	--	O	--	--	0.014	0 / 12	--	--	6.4E-04	0 / 12	--	--
Semivolatile Organics																										
1,2,4-Trichlorobenzene	120821	0 / 358	0	µg/L	1.36	11.2	0.68	3.454	5	5.6	1.928	--	--	--	--	O	--	--	--	--	--	--	70	0 / 358	--	--
1,2-Dichlorobenzene	95501	0 / 358	0	µg/L	1.36	11.2	0.68	3.456	5	5.6	1.926	--	--	--	--	O	--	--	--	--	--	--	1300	0 / 358	--	--
1,3-Dichlorobenzene	541731	0 / 358	0	µg/L	1.36	11.2	0.68	3.458	5	5.6	1.924	--	--	--	--	O	--	--	--	--	--	--	960	0 / 358	--	--
1,4-Dichlorobenzene	106467	0 / 358	0	µg/L	1.36	11.2	0.68	3.458	5	5.6	1.923	--	--	--	--	O	--	--	--	--	--	--	190	0 / 358	--	--
2,3,4,6-Tetrachlorophenol	58902	0 / 350	0	µg/L	1.36	11.2	0.68	3.417	5	5.6	1.934	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
2,4-Dimethylphenol	105679	23 / 346	6.65	µg/L	1.36	11.2	0.68	3.321	5	7.27	1.896	2.03	3.567	7.27	1.212	X	3.765	3.5	--	--	--	--	850	0 / 346	--	--
2,4-Dinitrophenol	51285	0 / 346	0	µg/L	2.27	50	1.135	8.189	12.5	25	5.328	--	--	--	--	O	--	--	--	--	--	--	5300	0 / 346	--	--
2-Methylnaphthalene	91576	0 / 356	0	µg/L	0.136	11.2	0.068	3.078	5	5.6	2.373	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
2-Methylphenol	95487	11 / 346	3.18	µg/L	1.36	11.2	0.68	3.322	5	5.6	1.921	2.02	2.586	3.39	0.3893	X	3.772	2.02	--	--	--	--	--	--	--	--
3- and 4- Methylphenol	N2799	41 / 186	22.0	µg/L	1.9	10.5	0.95	6.092	5.91	22	2.78	2.02	7.573	22	4.258	X*	7.735	13	--	--	--	--	--	--	--	--
4-Chloro-3-methylphenol	59507	0 / 336	0	µg/L	1.36	11.2	0.68	3.352	5	5.6	1.946	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
4-Methylphenol	106445	0 / 12	0	µg/L	10	11	5	5.042	5	5.5	0.1443	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Acenaphthene	83329	3 / 358	0.84	µg/L	0.136	11.2	0.068	3.09	5	5.6	2.369	0.165	0.2393	0.328	0.0824	X	3.635	0.165	--	--	--	--	990	0 / 358	--	--
Acenaphthylene	208968	0 / 336	0	µg/L	0.136	11.2	0.068	2.962	5	5.6	2.393	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Acetophenone	98862	3 / 326	0.92	µg/L	1.36	11.2	0.68	3.427	5	5.6	1.926	2.05	3.087	4	0.9808	X	3.892	2.05	--	--	--	--	--	--	--	--
Anthracene	120127	16 / 346	4.62	µg/L	0.136	11.2	0.068	2.927	5	5.6	2.351	0.183	2.072	3.44	0.9418	X	3.478	2.23	--	--	--	--	40,000	0 / 346	--	--
Benz(a)anthracene	56553	0 / 346	0	µg/L	0.136	11.2	0.068	3.038	5	5.6	2.371	--	--	--	--	O	--	--	--	--	--	--	0.18	0 / 346	--	--
Benzenemethanol	100516	0 / 336	0	µg/L	1.36	20	0.68	3.82	5	10	2.684	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Benzidine	92875	0 / 199	0	µg/L	1.47	51.5	0.735	8.431	1.95	25.8	10.7	--	--	--	--	O	--	--	--	--	--	--	0.002	0 / 199	--	--
Benzo(a)pyrene	50328	0 / 346	0	µg/L	0.136	11.2	0.068	3.024	5	5.6	2.378	--	--	--	--	O	--	--	--	--	--	--	0.18	0 / 346	--	--
Benzo(b)fluoranthene	205992	0 / 346	0	µg/L	0.136	11.2	0.068	3.021	5	5.6	2.383	--	--	--	--	O	--	--	--	--	--	--	0.18	0 / 346	--	--
Benzo(ghi)perylene	191242	0 / 346	0	µg/L	0.136	11.2	0.068	3.021	5	5.6	2.383	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	207089	0 / 346	0	µg/L	0.136	11.2	0.068	3.021	5	5.6	2.383	--	--	--	--	O	--	--	--	--	--	--	0.18	0 / 346	--	--
Benzoic acid	65850	72 / 358	20.1	µg/L	2.73	53	0.5	6.041	2.88	76.9	8.513	0.5	10.6	76.9	14.4	X*	8.854	20.7	--	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	117817	22 / 346	6.36	µg/L	0.15	11.2	0.075	3.313	5	11	1.988	0.5	3.561	11	2.403	X	3.779	3.6	--	--	--	--	22	0 / 346	--	--
Butyl benzyl phthalate	85687	1 / 346	0.29	µg/L	0.15	11.2	0.075	3.4	5	5.6	1.93	0.6	0.6	0.6	--	D	--	0.6	--	--	--	--	1900	0 / 346	--	--
Carbazole	86748	3 / 358	0.84	µg/L	0.136	11.2	0.068	3.091	5	5.6	2.367	0.274	0.4063	0.55	0.1383	X	3.636	0.274	--	--	--	--	--	--	--	--
Chrysene	218019	0 / 346	0	µg/L	0.136	11.2	0.068	3.021	5	5.6	2.383	--	--	--	--	O	--	--	--	--	--	--	0.18	0 / 346	--	--
Di-n-butyl phthalate	84742	10 / 358	2.79	µg/L	0.15	11.2	0.075	3.333	5	5.6	1.961	0.5	0.93	2	0.4165	X	3.785	0.5	--	--	--	--	4500	0 / 358	--	--
Di-n-octylphthalate	117840	0 / 346	0	µg/L	0.15	11.2	0.075	3.412	5	5.6	1.927	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	53703	0 / 346	0	µg/L	0.136	11.2	0.068	3.021	5	5.6	2.383	--	--	--	--	O	--	--	--	--	--	--	0.18	0 / 346	--	--
Dibenzofuran	132649	0 / 346	0	µg/L	1.36	11.2	0.68	3.399	5	5.6	1.938	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Diethyl phthalate	84662	12 / 346	3.47	µg/L	0.15	11.2	0.075	3.26	5	5.6	1.967	0.5	1.145	2.02	0.6522	X	3.72	0.6	--	--	--	--	44,000	0 / 346	--	--
Dimethyl phthalate	131113	1 / 346	0.29	µg/L	0.15	11.2	0.075	3.386	5	5.6	1.944	2.61	2.61	2.61	--	D	--	2.61	--	--	--	--	1.1E+06	0 / 346	--	--
Diphenylamine	122394	0 / 131	0	µg/L	1.36	3.33	0.68	1.111	0.8	1.665	0.3739	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Fluoranthene	206440	5 / 346	1.45	µg/L	0.136	11.2	0.068	3.023	5	5.6	2.38	0.172	0.2128	0.265	0.0382	X	3.58	0.172	--	--	--	--	140	0 / 346	--	--
Fluorene	86737	2 / 346	0.58	µg/L	0.136	11.2	0.068	3.021	5	5.6	2.382	0.2	0.221	0.242	0.0297	D	3.579	0.2	--	--	--	--	5300	0 / 346	--	--
Hexachlorobenzene	118741	0 / 254	0	µg/L	1.36	11.2	0.68	3.0	1.588	5.6	1.972	--	--	--	--	O	--	--	--	--	--	--	0.0029	0 / 254	--	--
Hexachlorobutadiene	87683	0 / 334	0	µg/L	1.36	11.2	0.68	3.342	5	5.6	1.948	--	--	--	--	O	--	--	--	--	--	--	180	0 / 334	--	--
Hexachloroethane	67721	0 / 17	0	µg/L	10	11	5	5.029	5	5.5	0.1213	--	--	--	--	O	--	--	--	--	--	--	33	0 / 17	--	--
Indeno(1,2,3-cd)pyrene	193395	0 / 346	0	µg/L	0.136	11.2	0.068	3.021	5	5.6	2.383	--	--	--	--	O	--	--	--	--	--	--	0.18	0 / 346	--	--
Isophorone	78591	0 / 346	0	µg/L	1.47	11.2	0.735	3.457	5	5.6	1.873	--	--	--	--	O	--	--	--	--	--	--	9600	0 / 346	--	--
Naphthalene	91203	6 / 358	1.68	µg/L	0.136	11	0.068	3.079	5	5.5	2.362	0.242	2.071	4.88	1.991	X	3.623	0.242	--	--	--	--	--	--	--	--

Attachment 2. EMWMF summary statistics and comparison to AWQC for Unfiltered Contact Water 2005-2021

Chemical	CAS Number	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	UTL 95/95[b]	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
Pentachlorophenol	87865	3 / 346	0.87	μg/L	0.0833	11.2	0.0417	0.4421	0.179	18.9	1.711	8.94	13.6	18.9	5.015	X*	1.41	8.94	15	**1 / 346**	19	0 / 346	30	0 / 346	--	--
Phenanthrene	85018	6 / 346	1.73	μg/L	0.136	10.5	0.068	3.013	5	5.25	2.376	0.195	0.5983	2.27	0.8204	X	3.57	0.195	--	--	--	--	--	--	--	--
Phenol	108952	46 / 350	13.1	μg/L	1.36	10.5	0.68	3.185	2.72	18.7	2.759	0.8	5.617	18.7	3.58	X*	4.461	7.94	--	--	--	--	1.7E+06	0 / 350	--	--
Pyrene	129000	0 / 346	0	μg/L	0.136	11.2	0.068	3.021	5	5.6	2.383	--	--	--	--	O	--	--	--	--	--	--	4000	0 / 346	--	--
m+p Methylphenol	65794969	4 / 159	2.52	μg/L	1.47	10.3	0.735	1.925	1.58	5.57	1.411	2.03	3.113	5.57	1.65	X	2.413	2.03	--	--	--	--	--	--	--	--
Volatile Organics																										
(1,1-Dimethylethyl)benzene	98066	0 / 29	0	μg/L	0.18	5	0.09	1.342	2.5	2.5	1.22	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
(1-Methylpropyl)benzene	135988	0 / 29	0	μg/L	0.17	5	0.085	1.34	2.5	2.5	1.222	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	71556	0 / 333	0	μg/L	0.17	5	0.085	1.475	2.5	2.5	1.169	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,1,2,2-Tetrachloroethane	79345	0 / 16	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	40	0 / 16	--	--
1,1,2-Trichloroethane	79005	0 / 305	0	μg/L	0.2	5	0.1	1.397	2.5	2.5	1.176	--	--	--	--	O	--	--	--	--	--	--	160	0 / 305	--	--
1,1-Dichloroethane	75343	0 / 333	0	μg/L	0.17	5	0.085	1.475	2.5	2.5	1.169	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,1-Dichloroethene	75354	0 / 311	0	μg/L	0.17	5	0.085	1.403	2.5	2.5	1.176	--	--	--	--	O	--	--	--	--	--	--	7100	0 / 311	--	--
1,2,3-Trimethylbenzene	526738	0 / 13	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,2,4-Trimethylbenzene	95636	0 / 322	0	μg/L	0.17	5	0.085	1.455	2.5	2.5	1.171	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,2-Dichloroethane	107062	0 / 16	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	370	0 / 16	--	--
1,2-Dichloroethene	540590	0 / 10	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,2-Dichloropropane	78875	0 / 16	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	150	0 / 16	--	--
1,2-Dimethylbenzene	95476	0 / 357	0	μg/L	0.17	5	0.085	1.557	2.5	2.5	1.155	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	108678	0 / 322	0	μg/L	0.17	5	0.085	1.463	2.5	2.5	1.163	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1,3-Dimethylbenzene	108383	0 / 24	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
1-Methyl-4-(1-methylethyl)benzene	99876	0 / 29	0	μg/L	0.17	5	0.085	1.34	2.5	2.5	1.222	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
2-Butanone	78933	4 / 346	1.16	μg/L	1.5	10	0.75	3.284	5	6	2.038	2	4.203	6	1.682	X	3.762	2	--	--	--	--	--	--	--	--
2-Hexanone	591786	1 / 337	0.3	μg/L	1.5	10	0.75	3.285	5	5	1.996	2	2	2	--	D	--	2	--	--	--	--	--	--	--	--
4-Methyl-2-pentanone	108101	0 / 358	0	μg/L	1.5	10	0.75	3.31	5	5	2.076	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Acetone	67641	104 / 360	28.9	μg/L	1.5	10	0.75	7.236	4.36	64.3	8.79	1	15.7	64.3	11.9	X*	9.528	31.1	--	--	--	--	--	--	--	--
Acrylonitrile	107131	0 / 254	0	μg/L	1.5	20	0.75	5.235	0.835	10	4.627	--	--	--	--	O	--	--	--	--	--	--	2.5	0 / 254	--	--
Benzene	71432	1 / 360	0.28	μg/L	0.17	5	0.085	1.549	2.5	2.5	1.155	1.26	1.26	1.26	--	D	--	1.26	--	--	--	--	510	0 / 360	--	--
Bromodichloromethane	75274	0 / 16	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	170	0 / 16	--	--
Bromoform	75252	0 / 148	0	μg/L	0.3	5	0.15	0.4059	0.15	2.5	0.7315	--	--	--	--	O	--	--	--	--	--	--	1400	0 / 148	--	--
Bromomethane	74839	0 / 16	0	μg/L	10	10	5	5	5	5	0	--	--	--	--	O	--	--	--	--	--	--	1500	0 / 16	--	--
Carbon disulfide	75150	0 / 347	0	μg/L	0.17	5	0.085	1.755	2.5	2.5	0.8942	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Carbon tetrachloride	56235	0 / 360	0	μg/L	0.17	5	0.085	1.479	2	2.5	1.108	--	--	--	--	O	--	--	--	--	--	--	16	0 / 360	--	--
Chlorobenzene	108907	0 / 358	0	μg/L	0.17	5	0.085	1.56	2.5	2.5	1.154	--	--	--	--	O	--	--	--	--	--	--	1600	0 / 358	--	--
Chloroethane	75003	0 / 331	0	μg/L	0.25	10	0.125	2.889	5	5	2.401	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Chloroform	67663	0 / 360	0	μg/L	0.17	5	0.085	1.552	2.5	2.5	1.156	--	--	--	--	O	--	--	--	--	--	--	4700	0 / 360	--	--
Chloromethane	74873	0 / 25	0	μg/L	10	10	5	5	5	5	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Cumene	98828	0 / 337	0	μg/L	0.17	5	0.085	1.501	2.5	2.5	1.165	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Dibromochloromethane	124481	0 / 16	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	170	0 / 16	--	--
Ethylbenzene	100414	0 / 337	0	μg/L	0.17	5	0.085	1.501	2.5	2.5	1.165	--	--	--	--	O	--	--	--	--	--	--	2100	0 / 337	--	--
Hexane	110543	0 / 76	0	μg/L	1.67	5	0.835	1.152	0.835	2.5	0.645	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
M + P Xylene	136777612	0 / 40	0	μg/L	0.19	5	0.095	1.779	2.5	2.5	1.116	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Methanol	67561	3 / 252	1.19	μg/L	200	5000	100	1273	125	2500	1185	440	767	1330	490	X	1598	440	--	--	--	--	--	--	--	--
Methylcyclohexane	108872	0 / 194	0	μg/L	0.3	5	0.15	0.9145	0.15	2.5	1.102	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Methylene chloride	75092	3 / 346	0.87	μg/L	0.17	6	0.085	1.678	2.5	3	0.9898	1	1.273	1.68	0.3591	X	1.91	1	--	--	--	--	5900	0 / 346	--	--
Propylbenzene	103651	0 / 281	0	μg/L	0.17	5	0.085	1.302	0.1665	2.5	1.179	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Propylene glycol	57556	5 / 254	1.97	μg/L	3000	30,000	1500	4445	3000	31,600	4182	11,300	20,340	31,600	8383	X*	7884	11,300	--	--	--	--	--	--	--	--
Styrene	100425	0 / 306	0	μg/L	0.17	5	0.085	1.4	2.5	2.5	1.176	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Tetrachloroethene	127184	1 / 360	0.28	μg/L	0.17	5	0.085	1.551	2.5	2.5	1.155	2	2	2	--	D	--	2	--	--	--	--	33	0 / 360	--	--
Toluene	108883	1 / 358	0.28	μg/L	0.17	5	0.085	1.556	2.5	2.5	1.154	1	1	1	--	D	--	1	--	--	--	--	15,000	0 / 358	--	--
Total Xylene	1330207	0 / 346	0	μg/L	0.3	5	0.15	1.626	2.5	2.5	1.123	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Trichloroethene	79016	0 / 360	0	μg/L	0.17	5	0.085	1.552	2.5	2.5	1.156	--	--	--	--	O	--	--	--	--	--	--	300	0 / 360	--	--
Trimethylbenzene	25551137	0 / 2	0	μg/L	0.33	0.33	0.165	0.165	0.165	0.165	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Vinyl chloride	75014	0 / 333	0	μg/L	0.17	10	0.085	1.49	2.5	5	1.198	--	--	--	--	O	--	--	--	--	--	--	24	0 / 333	--	--
cis-1,2-Dichloroethene	156592	2 / 331	0.6	μg/L	0.17	5	0.085	1.484	2.5	2.5	1.167	0.31	0.33	0.35	0.0283	D	1.764	0.31	--	--	--	--	--	--	--	--
cis-1,3-Dichloropropene	10061015	0 / 16	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
trans-1,2-Dichloroethene	156605	0 / 16	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	10,000	0 / 16	--	--
trans-1,3-Dichloropropene	10061026	0 / 16	0	μg/L	5	5	2.5	2.5	2.5	2.5	0	--	--	--	--	O	--	--	--	--	--	--	--	--	--	--
Radionuclides																										
Actinium-227	14952400	4 / 84	4.76	pCi/L	0.13	0.59	-0.08	0.0868	0.07	0.45	0.0952	0.18	0.2575	0.41	0.1047	N	0.1041	0.41	--	--	--	--	--	--	9.6	0 / 84

Attachment 2. EMWMF summary statistics and comparison to AWQC for Unfiltered Contact Water 2005-2021

Chemical	CAS Number	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	UTL 95/95[b]	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
Alpha activity	12587461	48 / 48	100	pCi/L	--	--	11.7	221	84.1	3160	532	11.7	221	3160	532	L	556	3160	--	--	--	--	--	--	--	--
Aluminum-26	14682667	0 / 33	0	pCi/L	2.78	9.96	-1.59	0.3436	0.4	2.56	1.023	--	--	--	--	N	--	--	--	--	--	--	--	--	9600	0 / 33
Americium-241	14596102	15 / 359	4.18	pCi/L	0.09	2.85	-0.27	0.0653	0.04	1.23	0.1141	0.18	0.356	1.23	0.29	L	0.109	0.19	--	--	--	--	--	--	28.8	0 / 359
Americium-243	14993750	13 / 68	19.1	pCi/L	0.08	0.54	-0.08	0.1398	0.11	0.5	0.1329	0.19	0.3377	0.5	0.0902	N	0.1666	0.5	--	--	--	--	--	--	28.8	0 / 68
Beta activity	12587472	48 / 48	100	pCi/L	--	--	11.1	370	110	3500	668	11.1	370	3500	668	L	570	3500	--	--	--	--	--	--	--	--
Californium-252	13981174	0 / 59	0	pCi/L	0.08	0.56	-0.06	0.0018	-0.01	0.2	0.047	--	--	--	--	L	--	--	--	--	--	--	--	--	96	0 / 59
Carbon-14	14762755	12 / 363	3.31	pCi/L	11.5	22	-9.26	3.526	3.78	31.3	5.764	13.1	18.9	31.3	4.547	X	4.844	13.1	--	--	--	--	--	--	67,200	0 / 363
Cesium-137	10045973	7 / 363	1.93	pCi/L	2.33	9.74	-4.76	0.4171	0.2	9.67	1.766	3.37	5.481	9.67	2.15	N	0.57	3.37	--	--	--	--	--	--	2880	0 / 363
Chlorine-36	13981436	98 / 363	27.0	pCi/L	0.22	4.81	-1.54	2.542	1.4	41.4	4.3	2.03	6.945	41.4	6.221	L	3.83	12.2	--	--	--	--	--	--	48,000	0 / 363
Cobalt-60	10198400	0 / 350	0	pCi/L	2.28	9.69	-3.5	0.4646	0.425	4.92	1.384	--	--	--	--	N	--	--	--	--	--	--	--	--	4800	0 / 350
Curium-242	15510733	0 / 72	0	pCi/L	0.08	0.56	-0.07	0.0027	-0.01	0.2	0.0453	--	--	--	--	L	--	--	--	--	--	--	--	--	960	0 / 72
Curium-243/244	N191	3 / 72	4.17	pCi/L	0.13	0.84	-0.16	0.1051	0.05	1.43	0.2092	0.47	0.8333	1.43	0.5208	L	0.2264	1.43	--	--	--	--	--	--	48	0 / 72
Curium-245	15621768	49 / 347	14.1	pCi/L	0.0691	0.99	-0.07	0.1396	0.1	1.24	0.1469	0.12	0.3596	1.24	0.1936	L	0.1809	0.464	--	--	--	--	--	--	28.8	0 / 347
Curium-246	15757901	49 / 347	14.1	pCi/L	0.0691	0.99	-0.07	0.1396	0.1	1.24	0.1469	0.12	0.3596	1.24	0.1936	L	0.1809	0.464	--	--	--	--	--	--	28.8	0 / 347
Curium-247	15758324	7 / 345	2.03	pCi/L	0.08	1.12	-0.1	0.0432	0.01	1.5	0.1198	0.23	0.5729	1.5	0.4729	X	0.0713	0.23	--	--	--	--	--	--	28.8	0 / 345
Curium-248	15758335	9 / 82	11.0	pCi/L	0.07	0.56	-0.04	0.1115	0.03	1.48	0.248	0.16	0.5842	1.48	0.4877	L	0.2273	1.48	--	--	--	--	--	--	7.68	0 / 82
Europium-152	14683239	4 / 350	1.14	pCi/L	7.77	65.9	-24.9	1.736	0.675	45.3	9.053	14.4	27.0	45.3	13.1	X	3.845	14.4	--	--	--	--	--	--	19,200	0 / 350
Europium-154	15585101	1 / 350	0.29	pCi/L	4.01	27	-9.63	-0.0014	-0.16	12.2	3.199	6.99	6.99	6.99	--	N	--	6.99	--	--	--	--	--	--	19,200	0 / 350
Europium-155	14391163	0 / 73	0	pCi/L	3.95	14.6	-58.8	-2.358	-0.72	8.1	10.1	--	--	--	--	X	--	--	--	--	--	--	--	--	96,000	0 / 73
Iodine-129	15046841	29 / 592	4.9	pCi/L	0.459	3.09	-1.65	0.5806	0.615	2.84	0.6953	0.534	1.666	2.84	0.6837	X	0.7052	1.23	--	--	--	--	--	--	480	0 / 592
Lead-210	14255040	42 / 305	13.8	pCi/L	0.533	1.82	-0.7	0.3982	0.35	3.42	0.4668	0.48	1.191	3.42	0.6079	X	0.5147	1.51	--	--	--	--	--	--	28.8	0 / 305
Neptunium-237	13994202	43 / 358	12.0	pCi/L	0.07	0.51	-0.09	0.1175	0.04	7.3	0.4939	0.12	0.6993	7.3	1.286	X	0.2313	0.49	--	--	--	--	--	--	28.8	0 / 358
Nickel-63	13981378	48 / 325	14.8	pCi/L	5.32	61	-44.7	13.4	4.48	273	33.2	19.5	69.6	273	56.6	X	21.4	94.5	--	--	--	--	--	--	288,000	0 / 325
Plutonium-236	15411924	0 / 73	0	pCi/L	0.08	0.54	-0.07	0.0178	0	0.47	0.0707	--	--	--	--	N	--	--	--	--	--	--	--	--	96	0 / 73
Plutonium-238	13981163	5 / 349	1.43	pCi/L	0.06	1.71	-0.48	0.0446	0.0124	5.35	0.3547	0.17	1.954	5.35	2.44	X	0.1274	0.17	--	--	--	--	--	--	38.4	0 / 349
Plutonium-239/240	E52450475	11 / 359	3.06	pCi/L	0.05	1.29	-0.16	0.0511	0.01	3.84	0.2582	0.18	0.9518	3.84	1.168	X	0.1105	0.18	--	--	--	--	--	--	28.8	0 / 359
Plutonium-241	14119325	1 / 327	0.31	pCi/L	8.69	126	-44	1.193	0	40.3	9.922	30	30	30	--	X	--	30	--	--	--	--	--	--	1920	0 / 327
Plutonium-242	13982100	73 / 345	21.2	pCi/L	0.04	1.18	-87.7	-0.1837	0.04	7.03	4.774	0.09	0.4971	4.6	0.616	L	0.3193	0.76	--	--	--	--	--	--	28.8	0 / 345
Plutonium-244	14119347	0 / 72	0	pCi/L	0.07	0.27	-0.06	0.0192	0.015	0.15	0.0408	--	--	--	--	G	--	--	--	--	--	--	--	--	28.8	0 / 72
Potassium-40	13966002	39 / 350	11.1	pCi/L	20.4	126	-80.7	16.7	17.4	81.2	24.0	30.1	48.1	81.2	13.9	N	18.8	59.9	--	--	--	--	--	--	6720	0 / 350
Protactinium-234m	378783767	358 / 363	98.6	pCi/L	0.13	0.61	0.1	7.874	3.01	93.1	11.9	0.3	7.981	93.1	12.0	X	10.6	36	--	--	--	--	--	--	67,200	0 / 363
Radioactive Strontium (Total)	NS951	449 / 596	75.3	pCi/L	0.596	2.1	-1.81	37.3	1.98	1620	137	0.463	49.2	1620	156	X	61.8	397	--	--	--	--	--	--	--	--
Radium-226	13982633	109 / 361	30.2	pCi/L	0.13	1.27	-0.09	0.318	0.29	1.32	0.2477	0.106	0.5822	1.32	0.2418	G	0.3314	0.92	--	--	--	--	--	--	96	0 / 361
Radium-228	15262201	40 / 361	11.1	pCi/L	0.39	9.19	-0.56	0.2957	0.21	5.34	0.4802	0.519	1.096	5.34	0.7981	X	0.4058	1.02	--	--	--	--	--	--	96	0 / 361
Technetium-99	14133767	580 / 591	98.1	pCi/L	3.83	5.3	-1.59	821	130	28,500	2232	3.98	837	28,500	2250	X	1221	4090	--	--	--	--	--	--	96,000	0 / 591
Thorium-227	15623479	2 / 72	2.78	pCi/L	0.13	0.59	-0.08	0.0859	0.07	0.45	0.0957	0.18	0.295	0.41	0.1626	N	0.1047	0.41	--	--	--	--	--	--	3840	0 / 72
Thorium-228	14274829	12 / 361	3.32	pCi/L	0.08	1.57	-0.165	0.05	0.04	0.55	0.0833	0.16	0.2771	0.55	0.1092	G	0.0511	0.16	--	--	--	--	--	--	384	0 / 361
Thorium-229	15594544	11 / 304	3.62	pCi/L	0.06	0.8	-5.92	0.0256	0.01	3.3	0.4679	0.09	0.4273	1.48	0.4279	X	0.1426	0.13	--	--	--	--	--	--	38.4	0 / 304
Thorium-230	14269637	203 / 363	55.9	pCi/L	0.07	1.37	-0.02	0.2787	0.223	1.68	0.2085	0.13	0.3728	1.68	0.2117	L	0.3121	0.75	--	--	--	--	--	--	288	0 / 363
Thorium-232	N2608	20 / 360	5.56	pCi/L	0.05	0.92	-0.124	0.0558	0.04	0.403	0.0765	0.13	0.2427	0.403	0.0903	L	0.0895	0.2	--	--	--	--	--	--	48	0 / 360
Thorium-234	15065108	347 / 352	98.6	pCi/L	0.13	0.61	0.1	6.916	2.795	93.1	10.2	0.3	7.012	93.1	10.2	X	9.281	25.8	--	--	--	--	--	--	9600	0 / 352
Tritium	10028178	335 / 592	56.6	pCi/L	185	608	-523	746	346	31,900	1708	243	1231	31,900	2147	X	1052	3010	--	--	--	--	--	--	1.9E+06	0 / 592
Uranium-232	14158293	9 / 70	12.9	pCi/L	0.14	0.4	-0.06	0.1274	0.065	0.82	0.2059	0.21	0.6078	0.82	0.1748	L	0.233	0.82	--	--	--	--	--	--	96	0 / 70
Uranium-233/234	NS632	594 / 595	99.8	pCi/L	0.39	0.39	0.35	57.3	27.4	2310	136	0.452	57.4	2310	136	L	81.5	233	--	--	--	--	--	--	480	6 / 595
Uranium-235	15117961	5 / 5	100	pCi/L	--	--	0.478	2.249	1.36	7.37	2.899	0.478	2.249	7.37	2.899	D	7.901	*7.37*	--	--	--	--	--	--	576	0 / 5
Uranium-235/236	N1047	561 / 590	95.1	pCi/L	0.21	2.02	-0.04	4.249	2.305	125	8.03	0.26	4.457	125	8.182	L	5.052	17.3	--	--	--	--	--	--	480	0 / 590
Uranium-238	24678828	589 / 595	99.0	pCi/L	0.13	0.61	-0.0307	8.973	6.27	93.1	10.3	0.3	9.062	93.1	10.3	X	10.8	27.3	--	--	--	--	--	--	576	0 / 595
Yttrium-90	10098916	248 / 351	70.7	pCi/L	0.687	2.1	-1.81	44.2	2.37	1620	145	1.07	62.2	1620	170	X	77.9	458	--	--	--	--	--	--	9600	0 / 351
Wet Chemistry																										
Cyanide	57125	17 / 562	3.02	μg/L	1.1	10	0.55	1.94	1.67	18.4	1.28	1.84	6.71	18.4	5.025	X*	2.315	1.84	5.2	**10 / 562**	22	0 / 562	140	0 / 562	--	--
Dissolved Solids	N340	231 / 231	100	mg/L	--	--	98.6	404	369	1020	162	98.6	404	1020	162	L	424	773	--	--	--	--	--	--	--	--
Suspended Solids	N873	257 / 269	95.5	μg/L	582	5700	291	12,043	8000	77,900	12,319	1040	12,487	77,900	12,449	L*	13,197	38,194	--	--	--	--	--	--	--	--
Total Organic Carbon Average	NS2302	231 / 231	100	μg/L	--	--	2400	7452	6420	17,700	3476	2400	7452	17,700	3476	L	7840	15,183	--	--	--	--	--	--	--	--

[a] One half of the detection limits shown are used as proxy values for chemicals for non-detects except where there is sufficient detected data to calculate Kaplan-Meier summary statistics.

[b] This summary statistic is calculated using both detects and non-detects. Kaplan-Meier is used where there is sufficient detected data for chemicals.

[c] CCC = Tennessee Department of Environment and Conservation chapter 0400-40-03 fish and aquatic life Criterion Continuous Concentration general water quality criteria September 2019.

[d] CMC = Tennessee Department of Environment and Conservation chapter 0400-40-03 fish and aquatic life Criterion Maximum Concentration general water quality criteria September 2019.

[e] Rec. OOC = Tennessee Department of Environment and Conservation chapter 0400-40-03 recreation Organisms Only Criteria general water quality criteria September 2019.

[f] DCG = U.S. Environmental Protection Agency derived concentration guideline for radionuclides.

Attachment 2. EMWMF summary statistics and comparison to AWQC for Unfiltered Contact Water 2005-2021

Chemical	CAS Number	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	UTL 95/95[b]	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]

Dist. = distribution. Distribution flags are defined as:

D = The distribution could not be determined with fewer than 6 samples and 3 detects. The UCL95 was calculated using the nonparametric Chebyshev inequality method with at least 2 detects and 3 samples.

G = gamma. UCL95 was calculated using either the adjusted or unadjusted gamma.

L = lognormal. UCL95 was calculated using Land's statistic, Chebyshev minimum variance unbiased estimator, or nonparametric Chebyshev inequality method.

N = normal. UCL95 was calculated using t statistic.

O = no detected results to calculate some summary statistics.

X = neither normal, lognormal nor gamma. UCL95 was calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.

mg/L = milligrams per liter.

µg/L = micrograms per liter.

pCi/L = picocuries per liter.

S.D. = standard deviation.

UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.

UTL95/95 = upper tolerance limit on individual concentrations with 95% confidence and 95% coverage. A nonparametric UTL95/95 requires at least 59 samples.

UTL95/95 values shown in italic font have less than 95% confidence with 95% coverage because there are either fewer than 59 samples for nonparametric or non-detects have higher concentrations than detects.

-- = Not applicable, not available or insufficient data to calculate the statistic.

* The mean, median, standard deviation and UCL95 were calculated using the Kaplan-Meier method for organics and inorganics. UTL95/95 used Kaplan-Meier for parametric distributions for organics and inorganics.

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APPENDIX C.
ATTACHMENT 3—LEACHATE DATA

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Attachment 3. EMWMF summary statistics and comparison to AWQC for unfiltered leachate 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Mean	Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
Unfiltered water that has leached through waste 2005-2021																				
Anions																				
Chloride	33 / 33	100	µg/L	--	--	5760	18,266	16,800	34,500	5760	18,266	34,500	--	--	--	--	--	--	--	--
Fluoride	31 / 33	93.9	µg/L	200	500	100	323	292	839	170	328	839	--	--	--	--	--	--	--	--
Nitrate	1 / 1	100	µg/L	--	--	2590	2590	2590	2590	2590	2590	2590	--	--	--	--	--	--	--	--
Nitrate/Nitrite	20 / 20	100	µg/L	--	--	324	882	786	1900	324	882	1900	--	--	--	--	--	--	--	--
Nitrate/Nitrite as Nitrogen	12 / 12	100	µg/L	--	--	295	591	496	1360	295	591	1360	--	--	--	--	--	--	--	--
Orthophosphate	0 / 1	0	µg/L	67	67	33.5	33.5	33.5	33.5	--	--	--	--	--	--	--	--	--	--	--
Sulfate	33 / 33	100	µg/L	--	--	91,700	379,291	356,000	881,000	91,700	379,291	881,000	--	--	--	--	--	--	--	--
Metals																				
Aluminum	177 / 288	61.5	µg/L	15	50	7.5	114	55.4	2370	22.9	163	2370	--	--	--	--	--	--	--	--
Antimony	8 / 290	2.76	µg/L	0.55	6	0.275	1.435	0.5	3.34	0.62	1.664	3.34	--	--	--	--	640	0 / 290	--	--
Arsenic	112 / 429	26.1	µg/L	0.65	5	0.325	2.104	2.25	5.19	0.94	2.534	5.19	150	0 / 429	340	0 / 429	10	0 / 429	--	--
Barium	290 / 290	100	µg/L	--	--	23.8	62.5	61.0	460	23.8	62.5	460	--	--	--	--	--	--	--	--
Beryllium	9 / 284	3.17	µg/L	0.02	1	0.01	0.2458	0.1	0.5	0.02	0.0511	0.12	--	--	--	--	--	--	--	--
Boron	290 / 290	100	µg/L	--	--	75.1	522	301	3470	75.1	522	3470	--	--	--	--	--	--	--	--
Cadmium	34 / 429	7.93	µg/L	0.08	1	0.04	0.1895	0.15	0.712	0.08	0.235	0.712	0.25	**12 / 429**	2.014	0 / 429	--	--	--	--
Calcium	289 / 289	100	µg/L	--	--	77,900	168,976	166,000	323,000	77,900	168,976	323,000	--	--	--	--	--	--	--	--
Chromium	159 / 435	36.6	µg/L	0.0996	5	0.0498	2.533	1.13	96.9	0.42	4.715	96.9	74	**1 / 435**	570	0 / 435	--	--	--	--
Chromium, hexavalent	1 / 164	0.61	µg/L	6	6	3	3.543	3	92	92	92	92	11	**1 / 164**	16	**1 / 164**	--	--	--	--
Cobalt	43 / 282	15.2	µg/L	0.22	5	0.1	0.6136	0.37	5.33	0.1	0.8882	5.33	--	--	--	--	--	--	--	--
Copper	206 / 429	48.0	µg/L	0.3	5	0.15	1.713	0.967	12.8	0.337	2.008	12.8	9	**1 / 429**	13	0 / 429	--	--	--	--
Hafnium	0 / 220	0	µg/L	3	50	1.5	9.586	1.5	25	--	--	--	--	--	--	--	--	--	--	--
Iron	238 / 288	82.6	µg/L	30	50	15	212	95	9000	22.3	249	9000	--	--	--	--	--	--	--	--
Lead	20 / 435	4.6	µg/L	0.4	3	0.2	0.6126	0.44	4.53	0.44	1.464	4.53	2.5	**3 / 435**	64.6	0 / 435	--	--	--	--
Lithium	73 / 289	25.3	µg/L	2	15	1	5.848	3.8	407	1.4	11.7	407	--	--	--	--	--	--	--	--
Magnesium	289 / 289	100	µg/L	--	--	9720	23,600	23,400	38,700	9720	23,600	38,700	--	--	--	--	--	--	--	--
Manganese	278 / 289	96.2	µg/L	1	1	0.5	290	130	7240	0.87	302	7240	--	--	--	--	--	--	--	--
Mercury	119 / 435	27.4	µg/L	2.0E-04	0.2	1.0E-04	0.0095	0.0056	0.342	0.0029	0.0158	0.342	0.77	0 / 435	1.4	0 / 435	0.051	**9 / 435**	--	--
Molybdenum	142 / 279	50.9	µg/L	0.165	5	0.0825	4.062	3.53	38.1	0.91	5.238	38.1	--	--	--	--	--	--	--	--
Nickel	209 / 435	48.0	µg/L	0.149	10	0.0745	7.189	3.82	125	0.76	11.0	125	52	**5 / 435**	468	0 / 435	4600	0 / 435	--	--
Phosphorus	223 / 263	84.8	µg/L	15	60	7.5	31.3	28.1	156	12.8	33.6	156	--	--	--	--	--	--	--	--
Potassium	288 / 288	100	µg/L	--	--	1930	9145	7440	25,400	1930	9145	25,400	--	--	--	--	--	--	--	--
Selenium	10 / 290	3.45	µg/L	0.02	5	0.01	0.9198	0.65	6.52	1.2	2.35	6.52	5	**1 / 290**	20	0 / 290	--	--	--	--
Silver	0 / 282	0	µg/L	0.1	5	0.05	1.019	0.125	2.5	--	--	--	--	--	3.217	0 / 282	--	--	--	--
Sodium	288 / 288	100	µg/L	--	--	12,100	49,623	46,600	118,000	12,100	49,623	118,000	--	--	--	--	--	--	--	--
Strontium	288 / 288	100	µg/L	--	--	152	569	519	1520	152	569	1520	--	--	--	--	--	--	--	--
Thallium	6 / 284	2.11	µg/L	0.25	40	0.125	1.348	0.3	20	1.05	1.52	2.02	--	--	--	--	0.47	**6 / 284**	--	--
Tin	13 / 288	4.51	µg/L	0.1	250	0.05	6.624	1.645	125	0.36	4.173	34	--	--	--	--	--	--	--	--
Titanium	87 / 274	31.8	µg/L	1	5	0.259	2.932	1.77	40.1	0.259	5.441	40.1	--	--	--	--	--	--	--	--
Uranium	312 / 429	72.7	µg/L	0.067	50	0.0335	15.3	9.93	388	0.523	18.0	388	--	--	--	--	--	--	--	--
Vanadium	107 / 288	37.2	µg/L	0.15	10	0.075	5.484	2.8	25.8	0.21	9.152	25.8	--	--	--	--	--	--	--	--
Zinc	124 / 288	43.1	µg/L	3.3	10	1.65	8.539	7	90.4	2.2	11.6	90.4	120	0 / 288	117	0 / 288	--	--	--	--
Zirconium	27 / 237	11.4	µg/L	0.66	50	0.33	6.647	0.33	25	0.91	2.63	14.7	--	--	--	--	--	--	--	--
Other Inorganics																				
Asbestos	0 / 14	0	MFL	--	--	0.1	0.1	0.1	0.1	--	--	--	--	--	--	--	--	--	--	--
Dioxins/Furans																				
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1 / 2	50	µg/L	2.6E-06	2.6E-06	7.3E-07	1.0E-06	1.0E-06	1.3E-06	7.3E-07	7.3E-07	7.3E-07	--	--	--	--	--	--	--	--
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0 / 2	0	µg/L	8.3E-07	9.9E-07	4.1E-07	4.5E-07	4.5E-07	4.9E-07	--	--	--	--	--	--	--	--	--	--	--
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0 / 2	0	µg/L	2.8E-07	1.4E-06	1.4E-07	4.1E-07	4.1E-07	6.9E-07	--	--	--	--	--	--	--	--	--	--	--
2,3,7,8-Tetrachlorodibenzo-p-dioxin	3 / 187	1.6	µg/L	0	5.0E-06	4.0E-08	2.6E-07	1.6E-07	2.2E-05	1.6E-07	7.6E-06	2.2E-05	--	--	--	--	--	--	--	--
Octachloro-dibenzo[b,e][1,4]dioxin	1 / 2	50	µg/L	4.4E-06	4.4E-06	2.2E-06	3.4E-06	3.4E-06	4.7E-06	4.7E-06	4.7E-06	4.7E-06	--	--	--	--	--	--	--	--
Octachlorodibenzofuran	1 / 2	50	µg/L	4.0E-06	4.0E-06	9.2E-07	1.4E-06	1.4E-06	2.0E-06	9.2E-07	9.2E-07	9.2E-07	--	--	--	--	--	--	--	--
Total Hexachlorodibenzo-p-dioxins	0 / 2	0	µg/L	--	--	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--
Total Hexachlorodibenzofurans	0 / 2	0	µg/L	--	--	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--
Total Pentachlorodibenzo-p-dioxins	0 / 2	0	µg/L	--	--	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--
Total Pentachlorodibenzofurans	0 / 2	0	µg/L	--	--	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--
Total Tetrachlorodibenzo-p-dioxins	0 / 2	0	µg/L	--	--	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--
Total Tetrachlorodibenzofuran	0 / 2	0	µg/L	--	--	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--
Herbicides																				

Attachment 3. EMWMF summary statistics and comparison to AWQC for unfiltered leachate 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
2,4,5-T	0 / 71	0	µg/L	0.0786	0.5	0.0393	0.084	0.0425	0.25	--	--	--	--	--	--	--	--	--	--	--
2,4-D	1 / 71	1.41	µg/L	0.0786	0.5	0.0393	0.0841	0.0425	0.25	0.052	0.052	0.052	--	--	--	--	--	--	--	--
Dinoseb	0 / 2	0	µg/L	0.5	0.5	0.25	0.25	0.25	0.25	--	--	--	--	--	--	--	--	--	--	--
Silvex	4 / 253	1.58	µg/L	0.0751	0.83	0.0376	0.1095	0.0783	1.54	0.174	0.85	1.54	--	--	--	--	--	--	--	--
								Pesticides												
2,4'-DDD	0 / 2	0	µg/L	0.05	0.05	0.025	0.025	0.025	0.025	--	--	--	--	--	--	--	--	--	--	--
2,4'-DDE	0 / 2	0	µg/L	0.05	0.05	0.025	0.025	0.025	0.025	--	--	--	--	--	--	--	--	--	--	--
2,4'-DDT	0 / 2	0	µg/L	0.05	0.05	0.025	0.025	0.025	0.025	--	--	--	--	--	--	--	--	--	--	--
4,4'-DDD	5 / 429	1.17	µg/L	0.0019	0.0526	9.4E-04	0.0029	0.0019	0.0767	0.0106	0.0252	0.0767	--	--	--	--	0.0031	**5 / 429**	--	--
4,4'-DDE	6 / 429	1.4	µg/L	0.0019	0.0581	9.4E-04	0.0101	0.0051	0.0291	0.0071	0.0164	0.02	--	--	--	--	0.0022	**6 / 429**	--	--
4,4'-DDT	6 / 422	1.42	µg/L	0.0019	0.0581	9.4E-04	0.0102	0.0051	0.0302	0.0073	0.0222	0.0302	0.001	**6 / 422**	1.1	0 / 422	0.0022	**6 / 422**	--	--
Aldrin	1 / 417	0.24	µg/L	0.0012	0.0581	6.2E-04	0.009	0.0033	0.0291	0.014	0.014	0.014	--	--	3	0 / 417	5.0E-04	**1 / 417**	--	--
Chlordane	0 / 120	0	µg/L	0.0143	0.153	0.0072	0.0243	0.0174	0.0765	--	--	--	0.0043	0 / 120	2.4	0 / 120	0.0081	0 / 120	--	--
Dieldrin	0 / 433	0	µg/L	0.0019	0.5	9.4E-04	0.0165	0.0051	0.25	--	--	--	0.056	0 / 433	0.24	0 / 433	5.4E-04	0 / 433	--	--
Endosulfan I	3 / 267	1.12	µg/L	0.0012	0.0581	6.2E-04	0.0126	0.0035	0.0291	0.011	0.012	0.014	0.056	0 / 267	0.22	0 / 267	89	0 / 267	--	--
Endosulfan II	0 / 275	0	µg/L	0.0019	0.0581	9.4E-04	0.0136	0.0055	0.0291	--	--	--	0.056	0 / 275	0.22	0 / 275	89	0 / 275	--	--
Endosulfan sulfate	4 / 272	1.47	µg/L	0.0019	0.0581	9.4E-04	0.0134	0.0055	0.0291	0.014	0.0163	0.0203	--	--	--	--	89	0 / 272	--	--
Endrin	1 / 275	0.36	µg/L	0.0019	0.0581	9.4E-04	0.0137	0.0056	0.0291	0.0155	0.0155	0.0155	0.036	0 / 275	0.086	0 / 275	0.06	0 / 275	--	--
Endrin aldehyde	3 / 282	1.06	µg/L	0.0012	0.0581	6.2E-04	0.0133	0.0065	0.031	0.011	0.019	0.031	--	--	--	--	0.3	0 / 282	--	--
Endrin ketone	0 / 254	0	µg/L	0.0019	0.0581	9.4E-04	0.0127	0.0052	0.0291	--	--	--	--	--	--	--	--	--	--	--
Heptachlor	0 / 254	0	µg/L	0.0012	0.0581	6.2E-04	0.0121	0.0034	0.0291	--	--	--	0.0038	0 / 254	0.52	0 / 254	7.9E-04	0 / 254	--	--
Heptachlor epoxide	8 / 275	2.91	µg/L	0.0012	0.0581	6.2E-04	0.0074	0.0014	0.419	0.0037	0.077	0.419	0.0038	**7 / 275**	0.52	0 / 275	3.9E-04	**8 / 275**	--	--
Lindane	1 / 159	0.63	µg/L	0.0012	0.052	6.2E-04	0.0043	0.0032	0.027	0.027	0.027	0.027	--	--	0.95	0 / 159	1.8	0 / 159	--	--
Methoxychlor	8 / 270	2.96	µg/L	0.0094	0.109	0.0047	0.0123	0.011	0.332	0.011	0.0521	0.332	0.001	**8 / 270**	--	--	--	--	--	--
Toxaphene	0 / 28	0	µg/L	0.0309	0.52	0.0155	0.1664	0.25	0.26	--	--	--	2.0E-04	0 / 28	0.73	0 / 28	0.0028	0 / 28	--	--
alpha-BHC	12 / 274	4.38	µg/L	0.0012	0.0581	6.2E-04	0.0128	0.0037	0.046	0.0065	0.0173	0.046	--	--	--	--	0.049	0 / 274	--	--
alpha-Chlordane	0 / 282	0	µg/L	0.0012	0.0581	6.2E-04	0.0134	0.0065	0.0291	--	--	--	--	--	--	--	--	--	--	--
beta-BHC	29 / 422	6.87	µg/L	0.0012	0.0581	6.2E-04	0.0063	0.0013	0.09	0.0104	0.0265	0.09	--	--	--	--	0.17	0 / 422	--	--
delta-BHC	1 / 274	0.36	µg/L	0.0012	0.0581	6.2E-04	0.013	0.0036	0.0291	0.0153	0.0153	0.0153	--	--	--	--	--	--	--	--
gamma-Chlordane	3 / 282	1.06	µg/L	0.0012	0.0581	6.2E-04	0.0133	0.0065	0.0291	0.013	0.0151	0.019	--	--	--	--	--	--	--	--
								Polychlorinated Biphenyls												
PCB-1016	0 / 282	0	µg/L	0.0311	0.465	0.0156	0.1055	0.0185	0.2325	--	--	--	--	--	0.5	0 / 282	6.4E-04	0 / 282	--	--
PCB-1221	0 / 282	0	µg/L	0.0311	0.465	0.0156	0.1055	0.0185	0.2325	--	--	--	--	--	0.5	0 / 282	6.4E-04	0 / 282	--	--
PCB-1232	0 / 282	0	µg/L	0.0311	0.465	0.0156	0.1055	0.0185	0.2325	--	--	--	--	--	0.5	0 / 282	6.4E-04	0 / 282	--	--
PCB-1242	1 / 288	0.35	µg/L	0.0311	0.465	0.0156	0.1084	0.0193	0.276	0.276	0.276	0.276	--	--	0.5	0 / 288	6.4E-04	**1 / 288**	--	--
PCB-1248	0 / 282	0	µg/L	0.0311	0.465	0.0156	0.1055	0.0185	0.2325	--	--	--	--	--	0.5	0 / 282	6.4E-04	0 / 282	--	--
PCB-1254	1 / 288	0.35	µg/L	0.0311	0.465	0.0156	0.1081	0.0193	0.2325	0.19	0.19	0.19	--	--	0.5	0 / 288	6.4E-04	**1 / 288**	--	--
PCB-1260	1 / 288	0.35	µg/L	0.0311	0.465	0.0156	0.1072	0.0188	0.2325	0.11	0.11	0.11	--	--	0.5	0 / 288	6.4E-04	**1 / 288**	--	--
PCB-1262	0 / 277	0	µg/L	0.0311	0.465	0.0156	0.1038	0.0179	0.2325	--	--	--	--	--	0.5	0 / 277	6.4E-04	0 / 277	--	--
PCB-1268	0 / 278	0	µg/L	0.0311	0.465	0.0156	0.1042	0.018	0.2325	--	--	--	--	--	0.5	0 / 278	6.4E-04	0 / 278	--	--
								Semivolatile Organics												
1,2,4,5-Tetrachlorobenzene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	1.1	0 / 2	--	--
1,2,4-Trichlorobenzene	0 / 286	0	µg/L	1.33	11.1	0.665	2.897	1.563	5.55	--	--	--	--	--	--	--	70	0 / 286	--	--
1,2-Dichlorobenzene	0 / 286	0	µg/L	1.33	11.1	0.665	2.897	1.563	5.55	--	--	--	--	--	--	--	1300	0 / 286	--	--
1,2-Diphenylhydrazine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	2	0 / 2	--	--
1,3-Dichlorobenzene	0 / 286	0	µg/L	1.33	11.1	0.665	2.897	1.563	5.55	--	--	--	--	--	--	--	960	0 / 286	--	--
1,3-Phenylenediamine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
1,4-Dichlorobenzene	0 / 286	0	µg/L	1.33	11.1	0.665	2.897	1.563	5.55	--	--	--	--	--	--	--	190	0 / 286	--	--
1,4-Dinitrobenzene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
1,4-Dioxane	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
2,3,4,6-Tetrachlorophenol	0 / 278	0	µg/L	1.33	11.1	0.665	2.836	1.5	5.55	--	--	--	--	--	--	--	--	--	--	--
2,4,5-Trichlorophenol	0 / 33	0	µg/L	1.35	25	0.675	4.731	5	12.5	--	--	--	--	--	--	--	3600	0 / 33	--	--
2,4,6-Trichlorophenol	0 / 28	0	µg/L	1.35	50	0.675	3.791	5	25	--	--	--	--	--	--	--	24	0 / 28	--	--
2,4-Dichlorophenol	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	290	0 / 2	--	--
2,4-Dimethylaniline	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
2,4-Dimethylphenol	0 / 274	0	µg/L	1.33	11.1	0.665	2.805	1.5	5.55	--	--	--	--	--	--	--	850	0 / 274	--	--
2,4-Dinitrophenol	0 / 274	0	µg/L	2.21	50	1.105	6.796	2.5	25	--	--	--	--	--	--	--	5300	0 / 274	--	--
2,4-Dinitrotoluene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	34	0 / 2	--	--
2,6-Dichlorophenol	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
2,6-Dinitrotoluene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--

Attachment 3. EMWMF summary statistics and comparison to AWQC for unfiltered leachate 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
2-Acetylaminofluorene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
2-Chloronaphthalene	0 / 33	0	µg/L	0.15	10	0.075	3.076	5	5	--	--	--	--	--	--	--	1600	0 / 33	--	--
2-Chlorophenol	0 / 33	0	µg/L	1.35	10	0.675	3.368	5	5	--	--	--	--	--	--	--	150	0 / 33	--	--
2-Methoxyaniline	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
2-Methyl-4,6-dinitrophenol	0 / 33	0	µg/L	1.35	10	0.675	3.368	5	5	--	--	--	--	--	--	--	280	0 / 33	--	--
2-Methylnaphthalene	0 / 282	0	µg/L	0.133	11.1	0.0665	2.495	0.15	5.55	--	--	--	--	--	--	--	--	--	--	--
2-Methylphenol	0 / 274	0	µg/L	1.33	11.1	0.665	2.805	1.5	5.55	--	--	--	--	--	--	--	--	--	--	--
2-Naphthalenamine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
2-Nitrobenzenamine	0 / 33	0	µg/L	1.35	25	0.675	6.095	5	12.5	--	--	--	--	--	--	--	--	--	--	--
2-Nitrophenol	0 / 28	0	µg/L	1.35	10	0.675	3.076	5	5	--	--	--	--	--	--	--	--	--	--	--
3,3'-Dichlorobenzidine	0 / 33	0	µg/L	0.5	3	0.25	0.4889	0.25	1.5	--	--	--	--	--	--	--	0.28	0 / 33	--	--
3- and 4- Methylphenol	0 / 114	0	µg/L	10	11.1	5	5.016	5	5.55	--	--	--	--	--	--	--	--	--	--	--
3-Methylcholanthrene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
4,4'-Methylenebis(2-chloroaniline)	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
4-Aminobiphenyl	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
4-Bromophenyl phenyl ether	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
4-Chloro-3-methylphenol	0 / 271	0	µg/L	1.33	11.1	0.665	2.78	1.5	5.55	--	--	--	--	--	--	--	--	--	--	--
4-Chlorobenzenamine	0 / 2	0	µg/L	25	25	12.5	12.5	12.5	12.5	--	--	--	--	--	--	--	--	--	--	--
4-Methylphenol	0 / 5	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
4-Nitrobenzenamine	0 / 33	0	µg/L	1.35	10	0.675	3.368	5	5	--	--	--	--	--	--	--	--	--	--	--
4-Nitrophenol	0 / 25	0	µg/L	1.35	25	0.675	6.445	1.5	12.5	--	--	--	--	--	--	--	--	--	--	--
5-(2-Propenyl)-1,3-benzodioxole (Safrole)	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
5-Nitro-o-toluidine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Acenaphthene	0 / 286	0	µg/L	0.133	11.1	0.0665	2.414	0.1563	5.55	--	--	--	--	--	--	--	990	0 / 286	--	--
Acenaphthylene	0 / 272	0	µg/L	0.133	11.1	0.0665	2.403	0.15	5.55	--	--	--	--	--	--	--	--	--	--	--
Acetophenone	0 / 274	0	µg/L	1.33	11.1	0.665	2.805	1.5	5.55	--	--	--	--	--	--	--	--	--	--	--
Aniline	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Anthracene	0 / 280	0	µg/L	0.133	11.1	0.0665	2.477	0.15	5.55	--	--	--	--	--	--	--	40,000	0 / 280	--	--
Aramite	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Benz(a)anthracene	1 / 280	0.36	µg/L	0.133	0.644	0.0665	0.1649	0.15	0.5	0.5	0.5	0.5	--	--	--	--	0.18	**1 / 280**	--	--
Benzenemethanol	0 / 274	0	µg/L	1.33	21	0.665	3.153	1.5	10.5	--	--	--	--	--	--	--	--	--	--	--
Benzidine	0 / 252	0	µg/L	1.5	55.6	0.75	11.5	1.03	27.8	--	--	--	--	--	--	--	0.002	0 / 252	--	--
Benzo(a)pyrene	1 / 280	0.36	µg/L	0.133	0.644	0.0665	0.1668	0.15	0.6	0.6	0.6	0.6	--	--	--	--	0.18	**1 / 280**	--	--
Benzo(b)fluoranthene	0 / 280	0	µg/L	0.133	0.644	0.0665	0.164	0.15	0.322	--	--	--	--	--	--	--	0.18	0 / 280	--	--
Benzo(ghi)perylene	0 / 275	0	µg/L	0.133	10	0.0665	0.4215	0.15	5	--	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	0 / 280	0	µg/L	0.133	0.644	0.0665	0.164	0.15	0.322	--	--	--	--	--	--	--	0.18	0 / 280	--	--
Benzoic acid	8 / 283	2.83	µg/L	2.65	52	0.6	7.911	3	26	0.6	2.666	5.68	--	--	--	--	--	--	--	--
Bis(2-chloroethoxy)methane	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Bis(2-chloroethyl) ether	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	5.3	0 / 2	--	--
Bis(2-chloroisopropyl) ether	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	65,000	0 / 2	--	--
Bis(2-ethylhexyl)phthalate	20 / 280	7.14	µg/L	0.3	10	0.15	1.338	0.8	16.9	0.5	3.799	16.9	--	--	--	--	22	0 / 280	--	--
Butyl benzyl phthalate	1 / 275	0.36	µg/L	0.142	11.1	0.071	2.79	1.5	5.55	0.7	0.7	0.7	--	--	--	--	1900	0 / 275	--	--
Carbazole	0 / 286	0	µg/L	0.133	5.56	0.0665	1.191	0.1563	2.78	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzilate	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Chrysene	0 / 275	0	µg/L	0.133	11.1	0.0665	2.432	0.15	5.55	--	--	--	--	--	--	--	0.18	0 / 275	--	--
Di-n-butyl phthalate	6 / 286	2.1	µg/L	0.142	11.1	0.071	2.734	1.443	5.55	1	1.333	2	--	--	--	--	4500	0 / 286	--	--
Di-n-octylphthalate	0 / 275	0	µg/L	0.142	11.1	0.071	2.806	1.5	5.55	--	--	--	--	--	--	--	--	--	--	--
Dibenz(a,h)anthracene	2 / 280	0.71	µg/L	0.133	0.644	0.0665	0.1525	0.147	0.7	0.18	0.44	0.7	--	--	--	--	0.18	**1 / 280**	--	--
Dibenzofuran	0 / 275	0	µg/L	1.33	11.1	0.665	2.813	1.5	5.55	--	--	--	--	--	--	--	--	--	--	--
Diethyl phthalate	1 / 275	0.36	µg/L	0.142	11.1	0.071	2.789	1.5	5.55	0.5	0.5	0.5	--	--	--	--	44,000	0 / 275	--	--
Dimethyl phthalate	3 / 275	1.09	µg/L	0.142	11.1	0.071	2.77	1.5	5.55	1	1.757	2.2	--	--	--	--	1.1E+06	0 / 275	--	--
Diphenylamine	0 / 144	0	µg/L	1.33	3.19	0.665	0.8088	0.75	1.595	--	--	--	--	--	--	--	--	--	--	--
Disulfoton	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Famphur	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Fluoranthene	0 / 280	0	µg/L	0.133	11.1	0.0665	2.477	0.15	5.55	--	--	--	--	--	--	--	140	0 / 280	--	--
Fluorene	0 / 280	0	µg/L	0.133	11.1	0.0665	2.477	0.15	5.55	--	--	--	--	--	--	--	5300	0 / 280	--	--
Hexachloro-1-propene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Hexachlorobenzene	0 / 224	0	µg/L	1.33	10	0.665	2.306	0.755	5	--	--	--	--	--	--	--	0.0029	0 / 224	--	--
Hexachlorobutadiene	0 / 271	0	µg/L	1.33	11.1	0.665	2.78	1.5	5.55	--	--	--	--	--	--	--	180	0 / 271	--	--
Hexachlorocyclopentadiene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	1100	0 / 2	--	--

Attachment 3. EMWMF summary statistics and comparison to AWQC for unfiltered leachate 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
Hexachloroethane	0 / 39	0	µg/L	1.35	10	0.675	3.619	5	5	--	--	--	--	--	--	--	33	0 / 39	--	--
Indeno(1,2,3-cd)pyrene	1 / 280	0.36	µg/L	0.133	0.644	0.0665	0.1652	0.15	0.6	0.6	0.6	0.6	--	--	--	--	0.18	**1 / 280**	--	--
Isodrin	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Isophorone	0 / 280	0	µg/L	1.5	11.1	0.75	2.916	1.75	5.55	--	--	--	--	--	--	--	9600	0 / 280	--	--
Isosafrole	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Kepone	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Methapyrilene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Methyl methanesulfonate	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Methyl parathion	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
N-Nitroso-di-n-butylamine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	2.2	0 / 2	--	--
N-Nitroso-di-n-propylamine	0 / 33	0	µg/L	1.35	10	0.675	3.368	5	5	--	--	--	--	--	--	--	5.1	0 / 33	--	--
N-Nitrosodiethylamine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	2.4	0 / 2	--	--
N-Nitrosodimethylamine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	30	0 / 2	--	--
N-Nitrosodiphenylamine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	60	0 / 2	--	--
N-Nitrosomethylethylamine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
N-Nitrosomorpholine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
N-Nitrosopiperidine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
N-Nitrosopyrrolidine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	340	0 / 2	--	--
Naphthalene	0 / 286	0	µg/L	0.133	11.1	0.0665	2.414	0.1563	5.55	--	--	--	--	--	--	--	--	--	--	--
Naphtho(1,2,3,4-def)chrysene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Nitrobenzene	0 / 28	0	µg/L	1.35	10	0.675	3.076	5	5	--	--	--	--	--	--	--	690	0 / 28	--	--
Parathion	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	0.013	0 / 2	0.065	0 / 2	--	--	--	--
Pentachlorobenzene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	1.5	0 / 2	--	--
Pentachloronitrobenzene	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Pentachlorophenol	22 / 279	7.89	µg/L	0.0467	0.526	0.0234	0.1627	0.104	1.75	0.104	0.4253	1.75	15	0 / 279	19	0 / 279	30	0 / 279	--	--
Phenacetin	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Phenanthrene	0 / 280	0	µg/L	0.133	11.1	0.0665	2.477	0.15	5.55	--	--	--	--	--	--	--	--	--	--	--
Phenol	0 / 281	0	µg/L	1.33	11.1	0.665	2.859	1.5	5.55	--	--	--	--	--	--	--	1.7E+06	0 / 281	--	--
Phorate	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Phthalic anhydride	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Pronamide	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Pyrene	0 / 275	0	µg/L	0.133	11.1	0.0665	2.432	0.15	5.55	--	--	--	--	--	--	--	4000	0 / 275	--	--
Pyridine	0 / 28	0	µg/L	1.35	10	0.675	3.076	5	5	--	--	--	--	--	--	--	--	--	--	--
Tris(2,3-dibromopropyl) phosphate	0 / 2	0	µg/L	50	50	25	25	25	25	--	--	--	--	--	--	--	--	--	--	--
m+p Methylphenol	0 / 161	0	µg/L	1.5	10.3	0.75	1.408	0.925	5.15	--	--	--	--	--	--	--	--	--	--	--
p-Cresidine	0 / 2	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
								Volatile Organics												
(1,1-Dimethylethyl)benzene	0 / 722	0	µg/L	0.3	5	0.15	1.986	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
(1-Methylpropyl)benzene	0 / 722	0	µg/L	0.3	5	0.15	1.986	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,1,1,2-Tetrachloroethane	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	0 / 881	0	µg/L	0.3	5	0.15	1.826	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,1,2,2-Tetrachloroethane	0 / 106	0	µg/L	0.3	5	0.15	1.99	2.5	2.5	--	--	--	--	--	--	--	40	0 / 106	--	--
1,1,2-Trichloro-1,2,2-trifluoroethane	0 / 89	0	µg/L	1.5	5	0.75	2.078	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,1,2-Trichloroethane	0 / 822	0	µg/L	0.3	5	0.15	1.783	2.5	2.5	--	--	--	--	--	--	--	160	0 / 822	--	--
1,1-Dichloroethane	0 / 881	0	µg/L	0.3	5	0.15	1.826	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,1-Dichloroethene	0 / 834	0	µg/L	0.3	5	0.15	1.788	2.5	2.5	--	--	--	--	--	--	--	7100	0 / 834	--	--
1,2,3-Trichloropropane	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,2,3-Trimethylbenzene	0 / 556	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,2,4-Trimethylbenzene	0 / 828	0	µg/L	0.3	5	0.15	1.788	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,2-Dibromo-3-chloropropane	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,2-Dibromoethane	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,2-Dichloroethane	0 / 106	0	µg/L	0.3	5	0.15	1.99	2.5	2.5	--	--	--	--	--	--	--	370	0 / 106	--	--
1,2-Dichloroethene	0 / 67	0	µg/L	0.3	5	0.15	2.257	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,2-Dichloropropane	0 / 106	0	µg/L	0.3	5	0.15	1.99	2.5	2.5	--	--	--	--	--	--	--	150	0 / 106	--	--
1,2-Dimethylbenzene	0 / 869	0	µg/L	0.3	5	0.15	1.822	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	0 / 828	0	µg/L	0.3	5	0.15	1.792	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1,3-Dimethylbenzene	0 / 4	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
1-Butanol	0 / 9	0	µg/L	250	250	125	125	125	125	--	--	--	--	--	--	--	--	--	--	--
1-Methyl-4-(1-methylethyl)benzene	0 / 722	0	µg/L	0.3	5	0.15	1.986	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
2-Butanone	11 / 898	1.22	µg/L	1.5	10	0.75	3.24	1	1770	2	164	1770	--	--	--	--	--	--	--	--

Attachment 3. EMWMF summary statistics and comparison to AWQC for unfiltered leachate 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
2-Chloro-1,3-butadiene	0 / 9	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
2-Hexanone	0 / 898	0	µg/L	1.5	10	0.75	3.868	5	5	--	--	--	--	--	--	--	--	--	--	--
4-Methyl-2-pentanone	0 / 916	0	µg/L	1.5	10	0.75	3.837	5	5	--	--	--	--	--	--	--	--	--	--	--
Acetone	58 / 918	6.32	µg/L	1.5	10	0.75	6.17	2	1730	2	60.0	1730	--	--	--	--	--	--	--	--
Acetonitrile	0 / 9	0	µg/L	20	20	10	10	10	10	--	--	--	--	--	--	--	--	--	--	--
Acrolein	0 / 9	0	µg/L	10	10	5	5	5	5	--	--	--	3	0 / 9	3	0 / 9	9	0 / 9	--	--
Acrylonitrile	0 / 684	0	µg/L	1.5	20	0.75	6.543	10	10	--	--	--	--	--	--	--	2.5	0 / 684	--	--
Allyl chloride	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Benzene	0 / 918	0	µg/L	0.3	5	0.15	1.853	2.5	2.5	--	--	--	--	--	--	--	510	0 / 918	--	--
Bromodichloromethane	0 / 106	0	µg/L	0.3	5	0.15	1.99	2.5	2.5	--	--	--	--	--	--	--	170	0 / 106	--	--
Bromoform	0 / 335	0	µg/L	0.3	5	0.15	0.7334	0.15	2.5	--	--	--	--	--	--	--	1400	0 / 335	--	--
Bromomethane	0 / 106	0	µg/L	0.3	10	0.15	3.948	5	5	--	--	--	--	--	--	--	1500	0 / 106	--	--
Carbon disulfide	1 / 899	0.11	µg/L	1.5	5	0.75	2.01	2.5	2.5	1.24	1.24	1.24	--	--	--	--	--	--	--	--
Carbon tetrachloride	0 / 918	0	µg/L	0.3	5	0.15	1.845	2.5	2.5	--	--	--	--	--	--	--	16	0 / 918	--	--
Chlorobenzene	0 / 916	0	µg/L	0.3	5	0.15	1.856	2.5	2.5	--	--	--	--	--	--	--	1600	0 / 916	--	--
Chloroethane	1 / 879	0.11	µg/L	0.3	10	0.1	2.063	2.5	5	0.1	0.1	0.1	--	--	--	--	--	--	--	--
Chloroform	2 / 918	0.22	µg/L	0.3	5	0.15	1.85	2.5	2.5	1	1.175	1.35	--	--	--	--	4700	0 / 918	--	--
Chloromethane	0 / 106	0	µg/L	0.3	10	0.15	3.948	5	5	--	--	--	--	--	--	--	--	--	--	--
Cumene	0 / 873	0	µg/L	0.3	5	0.15	1.825	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Cyclohexanone	0 / 9	0	µg/L	100	100	50	50	50	50	--	--	--	--	--	--	--	--	--	--	--
Dibromochloromethane	0 / 106	0	µg/L	0.3	5	0.15	1.99	2.5	2.5	--	--	--	--	--	--	--	170	0 / 106	--	--
Dibromomethane	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Dichlorodifluoromethane	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Diethyl ether	0 / 9	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Ethane	0 / 96	0	µg/L	5	10	2.5	3.125	2.5	5	--	--	--	--	--	--	--	--	--	--	--
Ethyl acetate	0 / 9	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Ethyl cyanide	0 / 9	0	µg/L	20	20	10	10	10	10	--	--	--	--	--	--	--	--	--	--	--
Ethyl methacrylate	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	0 / 898	0	µg/L	0.3	5	0.15	1.844	2.5	2.5	--	--	--	--	--	--	--	2100	0 / 898	--	--
Ethylene	0 / 96	0	µg/L	5	10	2.5	3.125	2.5	5	--	--	--	--	--	--	--	--	--	--	--
Ethylene oxide	0 / 9	0	µg/L	50	50	25	25	25	25	--	--	--	--	--	--	--	--	--	--	--
Hexane	1 / 798	0.13	µg/L	1.67	5	0.835	1.995	2.5	2.5	1.22	1.22	1.22	--	--	--	--	--	--	--	--
Iodomethane	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Isobutanol	0 / 9	0	µg/L	50	50	25	25	25	25	--	--	--	--	--	--	--	--	--	--	--
M + P Xylene	0 / 71	0	µg/L	0.3	5	0.15	2.403	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Methacrylonitrile	0 / 9	0	µg/L	10	10	5	5	5	5	--	--	--	--	--	--	--	--	--	--	--
Methane	13 / 96	13.5	µg/L	5	10	1.01	2.34	1.37	29.6	1.01	5.712	29.6	--	--	--	--	--	--	--	--
Methanol	3 / 222	1.35	µg/L	200	5000	100	378	250	5710	820	2777	5710	--	--	--	--	--	--	--	--
Methyl methacrylate	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Methylcyclohexane	0 / 912	0	µg/L	0.3	5	0.15	1.854	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Methylene chloride	12 / 898	1.34	µg/L	1	5	0.5	0.2743	0.1	7	1	2.483	7	--	--	--	--	5900	0 / 898	--	--
Propylbenzene	0 / 815	0	µg/L	0.3	5	0.15	1.777	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Propylene glycol	2 / 222	0.9	µg/L	3000	60,000	1500	5270	1500	30,000	14,400	14,750	15,100	--	--	--	--	--	--	--	--
Styrene	0 / 827	0	µg/L	0.3	5	0.15	1.787	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Tetrachloroethene	0 / 918	0	µg/L	0.3	5	0.15	1.853	2.5	2.5	--	--	--	--	--	--	--	33	0 / 918	--	--
Toluene	4 / 916	0.44	µg/L	0.3	5	0.15	0.3392	0.3	12.8	0.97	5.14	12.8	--	--	--	--	15,000	0 / 916	--	--
Total Xylene	0 / 916	0	µg/L	0.3	5	0.15	1.864	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Trichloroethene	0 / 918	0	µg/L	0.3	5	0.15	1.853	2.5	2.5	--	--	--	--	--	--	--	300	0 / 918	--	--
Trichlorofluoromethane	0 / 9	0	µg/L	5	5	2.5	2.5	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Trimethylbenzene	0 / 251	0	µg/L	0.3	0.33	0.15	0.1513	0.15	0.165	--	--	--	--	--	--	--	--	--	--	--
Vinyl chloride	0 / 881	0	µg/L	0.3	10	0.15	1.837	2.5	5	--	--	--	--	--	--	--	24	0 / 881	--	--
cis-1,2-Dichloroethene	0 / 879	0	µg/L	0.3	5	0.15	1.829	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
cis-1,3-Dichloropropene	0 / 106	0	µg/L	0.3	5	0.15	1.99	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
trans-1,2-Dichloroethene	0 / 106	0	µg/L	0.3	5	0.15	1.99	2.5	2.5	--	--	--	--	--	--	--	10,000	0 / 106	--	--
trans-1,3-Dichloropropene	0 / 106	0	µg/L	0.3	5	0.15	1.99	2.5	2.5	--	--	--	--	--	--	--	--	--	--	--
Radionuclides																				
Actinium-225	1 / 29	3.45	pCi/L	0.08	0.503	-0.18	0.0723	0.05	0.528	0.18	0.18	0.18	--	--	--	--	--	--	--	--
Actinium-227	17 / 208	8.17	pCi/L	0.08	0.96	-0.09	0.0966	0.07	0.48	0.16	0.2935	0.48	--	--	--	--	--	--	9.6	0 / 208
Alpha activity	33 / 33	100	pCi/L	--	--	5.7	97.6	58.5	832	5.7	97.6	832	--	--	--	--	--	--	--	--
Aluminum-26	2 / 185	1.08	pCi/L	1.6	9.84	-2.68	0.2506	0.19	7.34	2.33	4.835	7.34	--	--	--	--	--	--	9600	0 / 185

Attachment 3. EMWMF summary statistics and comparison to AWQC for unfiltered leachate 2005-2021

				Non-detect Detection Limits[a]						Detected				Freq. >		Freq. >		Freq. >		Freq. >
Chemical	Freq. of Detection	Percent Detected	Units	Min	Max	Min[b]	Mean[b]	Median[b]	Max[b]	Min	Mean	Max	Fish CCC[c]	Fish CCC[c]	Fish CMC[d]	Fish CMC[d]	Rec. OOC[e]	Rec. OOC[e]	96% of DCG[f]	96% of DCG[f]
Americium-241	8 / 287	2.79	pCi/L	0.05	0.99	-0.15	0.0636	0.04	1.46	0.14	0.5248	1.46	--	--	--	--	--	--	28.8	0 / 287
Americium-243	33 / 200	16.5	pCi/L	0.06	1.12	-0.09	0.1402	0.11	1.12	0.14	0.3624	1.12	--	--	--	--	--	--	28.8	0 / 200
Antimony-126	1 / 33	3.03	pCi/L	3.69	35.5	-10.5	-0.5769	-0.18	7.92	7.92	7.92	7.92	--	--	--	--	--	--	--	--
Barium-133	0 / 28	0	pCi/L	3.54	6.88	-4.07	-0.6425	-0.0087	1.62	--	--	--	--	--	--	--	--	--	--	--
Beta activity	33 / 33	100	pCi/L	--	--	2.94	210	94.9	1240	2.94	210	1240	--	--	--	--	--	--	--	--
Bismuth-207	1 / 33	3.03	pCi/L	2.48	6.97	-3.26	0.2563	0.16	5.16	3.5	3.5	3.5	--	--	--	--	--	--	--	--
Californium-249	2 / 33	6.06	pCi/L	0.07	0.55	-0.06	0.0621	0.05	0.31	0.12	0.215	0.31	--	--	--	--	--	--	--	--
Californium-250	0 / 33	0	pCi/L	0.03	0.575	-0.168	0.0126	0	0.192	--	--	--	--	--	--	--	--	--	--	--
Californium-251	1 / 33	3.03	pCi/L	0.11	0.86	-0.11	0.0755	0.07	0.39	0.39	0.39	0.39	--	--	--	--	--	--	--	--
Californium-252	0 / 195	0	pCi/L	0.03	1.07	-0.176	0.0123	0	0.22	--	--	--	--	--	--	--	--	--	96	0 / 195
Carbon-14	15 / 290	5.17	pCi/L	10.8	22.2	-21.7	4.774	4.195	22.7	14.3	17.8	22.7	--	--	--	--	--	--	67,200	0 / 290
Cesium-135	0 / 33	0	pCi/L	12.7	25.5	-7.9	1.284	1.06	14.6	--	--	--	--	--	--	--	--	--	--	--
Cesium-137	2 / 290	0.69	pCi/L	2.31	16.6	-4.07	0.6286	0.704	6.68	3.1	4.215	5.33	--	--	--	--	--	--	2880	0 / 290
Chlorine-36	69 / 290	23.8	pCi/L	0.02	5.2	-1.2	2.342	1.32	33.2	1.9	6.66	33.2	--	--	--	--	--	--	48,000	0 / 290
Cobalt-60	2 / 282	0.71	pCi/L	2.45	8.97	-3.1	0.529	0.41	10.1	6.96	8.53	10.1	--	--	--	--	--	--	4800	0 / 282
Curium-242	0 / 202	0	pCi/L	0.03	1.07	-0.176	0.0118	0	0.22	--	--	--	--	--	--	--	--	--	960	0 / 202
Curium-243/244	6 / 200	3	pCi/L	0.07	0.99	-0.21	0.0503	0.03	0.43	0.16	0.2667	0.43	--	--	--	--	--	--	48	0 / 200
Curium-245	41 / 279	14.7	pCi/L	0.07	1.14	-0.14	0.142	0.118	1.13	0.13	0.3738	1.13	--	--	--	--	--	--	28.8	0 / 279
Curium-246	41 / 279	14.7	pCi/L	0.07	1.14	-0.14	0.142	0.118	1.13	0.13	0.3738	1.13	--	--	--	--	--	--	28.8	0 / 279
Curium-247	3 / 282	1.06	pCi/L	0.08	1.2	-0.121	0.0332	0	0.758	0.34	0.536	0.758	--	--	--	--	--	--	28.8	0 / 282
Curium-248	8 / 206	3.88	pCi/L	0.05	1.22	-0.12	0.0535	0.03	0.96	0.18	0.3075	0.44	--	--	--	--	--	--	7.68	0 / 206
Europium-152	1 / 282	0.35	pCi/L	7.69	72.2	-26.3	0.7083	0.545	43.4	43.4	43.4	43.4	--	--	--	--	--	--	19,200	0 / 282
Europium-154	0 / 281	0	pCi/L	3.65	25.4	-8.72	0.2144	0.26	15.4	--	--	--	--	--	--	--	--	--	19,200	0 / 281
Europium-155	1 / 202	0.5	pCi/L	3.81	14.3	-40.5	-1.432	-0.125	6.2	5.31	5.31	5.31	--	--	--	--	--	--	96,000	0 / 202
Iodine-129	71 / 434	16.4	pCi/L	0.458	2.73	-0.97	0.7833	0.8015	3.51	0.531	1.355	3.51	--	--	--	--	--	--	480	0 / 434
Lead-210	39 / 263	14.8	pCi/L	0.41	1.37	-0.498	0.3431	0.31	1.63	0.42	0.9246	1.63	--	--	--	--	--	--	28.8	0 / 263
Lead-212	0 / 33	0	pCi/L	4.62	9.16	-5.26	1.024	1.01	7.55	--	--	--	--	--	--	--	--	--	--	--
Neptunium-237	22 / 287	7.67	pCi/L	0.0141	0.48	-0.09	0.0756	0.0348	3.33	0.15	0.5347	3.33	--	--	--	--	--	--	28.8	0 / 287
Nickel-59	0 / 32	0	pCi/L	132	346	-176	-14.6	-19.4	122	--	--	--	--	--	--	--	--	--	--	--
Nickel-63	39 / 282	13.8	pCi/L	13.1	278	-95.6	11.6	7.45	292	17.1	46.7	292	--	--	--	--	--	--	288,000	0 / 282
Niobium-93m	2 / 32	6.25	pCi/L	0.44	6860	-3630	-138	0	4350	86	236	386	--	--	--	--	--	--	--	--
Niobium-94	1 / 33	3.03	pCi/L	2.92	6.35	-2.54	0.4214	0.53	4.36	4.36	4.36	4.36	--	--	--	--	--	--	--	--
Plutonium-236	2 / 197	1.02	pCi/L	0.08	0.75	-0.18	0.0231	0.01	0.35	0.33	0.34	0.35	--	--	--	--	--	--	96	0 / 197
Plutonium-238	2 / 282	0.71	pCi/L	0.07	1.08	-0.1	0.0245	0.0132	0.35	0.15	0.2	0.25	--	--	--	--	--	--	38.4	0 / 282
Plutonium-239/240	7 / 288	2.43	pCi/L	0.07	0.66	-0.106	0.0319	0.02	0.45	0.17	0.3114	0.45	--	--	--	--	--	--	28.8	0 / 288
Plutonium-241	2 / 282	0.71	pCi/L	7.73	60.7	-25.6	0.4892	0	34.7	16.1	23.1	30	--	--	--	--	--	--	1920	0 / 282
Plutonium-242	54 / 274	19.7	pCi/L	0.04	0.693	-3.6	0.0619	0.05	2.26	0.09	0.429	2.26	--	--	--	--	--	--	28.8	0 / 274
Plutonium-244	6 / 201	2.99	pCi/L	0.06	0.79	-0.09	0.043	0.03	0.54	0.16	0.2857	0.54	--	--	--	--	--	--	28.8	0 / 201
Polonium-210	4 / 33	12.1	pCi/L	0.09	0.399	-0.04	0.1077	0.08	0.36	0.197	0.2918	0.36	--	--	--	--	--	--	--	--
Potassium-40	27 / 282	9.57	pCi/L	24.2	113	-59.1	21.1	21.8	183	28.3	57.6	183	--	--	--	--	--	--	6720	0 / 282
Protactinium-231	0 / 28	0	pCi/L	86	180	-57.4	12.5	-2.445	134	--	--	--	--	--	--	--	--	--	9.6	0 / 28
Protactinium-234m	287 / 288	99.7	pCi/L	1.97	1.97	0.56	6.632	3.055	117	0.56	6.651	117	--	--	--	--	--	--	67,200	0 / 288
Radioactive Strontium (Total)	17 / 17	100	pCi/L	--	--	4.18	10.0	10.3	16.1	4.18	10.0	16.1	--	--	--	--	--	--	--	--
Radium-223	3 / 33	9.09	pCi/L	0.16	0.46	-0.09	0.0877	0.07	0.26	0.17	0.2167	0.26	--	--	--	--	--	--	--	--
Radium-225	1 / 29	3.45	pCi/L	0.08	0.503	-0.18	0.0723	0.05	0.528	0.18	0.18	0.18	--	--	--	--	--	--	--	--
Radium-226	32 / 287	11.1	pCi/L	0.0943	0.97	-0.23	0.197	0.16	1.41	0.21	0.5287	1.41	--	--	--	--	--	--	96	0 / 287
Radium-228	56 / 288	19.4	pCi/L	0.43	1.55	-1.06	0.4246	0.297	8.74	0.33	1.269	8.74	--	--	--	--	--	--	96	0 / 288
Silver-108m	0 / 28	0	pCi/L	2.6	7.62	-3.28	0.0294	-0.135	5.66	--	--	--	--	--	--	--	--	--	--	--
Strontium-89	0 / 28	0	pCi/L	0.906	4.7	-15.1	-2.909	-2.41	2.65	--	--	--	--	--	--	--	--	--	--	--
Strontium-90	401 / 418	95.9	pCi/L	0.504	1.93	0.0634	30.4	8.685	471	0.819	31.6	471	--	--	--	--	--	--	960	0 / 418
Technetium-99	413 / 435	94.9	pCi/L	4.47	8.16	0	138	35.3	3110	2.56	145	3110	--	--	--	--	--	--	96,000	0 / 435
Thorium-227	17 / 202	8.42	pCi/L	0.08	0.96	-0.09	0.0969	0.07	0.48	0.16	0.2935	0.48	--	--	--	--	--	--	3840	0 / 202
Thorium-228	7 / 288	2.43	pCi/L	0.07	0.877	-0.267	0.0381	0.03	0.45	0.17	0.2489	0.382	--	--	--	--	--	--	384	0 / 288
Thorium-229	6 / 271	2.21	pCi/L	0.07	0.512	-8.55	0.0466	0	17.7	0.12	3.358	17.7	--	--	--	--	--	--	38.4	0 / 271
Thorium-230	142 / 289	49.1	pCi/L	0.07	0.884	-0.177	0.2415	0.19	2.1	0.107	0.3423	2.1	--	--	--	--	--	--	288	0 / 289
Thorium-232	12 / 288	4.17	pCi/L	0.07	0.69	-0.1	0.0533	0.04	0.43	0.16	0.2492	0.43	--	--	--	--	--	--	48	0 / 288
Thorium-234	275 / 282	97.5	pCi/L	1.97	132	-41.9	3.723	2.86	42.3	0.56	4.126	27.9	--	--	--	--	--	--	9600	0 / 282
Tin-126	0 / 33	0	pCi/L	4.18	11.7	-28.7	-5.565	-4.1	2.07	--	--	--	--	--	--	--	--	--	--	--
Tritium	426 / 435	97.9	pCi/L	229	305	-322	2248	1960	10,300	281	2296	10,300	--	--	--	--	--	--	1.9E+06	0 / 435
Uranium-232	8 / 200	4	pCi/L	0.06	1.15	-0.1	0.0658	0.04	0.76	0.192	0.4046	0.76	--	--	--	--	--	--	96	0 / 200

Attachment 3. EMWMF summary statistics and comparison to AWQC for unfiltered leachate 2005-2021

Chemical	Freq. of Detection	Percent Detected	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	Detected Min	Detected Mean	Detected Max	Fish CCC[c]	Freq. > Fish CCC[c]	Fish CMC[d]	Freq. > Fish CMC[d]	Rec. OOC[e]	Freq. > Rec. OOC[e]	96% of DCG[f]	Freq. > 96% of DCG[f]
Uranium-233	0 / 2	0	pCi/L	14.3	14.9	0.039	0.159	0.159	0.279	--	--	--	--	--	--	--	--	--	--	--
Uranium-233/234	435 / 435	100	pCi/L	--	--	1.45	84.7	52.5	2200	1.45	84.7	2200	--	--	--	--	--	--	480	8 / 435
Uranium-234	2 / 2	100	pCi/L	--	--	1670	1990	1990	2310	1670	1990	2310	--	--	--	--	--	--	480	2 / 2
Uranium-235	2 / 2	100	%	--	--	25.2	26.1	26.1	26.9	25.2	26.1	26.9	--	--	--	--	--	--	--	--
Uranium-235	2 / 2	100	pCi/L	--	--	83.5	101	101	119	83.5	101	119	--	--	--	--	--	--	576	0 / 2
Uranium-235/236	426 / 435	97.9	pCi/L	0.3	2.79	0.2	6.799	3.75	226	0.261	6.933	226	--	--	--	--	--	--	480	0 / 435
Uranium-236	2 / 2	100	pCi/L	--	--	13.4	15.5	15.5	17.6	13.4	15.5	17.6	--	--	--	--	--	--	480	0 / 2
Uranium-238	434 / 435	99.8	pCi/L	1.97	1.97	0.418	7.49	4.06	117	0.418	7.504	117	--	--	--	--	--	--	576	0 / 435
Yttrium-90	279 / 282	98.9	pCi/L	1.15	1.86	0.29	39.6	12.9	471	1.79	40.0	471	--	--	--	--	--	--	9600	0 / 282
Wet Chemistry																				
Bicarbonate	33 / 33	100	µg/L	--	--	107,000	188,212	186,000	299,000	107,000	188,212	299,000	--	--	--	--	--	--	--	--
Carbonate	0 / 33	0	µg/L	500	4000	250	702	725	2000	--	--	--	--	--	--	--	--	--	--	--
Cyanide	5 / 416	1.2	µg/L	1.67	5.32	0.835	1.753	1.67	5.97	1.95	2.836	5.97	5.2	**1 / 416**	22	0 / 416	140	0 / 416	--	--
Dissolved Solids	178 / 178	100	mg/L	--	--	1.1	852	850	4500	1.1	852	4500	--	--	--	--	--	--	--	--
Organic carbon	2 / 2	100	µg/L	--	--	9820	11,810	11,810	13,800	9820	11,810	13,800	--	--	--	--	--	--	--	--
Residue, Filterable (TDS)	2 / 2	100	µg/L	--	--	1.4E+06	1.4E+06	1.4E+06	1.4E+06	1.4E+06	1.4E+06	1.4E+06	--	--	--	--	--	--	--	--
Residue, Non-filterable (TSS)	1 / 2	50	µg/L	2500	2500	1250	8625	8625	16,000	16,000	16,000	16,000	--	--	--	--	--	--	--	--
Sulfide	0 / 2	0	µg/L	1000	1000	500	500	500	500	--	--	--	--	--	--	--	--	--	--	--
Suspended Solids	95 / 178	53.4	µg/L	549	10,000	275	3308	1850	51,000	600	4728	51,000	--	--	--	--	--	--	--	--
Total Organic Carbon (TOC)	18 / 18	100	µg/L	--	--	3060	6195	6520	9090	3060	6195	9090	--	--	--	--	--	--	--	--
Total Organic Carbon Average	160 / 160	100	µg/L	--	--	1910	11,514	11,600	20,200	1910	11,514	20,200	--	--	--	--	--	--	--	--

[a] One half of the detection limits shown are used as proxy values for chemicals for non-detects except where there is sufficient detected data to calculate Kaplan-Meier summary statistics.

[b] This summary statistic is calculated using both detects and non-detects. Kaplan-Meier is used where there is sufficient detected data for chemicals.

[c] CCC = Tennessee Department of Environment and Conservation chapter 0400-40-03 fish and aquatic life Criterion Continuous Concentration general water quality criteria September 2019.

[d] CMC = Tennessee Department of Environment and Conservation chapter 0400-40-03 fish and aquatic life Criterion Maximum Concentration general water quality criteria September 2019.

[e] Rec. OOC = Tennessee Department of Environment and Conservation chapter 0400-40-03 recreation Organisms Only Criteria general water quality criteria September 2019.

[f] DCG = U.S. Environmental Protection Agency derived concentration guideline for radionuclides.

Dist. = distribution. Distribution flags are defined as:

D = The distribution could not be determined with fewer than 6 samples and 3 detects. The UCL95 was calculated using the nonparametric Chebyshev inequality method with at least 2 detects and 3 samples.

G = gamma. UCL95 was calculated using either the adjusted or unadjusted gamma.

L = lognormal. UCL95 was calculated using Land's statistic, Chebyshev minimum variance unbiased estimator, or nonparametric Chebyshev inequality method.

N = normal. UCL95 was calculated using t statistic.

O = no detected results to calculate some summary statistics.

X = neither normal, lognormal nor gamma. UCL95 was calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.

mg/L = milligrams per liter.

µg/L = micrograms per liter.

pCi/L = picocuries per liter.

S.D. = standard deviation.

UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.

UTL95/95 = upper tolerance limit on individual concentrations with 95% confidence and 95% coverage. A nonparametric UTL95/95 requires at least 59 samples.

UTL95/95 values shown in italic font have less than 95% confidence with 95% coverage because there are either fewer than 59 samples for nonparametric or non-detects have higher concentrations than detects.

-- = Not applicable, not available or insufficient data to calculate the statistic.

* The mean, median, standard deviation and UCL95 were calculated using the Kaplan-Meier method for organics and inorganics. UTL95/95 used Kaplan-Meier for parametric distributions for organics and inorganics.

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APPENDIX C.
ATTACHMENT 4—WINNOWING TABLE

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Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
DI/FURA	2,3,7,8-Tetrachlorodibenzo-p-dioxin			X	M	-	M	L				
HERB	2,4,5-T/Silvex	X		X	M	L	M	L				Incidental constituent from herbicide use
HERB	2,4-D	X			---	L	M	L				Incidental constituent from herbicide use
METAL	Aluminum	X	X	X	---	-	L	L				Low mobility based on geologic setting
METAL	Antimony	X	X	X	R, M	M	L	L				Low mobility based on geologic setting
METAL	Arsenic	X	X	X	B, C, R, M	-	L	H	X	X		Low mobility based on geologic setting
METAL	Barium	X	X	X	M	H	L	L				Common in geologic setting
METAL	Beryllium	X	X	X	M	-	L	L				Low mobility based on geologic setting
METAL	Boron	X	X	X	---	L	H	L				Low mobility based on geologic setting
METAL	Cadmium	X	X	X	B, C, M	-	L	L	X	X		Low mobility based on geologic setting
METAL	Calcium	X	X	X	---	-	H	H				Water quality concern, but common in EMWMF geologic setting
METAL	Chromium	X	X	X	B, C, M	H	L/H	L/H	X	X	X	Except for Cr VI, low mobility based on geologic setting
METAL	Cobalt	X	X	X	---	-	L	L				Low mobility based on geologic setting
METAL	Copper	X	X	X	B, C,,M	-	L	H	X	X		Low mobility based on geologic setting
METAL	Hafnium	X	X	X	M	-	L	L				Low mobility based on geologic setting
METAL	Iron	X	X	X	---	-	L	L				Low mobility based on geologic setting
METAL	Lead	X	X	X	B, C, M	H	L	H	X	X		Low mobility based on geologic setting
METAL	Lithium	X	X	X	---	L	L	L				Low mobility based on geologic setting
METAL	Magnesium	X	X	X	---	-	L	L				Low mobility based on geologic setting
METAL	Manganese	X	X	X	---	M	L	L				Low mobility based on geologic setting
METAL	Mercury	X	X	X	B, C, R, M	L	H	H	X	X	X	Methylated mercury has high mobility
METAL	Molybdenum	X	X	X	---	M	L	L				Low mobility based on geologic setting
METAL	Nickel	X	X	X	B, C, R, M	-	L	L	X	X		Low mobility based on geologic setting
METAL	Phosphorous	X	X	X	---	-	H	L				

Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
METAL	Potassium	X	X	X	---	-	H	L				
METAL	Selenium	X	X	X	B, C, M	M	L	L				Low mobility based on geologic setting
METAL	Silver	X	X	X	B	-	L	L				Low mobility based on geologic setting
METAL	Sodium	X	X	X	---	-	H	L				
METAL	Strontium	X	X	X	---	M	L	L				Low mobility based on geologic setting
METAL	Thallium	X	X	X	R, M	-	L	L				Low mobility based on geologic setting
METAL	Tin	X	X	X	---	M	L	L				Low mobility based on geologic setting
METAL	Titanium	X	X	X	---	-	L	L				Low mobility based on geologic setting
METAL	Uranium	X	X	X	M	-	H	L	X	X	X	The radioactive isotopes will be included as COCs
METAL	Vanadium	X	X	X	---	H	L	L				Low mobility based on geologic setting
METAL	Zinc	X	X	X	B, C	-	L	L				Low mobility based on geologic setting
METAL	Zirconium	X	X	X	---	-	L	L				Low mobility based on geologic setting
Other	Ammonia Nitrogen. Total as N					-	H	H	X	X		Generally ubiquitous in leachate
Other	asbestos	X	X		---	-	L	L				Not detected in discharges
Other	Bicarbonate EPA-310.1	X			---	-	H	L				
Other	Carbonate EPA-310.1	X			---	-	H	L				
Other	Chloride	X			---	-	H	L				
Other	Cyanide	X	X	X	B, C, R, M	L	H	H	X	X		
Other	Total Dissolved Solids/Conductivity	X			---	-	H	H	X	X		Daily recommended to evaluate whether discharge changes have occurred (a pulse)
Other	Fluoride	X			---	-	H	L				
Other	Hardness as CaCO3, mg/l					-	-	-	x	x		Required to determine toxicity of the EMWMF some metal COCs
Other	Nitrite as Nitrogen	X			---	-	H	L				
Other	Nitrogen, total (as N)						H	H	x	x		Nutrient which may impact stream health
Other	Nitrogen, Nitrate total (N)					-	H	H	x	x		Nutrient which may impact stream health
Other	Phosphorous, total as P					-	H	H	x	x		Nutrient which may impact stream health
Other	Sulfate	X			---	-	H	-				

Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
Other	Total Suspended Solids	X			---	-	H	H	X	X		Transports adsorbed metals/PCBs - affects benthics
Other	Total Organic Carbon (TOC)	X			---	-	L	H	X	X		Instead of multiple VOCs/SVOCs
Other	Whole effluent toxicity - chronic/acute					-	-	H	X	X		Semi-annual or after a major change in waste characteristics. One sample during Sept–Nov low-flow period
PPCB	4,4'-DDD	X	X	X	R	L	I	H	X	X		From incidental use for intended purpose.
PPCB	4,4'-DDE	X	X	X	R	L	I	H	X	X		From incidental use for intended purpose.
PPCB	4,4'-DDT	X	X	X	B, C, R	-	I	H	X	X		From incidental use for intended purpose.
PPCB	Aldrin	X	X	X	B, R	L	I	L	X	X		
PPCB	alpha-BHC	X	X	X	R	L	L	L				
PPCB	alpha-Chlordane	X	X	X	---	-	L	L				
PPCB	beta-BHC	X	X	X	R	L	L	H	X	X		
PPCB	Chlordane	X	X	X	B, C, R, M	L	I	L				
PPCB	delta-BHC	X	X	X	---	L	L	L				
PPCB	Dieldrin	X	X	X	B, C, R	L	I	H	X	X		
PPCB	Endosulfan I	X	X	X	B, C, R	L	L	L				
PPCB	Endosulfan II	X	X	X	B, C, R	L	L	L				
PPCB	Endosulfan sulfate	X	X	X	R	-	I	L				
PPCB	Endrin	X	X	X	B, C, R, M	L	I	L				
PPCB	Endrin aldehyde	X	X	X	R	L	L	L				
PPCB	Endrin ketone	X	X	X	---	L	M	L				
PPCB	gamma-Chlordane	X	X	X	---	-	L	L				
PPCB	Heptachlor	X	X	X	B, C, R, M	L	I	L				
PPCB	Heptachlor epoxide	X	X	X	B, C, R	L	L	L				
PPCB	Lindane	X	X	X	B, R, M	L	L	L				
PPCB	Methoxychlor	X	X	X	M	-	L	L				
PPCB	PCB-1016	X	X	X	B, R, M	-	L	L				
PPCB	PCB-1221	X	X	X	B, R, M	-	L	L				
PPCB	PCB-1232	X	X	X	B, R, M	-	L	L				
PPCB	PCB-1242	X	X	X	B, R, M	-	L	L				
PPCB	PCB-1248	X	X	X	B, R, M	-	L	L				
PPCB	PCB-1254	X	X	X	B, R, M	-	I	L				
PPCB	PCB-1260	X	X	X	B, R, M	-	I	L				
PPCB	PCB-1262	X	X	X	B, R, M	-	L	L				
PPCB	PCB-1268	X	X	X	B, R, M	-	L	L				
PPCB	PCBs-Total	X	X		C, R	-	L	L				
PPCB	Toxaphene			X	M	-	L	L				

Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
RAD	Actinium-225	X			D	-	-	-				Minimal detects - no further evaluation
RAD	Actinium-227	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Alpha activity	X	X	X	M	-	-	-				Screening level analysis only
RAD	Aluminum-26	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Americium-241	X	X	X	D	M	L	-				Minimal detects - no further evaluation
RAD	Americium-243	X		X	D	-	-	-				Not in waste lot/detects < 10% of DCG
RAD	Antimony-126	X		X	---	-	-	-				Minimal detects - no further evaluation
RAD	Barium-133	X			---	-	-	-				Minimal detects - no further evaluation
RAD	Beta activity	X	X	X	M	-	-	-				Screening level analysis only
RAD	Bismuth-207	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Californium-249	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Californium-250	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Californium-251	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Californium-252	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Carbon-14	X	X	X	D	L	H	L				Minimal detects - no further evaluation
RAD	Cesium-135	X		X	D	-	H	-				Minimal detects - no further evaluation
RAD	Cesium-137	X	X	X	D	-	H	-				Minimal detects - no further evaluation
RAD	Chlorine-36	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Cobalt-60	X	X	X	D	-	M	-				Minimal detects - no further evaluation
RAD	Curium-242	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Curium-243/244	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Curium-245	X	X	X	D	-	-	-				Not in waste lot/detects < 10% of DCG
RAD	Curium-246	X	X	X	D	-	-	-				Not in waste lot/detects < 10% of DCG
RAD	Curium-247	X	X	X	D	-	-	-				Minimal detects - no further evaluation

Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
RAD	Curium-248	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Europium-152	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Europium-154	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Europium-155	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Iodine-129	X	X	X	D	L	H	H	X	X	X	
RAD	Lead-210	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Lead-212	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Neptunium-237	X	X	X	D	M	H	L				Minimal detects - no further evaluation
RAD	Nickel-59	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Nickel-63	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Niobium-93m	X			D	-	-	-				Not in waste lot/detects < 10% of DCG
RAD	Niobium-94	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Plutonium-236	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Plutonium-238	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Plutonium-239/240	X	X	X	D	M	L	L				Minimal detects - no further evaluation
RAD	Plutonium-241	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Plutonium-242	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Plutonium-244	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Polonium-210	X			D	-	-	-				Minimal detects - no further evaluation
RAD	Potassium-40	X	X	X	D	-	-	-				Not in waste lot/detects < 10% of DCG
RAD	Protactinium-231	X			D	-	-	-				Minimal detects - no further evaluation
RAD	Protactinium-234m	X	X	X	D	-	-	-				Not in waste lot/detects < 10% of DCG
RAD	Radium-223	X		X	---	-	-	-				Minimal detects - no further evaluation
RAD	Radium-225	X		X	---	-	-	-				Minimal detects - no further evaluation
RAD	Radium-226	X	X	X	D	-	-	-				Not in waste lot/detects < 10% of DCG

Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
RAD	Radium-228	X	X	X	D	-	-	-				Not in waste lot/detects < 10% of DCG
RAD	Silver-108m	X			---	-	-	-				Minimal detects - no further evaluation
RAD	Strontium-89	X		X	---	-	H	-				Minimal detects - no further evaluation
RAD	Strontium-90	X	X	X	D, M	-	H	-	X	X	X	
RAD	Technetium-99	X	X	X	D	H	H	H	X	X	X	
RAD	Thorium-227	X		X	D, M	-	-	-				Minimal detects - no further evaluation
RAD	Thorium-228	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Thorium-229	X	X	X	D	-	-	-				Minimal detects - no further evaluation
RAD	Thorium-230	X	X	X	D	-	-	-				U-234/238 daughter product (COCs)
RAD	Thorium-232	X	X	X	D	-	-	-				Not in waste lot/detects < 12% of DCG
RAD	Thorium-234	X	X	X	D	-	-	-				U-238 daughter/detects < 10% of DCG
RAD	Tin-126	X			D	-	-	-				Minimal detects - no further evaluation
RAD	Total Radium Alpha			X	---	-	-	-				Screening level analysis only
RAD	Tritium	X	X	X	D, M	L	H	H	X	X	X	
RAD	Uranium-232	X		X	D	-	-	-				Minimal detects - no further evaluation
RAD	Uranium-233/234	X	X	X	D	M	H	L	X	X	X	
RAD	Uranium-235/236	X	X	X	D	H	H	-	X	X	X	
RAD	Uranium-236	X	X	X	D	M	H	-				Minimal detects - no further evaluation
RAD	Uranium-238	X	X	X	D	H	H	-	X	X	X	
RAD	Yttrium-90	X	X	X	D	-	-	-				Not in waste lot/detects < 10% of DCG
SVOA	1,2,4-Trichlorobenzene	X	X	X	R, M	L	M	L				
SVOA	1,2-Dichlorobenzene	X	X	X	R, M	L	M	L				
SVOA	1,3-Dichlorobenzene	X	X	X	R	L	M	L				
SVOA	1,4-Dichlorobenzene	X	X	X	R, M	L	L	L				
SVOA	2,3,4,6-Tetrachlorophenol	X	X	X	---	L	H	L				
SVOA	2,4,5-Trichlorophenol	X		X	---	-	H	L				
SVOA	2,4,6-Trichlorophenol	X			R	-	H	L				
SVOA	2,4-Dimethylphenol	X	X	X	R	L	H	L				
SVOA	2,4-Dinitrophenol	X	X	X	R	-	H	L				
SVOA	2-Chloronaphthalene	X		X	R	-	L	L				
SVOA	2-Chlorophenol	X		X	R	-	H	L				
SVOA	2-Methyl-4,6-dinitrophenol	X		X	R	-	H	L				
SVOA	2-Methylnaphthalene	X	X	X	---	L	L	L				

Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
SVOA	2-MethylphenoL (*o*-cresol)	X	X	X	---	-	H	L				
SVOA	2-Nitrobenzenamine	X		X	---	-	L	L				
SVOA	2-Nitrophenol	X			---	-	H	L				
SVOA	3- and 4- Methylphenol (*p*-cresol)	X	X	X	---	-	H	L				
SVOA	3,3'-Dichlorobenzidine	X		X	R	-	L	L				
SVOA	4-Chloro-3-methylphenol	X	X	X	---	-	H	L				
SVOA	4-Methylphenol	X	X	X	---	-	H	L				
SVOA	4-Nitrobenzenamine	X			---	-	L	L				
SVOA	4-Nitrophenol	X			---	-	H	L				
SVOA	Acenaphthene	X	X	X	R	L	L	L				
SVOA	Acenaphthylene	X	X	X	---	L	L	L				
SVOA	Acetophenone	X	X	X	---	L	L	L				
SVOA	Anthracene	X	X	X	R	-	I	L				
SVOA	Benz(a)anthracene	X	X	X	R	-	I	L				
SVOA	Benzenemethanol	X	X	X	---	-	L	L				
SVOA	Benzidine	X	X	X	R	L	L	L				Detected in less than five waste lots
SVOA	Benzo(a)pyrene	X	X	X	R, M	-	I	L				
SVOA	Benzo(b)fluoranthene	X	X	X	R	-	I	L				
SVOA	Benzo(ghi)perylene	X	X	X	---	-	L	L				
SVOA	Benzo(k)fluoranthene	X	X	X	R	-	I	L				
SVOA	Benzoic acid	X	X	X	---	L	H	L				
SVOA	Bis(2-ethylhexyl)phthalate	X	X	X	R	-	L	L				
SVOA	Butyl benzyl phthalate	X	X	X	R	-	L	L				
SVOA	Carbazole	X	X	X	---	L	L	L				
SVOA	Chrysene	X	X	X	R	-	I	L				
SVOA	Dibenz(a,h)anthracene	X	X	X	R	-	L	L				
SVOA	Dibenzofuran	X	X	X	---	-	L	L				
SVOA	Diethyl phthalate	X	X	X	R	L	H	L				
SVOA	Dimethyl phthalate	X	X	X	R	L	L	L				
SVOA	Di-n-butyl phthalate	X	X	X	R	L	M	L				
SVOA	Di-n-octylphthalate	X	X	X	---	-	L	L				
SVOA	Diphenylamine			X	---	-	L	L				
SVOA	Fluoranthene	X	X	X	R	-	L	L				
SVOA	Fluorene	X	X	X	R	-	L	L				
SVOA	Hexachlorobenzene	X	X	X	R, M	-	L	L				
SVOA	Hexachlorobutadiene	X	X	X	R	L	L	L				
SVOA	Hexachloroethane			X	---	-	L	L				
SVOA	Indeno(1,2,3-cd)pyrene	X	X	X	R	-	L	L				
SVOA	Isophorone	X	X	X	R	L	H	L				
SVOA	m+p Methylphenol		X	X	---	-	H	L				
SVOA	Naphthalene	X	X	X	---	L	L	L				
SVOA	Nitrobenzene	X			R	-	L	L				
SVOA	N-Nitroso-di-n-propylamine	X		X	R	-	L	L				

Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
SVOA	N-Nitrosodiphenylamine	X			R	L	L	L				
SVOA	Pentachlorophenol	X	X	X	B, C, R, M	-	L	L				
SVOA	Phenanthrene	X	X	X	---	-	I	L				
SVOA	Phenol	X	X	X	R	L	H	L				
SVOA	Pyrene	X	X	X	R	-	I	L				
SVOA	Pyridine	X			---	-	L	L				
VOA	(1,1-Dimethylethyl)benzene			X	---	-	H	L				
VOA	(1-Methylpropyl)benzene			X	---	L	H	L				
VOA	1,1,1-Trichloroethane	X	X	X	M	-	M	L				
VOA	1,1,2,2-Tetrachloroethane	X		X	R	-	H	L				
VOA	1,1,2-Trichloro-1,2,2-trifluoroethane	X			---	-	M	L				
VOA	1,1,2-Trichloroethane	X	X	X	R	-	H	L				
VOA	1,1-Dichloroethane	X	X	X	---	-	H	L				
VOA	1,1-Dichloroethene	X	X	X	R, M	-	M	L				
VOA	1,2,3-Trimethylbenzene			X	---	-	H	L				
VOA	1,2,4-Trimethylbenzene	X	X	X	M	L	H	L				
VOA	1,2-Dichloroethane	X		X	R, M	-	H	L				
VOA	1,2-Dichloroethene	X		X	-	-	M	L				
VOA	1,2-Dichloropropane	X		X	R, M	-	H	L				
VOA	1,2-Dimethylbenzene	X	X	X	---	L	H	L				
VOA	1,3,5-Trimethylbenzene	X	X	X	---	L	H	L				
VOA	1-Methyl-4-(1-methylethyl)benzene	X		X	---	L	H	L				
VOA	2-Butanone (Methyl Ethyl Ketone)	X	X	X	---	-	M	L				
VOA	2-Hexanone	X	X	X	---	L	H	L				
VOA	4-Methyl-2-pentanone	X	X	X	---	-	H	L				
VOA	Acetone	X	X	X	---	L	H	L				
VOA	Acrylonitrile	X	X	X	R	-	H	L				
VOA	Benzene	X	X	X	R, M	L	H	L				
VOA	Bromodichloromethane	X		X	---	-	H	L				
VOA	Bromoform	X	X	X	R	L	H	L				
VOA	Bromomethane	X		X	---	-	H	L				
VOA	Carbon disulfide	X	X	X	---	L	M	L				
VOA	Carbon tetrachloride	X	X	X	R, M	L	M	L				
VOA	Chlorobenzene	X	X	X	R	L	M	L				
VOA	Chloroethane	X	X	X	---	-	H	L				
VOA	Chloroform	X	X	X	R	L	H	L				
VOA	Chloromethane	X		X	---	-	H	L				
VOA	cis-1,2-Dichloroethene	X	X	X	M	L	M	L				
VOA	cis-1,3-Dichloropropene	X		X	---	-	H	L				
VOA	Cumene	X	X	X	---	L	H	L				
VOA	Dibromochloromethane	X		X	R	-	H	L				
VOA	Ethane	X			---	-	H	L				
VOA	Ethylbenzene	X	X	X	R, M	L	L	L				
VOA	Ethylene	X			---	-	H	L				

Leachate		CURRENT leachate COC	CURRENT CW COC	CURRENT GW COC	AWQC (B, C, R, M, D)*	WASTE LOT ABUNDANCE (H, M, L)	MOBILITY (H, M, L, I)	POTENTIAL RISK CONCERN (H, M, L)	NEW COC			COMMENTS
Analysis type	Analyte								Leachate	CW	GW	
VOA	Hexane	X	X	X	---	L	M	L				n-hexane detected in less than five waste lots
VOA	M + P Xylene		X	X	---	-	L	L				
VOA	Methane	X			---	-	H	L				
VOA	Methanol	X	X	X	---	-	H	L				
VOA	Methylcyclohexane	X	X	X	---	L	M	L				
VOA	Methylene chloride	X	X	X	R, M	L	H	L				
VOA	Propylbenzene	X	X	X	---	L	H	L				
VOA	Propylene glycol	X	X	X	---	L	H	L				
VOA	Styrene	X	X	X	M	L	M	L				
VOA	Tetrachloroethene	X	X	X	R, M	L	M	L				
VOA	Toluene	X	X	X	R, M	L	M	L				
VOA	Total Xylene	X	X	X	M	L	M	L				
VOA	trans-1,2-Dichloroethene	X		X	M	L	H	L				
VOA	trans-1,3-Dichloropropene	X		X	---	-	H	L				
VOA	Trichloroethene	X	X	X	R, M	L	M	L				
VOA	Trimethylbenzene	X		X	---	-	H	L				
VOA	Vinyl chloride	X	X	X	R, M	L	H	L				

B AWQC CMC (Batch Discharge)
C AWQC CCC (Continuous Discharge)
D 96% of the DCG (DOE O 5400.5)
H High
I Immobile
L Low
M MCL for GW/Medium
R AWQC Recreation
\- Analyte not associated with a Waste Lot
Yellow Mobility class for common organic pollutants from C. W. Fetter (1994) *Applied Hydrogeology*, Prentice-Hall, Upper Saddle River, New Jersey.

AWQC = ambient water quality criteria
CCC = criterion continuous concentration
CMC = criterion maximum concentration
COC = contaminant of concern
CW = contact water
DCG = derived concentration guidelines
GW = groundwater
MCL = maximum contaminant level
MDA = minimum detectable activity
PCB = polychlorinated biphenyl
PPCB =pesticides and PCBs
RAD = radiological
SVOA = semivolatile organic analysis

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APPENDIX D.
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Section 121 and 40 *Code of Federal Regulations* (*CFR*) 300.430(f)(1)(ii)(B) specify that removal actions for cleanup of hazardous substances must attain or have waived legally applicable or relevant and appropriate requirements (ARARs) under federal or more stringent state environmental laws.

Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (40 *CFR* 300.5). Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 *CFR* 300.5). Pursuant to U.S. Environmental Protection Agency (EPA) guidance, where EPA has delegated to the State of Tennessee the authority to implement a federal program, the Tennessee regulations replace the equivalent federal requirements as the potential ARARs.

CERCLA onsite remedial response actions must comply only with the substantive requirements of a regulation and not the administrative requirements to obtain federal, state, or local permits [CERCLA Section 121(e)]. To ensure that CERCLA response actions proceed as rapidly as possible, EPA has reaffirmed this position in the final National Oil and Hazardous Substances Pollution Contingency Plan (55 *Federal Register* 8756, March 8, 1990). Substantive requirements pertain directly to the actions or conditions at a site, while administrative requirements facilitate their implementation (e.g., approval of or consultation with administrative bodies, documentation, permit issuance, reporting, record keeping, and enforcement).

In addition to ARARs, 40 *CFR* 300.400(g)(3) states that federal or state non-promulgated advisories or guidance may be identified as "to be considered" (TBC) guidance for contaminants, conditions, and/or actions at the site. TBCs include non-promulgated criteria, advisories, guidance, and proposed standards. TBCs are not ARARs because they are neither promulgated nor enforceable. TBCs may be used to interpret ARARs and to determine preliminary remediation goals when ARARs do not exist for particular contaminants or are not sufficiently protective to develop cleanup goals.

This appendix provides an identification of potential federal and state chemical-, location-, and action-specific ARARs and TBC guidance to consider to be added to the Environmental Management Waste Management Facility (EMWMF) Record of Decision (ROD) to complete that set of ARARs (primarily to address water management and treatment under the Clean Water Act [CWA]) and potentially included in the potential Environmental Management Disposal Facility (EMDF) ROD.

As an example, the Tennessee Water Quality Control Board assigned use classifications for surface water bodies in Tennessee. Those use classifications are not assigned based on surrounding land uses, and may have no relationship to how the surface water is currently being used. Tennessee surface water use classifications are listed in TDEC 0400-40-04. Bear Creek, near EMWMF and the proposed EMDF, is classified by the state for Fish and Aquatic Life (FAL), Recreation (REC), Irrigation (IRR), and Livestock Watering and Wildlife (LWW) uses. All other named and unnamed surface waters in the Clinch River Basin, with the exception of wet-weather conveyances, which have not been specifically treated, are classified for FAL, REC, LWW, and IRR uses per TDEC 0400-40-04-.09. Each of the use classifications has water quality standards set under TDEC 0400-40-03, although only the FAL and REC uses have specific numeric ambient water quality criteria (AWQC) set for particular compounds. The REC AWQC are human health criteria, and the FAL criteria are set for the protection of aquatic life. Although all of these criteria, both numeric and narrative, are all potential ARARs for any effluent discharges to Bear Creek, the specific criteria that would be applied and enforced as final limits at a point source outfall, should the selected remedy include an onsite water treatment facility at EMWMF/EMDF, would be negotiated and set in the final decision document for this action and could include any subset of these criteria, as determined by the regulatory authorities. A preliminary subset of key contaminants of concern in the leachate/contact water has been identified and agreed to by the Federal Facility Agreement parties; this subset has been used during the development and screening of remedial alternatives under this Focused Feasibility Study (FFS). AWQC for this subset of contaminants of concern are listed in Table D.2. Other narrative water quality standards are included in Table D.1 as potential chemical-specific ARARs.

Per TDEC 0400-40-05-.10(4), effluent discharges are required to meet the anti-degradation requirements of TDEC 0400-40-03-.06 to ensure that new or increased discharges do not cause measurable degradation of any parameter that is "unavailable." Unavailable parameters exist where water quality is at, or fails to meet, the levels specified as water quality criteria in TDEC 0400-40-03-.03.

As noted in Sect. 1.1, this revision to the FFS addresses the Summary of Major Findings provided in the EPA's Administrator's Dispute Resolution Decision (Appendix M) related to ARARs:

> NRC regulations at 10 *CFR* §61.41 and §61.43 are relevant and appropriate for purposes of developing PRGs in the ORR FFS for effluent limits for radionuclide-contaminated wastewater discharges from the EMWMF and EMDF.
>
> The EPA and Tennessee's NPDES regulations relating to water quality based effluent limitations and Tennessee Water Quality Standards regulations establishing designated uses and criteria to protect those uses (including the risk level of 10-5 for AWQC) are relevant and appropriate requirements for purposes of developing PRGs in the ORR FS for radionuclide-contaminated wastewater discharges from the EMWMF and EMDF.

Final ARARs will be provided in the EMWMF and EMDF RODs and/or applicable post-ROD documents. As noted in the introductory paragraphs of the EPA's Administrator's Dispute Resolution Decision:

> Of course, applicable or relevant and appropriate requirements are applicable or relevant and appropriate to the specific remedy that is selected so the final ARARs and final cleanup levels will be identified when the final remedy is selected, and a Record of Decision is issued.

Although the EMWMF and the proposed EMDF are designed to accept Resource Conservation and Recovery Act of 1976 (RCRA) Subtitle C hazardous waste, no RCRA-listed hazardous waste has been disposed at EMWMF and all RCRA characteristic waste sent to the EMWMF has been treated to meet RCRA land disposal restrictions prior to transfer. Years of leachate and contact water sampling data indicate none of the water contains RCRA characteristic waste. No RCRA-listed waste is expected to be disposed at the proposed EMDF.

Onsite wastewater treatment units that are part of a wastewater treatment facility subject to regulation under Section 402 or Section 307(b) of the CWA are exempt from the requirements of RCRA Subtitle C for all tank systems, conveyance systems (whether piped or trucked), and ancillary equipment used to store or transport RCRA contaminated water. Therefore, RCRA requirements are not legally applicable to the wastewater treatment facility(ies), including any tanks, containers, trucks, pipelines, or surface impoundments.

Because neither the EMWMF nor the proposed EMDF are RCRA Subtitle C hazardous waste landfills, effluent is not subject to effluent limits set under 40 *CFR* 445.11. In addition, even if these were RCRA Subtitle C landfills, both the EMWMF and the proposed EMDF only receive wastes generated by the industrial operations directly associated with the landfill (i.e., "captive landfills"), which EPA notes are exempt from these CWA effluent standards for Subtitle C hazardous waste landfills [40 *CFR* 445.1(e); 65 FR 3008, January 19, 2000].

Table D.1. ARARs and TBC guidance for landfill wastewater management at the ORR CERCLA EMWMF and the EMDF, Oak Ridge, Tennessee

Action	Requirements	Prerequisite	Citation
Chemical-specific ARARs			
Instream water quality criteria for release of contact water and leachate into Bear Creek tributary	Dissolved oxygen shall not be less than 5.0 mg/l. Substantial or frequent variations in dissolved oxygen levels, including diurnal fluctuations, are undesirable if caused by man-induced conditions. Diurnal fluctuations shall not be substantially different than the fluctuations noted in reference streams in the region.	Release of wastewater or effluents into surface water—**applicable** as instream criteria beyond the mixing zone. Release of wastewater or effluents into surface water – relevant and appropriate as instream criteria for radionuclides.	TDEC 0400-40-03-.03(3)(a)
	There shall always be sufficient dissolved oxygen present to prevent odors of decomposition and other offensive conditions.		TDEC 0400-40-03-.03(4)(a) TDEC 0400-40-03-.03(5)(a) TDEC 0400-40-03-.03(6)(a)
	The pH value shall not fluctuate more than 1.0 unit over a period of 24 hours and shall not be outside the range of: 6.0-9.0. In addition, for waters classified for fish and aquatic life, pH values in larger rivers, lakes, reservoirs, and wetlands shall not be outside the range of 6.5-9.0.		TDEC 0400-40-03-.03(3)(b) TDEC 0400-40-03-.03(4)(b) TDEC 0400-40-03-.03(5)(b) TDEC 0400-40-03-.03(6)(b)
	The hardness of or the mineral compounds contained in the water shall not impair its use for irrigation or livestock watering and wildlife.		TDEC 0400-40-03-.03(5)(c) TDEC 0400-40-03-.03(6)(c)
	There shall be no distinctly visible solids, scum, foam, oily slick, or the formation of slimes, bottom deposits or sludge banks of such size or character that may be detrimental to fish and aquatic life or recreation or impair its use for irrigation or interfere with livestock watering and wildlife.		TDEC 0400-40-03-.03(3)(c) TDEC 0400-40-03-.03(4)(c) TDEC 0400-40-03-.03(5)(d) TDEC 0400-40-03-.03(6)(d)
	There shall be no turbidity, total suspended solids, or color in such amounts or of such character that will materially affect fish and aquatic life (in wadeable streams, suspended solid levels over time should not be substantially different than conditions found in reference streams) or in waters classified for recreational use result in any objectionable appearance to the water, considering the nature and location of the water.		TDEC 0400-40-03-.03(3)(d) TDEC 0400-40-03-.03(4)(d)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
	The maximum water temperature shall not exceed 3 degrees C relative to an upstream control point. The temperature of the water shall not exceed 30.5 degrees C and the maximum rate of change shall not exceed 2 degrees C per hour. There shall be no abnormal water temperature changes that may affect aquatic life unless caused by natural conditions. The temperature in flowing streams shall be measured at mid-depth. The temperature of impoundments where stratification occurs will be measured at a depth of five feet, or mid- depth whichever is less. Temperature shall not interfere with its use for irrigation or livestock watering and wildlife purposes.		TDEC 0400-40-03-.03(3)(e) TDEC 0400-40-03-.03(4)(e) TDEC 0400-40-03-.03(5)(e) TDEC 0400-40-03-.03(6)(e)
Instream water quality criteria for release of contact water and leachate into Bear Creek tributary (continued)	Waters shall not contain substances that will impart unpalatable flavor to fish or result in noticeable offensive odors in the vicinity of the water or otherwise interfere with fish or aquatic life. Waters classified for recreational shall not contain substances that will result in objectionable taste or odor.		TDEC 0400-40-03-.03(3)(f) TDEC 0400-40-03-.03(4)(g)
	Waters shall not contain substances or combination of substances including disease-causing agents which, by way of either direct exposure or indirect exposure through food chains, may cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), physical deformations, or restrict or impair growth in fish or aquatic life or their offspring. See Table D.2 for list of criteria for key contaminants of concern. *NOTE: under TDEC 0400-40-03-.05 INTERPRETATION OF CRITERIA, mixing zones shall not apply to the discharge of bioaccumulative pollutants to waters of the state where the risk-based factors in Rule 0400-40-03-.03(4)(l) are exceeded for the pollutant group.*		TDEC 0400-40-03-.03(3)(g)
	Water shall not contain toxic substances that will render the water unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife. See Table D.2 for list of criteria for key contaminants of concern.		TDEC 0400-40-03-.03(4)(j)
	The waters shall not contain toxic substances whether alone or in combination with other substances which will produce toxic conditions that adversely affect the quality of the waters for irrigation for livestock watering and wildlife.		TDEC 0400-40-03-.03(5)(f) TDEC 0400-40-03-.03(6)(f)
	Water shall not contain other pollutants that will be detrimental to fish or aquatic life, or that have a detrimental effect on recreation, waters used for irrigation, or waters for livestock watering and wildlife.		TDEC 0400-40-03-.03(3)(h) TDEC 0400-40-03-.03(4)(k) TDEC 0400-40-03-.03(5)(g) TDEC 0400-40-03-.03(6)(g)
	Water shall not contain iron at concentrations that cause toxicity or in such amounts that interfere with habitat due to precipitation or bacteria growth.		TDEC 0400-40-03-.03(3)(i)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
	The concentration and thirty-day average concentrations of ammonia shall not exceed the acute criterion and chronic criteria, respectively, calculated using the equations given in TDEC 0400-40-03-.03(3)(j).		TDEC 0400-40-03-.03(3)(j)
	Water shall not contain nutrients in concentrations that stimulate aquatic plant and/or algae growth to the extent that aquatic habitat is substantially reduced and/or biological integrity fails to meet regional goals or that the public's recreational uses of the water body or downstream waters are affected. Quality of downstream waters shall not be detrimentally affected. Interpretation of this provision may be made using the document Development of Regionally based Interpretations of Tennessee's Narrative Nutrient Criterion and/or other scientifically defensible methods.		TDEC 0400-40-03-.03(3)(k) TDEC 0400-40-03-.03(4)(h)
Instream water quality criteria for release of contact water and leachate into Bear Creek tributary (continued)	In waters classified for fish and aquatic life, the concentration of the e. coli group shall not exceed 630 cfu per 100 ml as a geometric mean based on a minimum of 5 samples collected as specified in the regulation (the concentration of the E. coli group in any individual sample shall not exceed 2,880 cfu per 100 ml).		TDEC 0400-40-03-.03(3)(l)
	In waters classified for fish and aquatic life, the concentration of the *e. coli* group shall not exceed 126 per 100 ml as a geometric mean based on a minimum of 5 samples collected as specified in the regulation. The concentration of *e. coli* group in any individual sample shall not exceed 941 per 100 ml.		TDEC 0400-40-03-.03(4)(f)
	Waters shall not be modified through the addition of pollutants or through physical alteration to the extent that diversity and/or productivity of aquatic biota within the receiving waters are substantially decreased or, in the case of wadeable streams, substantially different from conditions in reference streams in the same ecoregion. The parameters associated with this criterion are the aquatic biota measured. These are response variables.		TDEC 0400-40-03-.03(3)(m)
	Quality of stream habitat shall provide for development of a diverse aquatic community that meets regionally based biological integrity goals. Types of habitat loss include channel and substrate alterations, rock and gravel removal, stream flow changes, accumulation of silt, precipitation of metals, and removal of riparian vegetation. For wadeable streams, instream habitat within each sub ecoregion shall be generally similar to that found at reference streams. However, streams shall not be assessed as impacted by habitat loss if it has been demonstrated that the biological integrity goal has been met.		TDEC 0400-40-03-.03(3)(n)
	Stream flow shall support fish and aquatic life criteria and recreational use.		TDEC 0400-40-03-.03(3)(o) TDEC 0400-40-03-.03(4)(m)
Antidegradation requirements	Effluent limitations may be required to insure [sic] compliance with the Antidegradation Statement in TDEC 0400-40-03-.06.	Point source discharge(s) of pollutants into waters of the U.S. **—applicable**	TDEC 0400-40-05-.10(4)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
	New or increased discharges that would cause measurable degradation of the parameter that is unavailable shall not be authorized. Nor will discharges be authorized if they cause additional loadings of unavailable parameters that are bioaccumulative or that have criteria below current method detection levels.	Waters with "unavailable" [as defined in TDEC 0400-40-03-.06(2)] parameters—**applicable**	TDEC 0400-40-03-.06(2)(a)
	No new or increased water withdrawals that will cause additional measurable degradation of the unavailable parameter shall be authorized.		TDEC 0400-40-03-.06(2)(b)
	Where one or more of the parameters comprising the habitat criterion are unavailable, habitat alterations that cause significant degradation shall not be authorized.		TDEC 0400-40-03-.06(2)(c)
Location-specific ARARs			
Wetlands			
Presence of jurisdictional wetlands as defined in 40 *CFR* 230.3; 33 *CFR* 328.3(a), and 33 *CFR* 328.4	The discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands, is prohibited if there is a practical alternative that would have less adverse impact. No discharge shall be permitted that results in violation of state water quality standards, violates any toxic effluent standard, and/or jeopardizes an endangered species or its critical habitat. No discharge will be permitted that will cause significant degradation of waters of the United States. No discharge is permitted unless mitigation measures have been taken in accordance with 40 *CFR* 230, Subpart H.	Actions that involve the discharge of dredged or fill material into waters of the United States, including jurisdictional wetlands—**applicable**	40 *CFR* 230.10(a), (b), (c) and (d) 40 *CFR* 230, Subpart H
Mitigation of state wetlands as defined under TDEC 0400-40-07-.03	If an activity in a wetland results in an appreciable permanent loss of resource values, mitigation must be provided which results in no overall net loss of resource values from existing conditions. To the extent practicable, any required mitigation shall be completed, excluding monitoring, prior to, or simultaneous with, any impacts. Acceptable mitigation mechanisms include any combination of in-lieu fee programs, mitigation banks, or other mechanisms that are reasonably assured to result in no overall net loss of resource values from existing conditions. Acceptable mitigation methods are prioritized in the following order: restoration, enhancement, preservation, creation, or any other measures that are reasonably assured to result in no net loss of resource values from existing conditions. Compensatory measures must be at a ratio no less than 2:1 for restoration, 4:1 for creation and enhancement, and 10:1 for preservation, or at a best professional judgment ratio agreed to by the state.	Activity that would cause loss of wetlands as defined in TDEC 0400-40-07-.03—**applicable**	TDEC 0400-40-07-.04(7)(a) TDEC 0400-40-07-.04 (7)(c)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Minor alterations to wetlands	Alteration must meet substantive requirements as follows: • Excavation and fill activities associated with wetland alteration shall be kept to a minimum • Wetlands outside of the impact areas shall be clearly marked with signs, high visibility fencing, or similar structures so that all the work performed by the contractor is solely within the permitted impact area. • Wetland alterations shall not cause measurable degradation to resource values and classified uses of hydraulically connected wetlands or other waters of the state, including disruption of sustaining surface or groundwater hydrology.	Minor alterations of up to 0.10 acres of moderate resource value wetlands or of up to 0.25 acres of degraded and of low resource value wetlands — **applicable**	*TCA* 69-3-108(l) TDEC 0400-40-07-.01 TDEC ARAP General Permit for Minor Alterations to Wetlands (effective April 7, 2020) (**TBC**)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Minor alterations to wetlands (continued)	• Temporary impacts to wetlands shall be mitigated by the removal and stockpiling of the first 12 inches of topsoil, prior to construction. Temporary wetland crossings or haul roads shall utilize timber matting. Gravel, riprap or other rock is not approved for construction of temporary crossings or haul roads across wetlands. Upon completion of construction activities, all temporary wetland impact areas are to be restored to pre-construction contours, and the stockpiled topsoil spread to restore these areas to pre-construction elevation. Other side-cast material shall not be placed within the temporary impact locations. Permanent vegetative stabilization using native species of all disturbed areas in or near the wetland must be initiated within 14 days of project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established. • Erosion prevention and sediment control measures such as fences shall be removed following completion of construction. • The amount of fill, stream channel and bank modifications, or other impacts associated with the activity shall be limited to the minimum necessary to accomplish the project purpose. Shall utilize the least impactful practicable method of construction. • Clearing, grubbing, or other disturbance to wetland vegetation shall be kept at the minimum. Unnecessary native vegetation removal, including tree removal, and soil disturbance is prohibited. Native wetland vegetation must be reestablished in all areas of disturbance outside of any permanent structure after work is completed. • Activity may not result in a disruption or barrier to the movement of fish or other aquatic life and wetland dependent species upon project completion. • Blasting within 50 feet of any jurisdictional stream or wetland is prohibited. • Where practicable, all activities shall be accomplished during drier times of the year or when recent conditions have been dry at the impact location. All surface water flowing towards or from the construction activity shall be diverted using cofferdams and/or berms constructed of sandbags, steel sheeting, or other non-erodible, non-toxic material. All such diversion materials shall be located outside the wetland and removed upon completion of the work. Activities may be conducted in the water if working in the dry will likely cause additional degradation. If work is conducted in the water, it must be of a short duration and with minimal impact.		

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Minor alterations to wetlands (continued)	• All activities must be carried out in such a manner as will prevent violations of water quality criteria or impairment of the designated uses of the waters of the state • Erosion and sedimentation control shall be in place and functional before earthmoving operations begin and shall be designed according to the department's Erosion and Sediment Control Handbook. Permanent vegetation stabilization using native species of all disturbed areas in or near the stream channel must be initiated within 14 days of the project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established.		
	• The use of monofilament-type erosion control netting or blanket is prohibited in the stream channel, stream banks, or any disturbed riparian areas within 30 feet of top of bank.		
Aquatic resources			
Waters of the state as defined in *TCA* 69-3-103(42) – Bank stabilization	Bank stabilization activities along state waters must be conducted in accordance with the requirements of the ARAP Program (Rules of the TDEC, Chap. 0400-40-07). The general permit requirements for stream bank stabilization include the following: • Any spraying, mowing, or other disturbance of the stabilization treatment that interferes with its ability to naturalize is prohibited. • Work performed by vehicles and other related heavy equipment may not be staged within the stream channel. Work performed by hand and related hand-operated equipment is allowed within the stream channel. • Materials used for bank stabilization shall consist of rock, wood, or products made specifically for use in earthen slope stabilization. Other salvaged materials not found in the natural environment cannot be used for bank stabilization. • The amount of fill, stream channel and bank modifications, or other impacts associated with the activity shall be limited to the minimum necessary to accomplish the project purpose. Shall utilize the least impactful practicable method of construction. • Clearing, grubbing, or other disturbance to riparian vegetation shall be kept at the minimum necessary for slope construction and equipment operation. Unnecessary native riparian vegetation removal, including tree removal, is prohibited. Native riparian vegetation must be reestablished in all areas of disturbance outside of any permanent structure after work is completed.	Bank-stabilization activities affecting waters of the state—**applicable**	*TCA* 69-3-108(l) TDEC 0400-40-07-.01 TDEC ARAP General Permit for Bank Armoring and Vegetative Stabilization Activities (effective January 6, 2021) (**TBC**)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Waters of the state as defined in *TCA* 69-3-103(42) – Bank stabilization (continued)	• Activity may not result in the permanent disruption to the movement of fish or other aquatic life upon project completion. • Blasting within 50 feet of any jurisdictional stream or wetland is prohibited. • Backfill activities must be accomplished in the least impactful manner possible that stabilizes the streambed and banks to prevent erosion. The completed activities may not disrupt or impound stream flow. • The use of monofilament-type erosion control netting or blanket is prohibited in the stream channel, stream banks, or any disturbed riparian areas within 30 feet of top of bank. • Where practicable, all activities shall be accomplished in the dry. All surface water flowing towards the work shall be diverted using cofferdams and/or berms constructed of sandbags, clean rock (no fines or soils), steel sheeting, or other non-erodible, non-toxic material. All such diversion materials shall be removed upon completion of the work. Any disturbance to the stream bed or banks must be restored to its original condition. Activities may be conducted in the water if working in the dry will likely cause additional degradation. If work is conducted in the water, it must be of a short duration and with minimal impact and conform to the Division-approved methodology. • All activities must be carried out in such a manner as will prevent violations of water quality criteria or impairment of the designated uses of the waters of the state • Erosion and sedimentation control shall be in place and functional before earthmoving operations begin and shall be designed according to the department's Erosion and Sediment Control Handbook. Permanent vegetation stabilization using native species of all disturbed areas in or near the stream channel must be initiated within 14 days of the project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established. • Temporary stream crossings shall be limited to one point in the construction area and erosion control measures shall be utilized where stream bank vegetation is disturbed. Stream beds shall not be used as linear transportation routes for mechanized equipment, rather, the stream channel may be crossed perpendicularly with equipment provided no additional fill or excavation is necessary.		
	• Except under certain conditions detailed in the permit, length of bank stabilization is limited to 300 linear ft.		

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Waters of the state as defined in *TCA* 69-3-103(42) – Culvert maintenance activities	The maintenance of existing serviceable structures or fills along waters of the state must be conducted in accordance with the requirements of the ARAP Program (Rules of the TDEC, Chap. 0400-40-07). The general permit requirements for maintenance activities include the following: • The length of the pipe or culvert structure may not be increased in a manner that encapsulates any additional length of open stream or wetland • The capacity or diameter of the culvert may be increased during replacement, providing it does not result in channel widening or other channel destabilization • Dewatering of impoundments to conduct dam maintenance must be performed in a controlled manner designed to prevent the release of accumulated sediments into downstream waters. • All riprap associated with maintenance activities shall be placed to mimic the existing contours of the stream channel. Riprap shall be countersunk and placed at grade with the existing stream substrate. Voids in the riprap shall be filled with suitable bedload substrate to prevent stream flow loss within riprap areas. Suitable substrate does not include soil. • Work performed by vehicles and other heavy equipment may not be staged within the stream channel. Work performed by hand and related hand-operated equipment is allowed within the stream channel. • The amount of fill, stream channel and bank modifications, or other impacts associated with the activity shall be limited to the minimum necessary to accomplish the project purpose. Shall utilize the least impactful practicable method of construction. • Clearing, grubbing, or other disturbance to riparian vegetation shall be kept at the minimum necessary for slope construction and equipment operations. Unnecessary native riparian vegetation removal, including tree removal is prohibited. Native riparian vegetation must be reestablished in all areas of disturbance outside of any permanent structure after work is completed. • Widening of the stream channel is prohibited • Activity may not result in a permanent disruption to the movement of fish or other aquatic life upon project completion.	Maintenance activities affecting waters of the state—**applicable**	*TCA* 69-3-108(l) TDEC 0400-40-07-.01 TDEC ARAP General Permit for Maintenance Activities (effective April 7, 2020) (**TBC**)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Waters of the state as defined in *TCA* 69-3-103(42) – Culvert maintenance activities (continued)	• Blasting within 50 feet of any jurisdictional stream or wetland is prohibited. • Backfill activities must be accomplished in the least impactful manner possible that stabilizes the streambed and banks to prevent erosion. The completed activities may not disrupt or impound stream flow.		
	• The use of monofilament-type erosion control netting or blanket is prohibited in the stream channel, stream banks, or any disturbed riparian areas within 30 feet of top of bank. • Where practicable, all activities shall be accomplished in the dry. All surface water flowing towards the work shall be diverted using cofferdams and/or berms constructed of sandbags, clean rock (no fines or soils), steel sheeting, or other non-erodible, non-toxic material. All such diversion materials shall be removed upon completion of the work. Any disturbance to the stream bed or banks must be restored to its original condition. Activities may be conducted in the flowing water if working in the dry will likely cause additional degradation. If work is conducted in the flowing water, it must be of a short duration and with minimal impact and conform to the Division-approved methodology. • All activities must be carried out in such a manner as will prevent violations of water quality criteria or impairment of the designated uses of the waters of the state • Erosion and sedimentation control shall be in place and functional before earthmoving operations begin and shall be designed according to the department's Erosion and Sediment Control Handbook. Permanent vegetation stabilization using native species of all disturbed areas in or near the stream channel must be initiated within 14 days of the project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established. • Temporary stream crossings shall be limited to one point in the construction area and erosion control measures shall be utilized where stream bank vegetation is disturbed. Stream beds shall not be used as linear transportation routes for mechanized equipment, rather, the stream channel may be crossed perpendicularly with equipment provided no additional fill or excavation is necessary.		

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Waters of the state as defined as *TCA* 69-3-103 – Wet weather conveyances	Wet-weather conveyances may be altered provided the following conditions are met:	Activities that alter wet-weather conveyances—**applicable**	TCA 69-3-108(q)
	• The activity must not result in the discharge of waste or other substances that may be harmful to humans or wildlife;		
	• Material must not be placed in a location or manner so as to impair surface water flow into or out of any wetland area; and		
	• Sediment shall be prevented from entering other waters of the state: - Erosion/sediment controls shall be designed according to size and slope of disturbed or drainage areas to detain runoff and trap sediment and shall be properly selected, installed, and maintained in accordance with manufacturer's specifications and good engineering practices.		
	- Erosion/sediment control measures must be in place and functional before earthmoving operations begin and must be constructed and maintained throughout the construction period. Temporary measures may be removed at the beginning of the workday, but shall be replaced at end of the work day.		
	- Checkdams must be utilized where runoff is concentrated. Clean rock, log, sandbag or straw bale checkdams shall be properly constructed to detain runoff and trap sediment. Checkdams or other erosion control devices are not to be constructed in stream. Clean rock can be of various type and size depending on the application and must not contain fines, soils, or other wastes or contaminants.		
	• Appropriate steps must be taken to ensure that petroleum products or other chemical pollutants are prevented from entering waters of the state. All spills shall be reported to the appropriate emergency management agency and TDEC. In event of a spill, measures shall be taken immediately to prevent pollution of waters of the state, including groundwater.		

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Mitigation of impacts to a stream as defined in TDEC 0400-40-07-.03, which includes all surface water except wetlands and wet weather conveyances	If an activity in a stream results in an appreciable permanent loss of resource values, the applicant must provide mitigation which results in no overall net loss of resource values from existing conditions. To the extent practicable, any required mitigation shall be completed, excluding monitoring, prior to, or simultaneous with, any impacts. Acceptable mitigation mechanisms include any combination of in-lieu fee programs, mitigation banks, or other mechanisms that are reasonably assured to result in no overall net loss of resource values from existing conditions. Acceptable mitigation methods are prioritized in the following order: restoration, enhancement, preservation, creation, or any other measures that are reasonably assured to result in no net loss of resource values from existing conditions. Mitigation for impacts to streams must be developed in a scientifically defensible manner that demonstrates a sufficient increase in resource values to compensate for impacts. At a minimum, all new or relocated streams must include a vegetated riparian zone, demonstrate lateral and vertical channel stability, and have a natural channel bottom. All mitigation watercourses must maintain or improve flow and classified uses after mitigation is complete.	Activity that would result in an appreciable permanent loss of resource value of a stream as defined in TDEC 0400-40-07-.03 **—applicable**	TDEC 0400-40-07-.04(7)(a) TDEC 0400-40-07-.04(7)(b)
Endangered, threatened, or rare species			
Presence of federally endangered or threatened species, as designated in 50 *CFR* 17.11 and 17.12 or critical habitat of such species	Actions that jeopardize the existence of a listed species or results in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken.	Action that is likely to jeopardize fish, wildlife, or plant species or destroy or adversely modify critical habitat—**applicable**	16 USC 1531 et seq., 16 USC 1536(a)(2) (Sect. 7(a)(2) of the Endangered Species Act)
Presence of migratory birds as defined in 50 *CFR* 10.13, and their habitats	Unlawful killing, possession, and sale of migratory bird species, as defined in 50 *CFR* 10.13, native to the U.S. or its territories is prohibited.	Federal agency action that is likely to impact migratory birds**—applicable**	16 USC 703-704
	Requirements are as follows: • avoid or minimize, to the extent practicable, adverse impacts on migratory bird resources when conducting agency action • restore and enhance the habitats of migratory birds, as practicable • prevent or abate the pollution or detrimental alteration of the environment for the benefit of migratory birds, as practicable	Federal agency action that is likely to impact migratory birds**—TBC**	Executive Order 13186

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Action-specific ARARs			
Waste characterization and management			
Characterization and management of universal waste	A large quantity handler of universal waste must manage universal waste in accordance with [substantive requirements of] 40 *CFR* 273 in a way that prevents releases of any universal waste or component of a universal waste to the environment.	Generation of universal waste [as defined in 40 *CFR* 273] for disposal—**applicable**	40 *CFR* 273 TDEC 0400-12-01-.12
	Must label or mark the universal waste to identify the type of universal waste.		40 *CFR* 273.34 TDEC 0400-12-01-.12(3)(e)
	A large quantity handler of universal waste must immediately contain all releases of universal wastes and other residues from universal wastes and must determine whether any material resulting from the release is hazardous waste, and if so, must manage the hazardous waste in compliance with all applicable requirements.		40 *CFR* 273.37 TDEC 0400-12-01-.12(3)(h)
Disposal of universal waste	The generator of the universal waste must determine whether the waste exhibits a characteristic of hazardous waste. If it is determined to exhibit such a characteristic, it must be managed in accordance with 40 *CFR* 260 through 272 [TDEC 0400-1-11-.01 through .10]. If the waste is not hazardous, the generator may manage and dispose of it in any way that is in compliance with applicable federal, state, and local solid waste regulations.	Generation of universal waste [as defined in 40 *CFR* 273] for disposal—**applicable**	40 *CFR* 273.33 TDEC 0400-12-01-.12(3)(d)
Management and storage of used oil	Used oil shall not be stored in a unit other than a tank or container.	Generation and storage of used oil, as defined in 40 *CFR* 279.1]—**applicable**	40 *CFR* 279.22(a) TDEC 0400-12-01-.11(3)(c)(1)
	Containers and aboveground tanks used to store used oil must be in good condition (no severe rusting, apparent structural defects or deterioration); and not leaking (no visible leaks).		40 *CFR* 279.22(b)(1) and (2) TDEC 0400-12-01-.11(3)(c)(2)(i) and (ii)
	Containers and aboveground tanks used to store used oil and fill pipes used to transfer used oil into USTs must be labeled or marked clearly with the words "Used Oil."		40 *CFR* 279.22(c)(1) and (2) TDEC 0400-12-01-.11(3)(c)(3)(i) and (ii)
	Upon detection of a release of used oil to the environment, a generator must stop the release; contain, clean up, and properly manage the released used oil; and, if necessary, repair or replace any leaking used oil storage containers or tanks prior to returning them to service.	Release of used oil to the environment—**applicable**	40 *CFR* 279.22(d) TDEC 0400-12-01.11(3)(c)(4)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Landfill liner system			
Leak detection system action leakage rate	Action leakage rate for liner system: (a) Action leakage rate is the maximum design flow rate that the leak detection system (LDS) can remove without fluid head on the bottom liner exceeding l foot. The action leakage rate must include an adequate safety margin to allow for uncertainties in the design (e.g., slope, hydraulic conductivity, thickness of drainage material), construction, operation, and location of the LDS, waste and leachate characteristics, likelihood and amounts of other sources of liquids in the LDS, and proposed response actions. (b) To determine if the action leakage rate has been exceeded, the owner or operator must convert the weekly or monthly flow rate from the monitoring data obtained under part (d)(3) of this paragraph to an average daily flow rate (gallons per acre per day) for each sump.	Design and construction of a hazardous waste landfill - **applicable**	40 *CFR* 264.302 TDEC 0400-12-01-.06(14)(c)
Water treatment			
Construction of new outfall structure for discharge of wastewater	Construction, maintenance, repair, rehabilitation or replacement of intake or outfall structures shall be carried out in such a way that work:	Construction of intake and outfall structures in waters of the state—**applicable** to Alternative 2	*TCA* 69-3-108(l) TDEC 0400-40-07-.01 TDEC General Permit for Construction of Intake and Outfall Structures (effective April 7, 2020) (**TBC**)
	• Shall be located and oriented so as to avoid permanent alteration or damage to the integrity of the stream channel including the opposite stream bank. Alignment of the structure (except for diffusers) should be as parallel to the stream flow as is practicable, with the discharge pointed downstream. Underwater diffusers may be placed perpendicular to stream flow for more complex mixing.		
	• Intake and outfall structures shall be designed to minimize harm and prevent impoundment of normal or base flows.		*TCA* 69-3-108(l) TDEC 0400-40-07-.01 TDEC General Permit for Construction of Intake and Outfall Structures (effective April 7, 2020) (**TBC**)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Construction of new outfall structure for discharge of wastewater (continued)	• Velocity dissipation devices shall be placed as needed at discharge locations to provide a non-erosive velocity from the structure. • Headwalls, bank stabilization materials, and any other hard armoring associated with the installation of each structure shall be limited to a total of 25 feet along the receiving stream bank. • The amount of fill, stream channel and bank modifications, or other impacts associated with the activity shall be limited to the minimum necessary to accomplish the project purpose. Shall utilize the least impactful practicable method of construction. • Clearing, grubbing, or other disturbance to riparian vegetation shall be kept at the minimum necessary for slope construction and equipment operations. Unnecessary native vegetation removal, including tree removal is prohibited. Native riparian vegetation must be reestablished in all areas of disturbance outside of any permanent structure after work is completed. • Widening of the stream channel is prohibited. Activity may not result in a permanent disruption to the movement of fish or other aquatic life upon project completion.		
	• Blasting within 50 feet of any jurisdictional stream or wetland is prohibited. • Backfill activities must be accomplished in the least impactful manner possible that stabilizes the streambed and banks to prevent erosion. The completed activities may not disrupt or impound stream flow. • The use of monofilament-type erosion control netting or blanket is prohibited in the stream channel, stream banks, or any disturbed riparian areas within 30 feet of top of bank. • Where practicable, all activities shall be accomplished in the dry. All surface water flowing towards the work shall be diverted using cofferdams and/or berms constructed of sandbags, clean rock (containing no fines or soils), steel sheeting, or other non-erodible, non-toxic material. All such diversion materials shall be removed upon completion of the work. Any disturbance to the stream bed or banks must be restored to its original condition. Activities may be conducted in the flowing water if working in the dry will likely cause additional degradation. If work is conducted in the flowing water it must be of a short duration and with minimal impact and conform to the Division-approved methodology.		

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Construction of new outfall structure for discharge of wastewater (continued)	• All activities must be carried out in such a manner as will prevent violations of water quality criteria or impairment of the designated uses of the waters of the state • Erosion and sedimentation control shall be in place and functional before earthmoving operations begin and shall be designed according to the department's Erosion and Sediment Control Handbook. Permanent vegetation stabilization using native species of all disturbed areas in or near the stream channel must be initiated within 14 days of the project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established. • Temporary stream crossings shall be limited to one point in the construction area and erosion control measures shall be utilized where stream bank vegetation is disturbed. Stream beds shall not be used as linear transportation routes for mechanized equipment, rather, the stream channel may be crossed perpendicularly with equipment provided no additional fill or excavation is necessary.		
Design and installation of a RCRA tank system (tanks and associated piping)	Must prepare an assessment attesting that the tank system design has sufficient structural integrity and is acceptable for the storing/treating of hazardous waste. The assessment must include the information specified in 40 *CFR* 264.192(a)(1)-(5) [TDEC 0400-12-01-.06(10)(c)(1)].	Storage of RCRA hazardous waste in a new tank system–**applicable** if water is determined to be hazardous	40 *CFR* 264.192(a) TDEC 0400-12-01-.06(10)(c)(1)
	Prior to use, must ensure that proper handling procedures are adhered to in order to prevent damage to the system during installation.		40 *CFR* 264.192(b) TDEC 0400-12-01-.06(10)(c)(2)
	Prior to use, must inspect the system for the presence of weld breaks, punctures, scrapes of protective coatings, cracks, corrosion, other structural damage, or inadequate construction/installation. All discrepancies must be remedied before the system is covered, enclosed or placed in use.		40 *CFR* 264.192(b)(1)-(6) TDEC 0400-12-01-.06(10)(c)(2)(i)-(vi)
	Prior to use, tanks and ancillary equipment must be tested for tightness. If a tank system is found not to be tight, all repairs necessary to remedy the leak(s) must be performed prior to the system being placed into use.		40 *CFR* 264.192(d) TDEC 0400-12-01-.06(10)(c)(4)
	Ancillary equipment (i.e., piping) must be supported and protected against physical damage and excessive stress due to settlement, vibration, expansion, or contraction.		40 *CFR* 264.192(e) TDEC 0400-12-01-.06(10)(c)(5)
	Must provide the degree of corrosion protection based upon the information in 40 *CFR* 264.192(a)(3) [TDEC 0400-12-01-.06(10)(c)(1)(iii)] to ensure the integrity of the tank system during use. Installation of field fabricated corrosion protection system must be supervised by an independent corrosion expert.		40 *CFR* 264.192(f) TDEC 0400-12-01-.06(10)(c)(6)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Design and installation of a RCRA tank system (tanks and associated piping) (continued)	Must provide secondary containment in order to prevent release of hazardous waste or constituents into the environment.		40 *CFR* 264.193(a)(1) TDEC 0400-12-01-.06(10)(d)(1)
	Secondary containment systems must be: • designed, installed, and operated to prevent any migration of wastes or accumulated liquid out of the system to the soil, ground water, or surface water at any time during the use of the tank system;		40 *CFR* 264.193(b)(1) TDEC 0400-12-01-.06(10)(d)(2)(i)
	• capable of detecting and collecting releases and accumulated liquids until the collected material is removed;		40 *CFR* 264.193(b)(2) TDEC 0400-12-01-.06(10)(d)(2)(ii)
	• constructed of or lined with materials that are compatible with the wastes to be placed in the tank system and must have sufficient strength and thickness to prevent failure owing to pressure gradients (including static head and external hydrological forces), physical contact with the waste to which it is exposed, climatic conditions, and the stress of daily operation (including stresses from nearby vehicular traffic)		40 *CFR* 264.193(c)(1) TDEC 0400-12-01-.06(10)(d)(3)(i)
	• placed on a foundation or base capable of providing support to the secondary containment system, resistance to pressure gradients above and below the system, and capable of preventing failure due to settlement, compression, or uplift;		40 *CFR* 264.193(c)(2) TDEC 0400-12-01-.06(10)(d)(3)(ii)
	• provided with a leak-detection system that is designed and operated so it will detect the failure of either the primary or secondary containment structure or presence of any release of hazardous waste or accumulated liquid in the secondary containment system within 24 hours, or at the earliest practicable time if the owner can demonstrate that existing detection technologies or site conditions will not allow detection of a release within 24 hours; and		40 *CFR* 264.193(c)(3) TDEC 0400-12-01-.06(10)(d)(3)(iii)
	• sloped or otherwise designed or operated to drain and remove liquids resulting from leaks, spills, or precipitation. Spilled or leaked waste and accumulated precipitation must be removed from the secondary containment system within 24 hours, or in as timely a manner as is possible to prevent harm to human health and the environment, if the owner can demonstrate that removal of the released waste or accumulated precipitation cannot be accomplished within 24 hours.		40 *CFR* 264.193(c)(4) TDEC 0400-12-01-.06(10)(d)(3)(iv)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Design and installation of a RCRA tank system (tanks and associated piping) (continued)	The secondary containment for tanks must include one or more of the following devices: • a liner (external to the tank) • a vault • a double-walled tank • an equivalent device as approved by the EPA		40 *CFR* 264.193(d)(1-4) TDEC 0400-12-01-.06(10)(d)(4)(i-iv)
	External liner systems must be: • designed and operated to contain 100 percent of the capacity of the largest tank within its boundary;		40 *CFR* 264.193(e)(1)(i) TDEC 0400-12-01-.06(10)(d)(5)(i)(I)
	• designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless the collection system has sufficient excess capacity to contain run-on or infiltration. [Such additional capacity must be sufficient to contain precipitation from a 25 year, 24-hour rainfall event];		40 *CFR* 264.193(e)(1)(ii) TDEC 0400-12-01-.06(10)(d)(5)(i)(II)
	• free of cracks or gaps; and		40 *CFR* 264.193(e)(1)(iii) TDEC 0400-12-01-.06(10)(d)(5)(i)(III)
	• designed and installed to surround the tank completely and to cover all surrounding earth likely to come into contact with the waste if the waste is released from the tank(s) (i.e., capable of preventing lateral as well as vertical migration of the waste).		40 *CFR* 264.193(e)(1)(iv) TDEC 0400-12-01-.06(10)(d)(5)(i)(IV)
	Vault system must be: • designed or operated to contain 100 percent of the capacity of the largest tank within its boundary;		40 *CFR* 264.193(e)(2)(i) TDEC 0400-12-01-.06(10)(d)(5)(ii)(I)
	• designed or operated to prevent run-on or infiltration of precipitation into the secondary containment system unless collection system has sufficient excess capacity to contain run-on or infiltration. [Such additional capacity must be sufficient to contain precipitation from a 25 year, 24-hour rainfall event];		40 *CFR* 264.193(e)(2)(ii) TDEC 0400-12-01-.06(10)(d)(5)(ii)(II)
	• constructed of chemical-resistant water stops in all joints (if any);		40 *CFR* 264.193(e)(2)(iii) TDEC 0400-12-01-.06(10)(d)(5)(ii)(III)
	• provided with an impermeable interior coating or lining that is compatible with the stored waste and that will prevent migration of the waste into the concrete;		40 *CFR* 264.193(e)(2)(iv) TDEC 0400-12-01-.06(10)(d)(5)(ii)(IV)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Design and installation of a RCRA tank system (tanks and associated piping) (continued)	• provided with a means to protect against formation of and ignition of vapors within the vault if the waste being stored or treated meets the definition of ignitable or reactive waste under 40 *CFR* 261.21 or 261.23; and		40 *CFR* 264.193(e)(2)(v) TDEC 0400-12-01-.06(10)(d)(5)(ii)(V)
	• provided with an exterior moisture barrier or otherwise designed or operated to prevent migration of moisture into the vault if the vault is subject to hydraulic pressure.		40 *CFR* 264.193(e)(2)(vi) TDEC 0400-12-01-.06(10)(d)(5)(ii)(VI)
	Double-walled tanks must be: • designed as an integral structure (i.e., an inner tank completely enveloped within and outer shell) so that any release from the inner tank is contained by the outer shell;		40 *CFR* 264.193(e)(3)(i) TDEC 0400-12-01-.06(10)(d)(5)(iii)(I)
	• protected, if constructed of metal, from both corrosion of the primary tank interior and of the external surface of the outer shell; and		40 *CFR* 264.193(e)(3)(ii) TDEC 0400-12-01-.06(10)(d)(5)(iii)(II)
	• provided with a built-in continuous leak detection system capable of detecting a release within 24 hours, or at the earliest practicable time.		40 *CFR* 264.193(e)(3)(iii) TDEC 0400-12-01-.06(10)(d)(5)(iii)(III)
	Ancillary equipment must be provided with secondary containment (e.g., trench, jacketing, double-walled piping) that meets the requirements of 40 *CFR* 264.193(b) and (c) [TDEC 0400-12-01-.06(10)(d)(2) and (3)] except for:		40 *CFR* 264.193(f) TDEC 0400-12-01-.06(10)(d)(6)
	• aboveground piping (exclusive of flanges, joints, valves, and other connections) that are visually inspected for leaks on a daily basis;		40 *CFR* 264.193(f)(1) TDEC 0400-12-01-.06(10)(d)(6)(i)
	• welded flanges, welded joints and welded connections, that are visually inspected for leaks on a daily basis;		40 *CFR* 264.193(f)(2) TDEC 0400-12-01-.06(10)(d)(6)(ii)
	• seamless or magnetic coupling pumps and seal-less valves, that are visually inspected for leaks on a daily basis; and		40 *CFR* 264.193(f)(3) TDEC 0400-12-01-.06(10)(d)(6)(iii)
	• pressurized aboveground piping systems with automatic shut-off devices (e.g., excess flow check valves, flow metering shutdown devices, loss of pressure actuated shut-off devices) that are visually inspected for leaks on a daily basis.		40 *CFR* 264.193(f)(4) TDEC 0400-12-01-.06(10)(d)(6)(iv)
Operation of RCRA tank system	Hazardous wastes or treatment reagents must not be placed in the tank system if they could cause the tank, its ancillary equipment or the containment system to rupture, leak, corrode, or otherwise fail.	Storage of RCRA hazardous waste in a new tank system—**applicable** if water is determined to be hazardous	40 *CFR* 264.194(a) TDEC 0400-12-01-.06(10)(e)(1)
	Must use appropriate controls and practices to prevent spills an overflows from the tank or containment system. These include at a minimum:		40 *CFR* 264.194(b) TDEC 0400-12-01-.06(10)(e)(2)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Operation of RCRA tank system (continued)	• spill prevention controls (e.g., check valves, dry disconnect couplings);		40 *CFR* 264.194(b)(1) TDEC 0400-12-01-.06(10)(e)(2)(i)
	• overfill prevention controls (e.g., level sensing devices, high level alarms, automatic feed cutoff, or bypass to a standby tank; and		40 *CFR* 264.194(b)(2) TDEC 0400-12-01-.06(10)(e)(2)(ii)
	• maintenance of sufficient freeboard in uncovered tanks to prevent overtopping by wave or wind action or by precipitation		40 *CFR* 264.194(b)(3) TDEC 0400-12-01-.06(10)(e)(2)(iii)
	Must comply with the requirements of 40 *CFR* 264.196 [TDEC 0400-12-01-.06(10)(g)] if a leak or a spill occurs in the tank system.		40 *CFR* 264.194(c) TDEC 0400-12-01-.06(10)(e)(3)
Control of air emissions from an above-grade RCRA tank system	The requirements of 40 *CFR* 264 Subpart CC do not apply to a waste management unit that is used solely for onsite treatment or storage of hazardous waste that is generated as a result of implementing remedial activities required under CERCLA authorities.	Storage of RCRA hazardous waste in a new tank system — **applicable** if water is determined to be hazardous	40 *CFR* 264.1080(b)(5) TDEC 0400-12-01-.06(32)(a)(2)(v)
Control of emissions from a WWTU treatment system	Onsite remediation and treatment of contaminated water using air strippers is an exempted air contaminant source provided the emissions are no more than 5 tons per year of any regulated pollutant that is not a hazardous air pollutant and less than 1000 pounds per year of each hazardous air pollutant.	Emissions of air pollutants from new air contaminant sources —**applicable**	TDEC 1200-03-09-.04(4)(d)(24)
Design and installation of a RCRA surface impoundment	Must install a liner system consisting of two or more liners and a leachate collection and removal system, constructed in accordance with 40 *CFR* 264.221(c)(1)-(4) [TDEC 0400-12-01-.06(11)(b)(3)(i)-(iv)].	Storage of RCRA hazardous waste in a new surface impoundment—**applicable** if water is determined to be hazardous	40 *CFR* 264.221(c) TDEC 0400-12-01-.06(11)(b)(3)
	Must implement a leak detection system capable of detecting, collecting and removing leaks of hazardous constituents from all areas of the top liner during the active life and post-closure care period.		40 *CFR* 264.221(c)(2) TDEC 0400-12-01-.06(11)(b)(3)(ii)
	Must design, construct and maintain dikes with sufficient structural integrity to prevent massive failure.		40 *CFR* 264.221(h) TDEC 0400-12-01-.06(11)(b)(8)
	Alternative design practices to those in 40 *CFR* 264.221(c) [TDEC 0400-12-01-.06(11)(b)(3)] may be approved by the Regional Administrator.		40 *CFR* 264.221(d) TDEC 0400-12-01-.06(11)(b)(4)
Operation of RCRA surface impoundment	Design and operate facility to prevent overtopping resulting from normal or abnormal operations; overfilling; wind and wave action; rainfall; run-on; malfunctions of level controllers, alarms and other equipment; and human error.	Storage of RCRA hazardous waste in a new surface impoundment— **applicable** if water is determined to be hazardous	40 *CFR* 264.221(g) TDEC 0400-12-01-.06(11)(b)(7)
	Remove surface impoundment from operation if the dike leaks or if there is a sudden drop in liquid level.		40 *CFR* 264.227 TDEC 0400-12-01-.06(11)(h)
	Ignitable or reactive waste must not be placed in a surface impoundment unless it is treated so that it is no longer ignitable or reactive or is managed so that it is protected from materials or conditions that may cause it to ignite or react.		40 *CFR* 264.229 TDEC 0400-12-01-.06(11)(j)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Closure of a RCRA tank system	Must remove or decontaminate all waste residues, contaminated containment system components (liners, etc.) contaminated soils, and structures and equipment contaminated with waste, and manage them as hazardous waste, unless 40 *CFR* 261.3(d) [TDEC 0400-12-01-.02(1)(c)(4)] applies.	Closure of a hazardous waste tank system—**relevant and appropriate** if water is determined to be hazardous	40 *CFR* 264.197(a) TDEC 0400-12-01-.06(10)(h)(1)
	If all contents cannot be practicably removed or decontaminated, consider the tank system a landfill and close in accordance with the landfill closure requirements of 40 *CFR* 264.310 [TDEC 0400-12-01-.06(14)(k).		40 *CFR* 264.197(b) TDEC 0400-12-01-.06(10)(h)(2)
Closure and post-closure care of a surface impoundment	Must remove or decontaminate all waste residues and contaminated materials; otherwise free liquids must be removed, the remaining wastes stabilized to a bearing capacity sufficient to support final cover, and the facility closed and covered with a final cover designed in accordance with 40 *CFR* 264.228(a)(2)(iii)(A)-(E) [TDEC 0400-12-01-.06(11)(i)(1)(ii)(III)].	Closure of a hazardous waste surface impoundment—**relevant and appropriate** if water is determined to be hazardous	40 *CFR* 264.228(a) TDEC 0400-12-01-.06(11)(i)(1)
	If some waste residues or contaminated materials are left in place at final closure, must comply with all post-closure requirements contained in §§264.117 through 264.120 [TDEC 0400-12-01-.06(7)(h) through (k)], including maintenance and monitoring throughout the post-closure period. Must also:		40 *CFR* 264.228(b) TDEC 0400-12-01-.06(11)(i)(2)
	• maintain integrity and effectiveness of final cover, making repairs to the cap as necessary;		40 *CFR* 264.228(b)(1) TDEC 0400-12-01-.06(11)(i)(2)(i)
	• maintain and monitor leak detection system;		40 *CFR* 264.228(b)(2) TDEC 0400-12-01-.06(11)(i)(2)(ii)
	• maintain and monitor groundwater monitoring system;		40 *CFR* 264.228(b)(3) TDEC 0400-12-01-.06(11)(i)(2)(iii)
	• prevent run-on and runoff from eroding or otherwise damaging final cover.		40 *CFR* 264.228(b)(4) TDEC 0400-12-01-.06(11)(i)(2)(iv)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Water Discharge			
Prevention of pollution through application of treatment	In order to permit the reasonable and necessary uses of the Waters of the State, existing pollution should be corrected as rapidly as practicable, and future pollution prevented through the level of treatment technology applicable to a specific source or that greater level of technology necessary to meet water quality standards, i.e., modeling and stream survey assessments, treatment plants or other control measures.[3]	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and appropriate**	TDEC 0400-40-03-.02(4)
	Technology-based treatment requirements cannot be satisfied through the use of "non-treatment" techniques such as flow augmentation and in-stream mechanical aerators.		40 *CFR* 125.3(f)
Application of most stringent criteria	Since all Waters of the State are classified for more than one use, the most stringent criteria will be applicable.		TDEC 0400-40-03-.02(5)
Compliance with narrative water quality criteria	Interpretation and application of narrative criteria shall be based on available scientific literature and EPA guidance and regulations. *<u>NOTE:</u> For radionuclides, exposure assumptions will be based on site specific exposures and DOE's reasonable anticipated future land uses.*	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and appropriate**	TDEC 0400-40-03-.02(10)

[3] Treatment may be necessary to meet Tennessee water quality standards. Consistent with the EPA Administrator's Dispute Resolution Decision (Appendix M), TBEL requirements are not considered relevant and appropriate to discharges of radionuclides at this Site.

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Application of stream flow for water quality criteria	Fish and aquatic life water quality criteria shall generally be applied on the basis of stream flows equal to or exceeding the 7-day minimum, 10-year recurrence interval. All other criteria shall be applied on the basis of stream flows equal to or exceeding the 30-day minimum 5-year recurrence interval.	Discharge of pollutants as defined in 40 *CFR* 122.2 into surface water Classified as *Fish and Aquatic Life* – **Applicable** Discharge of radionuclides into surface water Classified as *Fish and Aquatic Life* – **Relevant and appropriate**	TDEC 0400-40-03-.05(4)
	The frequency, magnitude and duration of deviations from normal water conditions shall be considered in interpreting the water quality criteria. When interpreting pathogen data, samples collected during or immediately after significant rain events may be treated as outliers unless caused by point source dischargers.	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and appropriate**	TDEC 0400-40-03-.05(5)
Application of water quality criteria	The criteria and standards provide that all discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards, or state or federal laws and regulations pursuant thereto, and where appropriate will comply with the "Standards of Performance" as required by the Tennessee Water Quality Control Act, (T.C.A., §§ 69-3-101, et seq.). (See FN 1.)	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and appropriate**	TDEC 0400-40-03-.05(6)
	Where naturally formed conditions or background water quality conditions are substantial impediments to attainment of the water quality standards, these conditions shall be taken into consideration in establishing any effluent limitations or restriction on discharge to such waters. For purposes of water quality assessment, exceedances of water quality standards caused by natural conditions will not be considered the condition of pollution impairment.	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and appropriate**	TDEC 0400-40-03-.05(7)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Use of Reporting Limits	All chemical data reported under this rule shall be generated using "sufficiently sensitive" analytical methods approved under 40 *CFR* part 136 (2018) or required under 40 *CFR* chapter I, subchapter N or O (2018). An approved method is "sufficiently sensitive" when: (a) The method minimum level (ML) is at or below the level of the applicable water quality criterion or the effluent limit established for the measured pollutant or pollutant parameter; or (b) The method ML is above the applicable water quality criterion or the effluent limit established, but the amount of the pollutant or pollutant parameter actually measured is high enough that the method detects and quantifies the level of the pollutant or pollutant parameter; or (c) Demonstration is made showing that the method used has the lowest ML of the approved methods for the measured pollutant or pollutant parameter in the sample/matrix being analyzed. (Documentation supporting this demonstration is to be submitted with reported data and shall include narrative justification for why the method chosen is believed to have the lowest ML of all approved methods identified in 40 *CFR* part 136 (2018). The Director shall determine whether the submitted information demonstrates sufficient method sensitivity.) When there is no analytical method that has been approved under 40 *CFR* part 136 (2018) or required under 40 *CFR* chapter I, subchapter N or O (2018), and a specific method is not otherwise required by the Director, the applicant may use any suitable method but shall provide a description of the method. When selecting a suitable method, factors such as a method's precision, accuracy, or resolution must be considered when assessing the performance of the method.	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and appropriate**	TDEC 0400-40-03-.05(8)
Target Risk Level for Recreation WQC	The 10-5 risk level is used for all carcinogenic pollutants.	Derivation of WQC for pollutants in surface water classified for Recreation use – **Applicable** Derivation of WQC Equivalents for radionuclides in surface water classified for Recreation use – **Relevant and Appropriate**	TDEC 0400-40-03.-03(4)(j) Footnote c

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Establishing effluent limits using a calculated numeric water quality criterion	Permitting authority must establish effluent limits using a calculated numeric water quality criterion for the pollutant which the permitting authority demonstrates will attain and maintain applicable narrative water quality criteria and will fully protect the designated use. Such criterion may be derived using an explicit State policy or regulation interpreting its narrative water quality criterion, supplemented with other relevant information which may include EPA's Water Quality Standards Handbook, October 1983, risk assessment data, exposure data … and current EPA criteria documents. *<u>NOTE</u>: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the terms "permit" and "permittee" reflect regulatory language; in this remedial action, "permit" can generally be taken to mean the Record of Decision, and "permittee" to mean DOE.* *<u>NOTE:</u> For radionuclides, exposure assumptions will be based on site specific exposures and DOE's reasonable anticipated future land uses.*	Determination of effluent limits where a State has not established a water quality criterion for a specific pollutant – **Applicable** Determination of effluent limits where a State has not established a water quality criterion for radionuclides – **Relevant and Appropriate**	40 *CFR* 122.44(d)(1)(vi)(A)
Operation and maintenance of treatment and control systems	Permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the condition of this permit. This provision requires the operation of backup or auxiliary facilities or similar systems, which are installed by a permittee only when the operation is necessary to achieve compliance with the conditions of the permit. *<u>NOTE</u>: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the terms "permit" and "permittee" reflect regulatory language; in this remedial action, "permit" can generally be taken to mean the Record of Decision, and "permittee" to mean DOE.*	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water where treatment is used **– Applicable** Point source discharge of radionuclides into surface water where treatment is used – **Relevant and Appropriate**	TDEC 0400-40-05-.07(2)(c)
Monitoring of effluent	Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and Appropriate**	TDEC 0400-40-05-.07(2)(h)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Monitoring of effluent (continued)	Permittee shall take all reasonable steps to minimize any adverse impact to the waters of Tennessee resulting from noncompliance with this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the non-complying discharge. *NOTE: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the terms "permit" and "permittee" reflect regulatory language; in this remedial action, "permit" can generally be taken to mean the Record of Decision, and "permittee" to mean DOE.*		TDEC 0400-40-05-.07(2)(q)
Minimum monitoring requirements	In addition to § 122.48, the following monitoring requirements: (1) To assure compliance with permit limitations, requirements to monitor: (i) The mass (or other measurement specified in the permit) for each pollutant limited in the permit; (ii) The volume of effluent discharged from each outfall; (iii) Other measurements as appropriate including pollutants in internal waste streams under § 122.45(i); pollutants in intake water for net limitations under § 122.45(f); frequency, rate of discharge, etc., for non-continuous discharges under § 122.45(e); pollutants subject to notification requirements under§ 122.42(a); and pollutants in sewage sludge or other monitoring as specified in 40 *CFR* part 503; or as determined to be necessary on a case-by-case basis pursuant to section 405(d)(4) of the CWA. *NOTE: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the terms "permit" and "permittee" reflect regulatory language; in this remedial action, "permit" can generally be taken to mean the Sampling and Analysis Plan, and "permittee" to mean DOE.*	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and appropriate**	40 *CFR* 122.44(i)
Waiver for monitoring certain pollutants under existing permit	The Director may authorize a discharger subject to technology-based effluent limitations guidelines and standards in an NPDES permit to forego sampling of a pollutant found at 40 *CFR* Subchapter N of this chapter if the discharger has demonstrated through sampling and other technical factors that the pollutant is not present in the discharge or is present only at background levels from intake water and without any increase in the pollutant due to activities of the discharger. *NOTE: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the terms "permit" and "permittee" reflect regulatory language; in this remedial action, "permit" can generally be taken to mean the Sampling and Analysis Plan, and "permittee" to mean DOE.*	Discharge of pollutants subject to TBELs in existing NPDES Permit – **Applicable**	40 *CFR* 122.44(a)(2)(i)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Monitoring parameter waiver demonstration	Any request for this waiver must be submitted when applying for a reissued permit or modification of a reissued permit. The request must demonstrate through sampling or other technical information, including information generated during an earlier permit term that the pollutant is not present in the discharge or is present only at background levels from intake water and without any increase in the pollutant due to activities of the discharger. *<u>NOTE</u>: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the terms "permit" and "permittee" reflect regulatory language; in this remedial action, "permit" can generally be taken to mean the Sampling and Analysis Plan, and "permittee" to mean DOE.*	Discharge of pollutants subject to TBELs in existing NPDES Permit – **Applicable**	40 *CFR* 122.44(a)(2)(iii)
	Any grant of the monitoring waiver must be included in the permit as an express permit condition and the reasons supporting the grant must be documented in the permit's fact sheet or statement of basis. *<u>NOTE</u>: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the terms "permit" and "permittee" reflect regulatory language; in this remedial action, "permit" can generally be taken to mean the Sampling and Analysis Plan, and "permittee" to mean DOE.*	Discharge of pollutants subject to TBELs in existing NPDES Permit – **Applicable**	40 *CFR* 122.44(a)(2)(iv)
Development of effluent limitations	For new sources, technology-based effluent limitations shall require the greatest degree of effluent reduction achievable through application of the best available demonstrated control technology, which shall be new source performance standards, if available.	Discharges of pollutants as defined in 40 *CFR* 122.2 from "new sources" – **Applicable**	TDEC 0400-40-05-.08(1)(b)
	Toxic effluent limitations shall be based on consideration of the toxicity of the pollutant, its persistence, its degradability, the usual or potential presence of the affected organisms in any waters, the importance of the affective organisms and the nature and extent of the effect of the toxic pollutant on such organisms.	Discharge of toxic pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and Appropriate**	TDEC 0400-40-05-.08(1)(d)
	All effluent limitations or standards shall meet or exceed any minimum standards promulgated by the Administrator and currently effective under the Federal Water Pollution Control Act, P.L. 92-500 as amended or any subsequent applicable acts.		TDEC 0400-40-05-.08(1)(f)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Development of effluent limitations (continued)	All pollutants shall receive treatment or corrective action to ensure compliance with effluent limitations established by the US EPA pursuant to Section 301 and 302 and standards of performance for new sources pursuant to Section 306, effluent limitations and prohibitions and pretreatment standards pursuant to Section 307 of the Federal Water Pollution Control Act, P.L. 92-500 as amended; also to insure compliance with any approved water quality standard.		TDEC 0400-40-05-.08(1)(g)
Compliance Point for Discharge	All permit effluent limitations, standards, and prohibitions shall be established for each outfall or discharge point of the permitted facility, except as otherwise provided for BMPs where limitations on effluent or internal waste streams are infeasible *<u>NOTE</u>: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the term "permit" reflects regulatory language; in this remedial action, "permit" can generally be taken to mean the Record of Decision.*	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water – **Relevant and Appropriate**	TDEC 0400-40-05-.08(1)(k)
	All permit effluent limitations, standards, and prohibitions shall be expressed as maximum daily and monthly average, unless impracticable. *<u>NOTE</u>: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the term "permit" reflects regulatory language; in this remedial action, "permit" can generally be taken to mean the Record of Decision.*	Continuous discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Continuous discharge of radionuclides into surface water – **Relevant and Appropriate**	TDEC 0400-40-05-.08(1)(m)
Effluent Limitations for metals	All permit effluent limitations, standards, or prohibitions for a metal shall be expressed as "total recoverable metal" unless a promulgated effluent guideline specifies otherwise. *<u>NOTE</u>: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the term "permit" reflects regulatory language; in this remedial action, "permit" can generally be taken to mean the Record of Decision.*	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides that are also metals into surface water – **Relevant and Appropriate**	TDEC 0400-40-05-.08(1)(p)

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Measurement of effluent standards	Any discharge which is not a minor discharge or activity, or that contains a toxic pollutant for which an effluent standard has been established shall be monitored for the following: • Flow (in million gallons per day); and • Pollutants which are subject to reduction or elimination under the terms and conditions of the permit *<u>NOTE</u>: DOE is not required to obtain a permit for any part of a remedial action conducted entirely onsite, per CERCLA §121(e). Use of the term "permit" reflects regulatory language; in this remedial action, "permit" can generally be taken to mean the Record of Decision. "Pollutant" in this requirement shall include all radionuclides for which an effluent limitation is established under this remedial action.*	Point source discharge of pollutants as defined in 40 *CFR* 122.2 into surface water – **Applicable** Point source discharge of radionuclides into surface water **– Relevant and Appropriate**	TDEC 0400-40-05-.08(1)(s)
Discharge of wastewater from RCRA hazardous waste landfills	Except as provided in 40 *CFR* § 125.30 through § 125.32, any existing point source subject to this subpart must achieve the Effluent Limitations listed in the regulation for each regulated parameter[4] which represent the application of *best practicable control technology* (BPT).	Discharge of wastewater[5] from landfills subject to 40 *CFR* 264, from an "*existing* "source **– Not Applicable[6]**	40 *CFR* 445.11
	Except as provided in 40 *CFR* § 125.30 through § 125.32, any existing point source subject to this subpart must achieve the following effluent limitations which represent the application of *best available technology economically* (BAT): Limitations for ammonia (as N), a-terpineol, aniline, benzoic acid, naphthalene, p-cresol, phenol, pyridine, arsenic, chromium and zinc are the same as the corresponding limitations specified in §445.11.		40 *CFR* 445.13

[4] Radionuclides are not on the list of *regulated parameters*.

[5] "*Landfill wastewater* means all wastewater associated with, or produced by, landfilling activities except for sanitary wastewater, non-contaminated storm water, contaminated ground water, and wastewater from recovery pumping wells. Landfill wastewater includes, but is not limited to, leachate, gas collection condensate, drained free liquids, laboratory derived wastewater, contaminated storm water and contact wash water from washing truck, equipment, and railcar exteriors and surface areas which have come in direct contact with solid waste at the landfill facility." 40 *CFR* 445. 2(f). "*Contaminated storm water* means storm water which comes in direct contact with landfill wastes, the waste handling and treatment areas, or landfill wastewater as defined in paragraph (f) of this section. Some specific areas of a landfill that may produce contaminated storm water include (but are not limited to): the open face of an active landfill with exposed waste (no cover added); the areas around wastewater treatment operations; trucks, equipment or machinery that has been in direct contact with the waste; and waste dumping areas." 40 *CFR* 445.2(b).

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Discharge of wastewater from RCRA hazardous waste landfills (continued)	Any new source subject to this subpart must achieve the following performance standards: Standards are the same as those specified in § 445.11.	Discharge of wastewater1 from landfills subject to 40 *CFR* Part 264, from a "new" source – **Not applicable**[4]	40 *CFR* 445.14
Protection of the general population from releases of radioactivity from land disposal facility	Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public.[7]	The siting, design, operation, closure, and control after closure of radioactive waste land disposal facilities – **Relevant and appropriate**	10 *CFR* 61.41 TDEC 0400-20-11-.16(2)
Protection of individuals during land disposal facility operations	Operations involving releases of radioactivity in effluents from the land disposal facility shall be governed by the 25/75/25 millirem per year dose limits in 10 *CFR* 61.41. (See FN4.)	The operation of radioactive waste land disposal facilities – **Relevant and appropriate**	10 *CFR* 61.43 TDEC 0400-20-11-.16(2)
Non-continuous batch discharges (those discharges which are not continuous as defined in 40 *CFR* 122.2) of leachate and contact water	Non-continuous discharges shall be particularly described and limited, considering the following factors, as appropriate: • Frequency • Total mass • Maximum rate of discharge of pollutants during the discharge; and • Mass or concentration of specified pollutants	Non-continuous discharge of pollutants to surface waters—**applicable** if water is released on a non-continuous batch basis rather than continuously	40 *CFR* 122.45(e) TDEC 0400-40-05-.08(1)(n)
Temporary bypass of waste stream	Bypass is prohibited unless: • Bypass was unavoidable to prevent loss of life, personal injury, or severe property damage; There were no feasible alternatives to bypass; condition not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance.	Bypass, as defined in TDEC 0400-40-05-.02(15), of waste stream—**applicable**	TDEC 0400-40-05-.07(2)(l)
	A bypass that does not cause effluent limitations to be exceeded may be allowed only if bypass is necessary for essential maintenance to assure efficient operation.		TDEC 0400-40-05-.07(2)(m)

[4] Because neither the EMWMF nor the proposed EMDF are RCRA Subtitle C hazardous waste landfills, effluent is not subject to effluent limits set under 40 *CFR* 445.11.

[7] NOTE: Under these regulations, concentrations of radioactive material that may be released to the general environment in groundwater, surface water, air, soil, plants or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public with flexibility on apportionment of that dose among exposure pathways.

Table D.1. ARARs and TBC guidance (cont.)

Action	Requirements	Prerequisite	Citation
Wastewater transferred by truck or pipeline to onsite on-ORR CWA-authorized WWTU	A user may not introduce into a wastewater facility any pollutant(s) which causes pass through or interference, and wastewater must meet the pretreatment standards and prohibitions [waste acceptance criteria and limits] set by the wastewater facility prior to transfer.	Transfer of contaminated wastewater to a CWA-authorized wastewater facility for treatment **—applicable**	TDEC 0400-40-14-.05(1) – (2) and (4)
Management of water generated from EMWMF landfill	Onsite wastewater treatment units that are part of a wastewater treatment facility subject to regulation under Section 402 or Section 307(b) of the CWA are exempt from the requirements of RCRA Subtitle C for all tank systems, conveyance systems (whether piped or trucked), and ancillary equipment used to store or transport RCRA contaminated water.	Onsite wastewater treatment units subject to regulation under §402 or §307(b) of the CWA—**applicable** if water is determined to be hazardous	40 *CFR* 264.1(g)(6) 40 *CFR* 260.10 40 *CFR* 270.1(c)(2)(v) TDEC 0400-12-01-.06(1)(b)(2)(v) TDEC 0400-12-01-.01(2)(a) TDEC 0400-12-01-.07(1)(b)(4)(iv) 53 FR 34079, September 2, 1988
Disposal of wastewaters containing RCRA hazardous constituents	Disposal is not prohibited if the wastes are managed in a treatment system which subsequently discharges to waters of the U.S. under the CWA unless the wastes are subject to a specified method of treatment other than DEACT in 40 *CFR* 268.40 or are D003 reactive cyanide.	Disposal of RCRA restricted hazardous wastes that are hazardous only because they exhibit a hazardous characteristic and are not otherwise prohibited under 40 *CFR* 268**—applicable** if water is determined to be hazardous	40 *CFR* 268.1(c)(4)(i) TDEC 0400-12-01-.10(1)(a)(3)(iv)(I)
Transportation			
Transportation of universal waste off-site	Off-site shipments of universal waste by a large quantity handler of universal waste shall be made in accordance with 40 *CFR* 273-38 [TDEC 0400-1-11-.12(3)(i)].	Off-site shipment of universal waste by a large quantity generator of universal waste—**applicable**	40 *CFR* 273.38 TDEC 0400-1-11-.12(3)(i)
Transportation of used oil off-site	Except as provided in paragraphs (a) to (c) of this rule, generators must ensure that their used oil is transported by transporters who have obtained U.S. EPA ID numbers.	Off-site shipment of used oil by generators of used oil—**applicable**	40 *CFR* 279.24 TDEC 0400-1-11-.11(3)(e)

ARAP = aquatic resource alteration permit
ARAR = applicable or relevant and appropriate requirement
BAT = best available technology
CERCLA = Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR = *Code of Federal Regulations*
CWA = Clean Water Act of 1974
DOE = U.S. Department of Energy
EMDF = Environmental Management Disposal Facility
EMWMF = Environmental Management Waste Management Facility
EO = Executive Order
EPA = U.S. Environmental Protection Agency
FEMA = Federal Emergency Management Agency
FWS = U.S. Fish and Wildlife Service
NRC = Nuclear Regulatory Commission
ORR = Oak Ridge Reservation
PPE = personal protective equipment
RCRA = Resource Conservation and Recovery Act of 1976
TBC = to be considered
TCA = *Tennessee Code Annotated*
TDEC = Tennessee Department of Environment and Conservation
T&E = threatened and endangered
TN = Tennessee
U.S. = United States
USC = *United States Code*
WWTU = wastewater treatment unit

Table D.2. Numeric AWQC that are potential chemical-specific ARARs/TBCs for key COCs in EMWMF/EMDF landfill wastewater[a]

Chemical	Fish and Aquatic Life [TDEC 0400-40-03-.03(3)]		Recreation[b] [TDEC 0400-40-03-.03(4)]
	CMC (µg/L or ppb)	CCC (µg/L or ppb)	Organisms only (µg/L or ppb)
Aldrin (c)	3.0		0.00050
Arsenic (c)			10.0
Arsenic (III)	340[c]	150[c]	
b-BHC (c)			0.17
Cadmium	1.8[d]	0.72[d]	
Chromium (III)	570[d]	74[d]	
Chromium (VI)	16[c]	11[c]	
Copper	13[d]	9.0[d]	
Cyanide	22	5.2	140
4,4'-DDT (b)(c)	1.1	0.001	0.0022
4,4'-DDE (b)(c)			0.0022
4,4'-DDD (b)(c)			0.0031
Dieldrin (b)(c)	0.24	0.056	0.00054
Lead	65[d]	2.5[d]	
Mercury (b)	1.4[c]	0.77[c]	0.051
Nickel	470[d]	52[d]	4600

(b) = bioaccumulative parameter
(c) = carcinogenic parameter

[a] https://publications.tnsosfiles.com/rules/0400/0400-40/0400-40-03.20190911.pdf
[b] A 10^{-5} risk level is used for setting TDEC recreational criteria for all carcinogenic pollutants. Recreational criteria for noncarcinogenic chemicals are set using a 10^{-6} risk level. [*Note*: All federal recreational criteria are set at a 10^{-6} risk level].
[c] Criteria are expressed as dissolved.
[d] Criteria are expressed as dissolved and are a function of total hardness (mg/L). Criteria displayed correspond to a total hardness of 100 mg/L.

ARARs = applicable or relevant and appropriate requirements
AWQC = ambient water quality criteria
CCC = criterion continuous concentration
CMC = criterion maximum concentration
COCs = contaminants of concern
EMDF = Environmental Management Disposal Facility
EMWMF = Environmental Management Waste Management Facility
TBC = to-be-considered [guidance]
TDEC = Tennessee Department of Environment and Conservation

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APPENDIX E.
MERCURY CONCENTRATION IN ENVIRONMENTAL MANAGEMENT DISPOSAL FACILITY LANDFILL WASTEWATER

Appendix E is from the FFS D3.

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Predicting Mercury Concentrations in Leachate

Mercury-contaminated building demolition debris and soils resulting from cleanup of Y-12 National Security Complex (Y-12) are assumed to be disposed of in the Environmental Management Disposal Facility (EMDF). Oak Ridge Environmental Management forecasts a total of about 380,000 cubic yards (CY) of debris waste to be disposed from the four large mercury-contaminated buildings at Y-12. The forecasted soils and sediments to be disposed total approximately 100,000 CY. It was assumed in the Integrated Facility Disposition Program (IFDP) that a portion of the debris and soil/sediments would require treatment to meet land disposal restrictions (LDRs) prior to land disposal. The soils/debris portions requiring treatment are those that do not pass the toxicity characteristic leaching procedure (TCLP) testing. This analysis will evaluate the IFDP-assumed quantities and mercury content of waste debris and soil to be disposed of at the future EMDF and estimate potential mercury concentrations in the landfill leachate.

For debris, LDR treatment was assumed to be macroencapsulation in place, in the landfill. For purposes of this analysis, macroencapsulation is assumed to totally stabilize the mercury, thus no mercury would leach from macroencapsulated debris during active landfill operations following treatment. Prior to treatment, however, the debris may be exposed to precipitation when it is placed in the landfill, and it is likely that some leaching of mercury prior to completion of the macroencapsulation may occur. Due to the short time that debris will be exposed prior to macroencapsulation, it is assumed this resulting contaminated leachate will be addressed similarly to leachate resulting from non-treated mercury waste, as discussed below. Debris that passes TCLP testing is assumed (for purposes of calculating a mercury leachate concentration) to exhibit the same characteristics as low mercury soil waste, since the debris would be surrounded within a soil matrix that would uptake the mercury leached from the debris.

For soils, it is assumed that treatment to meet LDRs would be carried out on the portion of waste that fails TCLP testing. This treatment method is assumed to be sulfur polymer stabilization/solidification (SPSS). United Cleanup Oak Ridge LLC (UCOR) completed a study in which soils from Y-12 were treated by this method (UCOR-4323, *Treatability Study Report for Y-12 Site Mercury Contaminated Soil, Oak Ridge, Tennessee*). The results of that study were used in this analysis to predict partition coefficients (Kd) for treated and untreated mercury-contaminated soils, and thus used to determine potential leachate mercury concentrations.

Mercury Concentrations in Building Debris

A thorough characterization was recently completed on the Alpha-5 Building at Y-12 (DOE-OR/01-2540&D2, *Characterization Report for Alpha 5 Building 9201-5 at the Y-12 National Security Complex, Oak Ridge, Tennessee*). Mercury characterization results are summarized here to give an indication of the expected concentrations in demolition debris that would be disposed of at EMDF.

Data taken from the Alpha-5 characterization report is given in Tables E.1 and E.2 (Tables 23 and 24 from the report). A discussion taken from the report is included, as well. The data show that 95% of mercury debris samples with a total mercury concentration of at least 247 mg/kg will exceed the Resource Conservation and Recovery Act (RCRA) limit of 0.2 mg/L in TCLP testing, and 95% of mercury samples with a total mercury concentration of up to 151 mg/kg would not exceed the TCLP RCRA limit. This implies that mercury-contaminated debris with mercury concentrations up to 151 mg/kg may pass TCLP and be placed in the landfill without treatment.

Summary statistics for total mercury concentrations (mg/kg) were developed (DOE-OR/01-2540&D2 and EPA/600/R-07/041, *Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations*, ProUCL 5.0.00) using core samples from Alpha-5 Building 9201-5 media (concrete floor, ceiling, interior wall, exterior wall, and roof) on floors 1, 1M, 2, 2M, 3, and 4. Kaplan-Meier (KM) estimation methods were used to account for non-detects, and no substitution methods (replacing the non-detect value by the detection limit or ½-detection) were employed. Results are summarized in Table E.3. A description of the derivation of the data follows.

Table E.1. Detected mercury samples exceeding TCLP mercury RCRA limit (Table 23 from DOE/OR/01-2540&D2)

Intrusive (mg/kg)	Number TCLP Samples ≥ 0.2 mg/L	Number Samples ≥ Intrusive	Percent Samples > 0.2 mg/L
0.00438	32	247	13.0
1.01	32	167	19.2
6.77	31	77	40.3
15.5	30	59	50.8
20.5	29	52	55.8
23.3	28	46	60.9
27.9	27	42	64.3
40.3	26	40	65.0
57.6	25	37	67.6
78.6	24	34	70.6
127	22	27	81.5
161	21	25	84
228	20	22	90.9
247	18	19	94.7
727	9	9	100

Table 23 summarizes the number of TCLP and detected intrusive mercury samples at or above each detected intrusive concentration. Table 23 provides the data to create the empirical distribution function shown in Figure 44, which relates the percentage of TCLP samples exceeding 0.2 mg/L for each detected intrusive sample concentration. Table 23 and Figure 44 show that 95% (18 out of 19) of the TCLP mercury samples exceeding the RCRA limit of 0.2 mg/L were also analyzed for total mercury with concentrations at or above 247 mg/kg. All (100%) of the TCLP mercury samples exceeding the RCRA limit of 0.2 mg/L were also analyzed for total mercury with concentrations at or above 727 mg/kg. Ninety-one percent (91%) of the TCLP mercury samples exceeding the RCRA limit of 0.2 mg/L were also analyzed for total mercury with concentrations at or above 228 mg/kg. Based upon this empirical data, there is a 95% probability that an intrusive mercury sample with a mercury concentration of at least 247 mg/kg would also fail the TCLP RCRA limit of 0.2 mg/L.

Table E.2. Detected mercury samples meeting TCLP mercury RCRA limit (Table 24 from DOE/OR/01-2540&D2)

Intrusive (mg/kg)	Number TCLP Samples < 0.2 mg/L	Number Samples ≤ Intrusive	Percent Samples < 0.2 mg/L
0.94	80	80	100.0
6.59	169	170	99.4
14.8	186	188	98.9
20.3	192	195	98.5
23	197	201	98.0
27	200	205	97.6
28.1	201	207	97.1
49.8	203	210	96.7
66.7	205	213	96.2
125	210	220	95.5
151	211	222	95.0
224	213	225	94.7
243	214	228	93.9
542	215	238	90.3
4340	215	247	87.0

Table 24 summarizes the number of TCLP and detected intrusive mercury samples at or below each detected intrusive concentration. Table 24 provides the data to create the empirical distribution function shown in Figure 45, which relates the percentage of TCLP samples below 0.2 mg/L for each detected intrusive sample concentration. Table 24 and Figure 45 show that 95% (211 out of 222) of the TCLP mercury samples below the RCRA limit of 0.2 mg/L were also analyzed for total mercury, with concentrations at or below 151 mg/kg. All (100%) of the TCLP mercury samples below the RCRA limit of 0.2 mg/L were also analyzed for total mercury, with concentrations at or below 0.94 mg/kg. Ninety percent (90%) of the TCLP mercury samples below the RCRA limit of 0.2 mg/L were also analyzed for total mercury, with concentrations at or below 542 mg/kg. Based upon this empirical data, there is a 95% probability that an intrusive mercury sample with a mercury concentration of up to 151 mg/kg would also pass the TCLP RCRA limit of 0.2 mg/L. More data are needed to bring the percentage of samples below 0.2 mg/L to below 87%.

Table E.3. Summary statistics for Alpha-5 (Bldg. 9201-5) total mercury (mg/kg)

Parameter	Result	Units	Comment
Total number of samples	543	Count	
Probability distribution	N/A	None	Data do not fit normal, lognormal, gamma distributions, or other similar distributions
Number of detects	534	Count	
Minimum of detects	0.00438	mg/kg	
Median of detects	1.955	mg/kg	
Maximum of detects	4340	mg/kg	
Mean of detects	63.59	mg/kg	
Standard deviation of detects	325.6	mg/kg	
Coefficient of variation of detects	512%	mg/kg	
95% KM Chebyshev UCL	123	mg/kg	Non-parametric UCL
99% KM Chebyshev UCL	200.5	mg/kg	Non-parametric UCL
95% UTL with 95% coverage	360	mg/kg	Non-parametric UTL
95% UTL with 99% coverage	3170	mg/kg	Non-parametric UTL

UCL = upper confidence limit
UTL = upper tolerance limit

Sample results for 467 of the 543 samples are greater than 0.1 mg/kg. The number of sample results and the range of sample results for floors and media types are presented in Table E.4. For example, 126 sample results were collected from Floor 1-Floor, and the range of sample results is 0.102 mg/kg to 4340 mg/kg. Blank cells, such as Floor 1M Ceiling, indicate no sample results for the floor/media combination. The wide ranges indicate heterogeneity of mercury contamination greater than 0.1 mg/kg for all floors and all media.

Table E.4. Sample results greater than 0.1 mg/kg for Alpha-5 (Bldg. 9201-5) total mercury

Floor	Media					
	Floor	Ceiling	Interior wall	Exterior wall	Roof	Total
	Entries are number of samples and range (minimum to maximum) of sample results (mg/kg)					
1	126 0.102 to 4340	33 0.172 to 101	30 0.128 to 69.4	28 0.115 to 10.5		217 0.102 to 4340
1M	2 0.503 to 0.586		2 2.63 to 5.28			4 0.503 to 5.28
2	56 0.141 to 1130	26 0.101 to 8.09	25 0.296 to 40.3	21 0.186 to 24		128 0.101 to 1130
2M	4 0.409 to 42.6	4 1.49 to 3.85	4 1.32 to 58.1	5 0.973 to 4.1		17 0.409 to 58.1
3	25 0.168 to 1410	21 0.475 to 12.5	23 0.106 to 8.17	16 0.119 to 43.3		85 0.106 to 1410
4	4 0.137 to 0.436	5 1.04 to 3.14		2 0.26 to 0.738		11 0.137 to 3.14
Roof					5 0.109 to 0.637	5 0.109 to 0.637
Total	217 0.102 to 4340	89 0.101 to 101	84 0.106 to 69.4	72 0.115 to 43.3	5 0.109 to 0.637	467 0.101 to 4340

The upper confidence limit (UCL) is the upper boundary (or limit) of the population mean. The KM Chebyshev UCL is based upon Kaplan-Meier estimates using the Chebyshev inequality. The Chebyshev inequality is the sum of the arithmetic average and the weighted standard error of the mean. The Chebyshev inequality does not rely on any underlying probability distribution of the data (e.g., normal, lognormal, gamma). The weighting factor is proportional to the square root of the confidence level, e.g., 95%. The upper tolerance limit (UTL) is a confidence limit on a percentile of the population rather than a confidence limit on the mean. For example, a 95% one-sided UTL for 95% coverage represents the value below which 95% of the population values are expected to fall with 95% confidence. In other words, a 95% UTL with coverage coefficient 95% represents a 95% UCL for the 95th percentile.

Mercury Concentrations in Soils and Sediments

Information about the extent of mercury contamination in soils at Y-12 is very limited, as are data on the specific soil mercury concentrations. Figure E.1 is a map showing aerial extent and ranges of mercury concentrations, taken from the *Record of Decision for Phase I Interim Source Control Actions in the Upper East Fork Poplar Creek Characterization Area, Oak Ridge, Tennessee* (DOE/OR/01-1951&D3). From the figure, it is assumed that the majority of soils would exhibit a mercury concentration of between 1 and 10 mg/kg.

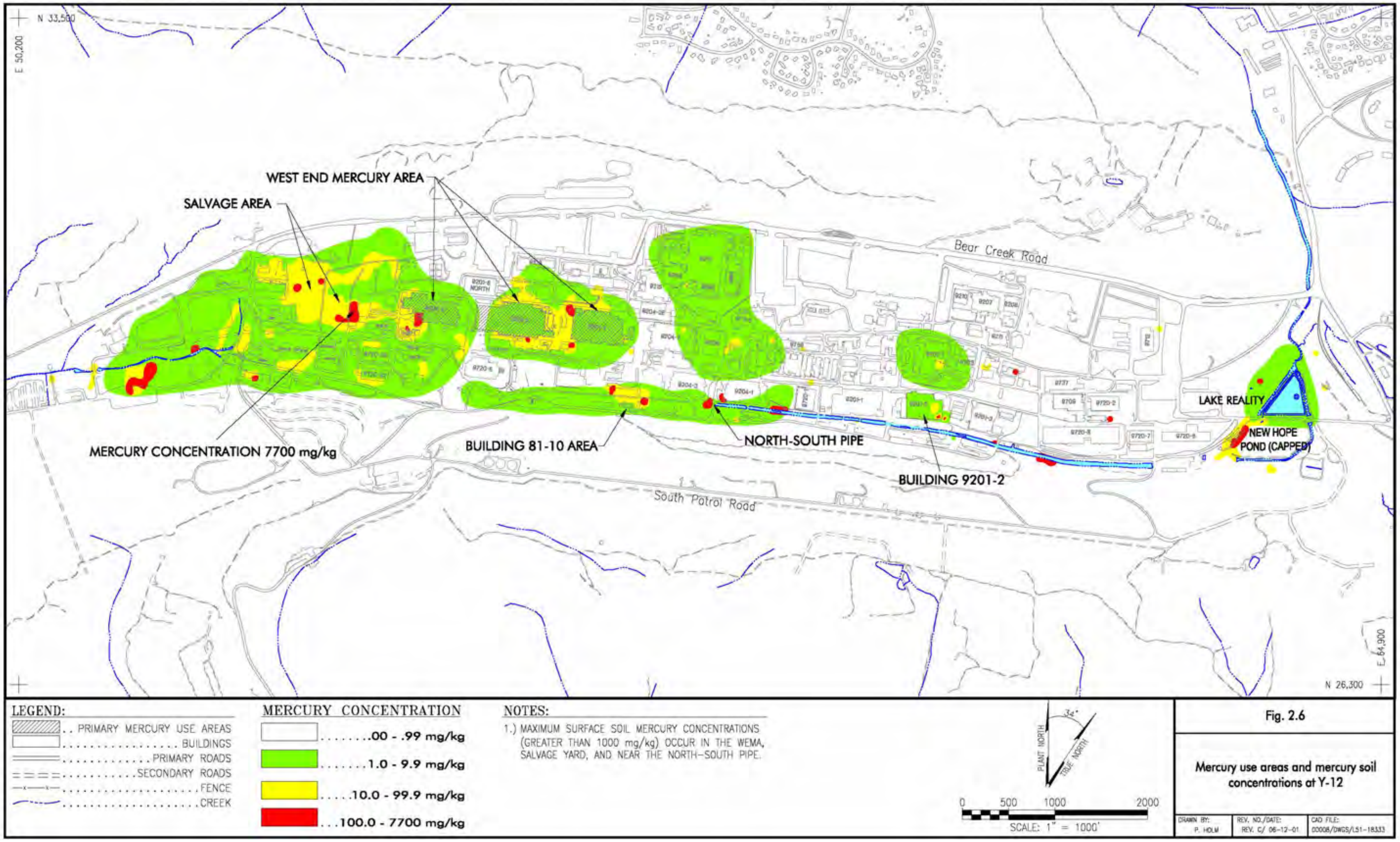

Fig. E.1. Upper East Fork Poplar Creek mercury soils concentrations.

Calculation of Kd

Kds indicate the equilibrium partitioning of a contaminant between the solid phase (in this case, soil) and the liquid phase (in this case leachate). High Kd indicates greater immobility, and low Kd indicates greater mobility in the soil-water environment. Kds were calculated for mercury based on the results of the UCOR soils study (UCOR-4323). Kds for untreated soils were also taken from literature, for comparison purposes (EPA/600/R-05/074, *Partition Coefficients for Metals in Surface Water, Soil, and Waste*). Following is a summary of those calculations and results.

A. Calculation of Field Leachate Concentrations

Leachate concentrations measured in the SPLP test are not equivalent to those that would be observed under field conditions because the relative amounts of soil and water used in the SPLP test are completely different from those in a natural soil system. (For a detailed explanation of the issues involved, refer to Appendix C.) For this reason, field leachate concentrations must be calculated for each sample using the SPLP leaching test results and its corresponding measured total soil concentration. The procedure to calculate field leachate concentrations is described below.

1. For each sample, calculate a soil water-partition coefficient (K_d) for each contaminant:

$$K_d = \frac{(C_T M_S - C_{SPLP} V_L)/M_S}{C_{SPLP}} \quad (1)$$

where

K_d = is the soil-water partition coefficient (L/kg)
C_T = the total concentration of the contaminant in the SPLP soil sample (mg/kg)
M_S = the total weight of the soil sample submitted for SPLP analysis (~0.1 kg for inorganic chemicals and semivolatiles, or ~0.025 kg for volatiles)
C_{SPLP} = the concentration of contaminant in the SPLP leachate (mg/L)
V_L = the volume of the SPLP leachate (~2 L for inorganic chemicals and semivolatiles, or ~0.5 L for volatiles)

NOTE: C_{SPLP} in Equation 1 must have units of mg/L

The excerpt above is from a 2013 New Jersey Department of Environmental Protection (NJDEP) Guidance Document (NJDEP 2013, *Development of Site-Specific Impact to Groundwater Soil Remediation Standards Using the Synthetic Precipitation Leaching Procedure*). SPLP is the synthetic precipitation leaching procedure and, in regards to this analysis of potential mercury concentrations, analogous to TCLP, so that $C_{SPLP} = C_{TCLP}$ and the results of the UCOR Soils Study can be substituted into the equation above.

The following is a calculation of Kd values using the UCOR treatability study data (UCOR-4323). Three separate vendor laboratories participated in the study: Brookhaven National Laboratory, Energy*Solutions*, and Materials and Energy Corporation. Each lab received spiked soil samples in order to test their treatment methods for immobilization of mercury to meet TCLP testing and allow land disposal of the treated forms. Soil samples were provided to the vendors that had been spiked with elemental mercury to produce mercury concentrations in the soil samples of nominally 2000 mg/kg and nominally 10,000 mg/kg. These mercury spiked soil samples were produced by a single separate lab and then supplied to the 3 vendor labs to perform the testing. The vendor labs then treated the samples with their respective methods of (some form of) SPSS. Prior to and after testing, the vendor laboratories calculated the total mercury concentrations in the soil samples. These actual measured values were used in the following calculations as the total concentration of the contaminant in the soil sample (C_T). See the previous equation for explanation.

<u>Treated Soils</u>*: Calculating Kd (L/kg) values for treated soils based on UCOR Soils Study data:*

C_T Values:	2,000	10,000	Nominal as Mixed (mg/kg)
BNL	1.91E+03	6.25E+03	Actual as Measured (mg/kg)
ES	1.36E+03	3.73E+03	
M&EC	1.60E+03	8.03E+03	

C_{TCLP} Values:	2,000	10,000	Nominal as Mixed (mg/kg)
BNL	0.0011	0.0013	TCLP (mg/L)
ES	0.00067	0.0233	
M&EC	0.00174	0.00067	

Kd:	2,000	10,000	Nominal as Mixed (mg/kg)
BNL	1.74E+06	4.81E+06	(L/kg)
ES	2.03E+06	1.60E+05	
M&EC	9.18E+05	1.20E+07	
AVERAGE:	3.61E+06	**Mercury Kd for Treated Soils**	

*Note BNL did not report starting soil concentrations, so averages from ES and M&EC used.

<u>Untreated Soils:</u> *Calculating Kd (L/kg) for untreated soils based on UCOR Soils Study data:*

C_T Values:	2,000	10,000	Nominal as Mixed (mg/kg)
BNL	1.91E+03	6.25E+03	Actual as Measured (mg/kg)
ES	2.96E+03	3.48E+03	
M&EC	2.28E+03	1.23E+04	

C_{TCLP} Values:	2,000	10,000	Nominal as Mixed (mg/kg)
BNL	6.5	11.9	TCLP (mg/L)
ES	11.2	6.86	
M&EC	7.71	6.97	

Kd:	2,000	10,000	Nominal as Mixed (mg/kg)
BNL	2.74E+02	5.05E+02	(L/kg)
ES	2.44E+02	4.87E+02	
M&EC	2.75E+02	1.75E+03	
AVERAGE:	5.89E+02	**Mercury Kd for Untreated Soils**	

BNL = Brookhaven National Laboratory
ES = Energy*Solutions*
M&EC = Materials and Energy Corporation

The average values for the treated and untreated soils (highlighted on the previous page) were carried forward for this evaluation. Further research of U.S. Environmental Protection Agency (EPA) literature was conducted in order to compare the Kds calculated above to other studies that have been performed. The EPA's 2005 report *Partition Coefficients for Metals in Surface Water, Soil, and Waste* cited mercury Kd values of 1000 L/kg and 3981 L/kg, which would represent untreated waste. Thus multiple Kd values for the untreated waste were examined at various mercury soil concentrations to predict leachate mercury concentrations. The following Kd values are those that were used in this analysis:

3.61E+06 L/kg for Treated Soil Waste, as calculated in UCOR Soils Study (see preceding Kd calc)

589 L/Kg for Untreated Soil Waste, as calculated in UCOR Soils Study (see preceding Kd calc)

1000 L/Kg for Untreated Soil Waste, quoted from reference as value used by EPA in studies (EPA/600/R-05/074).

3981 L/Kg for Untreated Waste, soil/water partition coefficient, mean from multiple data sets, per reference (EPA/600/R-05/074).

The following equation was then used to evaluate the potential leachate concentration range of future mercury-contaminated waste.

2. For each sample, substitute the K_d value in the following equation to calculate the estimated field leachate concentration:

$$C_L = \frac{C_T}{K_d + \frac{\theta_w + \theta_a H'}{\rho_b}} \qquad (2)$$

where
ρ_b = bulk density of the soil (1.6 kg/L)
θ_w = soil moisture content (0.23)
θ_a = soil air content (0.18)
H' = the dimensionless Henry's law constant
C_L = field leachate concentration (mg/L).

Equation 2 is a simple rearrangement of the USEPA Soil Screening Guidance soil-water partition equation. It is derived in Appendix C.

From the 2013 NJDEP Guidance Document

Equation Inputs to Estimate Mercury Concentrations in Leachate:

Kd, for treated soils:	3.61E+06	L/kg	
Kd, for untreated soils: ***	(Varied)	L/kg	
Henry's Law Constant for Hg:	0.467	dimensionless	
	total, CY	Volume assumed to require treatment (from IFDP, CD-1)....CY	Volume, no treatment (IFDP, CD-1).....CY
Total Bldg. Debris Volume	381,854	123,087	258,767
Total Soil Volume	95,574	53,882	41,692

***Vary Kd & Hg concentration:

Untreated Soil

Untreated Soil Hg concentration (mg/kg)	Kd = 589 L/kg Leachate C_L in ppt	Kd = 1,000 L/kg Leachate C_L in ppt	Kd = 3,981 L/kg Leachate C_L in ppt	AWQC Hg Limits, ppt
0.01	17	10	3	51 (recreational) 770 (fish/aquatic life, CCC) 1,400 (fish/aquatic life, CMC)
0.1	170	100	25	
1	1,697	1,000	251	
10	16,972	9,998	2,512	
20	33,945	19,996	5,024	
40	67,889	39,992	10,047	
100	169,723	99,980	25,118	
200	339,445	199,961	50,236	

Treated Soil

Treated Soil Hg concentration (mg/kg)	Kd = 3.61e6 L/kg Leachate C_L in ppt	AWQC Hg Limits, ppt
10	3	51 (recreational) 770 (fish/aquatic life, CCC) 1,400 (fish/aquatic life, CMC)
30	8	
100	28	
200	55	
500	139	
1000	277	
6000	1,662	
10000	2,770	

*** Various parameters were modified to better understand potential mercury concentrations in leachate under various circumstances

AWQC = ambient water quality criteria CCC = Criterion Continuous concentration CMC = Criterion Maximum Concentration

Graphs have been produced to predict a potential range of mercury concentrations in leachate as a function of the concentration of mercury in untreated and treated soils and varying Kd values. (See Figs. E.2 and E.3).

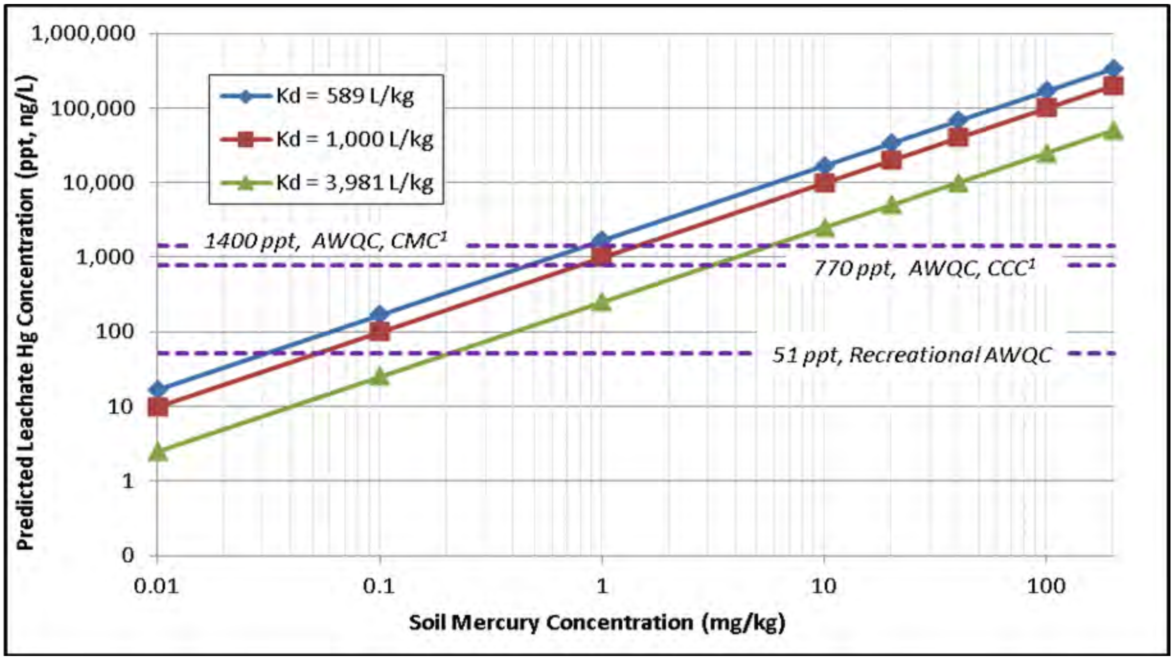

Fig. E.2. Predicted concentration of mercury in leachate given a soil concentration, for various untreated soil Kds.

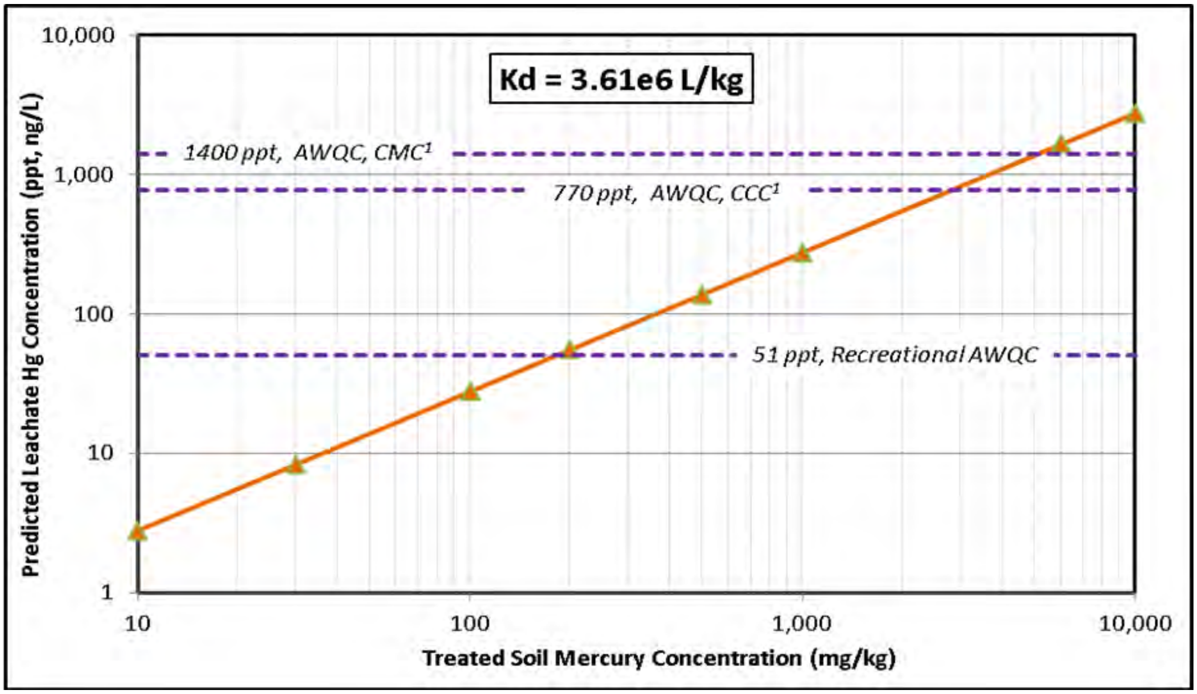

Fig. E.3. Predicted concentration of mercury in leachate given a treated (SPSS) Kd and soil concentration.

[1]CCC = Criterion Continuous Concentration, Fish & Aquatic Life; CMC = Criterion Maximum Concentration, Fish & Aquatic Life

Summary

Debris and soil wastes resulting from the demolition and remediation of Y-12 mercury-contaminated buildings and media will be disposed of in the future EMDF. Some of those wastes will require treatment to meet LDRs. Debris that fails TCLP are assumed to be macroencapsulated in place, in the future landfill; soil wastes that fail TCLP are assumed to be treated by SPSS prior to disposal in the future landfill. No measurable mercury leaching from these treated waste forms is expected during active operations of the landfill.

Untreated soils and debris that pass TCLP will be disposed of in the landfill. Although mercury has naturally high Kds, the amount of mercury-contaminated waste soil and debris expected to be disposed is large enough to result in significant "as-disposed" soil mercury concentrations that may result in measurable mercury concentrations in the leachate (see Fig. E.3). "As-generated" soil/debris mercury concentrations must be adjusted to account for the addition of soil fill, necessary for landfill stability, and the inclusion of other wastes in the landfill resulting in an "as-disposed" mercury concentration. The assumed volume of mercury-contaminated debris and soil to be disposed that will not require treatment to meet LDRs is approximately 300,000 CY. This material will be disposed along with the mercury-containing debris and soil within the first three cells resulting in a final as-disposed volume of approximately 1.25M CY. Consequently, the as-generated mercury concentrations would be reduced by a factor of about four. Assuming the resulting, as-disposed concentration is in the range of 0.03 to 0.25 mg/kg (equivalent to an as-generated waste mercury concentrations corresponding to 0.1 to ~1 mg/kg), leachate concentrations could exceed the 51 ppt ambient water quality criteria (AWQC) for mercury depending on the Kd exhibited (see Fig. E.3). As noted in the Alpha-5 characterization results, mercury concentrations are highly variable, and 95% of debris samples exhibiting mercury concentrations up to 151 mg/kg may pass TCLP. Taking this as an upper bound of the as-generated mercury concentration and assuming the Kds for contaminated debris would be the same as soil, a leachate mercury concentration in the range of 10,000 (highest Kd) to 90,000 ppt (lowest Kd) might be possible. With the uncertainty in volumes of soil/debris to be disposed, and the variability in as-generated mercury concentrations, predictions are highly uncertain. It is expected that leachate concentrations will vary widely for reasons such as variability in rainfall, sequencing of waste volumes, operations procedures, etc. Discussions and technology development activities are ongoing regarding the use of soil additives (for fill soil, landfill liner systems) that could help immobilize the mercury as well, thereby significantly reducing mercury leachate concentrations.

Soils that fail TCLP are assumed to be treated by SPSS. SPSS provides a large measure of protection against leaching, as seen by the very high calculated Kd (3.61e6 L/kg, see Fig. E.4). As-disposed soil mercury concentrations would have to exceed 200 mg/kg to result in leachate concentrations exceeding recreational AWQC. The mercury leached from these waste forms will not likely add significantly to mercury leachate concentrations, since the majority of the soils are expected to exhibit a concentration less than 10 mg/kg (refer to Fig. E.1)

Path Forward

The mercury concentrations estimated in this appendix are based on very simple, bounding assumptions. In addition, as noted in the summary, the mercury estimates in this appendix assumed waste with mercury above RCRA characteristic levels would be disposed in EMDF. As per the agreement in Appendix N, that is no longer a valid assumption.

These estimates are sufficient for use in the comparison of alternatives developed for this Focused Feasibility Study, but will continue to be refined as part of the remedial design report process to ensure the landfill wastewater treatment system is appropriately configured and sized to effectively treat landfill wastewater to the discharge limit of 51 ppt.

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APPENDIX F.
LEACHATE AND CONTACT WATER
WASTE DETERMINATION

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Leachate and Contact Water Waste Determination

This determination has been written to address the regulatory status of leachate and contact water under the Resource Conservation and Recovery Act of 1976 (RCRA).

Approach

Environmental Management Waste Management Facility (EMWMF) Operations has evaluated the regulations of 40 *CFR* 262.11, *Hazardous Waste Determination,* to ensure requirements were met for making a valid characterization decision. A combination of process knowledge, including physical characteristics of leachate and contact water, approved waste lots and disposal records, and historical analytical data, were then evaluated against the requirements of 40 *CFR* 262.11.

Requirements

40 *CFR* 262.11:

A person who generates a solid waste, as defined in 40 *CFR* 261.2, must determine if that waste is a hazardous waste using the following method:

(a) He should first determine if the waste is excluded from regulation under 40 *CFR* 261.4.

(b) He must then determine if the waste is listed as a hazardous waste in Subpart D of 40 *CFR* part 261.

NOTE: Even if the waste is listed, the generator still has an opportunity under 40 *CFR* 260.22 to demonstrate to the Administrator that the waste from his particular facility or operation is not a hazardous waste.

(c) For purposes of compliance with 40 *CFR* part 268, or if the waste is not listed in Subpart D of 40 *CFR* part 261, the generator must then determine whether the waste is identified in Subpart C of 40 *CFR* Part 261 by either:

(1) Testing the waste according to the methods set forth in Subpart C of 40 *CFR* part 261, or according to an equivalent method approved by the Administrator under 40 *CFR* 260.21; or

(2) Applying knowledge of the hazard characteristic of the waste in light of the materials or the processes used.

Process Knowledge

EMWMF Leachate Physical Characteristics

EMWMF leachate and contact water are water-based liquids that are derived from precipitation and application of fire water (potable water) for dust control that flows over and through disposed waste and is collected either in catchments within the disposal cells or by the leachate collection system. There are no impacts to EMWMF leachate and contact water from disposed liquids, as free liquids are prohibited from disposal at EMWMF by the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-1909&D3).

Approved Waste Lots and Disposal Record Information

Based on waste lots approved for disposal at EMWMF, no listed waste has been or is planned to be disposed at EMWMF. Therefore, EMWMF leachate and contact water are not listed waste.

Historical analytical data discussed below are based on analyses performed that include constituents identified as contaminants of concern (COCs) based on characterization information related to waste received. These COCs include all of the constituents identified in 40 *CFR* 261.24.

Historical Analytical Data

Historical EMWMF leachate and contact water data discussed in this waste determination were collected over the first 10 years of operations at EMWMF.

LEACHATE

EMWMF leachate samples were collected after the leachate from each active cell had been commingled in the leachate storage tanks. Leachate has been historically sampled and analyzed at a rate of one sample for every 140,000 gal generated, as well as one sample per calendar quarter for an expanded list of analytes.

Figure F.1 presents a timeline for when EMWMF Operations began managing leachate as each disposal cell came online:

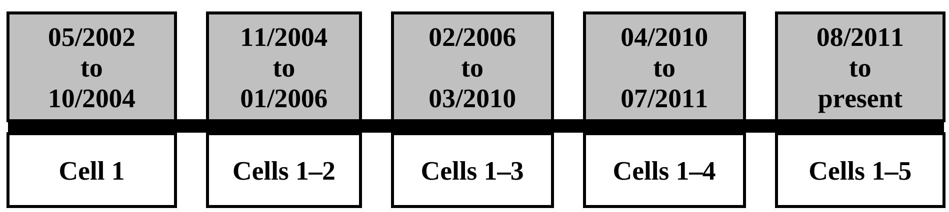

Fig. F.1. EMWMF leachate generation timeline.

The analyses performed on the leachate include the following U.S. Environmental Protection Agency-approved Methods, as defined in SW-846:

- Method 6010, Inductively Coupled Plasma-Atomic Emission Spectrometry (Metals)
- Method 7470, Mercury in Liquid Waste (Manual Cold-Vapor Technique)
- Method 8081, Organochlorine Pesticides by Gas Chromatography (GC)
- Method 8151, Chlorinated Herbicides by GC Using Methylation or Pentafluorobenzylation Derivatization
- Method 8260, Volatile Organic Compounds by GC/Mass Spectrometry (MS)
- Method 8270, Semivolatile Organic Compounds by GC/MS

CONTACT WATER

Contact water is collected in catchments within the disposal cell, then pumped to collection ponds or above-ground tanks. Each pond or tank is sampled when full; analytical results are compared against release criteria, and discharged to surface waters if the release criteria are met.

As shown in Table F.1, the maximum detected concentration values for toxicity characteristic (TC) constituents in leachate and contact water are well below regulatory levels. In all cases, the project quantitation levels are below the regulatory levels, but are greater that the method detection limits.

Table F.1. Comparison of 10-year leachate and contact water maximum values against 40 *CFR* 261.24 Table 1 regulatory levels

Chemical name	Maximum detected contact water value (mg/L)	Percent of regulatory level	Maximum detected leachate value (mg/L)	Percent of regulatory level	Regulatory level (mg/L)
Arsenic	0.0051	0.10%	0.00383 J	0.08%	5.0
Barium	0.0914	0.09%	0.46 N	0.46%	100.0
Benzene	0.005	1%	ND	N/A	0.5
Cadmium	0.001	0.1%	0.000712 J	0.07%	1.0
Carbon tetrachloride	0.005	0.1%	0.0082	1.64%	0.5
Chlordane	0.000119	0.4%	ND	N/A	0.03
Chlorobenzene	0.005	0.005%	ND	N/A	100.0
Chloroform	0.005	0.08%	0.00135 J	0.02%	6.0
Chromium	0.142	2.84%	0.00637	0.13%	5.0
2-Methylphenol (o-Cresol)	0.0112	0.056%	ND	N/A	200.0
3- and 4-Methylphenol (m-Cresol)	0.022	0.011%	ND	N/A	200.0
4-Methylphenol (p-Cresol)	0.022	0.011%	ND	N/A	200.0
Cresol	Not Applicable, based on 40 *CFR* 261.24, Table 1, Footnote 4.				
2,4-D	ND	N/A	0.00033 J	0.00%	10.0
1,4-Dichlorobenzene	0.0112	0.15%	ND	N/A	7.5
1,2-Dichloroethane	0.005	0.1%	ND	N/A	0.5
1,1-Dichloroethene	0.005	0.7%	ND	N/A	0.7
2,4-Dinitrotoluene	0.01	7.7%	ND	N/A	0.13
Endrin	0.0000595	0.3%	ND	N/A	0.02
Heptachlor	0.0000595	0.74%	ND	0.15%	0.008
Heptachlor epoxide	0.0000595	--	0.000012 J	--	--
Hexachlorobenzene	0.0112	8.6%	ND	N/A	0.13
Hexachlorobutadiene	0.0112	2.2%	ND	N/A	0.5
Hexachloroethane	0.01	0.33%	ND	N/A	3.0
Lead	0.005	0.1%	0.00453	0.09%	5.0
Lindane	0.00000133	0.0003%	0.000027 J	0.01%	0.4
Mercury	0.0002	0.1%	0.00022 *	0.11%	0.2
Methoxychlor	0.0000595	0.0006%	0.000015 J	0.00%	10.0
2-Butanone (MEK)	0.01	0.005%	1.77 D	0.89%	200.0
Nitrobenzene	0.01	0.5%	ND	N/A	2.0
Pentachlorophenol	0.025	0.025%	0.000124	0.00%	100.0
Pyridine	ND	N/A	ND	N/A	5.0
Selenium	0.01	1%	0.00446 J	0.45%	1.0
Silver	0.0025	0.05%	0.0088 N	0.18%	5.0
Tetrachloroethene	0.005	0.7%	ND	N/A	0.7
Toxaphene	ND	N/A	ND	N/A	0.5
Trichloroethene	0.005	1%	0.011	2.20%	0.5
2,4,5-Trichlorophenol	0.01	0.003%	ND	N/A	400.0
2,4,6-Trichlorophenol	0.01	0.5%	ND	N/A	2.0
Silvex	ND	N/A	0.000386 J	0.04%	1.0
Vinyl chloride	0.01	5%	ND	N/A	0.2

* = duplicate analysis not within control limits
D = identified at a secondary dilution factor
N = spike recovery not within control limits
ND = no detected values were identified
J = estimated value, between the project quantitation level and the method detection limit

As discussed above, the individual disposal cells were constructed and put into use sequentially, as necessary. Table F.2 presents the maximum detected values for TC constituents in EMWMF leachate during each phase noted in the timeline. Many TC constituents were not detected during analysis, and other TC constituent concentrations are estimated values. The results indicate that over time, most TC constituents are not present at detectable levels. Concentrations of those constituents that are detectable are estimated. As each EMWMF disposal cell came on line, there have been no notable increases in hazardous constituent concentrations, indicating negligible concentrations of hazardous constituents in leachate from each disposal cell. Therefore, analysis of samples from each disposal cell is not warranted.

Table F.2. Maximum detected values for TC constituents in EMWMF leachate

EPA HW No.	Chemical Name	Cell 1 Maximum Detected Results (05/02 - 10/04) (mg/L)	Qualifier	Cells 1-2 Maximum Detected Results (11/04 - 01/06) (mg/L)	Qualifier	Cells 1-3 Maximum Detected Results (02/06 - 03/10) (mg/L)	Qualifier	Cells 1-4 Maximum Detected Results (04/10 - 07/11) (mg/L)	Qualifier	Cells 1-5 Maximum Detected Results (08/11 - pres.) (mg/L)	Qualifier	Regulatory Level (mg/L)
D004	Arsenic	0.0011	B	0.0012	B	0.00383	J	0.00256	J	ND		5.0
D005	Barium	0.11	J	0.0954	*	0.46	*N	0.0804		0.12		100.0
D018	Benzene	ND		ND		ND		ND		ND		0.5
D006	Cadmium	0.00014	B	0.00013	B	0.000712	J	0.000332	J	0.000216	J	1.0
D019	Carbon tetrachloride	0.0082		ND		ND		ND		ND		0.5
D020	Chlordane	ND		ND		ND		ND		ND		0.0
D021	Chlorobenzene	ND		ND		ND		ND		ND		100.0
D022	Chloroform	0.00051	J	ND		0.00135	J	ND		ND		6.0
D007	Chromium	0.0031	B	0.004	B	0.00389	J	0.00387	J	0.00637		5.0
D023	2-Methylphenol (o-Cresol)	ND		ND		ND		ND		ND		200.0
D024	3- and 4- Methylphenol (m-Cresol)	ND		ND		ND		ND		ND		200.0
D025	4-Methylphenol (p-Cresol)	ND		ND		ND		ND		ND		200.0
D026	Cresol- NO DATA AVAILABLE	No data		No data		No data		No data		No data		200.0
D016	2,4-D	ND		ND		0.00033	J	ND		ND		10.0
D027	1,4-Dichlorobenzene	ND		ND		ND		ND		ND		7.5
D028	1,2-Dichloroethane	ND		ND		ND		ND		ND		0.5
D029	1,1-Dichloroethene	ND		ND		ND		ND		ND		0.7
D030	2,4-Dinitrotoluene	ND		ND		ND		ND		ND		0.13
D012	Endrin	ND		ND		ND		ND		ND		0.02
D031	Heptachlor	ND		ND		ND		ND		ND		0.008
	Heptachlor epoxide	ND		ND		0.000012	J	ND		ND		
D032	Hexachlorobenzene	ND		ND		ND		ND		ND		0.13
D033	Hexachlorobutadiene	ND		ND		ND		ND		ND		0.5
D034	Hexachloroethane	ND		ND		ND		ND		ND		3.0
D008	Lead	0.0023	B	0.0026	B	0.00453		0.00225	J	0.0043	J	5.0
D013	Lindane	ND		ND		ND		ND		0.000027	J	0.4
D009	Mercury	ND		0.0001	B	0.00022	*	0.000066	J	ND		0.2
D014	Methoxychlor	ND		ND		ND		ND		0.000015	J	10.0
D035	2-Butanone (MEK)	0.4		0.004	J	0.00908	J	ND		1.77	D	200.0
D036	Nitrobenzene	ND		ND		ND		ND		ND		2.0
D037	Pentachlorophenol	ND		ND		0.00025	J	0.00175		0.000384	J	100.0
D038	Pyridine	ND		ND		ND		ND		ND		5.0
D010	Selenium	0.0041	*	0.0011	B	0.00446	J	ND		ND		1.0
D011	Silver	0.00024	BJ	0.0088	N	ND		ND		ND		5.0
D039	Tetrachloroethene	ND		ND		ND		ND		ND		0.7
D015	Toxaphene	ND		ND		ND		ND		ND		0.5
D040	Trichloroethene	0.011		ND		ND		ND		ND		0.5
D041	2,4,5-Trichlorophenol	ND		ND		ND		ND		ND		400.0
D042	2,4,6-Trichlorophenol	ND		ND		ND		ND		ND		2.0
D017	Silvex	ND		ND		ND		0.000174	J	0.000386	J	1.0
D043	Vinyl chloride	ND		ND		ND		ND		ND		0.2

* – Duplicate analysis not within control limits
B – Result less than PQL but greater than IDL; analyte found in blank as well as sample
ND – No detected values were found in the database

D – Identified at a secondary dilution factor
J – Estimated value, btw. PQL and MDL
N – Spike recovery not within control limits

Waste Determination

This waste determination demonstrates (through a combination of process knowledge, historical analytical data, approved waste lots and disposal records, and physical characteristics) EMWMF leachate and contact water are neither a listed nor a characteristic hazardous waste under RCRA (see Table F.3). For planning purposes this same waste determination is assumed to apply to the landfill water from the proposed Environmental Management Disposal Facility.

Table F.3. Summary of 40 *CFR* 261 Subpart C criteria regarding EMWMF leachate

40 *CFR* 261 Subpart C criteria	EMWMF leachate status
§ 261.21 Characteristic of ignitability.	
(a) A solid waste exhibits the characteristic of ignitability if a representative sample of the waste has any of the following properties:	
(1) It is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume and has flash point less than 60°C (140°F), as determined by a Pensky-Martens Closed Cup Tester, using the test method specified in ASTM Standard D 93-79 or D 93-80 (incorporated by reference, see § 260.11), or a Setaflash Closed Cup Tester, using the test method specified in ASTM Standard D 3278-78 (incorporated by reference, see § 260.11).	**Addressed**; EMWMF leachate and contact water are aqueous solutions containing less than 24 percent alcohol by volume.
(2) It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that it creates a hazard.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
(3) It is an ignitable compressed gas.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
(4) It is an oxidizer. An oxidizer for the purpose of this subchapter is a substance such as a chlorate, permanganate, inorganic peroxide, or a nitrate, that yields oxygen readily to stimulate the combustion of organic matter (see Note 4). [Note 4: The DOT regulatory definition of an oxidizer was contained in § 173.151 of 49 *CFR*, and the definition of an organic peroxide was contained in paragraph 173.151a. An organic peroxide is a type of oxidizer.]	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
§ 261.22 Characteristic of corrosivity.	
(a) A solid waste exhibits the characteristic of corrosivity if a representative sample of the waste has either of the following properties:	
(1) It is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5, as determined by a pH meter using Method 9040C in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA Publication SW-846, as incorporated by reference in § 260.11 of this chapter.	**Addressed**; Numerous field pH measurements range from 5.46 to 10.27. The typical range is 6.8–7.85 with an average of 7.21.
(2) It is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55°C (130°F) as determined by Method 1110A in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA Publication SW-846, and as incorporated by reference in § 260.11 of this chapter.	**Addressed**; The leachate collection system and leachate and contact water transfer systems do not show evidence of excessive corrosion.

40 *CFR* 261 Subpart C criteria	EMWMF leachate status
§ 261.23 Characteristic of reactivity.	
(a) A solid waste exhibits the characteristic of reactivity if a representative sample of the waste has any of the following properties:	
(1) It is normally unstable and readily undergoes violent change without detonating.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
(2) It reacts violently with water.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
(3) It forms potentially explosive mixtures with water.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
(4) When mixed with water, it generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
(5) It is a cyanide or sulfide-bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.	**Addressed**; EMWMF leachate and contact water are aqueous solutions. Cyanides and Sulfides have not been identified as COCs in waste received to date at EMWMF and field pH measurements demonstrate that the leachate and contact water pH is greater than 2 and less than 12.5.
(6) It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
(7) It is readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
(8) It is a forbidden explosive as defined in 49 *CFR* 173.54, or is a Division 1.1, 1.2 or 1.3 explosive as defined in 49 *CFR* 173.50 and 173.53.	**Addressed**; EMWMF leachate and contact water are aqueous solutions.
§ 261.24 Toxicity characteristic.	
(a) A solid waste (except manufactured gas plant waste) exhibits the characteristic of toxicity if, using the Toxicity Characteristic Leaching Procedure, test Method 1311 in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA Publication SW-846, as incorporated by reference in § 260.11 of this chapter, the extract from a representative sample of the waste contains any of the contaminants listed in Table 2 (1) at the concentration equal to or greater than the respective value given in that table. Where the waste contains less than 0.5 percent filterable solids, the waste itself, after filtering using the methodology outlined in Method 1311, is considered to be the extract for the purpose of this section.	**Addressed**; Leachate and contact water samples have not been subjected to the TCLP Prep Method. Please refer to Table F.1 above for a comparison of historical leachate and contact water analytical data ("totals" analyses) against the regulatory levels.

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APPENDIX G.
ZERO DISCHARGE

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Zero Discharge Option for the EMWMF

Thermal processes, which include evaporation, are the only viable options for achieving zero discharge of leachate. This point was made at the Intercontinental Landfill Research Symposium at the Lulea University of Technology in Lulea, Sweden, December 11–13, 2000.

> Thermal processes, particularly evaporation, are the only "treatment" technologies available today that dispose of the water component of water-based waste streams, such as leachate. This technology can reduce the total volume of leachate to less than five percent of the original volume. Leachate evaporation systems generally are economically feasible at sites with an adequate supply of landfill gas (LFG) to evaporate the volume of leachate generated…
>
> The byproduct of these systems is a residual material that usually can be returned to the landfill for disposal…

Table G.1. Summary of selected treatment technologies with application for leachate service

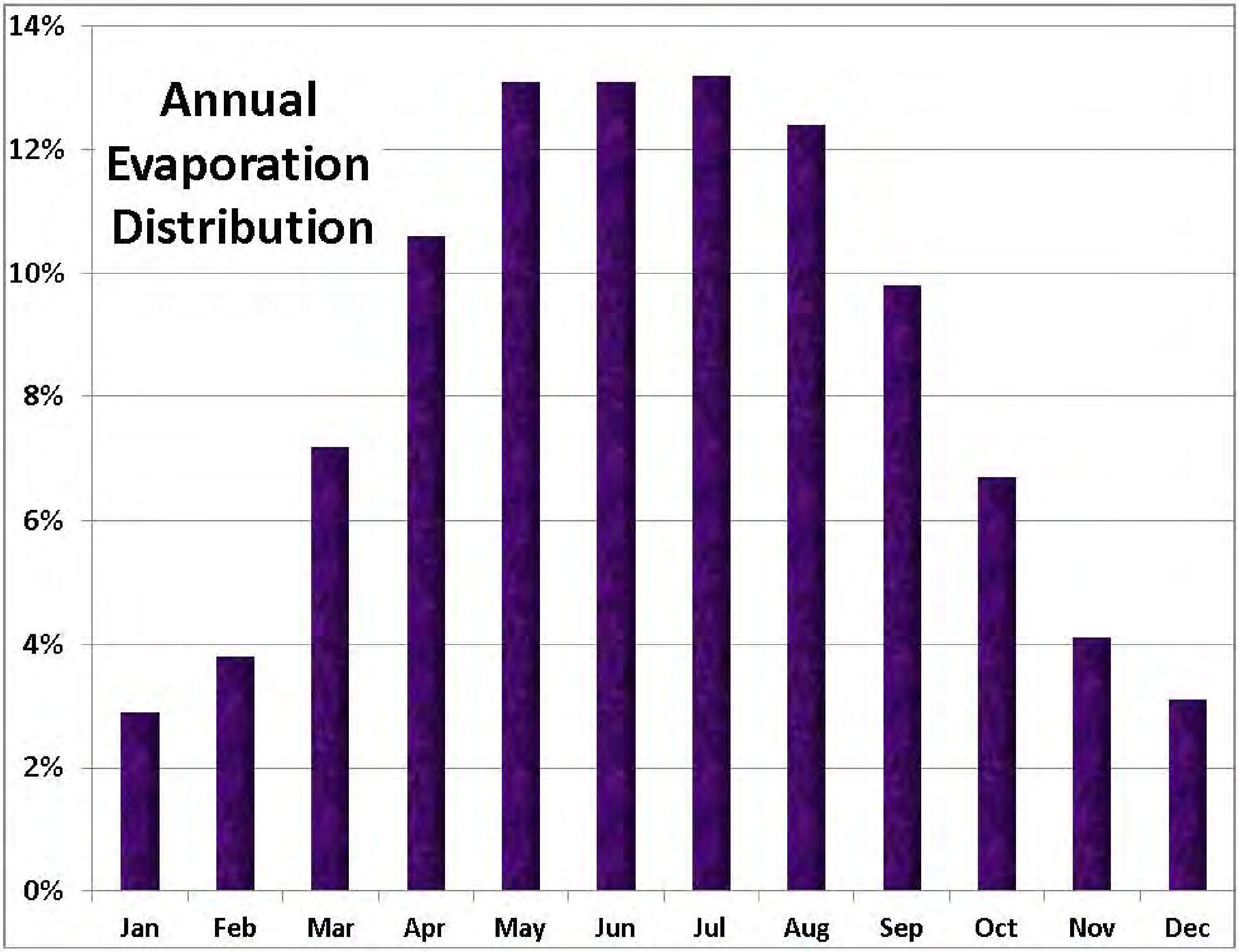
Treatment technology	Advantages	Disadvantages	Residuals
Thermal Evaporator	• No liquid effluent • Small footprint • Easy to operate	• Dependent on landfill gas supply for economical operation • Material compatibility	• Solids (minimal) • Flare emissions
Distillation	• Good VOC and Ammonia Removal • Energy Efficient • Small Footprint • High quality effluent	• Operational complexity	• VOC-laden liquid side stream • Concentrate • Air emission from boiler

Source: *Leachate Treatment Options for Sanitary Landfills* by J. M. Harris, D. E. Purschwitz, and C. D. Goldsmith, 2000.
VOC = volatile organic compound

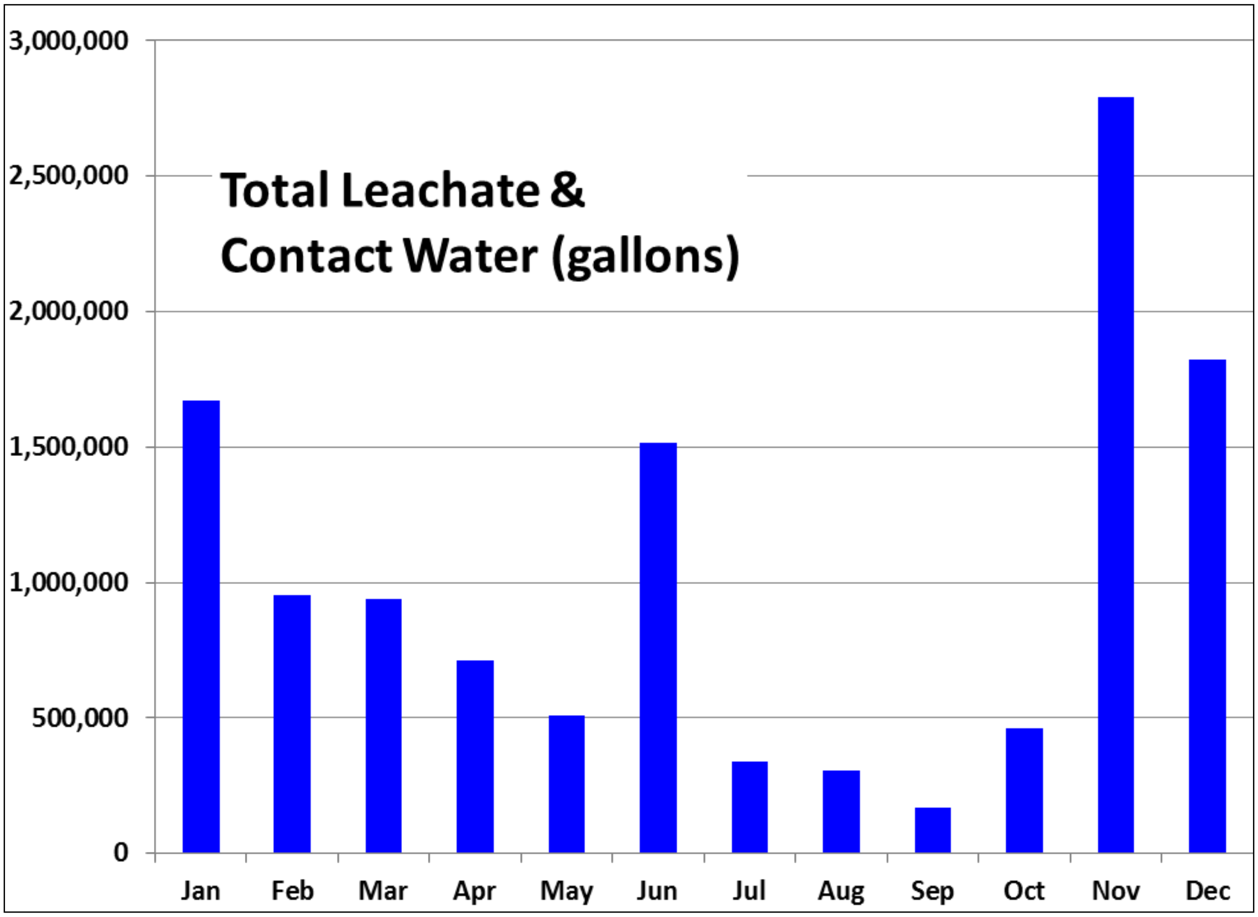
The above limitations were reiterated in the Environmental Research & Education Foundation Regional Summit on Sustainable Solid Waste Practices & Research [for] Managing & Treating Landfill Leachate in Philadelphia, Pennsylvania, October 8–9, 2013:

> …evaporation technology may be attractive due to discharge elimination but site constraints (e.g., availability of LFG or waste heat) may limit its application. (Source: *Leachate Management Decision Making & Available Technologies*, Kevin Torrens, Brown and Caldwell, 2013)

The most influential factors for evaporation are ambient relative humidity, ambient temperature, and the speed of turbulence when mixing the water and air. The Environmental Management Waste Management Facility (EMWMF) is located in a humid subtropical climate zone. Summers are hot and humid, and winters are cool to cold. As illustrated in the following figures, the evaporation potential at EMWMF is at its lowest when the amount of landfill water is at its greatest.



Source: http://knoxcounty.org/stormwater/pdfs/vol2/3-1-8%20Water%20Balance%20Calculations.pdf .



Source: EMWMF operational data for the past 12 months.

Zero discharge of leachate and contact water is not a viable option at the EMWMF for two key reasons:

- There is no landfill gas or waste heat to cost effectively evaporate these waters
- The lowest evaporation potential is present when water generation is greatest

Other factors that render thermal processing unattractive for EMWMF include:

- The droplets of water carried off in the air may have low levels of contaminants, with the potential for depositing contaminants downwind in previously un-impacted areas.
- The process is expected to require several large enclosed structures to prevent immediate precipitation of evaporated water, for which adequate footprint is not readily available.

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APPENDIX H.
WATER STORAGE REQUIREMENTS

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Environmental Management Waste Management Facility/Environmental Management Disposal Facility's (EMWMF/EMDF's) existing and proposed water handling systems, including water storage features and water processing rates, within this focused feasibility study (FFS) were limited to managing design storm events using conventional stormwater analysis, as is standard industry practice. Conventional analysis uses intensity, aerial distribution of a storm, and a storm's recurrence interval. Intensity is the relationship between the volume of a precipitation event and the duration of the event, and a storm's recurrence interval is the average number of years between storms of a given intensity. High-intensity storm events generally occur at greater intervals, such as 25, 50, to 100 years or more apart.

For this FFS, the National Oceanic and Atmospheric Administration 100-year, 24-hour design storm event for Oak Ridge, Tennessee of 6.85 inches of precipitation was the selected intensity based on the reasonably low daily probability of the event, historical rainfall data at EMWMF, duration of stormwater management at EMWMF/EMDF, and professional judgment. As the design life of the facility increases, the probability of experiencing the design storm event increases; therefore, this risk must be mitigated through properly designed water storage and processing rates.

The design storm event, over an assumed aerial distribution, provided a reasonably high volume that is likely to occur, and was used to size a feasible storage capacity within the existing and proposed water handling systems. It is important to note that for these aerial distributions analyzed, it is not practical to design a water processing system that will keep up in real-time with the rate of precipitation of the design 100-year, 24-hour storm event, or the precipitation resulting from more frequently occurring, lower intensity storm events. Similarly, it is not reasonable to design water storage features that can accommodate all storm events larger than the design event for this large of an aerial distribution.

Flood routing and/or bypass of the water handling systems may be expected if a storm event larger than the design storm event occurs or if a high-intensity storm event occurs while stormwater inventory remains in the water storage system.

An appropriate water processing rate for the various FFS alternatives requires that the EMWMF quantify and specify the assumed relationship between the aerial distribution and available water storage capacity, as well as identify potential operational constraints that could limit the ability to handle the 100-year, 24-hour design storm event. EMWMF and EMDF are each delineated into six (6) waste placement areas known as cells, and each area is assigned a label of Cell 1 through Cell 6.

For the FFS, EMWMF Cells 1–3 were considered to be in an interim cover state and shedding stormwater that does not contribute to the water handling system at EMWMF. Cells 4–5 are considered open, active waste placement areas, and all stormwater contributes to the water handling system as either leachate or contact water. As landfill progression continues, it is possible that three (3) cells will be considered open and active at any given time, based on demolition strategies observed at the Oak Ridge Reservation in the past; however, for this FFS, three (3) open and active cells, the aerial distribution used in the analysis varied from approximately 13 to 18 acres, depending on which configuration of cells were open.

The FFS assumes that EMWMF Cells 5 and 6 and EMDF Cell 1 were the three (3) cells open at a given time. The aerial distribution was 17.1 acres versus 16.3 acres, if EMDF Cells 1–3 were open. While determining inputs and assumptions to this FFS, we determined that the existing storage capacity at EMWMF would only be utilized by open cells at EMWMF. No in-cell storage is planned for EMDF; therefore, water handling systems and storage would be constructed for the design storm event and assume complete runoff to storage.

To assess the risk of bypassing the existing water management system at EMWMF, a calculation was developed for management called the EMWMF Water Balance Model. This tool accounts for configuration modifications of the facility, including aerial distribution and storage capacity increases and decreases while modeling design storm events over the design life of the facility. Using the daily probability of these design storm events occurring, the overall likelihood of a bypass can be quantified to a percent risk. Based on the design life expected of less than 50 years, a risk of less than 10% was considered an acceptable configuration, with little to no bypass volumes expected for the design 100-year, 24-hour storm event. Additionally, EMWMF Operations' continuing practice of processing water through the water handling system in a timely manner to keep water inventories low reduces the risk of a bypass.

Using the proposed maximum design flow rate of 60 gpm continuously taking away from the water management system, a worst-case scenario of existing EMWMF operational constraints, piping configurations, and pumping capacities (including the areal distribution referenced above of EMWMF Cells 5 and 6 and EMDF Cell 1) will require the minimum storage to be an EMWMF Cell 5 in-cell catchment reduced to 1.5 million gallons, EMWMF Cell 6 catchment of 2.0 million gallons, combined storage of Contact Water Ponds, Contact Water Tanks and Leachate Storage tanks of 3.0 million gallons, and proposed water storage feature for EMDF Cell 1 of 2.0 million gallons. As additional EMDF Cells are constructed and are opened, additional water storage must be constructed, or EMWMF water storage must be utilized.

APPENDIX I.
BASIS OF COST ESTIMATES

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EMWMF/EMDF LEACHATE FOCUSED FEASIBILITY STUDY	Alternative 2 Managed Discharge (20151112A_2_0)	Alternative 3A PWTC Treatment and Pipeline (20151112A_3A_0)	Alternative 3B PWTC Treatment and Trucking (20151112A_3B_0)	Alternative 4A OF200 Treatment and Pipeline (20151112A_4A_0)	Alternative 4B OF200 Treatment and Trucking (20151112A_4B_0)
Capital Costs During Design Phase (1 year duration):					
Perform Project Management During Design Phase	$ 342,509	$ 342,509	$ 342,509	$ 342,509	$ 342,509
Design Facilities	$ 898,674	$ 1,261,173	$ 1,182,128	$ 1,262,381	$ 1,186,327
Conduct Treatability Study	$ 50,000	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Prepare Regulatory Documents	$ 248,817	$ 284,362	$ 284,362	$ 284,362	$ 284,362
Subtotal:	$ 1,540,000	$ 1,938,044	$ 1,858,999	$ 1,939,252	$ 1,863,198
DOE Prime Contractor G&A and Fee (36 percent)	$ 554,400	$ 697,696	$ 669,240	$ 698,131	$ 670,751
Subtotal:	$ 2,094,400	$ 2,635,739	$ 2,528,238	$ 2,637,383	$ 2,533,950
Contingency Percentage	15%	25%	15%	25%	15%
Contingency Amount	$ 545,160	$ 1,143,446	$ 658,086	$ 1,144,159	$ 659,572
Capital Cost 1:	*$ 2,639,559*	*$ 3,779,185*	*$ 3,186,324*	*$ 3,781,542*	*$ 3,193,522*
Capital Costs During Construction Phase (1 year duration):					
Perform Project Management During Construction Phase	$ 342,509	$ 342,509	$ 342,509	$ 342,509	$ 342,509
Perform Construction Management During Construction Phase	$ 479,293	$ 672,625	$ 630,468	$ 673,270	$ 632,708
Perform Operational Readiness and Startup	$ 86,417	$ 86,417	$ 86,417	$ 86,417	$ 86,417
Construct Treatment Plant at EMWMF	$ 5,991,158	$ 5,991,158	$ 5,991,158	$ 5,991,158	$ 5,991,158
Construct Pipeline from EMWMF to PWTC (or OF200) plus Lift Station	$ -	$ 2,416,660	$ -	$ 1,655,967	$ -
Construct Tanker Loading Stations at EMWMF plus Purchase Additional Tankers	$ -	$ -	$ 528,125	$ -	$ 528,125
Construct Tanker Unloading Stations at PWTC (or OF200)	$ -	$ -	$ 1,241,202	$ -	$ 620,815
Perform Soil Remediation at PWTC	$ -	$ -	$ 120,367	$ -	$ -
Construct Additional Water Storage at OF200	$ -	$ -	$ -	$ 768,750	$ 768,750
Subtotal:	$ 6,899,377	$ 9,509,369	$ 8,940,246	$ 9,518,071	$ 8,970,482
DOE Prime Contractor G&A and Fee (36 percent)	$ 2,483,776	$ 3,423,373	$ 3,218,489	$ 3,426,506	$ 3,229,373
Subtotal:	$ 9,383,152	$ 12,932,742	$ 12,158,735	$ 12,944,577	$ 12,199,855
Contingency Percentage	15%	25%	15%	25%	15%
Contingency Amount	$ 1,407,473	$ 3,233,186	$ 1,823,810	$ 3,236,144	$ 1,829,978

EMWMF/EMDF LEACHATE FOCUSED FEASIBILITY STUDY	**Alternative 2 Managed Discharge (20151112A_2_0)**	**Alternative 3A PWTC Treatment and Pipeline (20151112A_3A_0)**	**Alternative 3B PWTC Treatment and Trucking (20151112A_3B_0)**	**Alternative 4A OF200 Treatment and Pipeline (20151112A_4A_0)**	**Alternative 4B OF200 Treatment and Trucking (20151112A_4B_0)**
Capital Cost 2:	*$ 10,790,625*	*$ 16,165,928*	*$ 13,982,545*	*$ 16,180,721*	*$ 14,029,834*
O&M Costs During EMDF Operations and Closure (30 years duration):					
Perform Project Management During EMDF Operations and Closure	$ 6,676,527	$ 6,676,527	$ 6,676,527	$ 6,676,527	$ 6,676,527
Operate Onsite Treatment Plant During EMDF Operations and Closure	$ 8,366,769	$ 8,366,769	$ 8,366,769	$ 8,366,769	$ 8,366,769
Purchase GAC and/or Treatment Resins	$ 5,794,800	$ 5,794,800	$ 5,794,800	$ 5,794,800	$ 5,794,800
Freight Charges on Materials	$ 463,584	$ 463,584	$ 463,584	$ 463,584	$ 463,584
Operate Pipeline During EMDF Operations	$ -	$ 1,457,957	$ -	$ 1,457,957	$ -
Sample/Test Leachate During EMDF Operations	$ 6,375,510	$ 7,013,070	$ 7,013,070	$ 7,013,070	$ 7,013,070
Truck Leachate Plus Contact Water During EMDF Operations	$ -	$ -	$ 45,000,000	$ -	$ 45,000,000
Subtotal:	$ 27,677,190	$ 29,772,707	$ 73,314,750	$ 29,772,707	$ 73,314,750
DOE Prime Contractor G&A and Fee (36 percent)	$ 9,963,788	$ 10,718,175	$ 26,393,310	$ 10,718,175	$ 26,393,310
Subtotal:	$ 37,640,978	$ 40,490,882	$ 99,708,060	$ 40,490,882	$ 99,708,060
Contingency Percentage	20%	20%	30%	20%	30%
Contingency Amount	$ 7,528,196	$ 8,098,176	$ 29,912,418	$ 8,098,176	$ 29,912,418
Total O&M Cost 2:	*$ 45,169,174*	*$ 48,589,058*	*$ 129,620,478*	*$ 48,589,058*	*$ 129,620,478*
Annual O&M Cost 2:	*$ 1,505,639*	*$ 1,619,635*	*$ 4,320,683*	*$ 1,619,635*	*$ 4,320,683*
O&M Costs During Post-Closure EMDF (30 years duration):					
Perform Project Management During EMDF Post-Closure	$ 2,690,869	$ 2,690,869	$ 2,690,869	$ 2,690,869	$ 2,690,869
Operate Onsite Treatment Plant During Post-Closure EMDF	$ 1,473,363	$ 1,473,363	$ 1,473,363	$ 1,473,363	$ 1,473,363
Sample/Test Leachate During Post-Closure EMDF	$ 1,097,880	$ 1,097,880	$ 1,097,880	$ 1,097,880	$ 1,097,880
Truck EMDF Leachate During Post-Closure EMDF	$ -	$ -	$ 799,056	$ -	$ 799,056
Subtotal:	$ 5,262,112	$ 5,262,112	$ 6,061,168	$ 5,262,112	$ 6,061,168
DOE Prime Contractor G&A and Fee (36 percent)	$ 1,894,360	$ 1,894,360	$ 2,182,020	$ 1,894,360	$ 2,182,020
Subtotal:	$ 7,156,472	$ 7,156,472	$ 8,243,188	$ 7,156,472	$ 8,243,188
Contingency Percentage	20%	20%	30%	20%	30%
Contingency Amount	$ 1,431,294	$ 1,431,294	$ 2,472,957	$ 1,431,294	$ 2,472,957

EMWMF/EMDF LEACHATE FOCUSED FEASIBILITY STUDY	**Alternative 2 Managed Discharge (20151112A_2_0)**	**Alternative 3A PWTC Treatment and Pipeline (20151112A_3A_0)**	**Alternative 3B PWTC Treatment and Trucking (20151112A_3B_0)**	**Alternative 4A OF200 Treatment and Pipeline (20151112A_4A_0)**	**Alternative 4B OF200 Treatment and Trucking (20151112A_4B_0)**
Total O&M Cost 4:	*$ 8,587,767*	*$ 8,587,767*	*$ 10,716,145*	*$ 8,587,767*	*$ 10,716,145*
Annual O&M Cost 4:	*$ 286,259*	*$ 286,259*	*$ 357,205*	*$ 286,259*	*$ 357,205*
Unescalated Total Cost:	***$ 67,187,125***	***$ 77,121,938***	***$ 157,505,492***	***$ 77,139,087***	***$ 157,559,978***
Present Value:	***$ 50,886,150***	***$ 59,848,906***	***$ 118,338,338***	***$ 59,865,807***	***$ 118,392,035***

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Basis of Estimate
EMWMF/EMDF Leachate Focused
Feasibility Study: Alternative 2:
Managed Discharge
February 9, 2016

Objective/Scope:

Method of Accomplishment:

URS|CH2M Oak Ridge LLC (UCOR) provides project management during design of a new Treatment Plant at the Environmental Management Waste Management Facility, preparation of required regulatory documents, project and construction management/oversight during facility construction, facility operational readiness and startup, and oversight and operations of the facility for thirty years, as well as oversight and operations during post-closure, also for thirty years. Subcontractors will perform the actual design of the treatment facility, conduct necessary treatability studies, and the actual construction of the facility. Subcontract labs were also assumed to provide the analytical service of samples taken during operations and post-closure.

Estimate Type and Approach:

This feasibility estimate is based upon the existing work and past work experience. The estimate was developed using a combination of bottoms-up approach, actual costs of similar work, and estimator and team experience with the existing operations.

Key Financial Data:

1. The estimate was prepared in the second quarter of fiscal year (FY)2016.
2. Any actual costs of work or similar work were provided by the project team.
3. General and Administrative costs and fee are not included in this estimate.
4. All UCOR and Staff Augmentation rates are fully burdened, including fringes. Staff Augmentation rates include overhead and profit.
5. A sales tax of 9.75% has been included on all material.
6. All prices are in FY2016 dollars and no escalation has been included.
7. There is no contingency in this estimate.
8. UCOR and staff augmentation rates were used for the U.S. Department of Energy prime contractor.

Estimate Assumptions and Exclusions:

1. One Full Time Equivalent (FTE) is equal to 1880 man-hours per year.
2. One FTE for facility operations is 2080 man-hours per year.
3. The Conceptual Design Report and the Critical Decision (CD-1, -2, -3, and -4) process was not included in this estimate.
4. The cost for final closure of the Environmental Management Disposal Facility (EMDF) is not included in this estimate.
5. There are no decontamination and demolition costs included in this estimate.
6. Design of the treatment facility is estimated at 15% of the total construction cost for the facility.
7. Construction management for the treatment facility is estimated at 8% of the total construction cost of the facility.
8. The treatability study is based on an AECOM estimate for the construction of the treatment facility; reference Landfill Wastewater Treatment System, dated 10/23/2015.

9. The following regulatory documents are included in this estimate: Post Construction Closure Report), Remedial Action Work Plan, Remedial Action Work Plan/Remedial Design Report, and a Record of Decision/Environmental Stewardship Document.
10. The actual treatment facility construction estimate is based on an AECOM estimate, dated 10/23/2015. The estimate for the facility less additional storage capacity was $6,905,000. The preliminary and final design, along with the treatability study, was deducted and is shown elsewhere within the estimate.
11. Operations of the treatment facility during the EMDF operating period was estimated at 30 years.
12. An annual material allowance for treatment-related materials is included in the estimate. Activated Carbon was considered as the treatment technology initially and an estimate was provided of $88,000 per year for materials. The technology was later changed to Ion Exchange; subject matter experts estimate that the materials allowance for Ion Exchange should be twice the amount for Activated Carbon.
13. Freight for the treatment materials delivery is included in the estimate at 8% of the material cost. This is based on the AECOM estimate for the treatment facility, dated 10/23/2015.
14. Annual analytical cost allowances during the time of the facility operation are included in the estimate and they were provided by the Feasibility Study project team.
15. Operations of the treatment facility during the EMDF post-closure period were estimated at 30 years.
16. Annual analytical cost allowances during the time of the facility operation are included in the estimate and they were provided by the Feasibility Study project team.

Schedule Assumptions:

1. No funding limitation impacts will be experienced.
2. Design will take approximately 12 months.
3. All construction is expected to take approximately 12 months.
4. The operation and maintenance of the treatment system is expected to last 30 years.
5. Post-closure leachate management is expected to last 30 years.

Estimate Uncertainty:

The estimate was prepared in support of a Feasibility Study quality, which places it as a Class 4 estimate as defined by the Association for the Advancement of Cost Engineering International. The uncertainty range for Class 4 estimates can be as low as -30% to as high as +50%. The recommended level of uncertainty to apply to this estimate is -20% to +40%.

All signatures on file.

ESTIMATOR: DATE:

PROJECT MANAGER: DATE:

ESTIMATING MANAGER: DATE:

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
01.01.01				Capital Costs During Design Phase																
	0100			Perform Project Management During Design Phase																
		0100		Perform Project Management During Design Phase																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25 ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25 ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25 ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25 ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25 ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			59Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25 FTE	0.25 ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25 ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0 .25 FTE	0.25 ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			3,760.00 ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0100 Perform Project Management During Design Phase						3,760.00	340,487		2,022							342,509
				0100 Perform Project Management During Design Phase						3,760.00	340,487		2,022							342,509
	0200			Design Facilities																
		0200		Design Facilities																
			—	Design Facilities		Calculated based on 15% of total construction cost (5,991,158)	0.15 pct		-	-	-	-	-	-	-	-	-	5,991,158.00 /pct	898,674	898,674
				0200 Design Facilities															898,674	898,674
				0200 Design Facilities															898,674	898,674
	0300			Conduct Treatability Study																
		0300		Conduct Treatability Study																
			—	Treatability Study		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15 under Direct Field Cost, Acct **	1.00 ea		-	-	-	-	-	-	-	-	-	50,000.00 /ea	50,000	50,000
				0300 Conduct Treatability Study															50,000	50,000
				0300 Conduct Treatability Study															50,000	50,000
	0400			Prepare Regulatory Documents																
		PCCR		PCCR																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				PCCR PCCR						539.00	70,807		284							71,090
		RAWP		RAWP																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP RAWP						539.00	70,807		284							71,090
		RAWP/RDR		RAWP/RDR																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP/RDR RAWP/RDR						539.00	70,807		284							71,090
		ROD ESD		ROD ESD																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142
				ROD ESD ROD ESD						269.50	35,403		142							35,545
				0400 Prepare Regulatory Documents						1,886.50	247,823		994							248,817
				01.01.01 Capital Costs During Design Phase						5,646.50	588,310		3,016						948,674	1,539,999
01.01.02				Capital Costs During Construction Phase (1 yr duration)																

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
	0120			**Perform Project Management During Construction Phase**																
		0120		Perform Project Management During Construction Phase																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25 ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25 ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25 ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25 ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25 ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25	0.25 ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25 ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0.25 FTE	0.25 ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost.			3,760.00 ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0120 Perform Project Management During Construction Phase						3,760.00	340,487		2,022							342,509
				0120 Perform Project Management During Construction Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
	0220			**Perform Construction Management During Construction Phase**																
		0220		Perform Construction Management During Construction Phase																
			----	Construction Management		Calculated based on 8% of total construction cost (5,991,158)	0.08 pct		-	-	-	-	-	-	-	-	-	5,991,158.00 /pct	479,293	479,293
				0220 Perform Construction Management During Construction Phase															479,293	479,293
				0220 Perform Construction Management During Construction Phase															**479,293**	**479,293**
	0230			**Perform Operational Readiness and Startup**																
		0231		Procedures and Training																
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.50 ea	80.00 hr/ea	75.81 /hr	40.00	3,032	-	-	-	-	-	-	-	-	3,032
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00 ea	80.00 hr/ea	120.72 /hr	160.00	19,315	-	-	-	-	-	-	-	-	19,315
			----	Material Allowance			1.00 ls		-	-	-	3,292.50 /ls	3,293	-	-	-	-	-	-	3,293
				0231 Procedures and Training						200.00	22,348		3,293							25,640
		0232		Readiness and Startup																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			4.00 ea	120.00 hr/ea	52.93 /hr	480.00	25,406	-	-	-	-	-	-	-	-	25,406
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.10 ea	120.00 hr/ea	75.81 /hr	12.00	910	-	-	-	-	-	-	-	-	910
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00 ea	120.00 hr/ea	120.72 /hr	240.00	28,973	-	-	-	-	-	-	-	-	28,973
			----	Material Allowance			1.00 ls		-	-	-	5,487.50 /ls	5,488	-	-	-	-	-	-	5,488
				0232 Readiness and Startup						732.00	55,289		5,488							60,776
				0230 Perform Operational Readiness and Startup		**Reference EMWMF/EMDF Leachate Feasibility Study On-Site Treatment Estimate, log # 20150324B_0 dated 4/8/15.**				**932.00**	**77,637**		**8,780**							**86,417**
	0240			**Construct Treatment Plant at EMWMF**																
		0240		Construct Treatment Plant at EMWMF																
			----	Construct Treatment Plant at EMWMF		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15. Estimate less additional storage was calculated at $6,905,000. Remove Preliminary and Final Design and Treatability Study which are all covered elsewhere for a resulting total of 5,991,158	1.00 ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF															5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF															**5,991,158**	**5,991,158**
				01.01.02 Capital Costs During Construction Phase (1 yr duration)						**4,692.00**	**418,123**		**10,802**						**6,470,451**	**6,899,376**

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
01.01.05				**O&M Costs During EMDF Operations and Closure (30 yrs duration)**																
	0510			**Perform Project Management During EMDF Operations**																
		0510		**Perform Project Management During EMDF Operations**																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.13 ea	56,400.00 hr/ea	88.97 /hr	7,050.00	627,239	-	-	-	-	-	-	-	-	627,239
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.05 ea	56,400.00 hr/ea	71.30 /hr	2,820.00	201,066	-	-	-	-	-	-	-	-	201,066
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.25 ea	56,400.00 hr/ea	139.59 /hr	14,100.00	1,968,219	-	-	-	-	-	-	-	-	1,968,219
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.13 ea	56,400.00 hr/ea	81.42 /hr	7,050.00	574,011	-	-	-	-	-	-	-	-	574,011
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.13 ea	56,400.00 hr/ea	47.47 /hr	7,050.00	334,684	-	-	-	-	-	-	-	-	334,684
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.13 ea	56,400.00 hr/ea	75.81 /hr	7,050.00	534,461	-	-	-	-	-	-	-	-	534,461
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.25 ea	56,400.00 hr/ea	120.72 /hr	14,100.00	1,702,152	-	-	-	-	-	-	-	-	1,702,152
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.13 ea	56,400.00 hr/ea	99.16 /hr	7,050.00	699,078	-	-	-	-	-	-	-	-	699,078
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			66,270.00 ea		-	-	-	0.54 /ea	35,638	-	-	-	-	-	-	35,638
				0510 Perform Project Management During EMDF Operations						66,270.00	6,640,889		35,638							6,676,527
				0510 Perform Project Management During EMDF Operations						**66,270.00**	**6,640,889**		**35,638**							**6,676,527**
	0520			**Operate Onsite Treatment Plant During EMDF Operations**																
		0520		**Operate Onsite Treatment Plant During EMDF Operations**																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		30 years at 2080 hours per year = 62400 hours	2.00 ea	62,400.00 hr/ea	52.93 /hr	124,800.00	6,605,664	-	-	-	-	-	-	-	-	6,605,664
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			0.12 ea	62,400.00 hr/ea	52.93 /hr	7,488.00	396,340	-	-	-	-	-	-	-	-	396,340
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	75.81 /hr	3,744.00	283,833	-	-	-	-	-	-	-	-	283,833
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	120.72 /hr	3,744.00	451,976	-	-	-	-	-	-	-	-	451,976
			PPE DMod	PPE Level D Modified			139,776.00 hr		-	-	-	4.50 /hr	628,957	-	-	-	-	-	-	628,957
				0520 Operate Onsite Treatment Plant During EMDF Operations						139,776.00	7,737,812		628,957							8,366,769
				0520 Operate Onsite Treatment Plant During EMDF Operations						**139,776.00**	**7,737,812**		**628,957**							**8,366,769**
	0530			**Purchase GAC and/or Treatment Resins**																
		0530		**Purchase GAC and/or Treatment Resins**																
			---	Annual Material Allowance		(Per R. McDonnell - $88,000/year allowance for GAC treatment technology. Per Ray and Stephen Hahn new technology is Ion Exchange and material allowance for Ion Exchange is approximately twice the needed allowance for GAC, therefore use 2 x $88,000/year or $176,000/year for materials) (plus tax)	30.00 yr		-	-	-	193,160.00 /yr	5,794,800	-	-	-	-	-	-	5,794,800
				0530 Purchase GAC and/or Treatment Resins									5,794,800							5,794,800
				0530 Purchase GAC and/or Treatment Resins									**5,794,800**							**5,794,800**
	0540			**Freight on Materials**																
		0540		**Freight on Materials**																
			---	Freight on Materials		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15. ACCT 80	0.08 pct		-	-	-	-	-	-	-	-	-	5,794,800.00 /pct	463,584	463,584
				0540 Freight on Materials															463,584	463,584
				0540 Freight on Materials															**463,584**	**463,584**
	0560			**Sample/Test Leachate During EMDF Operations**																
		0560		**Sample/Test Leachate During EMDF Operations**																
			---	Annual Analytical Costs		per FFS project team	30.00 yr		-	-	-	-	-	-	-	-	-	212,517.00 /yr	6,375,510	6,375,510
				0560 Sample/Test Leachate During EMDF Operations															6,375,510	6,375,510
				0560 Sample/Test Leachate During EMDF Operations															**6,375,510**	**6,375,510**

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY	UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
				01.01.05 O&M Costs During EMDF Operations and Closure (30 yrs duration)							**206,046.00**	**14,378,701**		**6,459,395**						**6,839,094**	**27,677,190**
01.01.07				**O&M Costs During Post-Closure EMDF (30 yrs duration)**																	
	0610			**Perform Project Management During EMDF Post-Closure**																	
		0610		**Perform Project Management During EMDF Post-Closure**																	
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.05	ea	56,400.00 hr/ea	88.97 /hr	2,820.00	250,895	-	-	-	-	-	-	-	-	250,895
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.03	ea	56,400.00 hr/ea	71.30 /hr	1,410.00	100,533	-	-	-	-	-	-	-	-	100,533
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.10	ea	56,400.00 hr/ea	139.59 /hr	5,640.00	787,288	-	-	-	-	-	-	-	-	787,288
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.05	ea	56,400.00 hr/ea	81.42 /hr	2,820.00	229,604	-	-	-	-	-	-	-	-	229,604
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.05	ea	56,400.00 hr/ea	47.47 /hr	2,820.00	133,865	-	-	-	-	-	-	-	-	133,865
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B03)		ES&H	0.05	ea	56,400.00 hr/ea	75.81 /hr	2,820.00	213,784	-	-	-	-	-	-	-	-	213,784
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B08)		Environmental Engr	0.10	ea	56,400.00 hr/ea	120.72 /hr	5,640.00	680,861	-	-	-	-	-	-	-	-	680,861
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.05	ea	56,400.00 hr/ea	99.16 /hr	2,820.00	279,631	-	-	-	-	-	-	-	-	279,631
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			26,790.00	ea		-	-	-	0.54 /ea	14,407	-	-	-	-	-	-	14,407
				0610 Perform Project Management During EMDF Post-Closure							**26,790.00**	**2,676,462**		**14,407**							**2,690,869**
				0610 Perform Project Management During EMDF Post-Closure							**26,790.00**	**2,676,462**		**14,407**							**2,690,869**
	0620			**Operate Onsite Treatment Plant During Post-Closure EMDF**																	
		0620		**Operate Onsite Treatment Plant During Post-Closure EMDF**																	
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		1 day once a month for 30 years	2.00	ea	3,600.00 hr/ea	52.93 /hr	7,200.00	381,096	-	-	-	-	-	-	-	-	381,096
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B03)		1 day once a month for 30 years	0.50	ea	3,600.00 hr/ea	75.81 /hr	1,800.00	136,458	-	-	-	-	-	-	-	-	136,458
			RSISA09	Senior Staff Engineer/Scientist (FY16 Rev1 B06)		1 day once a month for 30 years	2.00	ea	3,600.00 hr/ea	108.11 /hr	7,200.00	778,392	-	-	-	-	-	-	-	-	778,392
			SPTSA03	Senior RPT (FY16 Rev1 B08)		1 day once a month for 30 years	0.50	ea	3,600.00 hr/ea	43.69 /hr	1,800.00	78,642	-	-	-	-	-	-	-	-	78,642
			—	Material Allowance			30.00	yr		-	-	-	3,292.50 /yr	98,775	-	-	-	-	-	-	98,775
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF							**18,000.00**	**1,374,588**		**98,775**							**1,473,363**
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF							**18,000.00**	**1,374,588**		**98,775**							**1,473,363**
	0630			**Sample/Test Leachate During Post-Closure EMDF**																	
		0630		**Sample/Test Leachate During Post-Closure EMDF**																	
			—	Sampling/Analytical		From FFS team	30.00	yr		-	-	-	-	-	-	-	-	-	36,596.00 /yr	1,097,880	1,097,880
				0630 Sample/Test Leachate During Post-Closure EMDF																**1,097,880**	**1,097,880**
				0630 Sample/Test Leachate During Post-Closure EMDF																**1,097,880**	**1,097,880**
				01.01.07 O&M Costs During Post-Closure EMDF (30 yrs duration)							**44,790.00**	**4,051,050**		**113,182**						**1,097,880**	**5,262,112**

Estimate Totals

Description	Amount	Totals	Hours	Rate	Cost Basis	Cost per Unit	Percent of Total	
Labor	19,436,184		261,175 hrs				46.97%	
Material	6,586,395						15.92%	
Equipment								
Subcontract								
Other	15,356,098						37.11%	
	41,378,677	41,378,677					100.00	100.00%
Total		41,378,677						

Basis of Estimate
EMWMF/EMDF Leachate Focused Feasibility Study: Alternative 3a:
PWTC Treatment and Pipeline Alternative
February 9, 2016

Objective/Scope:

Method of Accomplishment:

URS|CH2M Oak Ridge LLC (UCOR) provides project management during design of a new Treatment Plant at the Environmental Management Waste Management Facility (EMWMF) and the pipeline from EMWMF to either Liquid and Gaseous Waste Operations, preparation of required regulatory documents, project and construction management/oversight during facility and pipeline construction, facility operational readiness and startup, and oversight and operations of the facility and pipeline for thirty years, as well as oversight and operations during post-closure, also for thirty years. Subcontractors will perform the actual design of the treatment facility and pipeline, conduct necessary treatability studies, and perform the actual construction of the facilities. Subcontract labs were also assumed to provide the analytical service of samples taken during operations and post-closure.

Estimate Type and Approach:

This feasibility estimate is based upon similar work proposed in the past and work experience. The estimate was developed using a combination of bottoms-up approach, parametric data from similar projects, actual costs of similar work, and estimator and team experience with similar projects and existing operations.

Key Financial Data:

1. The estimate was prepared in the second quarter of fiscal year (FY)2016.
2. Any actual costs of work or similar work were provided by the project team.
3. General and Administrative costs and fee are not included in this estimate.
4. All UCOR and Staff Augmentation rates are fully burdened, including fringes. Staff Augmentation rates include overhead and profit.
5. A sales tax of 9.75% has been included on all material.
6. All prices are in FY2016 dollars and no escalation has been included.
7. There is no contingency in this estimate.
8. UCOR and staff augmentation rates were used for the U.S. Department of Energy prime contractor.

Estimate Assumptions and Exclusions:

1. One Full Time Equivalent (FTE) is equal to 1880 man-hours per year.
2. One FTE for facility operations is 2080 man-hours per year.
3. The Conceptual Design Report and the Critical Decision (CD-1, -2, -3, and -4) process was not included in this estimate.
4. The cost for final closure of the Environmental Management Disposal Facility (EMDF) is not included in this estimate.
5. There are no decontamination and demolition costs included in this estimate.
6. Design of the facilities is estimated at 15% of the total construction cost for the facilities (water treatment, pipeline, and lift station).

7. Construction management for the facilities is estimated at 8% of the total construction cost for the facilities (water treatment, pipeline, and lift station).
8. The treatability study is based on an AECOM estimate for the construction of the treatment facility; reference Landfill Wastewater Treatment System, dated 10/23/2015.
9. The following regulatory documents are included in this estimate: National Pollutant Discharge Elimination System, Post Construction Closure Report, Remedial Action Work Plan, Remedial Action Work Plan/Remedial Design Report, and a Waste Acceptance Criteria.
10. The actual treatment facility construction estimate is based on an AECOM estimate, dated 10/23/2015. The estimate for the facility less additional storage capacity was $6,905,000. The preliminary and final design, along with the treatability study, was deducted and is shown elsewhere within the estimate.
11. Subcontractor Overhead and Profit is included in the estimate at 25% of the pipeline and lift station construction estimate. Overhead and Profit was not added to the treatment facility construction because it is already included in the AECOM estimate.
12. Operations of the treatment facility and pipeline during the EMDF operating period was estimated at 30 years.
13. An annual material allowance for treatment related materials is included in the estimate. Activated Carbon was considered as the treatment technology initially and an estimate was provided of $88,000 per year for materials. The technology was later changed to Ion Exchange; subject matter experts estimate that the material allowance for Ion Exchange should be twice the amount for Activated Carbon.
14. Freight for the treatment materials delivery is included in the estimate at 8% of the material cost. This is based on the AECOM estimate for the treatment facility, dated 10/23/2015.
15. Annual analytical cost allowances during the time of the facility operation are included in the estimate and they were provided by the Feasibility Study project team. Their estimate was increased by 10% to allow for additional sampling and analysis of water at the receiving facility.
16. Operations of the treatment facility during the EMDF post-closure period were estimated at 30 years.
17. Annual analytical cost allowances during the time of post-closure are included in the estimate for a period of 30 years and they were provided by the Feasibility Study project team.

Schedule Assumptions:

1. No funding limitation impacts will be experienced.
2. Design will take approximately 12 months.
3. All construction is expected to take approximately 12 months.
4. The operation and maintenance of the treatment system is expected to last 30 years.
5. Post closure leachate management is expected to last 30 years.

Estimate Uncertainty:

The estimate was prepared in support of a Feasibility Study quality, which places it as a Class 4 estimate as defined by the Association for the Advancement of Cost Engineering International. The uncertainty range for Class 4 estimates can be as low as -30% to as high as +50%. The recommended level of uncertainty to apply to this estimate is -20% to +40%.

All signatures on file.

ESTIMATOR: DATE:

PROJECT MANAGER: DATE:

ESTIMATING MANAGER: DATE:

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
01.01.01				**Capital Costs During Design Phase**																
	0100			**Perform Project Management During Design Phase**																
		0100		**Perform Project Management During Design Phase**																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25 ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25 ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25 ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25 ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25 ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25 FTE	0.25 ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25 ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0 .25 FTE	0.25 ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost.			3,760.00 ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0100 Perform Project Management During Design Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
				0100 Perform Project Management During Design Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
	0200			**Design Facilities**																
		0200		**Design Facilities**																
			—	Design Facilities		Calculated based on 15% of total construction cost (5,991,158+2,416,660=8,407,818)	0.15 pct		-	-	-	-	-	-	-	-	-	8,407,818.00 /pct	1,261,173	1,261,173
				0200 Design Facilities															**1,261,173**	**1,261,173**
				0200 Design Facilities															**1,261,173**	**1,261,173**
	0300			**Conduct Treatability Study**																
		0300		**Conduct Treatability Study**																
			—	Treatability Study		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15 under Direct Field Cost, Acct **	1.00 ea		-	-	-	-	-	-	-	-	-	50,000.00 /ea	50,000	50,000
				0300 Conduct Treatability Study															**50,000**	**50,000**
				0300 Conduct Treatability Study															**50,000**	**50,000**
	0400			**Prepare Regulatory Documents**																
		NPDES Permit Revisio		**NPDES**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030
			OffSpply	Office Supplies, from R.S. Means monthly Cost, 4Q CY2014			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142
				NPDES Permit Revisio NPDES						**269.50**	**35,403**		**142**							**35,545**
		PCCR		**PCCR**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost.			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				PCCR PCCR						**539.00**	**70,807**		**284**							**71,090**
		RAWP		**RAWP**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost.			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP RAWP						**539.00**	**70,807**		**284**							**71,090**
		RAWP/RDR		**RAWP/RDR**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost.			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP/RDR RAWP/RDR						**539.00**	**70,807**		**284**							**71,090**
		WAC Revision		**WAC Revision**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		WAC Revision		WAC Revision																
			OffSpply	Office Supplies, from R.S. Means monthly Cost, 4Q CY2014			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142
				WAC Revision WAC Revision						269.50	35,403		142							35,545
				0400 Prepare Regulatory Documents						**2,156.00**	**283,226**		**1,136**							**284,362**
				01.01.01 Capital Costs During Design Phase						**5,916.00**	**623,713**		**3,158**						**1,311,173**	**1,938,043**
01.01.02				**Capital Costs During Construction Phase (1 yr duration)**																
	0120			**Perform Project Management During Construction Phase**																
		0120		Perform Project Management During Construction Phase																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25 ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25 ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25 ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25 ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25 ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25	0.25 ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25 ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0.25 FTE	0.25 ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			3,760.00 ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0120 Perform Project Management During Construction Phase						3,760.00	340,487		2,022							342,509
				0120 Perform Project Management During Construction Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
	0220			**Perform Construction Management During Construction Phase**																
		0220		Perform Construction Management During Construction Phase																
			----	Construction Management		Calculated based on 8% of total construction cost (5,991,158+2,416,660=8,407,818)	0.08 pct		-	-	-	-	-	-	-	-	-	8,407,818.00 /pct	672,625	672,625
				0220 Perform Construction Management During Construction Phase															672,626	672,626
				0220 Perform Construction Management During Construction Phase															**672,625**	**672,625**
	0230			**Perform Operational Readiness and Startup**																
		0231		Procedures and Training																
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.50 ea	80.00 hr/ea	75.81 /hr	40.00	3,032	-	-	-	-	-	-	-	-	3,032
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00 ea	80.00 hr/ea	120.72 /hr	160.00	19,315	-	-	-	-	-	-	-	-	19,315
			----	Material Allowance			1.00 ls		-	-	-	3,292.50 /ls	3,293	-	-	-	-	-	-	3,293
				0231 Procedures and Training						200.00	22,348		3,293							25,640
		0232		Readiness and Startup																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			4.00 ea	120.00 hr/ea	52.93 /hr	480.00	25,406	-	-	-	-	-	-	-	-	25,406
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.10 ea	120.00 hr/ea	75.81 /hr	12.00	910	-	-	-	-	-	-	-	-	910
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00 ea	120.00 hr/ea	120.72 /hr	240.00	28,973	-	-	-	-	-	-	-	-	28,973
			----	Material Allowance			1.00 ls		-	-	-	5,487.50 /ls	5,488	-	-	-	-	-	-	5,488
				0232 Readiness and Startup						732.00	55,269		5,488							60,776
				0230 Perform Operational Readiness and Startup		**Reference EMWMF/EMDF Leachate Feasibility Study On-Site Treatment Estimate, log #20150324B_0 dated 4/8/15.**				**932.00**	**77,637**		**8,780**							**86,417**
	0240			**Construct Treatment Plant at EMWMF**																
		0240		Construct Treatment Plant at EMWMF																
			----	Construct Treatment Plant at EMWMF		Reference AECOM estimate for Landfill Wastewater Treatment System, dated	1.00 ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY	UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0240		Construct Treatment Plant at EMWMF																	
			---	Construct Treatment Plant at EMWMF		10/23/15 Estimate less additional storage was calculated at $8,805,000. Remove Preliminary and Final Design and Treatability Study which are all covered elsewhere for a resulting total of 5,991,158	1.00	ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF																5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF																**5,991,158**	**5,991,158**
	0250			**Construct Pipeline from EMWMF to LGWO (or OF200) Plus Lift Station**																	
		0250A		Construct Pipeline from EMWMF to LGWO (or OF200) Plus Lift Station																	
			Field Clerk 01	Field Clerk, Average, R.S. Means CostWorks, Bare Cost			28.00	wk		-	-	-	-	-	-	-	450.00 /wk	12,600	-	-	12,600
			Field Engr. 01	Field Engineer, Maximum, from R.S. Means CostWorks		2 each	56.00	wk		-	-	-	-	-	-	-	1,575.00 /wk	88,200	-	-	88,200
			Field Engr. 01	Field Engineer, Maximum, from R.S. Means CostWorks		Safety Rep	28.00	wk		-	-	-	-	-	-	-	1,575.00 /wk	44,100	-	-	44,100
			Proj. Mgr. 01	Project Manager, Maximum,from R.S. Means CostWorks, with O&P			28.00	wk		-	-	-	-	-	-	-	2,600.00 /wk	72,800	-	-	72,800
			Suptdt 01	Superintendent, Maximum,from R.S. Means CostWorks, w/O&P			28.00	wk		-	-	-	-	-	-	-	2,400.00 /wk	67,200	-	-	67,200
			---	Rent Office Trailer, 50' X 10'		Assumes utilities are covered by site.	6.00	mnt		-	-	-	-	-	-	-	298.29 /mnt	1,790	-	-	1,790
				0250A Construct Pipeline from EMWMF to LGWO (or OF200) Plus Lift Station														286,690			286,690
		0250B																			
			Laborer II	Laborer, Group II, CLA + Burden		1 week of safety/site/procedure training per person	240.00	hr		-	-	-	-	-	-	-	33.62 /hr	8,069	-	-	8,069
			Oper A - Frmn	Equip. Operator, Group A, Foreman. CLA + Burden		1 week of safety/site/procedure training per person	40.00	hr		-	-	-	-	-	-	-	50.56 /hr	2,022	-	-	2,022
			PipeFttr	Pipe Fitter - Journeyman, CLA + Burden		1 week of safety/site/procedure training per person	160.00	hr		-	-	-	-	-	-	-	47.26 /hr	7,562	-	-	7,562
			PipeFttr - Frmn	Pipe Fitter - Foreman, CLA + Burden		1 week of safety/site/procedure training per person	40.00	hr		-	-	-	-	-	-	-	49.69 /hr	1,988	-	-	1,988
			Trnstr Drvr	Teamster - Truck Driver, CLA + Burden		1 week of safety/site/procedure training per person	40.00	hr		-	-	-	-	-	-	-	35.57 /hr	1,423	-	-	1,423
			---	Mob. Equipment & Job Trailer			1.00	ls		-	-	-	-	-	-	-	8,000.00 /ls	8,000	-	-	8,000
				0250B														29,063			29,063
		0250C																			
			Laborer II	Laborer, Group II, CLA + Burden		2 each to run concrete saw and tarp trucks for 4 weeks	320.00	hr		-	-	-	-	-	-	-	33.62 /hr	10,758	-	-	10,758
			Trnstr Drvr	Teamster - Truck Driver, CLA + Burden		w/o O&P	80.00	hr		-	-	-	-	-	-	-	35.57 /hr	2,846	-	-	2,846
			---	Rent Backhoe-Loader, 5/8 CY		Assume 2 week total. Includes operating rate.	2.00	wk		-	-	-	-	-	-	-	1,276.10 /wk	2,552	-	-	2,552
			---	Rent Concrete Saw		Assume 2 weeks total. Includes $14.18/hr operating cost.	2.00	wk		-	-	-	-	-	-	-	207.00 /wk	414	-	-	414
			---	PPE Level D			400.00	hr		-	-	-	-	-	-	-	5.00 /hr	2,000	-	-	2,000
			---	Dump Truck Rental		Assume 2 weeks total. Includes $14.18/hr operating cost	2.00	wk		-	-	-	-	-	-	-	3,402.20 /wk	6,804	-	-	6,804
				0250C														25,376			25,376
		0250D																			
			Laborer II	Laborer, Group II, CLA + Burden		2 each for 8 weeks = 640 Hrs	640.00	hr		-	-	-	-	-	-	-	33.62 /hr	21,517	-	-	21,517
			Oper A - Frmn	Equip. Operator, Group A, Foreman. CLA + Burden		8 weeks	320.00	hr		-	-	-	-	-	-	-	50.56 /hr	16,179	-	-	16,179
			---	Rent Wheel Trencher		Average 1,000 LF per day	2.00	mnt		-	-	-	-	-	-	-	17,005.90 /mnt	34,012	-	-	34,012
			---	Rent Wheel Trencher Operatng Rate			320.00	hr		-	-	-	-	-	-	-	98.11 /hr	31,395	-	-	31,395
			---	PPE Level D			1,282.00	hr		-	-	-	-	-	-	-	5.00 /hr	6,410	-	-	6,410
				0250D														109,513			109,513
		0250E																			
			Laborer II	Laborer, Group II, CLA + Burden		3 each to lay sand bedding in bottom of trench	2,250.00	hr		-	-	-	-	-	-	-	33.62 /hr	75,645	-	-	75,645
			PipeFttr	Pipe Fitter - Journeyman, CLA + Burden		4 each	3,000.00	hr		-	-	-	-	-	-	-	47.26 /hr	141,780	-	-	141,780
			PipeFttr - Frmn	Pipe Fitter - Foreman, CLA + Burden		1 each	750.00	hr		-	-	-	-	-	-	-	49.69 /hr	37,268	-	-	37,268
			---	Leak Detection Sensors & Alarms		Price from P2S	1.00	ls		-	-	-	-	-	-	-	31,080.00 /ls	31,080	-	-	31,080
			---	Power & Communication		from P2S	1.00	ls		-	-	-	-	-	-	-	39,895.00 /ls	39,895	-	-	39,895
			---	Manufactured Sand , Delivered		.5'X1.5'X26,500' /27CF/CY= 736 CY @ 2,850 lb/CY /2,000lb/tn = 1,049 Tn with waste call it 1,080 tons	1,080.00	ton		-	-	-	-	-	-	-	18.50 /ton	19,810	-	-	19,810
			---	SDR11 4" X 8" SDR17 HDPE Double Wall Pipe		RS Means 22.11.13.78.5090	26,500.00	ft		-	-	-	-	-	-	-	19.75 /lf	523,375	-	-	523,375
			---	Allowance for Fittings at 10%			1.00	ls		-	-	-	-	-	-	-	52,388.00 /ls	52,388	-	-	52,388
			---	Rent Welding Machine Means 22.11.13.78.9390			75.00	day		-	-	-	-	-	-	-	207.00 /day	15,525	-	-	15,525

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0250E																		
			---	PPE Level D			6,000.00 hr		-	-	-	-	-	-	-	5.00 /hr	30,000	-	-	30,000
				0250E													966,666			966,666
		0250F																		
			---	Install 2 Pumps, Concr. Pad, Prefab. Metal Bldg.		from P2S	1.00 ls		-	-	-	-	-	-	-	110,000.00 /ls	110,000	-	-	110,000
			---	Install Emergency Generator		from P2S	1.00 ls		-	-	-	-	-	-	-	15,000.00 /ls	15,000	-	-	15,000
			---	Install Emergency Generator		from P2S	1.00 ls		-	-	-	-	-	-	-	15,000.00 /ls	15,000	-	-	15,000
				0250F													140,000			140,000
		0250G																		
			Laborer II	Laborer, Group II, CLA + Burden		2 each for 19 weeks = 1520 Hrs	1,520.00 hr		-	-	-	-	-	-	-	33.62 /hr	51,102	-	-	51,102
			Oper A - Frmn	Equip. Operator, Group A, Foreman. CLA + Burden		19 weeks	760.00 hr		-	-	-	-	-	-	-	50.56 /hr	38,426	-	-	38,426
			---	Replace Asphalt & Concrete Allowance		from P2S	1.00 ls		-	-	-	-	-	-	-	52,564.00 /ls	52,564	-	-	52,564
			---	Manufactured Sand , Delivered		1 foot for around pipe and cover is double needed for bedding. Rogers price.	2,120.00 ton		-	-	-	-	-	-	-	18.50 /ton	39,220	-	-	39,220
			---	Underground Safety Tape Alum Backing			265.00 clf		-	-	-	-	-	-	-	19.25 /clf	5,101	-	-	5,101
			---	Rent Manual Guided Compactor		Follow Pipe Installation	19.00 wk		-	-	-	-	-	-	-	898.66 /wk	17,075	-	-	17,075
			---	Rent Backhoe-Loader, 5/8 CY			19.00 wk		-	-	-	-	-	-	-	1,276.10 /wk	24,246	-	-	24,246
			---	Seed & Mulch by Hand Allowance			1.00 ls		-	-	-	-	-	-	-	5,000.00 /ls	5,000	-	-	5,000
			---	PPE Level D			2,280.00 hr		-	-	-	-	-	-	-	5.00 /hr	11,400	-	-	11,400
				0250G													244,134			244,134
		0250H																		
			Laborer II	Laborer, Group II, CLA + Burden		2 each	80.00 hr		-	-	-	-	-	-	-	33.62 /hr	2,690	-	-	2,690
			Oper A - Frmn	Equip. Operator, Group A, Foreman. CLA + Burden		19 weeks	40.00 hr		-	-	-	-	-	-	-	50.56 /hr	2,022	-	-	2,022
			---	Demobilization Allowance			1.00 ls		-	-	-	-	-	-	-	8,000.00 /ls	8,000	-	-	8,000
			---	Rent Backhoe-Loader, 5/8 CY			1.00 wk		-	-	-	-	-	-	-	1,276.10 /wk	1,276	-	-	1,276
			---	PPE Level D			120.00 hr		-	-	-	-	-	-	-	5.00 /hr	600	-	-	600
				0250H													14,588			14,588
		0250I																		
			---	Component Testing & System Operability Allowance		from P2S	1.00 ls		-	-	-	-	-	-	-	117,300.00 /ls	117,300	-	-	117,300
				0250I													117,300			117,300
		0250J		Subcontract Overhead and Profit																
			---	Subcontract Overhead and Profit		Overhead and profit at 25% of subcontract construction cost	0.25 pct		-	-	-	-	-	-	-	1,933,328.00 /pct	483,332	-	-	483,332
				0250J Subcontract Overhead and Profit													483,332			483,332
				0250 Construct Pipeline from EMWMF to LGWO (or OF200) Plus Lift Station													**2,416,660**			**2,416,660**
				01.01.02 Capital Costs During Construction Phase (1 yr duration)						**4,692.00**	**418,123**		**10,802**				**2,416,660**		**6,663,783**	**9,509,369**
01.01.05				**O&M Costs During EMDF Operations and Closure (30 yrs duration)**																
	0510			**Perform Project Management During EMDF Operations**																
		0510		Perform Project Management During EMDF Operations																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.13 ea	56,400.00 hr/ea	88.97 /hr	7,050.00	627,239	-	-	-	-	-	-	-	-	627,239
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.05 ea	56,400.00 hr/ea	71.30 /hr	2,820.00	201,066	-	-	-	-	-	-	-	-	201,066
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.25 ea	56,400.00 hr/ea	139.59 /hr	14,100.00	1,968,219	-	-	-	-	-	-	-	-	1,968,219
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.13 ea	56,400.00 hr/ea	81.42 /hr	7,050.00	574,011	-	-	-	-	-	-	-	-	574,011
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.13 ea	56,400.00 hr/ea	47.47 /hr	7,050.00	334,664	-	-	-	-	-	-	-	-	334,664
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.13 ea	56,400.00 hr/ea	75.81 /hr	7,050.00	534,461	-	-	-	-	-	-	-	-	534,461
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.25 ea	56,400.00 hr/ea	120.72 /hr	14,100.00	1,702,152	-	-	-	-	-	-	-	-	1,702,152
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.13 ea	56,400.00 hr/ea	99.16 /hr	7,050.00	699,078	-	-	-	-	-	-	-	-	699,078
			OffSpply	Office Supplies, from R.S. Means monthly Cost.			66,270.00 ea		-	-	-	0.54 /ea	35,638	-	-	-	-	-	-	35,638
				0510 Perform Project Management During EMDF Operations						66,270.00	6,640,889		35,638							6,676,527
				0510 Perform Project Management During EMDF Operations						**66,270.00**	**6,640,889**		**35,638**							**6,676,527**
	0520			**Operate Onsite Treatment Plant During EMDF Operations**																
		0520		Operate Onsite Treatment Plant During EMDF Operations																

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0520		Operate Onsite Treatment Plant During EMDF Operations																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		30 years at 2080 hours per year = 62400 hours	2.00 ea	62,400.00 hr/ea	52.93 /hr	124,800.00	6,605,664	-	-	-	-	-	-	-	-	6,605,664
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			0.12 ea	62,400.00 hr/ea	52.93 /hr	7,488.00	396,340	-	-	-	-	-	-	-	-	396,340
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	75.81 /hr	3,744.00	283,833	-	-	-	-	-	-	-	-	283,833
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	120.72 /hr	3,744.00	451,976	-	-	-	-	-	-	-	-	451,976
			PPE DMod	PPE Level D Modified			139,776.00 hr		-	-	-	4.50 /hr	628,957	-	-	-	-	-	-	628,957
				0520 Operate Onsite Treatment Plant During EMDF Operations						139,776.00	7,737,812		628,957							8,366,769
				0520 Operate Onsite Treatment Plant During EMDF Operations						**139,776.00**	**7,737,812**		**628,957**							**8,366,769**
	0530			**Purchase GAC and/or Treatment Resins**																
		0530		Purchase GAC and/or Treatment Resins																
			----	Annual Material Allowance		(Per R. McDonnell - $88,000/year allowance for GAC treatment technology. Per Ray and Stephen Hahn new technology is Ion Exchange and material allowance for Ion Exchange is approximately twice the needed allowance for GAC, therefore use 2 x $88,000/year or $176,000/year for mateirals) (plus tax)	30.00 yr		-	-	-	193,160.00 /yr	5,794,800	-	-	-	-	-	-	5,794,800
				0530 Purchase GAC and/or Treatment Resins									5,794,800							5,794,800
				0530 Purchase GAC and/or Treatment Resins									**5,794,800**							**5,794,800**
	0540			**Freight on Materials**																
		0540		Freight on Materials																
			----	Freight on Materials		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15. ACCT 80	0.08 pct		-	-	-	-	-	-	-	-	-	5,794,800.00 /pct	463,584	463,584
				0540 Freight on Materials															463,584	463,584
				0540 Freight on Materials															**463,584**	**463,584**
	0550			**Operate Pipeline During EMDF Operations**																
		0550		Operate Pipeline During EMDF Operations																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		Assume 1/3 of a FTE to cover incremental work. (30 yrs)	0.33 ea	62,400.00 hr/ea	52.93 /hr	20,592.00	1,089,935	-	-	-	-	-	-	-	-	1,089,935
			PPE DMod	PPE Level D Modified			20,592.00 hr		-	-	-	9.88 /hr	203,397	-	-	-	-	-	-	203,397
			----	Annual Material Allowance			30.00 yr		-	-	-	5,487.50 /yr	164,625	-	-	-	-	-	-	164,625
				0550 Operate Pipeline During EMDF Operations						20,592.00	1,089,935		368,022							1,457,957
				0550 Operate Pipeline During EMDF Operations						**20,592.00**	**1,089,935**		**368,022**							**1,457,957**
	0560			**Sample/Test Leachate During EMDF Operations**																
		0560		Sample/Test Leachate During EMDF Operations																
			----	Annual Analytical Costs		per FFS project team (include additional 10% for analysis at receiving facility, 212,517+10%=233,769)	30.00 yr		-	-	-	-	-	-	-	-	-	233,769.00 /yr	7,013,070	7,013,070
				0560 Sample/Test Leachate During EMDF Operations															7,013,070	7,013,070
				0560 Sample/Test Leachate During EMDF Operations															**7,013,070**	**7,013,070**
				01.01.05 O&M Costs During EMDF Operations and Closure (30 yrs duration)						**226,638.00**	**15,468,635**		**6,827,418**						**7,476,654**	**29,772,707**
01.01.07				**O&M Costs During Post-Closure EMDF (30 yrs duration)**																
	0610			**Perform Project Management During EMDF Post-Closure**																
		0610		Perform Project Management During EMDF Post-Closure																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.05 ea	56,400.00 hr/ea	88.97 /hr	2,820.00	250,895	-	-	-	-	-	-	-	-	250,895
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.03 ea	56,400.00 hr/ea	71.30 /hr	1,410.00	100,533	-	-	-	-	-	-	-	-	100,533
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.10 ea	56,400.00 hr/ea	139.59 /hr	5,640.00	787,288	-	-	-	-	-	-	-	-	787,288

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0610		Perform Project Management During EMDF Post-Closure																
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.05 ea	56,400.00 hr/ea	81.42 /hr	2,820.00	229,604	-	-	-	-	-	-	-	-	229,604
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.05 ea	56,400.00 hr/ea	47.47 /hr	2,820.00	133,865	-	-	-	-	-	-	-	-	133,865
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.05 ea	56,400.00 hr/ea	75.81 /hr	2,820.00	213,784	-	-	-	-	-	-	-	-	213,784
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.10 ea	56,400.00 hr/ea	120.72 /hr	5,640.00	680,861	-	-	-	-	-	-	-	-	680,861
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.05 ea	56,400.00 hr/ea	99.16 /hr	2,820.00	279,631	-	-	-	-	-	-	-	-	279,631
			OffSpply	Office Supplies, from R.S. Means monthly Cost,			26,790.00 ea		-	-	-	0.54 /ea	14,407	-	-	-	-	-	-	14,407
				0610 Perform Project Management During EMDF Post-Closure						26,790.00	2,676,462		14,407							2,690,869
				0610 Perform Project Management During EMDF Post-Closure						**26,790.00**	**2,676,462**		**14,407**							**2,690,869**
	0620			**Operate Onsite Treatment Plant During Post-Closure EMDF**																
		0620		Operate Onsite Treatment Plant During Post-Closure EMDF																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		1 day once a month for 30 years.	2.00 ea	3,600.00 hr/ea	52.93 /hr	7,200.00	381,096	-	-	-	-	-	-	-	-	381,096
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		1 day once a month for 30 years	0.50 ea	3,600.00 hr/ea	75.81 /hr	1,800.00	136,458	-	-	-	-	-	-	-	-	136,458
			RSISA09	Senior Staff Engineer/Scientist (FY16 Rev1 B06)		1 day once a month for 30 years	2.00 ea	3,600.00 hr/ea	108.11 /hr	7,200.00	778,392	-	-	-	-	-	-	-	-	778,392
			SPTSA03	Senior RPT (FY16 Rev1 B06)		1 day once a month for 30 years	0.50 ea	3,600.00 hr/ea	43.69 /hr	1,800.00	78,642	-	-	-	-	-	-	-	-	78,642
			----	Material Allowance			30.00 yr		-	-	-	3,292.50 /yr	98,775	-	-	-	-	-	-	98,775
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF						18,000.00	1,374,588		98,775							1,473,363
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF						**18,000.00**	**1,374,588**		**98,775**							**1,473,363**
	0630			**Sample/Test Leachate During Post-Closure EMDF**																
		0630		Sample/Test Leachate During Post-Closure EMDF																
			----	Sampling/Analytical		From FFS team	30.00 yr		-	-	-	-	-	-	-	-	-	36,596.00 /yr	1,097,880	1,097,880
				0630 Sample/Test Leachate During Post-Closure EMDF															1,097,880	1,097,880
				0630 Sample/Test Leachate During Post-Closure EMDF															**1,097,880**	**1,097,880**
				01.01.07 O&M Costs During Post-Closure EMDF (30 yrs duration)						**44,790.00**	**4,051,050**		**113,182**						**1,097,880**	**5,262,112**

Estimate Totals

Description	Amount	Totals	Hours	Rate	Cost Basis	Cost per Unit	Percent of Total	
Labor	20,561,521		282,036 hrs				44.24%	
Material	6,954,560						14.96%	
Equipment								
Subcontract	2,416,660						5.20%	
Other	16,549,490						35.60%	
	46,482,231	46,482,231					100.00	100.00%
Total		46,482,231						

Basis of Estimate
EMWMF/EMDF Leachate Focused Feasibility Study: Alternative 3b:
PWTC Treatment and Trucking Alternative
February 10, 2016

Objective/Scope:

Method of Accomplishment:

URS|CH2M Oak Ridge LLC (UCOR) provides project management during design of a new Treatment Plant at the Environmental Management Waste Management Facility (EMWMF) and the loading and unloading stations at EMWMF and the Liquid Gaseous Waste Operations (LGWO), preparation of required regulatory documents, project and construction management/oversight during facility and transfer station construction, facility operational readiness and startup, oversight and operations of the facility for thirty years (as well as oversight and operations during post-closure, also for thirty years), and the trucking of leachate and contact water from the landfill to LGWO. Subcontractors will perform the actual design of the treatment facility and transfer stations, conduct necessary treatability studies, and perform the actual construction of the facilities. Subcontract labs were also assumed to provide the analytical service of samples taken during operations and post-closure.

Estimate Type and Approach:

This feasibility estimate is based upon similar work proposed in the past and work experience. The estimate was developed using a combination of bottoms-up approach, parametric data from similar projects, actual costs of similar work, and estimator and team experience with similar projects and existing operations.

Key Financial Data:

1. The estimate was prepared in the second quarter of fiscal year (FY)2016.
2. Any actual costs of work or similar work were provided by the project team.
3. General and Administrative costs and fee are not included in this estimate.
4. All UCOR and Staff Augmentation rates are fully burdened, including fringes. Staff Augmentation rates include overhead and profit.
5. A sales tax of 9.75% has been included on all material.
6. All prices are in FY2016 dollars and no escalation has been included.
7. There is no contingency in this estimate.
8. UCOR and staff augmentation rates were used for the U.S. Department of Energy prime contractor.

Estimate Assumptions and Exclusions:

1. One Full Time Equivalent (FTE) is equal to 1880 man-hours per year.
2. One FTE for facility operations is 2080 man-hours per year.
3. The Conceptual Design Report and the Critical Decision (CD-1, -2, -3, and -4) process was not included in this estimate.
4. The cost for final closure of the Environmental Management Disposal Facility (EMDF) is not included in this estimate.
5. There are no decontamination and demolition costs included in this estimate.

6. Design of the facilities is estimated at 15% of the total construction cost for the facilities (water treatment, transfer stations at the landfill and the receiving site, and for one small soil remediation task at the receiving facility).
7. Construction management for the facilities is estimated at 8% of the total construction cost for the facilities (water treatment, transfer stations at the landfill and the receiving site, and for one small soil remediation task at the receiving facility).
8. The treatability study is based on an AECOM estimate for the construction of the treatment facility, reference Landfill Wastewater Treatment System, dated 10/23/2015.
9. The following regulatory documents are included in this estimate: National Pollutant Discharge Elimination System, Post Construction Closure Report, Remedial Action Work Plan, Remedial Action Work Plan/Remedial Design Report, and a Waste Acceptance Criteria).
10. The actual treatment facility construction estimate is based on an AECOM estimate, dated 10/23/2015. The estimate for the facility less additional storage capacity was $6,905,000. The preliminary and final design, along with the treatability study, was deducted and is shown elsewhere within the estimate.
11. Subcontractor Overhead and Profit is included in the estimate at 25% of the construction estimate for the transfer stations at the landfill and the receiving site, and for one small soil remediation task at the receiving facility. Overhead and Profit was not added to the treatment facility construction because it is already included in the AECOM estimate.
12. Operations of the treatment facility during the EMDF operating period was estimated at 30 years.
13. An annual material allowance for treatment related materials is included in the estimate. Activated Carbon was considered as the treatment technology initially and an estimate was provided of $88,000 per year for materials. The technology was later changed to Ion Exchange, subject matter experts estimate that the material allowance for Ion Exchange should be twice the amount for Activated Carbon.
14. Freight for the treatment materials delivery is included in the estimate at 8% of the material cost. This is based on the AECOM estimate for the treatment facility, dated 10/23/2015.
15. Annual analytical cost allowances during the time of the facility operation are included in the estimate and they were provided by the Feasibility Study project team. Their estimate was increased by 10% to allow for additional sampling and analysis of water at the receiving facility.
16. Leachate and contact water transportation costs during the 30 years of facility operations are included in the estimate. The annual value is based on FY15 actual transportation costs adjusted to remove elements not directly associated with transportation of the water and to cover projected increases in the number of truck load required during operations.
17. Operations of the treatment facility during the EMDF post-closure period were estimated at 30 years.
18. Annual analytical cost allowances during the time of post-closure are included in the estimate for a period of 30 years and they were provided by the Feasibility Study project team.
19. The estimate includes trucking of EMDF leachate water during post-closure. The estimate is based on two tractor/tankers one day per month for 30 years.

Schedule Assumptions:

1. No funding limitation impacts will be experienced.
2. Design will take approximately 12 months.
3. All construction is expected to take approximately 12 months.
4. The operation and maintenance of the treatment system is expected to last 30 years.
5. Post closure leachate management is expected to last 30 years.

Estimate Uncertainty:

The estimate was prepared in support of a Feasibility Study quality, which places it as a Class 4 estimate as defined by the Association for the Advancement of Cost Engineering International. The uncertainty range for Class 4 estimates can be as low as -30% to as high as +50%. The recommended level of uncertainty to apply to this estimate is -20% to +40%.

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ESTIMATOR: DATE:

PROJECT MANAGER: DATE:

ESTIMATING MANAGER: DATE:

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
01.01.01				**Capital Costs During Design Phase**																
	0100			**Perform Project Management During Design Phase**																
		0100		**Perform Project Management During Design Phase**																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25 ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25 ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25 ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25 ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25 ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25 FTE	0.25 ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25 ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0. 25 FTE	0.25 ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost			3,760.00 ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0100 Perform Project Management During Design Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
				0100 Perform Project Management During Design Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
	0200			**Design Facilities**																
		0200		**Design Facilities**																
			----	Design Facilities		Calculated based on 15% of total construction cost (120,368+1,241,203+528,125+5,991,158=7,880,854)	0.15 pct		-	-	-	-	-	-	-	-	-	7,880,854.00 /pct	1,182,128	1,182,128
				0200 Design Facilities															**1,182,128**	**1,182,128**
				0200 Design Facilities															**1,182,128**	**1,182,128**
	0300			**Conduct Treatability Study**																
		0300		**Conduct Treatability Study**																
			----	Treatability Study		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15 under Direct Field Cost, Acct **	1.00 ea		-	-	-	-	-	-	-	-	-	50,000.00 /ea	50,000	50,000
				0300 Conduct Treatability Study															**50,000**	**50,000**
				0300 Conduct Treatability Study															**50,000**	**50,000**
	0400			**Prepare Regulatory Documents**																
		NPDES Permit Revisio		**NPDES**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030
			OffSpply	Office Supplies, from R.S. Means monthly Cost			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142
				NPDES Permit Revisio NPDES						**269.50**	**35,403**		**142**							**35,545**
		PCCR		**PCCR**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				PCCR PCCR						**539.00**	**70,807**		**284**							**71,090**
		RAWP		**RAWP**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP RAWP						**539.00**	**70,807**		**284**							**71,090**
		RAWP/RDR		**RAWP/RDR**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP/RDR RAWP/RDR						**539.00**	**70,807**		**284**							**71,090**
		WAC Revision		**WAC Revision**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		WAC Revision		WAC Revision																
			OffSpply	Office Supplies, from R.S. Means monthly Cost			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142
				WAC Revision WAC Revision						269.50	35,403		142							35,545
				0400 Prepare Regulatory Documents						**2,156.00**	**283,226**		**1,136**							**284,362**
				01.01.01 Capital Costs During Design Phase						**5,916.00**	**623,713**		**3,158**						**1,232,128**	**1,858,999**
01.01.02				**Capital Costs During Construction Phase (1 yr duration)**																
	0120			**Perform Project Management During Construction Phase**																
		0120		Perform Project Management During Construction Phase																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25 ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25 ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25 ea	1,880.00 hr/ea	139.58 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25 ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25 ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25	0.25 ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25 ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0.25 FTE	0.25 ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost			3,760.00 ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0120 Perform Project Management During Construction Phase						3,760.00	340,487		2,022							342,509
				0120 Perform Project Management During Construction Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
	0220			**Perform Construction Management During Construction Phase**																
		0220		Perform Construction Management During Construction Phase																
			----	Construction Management		Calculated based on 8% of total construction cost (120,368+1,241,203+528,125+5,991,158=7,880,854)	0.08 pct		-	-	-	-	-	-	-	-	-	7,880,854.00 /pct	630,468	630,468
				0220 Perform Construction Management During Construction Phase															630,468	630,468
				0220 Perform Construction Management During Construction Phase															**630,468**	**630,468**
	0230			**Perform Operational Readiness and Startup**																
		0231		Procedures and Training																
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.50 ea	80.00 hr/ea	75.81 /hr	40.00	3,032	-	-	-	-	-	-	-	-	3,032
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00 ea	80.00 hr/ea	120.72 /hr	160.00	19,315	-	-	-	-	-	-	-	-	19,315
			----	Material Allowance			1.00 ls		-	-	-	3,292.50 /ls	3,293	-	-	-	-	-	-	3,293
				0231 Procedures and Training						200.00	22,348		3,293							25,640
		0232		Readiness and Startup																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			4.00 ea	120.00 hr/ea	52.93 /hr	480.00	25,406	-	-	-	-	-	-	-	-	25,406
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.10 ea	120.00 hr/ea	75.81 /hr	12.00	910	-	-	-	-	-	-	-	-	910
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00 ea	120.00 hr/ea	120.72 /hr	240.00	28,973	-	-	-	-	-	-	-	-	28,973
			----	Material Allowance			1.00 ls		-	-	-	5,487.50 /ls	5,488	-	-	-	-	-	-	5,488
				0232 Readiness and Startup						732.00	55,289		5,488							60,776
				0230 Perform Operational Readiness and Startup		**Reference EMWMF/EMDF Leachate Feasibility Study On-Site Treatment Estimate, log # 20150324B_0 dated 4/8/15.**				**932.00**	**77,637**		**8,780**							**86,417**
	0240			**Construct Treatment Plant at EMWMF**																
		0240		Construct Treatment Plant at EMWMF																
			----	Construct Treatment Plant at EMWMF		Reference AECOM estimate for Landfill	1.00 ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY	UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0240		Construct Treatment Plant at EMWMF																	
			----	Construct Treatment Plant at EMWMF		Wastewater Treatment System, dated 10/23/15. Estimate less additional storage was calculated at $6,905,000. Remove Preliminary and Final Design and Treatability Study which are all covered elsewhere for a resulting total of 5,991,158.	1.00	ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF																5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF																**5,991,158**	**5,991,158**
	0260			**Construct Tanker Loading Stations at EMWMF plus Purchase Additional Ta**																	
		0261		Construct New Loading Stations																	
			----	Remove Existing Loading		from FFS Team	1.00	ls		-	-	-	-	-	-	-	2,000.00 /ls	2,000	-	-	2,000
			----	Install New Footing/Foundation for Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	15,000.00 /ls	15,000	-	-	15,000
			----	Procure Loaing Arm & Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	65,000.00 /ls	65,000	-	-	65,000
			----	Modify Existing Loading Arm Support		from FFS Team	1.00	ls		-	-	-	-	-	-	-	8,000.00 /ls	8,000	-	-	8,000
			----	Install Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	9,000.00 /ls	9,000	-	-	9,000
			----	Install Loading Arm		from FFS Team	1.00	ls		-	-	-	-	-	-	-	3,000.00 /ls	3,000	-	-	3,000
			----	Piping, Electrical, Insulation Allowance		from FFS Team	1.00	ls		-	-	-	-	-	-	-	10,500.00 /ls	10,500	-	-	10,500
			----	Prepare Subgrade for Unloading Slab		from FFS Team	1.00	ls		-	-	-	-	-	-	-	6,500.00 /ls	6,500	-	-	6,500
			----	Excavate & Form Slab, Access Platform, & Sump		from FFS Team	1.00	ls		-	-	-	-	-	-	-	9,500.00 /ls	9,500	-	-	9,500
			----	Place & Tie Rebar, Waterstop, Set Anchor Bolts, Etc		from FFS Team	1.00	ls		-	-	-	-	-	-	-	11,500.00 /ls	11,500	-	-	11,500
			----	Place & Finish Concrete		from FFS Team	1.00	ls		-	-	-	-	-	-	-	9,000.00 /ls	9,000	-	-	9,000
			----	Rack Forms & Backfill to Finished Grade		from FFS Team	1.00	ls		-	-	-	-	-	-	-	2,000.00 /ls	2,000	-	-	2,000
			----	Procure Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	65,000.00 /ls	65,000	-	-	65,000
			----	Install Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	9,000.00 /ls	9,000	-	-	9,000
			----	Install Loading Arm		from FFS Team	1.00	ls		-	-	-	-	-	-	-	3,000.00 /ls	3,000	-	-	3,000
			----	Matl's/Labor for CWT's to Tanker Transfer Ancillary Equip		from FFS Team	1.00	ls		-	-	-	-	-	-	-	25,000.00 /ls	25,000	-	-	25,000
			----	Remove Existing Transfer Pump		from FFS Team	1.00	ls		-	-	-	-	-	-	-	1,500.00 /ls	1,500	-	-	1,500
			----	Install New 250 GPM Pump		from FFS Team	1.00	ls		-	-	-	-	-	-	-	8,000.00 /ls	8,000	-	-	8,000
				0261 Construct New Loading Stations														262,500			262,500
		0262		Purchase New Tankers																	
			----	Purchase Water Tanker Trailers			2.00	ea		-	-	-	-	-	-	-	-	-	80,000.00 /ea	160,000	160,000
				0262 Purchase New Tankers																160,000	160,000
		0263		Subcontract Overhead and Profit																	
			----	Subcontract Overhead and Profit		Subcontractor Overhead and Profit @ 25%	0.25	ls		-	-	-	-	-	-	-	422,500.00 /ls	105,625	-	-	105,625
				0263 Subcontract Overhead and Profit														105,625			105,625
				0260 Construct Tanker Loading Stations at EMWMF plus Purchase Additional Ta														**368,125**		**160,000**	**528,125**
	0270			**Construct Tanker Unloading Stations at LGWO (or OF200)**																	
		0270		Construct Tanker Unloading Stations at LGWO (or OF200)																	
			SPTSA03	Senior RPT (FY18 Rev1 B08)		Oversight During Excavation	1.00	ea	200.00 hr/ea	43.69 /hr	200.00	8,738	-	-	-	-	-	-	-	-	8,738
			Field Engr. 01	Field Engineer, Maximum, R.S. Means CostWorks, Bare Cost		1 Safety & 1 Field Engr	18.00	wk		-	-	-	-	-	-	-	1,575.00 /wk	28,350	-	-	28,350
			Proj. Mgr. 01	Project Manager, Maximum, R.S. Means CostWorks, Bare Cost			9.00	wk		-	-	-	-	-	-	-	2,600.00 /wk	23,400	-	-	23,400
			Suptdt 01	Superintendent, Maximum, R.S. Means CostWorks, Bare Cost			9.00	wk		-	-	-	-	-	-	-	2,400.00 /wk	21,600	-	-	21,600
			TFE1.3.1.0	TFE: Straight Frame Tri-Axle Dump Truck, Regulated; Fueling,		Assume soil & concrete goes to EMWMF	2,000.00	hr		-	-	-	-	-	-	-	6.55 /hr	13,100	-	-	13,100
			TFE1.4.3.1	TFE: Stanght Frame Tri-Axle Dump Truck, Non-Regulated, Incl All Maintenance; 1-10 Trks		10 trucks for 5 weeks	200.00	day		-	-	-	-	-	-	-	474.71 /day	94,942	-	-	94,942
			TFE1.6.1.3	TFE: Truck Operator, Fully Trained & Certified			2,000.00	hr		-	-	-	-	-	-	-	40.84 /hr	81,680	-	-	81,680
			TFE1.7.7.0	TFE: Clean Fill Haul, Includes Material,		3,300#/CY Bank. (2500 CY* 3,300#/CY) / 2,000 /Ton =	4,125.00	ton		-	-	-	-	-	-	-	8.31 /ton	34,279	-	-	34,279
			----	Selective demolition, retaining walls, concrete retaining wall, 10' high, includes reinforcing			310.00	lf		-	-	-	-	-	-	-	284.49 /lf	88,192	-	-	88,192
			----	Cast-in place retaining walls, reinforced concrete cantilever, 33 degree slope embankment, 10' high, includes excavation, backfill & reinforcing			325.00	lf		-	-	-	-	-	-	-	333.80 /lf	108,485	-	-	108,485

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0270		**Construct Tanker Unloading Stations at LGWO (or OF200)**																
			----	Excavating, trench or continuous footing, dense hard clay, 3/4 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering		Additional excavation not included demolition and retaining wall	35,000.00 bcy		-	-	-	-	-	-	-	7.42 /bcy	259,700	-	-	259,700
			----	Pipe, stainless steel, threaded, 2" diameter, schedule 40, type 304, includes couplings and hangers 10' OC		Relocated pipe	180.00 lf		-	-	-	-	-	-	-	68.34 /lf	12,301	-	-	12,301
			----	Structural concrete, in place, slab on grade (3500 psi), 6" thick, includes forms(4 uses), Grade 60 rebar, concrete (Portland cement Type I), and plac		Tanker spill containment slab	30.00 cy		-	-	-	-	-	-	-	152.70 /cy	4,581	-	-	4,581
			----	Structural concrete, thickened edge for slab on grade (3500 psi), depth is added to and poured monolithically with slab, 12" wide x 12" deep, unreinfo		Use price for curb	60.00 lf		-	-	-	-	-	-	-	8.75 /lf	525	-	-	525
			----	Sump and pipe Allowance			1.00 LS		-	-	-	-	-	-	-	1,500.00 /LS	1,500	-	-	1,500
			----	Pipe, stainless steel, threaded, 4" diameter, schedule 40, type 304, includes couplings and hangers 10' OC		Unloading pipe header	110.00 lf		-	-	-	-	-	-	-	173.80 /lf	19,118	-	-	19,118
			----	Asphaltic concrete paving, parking lots & driveways, 6" stone base, 4" binder course, 4" topping, no asphalt hauling included		Asphalt repair	6,000.00 sf		-	-	-	-	-	-	-	4.20 /sf	25,200	-	-	25,200
			----	Unidentified Upgrades Allowance			1.00 ls		-	-	-	-	-	-	-	150,000.00 /ls	150,000	-	-	150,000
			----	Seeding, mechanical seeding grass seed, 4.5 lbs per M.S.F., hand push spreader			7.50 msf		-	-	-	-	-	-	-	20.80 /msf	156	-	-	156
			----	Seeding, mechanical apply fertilizer, 35 lbs per M.S.F., hand push spreader			7.50 msf		-	-	-	-	-	-	-	15.31 /msf	115	-	-	115
			----	Mobilization & Training			1.00 ls		-	-	-	-	-	-	-	12,000.00 /ls	12,000	-	-	12,000
			----	Demobilization			1.00 ls		-	-	-	-	-	-	-	5,000.00 /ls	5,000	-	-	5,000
				0270 Construct Tanker Unloading Stations at LGWO (or OF200)						**200.00**	**8,738**						**984,224**			**992,962**
		0271		**Subcontract Overhead and Profit**																
			----	Subcontract Overhead and Profit		Subcontractor Overhead and Profit @ 25%	0.25 ls		-	-	-	-	-	-	-	992,962.00 /ls	248,241	-	-	248,241
				0271 Subcontract Overhead and Profit													**248,241**			**248,241**
				0270 Construct Tanker Unloading Stations at LGWO (or OF200)						**200.00**	**8,738**						**1,232,464**			**1,241,202**
	0280			**Perform Soil Remediation at LGWO**																
		0280		**Perform Soil Remediation at LGWO**																
			13Craft	Building Trades Skilled Craft (FY16 Rev1 B06)		Foreman - 5 days	1.00 ea	50.00 hr/ea	38.12 /hr	50.00	1,906	-	-	-	-	-	-	-	-	1,906
			13Craft	Building Trades Skilled Craft (FY16 Rev1 B06)		Excavator Operator - 5 days	1.00 ea	50.00 hr/ea	38.12 /hr	50.00	1,906	-	-	-	-	-	-	-	-	1,906
			13Labor	Building Trades Craft Laborers (FY16 Rev1 B06)		Spotter for Trucks	1.00 ea	50.00 hr/ea	28.12 /hr	50.00	1,406	-	-	-	-	-	-	-	-	1,406
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Allow for 5 days	1.00 ea	50.00 hr/ea	139.59 /hr	50.00	6,980	-	-	-	-	-	-	-	-	6,980
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		Allow for 5 days	1.00 ea	50.00 hr/ea	75.81 /hr	50.00	3,791	-	-	-	-	-	-	-	-	3,791
			RSISA06	Staff Engineer/Scientist (FY16 Rev1 B06)		Collect Samples	3.00 ea	50.00 hr/ea	84.83 /hr	150.00	12,725	-	-	-	-	-	-	-	-	12,725
			SPTSA03	Senior RPT (FY16 Rev1 B06)		Allow for 5 days	1.00 ea	50.00 hr/ea	43.69 /hr	50.00	2,185	-	-	-	-	-	-	-	-	2,185
			----	SR-90 by Beta GPC		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	114.45 /ea	572	-	-	572
			----	TH ISO by Alpha		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	111.51 /ea	558	-	-	558
			----	PU ISO by Alpha		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	111.51 /ea	558	-	-	558
			Excav2.5-Op n	Excavator, 2.5 CY, Operating Rate for Rental		Allow for 5 days	50.00 hr		-	-	-	-	-	100.27 /hr	5,014	-	-	-	-	5,014
			Excav2.5-Wk	Excavator, 2.5 CY, Rental, Weekly Rate		Allow for 5 days - Assume 50 CY/hr & 2500 CY Total	2.00 wk		-	-	-	-	-	3,764.89 /wk	7,530	-	-	-	-	7,530
			AVGLAB089	SW846-1311/7470: TCLP Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique) SOLID 30Day		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	23.97 /ea	120	-	-	120
			AVGLAB099	SW846-8082: Polychlorinated Biphenyls (PCBs) by Gas Chromatography SOLID 30 Day		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	81.93 /ea	410	-	-	410
			AVGLAB101	SW846-8260: Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) SOLID 30 Day		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	108.35 /ea	542	-	-	542
			AVGLAB102	SW846-8270: Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) SOLID 30 Day		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	183.87 /ea	919	-	-	919
			AVGLAB117	GAMMA SPECTROSCOPY: Gamma Spectroscopy SOLID 30 Day		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	78.40 /ea	392	-	-	392
			AVGLAB118	GROSS A/B GFPC: Gross Alpha/Beta by GFPC SOLID 30 Day		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	48.70 /ea	244	-	-	244
			AVGLAB125	TC-99 BY BETA LSC: Technetium-99 by Beta Liquid Scintillation Counting SOLID 30 Day		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	96.00 /ea	480	-	-	480

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0280		Perform Soil Remediation at LGWO																
			AVGLAB128	U ISO BY ALPHA: Isotopic Uranium by Alpha Spectroscopy SOLID 30 Day		Allow for 1 per day for 5 days	5.00 ea		-	-	-	-	-	-	-	100.40 /ea	502	-	-	502
			TFE1.3.1.0	TFE: Straight Frame Tri-Axle Dump Truck, Regulated; Fueling,		Assume contaminated soil goes to EMWMF	50.00 hr		-	-	-	-	-	-	-	6.55 /hr	328	-	-	328
			TFE1.4.3.1	TFE: Staright Frame Tri-Axle Dump Truck, Non-Regulated; Incl All Maintenance; 1-10 Trks		Allow for 5 days	5.00 day		-	-	-	-	-	-	-	474.71 /day	2,374	-	-	2,374
			TFE1.8.1.3	TFE: Truck Operator, Fully Trained & Certified		Allow for 5 days	50.00 hr		-	-	-	-	-	-	-	40.84 /hr	2,042	-	-	2,042
			TFE1.7.7.0	TFE: Clean Fill Haul; Includes Material;		3,300#/CY Bank. (2500 CY* 3,300#/CY) / 2,000 /Ton =	4,125.00 ton		-	-	-	-	-	-	-	8.31 /ton	34,279	-	-	34,279
			—	Seeding, mechanical seeding grass seed, 4.5 lbs per M.S.F., hand push spreader			1.00 msf		-	-	-	-	-	-	-	20.80 /msf	21	-	-	21
			—	Seeding, mechanical apply fertilizer, 35 lbs per M.S.F., hand push spreader			1.00 msf		-	-	-	-	-	-	-	15.31 /msf	15	-	-	15
			—	Mobilization & Training			1.00 ls		-	-	-	-	-	-	-	6,000.00 /ls	6,000	-	-	6,000
			—	Demobilization			1.00 ls		-	-	-	-	-	-	-	2,500.00 /ls	2,500	-	-	2,500
				0280 Perform Soil Remediation at LGWO						450.00	30,897				12,543		52,863			96,294
		0281		Subcontract Overhead and Profit																
			—	Subcontract Overhead and Profit		Subcontractor Overhead and Profit @ 25%	0.25 ls		-	-	-	-	-	-	-	96,294.00 /ls	24,074	-	-	24,074
				0281 Subcontract Overhead and Profit													24,074			24,074
				0280 Perform Soil Remediation at LGWO						**450.00**	**30,897**				**12,543**		**76,927**			**120,367**
				01.01.02 Capital Costs During Construction Phase (1 yr duration)						**5,342.00**	**457,758**		**10,802**		**12,543**		**1,677,516**		**6,781,626**	**8,940,246**
01.01.05				**O&M Costs During EMDF Operations and Closure (30 yrs duration)**																
	0510			**Perform Project Management During EMDF Operations**																
		0510		Perform Project Management During EMDF Operations																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.13 ea	56,400.00 hr/ea	88.97 /hr	7,050.00	627,239	-	-	-	-	-	-	-	-	627,239
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.05 ea	56,400.00 hr/ea	71.30 /hr	2,820.00	201,066	-	-	-	-	-	-	-	-	201,066
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.25 ea	56,400.00 hr/ea	139.59 /hr	14,100.00	1,968,219	-	-	-	-	-	-	-	-	1,968,219
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.13 ea	56,400.00 hr/ea	81.42 /hr	7,050.00	574,011	-	-	-	-	-	-	-	-	574,011
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.13 ea	56,400.00 hr/ea	47.47 /hr	7,050.00	334,664	-	-	-	-	-	-	-	-	334,664
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.13 ea	56,400.00 hr/ea	75.81 /hr	7,050.00	534,461	-	-	-	-	-	-	-	-	534,461
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.25 ea	56,400.00 hr/ea	120.72 /hr	14,100.00	1,702,152	-	-	-	-	-	-	-	-	1,702,152
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.13 ea	56,400.00 hr/ea	99.16 /hr	7,050.00	699,078	-	-	-	-	-	-	-	-	699,078
			OffSpply	Office Supplies, from R.S. Means monthly Cost			66,270.00 ea		-	-	-	0.54 /ea	35,638	-	-	-	-	-	-	35,638
				0510 Perform Project Management During EMDF Operations						66,270.00	6,640,889		35,638							6,676,527
				0510 Perform Project Management During EMDF Operations						**66,270.00**	**6,640,889**		**35,638**							**6,676,527**
	0520			**Operate Onsite Treatment Plant During EMDF Operations**																
		0520		Operate Onsite Treatment Plant During EMDF Operations																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		30 years at 2080 hours per year = 62400 hours	2.00 ea	62,400.00 hr/ea	52.93 /hr	124,800.00	6,605,664	-	-	-	-	-	-	-	-	6,605,664
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			0.12 ea	62,400.00 hr/ea	52.93 /hr	7,488.00	396,340	-	-	-	-	-	-	-	-	396,340
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	75.81 /hr	3,744.00	283,833	-	-	-	-	-	-	-	-	283,833
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	120.72 /hr	3,744.00	451,976	-	-	-	-	-	-	-	-	451,976
			PPE DMod	PPE Level D Modified			139,776.00 hr		-	-	-	4.50 /hr	628,957	-	-	-	-	-	-	628,957
				0520 Operate Onsite Treatment Plant During EMDF Operations						139,776.00	7,737,812		628,957							8,366,769
				0520 Operate Onsite Treatment Plant During EMDF Operations						**139,776.00**	**7,737,812**		**628,957**							**8,366,769**
	0530			**Purchase GAC and/or Treatment Resins**																
		0530		Purchase GAC and/or Treatment Resins																
			—	Annual Material Allowance		(Per R. McDonnell - $88,000/year	30.00 yr		-	-	-	193,160.00 /yr	5,794,800	-	-	-	-	-	-	5,794,800

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0530		Purchase GAC and/or Treatment Resins																
			—	Annual Material Allowance		allowance for GAC treatment technology. Per Ray and Stephen Hahn new technology is Ion Exchange and material allowance for Ion Exchange is approximately twice the needed allowance for GAC, therefore use 2 x $88,000/year or $176,000/year for materials) (plus tax)	30.00 yr		-	-	-	193,160.00 /yr	5,794,800	-	-	-	-	-	-	5,794,800
				0530 Purchase GAC and/or Treatment Resins									5,794,800							5,794,800
				0530 Purchase GAC and/or Treatment Resins									**5,794,800**							**5,794,800**
	0540			**Freight on Materials**																
		0540		Freight on Materials																
			—	Freight on Materials		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15. ACCT 00	0.08 pct		-	-	-	-	-	-	-	-	-	5,794,800.00 /pct	463,584	463,584
				0540 Freight on Materials															463,584	463,584
				0540 Freight on Materials															**463,584**	**463,584**
	0560			**Sample/Test Leachate During EMDF Operations**																
		0560		Sample/Test Leachate During EMDF Operations																
			—	Annual Analytical Costs		per FFS project team (plus 10% for additional analysis for receiving site = 212,517x1.1=233,769)	30.00 yr		-	-	-	-	-	-	-	-	-	233,769.00 /yr	7,013,070	7,013,070
				0560 Sample/Test Leachate During EMDF Operations															7,013,070	7,013,070
				0560 Sample/Test Leachate During EMDF Operations															**7,013,070**	**7,013,070**
	0570			**Truck Leachate Plus Contact Water During EMDF Operations**																
		0570		Truck Leachate Plus Contact Water During EMDF Operations																
			—	Leachate and Contact Water Transportation Cost		Based on FY15 actual transportation costs (reference ROS 200) adjusted to remove elements not associated with transportation costs, adjusted up to cover projected increases in number of truck loads.	30.00 yr		-	-	-	-	-	-	-	-	-	1,500,000.00 /yr	45,000,000	45,000,000
				0570 Truck Leachate Plus Contact Water During EMDF Operations															45,000,000	45,000,000
				0570 Truck Leachate Plus Contact Water During EMDF Operations															**45,000,000**	**45,000,000**
				01.01.05 O&M Costs During EMDF Operations and Closure (30 yrs duration)						**206,046.00**	**14,378,701**		**6,459,395**						**52,476,654**	**73,314,750**
01.01.07				**O&M Costs During Post-Closure EMDF (30 yrs duration)**																
	0610			**Perform Project Management During EMDF Post-Closure**																
		0610		Perform Project Management During EMDF Post-Closure																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.05 ea	56,400.00 hr/ea	88.97 /hr	2,820.00	250,095	-	-	-	-	-	-	-	-	250,095
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.03 ea	56,400.00 hr/ea	71.30 /hr	1,410.00	100,533	-	-	-	-	-	-	-	-	100,533
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.10 ea	56,400.00 hr/ea	139.59 /hr	5,640.00	787,288	-	-	-	-	-	-	-	-	787,288
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.05 ea	56,400.00 hr/ea	81.42 /hr	2,820.00	229,604	-	-	-	-	-	-	-	-	229,604
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.05 ea	56,400.00 hr/ea	47.47 /hr	2,820.00	133,865	-	-	-	-	-	-	-	-	133,865
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.05 ea	56,400.00 hr/ea	75.81 /hr	2,820.00	213,784	-	-	-	-	-	-	-	-	213,784
			RSISA00	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.10 ea	56,400.00 hr/ea	120.72 /hr	5,640.00	680,861	-	-	-	-	-	-	-	-	680,861
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.05 ea	56,400.00 hr/ea	99.16 /hr	2,820.00	279,631	-	-	-	-	-	-	-	-	279,631
			OffSpply	Office Supplies, from R.S. Means monthly Cost			26,790.00 ea		-	-	-	0.54 /ea	14,407	-	-	-	-	-	-	14,407
				0610 Perform Project Management During EMDF Post-Closure						26,790.00	2,676,462		14,407							2,690,869
				0610 Perform Project Management During EMDF Post-Closure						**26,790.00**	**2,676,462**		**14,407**							**2,690,869**

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
	0620			**Operate Onsite Treatment Plant During Post-Closure EMDF**																
		0620		**Operate Onsite Treatment Plant During Post-Closure EMDF**																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		1 day once a month for 30 years.	2.00 ea	3,600.00 hr/ea	52.93 /hr	7,200.00	381,096	-	-	-	-	-	-	-	-	381,096
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		1 day once a month for 30 years	0.50 ea	3,600.00 hr/ea	75.81 /hr	1,800.00	136,458	-	-	-	-	-	-	-	-	136,458
			RSISA09	Senior Staff Engineer/Scientist (FY16 Rev1 B06)		1 day once a month for 30 years	2.00 ea	3,600.00 hr/ea	108.11 /hr	7,200.00	778,392	-	-	-	-	-	-	-	-	778,392
			SPTSA03	Senior RPT (FY16 Rev1 B06)		1 day once a month for 30 years	0.50 ea	3,600.00 hr/ea	43.69 /hr	1,800.00	78,642	-	-	-	-	-	-	-	-	78,642
			----	Material Allowance			30.00 yr		-	-	-	3,292.50 /yr	98,775	-	-	-	-	-	-	98,775
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF						**18,000.00**	**1,374,588**		**98,775**							**1,473,363**
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF						**18,000.00**	**1,374,588**		**98,775**							**1,473,363**
	0630			**Sample/Test Leachate During Post-Closure EMDF**																
		0630		**Sample/Test Leachate During Post-Closure EMDF**																
			----	Sampling/Analytical		From FFS team	30.00 yr		-	-	-	-	-	-	-	-	-	36,596.00 /yr	1,097,880	1,097,880
				0630 Sample/Test Leachate During Post-Closure EMDF															**1,097,880**	**1,097,880**
				0630 Sample/Test Leachate During Post-Closure EMDF															**1,097,880**	**1,097,880**
	0640			**Truck EMDF Leachate During Post-Closure EMDF**																
		0640		**Truck EMDF Leachate During Post-Closure EMDF**																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		1 day once a month for 30 years. 2 personnel, drivers.	2.00 ea	3,600.00 hr/ea	52.93 /hr	7,200.00	381,096	-	-	-	-	-	-	-	-	381,096
			GFETrkTrctr	GFE Truck Tractor (Semi), 6X4, 400HP, Oper Cost		Assume 2 tractors @ 1 day/month for 30 years = 10 hrs X 12 months X 30 yrs X 2 ea = 7,200 hrs	7,200.00 hr		-	-	-	-	-	51.05 /hr	367,560	-	-	-	-	367,560
			GFEWtrTrlr	GFE Water Trailer, 5K Gallons, Oper Cost		2 trailers	7,200.00 hr		-	-	-	-	-	7.00 /hr	50,400	-	-	-	-	50,400
				0640 Truck EMDF Leachate During Post-Closure EMDF						**7,200.00**	**381,096**				**417,960**					**799,056**
				0640 Truck EMDF Leachate During Post-Closure EMDF						**7,200.00**	**381,096**				**417,960**					**799,056**
				01.01.07 O&M Costs During Post-Closure EMDF (30 yrs duration)						**51,990.00**	**4,432,146**		**113,182**		**417,960**				**1,097,880**	**6,061,168**

Estimate Totals

Description	Amount	Totals	Hours		Rate	Cost Basis	Cost per Unit	Percent of Total	
Labor	19,892,318		269,294 hrs					22.06%	
Material	6,586,537							7.30%	
Equipment	430,503		14,530	hrs				0.48%	
Subcontract	1,677,516							1.86%	
Other	61,588,288							68.30%	
	90,175,163	90,175,163						100.00	100.00%
Total		90,175,163							

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Basis of Estimate
EMWMF/EMDF Leachate Focused Feasibility Study: Alternative 4a:
OF200 Treatment and Pipeline Alternative
February 9, 2016

Objective/Scope:

Method of Accomplishment:

URS|CH2M Oak Ridge LLC (UCOR) provides project management during design of a new Treatment Plant at the Environmental Management Waste Management Facility (EMWMF) and the pipeline from EMWMF to OF200, preparation of required regulatory documents, project and construction management/oversight during facility, pipeline, and additional storage capacity construction, facility operational readiness and startup, oversight and operations of the facility and pipeline for thirty years, as well as oversight and operations during post-closure, also for thirty years. Subcontractors will perform the actual design of the treatment facility and pipeline, conduct necessary treatability studies and perform the actual construction of the facilities. Subcontract labs were also assumed to provide the analytical service of samples taken during operations and post-closure.

Estimate Type and Approach:

This feasibility estimate is based upon similar work proposed in the past and work experience. The estimate was developed using a combination of bottoms-up approach, parametric data from similar projects, actual costs of similar work, and estimator and team experience with similar projects and existing operations.

Key Financial Data:

1. The estimate was prepared in the second quarter of fiscal year (FY)2016.
2. Any actual costs of work or similar work were provided by the project team.
3. General and Administrative costs and fee are not included in this estimate.
4. All UCOR and Staff Augmentation rates are fully burdened, including fringes. Staff Augmentation rates include overhead and profit.
5. A sales tax of 9.75% has been included on all material.
6. All prices are in FY2016 dollars and no escalation has been included.
7. There is no contingency in this estimate.
8. UCOR and staff augmentation rates were used for the U.S. Department of Energy prime contractor.

Estimate Assumptions and Exclusions:

1. One Full Time Equivalent (FTE) is equal to 1880 man-hours per year.
2. One FTE for facility operations is 2080 man-hours per year.
3. The Conceptual Design Report and the Critical Decision (CD-1, -2, -3, and -4) process was not included in this estimate.
4. The cost for final closure of the Environmental Management Disposal Facility (EMDF) is not included in this estimate.
5. There are no decontamination and demolition costs included in this estimate.
6. Design of the facilities is estimated at 15% of the total construction cost for the facilities (water treatment, pipeline, and additional storage capacity).

7. Construction management for the facilities is estimated at 8% of the total construction cost for the facilities (water treatment, pipeline, and additional storage capacity).
8. The treatability study is based on an AECOM estimate for the construction of the treatment facility; reference Landfill Wastewater Treatment System, dated 10/23/2015.
9. The following regulatory documents are included in this estimate: Post Construction Closure Report, Remedial Action Work Plan, Remedial Action Work Plan/Remedial Design Report, Record of Decision/Environmental Stewardship Document, and a Waste Acceptance Criteria.
10. The actual treatment facility construction estimate is based on an AECOM estimate, dated 10/23/2015. The estimate for the facility less additional storage capacity was $6,905,000. The preliminary and final design, along with the treatability study, was deducted and is shown elsewhere within the estimate.
11. Subcontractor Overhead and Profit is included in the estimate at 25% of the pipeline and additional storage capacity construction estimate. Overhead and Profit was not added to the treatment facility construction because it is already included in the AECOM estimate.
12. Operations of the treatment facility and pipeline during the EMDF operating period was estimated at 30 years.
13. An annual material allowance for treatment related materials is included in the estimate. Activated Carbon was considered as the treatment technology initially and an estimate was provided of $88,000 per year for materials. The technology was later changed to Ion Exchange; subject matter experts estimate that the material allowance for Ion Exchange should be twice the amount for Activated Carbon.
14. Freight for the treatment materials delivery is included in the estimate at 8% of the material cost. This is based on the AECOM estimate for the treatment facility, dated 10/23/2015.
15. Annual analytical cost allowances during the time of the facility operation are included in the estimate and they were provided by the Feasibility Study project team. Their estimate was increased by 10% to allow for additional sampling and analysis of water at the receiving facility.
16. Operations of the treatment facility during the EMDF post-closure period were estimated at 30 years.
17. Annual analytical cost allowances during the time of post-closure are included in the estimate for a period of 30 years and they were provided by the Feasibility Study project team.

Schedule Assumptions:

1. No funding limitation impacts will be experienced.
2. Design will take approximately 12 months.
3. All construction is expected to take approximately 12 months.
4. The operation and maintenance of the treatment system is expected to last 30 years.
5. Post-closure leachate management is expected to last 30 years.

Estimate Uncertainty:

The estimate was prepared in support of a Feasibility Study quality, which places it as a Class 4 estimate as defined by the Association for the Advancement of Cost Engineering International. The uncertainty range for Class 4 estimates can be as low as -30% to as high as +50%. The recommended level of uncertainty to apply to this estimate is -20% to +40%.

All signatures on file.

ESTIMATOR: DATE:

PROJECT MANAGER: DATE:

ESTIMATING MANAGER: DATE:

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
01.01.01				Capital Costs During Design Phase																
	0100			Perform Project Management During Design Phase																
		0100		Perform Project Management During Design Phase																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25 ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25 ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25 ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25 ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25 ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25 FTE	0.25 ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25 ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0..25 FTE	0.25 ea	1,880.00 hr/ea	99.18 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost			3,760.00 ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0100 Perform Project Management During Design Phase						3,760.00	340,487		2,022							342,509
				0100 Perform Project Management During Design Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
	0200			Design Facilities																
		0200		Design Facilities																
			----	Design Facilities		Calculated based on 15% of total construction cost (5,991,158+1,655,966+768,750=8,415,874)	0.15 pct		-	-	-	-	-	-	-	-	-	8,415,874.00 /pct	1,262,381	1,262,381
				0200 Design Facilities															1,262,381	1,262,381
				0200 Design Facilities															**1,262,381**	**1,262,381**
	0300			Conduct Treatability Study																
		0300		Conduct Treatability Study																
			----	Treatability Study		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15 under Direct Field Cost, Acct **	1.00 ea		-	-	-	-	-	-	-	-	-	50,000.00 /ea	50,000	50,000
				0300 Conduct Treatability Study															50,000	50,000
				0300 Conduct Treatability Study															**50,000**	**50,000**
	0400			Prepare Regulatory Documents																
		PCCR		PCCR																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				PCCR PCCR						539.00	70,807		284							71,090
		RAWP		RAWP																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP RAWP						539.00	70,807		284							71,090
		RAWP/RDR		RAWP/RDR																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP/RDR RAWP/RDR						539.00	70,807		284							71,090
		ROD ESD		ROD ESD																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030
			OffSpply	Office Supplies, from R.S. Means monthly Cost			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142
				ROD ESD ROD ESD						269.50	35,403		142							35,546
		WAC Revision		WAC Revision																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030
			OffSpply	Office Supplies, from R.S. Means monthly Cost			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY	UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
				WAC Revision WAC Revision							269.50	35,403		142							35,545
				0400 Prepare Regulatory Documents							**2,166.00**	**283,226**		**1,136**							**284,362**
				01.01.01 Capital Costs During Design Phase							**5,916.00**	**623,713**		**3,158**						**1,312,381**	**1,939,252**
01.01.02				**Capital Costs During Construction Phase (1 yr duration)**																	
	0120			**Perform Project Management During Construction Phase**																	
		0120		Perform Project Management During Construction Phase																	
			32Labor	UCOR - Engineering (FY16 Rev1 B08)		Project Engineer - 0.25 FTE	0.25	ea	1,880.00 hr/ea	88.97 /hr	470.00	41,818	-	-	-	-	-	-	-	-	41,818
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25	ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B08)		Project Manager - .25 FTE	0.25	ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25	ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25	ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25	0.25	ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25	ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0.25 FTE	0.25	ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost			3,760.00	ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0120 Perform Project Management During Construction Phase							3,760.00	340,487		2,022							342,509
				0120 Perform Project Management During Construction Phase							**3,760.00**	**340,487**		**2,022**							**342,509**
	0220			**Perform Construction Management During Construction Phase**																	
		0220		Perform Construction Management During Construction Phase																	
			---	Construction Management		Calculated based on 8% of total construction cost (5,991,158+1,655,966+768,750=8,415,874)	0.08	pct		-	-	-	-	-	-	-	-	-	8,415,874.00 /pct	673,270	673,270
				0220 Perform Construction Management During Construction Phase																673,270	673,270
				0220 Perform Construction Management During Construction Phase																**673,270**	**673,270**
	0230			**Perform Operational Readiness and Startup**																	
		0231		Procedures and Training																	
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.50	ea	80.00 hr/ea	75.81 /hr	40.00	3,032	-	-	-	-	-	-	-	-	3,032
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00	ea	80.00 hr/ea	120.72 /hr	160.00	19,315	-	-	-	-	-	-	-	-	19,315
			---	Material Allowance			1.00	ls		-	-	-	3,292.50 /ls	3,293	-	-	-	-	-	-	3,293
				0231 Procedures and Training							200.00	22,348		3,293							25,640
		0232		Readiness and Startup																	
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			4.00	ea	120.00 hr/ea	52.93 /hr	480.00	25,406	-	-	-	-	-	-	-	-	25,406
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.10	ea	120.00 hr/ea	75.81 /hr	12.00	910	-	-	-	-	-	-	-	-	910
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00	ea	120.00 hr/ea	120.72 /hr	240.00	28,973	-	-	-	-	-	-	-	-	28,973
			---	Material Allowance			1.00	ls		-	-	-	5,487.50 /ls	5,488	-	-	-	-	-	-	5,488
				0232 Readiness and Startup							732.00	56,289		5,488							60,776
				0230 Perform Operational Readiness and Startup		**Reference EMWMF/EMDF Leachate Feasibility Study On-Site Treatment Estimate, log # 20150324B_0 dated 4/8/15.**					**932.00**	**77,637**		**8,780**							**86,417**
	0240			**Construct Treatment Plant at EMWMF**																	
		0240		Construct Treatment Plant at EMWMF																	
			---	Construct Treatment Plant at EMWMF		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15. Estimate less additional storage was calculated at $6,905,000. Remove Preliminary and Final Design and Treatability Study which are all covered	1.00	ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY	UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0240		**Construct Treatment Plant at EMWMF**																	
			----	Construct Treatment Plant at EMWMF		elsewhere for a resulting total of 5,991,158	1.00	ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF																5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF																5,991,158	5,991,158
	0250			**Construct Pipeline from EMWMF to LGWO (or OF200) Plus Lift Station**																	
		0250A		**Construct Pipeline from EMWMF to LGWO (or OF200) Plus Lift Station**																	
			Field Clerk 01	Field Clerk, Average, R.S. Means CostWorks, Bare Cost			18.00	wk		-	-	-	-	-	-	-	450.00 /wk	8,100	-	-	8,100
			Field Engr 01	Field Engineer, Maximum, from R.S. Means CostWorks			18.00	wk		-	-	-	-	-	-	-	1,575.00 /wk	28,350	-	-	28,350
			Field Engr 01	Field Engineer, Maximum, from R.S. Means CostWorks			18.00	wk		-	-	-	-	-	-	-	1,575.00 /wk	28,350	-	-	28,350
			Proj. Mgr. 01	Project Manager, Maximum,from R.S. Means CostWorks, with O&P			18.00	wk		-	-	-	-	-	-	-	2,600.00 /wk	46,800	-	-	46,800
			Suptdt 01	Superintendent, Maximum,from R.S. Means CostWorks, w/O&P			18.00	wk		-	-	-	-	-	-	-	2,400.00 /wk	43,200	-	-	43,200
			----	Rent Office Trailer, 50' X 10'			4.00	mnt		-	-	-	-	-	-	-	298.29 /mnt	1,193	-	-	1,193
				0250A Construct Pipeline from EMWMF to LGWO (or OF200) Plus Lift Station														155,993			155,993
		0250B																			
			Laborer II	Laborer, Group II, CLA + Burden			240.00	hr		-	-	-	-	-	-	-	33.62 /hr	8,069	-	-	8,069
			Oper A - Frmn	Equip. Operator, Group A, Foreman. CLA + Burden			40.00	hr		-	-	-	-	-	-	-	50.56 /hr	2,022	-	-	2,022
			PipeFttr	Pipe Fitter - Journeyman, CLA + Burden			160.00	hr		-	-	-	-	-	-	-	47.26 /hr	7,562	-	-	7,562
			PipeFttr - Frmn	Pipe Fitter - Foreman, CLA + Burden			40.00	hr		-	-	-	-	-	-	-	49.69 /hr	1,988	-	-	1,988
			Tmstr Drvr	Teamster - Truck Driver, CLA + Burden			40.00	hr		-	-	-	-	-	-	-	35.57 /hr	1,423	-	-	1,423
			----	Mob. Equipment & Job Trailer			1.00	ls		-	-	-	-	-	-	-	8,000.00 /ls	8,000	-	-	8,000
				0250B														29,063			29,063
		0250C																			
			Laborer II	Laborer, Group II, CLA + Burden		2 each for 6 weeks = 480 Hrs	480.00	hr		-	-	-	-	-	-	-	33.62 /hr	16,138	-	-	16,138
			Oper A - Frmn	Equip. Operator, Group A, Foreman. CLA + Burden		6 weeks	240.00	hr		-	-	-	-	-	-	-	50.56 /hr	12,134	-	-	12,134
			----	Rent Wheel Trencher		Average 1,000 LF per day	1.30	mnt		-	-	-	-	-	-	-	17,005.90 /mnt	22,108	-	-	22,108
			----	Rent Wheel Trencher Operatng Rate			240.00	hr		-	-	-	-	-	-	-	98.11 /hr	23,546	-	-	23,546
			----	PPE Level D			720.00	hr		-	-	-	-	-	-	-	5.00 /hr	3,600	-	-	3,600
				0250C														77,526			77,526
		0250D																			
			Laborer II	Laborer, Group II, CLA + Burden		3 each to lay sand bedding in bottom of trench - 380 hrs/ea	1,140.00	hr		-	-	-	-	-	-	-	33.62 /hr	38,327	-	-	38,327
			PipeFttr	Pipe Fitter - Journeyman, CLA + Burden		4 each	1,520.00	hr		-	-	-	-	-	-	-	47.26 /hr	71,836	-	-	71,836
			PipeFttr - Frmn	Pipe Fitter - Foreman, CLA + Burden		1 each	380.00	hr		-	-	-	-	-	-	-	49.69 /hr	18,882	-	-	18,882
			----	Leak Detection Sensors & Alarms		Price from P2S - add 8% to WBCV estimate	1.00	ls		-	-	-	-	-	-	-	33,566.00 /ls	33,566	-	-	33,566
			----	Power & Communication		from P2S - add 8% to WBCV estimate	1.00	ls		-	-	-	-	-	-	-	43,195.00 /ls	43,195	-	-	43,195
			----	Manufactured Sand , Delivered		.5'X1.5'X18,875' /27CF/CY= 527 CY @ 2,850 lb/CY /2,000lb/tn = 751 Tn with waste call it 760 tons	760.00	ton		-	-	-	-	-	-	-	18.85 /ton	14,326	-	-	14,326
			----	SDR11 4" X 8" SDR17 HDPE Double Wall Pipe		RS Means 22.11.13.78.5090. Approx. 17,250 feet + 10% for waste and hook-ups = 18,975 LF. 20 foot lengths - 18,980	18,980.00	lf		-	-	-	-	-	-	-	20.50 /lf	389,090	-	-	389,090
			----	Allowance for Fittings at 5%			0.05	pct		-	-	-	-	-	-	-	389,090.00 /pct	19,455	-	-	19,455
			----	Rent Welding Machine Means 22.11.13.78.9390			40.00	day		-	-	-	-	-	-	-	207.00 /day	8,280	-	-	8,280
			----	PPE Level D			3,040.00	hr		-	-	-	-	-	-	-	0.24 /hr	730	-	-	730
				0250D														637,686			637,686
		0250E																			
			----	Install 2 Pumps, Concr. Pad, Prefab. Metal Bldg		from P2S	1.00	ls		-	-	-	-	-	-	-	110,000.00 /ls	110,000	-	-	110,000
			----	Install Emergency Generator		from P2S	1.00	ls		-	-	-	-	-	-	-	15,000.00 /ls	15,000	-	-	15,000
			----	Install Emergency Generator		from P2S	1.00	ls		-	-	-	-	-	-	-	15,000.00 /ls	15,000	-	-	15,000
				0250E														140,000			140,000
		0250F																			
			Laborer II	Laborer, Group II, CLA + Burden		2 each for 9 weeks = 720 Hrs	720.00	hr		-	-	-	-	-	-	-	33.62 /hr	24,206	-	-	24,206
			Oper A - Frmn	Equip. Operator, Group A, Foreman. CLA + Burden		9 weeks	360.00	hr		-	-	-	-	-	-	-	50.56 /hr	18,202	-	-	18,202
			----	Replace Asphalt & Concrete Allowance		from P2S - add 8% to WBCV estimate	1.00	ls		-	-	-	-	-	-	-	56,769.00 /ls	56,769	-	-	56,769
			----	Manufactured Sand , Delivered		1 foot for around pipe and cover is double needed for bedding. Rogers price.	1,555.00	ton		-	-	-	-	-	-	-	18.85 /ton	29,312	-	-	29,312
			----	Underground Safety Tape Alum Backing		add 8% to WBCV estimate	192.00	clf		-	-	-	-	-	-	-	22.87 /clf	4,391	-	-	4,391
			----	Rent Manual Guided Compactor		Follow Pipe Installation	9.00	wk		-	-	-	-	-	-	-	898.68 /wk	8,088	-	-	8,088

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0250F																		
			----	Rent Backhoe-Loader, 5/8 CY		includes operating rate	9.00 wk		-	-	-	-	-	-	-	1,296.68 /wk	11,670	-	-	11,670
			----	Seed & Mulch by Hand Allowance		add 8% to WBCV estimate	1.00 ls		-	-	-	-	-	-	-	2,700.00 /ls	2,700	-	-	2,700
			----	PPE Level D			1,080.00 hr		-	-	-	-	-	-	-	0.24 /hr	259	-	-	259
				0250F													155,697			155,697
		0250G																		
			Laborer II	Laborer, Group II, CLA + Burden		2 each	80.00 hr		-	-	-	-	-	-	-	33.62 /hr	2,690	-	-	2,690
			Oper A - Frmn	Equip. Operator, Group A, Foreman. CLA + Burden		1 week	40.00 hr		-	-	-	-	-	-	-	50.56 /hr	2,022	-	-	2,022
			----	Demobilization Allowance			1.00 ls		-	-	-	-	-	-	-	5,000.00 /ls	5,000	-	-	5,000
			----	Rent Backhoe-Loader, 5/8 CY			1.00 wk		-	-	-	-	-	-	-	1,296.68 /wk	1,297	-	-	1,297
			----	PPE Level D			120.00 hr		-	-	-	-	-	-	-	5.00 /hr	600	-	-	600
				0250G													11,609			11,609
		0250H																		
			----	Component Testing & System Operability Allowance		from P2S	1.00 ls		-	-	-	-	-	-	-	117,300.00 /ls	117,300	-	-	117,300
				0250H													117,300			117,300
		0250I		Subcontract Overhead and Profit																
			----	Subcontract Overhead and Profit		Subcontractor Overhead and Profit at 25%	0.25 ls		-	-	-	-	-	-	-	1,324,773.00 /ls	331,193	-	-	331,193
				0250I Subcontract Overhead and Profit													331,193			331,193
				0250 Construct Pipeline from EMWMF to LGWO (or OF200) Plus Lift Station													**1,655,967**			**1,655,967**
	0290			**Construct Additional Water Storage at OF200**																
		0290		Construct Additional Water Storage at OF200																
			----	New Tank and associated pumps, foundations, etc		From Tyler Searle - Exclude Markups & Fee	1.00 ls		-	-	-	-	-	-	-	615,000.00 /ls	615,000	-	-	615,000
				0290 Construct Additional Water Storage at OF200													615,000			615,000
		0291		Subcontract Overhead and Profit																
			----	Subcontract Overhead and Profit		Subcontractor Overhead and Profit at 25%	0.25 ls		-	-	-	-	-	-	-	615,000.00 /ls	153,750	-	-	153,750
				0291 Subcontract Overhead and Profit													153,750			153,750
				0290 Construct Additional Water Storage at OF200													**768,750**			**768,750**
				01.01.02 Capital Costs During Construction Phase (1 yr duration)						**4,692.00**	**418,123**		**10,802**				**2,424,717**		**6,664,428**	**9,518,070**
01.01.05				**O&M Costs During EMDF Operations and Closure (30 yrs duration)**																
	0510			**Perform Project Management During EMDF Operations**																
		0510		Perform Project Management During EMDF Operations																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.13 ea	56,400.00 hr/ea	88.87 /hr	7,050.00	627,239	-	-	-	-	-	-	-	-	627,239
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.05 ea	56,400.00 hr/ea	71.30 /hr	2,820.00	201,066	-	-	-	-	-	-	-	-	201,066
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.25 ea	56,400.00 hr/ea	139.59 /hr	14,100.00	1,968,219	-	-	-	-	-	-	-	-	1,968,219
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.13 ea	56,400.00 hr/ea	81.42 /hr	7,050.00	574,011	-	-	-	-	-	-	-	-	574,011
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.13 ea	56,400.00 hr/ea	47.47 /hr	7,050.00	334,664	-	-	-	-	-	-	-	-	334,664
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.13 ea	56,400.00 hr/ea	75.81 /hr	7,050.00	534,461	-	-	-	-	-	-	-	-	534,461
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.25 ea	56,400.00 hr/ea	120.72 /hr	14,100.00	1,702,152	-	-	-	-	-	-	-	-	1,702,152
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.13 ea	56,400.00 hr/ea	99.16 /hr	7,050.00	699,078	-	-	-	-	-	-	-	-	699,078
			OffSpply	Office Supplies, from R.S. Means monthly Cost			66,270.00 ea		-	-	-	0.54 /ea	35,638	-	-	-	-	-	-	35,638
				0510 Perform Project Management During EMDF Operations						66,270.00	6,640,889		35,638							6,676,527
				0510 Perform Project Management During EMDF Operations						**66,270.00**	**6,640,889**		**35,638**							**6,676,527**
	0520			**Operate Onsite Treatment Plant During EMDF Operations**																
		0520		Operate Onsite Treatment Plant During EMDF Operations																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		30 years at 2080 hours per year = 62400 hours	2.00 ea	62,400.00 hr/ea	52.93 /hr	124,800.00	6,605,664	-	-	-	-	-	-	-	-	6,605,664
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			0.12 ea	62,400.00 hr/ea	52.93 /hr	7,488.00	396,340	-	-	-	-	-	-	-	-	396,340

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0520		Operate Onsite Treatment Plant During EMDF Operations																
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	75.81 /hr	3,744.00	283,833	-	-	-	-	-	-	-	-	283,833
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	120.72 /hr	3,744.00	451,976	-	-	-	-	-	-	-	-	451,976
			PPE DMod	PPE Level D Modified			139,776.00 hr		-	-	-	4.50 /hr	628,957	-	-	-	-	-	-	628,957
				0520 Operate Onsite Treatment Plant During EMDF Operations						139,776.00	7,737,812		628,957							8,366,769
				0520 Operate Onsite Treatment Plant During EMDF Operations						139,776.00	7,737,812		628,957							8,366,769
	0530			Purchase GAC and/or Treatment Resins																
		0530		Purchase GAC and/or Treatment Resins																
			---	Annual Material Allowance		(Per R. McDonnell - $88,000/year allowance for GAC treatment technology. Per Ray and Stephen Hahn new technology is Ion Exchange and material allowance for Ion Exchange is approximately twice the needed allowance for GAC, therefore use 2 x $88,000/year or $176,000/year for mateirals) (plus tax)	30.00 yr		-	-	-	193,160.00 /yr	5,794,800	-	-	-	-	-	-	5,794,800
				0530 Purchase GAC and/or Treatment Resins									5,794,800							5,794,800
				0530 Purchase GAC and/or Treatment Resins									5,794,800							5,794,800
	0540			Freight on Materials																
		0540		Freight on Materials																
			---	Freight on Materials		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15. ACCT 80	0.08 pct		-	-	-	-	-	-	-	-	-	5,794,800.00 /pct	463,584	463,584
				0540 Freight on Materials															463,584	463,584
				0540 Freight on Materials															463,584	463,584
	0550			Operate Pipeline During EMDF Operations																
		0550		Operate Pipeline During EMDF Operations																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		Assume 1/3 of a FTE to cover incremental work. (30 yrs)	0.33 ea	62,400.00 hr/ea	52.93 /hr	20,592.00	1,089,935	-	-	-	-	-	-	-	-	1,089,935
			PPE DMod	PPE Level D Modified			20,592.00 hr		-	-	-	9.88 /hr	203,397	-	-	-	-	-	-	203,397
			---	Annual Material Allowance			30.00 yr		-	-	-	5,487.50 /yr	164,625	-	-	-	-	-	-	164,625
				0550 Operate Pipeline During EMDF Operations						20,592.00	1,089,935		368,022							1,457,957
				0550 Operate Pipeline During EMDF Operations						20,592.00	1,089,935		368,022							1,457,957
	0560			Sample/Test Leachate During EMDF Operations																
		0560		Sample/Test Leachate During EMDF Operations																
			---	Annual Analytical Costs		per FFS project team (plus additional 10% for analysis at receiving facility 212,517 x 1.1=233,769)	30.00 yr		-	-	-	-	-	-	-	-	-	233,769.00 /yr	7,013,070	7,013,070
				0560 Sample/Test Leachate During EMDF Operations															7,013,070	7,013,070
				0560 Sample/Test Leachate During EMDF Operations															7,013,070	7,013,070
				01.01.05 O&M Costs During EMDF Operations and Closure (30 yrs duration)						226,638.00	15,468,635		6,827,418						7,476,654	29,772,707
01.01.07				**O&M Costs During Post-Closure EMDF (30 yrs duration)**																
	0610			Perform Project Management During EMDF Post-Closure																
		0610		Perform Project Management During EMDF Post-Closure																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.05 ea	56,400.00 hr/ea	88.97 /hr	2,820.00	250,895	-	-	-	-	-	-	-	-	250,895
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.03 ea	56,400.00 hr/ea	71.30 /hr	1,410.00	100,533	-	-	-	-	-	-	-	-	100,533
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.10 ea	56,400.00 hr/ea	139.59 /hr	5,640.00	787,288	-	-	-	-	-	-	-	-	787,288
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.05 ea	56,400.00 hr/ea	81.42 /hr	2,820.00	229,604	-	-	-	-	-	-	-	-	229,604
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.05 ea	56,400.00 hr/ea	47.47 /hr	2,820.00	133,865	-	-	-	-	-	-	-	-	133,865

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0610		Perform Project Management During EMDF Post-Closure																
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.05 ea	56,400.00 hr/ea	75.81 /hr	2,820.00	213,784	-	-	-	-	-	-	-	-	213,784
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.10 ea	56,400.00 hr/ea	120.72 /hr	5,640.00	680,861	-	-	-	-	-	-	-	-	680,861
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.05 ea	56,400.00 hr/ea	99.16 /hr	2,820.00	279,631	-	-	-	-	-	-	-	-	279,631
			OffSpply	Office Supplies, from R.S. Means monthly Cost			26,790.00 ea		-	-	-	0.54 /ea	14,407	-	-	-	-	-	-	14,407
				0610 Perform Project Management During EMDF Post-Closure						26,790.00	2,676,462		14,407							2,690,869
				0610 Perform Project Management During EMDF Post-Closure						**26,790.00**	**2,676,462**		**14,407**							**2,690,869**
	0620			**Operate Onsite Treatment Plant During Post-Closure EMDF**																
		0620		Operate Onsite Treatment Plant During Post-Closure EMDF																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		1 day once a month for 30 years. 2 personnel ont including drivers.	2.00 ea	3,600.00 hr/ea	52.93 /hr	7,200.00	381,096	-	-	-	-	-	-	-	-	381,096
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		1 day once a month for 30 years	0.50 ea	3,600.00 hr/ea	75.81 /hr	1,800.00	136,458	-	-	-	-	-	-	-	-	136,458
			RSISA09	Senior Staff Engineer/Scientist (FY16 Rev1 B06)		1 day once a month for 30 years	2.00 ea	3,600.00 hr/ea	108.11 /hr	7,200.00	778,392	-	-	-	-	-	-	-	-	778,392
			SPTSA03	Senior RPT (FY16 Rev1 B06)		1 day once a month for 30 years	0.50 ea	3,600.00 hr/ea	43.69 /hr	1,800.00	78,642	-	-	-	-	-	-	-	-	78,642
			----	Material Allowance			30.00 yr		-	-	-	3,292.50 /yr	98,775	-	-	-	-	-	-	98,775
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF						18,000.00	1,374,588		98,775							1,473,363
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF						**18,000.00**	**1,374,588**		**98,775**							**1,473,363**
	0630			**Sample/Test Leachate During Post-Closure EMDF**																
		0630		Sample/Test Leachate During Post-Closure EMDF																
			----	Sampling/Analytical		From FFS team	30.00 yr		-	-	-	-	-	-	-	-	-	36,596.00 /yr	1,097,880	1,097,880
				0630 Sample/Test Leachate During Post-Closure EMDF															1,097,880	1,097,880
				0630 Sample/Test Leachate During Post-Closure EMDF															**1,097,880**	**1,097,880**
				01.01.07 O&M Costs During Post-Closure EMDF (30 yrs duration)						**44,790.00**	**4,051,050**		**113,182**						**1,097,880**	**5,262,112**

Estimate Totals

Description	Amount	Totals	Hours	Rate	Cost Basis	Cost per Unit	Percent of Total	
Labor	20,561,521		282,036 hrs				44.23%	
Material	6,954,560						14.96%	
Equipment								
Subcontract	2,424,717						5.22%	
Other	16,551,343						35.60%	
	46,492,141	46,492,141					100.00	100.00%
Total		46,492,141						

Basis of Estimate
EMWMF/EMDF Leachate Focused Feasibility Study: Alternative 4b:
OF200 Treatment and Trucking Alternative
February 10, 2016

Objective/Scope:

Method of Accomplishment:

URS|CH2M Oak Ridge LLC (UCOR) provides project management during design of a new Treatment Plant at the Environmental Management Waste Management Facility (EMWMF) and the loading and unloading stations at EMWMF and OF200, preparation of required regulatory documents, project and construction management/oversight during facility and transfer station and additional storage capacity construction, facility operational readiness and startup, oversight and operations of the facility for thirty years (as well as oversight and operations during post-closure, also for thirty years), and the trucking of leachate and contact water from the landfill to OF200. Subcontractors will perform the actual design of the treatment facility and transfer stations, conduct necessary treatability studies, and perform the actual construction of the facilities. Subcontract labs were also assumed to provide the analytical service of samples taken during operations and post-closure.

Estimate Type and Approach:

This feasibility estimate is based upon similar work proposed in the past and work experience. The estimate was developed using a combination of bottoms-up approach, parametric data from similar projects, actual costs of similar work, and estimator and team experience with similar projects and existing operations.

Key Financial Data:

1. The estimate was prepared in the second quarter of fiscal year (FY)2016.
2. Any actual costs of work or similar work were provided by the project team.
3. General and Administrative costs and fee are not included in this estimate.
4. All UCOR and staff augmentation rates are fully burdened, including fringes. Staff augmentation rates include overhead and profit.
5. A sales tax of 9.75% has been included on all material.
6. All prices are in FY2016 dollars and no escalation has been included.
7. There is no contingency in this estimate.
8. UCOR and staff augmentation rates were used for the U.S. Department of Energy prime contractor.

Estimate Assumptions and Exclusions:

1. One Full Time Equivalent (FTE) is equal to 1880 man-hours per year.
2. One FTE for facility operations is 2080 man-hours per year.
3. The Conceptual Design Report and the Critical Decision (CD-1, -2, -3, and -4) process was not included in this estimate.
4. The cost for final closure of the Environmental Management Disposal Facility (EMDF) is not included in this estimate.
5. There are no decontamination and demolition costs included in this estimate.

6. Design of the facilities is estimated at 15% of the total construction cost for the facilities (water treatment, transfer stations at the landfill and the receiving site, and for increased storage capacity).
7. Construction management for the facilities is estimated at 8% of the total construction cost for the facilities (water treatment, transfer stations at the landfill and the receiving site, and for increased storage capacity).
8. The treatability study is based on an AECOM estimate for the construction of the treatment facility; reference Landfill Wastewater Treatment System, dated 10/23/2015.
9. The following regulatory documents are included in this estimate: Post Construction Closure Report, Remedial Action Work Plan, Remedial Action Work Plan/Remedial Design Report, Record of Decision/Environmental Stewardship Document, and a Waste Acceptance Criteria.
10. The actual treatment facility construction estimate is based on an AECOM estimate, dated 10/23/2015. The estimate for the facility less additional storage capacity was $6,905,000. The preliminary and final design, along with the treatability study, was deducted and is shown elsewhere within the estimate.
11. Subcontractor Overhead and Profit is included in the estimate at 25% of the construction estimate for the transfer stations at the landfill and the receiving site, and for increased storage capacity. Overhead and Profit was not added to the treatment facility construction because it is already included in the AECOM estimate.
12. Operations of the treatment facility during the EMDF operating period was estimated at 30 years.
13. An annual material allowance for treatment related materials is included in the estimate. Activated Carbon was considered as the treatment technology initially and an estimate was provided of $88,000 per year for materials. The technology was later changed to Ion Exchange; subject matter experts estimate that the material allowance for Ion Exchange should be twice the amount for Activated Carbon.
14. Freight for the treatment materials delivery is included in the estimate at 8% of the material cost. This is based on the AECOM estimate for the treatment facility dated 10/23/2015.
15. Annual analytical cost allowances during the time of the facility operation are included in the estimate and they were provided by the Feasibility Study project team. Their estimate was increased by 10% to allow for additional sampling and analysis of water at the receiving facility.
16. Leachate and contact water transportation costs during the 30 years of facility operations are included in the estimate. The annual value is based on FY15 actual transportation costs adjusted to remove elements not directly associated with transportation of the water and to cover projected increases in the number of truck loads required during operations.
17. Operations of the treatment facility during the EMDF post-closure period were estimated at 30 years.
18. Annual analytical cost allowances during the time of post-closure are included in the estimate for a period of 30 years and they were provided by the Feasibility Study project team.
19. The estimate includes trucking of EMDF leachate water during post-closure. The estimate is based on two tractor/tankers one day per month for 30 years.

Schedule Assumptions:

1. No funding limitation impacts will be experienced.
2. Design will take approximately 12 months.
3. All construction is expected to take approximately 12 months.
4. The operation and maintenance of the treatment system is expected to last 30 years.
5. Post-closure leachate management is expected to last 30 years.

Estimate Uncertainty:

The estimate was prepared in support of a Feasibility Study quality, which places it as a Class 4 estimate as defined by the Association for the Advancement of Cost Engineering International. The uncertainty range for Class 4 estimates can be as low as -30% to as high as +50%. The recommended level of uncertainty to apply to this estimate is -20% to +40%.

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ESTIMATOR:	DATE:
PROJECT MANAGER:	DATE:
ESTIMATING MANAGER:	DATE:

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
01.01.01				**Capital Costs During Design Phase**																
	0100			**Perform Project Management During Design Phase**																
		0100		**Perform Project Management During Design Phase**																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25 ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25 ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25 ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25 ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25 ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25 FTE	0.25 ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25 ea	1,880.00 hr/ea	120.72 /hr	470.00	56,738	-	-	-	-	-	-	-	-	56,738
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0. 25 FTE	0.25 ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost			3,760.00 ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0100 Perform Project Management During Design Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
				0100 Perform Project Management During Design Phase						**3,760.00**	**340,487**		**2,022**							**342,509**
	0200			**Design Facilities**																
		0200		**Design Facilities**																
			---	Design Facilities		Calculated based on 15% of total construction cost (820,815+528,125+5,991,158+768,750=7,908,848)	0.15 pct		-	-	-	-	-	-	-	-	-	7,908,848.00 /pct	1,186,327	1,186,327
				0200 Design Facilities															**1,186,327**	**1,186,327**
				0200 Design Facilities															**1,186,327**	**1,186,327**
	0300			**Conduct Treatability Study**																
		0300		**Conduct Treatability Study**																
			---	Treatability Study		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15 under Direct Field Cost, Acct **	1.00 ea		-	-	-	-	-	-	-	-	-	50,000.00 /ea	50,000	50,000
				0300 Conduct Treatability Study															**50,000**	**50,000**
				0300 Conduct Treatability Study															**50,000**	**50,000**
	0400			**Prepare Regulatory Documents**																
		PCCR		**PCCR**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				PCCR PCCR						**539.00**	**70,807**		**284**							**71,090**
		RAWP		**RAWP**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP RAWP						**539.00**	**70,807**		**284**							**71,090**
		RAWP/RDR		**RAWP/RDR**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			197.00 ea	1.00 hr/ea	180.10 /hr	197.00	35,480	-	-	-	-	-	-	-	-	35,480
			RSISA05	Technician (FY16 Rev1 B06)			93.00 ea	1.00 hr/ea	56.64 /hr	93.00	5,268	-	-	-	-	-	-	-	-	5,268
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			249.00 ea	1.00 hr/ea	120.72 /hr	249.00	30,059	-	-	-	-	-	-	-	-	30,059
			OffSpply	Office Supplies, from R.S. Means monthly Cost			539.00 hr		-	-	-	0.53 /hr	284	-	-	-	-	-	-	284
				RAWP/RDR RAWP/RDR						**539.00**	**70,807**		**284**							**71,090**
		ROD ESD		**ROD ESD**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030
			OffSpply	Office Supplies, from R.S. Means monthly Cost			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142
				ROD ESD ROD ESD						**269.50**	**35,403**		**142**							**35,545**
		WAC Revision		**WAC Revision**																
			RSISA04	Principal Engineer (FY16 Rev1 B06)			98.50 ea	1.00 hr/ea	180.10 /hr	98.50	17,740	-	-	-	-	-	-	-	-	17,740
			RSISA05	Technician (FY16 Rev1 B06)			46.50 ea	1.00 hr/ea	56.64 /hr	46.50	2,634	-	-	-	-	-	-	-	-	2,634
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			124.50 ea	1.00 hr/ea	120.72 /hr	124.50	15,030	-	-	-	-	-	-	-	-	15,030
			OffSpply	Office Supplies, from R.S. Means monthly Cost			269.50 hr		-	-	-	0.53 /hr	142	-	-	-	-	-	-	142

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY	UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
				WAC Revision WAC Revision							269.50	35,403		142							35,545
				0400 Prepare Regulatory Documents							**2,156.00**	**283,226**		**1,136**							**284,362**
				01.01.01 Capital Costs During Design Phase							**5,916.00**	**623,713**		**3,158**						**1,236,327**	**1,863,198**
01.01.02				**Capital Costs During Construction Phase (1 yr duration)**																	
	0120			**Perform Project Management During Construction Phase**																	
		0120		Perform Project Management During Construction Phase																	
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer - 0.25 FTE	0.25	ea	1,880.00 hr/ea	88.97 /hr	470.00	41,816	-	-	-	-	-	-	-	-	41,816
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement - 0.25 FTE	0.25	ea	1,880.00 hr/ea	71.30 /hr	470.00	33,511	-	-	-	-	-	-	-	-	33,511
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager - .25 FTE	0.25	ea	1,880.00 hr/ea	139.59 /hr	470.00	65,607	-	-	-	-	-	-	-	-	65,607
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA - 0.25 FTE	0.25	ea	1,880.00 hr/ea	81.42 /hr	470.00	38,267	-	-	-	-	-	-	-	-	38,267
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin - 0.25 FTE	0.25	ea	1,880.00 hr/ea	47.47 /hr	470.00	22,311	-	-	-	-	-	-	-	-	22,311
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H - .25	0.25	ea	1,880.00 hr/ea	75.81 /hr	470.00	35,631	-	-	-	-	-	-	-	-	35,631
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr - .25 FTE	0.25	ea	1,880.00 hr/ea	120.72 /hr	470.00	56,739	-	-	-	-	-	-	-	-	56,739
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE - 0.25 FTE	0.25	ea	1,880.00 hr/ea	99.16 /hr	470.00	46,605	-	-	-	-	-	-	-	-	46,605
			OffSpply	Office Supplies, from R.S. Means monthly Cost			3,760.00	ea		-	-	-	0.54 /ea	2,022	-	-	-	-	-	-	2,022
				0120 Perform Project Management During Construction Phase							3,760.00	340,487		2,022							342,509
				0120 Perform Project Management During Construction Phase							**3,760.00**	**340,487**		**2,022**							**342,509**
	0220			**Perform Construction Management During Construction Phase**																	
		0220		Perform Construction Management During Construction Phase																	
			----	Construction Management		Calculated based on 8% of total construction cost (620,815+528,125+5,991,158+768,750=7,908,848)	0.08	pct		-	-	-	-	-	-	-	-	-	7,908,848.00 /pct	632,708	632,708
				0220 Perform Construction Management During Construction Phase																632,708	632,708
				0220 Perform Construction Management During Construction Phase																**632,708**	**632,708**
	0230			**Perform Operational Readiness and Startup**																	
		0231		Procedures and Training																	
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.50	ea	80.00 hr/ea	75.81 /hr	40.00	3,032	-	-	-	-	-	-	-	-	3,032
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00	ea	80.00 hr/ea	120.72 /hr	160.00	19,315	-	-	-	-	-	-	-	-	19,315
			----	Material Allowance			1.00	ls		-	-	-	3,292.50 /ls	3,293	-	-	-	-	-	-	3,293
				0231 Procedures and Training							200.00	22,348		3,293							25,640
		0232		Readiness and Startup																	
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			4.00	ea	120.00 hr/ea	52.93 /hr	480.00	25,408	-	-	-	-	-	-	-	-	25,408
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.10	ea	120.00 hr/ea	75.81 /hr	12.00	910	-	-	-	-	-	-	-	-	910
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			2.00	ea	120.00 hr/ea	120.72 /hr	240.00	28,973	-	-	-	-	-	-	-	-	28,973
			----	Material Allowance			1.00	ls		-	-	-	5,487.50 /ls	5,488	-	-	-	-	-	-	5,488
				0232 Readiness and Startup							732.00	55,289		5,488							60,776
				0230 Perform Operational Readiness and Startup		**Reference EMWMF/EMDF Leachate Feasibility Study On-Site Treatment Estimate, log # 20150324B_0 dated 4/8/15.**					**932.00**	**77,637**		**8,780**							**86,417**
	0240			**Construct Treatment Plant at EMWMF**																	
		0240		Construct Treatment Plant at EMWMF																	
			----	Construct Treatment Plant at EMWMF		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15. Estimate less additional storage was calculated at $6,905,000. Remove Preliminary and Final Design and Treatability Study which are all covered	1.00	ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY	UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0240		Construct Treatment Plant at EMWMF																	
			----	Construct Treatment Plant at EMWMF		elsewhere for a resulting total of 5,991,158	1.00	ls		-	-	-	-	-	-	-	-	-	5,991,158.00 /ls	5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF																5,991,158	5,991,158
				0240 Construct Treatment Plant at EMWMF																**5,991,158**	**5,991,158**
	0260			**Construct Tanker Loading Stations at EMWMF plus Purchase Additional Ta**																	
		0261		Construct New Loading Stations																	
			----	Remove Existing Loading		from FFS Team	1.00	ls		-	-	-	-	-	-	-	2,000.00 /ls	2,000	-	-	2,000
			----	Install New Footing/Foundation for Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	15,000.00 /ls	15,000	-	-	15,000
			----	Procure Loaing Arm & Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	65,000.00 /ls	65,000	-	-	65,000
			----	Modify Existing Loading Arm Support		from FFS Team	1.00	ls		-	-	-	-	-	-	-	8,000.00 /ls	8,000	-	-	8,000
			----	Install Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	9,000.00 /ls	9,000	-	-	9,000
			----	Install Loading Arm		from FFS Team	1.00	ls		-	-	-	-	-	-	-	3,000.00 /ls	3,000	-	-	3,000
			----	Piping, Electrical, Insulation Allowance		from FFS Team	1.00	ls		-	-	-	-	-	-	-	10,500.00 /ls	10,500	-	-	10,500
			----	Prepare Subgrade for Unloading Slab		from FFS Team	1.00	ls		-	-	-	-	-	-	-	6,500.00 /ls	6,500	-	-	6,500
			----	Excavate & Form Slab, Access Platform, & Sump		from FFS Team	1.00	ls		-	-	-	-	-	-	-	9,500.00 /ls	9,500	-	-	9,500
			----	Place & Tie Rebar, Waterstop, Set Anchor Bolts, Etc		from FFS Team	1.00	ls		-	-	-	-	-	-	-	11,500.00 /ls	11,500	-	-	11,500
			----	Place & Finish Concrete		from FFS Team	1.00	ls		-	-	-	-	-	-	-	9,000.00 /ls	9,000	-	-	9,000
			----	Rack Forms & Backfill to Finished Grade		from FFS Team	1.00	ls		-	-	-	-	-	-	-	2,000.00 /ls	2,000	-	-	2,000
			----	Procure Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	65,000.00 /ls	65,000	-	-	65,000
			----	Install Access Platform		from FFS Team	1.00	ls		-	-	-	-	-	-	-	9,000.00 /ls	9,000	-	-	9,000
			----	Install Loading Arm		from FFS Team	1.00	ls		-	-	-	-	-	-	-	3,000.00 /ls	3,000	-	-	3,000
			----	Matl's/Labor for CWT's to Tanker Transfer Ancillary Equip		from FFS Team	1.00	ls		-	-	-	-	-	-	-	25,000.00 /ls	25,000	-	-	25,000
			----	Remove Existing Transfer Pump		from FFS Team	1.00	ls		-	-	-	-	-	-	-	1,500.00 /ls	1,500	-	-	1,500
			----	Install New 250 GPM Pump		from FFS Team	1.00	ls		-	-	-	-	-	-	-	8,000.00 /ls	8,000	-	-	8,000
				0261 Construct New Loading Stations														262,500			262,500
		0262		Purchase New Tankers																	
			----	Purchase Water Tanker Trailers			2.00	ea		-	-	-	-	-	-	-	-	-	80,000.00 /ea	160,000	160,000
				0262 Purchase New Tankers																160,000	160,000
		0263		Subcontractor Overhead and Profit																	
			----	Subcontractor Overhead and Profit		25% of subcontractor cost	0.25	ls		-	-	-	-	-	-	-	422,500.00 /ls	105,625	-	-	105,625
				0263 Subcontractor Overhead and Profit														105,625			105,625
				0260 Construct Tanker Loading Stations at EMWMF plus Purchase Additional Ta														**368,125**		**160,000**	**528,125**
	0270			**Construct Tanker Unloading Stations at LGWO (or OF200)**																	
		0270		Construct Tanker Unloading Stations at LGWO (or OF200)																	
			SPTSA03	Senior RPT (FY16 Rev1 B08)		Oversight During Excavation	1.00	ea	100.00 hr/ea	43.89 /hr	100.00	4,389	-	-	-	-	-	-	-	-	4,389
			Field Engr 01	Field Engineer, Maximum, R.S. Means CostWorks, Bare Cost		1 Safety & 1 Field Engr	9.00	wk		-	-	-	-	-	-	-	1,575.00 /wk	14,175	-	-	14,175
			Proj. Mgr. 01	Project Manager, Maximum, R.S. Means CostWorks, Bare Cost			4.50	wk		-	-	-	-	-	-	-	2,600.00 /wk	11,700	-	-	11,700
			Suptdt 01	Superintendent, Maximum, R.S. Means CostWorks, Bare Cost			4.50	wk		-	-	-	-	-	-	-	2,400.00 /wk	10,800	-	-	10,800
			TFE1.3.1.0	TFE: Straight Frame Tri-Axle Dump Truck, Regulated; Fueling,		Assume soil & concrete goes to EMWMF	1,000.00	hr		-	-	-	-	-	-	-	6.55 /hr	6,550	-	-	6,550
			TFE1.4.3.1	TFE: Staright Frame Tri-Axle Dump Truck, Non-Regulated, Incl All Maintenance; 1-10 Trks		10 trucks for 2.5 weeks	100.00	day		-	-	-	-	-	-	-	474.71 /day	47,471	-	-	47,471
			TFE1.6.1.3	TFE: Truck Operator; Fully Trained & Certified			1,000.00	hr		-	-	-	-	-	-	-	40.84 /hr	40,840	-	-	40,840
			TFE1.7.7.0	TFE: Clean Fill Haul, Includes Material;		3,300#/CY Bank (1250 CY* 3,300#/CY) / 2,000 /Ton =	2,063.00	ton		-	-	-	-	-	-	-	8.31 /ton	17,144	-	-	17,144
			----	Selective demolition, retaining walls, concrete retaining wall, 10' high, includes reinforcing			155.00	lf		-	-	-	-	-	-	-	284.49 /lf	44,096	-	-	44,096
			----	Cast-in place retaining walls, reinforced concrete cantilever, 33 degree slope embankment, 10' high, includes excavation, backfill & reinforcing			163.00	lf		-	-	-	-	-	-	-	333.80 /lf	54,409	-	-	54,409
			----	Excavating, trench or continuous footing, dense hard clay, 3/4 C.Y. excavator, 6' to 10' deep, excludes sheeting or dewatering		Additional excavation not included demolition and retaining wall	17,500.00	bcy		-	-	-	-	-	-	-	7.42 /bcy	129,850	-	-	129,850
			----	Pipe, stainless steel, threaded, 2" diameter, schedule 40, type 304, includes couplings and hangers 10' OC		Relocated pipe	90.00	lf		-	-	-	-	-	-	-	68.34 /lf	6,151	-	-	6,151

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0270		Construct Tanker Unloading Stations at LGWO (or OF200)																
			----	Structural concrete, in place, slab on grade (3500 psi), 6" thick, includes forms(4 uses), Grade 60 rebar, concrete (Portland cement Type I), and plac		Tanker spill containment slab	15.00 cy		-	-	-	-	-	-	-	152.70 /cy	2,291	-	-	2,291
			----	Structural concrete, thickened edge for slab on grade (3500 psi), depth is added to and poured monolithically with slab, 12" wide x 12" deep, unreinfo		Use price for curb	30.00 lf		-	-	-	-	-	-	-	8.75 /lf	263	-	-	263
			----	Sump and pipe Allowance			1.00 LS		-	-	-	-	-	-	-	750.00 /LS	750	-	-	750
			----	Pipe, stainless steel, threaded, 4" diameter, schedule 40, type 304, includes couplings and hangers 10' OC		Unloading pipe header	55.00 lf		-	-	-	-	-	-	-	173.80 /lf	9,559	-	-	9,559
			----	Asphaltic concrete paving, parking lots & driveways, 6" stone base, 4" binder course, 4" topping, no asphalt hauling included		Asphalt repair	3,000.00 sf		-	-	-	-	-	-	-	4.20 /sf	12,600	-	-	12,600
			----	Unidentified Upgrades Allowance			1.00 ls		-	-	-	-	-	-	-	75,000.00 /ls	75,000	-	-	75,000
			----	Seeding, mechanical seeding grass seed, 4.5 lbs per M.S.F., hand push spreader			3.75 msf		-	-	-	-	-	-	-	20.80 /msf	78	-	-	78
			----	Seeding, mechanical apply fertilizer, 35 lbs per M.S.F., hand push spreader			3.75 msf		-	-	-	-	-	-	-	15.31 /msf	57	-	-	57
			----	Mobilization & Training			1.00 ls		-	-	-	-	-	-	-	6,000.00 /ls	6,000	-	-	6,000
			----	Demobilization			1.00 ls		-	-	-	-	-	-	-	2,500.00 /ls	2,500	-	-	2,500
				0270 Construct Tanker Unloading Stations at LGWO (or OF200)						100.00	4,369						492,283			496,652
		0271		Subcontractor Overhead and Profit																
			----	Subcontractor Overhead and Profit		25% of subcontractor cost	0.25 ls		-	-	-	-	-	-	-	496,652.00 /ls	124,163	-	-	124,163
				0271 Subcontractor Overhead and Profit													124,163			124,163
				0270 Construct Tanker Unloading Stations at LGWO (or OF200)		**Estimated to be 50% of that required for Tanker Unloading Station for Alternative 3B**				**100.00**	**4,369**						**616,446**			**620,815**
	0290			**Construct Additional Water Storage at LGWO**																
		0290		Construct Additional Water Storage at LGWO																
			----	Construct Additional Water Storage at LGWO		New tank and associated pumps, foundations, etc. from Tyler Searle - Exclude Markups and fee	1.00 ls		-	-	-	-	-	-	-	615,000.00 /ls	615,000	-	-	615,000
				0290 Construct Additional Water Storage at LGWO													615,000			615,000
		0291		Subcontractor Overhead and Profit																
			----	Subcontractor Overhead and Profit		25% of subcontractor cost	0.25 ls		-	-	-	-	-	-	-	615,000.00 /ls	153,750	-	-	153,750
				0291 Subcontractor Overhead and Profit													153,750			153,750
				0290 Construct Additional Water Storage at LGWO													**768,750**			**768,750**
				01.01.02 Capital Costs During Construction Phase (1 yr duration)						**4,792.00**	**422,492**		**10,802**				**1,753,321**		**6,783,866**	**8,970,481**
01.01.05				**O&M Costs During EMDF Operations and Closure (30 yrs duration)**																
	0510			**Perform Project Management During EMDF Operations**																
		0510		Perform Project Management During EMDF Operations																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.13 ea	56,400.00 hr/ea	88.97 /hr	7,050.00	627,239	-	-	-	-	-	-	-	-	627,239
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.05 ea	56,400.00 hr/ea	71.30 /hr	2,820.00	201,066	-	-	-	-	-	-	-	-	201,066
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.25 ea	56,400.00 hr/ea	139.59 /hr	14,100.00	1,968,219	-	-	-	-	-	-	-	-	1,968,219
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.13 ea	56,400.00 hr/ea	81.42 /hr	7,050.00	574,011	-	-	-	-	-	-	-	-	574,011
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.13 ea	56,400.00 hr/ea	47.47 /hr	7,050.00	334,664	-	-	-	-	-	-	-	-	334,664
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.13 ea	56,400.00 hr/ea	75.81 /hr	7,050.00	534,461	-	-	-	-	-	-	-	-	534,461
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.25 ea	56,400.00 hr/ea	120.72 /hr	14,100.00	1,702,152	-	-	-	-	-	-	-	-	1,702,152
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.13 ea	56,400.00 hr/ea	99.16 /hr	7,050.00	699,078	-	-	-	-	-	-	-	-	699,078
			OffSpply	Office Supplies, from R.S. Means monthly Cost			66,270.00 ea		-	-	-	0.54 /ea	35,638	-	-	-	-	-	-	35,638
				0510 Perform Project Management During EMDF Operations						66,270.00	6,640,889		35,638							6,676,527

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
				0510 Perform Project Management During EMDF Operations						**66,270.00**	**6,640,889**		**35,638**							**6,676,527**
	0520			**Operate Onsite Treatment Plant During EMDF Operations**																
		0520		Operate Onsite Treatment Plant During EMDF Operations																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		30 years at 2080 hours per year = 62400 hours	2.00 ea	62,400.00 hr/ea	52.93 /hr	124,800.00	6,605,664	-	-	-	-	-	-	-	-	6,605,664
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)			0.12 ea	62,400.00 hr/ea	52.93 /hr	7,488.00	396,340	-	-	-	-	-	-	-	-	396,340
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	75.81 /hr	3,744.00	283,833	-	-	-	-	-	-	-	-	283,833
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)			0.06 ea	62,400.00 hr/ea	120.72 /hr	3,744.00	451,976	-	-	-	-	-	-	-	-	451,976
			PPE DMod	PPE Level D Modified			139,776.00 hr		-	-	-	4.50 /hr	628,957	-	-	-	-	-	-	628,957
				0520 Operate Onsite Treatment Plant During EMDF Operations						139,776.00	7,737,812		628,957							8,366,769
				0520 Operate Onsite Treatment Plant During EMDF Operations						**139,776.00**	**7,737,812**		**628,957**							**8,366,769**
	0530			**Purchase GAC and/or Treatment Resins**																
		0530		Purchase GAC and/or Treatment Resins																
			----	Annual Material Allowance		(Per R. McDonnell - $88,000/year allowance for GAC treatment technology. Per Ray and Stephen Hahn new technology is Ion Exchange and material allowance for Ion Exchange is approximately twice the needed allowance for GAC, therefore use 2 x $88,000/year or $176,000/year for mateirals) (plus tax)	30.00 yr		-	-	-	193,160.00 /yr	5,794,800	-	-	-	-	-	-	5,794,800
				0530 Purchase GAC and/or Treatment Resins									5,794,800							5,794,800
				0530 Purchase GAC and/or Treatment Resins									**5,794,800**							**5,794,800**
	0540			**Freight on Materials**																
		0540		Freight on Materials																
			----	Freight on Materials		Reference AECOM estimate for Landfill Wastewater Treatment System, dated 10/23/15. ACCT 80	0.08 pct		-	-	-	-	-	-	-	-	-	5,794,800.00 /pct	463,584	463,584
				0540 Freight on Materials															463,584	463,584
				0540 Freight on Materials															**463,584**	**463,584**
	0560			**Sample/Test Leachate During EMDF Operations**																
		0560		Sample/Test Leachate During EMDF Operations																
			----	Annual Analytical Costs		per FFS project team (plus 10% for additional analysis at receiving facility 212,517 x 11=233,769)	30.00 yr		-	-	-	-	-	-	-	-	-	233,769.00 /yr	7,013,070	7,013,070
				0560 Sample/Test Leachate During EMDF Operations															7,013,070	7,013,070
				0560 Sample/Test Leachate During EMDF Operations															**7,013,070**	**7,013,070**
	0570			**Truck Leachate Plus Contact Water During EMDF Operations**																
		0570		Truck Leachate Plus Contact Water During EMDF Operations																
			----	Leachate and Contact Water Transportation Cost		Based on FY15 actual transportation costs (reference ROS 280) adjusted to remove elements not associated with transportation costs, adjusted up to cover projected increases in number of truck loads	30.00 yr		-	-	-	-	-	-	-	-	-	1,500,000.00 /yr	45,000,000	45,000,000
				0570 Truck Leachate Plus Contact Water During EMDF Operations															45,000,000	45,000,000
				0570 Truck Leachate Plus Contact Water During EMDF Operations															**45,000,000**	**45,000,000**
				01.01.05 O&M Costs During EMDF Operations and Closure (30 yrs duration)						**206,046.00**	**14,378,701**		**6,459,395**						**52,476,654**	**73,314,750**
01.01.07				**O&M Costs During Post-Closure EMDF (30 yrs duration)**																
	0610			**Perform Project Management During EMDF Post-Closure**																

WBS	Activity	Task	Item	Description	Ex-hibit	Notes	QTY UM	Labor Hours	Labor Rate	Total Labor Hours	Total Labor	Unit Material Price	Total Material	Unit Equip Price	Total Equip	Unit Sub Price	Total Sub	Unit ODC Price	Total ODC	Total Amount
		0610		Perform Project Management During EMDF Post-Closure																
			32Labor	UCOR - Engineering (FY16 Rev1 B06)		Project Engineer	0.05 ea	56,400.00 hr/ea	88.97 /hr	2,820.00	250,895	-	-	-	-	-	-	-	-	250,895
			41Labor	UCOR - Procurement (FY16 Rev1 B06)		Procurement	0.03 ea	56,400.00 hr/ea	71.30 /hr	1,410.00	100,533	-	-	-	-	-	-	-	-	100,533
			51Labor	UCOR - Project Management (FY16 Rev1 B06)		Project Manager	0.10 ea	56,400.00 hr/ea	139.59 /hr	5,640.00	787,288	-	-	-	-	-	-	-	-	787,288
			52Labor	UCOR - Quality Assurance (FY16 Rev1 B06)		QA	0.05 ea	56,400.00 hr/ea	81.42 /hr	2,820.00	229,604	-	-	-	-	-	-	-	-	229,604
			55Labor	UCOR - Administrative Services (FY16 Rev1 B06)		Admin	0.05 ea	56,400.00 hr/ea	47.47 /hr	2,820.00	133,865	-	-	-	-	-	-	-	-	133,865
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		ES&H	0.05 ea	56,400.00 hr/ea	75.81 /hr	2,820.00	213,784	-	-	-	-	-	-	-	-	213,784
			RSISA08	Senior Engineer/Scientist (FY16 Rev1 B06)		Environmental Engr	0.10 ea	56,400.00 hr/ea	120.72 /hr	5,640.00	680,861	-	-	-	-	-	-	-	-	680,861
			SATCH03	SA Technical - Level 3 (FY16 Rev1 B06)		PCE	0.05 ea	56,400.00 hr/ea	99.16 /hr	2,820.00	279,631	-	-	-	-	-	-	-	-	279,631
			OffSpply	Office Supplies, from R.S. Means monthly Cost			26,790.00 ea		-	-	-	0.54 /ea	14,407	-	-	-	-	-	-	14,407
				0610 Perform Project Management During EMDF Post-Closure						26,790.00	2,676,462		14,407							2,690,869
				0610 Perform Project Management During EMDF Post-Closure						**26,790.00**	**2,676,462**		**14,407**							**2,690,869**
	0620			**Operate Onsite Treatment Plant During Post-Closure EMDF**																
		0620		Operate Onsite Treatment Plant During Post-Closure EMDF																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		1 day once a month for 30 years.	2.00 ea	3,600.00 hr/ea	52.93 /hr	7,200.00	381,096	-	-	-	-	-	-	-	-	381,096
			58Labor	UCOR - Environmental Safety & Health (FY16 Rev1 B06)		1 day once a month for 30 years	0.50 ea	3,600.00 hr/ea	75.81 /hr	1,800.00	136,458	-	-	-	-	-	-	-	-	136,458
			RSISA08	Senior Staff Engineer/Scientist (FY16 Rev1 B06)		1 day once a month for 30 years	2.00 ea	3,600.00 hr/ea	108.11 /hr	7,200.00	778,392	-	-	-	-	-	-	-	-	778,392
			SPTSA03	Senior RPT (FY16 Rev1 B06)		1 day once a month for 30 years	0.50 ea	3,600.00 hr/ea	43.69 /hr	1,800.00	78,642	-	-	-	-	-	-	-	-	78,642
			—	Material Allowance			30.00 yr		-	-	-	3,292.50 /yr	98,775	-	-	-	-	-	-	98,775
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF						18,000.00	1,374,588		98,775							1,473,363
				0620 Operate Onsite Treatment Plant During Post-Closure EMDF						**18,000.00**	**1,374,588**		**98,775**							**1,473,363**
	0630			**Sample/Test Leachate During Post-Closure EMDF**																
		0630		Sample/Test Leachate During Post-Closure EMDF																
			—	Sampling/Analytical		From FFS team	30.00 yr		-	-	-	-	-	-	-	-	-	36,596.00 /yr	1,097,880	1,097,880
				0630 Sample/Test Leachate During Post-Closure EMDF															1,097,880	1,097,880
				0630 Sample/Test Leachate During Post-Closure EMDF															**1,097,880**	**1,097,880**
	0640			**Truck EMDF Leachate During Post-Closure EMDF**																
		0640		Truck EMDF Leachate During Post-Closure EMDF																
			10Craft	Maintenance Skilled Craft Workers (FY16 Rev1 B06)		1 day once a month for 30 years. 2 personnel, drivers.	2.00 ea	3,600.00 hr/ea	52.93 /hr	7,200.00	381,096	-	-	-	-	-	-	-	-	381,096
			GFETrkTrctr	GFE Truck Tractor (Semi), 6X4, 400HP, Oper Cost		Assume 2 tractors @ 1 day/month for 30 years = 10 hrs X 12 months X 30 yrs X 2 ea = 7,200 hrs	7,200.00 hr		-	-	-	-	-	51.05 /hr	367,560	-	-	-	-	367,560
			GFEWtrTrlr	GFE Water Trailer, 5K Gallons, Oper Cost		2 trailers	7,200.00 hr		-	-	-	-	-	7.00 /hr	50,400	-	-	-	-	50,400
				0640 Truck EMDF Leachate During Post-Closure EMDF						7,200.00	381,096				417,960					799,056
				0640 Truck EMDF Leachate During Post-Closure EMDF						**7,200.00**	**381,096**				**417,960**					**799,056**
				01.01.07 O&M Costs During Post-Closure EMDF (30 yrs duration)						**51,990.00**	**4,432,146**		**113,182**		**417,960**				**1,097,880**	**6,061,168**

Estimate Totals

Description	Amount	Totals	Hours		Rate	Cost Basis	Cost per Unit	Percent of Total	
Labor	19,857,052		268,744 hrs					22.01%	
Material	6,586,537							7.30%	
Equipment	417,960		14,400	hrs				0.46%	
Subcontract	1,753,321							1.94%	
Other	61,594,727							68.28%	
	90,209,597	90,209,597						100.00	100.00%
Total		90,209,597							

APPENDIX J.
SCREENING WATER SAMPLING RESULTS
FOR EVALUATING COMPLIANCE WITH ARARs

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Screening Water Sampling Results for Evaluating Compliance with ARARs

In accordance with the Federal Facility Agreement (FFA) parties agreement, a post-Record of Decision FFA primary document, such as the Remedial Action Work Plan, will establish details of wastewater and/or receiving water sampling, fish tissue sampling, and other specifics of the monitoring and compliance program. This is consistent with the approach used for non-radiological chemicals with established Ambient Water Quality Criteria and/or Tennessee Water Quality Standards. As needed, compliance criteria that correspond with the Preliminary Remediation Goals/Cleanup Levels may be documented in an Explanation of Significant Differences.

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APPENDIX K.
DEVELOPMENT OF PRELIMINARY REMEDIATION GOALS FOR FISH TISSUE AND SURFACE WATER FOR LANDFILL WASTEWATER

K.1. DEVELOPMENT OF RADIOLOGICAL PRELIMINARY REMEDIATION GOALS FOR FISH TISSUE AND SURFACE WATER FOR LANDFILL WASTEWTER/BASELINE RISK ASSESSMENT

K.2. NON-RADIOLOGICAL DISCHARGE LIMITS

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CONTENTS

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OVERVIEW

Effluent from the existing disposal facility (EMWMF) and proposed future disposal facility (EMDF) will be discharged into Bear Creek, a 7.5 mile long (12 km) stream located entirely within the Oak Ridge Reservation (Fig. K.1). Bear Creek joins with East Fork Poplar Creek near the Heritage Center, flows into Poplar Creek, and eventually enters the Clinch River.

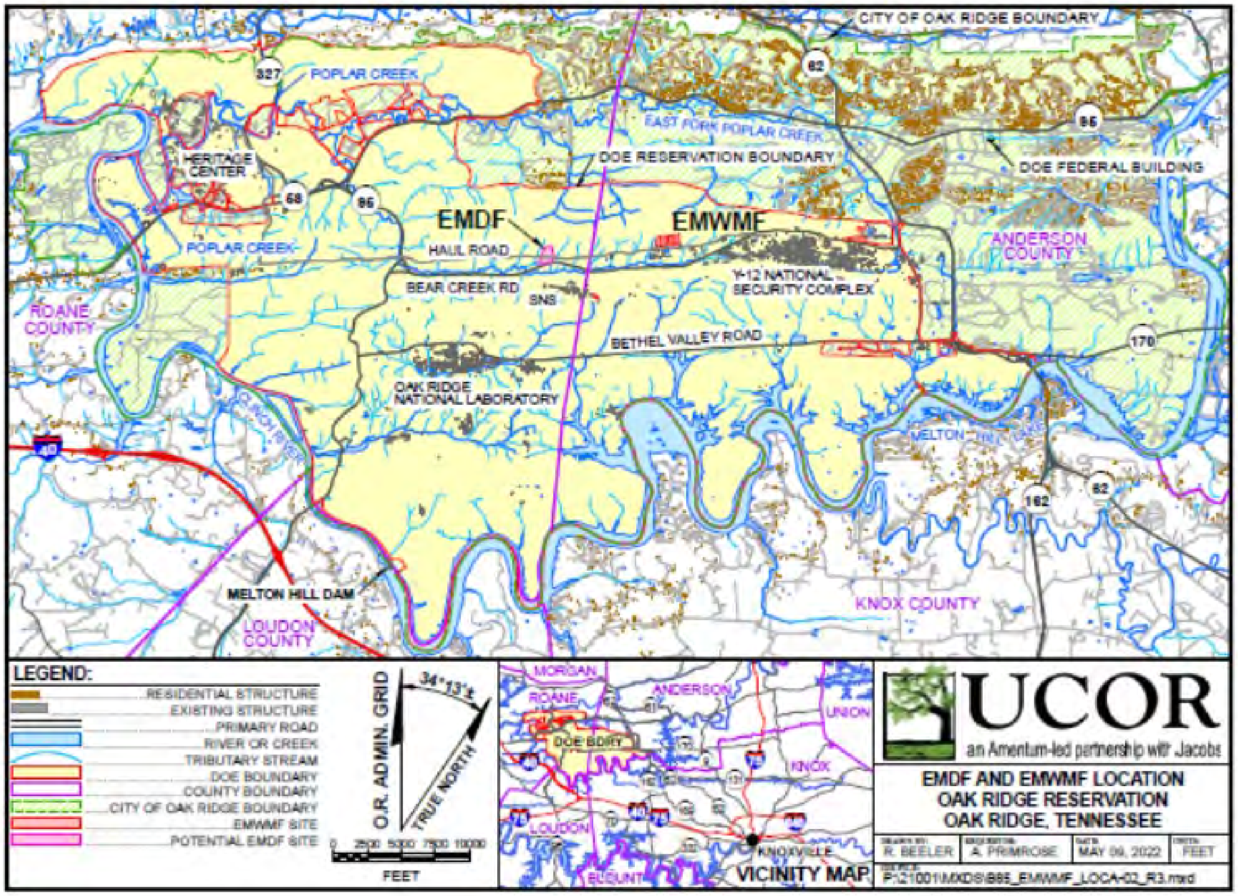

Fig. K.1. Oak Ridge Reservation Locations.

The current non-radiological and radiological landfill wastewater discharge limits for EMWMF were negotiated by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Tennessee Department of Environment and Conservation (TDEC) in 2002 and documented in the *Environmental Monitoring Plan* which is an appendix to the *Addendum to the Remedial Design Report for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee* (DOE/OR/01-1873&D2/A1/R2). Subsequent revisions to the *Environmental Monitoring Plan* were agreed to by DOE, EPA, and TDEC, and annual reports of the monitoring to verify compliance with the current discharge limits have been submitted by DOE to EPA and TDEC.

This *Focused Feasibility Study for Water Management for the Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2664&D3) (FFS) evaluates the management of landfill wastewater generated from EMWMF and the proposed EMDF. In order to ensure that the discharge of landfill wastewater is protective of human health and the environment and complies with applicable or relevant and appropriate requirements (ARARs), revised discharge limits for landfill wastewater into Bear Creek or its tributaries must be developed.

There are two components of this appendix:

- Chapter K.1—Baseline Risk Assessment and Radiological Discharge Limits/Preliminary Remediation Goals—total revision of the D3 FFS and new section created.
- Chapter K.2—Non-Radiological Discharge limits, including total uranium and mercury.

APPENDIX K.1
DEVELOPMENT OF RADIOLOGICAL PRELIMINARY REMEDIATION GOALS FOR FISH TISSUE AND SURFACE WATER FOR LANDFILL WASTEWATER/BASELINE RISK ASSESSMENT

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ACRONYMS

BCF	bioconcentration factor
BCK	Bear Creek kilometer
BFK	Brushy Fork kilometer
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COPC	contaminant of potential concern
CSF	cancer slope factor
DOE	U.S. Department of Energy
DQO	data quality objective
EFK	East Fork kilometer
EMDF	Environmental Management Disposal Facility
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
FFA	Federal Facility Agreement
HHRA	Human Health Risk Assessment
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ILCR	incremental lifetime cancer risk
MDC	maximum detected concentration
MLC	maximum contaminant level
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
POE	point of exposure
PRG	preliminary remediation goal
RESRAD	Residual Radioactive
RG	remediation goals
ROD	Record of Decision
SAP	sampling and analysis plan
SE	secular equilibrium
TDEC	Tennessee Department of Environment and Conservation
UCL-95	95th percentile upper confidence level
Y-12	Y-12 National Security Complex

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K.1 DEVELOPMENT OF RADIOLOGICAL PRELIMINARY REMEDIATION GOALS FOR FISH TISSUE AND SURFACE WATER FOR LANDFILL WASTEWATER/BASELINE RISK ASSESSMENT

K.1.1 INTRODUCTION AND OBJECTIVE

As noted in Sect. 1.1, this revision to the Federal Facility Study (FFS) addresses the direction given in the U.S. Environmental Protection Agency's (EPA's) Administrator's Dispute Resolution Decision (Wheeler, A. R. and Appendix M). The remediation goals (RGs) and preliminary discharge limits contained in this appendix were developed solely for the purpose of evaluating and screening landfill wastewater discharge alternatives. Final discharge limits will be developed by the Environmental Management Waste Management Facility (EMWMF) and the Environmental Management Disposal Facility (EMDF) project teams and will be provided in the EMWMF and EMDF Records of Decisions (RODs) and/or applicable post-ROD documents. As noted in the summary of issues (Appendix M):

> For the proposed landfill, final effluent limits will not be set until the Record of Decision is issued by the DOE and the EPA with the concurrence of the TDEC. For the existing landfill, the preliminary goals will inform effluent discharge limits that may be selected in a post-ROD modification to the EMWMF ROD that will govern future effluent discharges.

In accordance with the EPA's Administrator's Dispute Resolution Decision (Wheeler, A. R. and Appendix M), "the individual with the potential for reasonable maximum exposure to radionuclides in effluent from ORR landfills would be a recreational fisherman who fishes at a location downstream from the discharge." Therefore, the approach performed to obtain information and develop these risk-based radiological discharge limits is documented in this Appendix (Appendix K).

Landfill wastewater from EMWMF currently is being discharged in accordance with dose-based discharge limits per DOE Order 5400.5 (*Radiation Protection of the Public and the Environment*). Revised discharge limits were calculated utilizing default EPA risk assessment parameters for ingestion of fish.

A collaborative technical team was formed with U.S. Department of Energy (DOE), EPA, and Tennessee Department of Environment and Conservation (TDEC) technical staff and management to develop the risk-based discharge limits for 21 radionuclides and associated progeny, which bioaccumulate and have the potential to be present in landfill wastewater at some time during the operational life of EMDF. This included developing the approach for collecting fish tissue data, collecting, analyzing fish tissue and evaluating the results, determining fish consumption rates, and developing water column and fish tissue RGs.

K.1.2 INVESTIGATION APPROACH

A data quality objective (DQO) session was held on April 1, 2021, between EPA, TDEC, DOE, and UCOR LLC (UCOR) to develop the approach for obtaining information to support the determination of risk-based radiological discharge limits for EMWMF and the proposed EMDF. A Sampling and Analysis Plan (SAP) was then prepared and approved by EPA and TDEC as SAP Erratum FY21-BCV-01 (*Fiscal Year 2021 Fish Tissue Sampling in Bear Creek in Support of the EPA Administrator's Dispute Resolution Decision for Radiological Discharge Limits*) to DOE/OR/01-2457&D4 (*Bear Creek Valley Watershed Remedial Action Report Comprehensive Monitoring Plan Oak Ridge, Tennessee*). This SAP was prepared in consultation with the Federal Facility Agreement (FFA) parties to ensure the field investigation met the objectives of the EPA Administrator's Decision and reflected the objectives determined at the DQO session.

The SAP had three objectives: (1) collect fish tissue data that will be used to define the human health risk from fish consumption from these sites and will be considered in determining the appropriate discharge limits for radionuclides from EMWMF and the proposed EMDF, (2) collect additional fish community data to determine the most appropriate location(s) to evaluate risk to fishermen who consume fish, and (3) assess possible radiologically contaminated fish along Bear Creek where security restrictions prevent a fisher access to the creek. All sampling was conducted in accordance with the approved SAP, and Sects. K.1.2.1, K.1.2.2, K.1.2.3, and K.1.2.4 are excerpted from this SAP.

Although the area is posted and fishing is not allowed on Bear Creek, the FFA parties agreed that people could fish in the area because there are locations where public access is possible. Three potential points of exposure (POEs) were identified as (Bear Creek kilometer [BCK] 3.3–4.5, BCK 0.5–1.5, and East Fork kilometer [EFK] 0–1.0) consistent with the DQO (Table K.1.1 and Fig. K.1.1). At each location, fish community surveys were performed, and fish tissue samples were collected. These locations are shown on Fig. K.1.1.

The Brushy Fork reference location was selected because it is upstream of the Oak Ridge Reservation (ORR) and is similar to Bear Creek. The stream valley is underlain by the Maynardville Limestone, and a broader portion of its watershed drains terrain underlain by Conasauga Group and Rome Formation bedrock and residual soils.

Table K.1.1. Sampling locations

Reach	Site name	Location description
EFK 0.0 to 1.0	EFK 0.0	Lower EFPC accessible by bridge from greenway trail
BCK 0.5 to 1.5	BCK 0.5	Stream crossing on greenway trail
BCK 3.3 to 4.5	BCK 3.3	Stream access from unnamed gravel road off Hwy 95 upstream to triangle intersection of Hwy 95 and Bear Creek Rd.
BCK 7.0 - 9.9	BCK 9.9	Stream reach at Bear Creek BMAP location
BCK 11.9 - 12.4	BCK 12.4	Stream reach at Bear Creek BMAP location
BFK 7.6	BFK 7.6	Reference reach on Brushy Fork of Poplar Creek

BCK = Bear Creek kilometer
BFK = Brushy Fork kilometer
BMAP = Biological Monitoring and Abatement Program
EFK = East Fork kilometer
EFPC = East Fork Poplar Creek

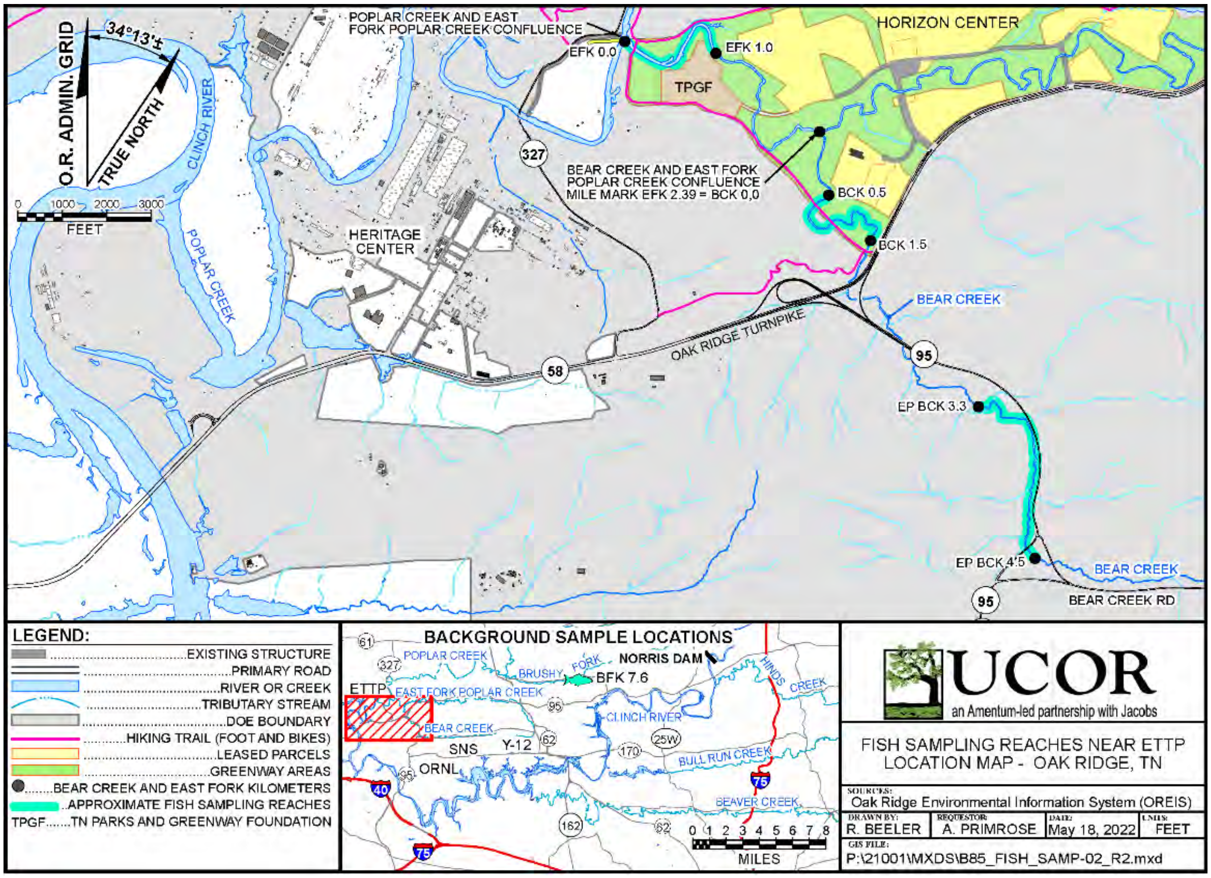

Fig. K.1.1. Fish tissue sample collection and fish community survey locations.

K.1.2.1 Fish Community Surveys

Fish community surveys were conducted at the POE locations and at Brushy Fork kilometer (BFK) 7.6, the background location (Fig. K.1.1). Fish community surveys determined fish availability and size, species richness, and diversity in a reach of stream through field identification and enumeration of individuals. Fish community surveys were performed over about an 80- to 100-m stretch with fish collected by electroshock. Electroshock successfully reached all depths of the streams in question, except for potentially deeper portions at EFK 0.0 to 1.0. Figure K.1.2 provides the locations and existing biological sampling locations in Bear Creek.

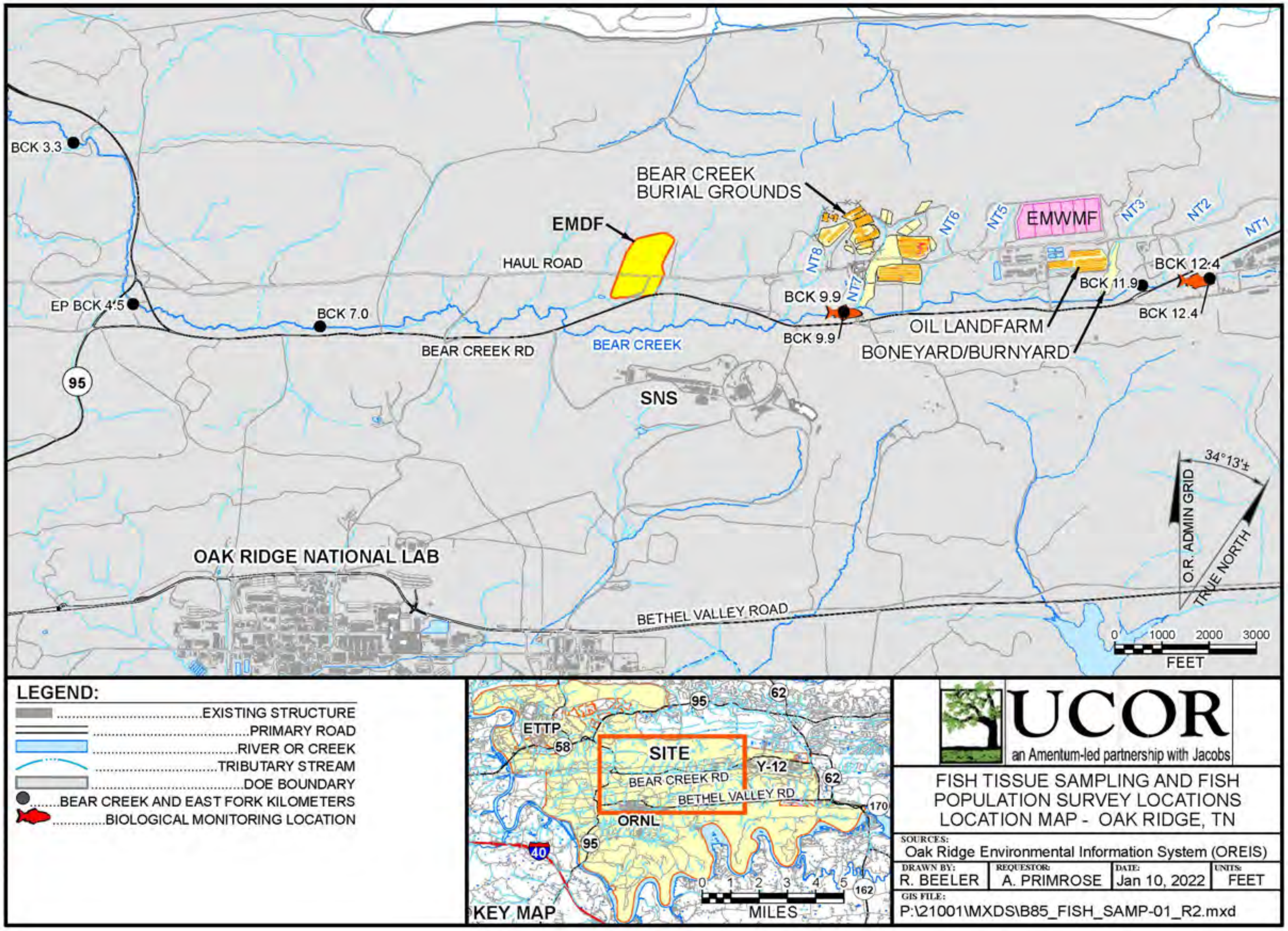

Fig. K.1.2. Locations and existing biological monitoring locations in Bear Creek.

K.1.2.2 Fish Tissue Sampling

The technical team determined that game fish greater than 1 oz (30 g) were edible. A photo of a 1.5-oz (45 g) sunfish from the study area is provided in Fig. K.1.3 as an illustration of the typical, minimum size fish collected. Radiological contaminants of concern (COCs) were identified, along with the low detection limits needed to achieve results suitable for establishing RGs and to set effluent discharge limits. Sampling was performed in accordance with SAP procedures.

Fig. K.1.3. Sunfish from study area.

K.1.2.3 Determination of COCs

Radionuclide COCs were selected that represent the contaminants in the waste disposed in EMWMF and/or proposed to be disposed in EMDF. These are provided in Table K.1.3. Additional radionuclides were considered, but not included, as described in Table K.1.4.

Table K.1.3. COCs for Fish Sampling

Media	Stream Reach or Location	Parameters/Analyses	Comments
Fish Tissue	EFK 0.0 – EFK 1.0 BCK 0.5 – BCK 1.5 BCK 3.3 –BCK 4.5 BFK 7.6	^{241}Am, ^{14}C, ^{36}Cl, ^{60}Co, ^{137}Cs, ^{154}Eu, ^{3}H, ^{129}I, ^{237}Np, ^{210}Pb, ^{238}Pu, $^{239/240}$Pu, ^{226}Ra, ^{228}Ra, ^{90}Sr, ^{99}Tc, ^{228}Th, ^{230}Th, ^{232}Th, $^{233/234}$U, $^{235/236}$U, ^{238}U	Bioaccumulation of COCs (radiological) in fish fillet samples to assess risk to recreational fishermen.
Whole fish	BCK 0.5 – BCK 1.5 BCK 3.3 –BCK 4.5 BCK 7.0- 9.9 BCK 11.9 - 12.4	^{60}Co, ^{137}Cs, ^{154}Eu, ^{3}H, ^{129}I, ^{237}Np, $^{239/240}$Pu, ^{226}Ra, ^{228}Ra, ^{90}Sr, ^{99}Tc, ^{228}Th, ^{230}Th, ^{232}Th, $^{233/234}$U, $^{235/236}$U, ^{238}U	Bioaccumulation of COCs (radiological) in whole body fish samples to assess stream conditions.

Table K.1.4. Additional COCs considered, but not included

Radionuclide Considered	Rationale for not including
Cesium-134	Not expected in EMWMF or EMDF waste streams. This radionuclide is a short-lived fission product with a half-life of about 2 years.
Cesium-135	Limited presence in EMWMF or projected EMDF waste streams. Present in very low quantities, with Cs-137 extremely difficult to detect (low energy beta emitter), and risk factor for food ingestion is only 15.7 percent of that of Cs-137 (3.74E-11 risk/pCi), or 5.88E-12 risk/pCi (for Cs-135).
Curium isotopes	Limited presence in EMWMF or projected EMDF waste streams. Most isotopes have low specific activity (low hazard). The highest specific activity isotope is Cm-242, with the shortest half-life of less than 1 yr. These isotopes are not particularly mobile in the environment. A dose impact to a recreational fisher is not expected based on low mobility and low bioaccumulation factors.
Polonium-210	Very short half-life and limited presence in EMWMF or projected EMDF waste streams.
Uranium metal	Common isotopes were evaluated (see table K.1.3). Toxicity risk from the metal is evaluated in Sect. K.2.

K.1.2.4 Selection of Detection Limits

Analytical methods and detection limits were selected for each analysis that were reasonably achievable and fully protective based on other projects in the past. These are provided in Table K.1.5. The amount of sample needed to perform these analyses was used to determine the sample weight collected.

Table K.1.5. Detection limits

Analyte	Method alias	Method*	Requested reporting limit***	Units
Americium-241	Alpha Spectroscopy	EPA-908.0	0.1	pCi/g
Carbon-14	Carbon-14 by LSC	EPA-906.0	3	pCi/g
Chlorine-36	GFPC	EPA-904.0	0.4	pCi/g
Cobalt-60	Gamma Spectroscopy**	EPA-901.1	0.1	pCi/g
Cesium-137	Gamma Spectroscopy**	EPA-901.1	0.1	pCi/g
Europium-154	Gamma Spectroscopy**	EPA-901.1	0.5	pCi/g
Tritium	LSC	EPA-906.0	3	pCi/g
Iodine-129	Gamma Spectroscopy (LEPS)	EPA-901.1 (LEPS)	0.1	pCi/g
Lead-210	GFPC	EPA-904.0	0.1	pCi/g
Neptunium-237	Alpha Spectroscopy	EPA-907.0	0.01	pCi/g
Plutonium-238	Alpha Spectroscopy	EPA-907.0	0.01	pCi/g
Plutonium-239/240	Alpha Spectroscopy	EPA-907.0	0.01	pCi/g
Radium-226	Lucas Cell	EPA-903.1	0.1	pCi/g
Radium-228	GFPC	EPA-904.0	0.2	pCi/g
Strontium-90	Beta GFPC	EPA-905.0	0.5	pCi/g
Technetium-99	Beta LSC	Beta Liquid Scintillation	0.5	pCi/g
Thorium-228	Alpha Spectroscopy	EPA-907.0	0.1	pCi/g
Thorium-230	Alpha Spectroscopy	EPA-907.0	0.1	pCi/g
Thorium-232	Alpha Spectroscopy	EPA-907.0	0.1	pCi/g
Uranium-233/234	Alpha Spectroscopy	EPA-908.0	0.1	pCi/g

Table K.1.5. Detection limits (cont.)

Analyte	Method alias	Method*	Requested reporting limit***	Units
Uranium-235/236	Alpha Spectroscopy	EPA-908.0	0.1	pCi/g
Uranium-238	Alpha Spectroscopy	EPA-908.0	0.1	pCi/g

*Methods modified for fish tissue.
**Samples for Gamma Spectroscopy can be reused for other analyses.
***Detection limits were selected for each analysis that are reasonably achievable and fully protective based on other projects in the past.
GFPC = Gas flow proportional counting
LSC = Liquid scintillation counting
LEPS = Low-Energy Photon Spectroscopy

K.1.3 INVESTIGATION RESULTS

K.1.3.1 Fish Community Surveys

Results of the fish community surveys are presented in Tables K.1.6 to K.1.9 for the three different POEs and background location. These data include all game fish greater than 30 g, with the exclusion of catfish. As shown, the largest population of game fish is present at East Fork Poplar Creek (EFK 1.0) where the stream flow is greatest and there is more desirable habitat. Game fish populations decrease upstream in Bear Creek due to lower flow and poorer game fish habitat.

Table K.1.6. EFK-1.0 Fish community survey data

EFK 1.0 (65-m reach, gamefish greater than 30 g)

Common name	Number of fish	Minimum weight (g)	Maximum weight (g)	Average weight (g)
largemouth bass	1	66.2	66.2	66.2
white crappie	1	183	183	183
bluegill	5	30.3	80	46.9
redbreast sunfish	1	112	112	112.0
redear sunfish	1	36.6	36.6	36.6
warmouth	3	36.3	43.8	39.3
yellow bass	11	30.4	196	87.6
yellow perch	2	32.6	32.9	32.8

Table K.1.7. BCK 0.7 Fish community survey data

BCK 0.7 (95-m reach, gamefish greater than 30 g)

Common name	Number of fish	Minimum weight (g)	Maximum weight (g)	Average weight (g)
largemouth bass	1	73.1	73.1	73.1
green sunfish	3	33.2	72.1	46.5
redbreast sunfish	3	32.8	59	41.8
rock bass	4	36.7	116	77.5
warmouth	1	34.4	34.4	34.4

Total weight of fish greater than 30 g was 682 g based on community survey of 95-m reach.

Table K.1.8. BCK 3.3 Fish community survey data

BCK 3.3 (84-m reach, gamefish greater than 30 g)

Common name	Number of fish	Minimum weight (g)	Maximum weight (g)	Average weight (g)
green sunfish	1	38.1	38.1	38.1

Table K.1.9. Background location Brushy Fork (BFK 7.6)

Common name	Number of fish	Minimum weight (g)	Maximum weight (g)	Average weight (g)
bluegill	1	46	46	46.0
green sunfish	1	34.5	34.5	34.5
largemouth bass	0	0	0	n/a
redbreast sunfish	5	35	86.7	59.4
rock bass	3	44	185	91.4

K.1.3.1.1 Additional BCK 3.3 fish community survey results

Because of the few game fish encountered at BCK 3.3, additional historical information was compiled (Table K.1.10) to reflect the variation in game fish present at this location. The historical data indicates that 0 to 7 game fish could be present at any given time at this location.

Table K.1.10. Summary of previous fish community survey results—gamefish over 30 g

Common name	Number of fish	Minimum weight (g)	Maximum weight (g)	Average weight (g)
Spring 2016				
redbreast sunfish	1	69	69	69.0
rock bass	1	34.9	34.9	34.9
Fall 2016				
redbreast sunfish	2	36	69	52.5
rock bass	5	34.9	110	72.2
Spring 2017				
green sunfish	2	35	35.5	35.3
rock bass	5	38.7	176	75.2
Fall 2017				
rock bass	1	58.9	58.9	58.9
Spring 2018				
green sunfish	2	36.4	39.7	38.1
Fall 2018—no game fish greater than 30 g				
Spring 2019—no game fish greater than 30 g				
Fall 2019				
green sunfish	2	35.1	41.5	38.3
redbreast sunfish	1	32.5	32.5	32.5
bluegill	1	72.5	72.5	72.5

Table K.1.10. Summary of previous fish community survey results—gamefish over 30 g (cont.)

Common name	Number of fish	Minimum weight (g)	Maximum weight (g)	Average weight (g)
Spring 2020				
green sunfish	1	36	36	36.0
rock bass	1	34	34	34.0
Fall 2020				
green sunfish	1	55.1	55.1	55.1
rock bass	1	42.9	42.9	42.9
bluegill	1	32.7	32.7	32.7

K.1.3.1.2 Number of fish meals per year

Based on the fish community data, on October 21, 2021, the Dispute Resolution Agreement Team (EPA, TDEC, DOE and UCOR) agreed to a fish consumption rate of 11 fish meals/year for the Bear Creek POE (BCK 0.5 to 3.3) using the process and calculations shown in Table K.1.11.

Table K.1.11 Calculated number of fish meals

BCK 0.5 (0.5-1.5) Calculated number of fish meals					Based on community survey at BCK 0.5 (95-m reach, gamefish greater than 30 g)
Common name	**No. of fish**	**Min. weight (g)**	**Max. weight (g)**	**Avg. weight (g)**	Comments
largemouth bass	1	73.1	73.1	73.1	
green sunfish	3	33.2	72.1	46.5	
redbreast sunfish	3	32.8	59	41.8	
rock bass	4	36.7	116	77.5	
warmouth	1	34.4	34.4	34.4	
Total weight (g) of fish greater than 30 g				682.4	
Edible weight of each fish, e.g., grams of filet in total fish weight				341.2	Assume 1/2 of fish is edible (fillets)
Fish catch rate per trip – fish per trip of total				58%	7/(sum of the Number of fish)
Edible grams caught - Assumes a person a person fishes 9 months per year, for a total of 30 trips				4401.48	Edible weight of each fish x (average of fish catch rate at BCK .5 and BCK 3.3) x total trips 341.2 x .58 x 30
No. of meals/year at BCK 0.5 - Assumes 227 g (8 oz) per meal				19.39	Edible grams caught/grams per meal 4401/227

Table K.1.11 Calculated number of fish meals (cont.)

BCK 3.3 (3.3-4.5) Calculated number of fish meals					Community BCK 3.3 (84-m reach, gamefish greater than 30 g) plus additional gamefish from the 5-year BMAP fish data
Common name	**No. of fish**	**Min. weight (g)**	**Max. weight (g)**	**Avg. weight (g)**	These data represent the compiled fish counts/species from the last 5 years of BMAP data plus the 1 green sunfish from 2021 Spring Sampling Event (below assumed from one year)
bluegill	2	32.7	72.5	52.6	
green sunfish	9	35	55.1	39.2	
redbreast sunfish	4	32.5	69	42.9	
rock bass	12	34.9	176	69.9	
Total weight (g) of fish greater than 30 g				99.2	Based on 95% Percentile.
Edible weight of each fish (g), e.g., grams of filet in total fish weight				49.6	Assume 1/2 of fish is edible (fillets)
Fish catch rate per trip - % of available fish caught each trip.				26%	Average of the fish catch rate for Bear Creek is 43%. The 26% value factors in the mean catch rate for BCK 0.0 to 1.5 and BCK 3.3 to 4.5.
Edible grams caught - Assumes a person fishes 9 months per year, for a total of 30 trips				639.84	Edible weight of each fish x (average of fish catch rate at BCK .5 and BCK 3.3) x total trips 49.6 x .43 x 30
No. of meals/year at BCK 3.3 - Assumes 227 g (8 oz) per meal				2.82	Edible grams caught/grams per meal 639.84/227
Average BCK Fish Meals/Year (BCK 0.7 and 3.3) Average = (19.39 fish meals at BCK 0.5 + 2.82 fish meals at BCK 3.3)/2				**11**	**Represents the average fish meals/year for the entire reach of Bear Creek (BCK 0.5 and BCK 3.3)**

The ingestion rate in g per year for the risk assessment site-specific exposure scenario was calculated by multiplying the amount of fish consumed per meal (227 g/8oz—see sect K.1.5.3.1) by the number of meals per year (11 meals/year—see sect K.1.5.3.1). This resulted in 2497 g/year that was rounded up to 2500 g/year. However, this number was not carried forward into the PRG calculation (Sect. K.1.4). Instead, the TDEC Water Quality Standard (WQS) default fish ingestion rate (17.5 grams/day) was used to develop the Preliminary Remediation Goals (PRGs). The inclusion of this site-specific information and calculation illustrates the conservatism in the default assumption of 6387 g/year that was used to develop PRGs.

K.1.3.2 Fish Tissue Sampling Results

Data were received and validation was performed for all results.

The summary of the detected analytical results is provided in Table K.1.12. Summary statistics for each location are provided in Table K.1.13 (radionuclides detected at least one time) and Attachment 2 (results for all radionuclides. Locations of these samples are provided in Fig. K.1. 3.

As shown in Table K.1.12, the similar number of detects were identified at both the Bear Creek and Brushy Fork (background) locations. Many detects were of radium (Ra)-226 and Ra-228, likely decay products from the naturally occurring uranium typically found in the black shales in both Bear Creek and Brushy Fork. These did not result from decay of uranium contamination due to the long half-lives in the uranium decay chain and because uranium used at the ORR was processed prior to arrival at the site, eliminating the decay chain daughters that would decay to these isotopes.

Table K.1.12 Summary of detected isotopes by location

	Location – Sample type	Total Detects	Americium-241	Carbon-14	Cesium-137	Chlorine-36	Cobalt-60	Europium-154	Iodine-129	Lead-210	Neptunium-237	Plutonium-238	Plutonium-239/240	Radium-226	Radium-228	Strontium-90	Technetium-99	Thorium-228	Thorium-230	Thorium-232	Tritium	Uranium-233/234	Uranium-235/236	Uranium-238
Bear Creek	EFK 0.0-fillet	14	-	-	-	-	-	-	-	-	-	-	-	5	3	2	-	1	3	-	-	-	-	-
	EFK 0.0-carcass	15	-	-	-	-	-	-	-	4	-	-	-	1	5	-	1	-	1	-	1	1	-	1
	BCK 0.5-fillet	12	-	-	-	-	-	-	-	-	-	1	-	5	5	-	-	-	-	-	1	-	-	-
	BC0.5-carcass	9	-	-	-	1				1	-	-	-	-	1	2	-	-	1	-	-	-	-	3
	BCK 0.5-whole body	2	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-
	BCK 3.3-fillet	13	1	-	-	-	-	-	-	3	-	-	-	2	5	1	-	-	-	-	1	-	-	-
	BCK 3.3-carcass	10	-	-	-	-	-	-	-	2	-	-	-	-	2	2	-	-	1	-	-	-	-	3
	BCK 3.3-whole body	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	BCK 9.9-whole body	6	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	1	-	-	-	-	2
	BCK 12.4-whole body	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3
BFK	BFK 7.6-fillet	14	1	-	-	-	-	-	-	2	-	-	-	3	3	3	-	-	2	-	-	-	-	-
	BFK 7.6-carcass	5	-	-	-	-	-	-	-	2	-	-	-	-	2	-	-	-	1	-	-	-	-	-

BCK = Bear Creek kilometer
BFK = Brushy Fork kilometer
EFK = East Fork kilometer

Table K.1.13. Summary statistics for radionuclides in fish filet samples from 2021 spring and fall sampling events

Chemical	Units	Freq. of Detection	Detected			Freq. of Detection	Detected			Freq. of Detection	Detected		
			Min	Mean	Max		Min	Mean	Max		Min	Mean	Max
		BFK 7.6				*BCK 0.5 and BCK 3.3*				*EFK 0.0*			
Americium-241	pCi/g	1/19	0.042	0.042	0.042	1/37	0.042	0.042	0.042	0/20	--	--	--
Carbon-14	pCi/g	1/19	5.08	5.08	5.08	1/37	4.88	4.88	4.88	5/20	5.21	9.7	23.2
Chlorine-36	pCi/g	0/19	--	--	--	2/37	0.382	0.583	0.784	0/20	--	--	--
Lead-210	pCi/g	2/19	0.081	0.086	0.091	5/37	0.078	0.194	0.483	3/20	0.138	0.315	0.449
Plutonium-238	pCi/g	0/19	--	--	--	1/37	0.005	0.005	0.005	0/20	--	--	--
Radium-226	pCi/g	3/19	0.131	0.211	0.294	9/37	0.042	0.296	1.89	10/20	0.045	0.114	0.277
Radium-228	pCi/g	5/19	0.172	0.392	0.677	12/37	0.103	0.252	0.625	5/20	0.117	0.389	1.3
Strontium-90	pCi/g	4/19	0.204	0.295	0.348	3/37	0.33	0.354	0.372	2/20	0.14	0.179	0.218
Thorium-228	pCi/g	0/19	--	--	--	0/37	--	--	--	1/20	0.035	0.035	0.035
Thorium-230	pCi/g	6/19	0.056	0.083	0.12	4/37	0.068	0.093	0.115	10/20	0.027	0.059	0.163
Tritium	pCi/g	0/19	--	--	--	2/37	1.65	2.34	3.02	0/20	--	--	--

K.1.4 PRELIMINARY REMEDIATION GOALS FOR RADIOLOGICAL DISCHARGES

PRGs were developed to obtain in-stream water quality and fish tissue values. Discharge limits will be calculated when the discharge location for EMDF and flow rates for Bear Creek are determined.

K.1.4.1 PRG Development

The EPA Administrator's Dispute Decision Letter (Wheeler, A. R. and Appendix M) determined that the reasonable maximum exposure scenario was a recreational fisherman at a reasonable point of public exposure.

The working group of DOE, EPA, and TDEC risk assessors and subject matter experts thoroughly reviewed and evaluated all available data from the fish community and fish tissue sampling efforts (Sect. 1.3). Based on this evaluation, the working group determined that the reasonable point of public exposure was the stretch of Bear Creek along from BCK 4.5 to the confluence of Bear Creek with East Fork Poplar Creek (Fig. K1.1.).

Fishermen are not typically observed along this stretch of Bear Creek and there are few if any indications that fishing is occurring along this reach, and the area is not fenced or routinely patrolled to prevent fishing. Based on the number, size, and species of game fish collected for both the fish tissue sampling effort and the fish community surveys, the working group established a conservative estimate for input into the PRG calculator. This estimate assumes a fisher would consistently fish a large stretch of this reach, and consume all fish caught, regardless of species. This estimate also assumed that fish would repopulate this stretch between fishing events, either by swimming upstream from the Poplar Creek area, or downstream from the upper reaches of Bear Creek. However, PRGs were ultimately developed using the default fish consumption rate used in Tennessee WQS rather than relying on the Bear Creek specific data, as described in Section K.1.4.2. The PRGs apply to all of Bear Creek per the state designated use.

K.1.4.2 Approach to Develop Preliminary Remediation Goals

The EPA PRG calculator was used to develop fish PRGs. Details on the PRG calculations are presented in *Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee* (UCOR- 5550) and summarized below. The general equation for the calculation of PRGs is:

$$PRG_{f} = \left(\frac{Target\ Risk\ 10^{-5}}{SF_i \times IR \times ED}\right)$$

Where:

PRGf = Preliminary Remediation Goal for fish (pCi/g)
SFi = Radionuclide specific Food Ingestion Slope Factor (pCi^{-1})
IR = Ingestion Rate (6,388 g/year)
ED = Exposure Duration (26 years – 20 years as an adult and 6 years as a child)

The instream water PRGs were then calculated by dividing the fish tissue PRG by the bioconcentration factor (BCF) converted to the same units as the fish PRGs by dividing by 1000.

A summary of conditions/assumptions considered in developing the fish tissue and surface water PRGs for EMDF include:

- The radionuclides of interest were either received or generated at the ORR without their progeny (e.g., uranium that was milled and refined, transuranics, and fission products produced from reactor operations).
- Considering the beginning of the Oak Ridge site (1942), the expected 26-year operational period of EMDF, and the possible lifespan of an exposed individual starting with the beginning of the EMDF operational period, a bounding timeframe for considering ingrowth of progeny radionuclides received or generated at the ORR is 160 years.
- Fish tissue and surface water PRGs are protective of recreation use, specifically fish ingestion, at a target risk of 1E-05. Default assumptions were used to calculate PRGs as follows:
    - An exposure duration of 26 years
    - An exposure frequency of 365 days/year
    - A fish ingestion rate of 17.5 g/day
    - This equates to an annual fish ingestion rate for a recreational user of 6387.5 g/year.

UCOR-5550 provides additional documentation for fish tissue and surface water PRGs, including slope factors, fish BCFs, fish ingestion parameters, and equations used to calculate the PRGs.

K.1.4.2.1 Uranium used on the Oak Ridge Reservation

As noted above, the radioactive isotopes are not in secular equilibration. Secular radioactive equilibrium exists when the parent nucleus has an extremely long half-life and is common for long-lived natural radioactive series, such as the uranium series. For a decay chain where all the isotopes are in secular equilibrium (SE), each of the descendants has built up to an equilibrium amount and all decay is at the rate set by the original parent (https://www.radiation-dosimetry.org/what-is-secular-equilibrium-radioactive-equilibrium-definition/).

The decay chain for natural occurring uranium (U)-238) is very long, around 4.5 billion years (Fig. K.1. 4). For unprocessed uranium in the environment, the decay chain progeny are in SE. However, at the ORR, uranium ore, with all its naturally occurring radioactive decay products, was not used for the weapons or energy research projects. As described in *Linking Legacies, Connecting the Cold War Nuclear Weapons Production Processes to Their Environmental Consequences* (DOE 1997) (https://www.energy.gov/sites/default/files/2014/03/f8/Linking_Legacies.pdf): "Nuclear materials production started with mined and milled uranium."

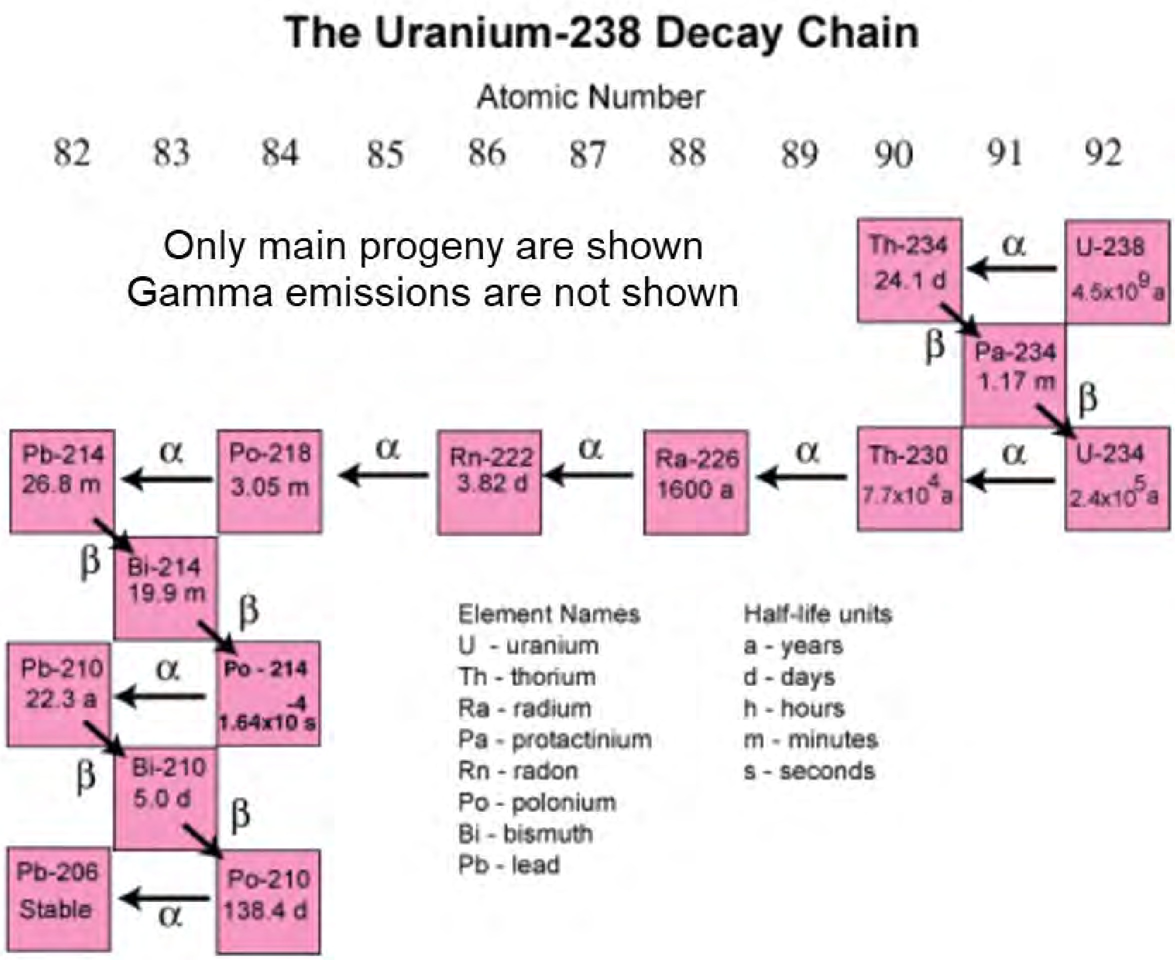

Fig. K.1.4. Uranium decay chain.

Natural uranium ore consists primarily of two isotopes by mass—U-235 and U-238—with 0.7% of the uranium as U-235. The remaining 99.3% is mostly U-238, with a small amount of U-234 at 0.0055%. Uranium milling concentrates the uranium and removes the decay products during the various processing steps, including chemical separation of uranium. Milling thus interrupts the equilibrium. The isotopic composition of the uranium remains unchanged (e.g., the U-235 and U-238 ratios). The mill tailings contain the decay products from the uranium chains (https://www.nrc.gov/waste/mill-tailings.html).

The uranium source material, including the material used at the East Tennessee Technology Park for enrichment, plutonium production, and weapons research, was chemically processed and separated to remove unwanted elements, leaving the uranium as an oxide or in another chemical form. This chemical processing was performed at other facilities, not at the ORR, prior to coming to the ORR for enrichment or energy/weapons research, eliminating the decay chain present with uranium in SE.

The uranium processing facilities in the Tennessee region are shown in Fig. K.1.5. As an example, the uranium feed material used for enrichment at K-25 originally (September 1941) came from the Harshaw Chemical Company in Cleveland, Ohio (http://www.k-25virtualmuseum.org/timeline).

The closest processing facilities to Oak Ridge were the Fernald Site near Cincinnati, Ohio; the Mallinckrodt site in downtown St. Louis (now a Formerly Utilized Sites Remedial Action Program cleanup site) that refined and purified the uranium prior to being enriched at Oak Ridge; and the Allied Chemical Plant in Metropolis, Illinois (now Honeywell Metropolis Works Facility) that produced feedstock for the Paducah Gaseous Diffusion Plant and the other gaseous diffusion plants.

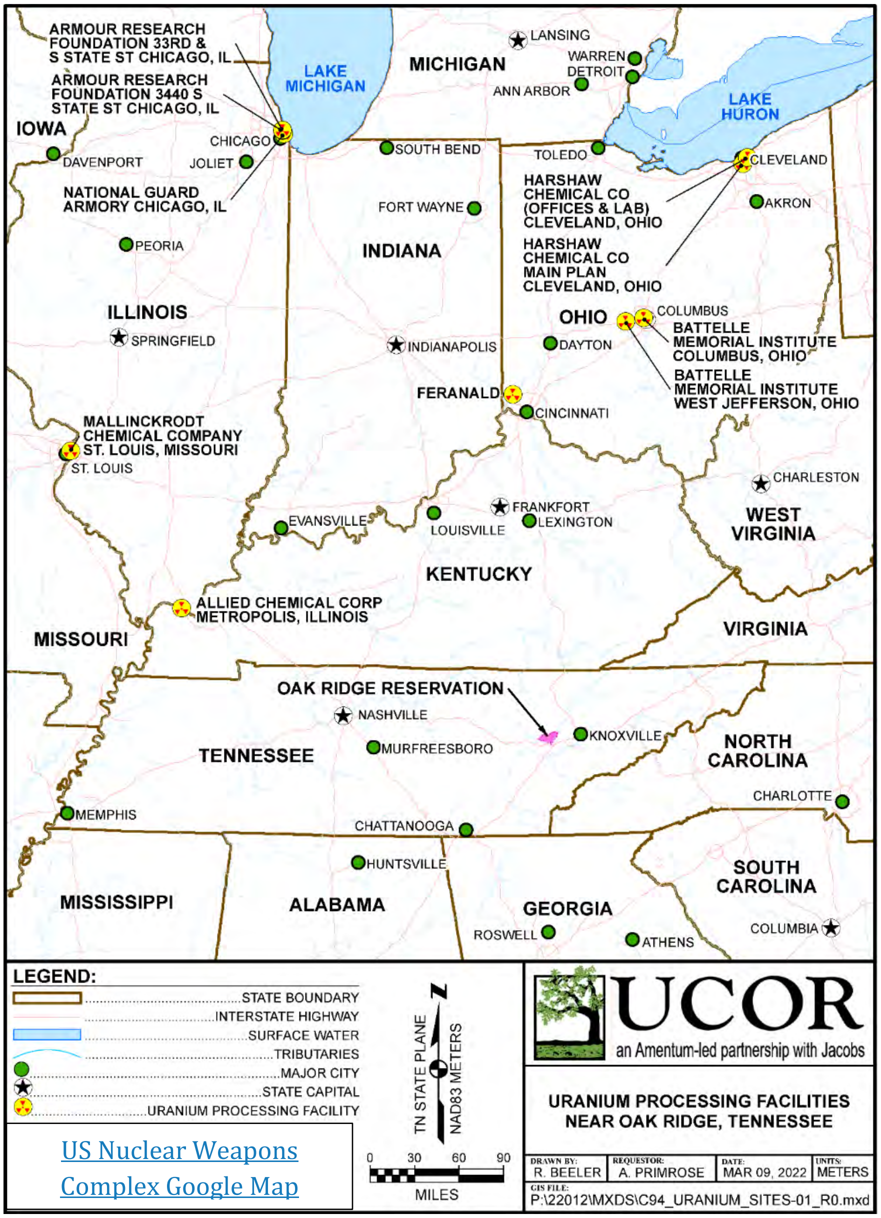

Fig. K.1.5. Uranium processing facilities near Oak Ridge.

Enrichment is a physical process to concentrate U-235. Uranium-235 and U-238 are chemically identical, but differ in their physical properties, notably their mass. The difference in mass between U-235 and U-238 allows the isotopes to be separated and makes it possible to increase or "enrich" the percentage of U-235. All present and historic enrichment processes make use of this small mass difference.

Uranium used for nuclear weapons is enriched in plants specially designed to produce at least 90% U-235. Enrichment processes require uranium to be in a gaseous form at relatively low temperature, hence uranium oxide ore is converted to uranium hexafluoride in a preliminary process, at a separate processing plant (https://world-nuclear.org/information-library/nuclear-fuel-cycle/conversion-enrichment-and-fabrication/uranium-enrichment.aspx). For the gaseous diffusion plants (e.g., K-25), uranium hexafluoride gas was used as feedstock for the process (https://www.atomicheritage.org/location/oak-ridge-tn K-25).

However, within a month, the short-lived decay products thorium (Th)-234 and protactinium (Pa)-234m from U-238 and Th-231 from U-235, begin to in-grow. As a result, these progeny must be considered to be present in ORR uranium. The other decay products require 10,000 years or more to grow into equilibrium with the parent U-238 and U-235 and are therefore considered to be absent in ORR uranium. Ingrowth of the daughter products from decay of U-234 is not relevant because of the long half-life of U-234 (240,000 years). In addition, the first daughter product of U-234 (Th-230) has a half-life of 77,000 years. As a result, the decay chain for ORR materials is not present past U-234.

Because the progeny were removed from ORR uranium prior to receipt, the higher risk decay products that drive risk are not expected to be present during the remaining 30-year operational life of EMDF/EMWMF, and therefore are not considered during PRG development (Fig. K.1.6).

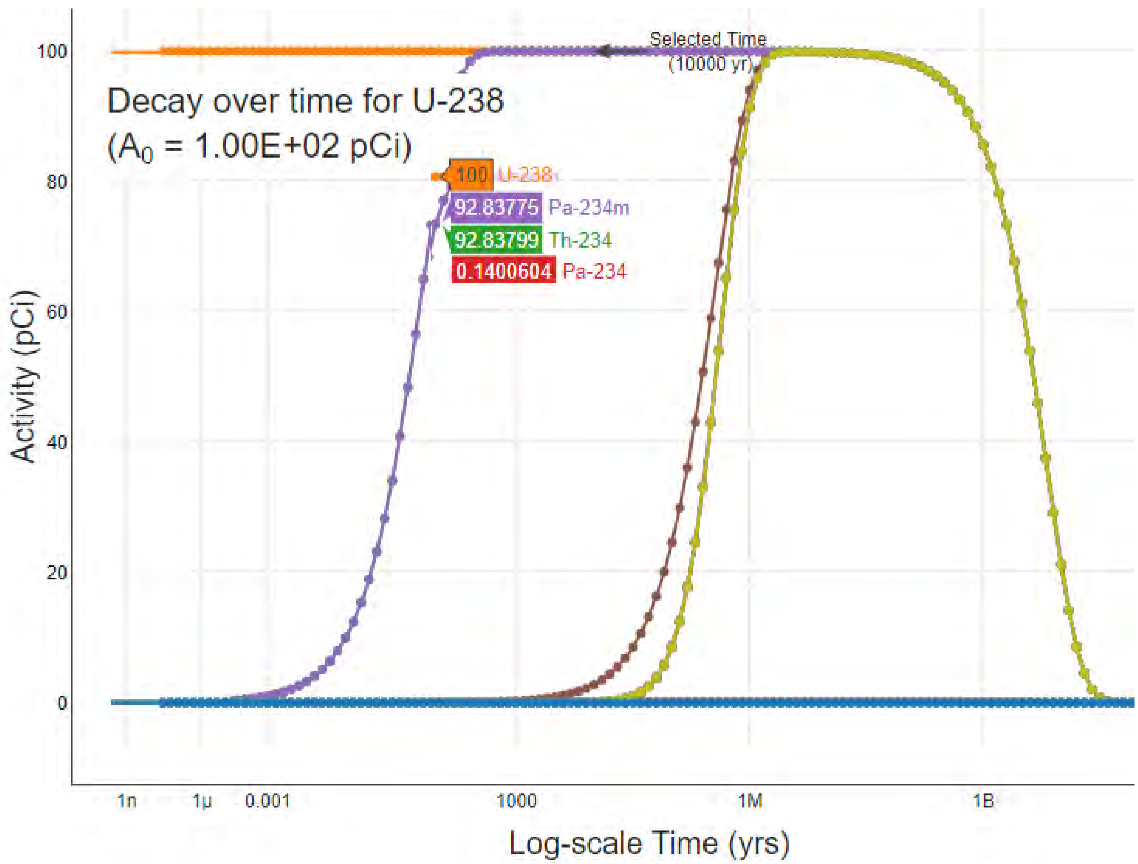

Fig. K.1.6. Uranium-238 decay and progeny over time.

Table K.1.14 below shows the ingrowth of progeny of refined U-238 at 10,000 years. This table, and the above graph, show that progeny Th-234, Pa-234, and Pa-234m reach equilibrium quickly, but U-234 and the rest of the chain are just beginning to in grow at 10,000 years.

Table K.1.14 Summary of detected isotopes by location

Activities for U-238 and daughters at T = 10000 yrs where initial activity = 100 pCi

Time of Interest (yrs)	U-238	Th-234	Pa-234	Pa-234m	U-234	Th-230	Ra-226	Rn-222	Po-218	At-218	Rn-218	Pb-214
10000.000	1.00E+02	1.00E+02	1.60E-01	1.00E+02	2.78E+00	1.25E-01	8.07E-02	8.07E-02	8.07E-02	1.61E-05	1.61E-08	8.07E-02

K.1.4.2.2 Radionuclides of interest

The following information in Sect K.1.4.2.2 through K.1.4.2.5 summarizes more detailed information presented in UCOR-5550. Twenty-one radionuclides, and associated progeny, which bioaccumulate and have the potential to be present in landfill wastewater at some time during the operational life of EMDF, have been identified as "radionuclides of interest." For the 21 radionuclides of interest, fish tissue and instream water column PRGs/Cleanup Levels have been developed to be protective of recreational use (human health), specifically fish ingestion.

The radionuclides of interest are grouped as follows:

1. Radionuclides that decay to a stable element (i.e., there are no progeny to account for).
2. Radionuclides that reach SE with their progeny within 160 years.
3. Radionuclides that have chains segmented for measurement purposes.
4. Radionuclides that do not reach SE within 160 years.

Radionuclides that decay to a stable element (no progeny)

Radionuclides in Group 1 decay directly to a stable isotope. For this group, the PRG Calculator is run in its SE mode and there are no progeny to account for. This group consists of the following seven radionuclides:

- Carbon (C)-14
- Chlorine (Cl)-36
- Cobalt (Co)-60
- Europium (Eu)-154
- Hydrogen (H)-3
- Iodine (I)-129
- Technetium (Tc)-99

Radionuclides that reach SE with their progeny within 160 years

For radionuclides in Group 2, their progeny build-in within 160 years and reach peak activity within the 160-year period of interest. For this group, the PRG Calculator is run in its SE mode, and all of the progeny are accounted for at their most conservative activity. This group includes the following four radionuclides:

- Cesium (Cs)-137 (including barium [Ba]-137m)
- Strontium (Sr)-90 (including yttrium [Y]-90)
- Ra-226 (including radon [Rn]-222, polonium [Po]-218, astatine [At]-218, Rn-218, lead [Pb]-214, bismuth [Bi]-214, Po-214, thallium [Tl]-210, Pb-210, Bi-210, Po-210, mercury [Hg]-206, and Tl-206)
- Thorium (Th)-228 (including Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Po-212, and Tl-208)

Radionuclides that have chains segmented for measurement purposes

Group three radionuclides have their decay chains appropriately segmented to represent portions of a chain in equilibrium, with the remainder of the chain being tracked separately. For this group, the PRG Calculator is run in its secular equilibrium mode, and progeny are accounted for at their most conservative activity. The parent and any progeny included are shaded in gray in Tables 2 and 3. If only the parent is included, the resulting PRG is the secular equilibrium PRG contributed by the parent (as is the case for americium [Am]-241, plutonium [Pu]-238, Pu-240, Th-230, Th-232, U-234, and U-236). If there are progeny prior to reaching a radionuclide that is tracked separately (as is the case for neptunium [Np]-237, Pu-239, Ra-228, and U-238), then PRGs are calculated with the inverse sum of reciprocals process, and the last column in Tables 2 and 3 show the resulting partial chain secular equilibrium PRG calculation. These radionuclides and their progeny in-growth are illustrated in Figs. 5 through 15. Appendix A of UCOR 5550 offers an example calculation.

This third group includes the following eleven radionuclides:

- **Am-241** (432.5 y) → Np-237 (2.14 ×106 y) → Pa-233 (26.98 d) → U-233 (159,200 y) → …
  - Only Am-241 is included since Np-237 is tracked separately.
- **Np-237** (2.14 ×10^6 y) → Pa-233 (26.98 d) → U-233 (159,200 y) → Th-229 (7,880 y) → Rn 225 (14.9 d) → …
  - Np-237 and Pa-233 are calculated together. The next progeny, U-233, is tracked separately.
- **Pu-238** (87.8 y) → U-234 (245,500 y) → Th-230 (75,437 y) → Ra-226 (1,585.5 y) → Rn-222 (3.8 d) → …
  - Only Pu-238 is included since U-234 is tracked separately.
- **Pu-239/Pu-240**

  Pu-239/Pu-240 are reported together from the laboratory. Distinguishing the pairs is expensive, and for ease of measurement, the most protective PRG of the pairs is selected.

  - Pu-239 (24,110 y) → U-235m → U-235 (7.04 ×10^8) → Th-231 (1 d) → Pa-231 (32,760 y) → …
    - Pu-239 and U-235m are calculated together. The next progeny, U-235, is tracked separately.
  - Pu-240 (6561 y) → U-236 (2.342 × 107 y) → Th-232 (1.4 × 1010 y) → …
    - Only Pu-240 is included since U-236 is tracked separately.
- **Ra-228** (5.7 y) → Ac-228 (6.1 h) → Th-228 (1.9 y) → Ra-224 (3.6 d) → Rn-220 (55.6 s) → Po-216 (145 ms)
  - Ra-228 and actinium (Ac)-228 are calculated together. Th-228 is tracked separately.
- **Th-230** (75,437 y) → Ra-226 (1585.5 y) → …

— Only Th-230 is included since Ra-226 is tracked separately.

- **Th-232** (1.4 × 1010 y) → Ra-228 (5.7 y) → …

  — Only Th-232 is included since Ra-228 is tracked separately.

- **U-234** (245,500 y) → Th-230 (75,437 y) → …

  — Only U-234 is included since Th-230 is tracked separately.

- **U-236** (2.342 × 107 y) → Th-232 (1.4 × 1010 y) → …

  — Only U-236 is included since Th-232 is tracked separately.

- **U-238** (4.47 × 109 y) → Th-234 (24.1 d) → Pa-234 (6.67 h) → U-234 (245,500 y) → …

  — U-238, Th-234, and Pa-234m/Pa-234 are calculated together. U-234 is tracked separately.

Radionuclides that do not reach SE within 160 years

Group 4 radionuclides require tens of thousands of years for all their progeny to build in and reach SE. Because the radionuclides of interest were received or generated at the ORR during the ORR's operating lifetime, a simple SE approach is not appropriate, and the 160-year period of interest must be considered.

This fourth group includes the following two radionuclides:

- **U-233** (159,200 y) → Th-229 (7880 y) → Ra-225 (14.9 d) → Ac-225 (9.95 d) → francium (Fr)-221 (4.8 m) → …

  — All progeny accounted for at their respective contribution in the 160-year period.

- **U-235** (7.04 × 108 y) → Th-231 (1.06 d) → Pa-231 (32,760 y) → Ac-227 (21.8 y) → …

  — All progeny accounted for at their respective contribution in the 160-year period.

Similar to Pu-239/Pu-240, U-233/234 and U-235/236 are reported together from the laboratory. Distinguishing the pairs is expensive, and for ease of measurement, the most protective PRG of the pairs is selected.

The Group 4 radionuclides progeny are growing in during the 160-year period. As a result, the fractional activity for the progeny at 160 years is the bounding fractional activity for that progeny during the 160-year period. However, this is not the case for the parent, which decreases during the 160-year period. The effect is very small, but to remain bounding, a parent activity fraction of 1.0 at 160 years was used in calculating the Total PRG.

The resulting Total PRG conservatively accounts for the contribution from all progeny during the 160-year period of interest.

K.1.4.3 Calculating the PRGs

The EPA PRG Calculator (EPA 2021) farmer scenario was used to generate the PRGs. The media selected were "Biota Direct" for fish tissue, and "Combined Water and Biota" for the instream water column for surface water. The PRG output option used was "Assumes SE throughout chain (no decay)." Many of the PRGs presented are the PRG Calculator output of FinFish Consumption PRG. A few required some post processing, as described in the main body of this report (i.e., Groups 3 and 4).

Input into the PRG calculator requires the inputs shown in Table K.1.15. The site-specific inputs are described below.

Table K.1.15 PRG calculator inputs

Variable	Farmer food products default value	Site-specific value	Site-specific value source
$CF_{far-finfish}$ (finfish contaminated fraction) unitless	1	1	Residential default for CERCLA risk assessment, and consistent with EMDF Operational Life.
ED_{far} (exposure duration - farmer) yr	40	26	Residential default for CERCLA risk assessment, and consistent with EMDF Operational Life.
ED_{far-a} (exposure duration - farmer adult) yr	34	26	Residential default for CERCLA risk assessment, and consistent with EMDF Operational Life.
ED_{far-c} (exposure duration - farmer child) yr	6	0	Risk to the adult is protective of child risk.
EF_{far-a} (exposure frequency - farmer adult) day/yr	350	365	EPA Office of Water value.
EF_{far-c} (exposure frequency - farmer child) day/yr	350	0	Risk to the adult is protective of child risk.
$IFFI_{far-adj}$ (age-adjusted finfish ingestion fraction) g	1,931,020	166,075	Calculated based on current TN state guidance.
$IRFI_{far-a}$ (finfish ingestion rate - farmer adult) g/day	155.9	17.5	TDEC instream value
$IRFI_{far-c}$ (finfish ingestion rate - farmer child) g/day	36.1	0	Risk to the adult is protective of child risk.
t_{far} (time - farmer) yr	40	26	Residential default for CERCLA risk assessment, and consistent with EMDF Operational Life.
TR (target cancer risk) unitless	0.000001	0.00001	TN General Water Quality Criteria (per EPA Headquarters 12/31/2020 Dispute Resolution Letter).
Soil Type	Default	Default	

Output generated 01APR2022:09:58:02
DOE = U.S. Department of Energy
EMDF = Environmental Management Disposal Facility

K.1.4.3.1 Slope factors and BCFs

All the radionuclide toxicity values included in the PRG calculations were obtained from information drawn from https://epa-prgs.ornl.gov/radionuclides/ (EPA 2021). This website is the Preliminary Remediation

Goals for Radionuclide Contaminants at Superfund Sites, prepared by the Oak Ridge National Laboratory (ORNL) for EPA. For radionuclide isotopes, this site uses slope factors from *Calculation of Slope Factors and Dose Coefficients* (ORNL/TM-2013/000), prepared by the Center for Radiation Protection Knowledge. These slope factors are updated values from the *Federal Guidance Report 13* (EPA/402-R-99-001), supplemented using International Commission on Radiological Protection (ICRP) Publication 107 (*Nuclear Decay Data for Dosimetric Calculations*) decay data.

All the fish BCFs included in the PRG calculations were obtained from information drawn from https://epa-prgs.ornl.gov/radionuclides. The fish BCFs were selected from a hierarchy of sources in the following order: International Atomic Energy Agency (IAEA 2010), RESidual RADioactive materials (RESRAD) (ANL/EAD-4 2001).

K.1.4.3.2 PRGs/cleanup goals

Based on the information provided in the previous sections, the PRGs/cleanup goals were calculated for both fish tissue and in stream water (water column). The values are provided in Table K.1.16.

Table K.1.16. Fish tissue and surface water PRGs

Isotope	Fish tissue PRGs TR = 1E-05 (pCi/g)	Surface water PRGs TR = 1E-05 (pCi/L)
Am-241	4.51E-01	1.88E+00
C-14	3.01E+01	7.53E-02
Cl-36	1.36E+01	2.89E+02
Co-60	2.70E+00	3.55E+01
Cs-137	1.61E+00	6.45E-01
Eu-154	4.25E+00	3.27E+01
H-3	4.18E+02	4.65E+05
I-129	3.06E-01	1.02E+01
Np-237	6.56E-01	2.34E+01
Pu-238	3.55E-01	1.69E-02
Pu-239/240	3.46E-01	1.65E-02
Ra-226	1.52E-02	5.34E-01
Ra-228	4.22E-02	1.05E+01
Sr-90	6.32E-01	4.79E+01
Tc-99	1.51E+01	1.00E+03
Th-228	1.42E-01	2.19E+01
Th-230	5.05E-01	8.42E+01
Th-232	4.52E-01	7.53E+01
U-233/234	5.59E-01	3.17E+02
U-235/236	6.01E-01	4.55E+02
U-238	4.99E-01	2.10E+02

TR = target risk

Note, these are not discharge limits. The design of the EMDF Landfill Water Treatment System is still under development and the discharge location and associated stream conditions are not yet known. Discharge limits will be developed as part of a primary, post-ROD document.

K.1.4.3.3 Uncertainty concerning certain BCFs

Certain of the evaluated radionuclides have very high BCFs, indicating these are readily taken up by fish. These BCFs result in very low PRGs for surface water and fish, well below detection limits in some instances. However, these radionuclides were not found in high concentrations in the fish tissue samples collected (see Sect. K.1.2.2), even considering ongoing discharges from EMWMF and releases from the legacy contamination sites in Bear Creek Valley. This indicates that there are other, possibly site-specific factors that reduce the bioaccumulation of these radionuclides or that the radionuclide was not present in the water column during the lifetime of the fish.

The radionuclides with uncertainty in the bioconcentration factors are C-14, Co-60, Cs-137, Eu-154, Pu-238, and Pu-239. These are described below and were assessed relative to several factors: (1) expected to be present in the background environment from both natural and anthropogenic sources, (2) expected quantities in the EMDF inventory, (3) routinely observed in EMWMF landfill wastewater, and (4) ability to measure calculated instream water concentrations at PRG level based on analytical detection limits.

Carbon-14

C-14 is produced naturally by cosmic ray interactions in the atmosphere and is found in all-natural rainwater. C-14 is not a widespread contributor to EMWMF or projected EMDF waste streams. However, C-14 is anticipated in waste from demolition of Isotope Row buildings at ORNL planned for disposal in EMDF. As a conservative estimate, C-14 is anticipated to be about 0.03% of the radiological inventory in EMDF at closure (about 0.05% of the total radiological inventory at closure if operational losses are not credited).

C-14 was infrequently observed in EMWMF discharge (38 detects in 646 samples [5.9%] between 2010 and 2020). Maximum detected C-14 between 2010 and 2020 was 33.4 pCi/L; however, the maximum observed activity was 230.6 pCi/L in 2003, an outlier that has not been repeated. The average for the EMWMF operations life is 3.13 pCi/L. There were no C-14 detections at the V-Weir from January 2020 to present.

Considered a risk driver; however, the Institute of Radioprotection and Nuclear Safety cites that there is not enough information to determine if the radiological benchmark set for other radionuclides is relevant for C-14 (IRNS 2012, *Radionuclide sheet, Carbon-14 and the environment*). In addition, the IAEA indicate that uptake of C-14 is reduced by other sources of carbon in the environment. Therefore, use of a conservative BCF for C-14 likely overestimates potential uptake (IAEA 2010, *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments*, Technical Reports Series No. 472). There is a wide range of BCFs in the literature, from 50,000 (RESRAD) to 400,000 (ORNL Risk Assessment Information System).

Default BCFs for C-14 results in a highly conservative instream water column PRG (i.e., 0.141 pCi/L) that is below analytical detection levels. Importantly, there were no detects of C-14 in recent fish samples indicating limited (if any) bioaccumulation in Bear Creek fish.

Furthermore, the calculated instream water PRG for C-14 of 0.141 pCi/L is significantly less than EPA's maximum contaminant level (MCL) for drinking water of 2000 pCi/L. In fact, the instream water PRG is also much lower than analytical detection levels for C-14 in water of 4 pCi/L.

Cobalt-60

Co-60 is produced in nuclear reactors and is not naturally occurring. It has a very short half-life—on the order of 5 years, and therefore, does not persist in waste or in the environment. It is not currently produced at the legacy (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]) sites on the ORR, so Co-60 in projected future waste streams is already undergoing significant radioactive decay.

Co-60 is not a major contributor to EMDF or EMWMF waste inventories (about 0.2% of the EMDF radiological inventory at closure if operational losses are not credited). Co-60 was not a major contributor to EMWMF waste streams.

Co-60 was infrequently observed in EMWMF discharge (16 detects in 659 samples [2.4%] between 2010 and 2020). Maximum detected Co-60 between 2010 and 2020 was 6.6 pCi/L, and the average for the EMWMF operations life is 3.46 pCi/L. There were no Co-60 detections at the V-Weir from January 2020 to present.

Default BCFs for Co-60 results in conservative instream water column PRG (i.e., 66.6 pCi/L) that is below EPA's drinking water standards. The published range of BCFs in the literature ranges from 76 (EPA) to 300 (RESRAD). Importantly, there were zero (0) detects of Co-60 in recent fish samples, indicating little to no bioconcentration in Bear Creek fish.

The analytical detection level for Co-60 in water is 5 pCi/L, well above the calculated PRG of 0.9 pCi/L. Furthermore, the calculated instream water PRG for Co-60 of 66.6 pCi/L is less than EPA's MCL for drinking water of 100 pCi/L.

Cesium-137

Although natural sources exist for Cs-137, man-made sources dominate in the global environment. Cs-137 is a naturally occurring fission product, and xenon (Xe)-137 can be produced in nature by cosmic muons, then decays to Cs-137. There are no new sources of Cs-137 being generated at the CERCLA sites on the ORR. With a half-life of 30 years, the waste streams are already undergoing significant radioactive decay.

Cs-137 is considered a major dose contributor to the EMDF inventory (about 40% of the total radiological inventory at closure, if operational losses are not credited). Cs-137 is not a major contributor to EMWMF waste streams. Cs-137 has been detected in fish tissue samples collected adjacent to the ORR, at the confluence of Poplar Creek and the Clinch River, primarily near the White Oak Dam. Monitoring will be conducted to determine if releases of Cs-137 from EMDF waste streams could result in detections of Cs-137 in Bear Creek fish tissue.

Cs-137 was infrequently observed in EMWMF discharge (18 detects in 659 samples [2.7%] between 2010 and 2020). Maximum detected between 2010 and 2020 was 13 pCi/L, and the average for the EMWMF operations life is 5.05 pCi/L. There were no Cs-137 detections at the V-Weir above detection limits from January 2020 to present.

The default BCF for Cs-137 results in conservative instream water column PRG values (1.21 pCi/L) that are below analytical detection levels. The published range of BCFs in the literature ranges from 2000 (RESRAD) to 2500 (EPA). Importantly, there were zero (0) detects of Cs-137 in recent fish samples, indicating little to no bioconcentration in Bear Creek fish, which is unexpected based on the BCF.

Furthermore, the calculated instream water PRG for Cs-137 of 1.21 pCi/L is less than EPA's MCL for drinking water of 200 pCi/L, and below analytical detection levels for Cs-137 in water of 3 to 5 pCi/L.

While higher concentrations of Cs-137 can be significantly reduced, this is difficult to treat at very low levels. (Ablequist 2021, personal communication with the ORR Liquid Gaseous Waste Operations).

Europium-154

Europium is naturally occurring in very small quantities; however, it is often used in the operation of nuclear reactors. Eu-154 is not a major contributor in EMWMF or EMDF inventories (less than 0.01% of the projected EMDF radiological inventory at closure if operational losses are not credited).

Eu-154 was infrequently observed in EMWMF discharge (15 detects in 645 samples [2.3%] between 2010 and 2020). Maximum detected between 2010 and 2020 was 17.7 pCi/L, and the average for the EMWMF operations life is 8.65 pCi/L. There were no Eu-154 detections at the V-Weir from January 2020 to present.

Default BCFs for Eu-154 results in conservative instream water column PRG (i.e., 61.2 pCi/L) that is comparable to EPA's drinking water standards (60 pCi/L). The published range of BCFs in the literature ranges from 50 (RESRAD) to 130 (EPA). Importantly, there were zero (0) detects of Eu-154 in recent fish samples, indicating no bioaccumulation in Bear Creek fish.

While Bear Creek is designated for recreational use, the calculated instream water PRG for Eu-154 of 61.2 pCi/L is comparable to EPA's MCL for drinking water (60 pCi/L). The analytical detection level for Eu-154 in water is 11 to 15 pCi/L.

Plutonium-238

Man-made sources of plutonium from historic atmospheric weapons testing remain suspended and continually slowly settle into ecological systems. As a result, plutonium typically occurs globally in fresh surface water.

Plutonium has very low mobility in waste and the environment, which limits concentrations in surface water. There is limited inventory in the EMWMF waste. However, Pu-238 is expected to be present in the EMDF waste as sites at the Y-12 National Security Complex (Y-12) and ORNL are demolished. As a conservative estimate, Pu-238 is anticipated to be about 1.7% of the EMDF radiological inventory at closure. Monitoring will be conducted to determine if releases of Pu-238 from EMDF waste streams could result in detections of Pu-238 in Bear Creek fish tissue.

Pu-238 was detected in about 0.5% of EMWMF discharges from 2010 through 2020 (3 detects in 646 samples). The maximum detected activity observed at the EMWMF V-weir was 0.58 pCi/L, with an average of 0.022 pCi/L. There were no Pu-238 detections at the V-Weir from January 2020 to present.

Default BCFs for Pu-238 results in a highly conservative instream water column PRG (i.e., 0.0318 pCi/L) that is near analytical detection levels. The published range of BCF in the literature ranges from 30 (RESRAD) to 21,000 (EPA). There was one detect of Pu-238 in the recent fish samples, in a fillet sample collected at BCK 0.5. This was unexpected because plutonium is an actinide element and does not show a tropism for muscle (typically it is a bone seeker), and its presence in the tissue is unusual. This condition is demonstrated by fish samples collected from around Chernobyl that were all below any risk threshold for radioactivity due to Pu-238. Sample results indicate limited bioaccumulation in Bear Creek fish.

Furthermore, the calculated instream water PRG for Pu-238 of 0.0318 pCi/L is significantly below the EPA's MCL for gross alpha emitters of 15 pCi/L. The analytical detection levels for Pu-238 in water is around 0.01 to 0.08 pCi/L.

Plutonium-239

Man-made sources of plutonium from historic atmospheric weapons testing remain suspended and continually slowly settle into ecological systems. As a result, plutonium typically occurs globally in fresh surface water.

Plutonium has very low mobility in waste and the environment, which limits concentrations in surface water. There is limited inventory in the EMWMF waste but is expected to be present in the EMDF waste as sites at Y-12 and ORNL are demolished. As a conservative estimate, Pu-239 is anticipated to be about 1.1% of the EMDF radiological inventory at closure. Monitoring will be conducted to determine if releases of Pu-239 from EMDF waste streams could result in detections of Pu-239 in Bear Creek fish tissue.

Pu-239 is analyzed with Pu-240 due to the difficulty in separating low concentrations of the two isotopes analytically. Pu-239/240 was detected in about 2% of EMWMF discharges from 2010 through 2020 (13 detects in 645 samples). The maximum detected activity observed at the EMWMF V-Weir was 0.43 pCi/L, with an average of 0.276 pCi/L. There was one Pu-239/240 detection at the V-Weir from January 2020 to present, 0.382 pCi/L on July 14, 2020.

Default BCFs for Pu-239 results in a highly conservative instream water column PRG (i.e., 0.0309 pCi/L) that is near analytical detection levels. The published range of BCFs in the literature ranges from 30 (RESRAD) to 21,000 (EPA). Plutonium is an actinide element and does not show a tropism for muscle (typically it is a bone seeker), and its presence in the tissue is unusual. Importantly, there were zero (0) detects of Pu-239 in recent fish samples indicating no bioaccumulation in Bear Creek fish.

Furthermore, the calculated instream water PRG for Pu-239 of 0.0309 pCi/L is significantly below the EPA's MCL for gross alpha emitters of 15 pCi/L. The analytical detection levels for Pu-239 in water of 0.01 to 0.08 pCi/L.

K.1.4.4 Future Discharge Limit Development

Site-specific, protective radiological effluent limits for discharges from EMWMF and EMDF will be based on the fish tissue and surface water PRGs and in accordance with applicable or relevant and appropriate requirements and CERCLA. Although recent field studies showed limited availability of harvestable fish, in-stream PRGs were based on default fish consumption rates (applicable to the most productive fisheries in Tennessee) and default EPA radioisotope biological concentration factors (bounding factors for all sizes and types of fish). Fish tissue measurements taken during these field studies also showed that ongoing discharges into Bear Creek, including discharges from the existing EMWMF disposal facility since 2002, are protective of a hypothetical, conservative recreational fisher annually consuming 6387.5 g (14 lb) of fish exclusively from Bear Creek (the default fish consumption rates). Levels of radioactivity observed in Bear Creek fish tissue samples were either non-detectable, at levels that present no unacceptable risk to hypothetical fishing activity, or at levels that are similar to uncontaminated background locations (see Sect. K.1.5.8).

EMDF design information is not yet available, including details such as discharge point, discharge rate, assimilative capacity of the receiving surface water body, etc. As a result, prior to operation, a post-ROD FFA primary document, such as the Remedial Action Work Plan, will establish details of wastewater and/or receiving water sampling, fish tissue sampling, and other specifics of the monitoring and compliance program. This is consistent with the approach used for non-radiological chemicals with established Ambient Water Quality Criteria and/or Tennessee Water Quality Standards. As needed, compliance criteria that correspond with the PRGs/cleanup levels may be documented in an Explanation of Significant Differences.

K.1.5 BASELINE RISK ASSESSMENT

K.1.5.1 Introduction—POE

This appendix presents the Human Health Risk Assessment (HHRA) and development of remedial goals. The HHRA documents the human health risks resulting from potential exposure to radionuclides in fish consumed from Bear Creek.

The HHRA follows guidance from EPA including, but not limited to:

- *Risk Assessment Guidance for Superfund, Vol. 1: Human Health Evaluation Manual (Part A)*, EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, D.C.
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors, Interim Final*, OSWER Directive 9285.6-03, Office of Emergency and Remedial Response, Washington, D.C.
- *Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*, OSWER Directive 9285.7-01B, Office of Emergency and Remedial Response, Washington, D.C.
- *Region 4 Human Health Risk Assessment Supplemental Guidance*, Atlanta, GA.
- *Exposure Factors Handbook*, EPA/600/P-95/002Fa, Office of Research and Development, National Center for Environmental Assessment, Washington, D.C.
- *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites*, EPA 540-R-01-003, Office of Solid Waste and Emergency Response, Washington, D.C.
- *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites*, OSWER Directive No. 9285.6-10, Office of Emergency and Remedial Response, Washington, D.C.

The results of the HHRA will be used to (1) document and evaluate risks to human health using default and site-specific exposure parameters, (2) identification of COCs that contribute to risk over thresholds, (3) quantify background risks, and (4) develop remedial goals based on the site-specific risk.

This HHRA was developed using the data collected in accordance with SAP Erratum FY21-BCV-01 to DOE/OR/01-2457&D4. The data were aggregated into three POEs:

- Brushy Fork Creek Kilometer 7.6 (BFK 7.6) – Reference Location
- Bear Creek Kilometers 0.5 to 3.3 (BCK)
- East Poplar Fork Creek Kilometer 0.0 (EFK).

The East Fork Poplar Creek POE has non-resident fish species including bass, crappie, and walleye that enter the creek from outside the study area (i.e., the Clinch River via Poplar Creek) with contamination from sources other than Bear Creek. These fish enter East Fork Poplar Creek to forage and possibly reproduce. East Fork Poplar Creek was evaluated in this HHRA for informational purposes only.

Fish tissue samples (filet and carcass) were collected from each POE in May 2021. Fish were collected by electro-shocking, targeting species commonly consumed by humans (i.e., sunfish, bass, and catfish). The necessary sample size to perform the radionuclide analyses was approximately 60 g (2.1 oz) of fish tissue. The average size of fish collected at the Bear Creek POE for analysis was 6 in. in length and weighed on average 87 g (3 oz). The average filet weight from these fish was 28 grams (1 oz). Approximately 8 to 10 fish tissue samples (40-60 g each) consisting of individual fish or composites of samples were necessary to perform a statistical analysis of the fish tissue data.

K.1.5.2 Data Evaluation

Data evaluation was conducted to establish that the data were of sufficient quality for use in the quantitative HHRA. The data evaluation process involved four steps: (1) validating the data, (2) group data according to POE and tissue type, (3) evaluate the data for usability, (4) make the data consistent within the database, and (5) create electronic data sets for each POE.

The agreed-upon COC list developed for the SAP was used for this evaluation. A background comparison was also performed in order to provide perspective related to typical naturally occurring radionuclides in the environment, but not to eliminate contaminants from the contaminant of potential concern (COPC) lists. This process is presented in Attachment A. Pb-210, Ra-226, and Ra-228 were determined to be equal to background. At the end of the risk assessment process, site risks are compared to background risk in the Uncertainty Analysis.

K.1.5.3 Exposure Assessment

The exposure assessment quantifies the amount of a COPC that an individual could come into contact with at a site. The exposure assessment only considers the ingestion of fish, the magnitude of potential exposure, the frequency (meals/year), and duration (years) of exposure. The process for estimating exposure consists of the following elements: (1) characterization of the exposure setting in terms of the physical and demographic characteristics of the site, (2) identification of receptor populations, (3) identification of exposure pathways by which an individual could come into contact with a COPC, (4) estimation of the exposure point concentration (EPC), and (5) quantification of the intake or dose to which an individual might be exposed.

K.1.5.3.1 Characterization of the exposure setting

The waters adjacent to the ORR are widely used for recreational and sport fishing (Campbell, et.al, 2002, and Burger et. al., 2008).

Recreational fishers. This receptor population was used to evaluate the potential risks associated with consumption of fish. The recreational fisher was evaluated for the consumption of 227 g (8 oz) fish meals. The number of potential meals using the default scenario is 34 per year. The number of potential meals using site-specific assumptions are 30 meals at BFK, and 11 meals at BCK 0.5 - 3.3.

K.1.5.4 Estimation of Exposure Concentration

The HHRA is based on a reasonable maximum exposure assumption. The intent is to provide an estimate of the highest exposure reasonably expected, but not necessarily the worst possible case (EPA 1989a; OSWER Directive 9200.1-120, *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors*).

The EPCs for fish are equal to the 95% upper confidence limit on the mean (UCL-95), unless this value is greater than the maximum detected concentration (MDC). In this case, the EPC defaults to the MDC. The concentration data sets were tested using the SAS software package to determine the type of distribution that best fits the data; the UCL-95 were calculated according to the best-fit distribution using SAS in ProUCL mode. The MDC was also used as the EPC where there were insufficient detected concentrations to derive a UCL-95. The UCL-95, MDCs, and resulting EPCs are presented in Attachment 2.

In the survey of local fishers, Burger et. al (2008) reported that a small percentage of fishers reported consuming whole fish. Therefore, a whole-body reconstruction was performed for matching filet and carcass samples using the methods in ES/ER/TM-202 (*Estimation of Whole-Fish Contaminant Concentrations for Filet Data)*. The method uses the following equation to derive the whole-body concentration:

$$C_{wb} = \left(C_f \times W_f + C_c \times W_c\right)/\left(W_c + W_f\right)$$

Where:

C_{wb} = Concentration in whole body (pCi/g)
C_f = Concentration in filet (pCi/g)
W_f = Weight of filet (g)
C_c = Concentration in carcass (pCi/g)
W_c = Weight of carcass (g)

The UCL-95, MDCs, and resulting EPCs are presented in Attachment 2.

K.1.5.5 Quantification of Intake and Dose

The quantification of potential exposure to COPCs involves estimating the amount of contaminant that is taken into the body through the route of exposure as discussed above for the receptor. This section describes the parameters used to quantify doses or intakes of the COPCs by the ingestion of fish.

The potential intakes represent the reasonable maximum for each defined POE, which is achieved by using conservative assumptions for the exposure factors for estimating potential. Default exposure factors for exposure frequency (meals/year) and ingestion rate (meal size [g/day]) were derived from the EPA's the Office of Water's default fish ingestion rate of 22 g/day (EPA 820-F-15-001, *Human Health Ambient Water Quality Criteria*) (as agreed to by the working group), which is equivalent to 7700 g/year. Dividing 7700 g/year by 227 g/day (equivalent to an 8-oz meal) equals 34 meals/year. A 26-year exposure duration was obtained from OSWER Directive 9200.1-120. Site-specific exposure frequencies (meals/year) were derived based on the results of the fish community surveys for the POEs and agreed upon by DOE, EPA, and TDEC (K.1.4.2.2). The values used for the intake variables are summarized in Table K.1.17.

Table K.1.17. Human health risk assessment parameters for the ingestion of fish at three POEs

Parameter	Units	BFK default	BFK site-specific	BCK default	BCK site-specific	EFK default
Ingestion rate	g/meal	227[a]	227[a]	227[a]	227[a]	227[a]
Fraction ingested from area	unitless	1	1	1	1	1
Exposure frequency	meals/year	34	30	34	11	34
Exposure duration	years	26	26	26	26	26

[a]Equivalent to 8 oz

K.1.5.6 Toxicity Assessment

To understand the potential human health risk associated with a hazardous contaminant, information on contaminant-specific toxicity is required. Toxicity information was used in conjunction with the results of the exposure assessment (Sect. K.1.5.3) to characterize potential human health risks (Sect. K.1.5.5). The toxicity end point for radionuclides evaluated in this HHRA is carcinogenicity. The source of toxicity values (cancer slope factors [CSFs]) was the EPA PRG calculator for radionuclides (EPA 2021, https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search).

K.1.5.7 Risk Characterization

The purpose of the risk characterization is to evaluate the information obtained through the exposure and toxicity assessments to estimate potential cancer risks. Potential carcinogenic effects are characterized by using projected intakes and chemical-specific dose-response data (i.e., CSFs) to estimate the probability that an individual will develop cancer over a lifetime. Cancer is the toxicity end point evaluated for radionuclides in this HHRA. The resulting numerical risk estimates must be interpreted in the context of the uncertainties and assumptions associated with the risk assessment process and with the data upon which the risk estimates are based (Sect. K.1.5.6).

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the incremental lifetime cancer risk (ILCR), or the increased chance of cancer above the normal background rate of cancer. In the United States, men have a little less than 1 in 2 lifetime risk of developing cancer; for women the risk is a little more than 1 in 3 (American Cancer Society 2009, *The Lifetime Probability of Developing and Dying from Cancer*). Typically, the calculated ILCRs are compared to the range specified in the *National Oil and Hazardous Substances Pollution Contingency Plan* of 10^{-6} to 10^{-4}, or 1 in 1 million to 1 in 10,000 exposed persons developing cancer (EPA 1990). ILCRs below 10^{-6} are considered acceptable. ILCRs above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} referred to as the target risk range. For this HHRA, a cancer risk of 10^{-5} was specified by the EPA Administrator in the dispute resolution letter (EPA 2020).

The cancer risk estimate for each POE is summarized in Table K.1.18 and presented in Attachment 3

Table K.1.18. Cancer risk estimates for ingestion of filets and whole-body fish from the three POEs

Location	Cancer risk estimates (filet)		Cancer risk estimates (whole body)	
	Default parameters	Site-specific parameters	Default parameters	Site-specific parameters
Brushy Fork Creek (BFK -background)	1.E-04	9.E-05	2.E-04	1.E-04
Bear Creek (BCK)	1.E-04	5.E-05	9.E-05	3.E-05
East Fork Poplar Creek (EFK)	9.E-05	NA	9.E-05	NA

K.1.5.8 Uncertainty Analysis

There are uncertainties associated with all phases of the HHRA, including collection and laboratory analysis of the samples, identification of COPCs, exposure assessment, toxicity assessment, risk characterization, and comparison to background. The major uncertainties associated with this HHRA are summarized below.

- **Sample collection and analysis.** There is low uncertainty in the collection of fish tissue samples. Samples were collected in accordance with the Sampling and Analysis Plan. Radiochemistry data from the laboratory was fully validated (level 4) by UCOR chemists.

- **Identification of COPCs.** All detected radionuclides were included in the HHRA and were positively detected fish tissue samples. Therefore, there is low uncertainty in the identification of COPCs.
- **Exposure assessment.** There is moderate to high uncertainty in the exposure assessment, especially at the Bear Creek POE. As a result of the uncertainty, the number of fish meals per year is expected to be biased high. The uncertainty associated with the Bear Creek POE is two-fold. First, ORNL Environmental Sciences Division team members who sample Bear Creek on at least a yearly basis have never observed evidence of fishing (e.g., lost tackle or trash associated with fishing). Second, as shown below in Tables K.1.19 and K.1.20, edible size would likely be depleted within one to two years at the default and site-specific exposure frequencies.

Table K.1.19. Cancer risk estimates for ingestion of filets and whole-body fish from the three POEs

Area sampled for community survey

Site	area sampled (m^2)	reach length (m)
BCK0.7	619	95
BCK3.3	436	84

Table K.1.20. Extrapolated Number of Fish in POE

Number of Fish Collected/Length of Reach Sampled) multiplied by length of POE from (community survey)

BCK 0.7					
Common name	**Number of fish**	**Minimum weight (g)**	**Maximum weight (g)**	**Average weight (g)**	**Extrapolated number of fish in 500 m[b]**
largemouth bass	1	73.1	73.1	73.1	5
green sunfish	3	33.2	72.1	46.5	16
redbreast sunfish	3	32.8	59	41.833333	16
rock bass	4	36.7	116	77.5	21
warmouth	1	34.4	34.4	34.4	5
Total	12				63
BCK 3.3					
Common name	**Number of fish**	**Minimum weight (g)**	**Maximum weight (g)**	**Average weight (g)**	**Extrapolated number of fish 1.2 Km[b]**
green sunfish	1	38.1	38.1	38.1	14
Total	5[a]	95th percentile fish			71

[a]The number of fish is derived from the 95[th] percentile of all fish greater than 30 g caught annually between 2016 and 2020 at BCK 3.3.
[b]Fish counts were extrapolated from the length of the reach sampled to the length of the POE. BCK 0.7 has limited access and stretches from BCK 0.0 to BCK 0.5 (500m) whereas the BCK POE has greater access and stretches from BCK 3.3 to BCK 4.5 (i.e., 1.2 km)."

- **Toxicity assessment and risk characterization.** There is low uncertainty associated with the risk characterization. The methods and toxicity values are widely used in risk assessments and have been reviewed extensively by the scientific community.
- **Comparison to background.** Site risk estimates from naturally occurring radionuclides are likely overestimated. The concentrations of naturally occurring radionuclides in Bear Creek were determined to be statistically indistinguishable from those in the reference location (Brushy Fork Creek). The

statistical comparison of Pb-210, Ra-226, and Ra-228 at locations BCK 0.7 and BCK 3.3 to the reference location BFK 7.6 is provided in Attachment 1.

- Therefore, when site risks are compared to the risk at the reference location or when Pb-210, Ra-226, and Ra-228 are eliminated as COPCs from the Bear Creek POE, the risk associated with the Bear Creek POE is less than 10^{-5}.

K.1.5.9 Development of RGs

Region 4 Human Health Risk Assessment Supplemental Guidance (EPA 2018), states that the HHRA should include development of RGs. These were previously calculated as part of PRG development and are provided in Sect. 1.4.3.2, Table K.1.15.

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ATTACHMENT 1

STATISTICAL COMPARISON OF PB-210, RA-226, AND RA-228 BCK 0.7 AND BCK 3.3 TO THE REFERENCE LOCATION BFK 7.6

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DEMONSTRATING FISH TISSUE INDISTINGUISHABLE FROM BACKGROUND CONCENTRATIONS

The radionuclides in fish tissue for Pb-210, Ra-226, and Ra-228 from BCK 3.3, BCK 0.7, and EFK 0.0 were compared to the background location BFK 7.6. An assessment for normality was performed to determine that the data set are normally distributed. This will allow the performance of the t test to demonstrate that the means are statistically equal. If radionuclide concentrations are shown to be indistinguishable from background (i.e., means are shown to be statistically equal), then “zero” concentration will be used for those naturally occurring radionuclide concentrations.

For example, the student’s t test can be used to demonstrate whether the mean Pb-210 concentrations in fish tissue are statistically equal for BCK 3.3 and BFK 7.6 (background reference). Ten (n = 10) fish samples were collected and analyzed from each creek location. The resulting data were reported in Table 1.1.

Table 1.1. Pb-210 in fish tissue from BCK 3.3.and BFK 7.6

Pb-210 concentrations in fish tissue at BCK 3.3 (pCi/g)

0.1310	
0.1140	
0.1660	$\overline{x}_1 = 0.0639$
0.0521	$s_1 = 0.0598$
0.0542	
0.0776	
0.0238	
0.0435	
0.0086	
-0.0321	

Pb-210 concentrations in fish tissue at BFK 7.6 (pCi/g)

0.0319	
0.0805	
0.0749	$\overline{x}_2 = 0.0529$
0.0531	$s_2 = 0.0337$
-0.0118	
0.0907	
0.0869	
0.0127	
0.0639	
0.0462	

In addition to the individual fish tissue sample results provided in Table 1.1, the sample mean ($\overline{x}$) and sample standard deviation (s) are provided for each population. First the F test must be used to statistically test the null hypothesis of equal variances between site and background versus the alternate hypothesis of unequal variances. The F test shows the site and background variances to be statistically equal at the 0.05 significance level with an F two-sided *p*-value of 0.1035. Therefore, the appropriate statistical test in this situation is the t test with equal variances. The null hypothesis is stated as follows:

H_0: The means of the Pb-210 in fish tissue from BCK 3.3 and BFK 7.6 are equal versus the alternative hypothesis

H_a: The means of the Pb-210 in fish tissue from BCK 3.3 and BFK 7.6 are <u>not</u> equal

The t statistic with equal variances is calculated as follows:

$$t = \frac{\overline{x}_1 - \overline{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where:

$s_1^2 = s_2^2$ = the pooled variance estimator 0.0485. This test statistic will have a t-distribution with 10 -1 + 10 - 1 = 18 degrees of freedom (df).

For the Pb-210 concentration in fish, the test statistic is calculated

$$t = \frac{0.0639 - 0.0529}{\sqrt{\frac{0.0485^2}{10} + \frac{0.0485^2}{10}}} = 0.507$$

For Type I error of 0.05 (i.e., 5% level of significance), and df = 18, the critical values of t are ± 2.101. Since t = 0.507 does not fall in the critical region (i.e., not greater than 2.101 nor less than -2.101), we fail to reject the null hypothesis. The two-sided t-test *p*-value assuming equal variances = 0.6194 which exceeds the significance level 0.05. This means that we are 95% confident that the BCK 3.3 site and BFK 7.6 background means are statistically equal at the 0.05 significance level.

ATTACHMENT 2
EPCs

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Radiochemistry is different from analytical chemistry (i.e., for chemicals) in that the lab also reports a total uncertainty—usually a 2-sigma Total Propagated Uncertainty (TPU) (or sometimes called Combined Standard Uncertainty). It gives an additional measure of the significance of the data. The lab reports a quantified result for both detects and non-detects. The non-detect may be qualified as non-detect (U or UJ) because it is below certain criterion (such as a critical level, detection limit, TPU, rad error, etc.), but it is still quantified.

For most radiological analysis techniques, the devices are so sensitive that there is always a signal, even when nothing is present. Consequently, for alpha spectroscopy, gas flow, and liquid scintillation, a background count equivalent to an empty detector reading is subtracted from the sample counts. A mathematical technique is used to calculate gamma signal backgrounds, which are also subtracted. Sometimes the net result can be less than background, giving rise to negative numbers, but the intent in using the negative numbers is that the long-term average of those low positive and negative numbers should be zero. Otherwise, there would be a positive bias in the data set. Statistical measures are used to reject or flag numbers that are too negative to be realistic.

For chemicals, the lab does not report a quantified result for non-detects because the concentration is known only to be within a range of values. So, for a 5 U non-detect chemical result, the true concentration is unknown, but is somewhere between 0 and 5. In statistics we call that left-censored data since the data are censored at 5. Of course, there are estimated values reported below detection limits that are J flagged, but these are considered detected.

ProUCL was designed to handle chemical data and there is a difference in how chemical and radiological non-detects are handled. Chemical non-detects are assumed to be left-censored results. However, according to radiochemists, the radiological analytical labs report actual concentrations for radiological non-detects, so these rad non-detects are not censored like chemical non-detects. Non-detect rad results are quantified estimated concentrations. So, for ProUCL and SAS, it is appropriate to input all reported concentrations for radionuclides as detected results for calculating upper confidence level-95s. The radiological non-detects are handled in that manner for the ProUCL input and SAS output files presented in the following tables. EPCs are reported as the UCL-95.

EMDF Fish summary statistics in ProUCL mode for BFK 7.6 Muscle

Chemical	CAS Number	Freq. of Detection	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	Method
BFK 7.6 Muscle																	
Radionuclides																	
Americium-241	14596102	1/10	pCi/g	0.022	0.048	-0.004	0.004	5.6E-04	0.042	0.014	0.042	0.042	0.042	--	X	0.042	Maximum detected concentration
Carbon-14	14762755	0/10	pCi/g	2.08	4.58	-2.04	-0.417	-0.414	1.73	1.09	--	--	--	--	X	--	
Cesium-137	10045973	0/10	pCi/g	0.101	0.181	-0.076	-0.007	-0.005	0.055	0.045	--	--	--	--	X	--	
Chlorine-36	13981436	0/10	pCi/g	0.339	0.395	-0.331	-0.027	-0.01	0.29	0.178	--	--	--	--	X	--	
Cobalt-60	10198400	0/10	pCi/g	0.122	0.243	-0.135	0.017	0.025	0.121	0.076	--	--	--	--	X	--	
Europium-154	15585101	0/10	pCi/g	0.327	0.607	-0.203	-0.018	-0.015	0.157	0.12	--	--	--	--	X	--	
Iodine-129	15046841	0/10	pCi/g	0.02	0.075	-0.237	-0.042	-6.4E-04	0.02	0.097	--	--	--	--	X	--	
Lead-210	14255040	2/10	pCi/g	0.09	0.099	-0.012	0.053	0.059	0.091	0.034	0.081	0.086	0.091	0.007	N	0.072	parametric normal
Neptunium-237	13994202	0/10	pCi/g	0.006	0.012	-0.004	-0.001	-0.001	0.003	0.003	--	--	--	--	X	--	
Plutonium-238	13981163	0/10	pCi/g	0.007	0.025	-3.9E-04	0.002	0.001	0.011	0.003	--	--	--	--	X	--	
Plutonium-239/240	E52450475	0/10	pCi/g	0.007	0.025	-0.003	0.002	0.002	0.007	0.003	--	--	--	--	X	--	
Radium-226	13982633	3/10	pCi/g	0.041	0.201	0.008	0.106	0.084	0.294	0.089	0.131	0.211	0.294	0.082	N	0.158	parametric normal
Radium-228	15262201	3/10	pCi/g	0.126	0.201	-0.136	0.091	0.064	0.425	0.168	0.172	0.294	0.425	0.127	N	0.189	parametric normal
Strontium-90	10098972	3/10	pCi/g	0.147	0.376	-0.2	0.08	0.064	0.348	0.171	0.204	0.281	0.348	0.072	N	0.179	parametric normal
Technetium-99	14133767	0/10	pCi/g	1.15	2.25	-0.172	0.449	0.405	1.36	0.495	--	--	--	--	X	--	
Thorium-228	14274829	0/10	pCi/g	0.03	0.092	-0.038	-0.005	-0.004	0.017	0.015	--	--	--	--	X	--	
Thorium-230	14269637	3/10	pCi/g	0.042	0.127	0.009	0.054	0.041	0.12	0.038	0.074	0.101	0.12	0.024	N	0.076	parametric normal
Thorium-232	N2608	0/10	pCi/g	0.025	0.076	-2.0E-04	0.007	0.006	0.017	0.005	--	--	--	--	X	--	
Tritium	10028178	0/10	pCi/g	1.65	2.99	-0.354	0.124	0.034	0.745	0.4	--	--	--	--	X	--	
Uranium-233/234	NS632	0/10	pCi/g	0.029	0.092	-0.005	-6.9E-04	-0.001	0.007	0.004	--	--	--	--	X	--	
Uranium-235/236	N1047	0/10	pCi/g	0.022	0.068	-0.003	1.3E-04	5.2E-04	0.002	0.002	--	--	--	--	X	--	
Uranium-238	24678828	0/10	pCi/g	0.018	0.057	-0.002	0.001	0.001	0.005	0.002	--	--	--	--	X	--	

[a] Full detection limits are shown.
[b] This summary statistic is calculated using both detects and non-detects.
Dist. = distribution. Distribution flags are defined as:
N = normal. UCL95 was calculated using t statistic.
X = neither normal, lognormal nor gamma. UCL95 was calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.
S.D. = standard deviation.
UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.
-- = Not applicable, not available or insufficient data to calculate the statistic.

EMDF Fish summary statistics in ProUCL mode for BCK 0.5 and BCK 3.3 Muscle

Chemical	CAS Number	Freq. of Detection	Units	Non-detect Detection Limits[a] Min	Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Mean	Max	S.D.	Dist.	UCL 95[b]	Method
BCK 0.5 and BCK 3.3 Muscle																	
Radionuclides																	
Americium-241	14596102	1/20	pCi/g	0.007	0.042	-0.002	0.004	0.002	0.042	0.009	0.042	0.042	0.042	--	X	0.042	Maximum detected concentration
Carbon-14	14762755	0/20	pCi/g	2.07	5.33	-1.65	-0.09	-0.544	2.45	1.13	--	--	--	--	X	--	
Cesium-137	10045973	0/20	pCi/g	0.095	0.21	-0.054	-0.001	-0.004	0.063	0.035	--	--	--	--	X	--	
Chlorine-36	13981436	0/20	pCi/g	0.282	0.397	-0.291	-0.021	-0.031	0.25	0.144	--	--	--	--	X	--	
Cobalt-60	10198400	0/20	pCi/g	0.12	0.318	-0.076	0.007	0.008	0.089	0.04	--	--	--	--	X	--	
Europium-154	15585101	0/20	pCi/g	0.287	0.748	-0.228	0.022	0.038	0.205	0.101	--	--	--	--	X	--	
Iodine-129	15046841	0/20	pCi/g	0.024	0.131	-0.038	-0.007	-0.005	0.022	0.015	--	--	--	--	X	--	
Lead-210	14255040	4/20	pCi/g	0.094	0.104	-0.032	0.068	0.07	0.166	0.046	0.078	0.122	0.166	0.037	N	0.086	parametric normal
Neptunium-237	13994202	0/20	pCi/g	0.005	0.015	-0.011	-0.002	-7.0E-04	0.008	0.004	--	--	--	--	X	--	
Plutonium-238	13981163	1/20	pCi/g	0.006	0.014	-0.002	0.002	0.001	0.005	0.002	0.005	0.005	0.005	--	X	0.005	Maximum detected concentration
Plutonium-239/240	E52450475	0/20	pCi/g	0.006	0.014	-0.002	0.002	0.002	0.005	0.002	--	--	--	--	X	--	
Radium-226	13982633	7/20	pCi/g	0.046	0.175	-0.035	0.159	0.068	1.89	0.41	0.068	0.363	1.89	0.674	X	0.559	Chebyshev nonparametric
Radium-228	15262201	10/20	pCi/g	0.128	0.199	-0.076	0.098	0.098	0.298	0.099	0.103	0.178	0.298	0.063	N	0.137	parametric normal
Strontium-90	10098972	1/20	pCi/g	0.16	0.483	-0.101	0.08	0.072	0.33	0.102	0.33	0.33	0.33	--	X	0.33	Maximum detected concentration
Technetium-99	14133767	0/20	pCi/g	1.16	2.73	-1.42	-0.294	-0.236	0.943	0.673	--	--	--	--	X	--	
Thorium-228	14274829	0/20	pCi/g	0.036	0.16	-0.084	-0.011	-0.006	0.015	0.02	--	--	--	--	X	--	
Thorium-230	14269637	0/20	pCi/g	0.05	0.221	-0.016	0.01	0.007	0.048	0.016	--	--	--	--	X	--	
Thorium-232	N2608	0/20	pCi/g	0.029	0.131	-0.017	9.3E-04	0.001	0.013	0.008	--	--	--	--	X	--	
Tritium	10028178	2/20	pCi/g	0.9	2.14	-0.824	0.534	0.492	3.02	0.828	1.65	2.34	3.02	0.969	N	0.855	parametric normal
Uranium-233/234	NS632	0/20	pCi/g	0.016	0.063	-0.011	-0.003	-0.002	0.003	0.004	--	--	--	--	X	--	
Uranium-235/236	N1047	0/20	pCi/g	0.012	0.047	-0.002	0.001	9.9E-04	0.006	0.002	--	--	--	--	X	--	
Uranium-238	24678828	0/20	pCi/g	0.01	0.039	-0.004	2.7E-04	5.8E-04	0.006	0.002	--	--	--	--	X	--	

[a] Full detection limits are shown.
[b] This summary statistic is calculated using both detects and non-detects.
Dist. = distribution. Distribution flags are defined as:
N = normal. UCL95 was calculated using t statistic.
X = neither normal, lognormal nor gamma. UCL95 was calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.
S.D. = standard deviation.
UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.
-- = Not applicable, not available or insufficient data to calculate the statistic.

EMDF Fish summary statistics in ProUCL mode for EFK 0.0 Muscle

				Non-detect Detection Limits[a]							Detected					UCL	
Chemical	CAS Number	Freq. of Detection	Units	Min	Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Min	Mean	Max	S.D.	Dist.	95[b]	Method
EFK 0.0 Muscle																	
Radionuclides																	
Americium-241	14596102	0/10	pCi/g	0.018	0.037	-8.9E-04	0.002	8.9E-04	0.006	0.002	--	--	--	--	X	--	
Carbon-14	14762755	0/10	pCi/g	2.23	4.81	-2.13	-0.936	-0.969	1.24	1.04	--	--	--	--	X	--	
Cesium-137	10045973	0/10	pCi/g	0.088	0.207	-0.041	0.023	0.018	0.116	0.042	--	--	--	--	X	--	
Chlorine-36	13981436	0/10	pCi/g	0.248	0.395	-0.197	-0.057	-0.074	0.108	0.099	--	--	--	--	X	--	
Cobalt-60	10198400	0/10	pCi/g	0.103	0.26	-0.047	-0.003	0.001	0.027	0.022	--	--	--	--	X	--	
Europium-154	15585101	0/10	pCi/g	0.284	0.753	-0.111	0.01	0.003	0.21	0.095	--	--	--	--	X	--	
Iodine-129	15046841	0/10	pCi/g	0.038	0.099	-0.024	0.009	0.013	0.035	0.02	--	--	--	--	X	--	
Lead-210	14255040	1/10	pCi/g	0.097	0.105	-0.02	0.046	0.046	0.138	0.055	0.138	0.138	0.138	--	X	0.138	Maximum detected concentration
Neptunium-237	13994202	0/10	pCi/g	0.005	0.009	-0.004	-7.5E-04	-5.5E-04	0.001	0.002	--	--	--	--	X	--	
Plutonium-238	13981163	0/10	pCi/g	0.004	0.027	5.5E-04	0.002	0.002	0.007	0.002	--	--	--	--	X	--	
Plutonium-239/240	E52450475	0/10	pCi/g	0.005	0.027	0.001	0.002	0.002	0.008	0.002	--	--	--	--	X	--	
Radium-226	13982633	6/10	pCi/g	0.045	0.068	0.03	0.097	0.049	0.277	0.093	0.045	0.137	0.277	0.105	N	0.151	parametric normal
Radium-228	15262201	4/10	pCi/g	0.079	0.174	-0.094	0.07	0.053	0.211	0.092	0.117	0.161	0.211	0.042	N	0.123	parametric normal
Strontium-90	10098972	2/10	pCi/g	0.108	0.32	-0.193	0.073	0.082	0.218	0.119	0.14	0.179	0.218	0.055	N	0.142	parametric normal
Technetium-99	14133767	0/10	pCi/g	1.2	1.3	-0.897	-0.423	-0.513	0.069	0.288	--	--	--	--	X	--	
Thorium-228	14274829	1/10	pCi/g	0.038	0.059	-0.007	0.004	0.002	0.035	0.013	0.035	0.035	0.035	--	X	0.035	Maximum detected concentration
Thorium-230	14269637	3/10	pCi/g	0.047	0.07	-0.006	0.019	0.02	0.044	0.019	0.034	0.039	0.044	0.005	N	0.03	parametric normal
Thorium-232	N2608	0/10	pCi/g	0.031	0.048	-0.008	0.002	0.002	0.011	0.005	--	--	--	--	X	--	
Tritium	10028178	0/10	pCi/g	1.44	2.11	-0.4	0.241	0.217	1.06	0.465	--	--	--	--	X	--	
Uranium-233/234	NS632	0/10	pCi/g	0.013	0.036	-0.002	1.1E-04	4.0E-04	0.002	0.002	--	--	--	--	X	--	
Uranium-235/236	N1047	0/10	pCi/g	0.01	0.027	-0.002	0.001	9.5E-04	0.004	0.002	--	--	--	--	X	--	
Uranium-238	24678828	0/10	pCi/g	0.008	0.022	-0.002	1.9E-04	3.3E-04	0.002	0.001	--	--	--	--	X	--	

[a] Full detection limits are shown.
[b] This summary statistic is calculated using both detects and non-detects.
Dist. = distribution. Distribution flags are defined as:
N = normal. UCL95 was calculated using t statistic.
X = neither normal, lognormal nor gamma. UCL95 was calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.
S.D. = standard deviation.
UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.
-- = Not applicable, not available or insufficient data to calculate the statistic.

Table 2. EMDF whole body fish summary statistics in ProUCL mode for BFK 7.6 whole body muscle

Chemical	CAS Number	Freq. of Detection	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	Method
BFK 7.6 whole body muscle																	
Radionuclides																	
Americium-241	14596102	1/4	pCi/g	0.03	0.04	-0.002	0.014	0.011	0.034	0.016	0.019	0.019	0.019	--	D	--	
Carbon-14	14762755	0/4	pCi/g	2.1	4.46	-0.495	-0.016	0.072	0.285	0.369	--	--	--	--	O	--	
Cesium-137	10045973	0/4	pCi/g	0.134	0.155	-0.035	-0.007	-0.005	0.019	0.027	--	--	--	--	O	--	
Chlorine-36	13981436	0/4	pCi/g	0.339	0.389	-0.163	0.004	-0.015	0.208	0.153	--	--	--	--	O	--	
Cobalt-60	10198400	0/4	pCi/g	0.14	0.223	0.002	0.034	0.028	0.078	0.033	--	--	--	--	O	--	
Europium-154	15585101	0/4	pCi/g	0.409	0.511	-0.13	-0.002	-0.005	0.131	0.107	--	--	--	--	O	--	
Iodine-129	15046841	0/4	pCi/g	0.02	0.065	-0.097	-0.045	-0.05	0.018	0.058	--	--	--	--	O	--	
Lead-210	14255040	3/4	pCi/g	0.098	0.098	0.055	0.071	0.071	0.085	0.014	0.055	0.073	0.085	0.016	D	0.1	Chebyshev nonparametric
Neptunium-237	13994202	0/4	pCi/g	0.006	0.011	-0.002	-8.7E-04	-9.8E-04	6.8E-04	0.001	--	--	--	--	O	--	
Plutonium-238	13981163	0/4	pCi/g	0.007	0.025	4.1E-04	0.003	0.002	0.007	0.003	--	--	--	--	O	--	
Plutonium-239/240	E52450475	0/4	pCi/g	0.007	0.025	-0.003	0.004	0.004	0.01	0.005	--	--	--	--	O	--	
Radium-226	13982633	1/4	pCi/g	0.041	0.097	0.079	0.157	0.164	0.222	0.064	0.222	0.222	0.222	--	D	--	
Radium-228	15262201	3/4	pCi/g	0.193	0.193	0.108	0.13	0.124	0.165	0.026	0.108	0.119	0.137	0.016	D	0.188	Chebyshev nonparametric
Strontium-90	10098972	2/4	pCi/g	0.147	0.283	-0.095	0.096	0.14	0.198	0.134	0.1	0.149	0.198	0.07	D	0.389	Chebyshev nonparametric
Technetium-99	14133767	0/4	pCi/g	1.15	2.12	0.156	0.287	0.263	0.466	0.13	--	--	--	--	O	--	
Thorium-228	14274829	0/4	pCi/g	0.03	0.074	-0.003	0.002	0.003	0.004	0.003	--	--	--	--	O	--	
Thorium-230	14269637	2/4	pCi/g	0.042	0.057	0.006	0.03	0.032	0.05	0.021	0.044	0.047	0.05	0.005	D	0.075	Chebyshev nonparametric
Thorium-232	N2608	0/4	pCi/g	0.025	0.061	1.5E-04	0.004	0.004	0.007	0.003	--	--	--	--	O	--	
Tritium	10028178	0/4	pCi/g	1.65	2.88	-0.174	0.184	0.112	0.687	0.378	--	--	--	--	O	--	
Uranium-233/234	NS632	0/4	pCi/g	0.03	0.057	-0.005	-0.002	-0.002	-3.2E-04	0.002	--	--	--	--	O	--	
Uranium-235/236	N1047	0/4	pCi/g	0.023	0.042	-0.002	-4.6E-05	2.2E-04	0.002	0.002	--	--	--	--	O	--	
Uranium-238	24678828	0/4	pCi/g	0.019	0.035	-0.001	0.002	-2.6E-05	0.008	0.005	--	--	--	--	O	--	

[a] Full detection limits are shown.
[b] This summary statistic is calculated using both detects and non-detects.
Dist. = distribution. Distribution flags are defined as:
D = The distribution could not be determined with fewer than 6 samples and 3 detects. The UCL95 was calculated using the nonparametric Chebyshev inequality method with at least 2 detects and 3 samples.
O = no detected results to calculate some summary statistics.
S.D. = standard deviation.
UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.
-- = Not applicable, not available or insufficient data to calculate the statistic.

EMDF whole body fish summary statistics in ProUCL mode for BCK 0.5 and BCK 3.3 muscle

Chemical	CAS Number	Freq. of Detection	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	Method
BCK 0.5 and BCK 3.3 whole body muscle																	
Radionuclides																	
Americium-241	14596102	0/7	pCi/g	0.008	0.042	-4.7E-04	0.005	0.003	0.02	0.007	--	--	--	--	X	--	
Carbon-14	14762755	0/7	pCi/g	2.07	4.89	-0.902	0.222	0.02	1.04	0.696	--	--	--	--	X	--	
Cesium-137	10045973	0/7	pCi/g	0.095	0.21	-0.065	-0.004	-0.006	0.036	0.033	--	--	--	--	X	--	
Chlorine-36	13981436	1/7	pCi/g	0.318	0.392	-0.086	0.009	-0.019	0.19	0.102	0.096	0.096	0.096	--	X	--	
Cobalt-60	10198400	0/7	pCi/g	0.142	0.318	-0.004	0.01	0.01	0.021	0.01	--	--	--	--	X	--	
Europium-154	15585101	0/7	pCi/g	0.335	0.748	-0.024	0.061	0.044	0.252	0.091	--	--	--	--	X	--	
Iodine-129	15046841	0/7	pCi/g	0.05	0.131	-0.075	-0.012	-0.006	0.012	0.029	--	--	--	--	X	--	
Lead-210	14255040	3/7	pCi/g	0.097	0.104	-0.019	0.064	0.078	0.111	0.043	0.078	0.094	0.111	0.017	N	0.096	parametric normal
Neptunium-237	13994202	0/7	pCi/g	0.005	0.015	-0.005	-0.001	-0.002	0.002	0.003	--	--	--	--	X	--	
Plutonium-238	13981163	1/7	pCi/g	0.006	0.014	-5.3E-05	0.002	0.002	0.004	0.001	0.003	0.003	0.003	--	X	--	
Plutonium-239/240	E52450475	0/7	pCi/g	0.006	0.014	4.0E-04	0.002	0.003	0.006	0.002	--	--	--	--	X	--	
Radium-226	13982633	1/7	pCi/g	0.049	0.175	0.006	0.057	0.049	0.116	0.041	0.116	0.116	0.116	--	X	--	
Radium-228	15262201	6/7	pCi/g	0.132	0.132	0.05	0.103	0.07	0.212	0.061	0.05	0.111	0.212	0.063	N	0.148	parametric normal
Strontium-90	10098972	4/7	pCi/g	0.193	0.263	-0.027	0.104	0.128	0.239	0.09	0.073	0.151	0.239	0.069	N	0.17	parametric normal
Technetium-99	14133767	0/7	pCi/g	1.19	2.32	-0.536	0.074	0.027	0.674	0.407	--	--	--	--	X	--	
Thorium-228	14274829	0/7	pCi/g	0.04	0.16	-0.036	-0.003	7.2E-04	0.008	0.015	--	--	--	--	X	--	
Thorium-230	14269637	2/7	pCi/g	0.055	0.221	-1.7E-04	0.017	0.017	0.036	0.012	0.018	0.027	0.036	0.012	N	0.026	parametric normal
Thorium-232	N2608	0/7	pCi/g	0.033	0.131	-0.007	0.002	0.005	0.009	0.006	--	--	--	--	X	--	
Tritium	10028178	1/7	pCi/g	0.9	2.14	-0.057	0.324	0.312	1.1	0.373	1.1	1.1	1.1	--	X	--	
Uranium-233/234	NS632	0/7	pCi/g	0.027	0.063	-0.004	6.2E-04	4.0E-04	0.005	0.003	--	--	--	--	X	--	
Uranium-235/236	N1047	0/7	pCi/g	0.02	0.047	-6.3E-04	0.002	0.002	0.004	0.002	--	--	--	--	X	--	
Uranium-238	24678828	6/7	pCi/g	0.021	0.021	-0.001	0.007	0.008	0.011	0.004	0.005	0.008	0.011	0.002	N	0.01	parametric normal

[a] Full detection limits are shown.
[b] This summary statistic is calculated using both detects and non-detects.
Dist. = distribution. Distribution flags are defined as:
N = normal. UCL95 was calculated using t statistic.
X = neither normal, lognormal nor gamma. UCL95 was calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.
S.D. = standard deviation.
UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.
-- = Not applicable, not available or insufficient data to calculate the statistic.

EMDF whole body fish summary statistics in ProUCL mode for EFK 0.0 whole body muscle

Chemical	CAS Number	Freq. of Detection	Units	Non-detect Detection Limits[a] Min	Non-detect Detection Limits[a] Max	Min[b]	Mean[b]	Median[b]	Max[b]	S.D.[b]	Detected Min	Detected Mean	Detected Max	Detected S.D.	Dist.	UCL 95[b]	Method
EFK 0.0 whole body muscle																	
Radionuclides																	
Americium-241	14596102	0/7	pCi/g	0.018	0.029	-4.0E-04	0.004	0.002	0.016	0.005	--	--	--	--	X	--	
Carbon-14	14762755	0/7	pCi/g	2.23	4.56	-0.553	0.002	-0.146	1.03	0.526	--	--	--	--	X	--	
Cesium-137	10045973	0/7	pCi/g	0.088	0.207	-0.028	0.018	0.02	0.076	0.038	--	--	--	--	X	--	
Chlorine-36	13981436	0/7	pCi/g	0.248	0.388	-0.217	-0.114	-0.136	-0.042	0.065	--	--	--	--	X	--	
Cobalt-60	10198400	0/7	pCi/g	0.103	0.26	-0.026	2.1E-04	-0.001	0.03	0.018	--	--	--	--	X	--	
Europium-154	15585101	0/7	pCi/g	0.284	0.753	-0.087	-0.006	-0.011	0.056	0.063	--	--	--	--	X	--	
Iodine-129	15046841	0/7	pCi/g	0.038	0.099	-0.012	0.004	0.006	0.011	0.008	--	--	--	--	X	--	
Lead-210	14255040	5/7	pCi/g	0.103	0.104	0.004	0.069	0.086	0.105	0.041	0.058	0.091	0.105	0.02	N	0.099	parametric normal
Neptunium-237	13994202	0/7	pCi/g	0.005	0.009	-0.004	-0.002	-0.001	4.3E-04	0.002	--	--	--	--	X	--	
Plutonium-238	13981163	0/7	pCi/g	0.004	0.008	0.001	0.002	0.002	0.003	5.7E-04	--	--	--	--	X	--	
Plutonium-239/240	E52450475	0/7	pCi/g	0.005	0.008	0.001	0.002	0.002	0.004	0.001	--	--	--	--	X	--	
Radium-226	13982633	6/7	pCi/g	0.068	0.068	0.071	0.129	0.121	0.176	0.036	0.108	0.139	0.176	0.027	N	0.156	parametric normal
Radium-228	15262201	5/7	pCi/g	0.079	0.128	0.036	0.114	0.083	0.243	0.07	0.036	0.13	0.243	0.079	N	0.165	parametric normal
Strontium-90	10098972	2/7	pCi/g	0.108	0.32	-0.102	0.107	0.12	0.181	0.096	0.155	0.168	0.181	0.018	N	0.177	parametric normal
Technetium-99	14133767	1/7	pCi/g	1.2	1.3	-0.111	0.09	0.076	0.422	0.175	0.422	0.422	0.422	--	X	--	
Thorium-228	14274829	1/7	pCi/g	0.038	0.054	-0.004	0.005	0.003	0.02	0.01	0.02	0.02	0.02	--	X	--	
Thorium-230	14269637	4/7	pCi/g	0.049	0.056	0.015	0.025	0.02	0.044	0.012	0.015	0.03	0.044	0.013	N	0.033	parametric normal
Thorium-232	N2608	0/7	pCi/g	0.031	0.043	-0.002	0.002	0.002	0.009	0.004	--	--	--	--	X	--	
Tritium	10028178	1/7	pCi/g	1.44	1.71	-0.201	0.42	0.476	1.84	0.706	1.84	1.84	1.84	--	X	--	
Uranium-233/234	NS632	1/7	pCi/g	0.013	0.036	0.002	0.007	0.002	0.018	0.007	0.018	0.018	0.018	--	X	--	
Uranium-235/236	N1047	0/7	pCi/g	0.01	0.027	-6.2E-04	0.002	0.002	0.004	0.002	--	--	--	--	X	--	
Uranium-238	24678828	1/7	pCi/g	0.008	0.022	-0.002	0.003	0.002	0.009	0.003	0.009	0.009	0.009	--	X	--	

[a] Full detection limits are shown.
[b] This summary statistic is calculated using both detects and non-detects.
Dist. = distribution. Distribution flags are defined as:
N = normal. UCL95 was calculated using t statistic.
X = neither normal, lognormal nor gamma. UCL95 was calculated using a nonparametric bootstrap or the nonparametric Chebyshev inequality method.
S.D. = standard deviation.
UCL95 = upper confidence limit on the mean concentration with 95% confidence was calculated with at least 2 detected results and at least 3 samples.
-- = Not applicable, not available or insufficient data to calculate the statistic.

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ATTACHMENT 3
CANCER RISK ESTIMATES

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Risk from ingestion of Brushy Fork Creek fish (filets) using default parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Am-241	0.0423	8.49E+03	1.34E-10	1.E-06	0.372
Pb-210	0.072	1.44E+04	1.18E-09	2.E-05	0.042
Ra-226	0.158	3.17E+04	1.74E-10	6.E-06	0.286
Ra-228	0.189	3.79E+04	5.14E-10	2.E-05	0.097
Sr-90	0.179	3.59E+04	1.42E-09	5.E-05	0.035
Th-230	0.076	1.53E+04	1.48E-10	2.E-06	0.337
Total Cancer Risk				**1.E-04**	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of Bear Creek fish (filets) using default parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Am-241	4.20E-02	8.43E+03	1.34E-10	1.E-06	3.72E-01
Pb-210	8.60E-02	1.73E+04	1.18E-09	2.E-05	4.22E-02
Pu-238	5.00E-03	1.00E+03	1.69E-10	2.E-07	2.95E-01
Ra-226	5.59E-01	1.12E+05	1.74E-10	2.E-05	2.86E-01
Ra-228	1.37E-01	2.74E+04	5.14E-10	1.E-05	9.70E-02
Sr-90	3.30E-01	6.62E+04	1.42E-09	9.E-05	3.51E-02
H-3	8.55E-01	1.72E+05	1.44E-13	2.E-08	3.46E+02
Total Cancer Risk				**1.E-04**	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of East Fork Poplar Creek fish (filets) using default parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Pb-210	1.38E-01	2.77E+04	1.18E-09	3.E-05	4.22E-02
Ra-226	1.51E-01	3.04E+04	5.14E-10	2.E-05	9.70E-02
Ra-228	1.23E-01	2.48E+04	1.42E-09	4.E-05	3.51E-02
Sr-90	1.42E-01	2.85E+04	6.88E-11	2.E-06	7.24E-01
Th-228	3.53E-02	7.08E+03	1.48E-10	1.E-06	3.37E-01
Th-230	3.02E-02	6.07E+03	1.19E-10	7.E-07	4.19E-01
Total Cancer Risk				**9.E-05**	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of Brushy Fork Creek fish (filets) using site-specific parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Am-241	0.0423	7.49E+03	1.34E-10	1.E-06	0.421
Pb-210	0.072	1.27E+04	1.18E-09	2.E-05	0.048
Ra-226	0.158	2.80E+04	1.74E-10	5.E-06	0.325
Ra-228	0.189	3.35E+04	5.14E-10	2.E-05	0.110
Sr-90	0.179	3.17E+04	1.42E-09	5.E-05	0.040
Th-230	0.076	1.35E+04	1.48E-10	2.E-06	0.382
Total Cancer Risk				**9.E-05**	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of Bear Creek fish (filets) using site-specific parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Am-241	4.20E-02	2.73E+03	1.34E-10	4.E-07	1.15E+00
Pb-210	8.60E-02	5.58E+03	1.18E-09	7.E-06	1.31E-01
Pu-238	5.00E-03	3.25E+02	1.69E-10	5.E-08	9.11E-01
Ra-226	5.59E-01	3.63E+04	1.74E-10	6.E-06	8.85E-01
Ra-228	1.37E-01	8.88E+03	5.14E-10	5.E-06	3.00E-01
Sr-90	3.30E-01	2.14E+04	1.42E-09	3.E-05	1.08E-01
H-3	8.55E-01	5.55E+04	1.44E-13	8.E-09	1.07E+03
Total Cancer Risk				**5.E-05**	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of Brushy Fork Creek fish (whole body) using default parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Am-241	1.90E-02	3.82E+03	1.34E-10	5.E-07	3.72E-01
Pb-210	1.00E-01	2.01E+04	1.18E-09	2.E-05	4.22E-02
Ra-226	2.22E-01	4.46E+04	1.74E-10	8.E-06	2.86E-01
Ra-228	1.88E-01	3.76E+04	5.14E-10	2.E-05	9.70E-02
Sr-90	3.89E-01	7.80E+04	1.42E-09	1.E-04	3.51E-02
Th-230	7.52E-02	1.51E+04	1.48E-10	2.E-06	3.37E-01
Total Cancer Risk				**2.E-04**	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of Bear Creek fish (whole body) using default parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Cl-36	9.56E-02	1.92E+04	4.44E-12	9.E-08	3.47E+01
Pb-210	9.58E-02	1.92E+04	1.18E-09	2.E-05	1.31E-01
Pu-238	3.06E-03	6.14E+02	1.69E-10	1.E-07	9.11E-01
Ra-226	1.16E-01	2.32E+04	1.74E-10	4.E-06	8.85E-01
Ra-228	1.48E-01	2.97E+04	5.14E-10	2.E-05	3.00E-01
Sr-90	1.70E-01	3.41E+04	1.42E-09	5.E-05	1.08E-01
Th-230	2.61E-02	5.23E+03	1.48E-10	8.E-07	1.04E+00
H-3	1.10E+00	2.20E+05	1.44E-13	3.E-08	1.07E+03
U-238	1.01E-02	2.02E+03	8.66E-11	2.E-07	1.78E+00
Total Cancer Risk				9.E-05	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of East Fork Poplar Creek fish (whole body) using default parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Pb-210	9.92E-02	1.99E+04	1.18E-09	2.E-05	4.22E-02
Ra-226	1.56E-01	3.12E+04	5.14E-10	2.E-05	9.70E-02
Ra-228	1.65E-01	3.32E+04	1.42E-09	5.E-05	3.51E-02
Sr-90	1.77E-01	3.56E+04	6.88E-11	2.E-06	7.24E-01
Tc-99	4.22E-01	8.47E+04	4.00E-12	3.E-07	1.25E+01
Th-228	2.00E-02	4.02E+03	1.48E-10	6.E-07	3.37E-01
Th-230	4.38E-02	8.80E+03	1.19E-10	1.E-06	4.19E-01
H-3	1.84E+00	3.70E+05	1.44E-13	5.E-08	3.46E+02
U-234	1.83E-02	3.68E+03	9.55E-11	4.E-07	5.22E-01
U-238	8.70E-03	1.75E+03	8.66E-11	2.E-07	5.75E-01
Total Cancer Risk				9.E-05	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of Brushy Fork Creek fish (whole body) using site-specific parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Am-241	0.0190439	3.37E+03	1.34E-10	5.E-07	4.21E-01
Pb-210	0.1002941	1.78E+04	1.18E-09	2.E-05	4.79E-02
Ra-226	0.2220282	3.93E+04	1.74E-10	7.E-06	3.25E-01
Ra-228	0.1876044	3.32E+04	5.14E-10	2.E-05	1.10E-01
Sr-90	0.3888312	6.88E+04	1.42E-09	1.E-04	3.98E-02
Th-230	0.075242	1.33E+04	1.48E-10	2.E-06	3.82E-01
Total Cancer Risk				**1.E-04**	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

Risk from ingestion of Bear Creek fish (whole body) using site-specific parameters

Chemical	Exposure point concentration in fish (pCi/g) RME	Intake values (pCi) RME	Cancer slope factor pCi^{-1}	Excess lifetime cancer risk (intake × sf) RME	RG (pCi/g)
Cl-36	9.56E-02	6.21E+03	4.44E-12	3.E-08	2.54E+01
Pb-210	9.58E-02	6.22E+03	1.18E-09	7.E-06	9.57E-02
Pu-238	3.06E-03	1.99E+02	1.69E-10	3.E-08	6.68E-01
Ra-226	1.16E-01	7.51E+03	1.74E-10	1.E-06	6.49E-01
Ra-228	1.48E-01	9.61E+03	5.14E-10	5.E-06	2.20E-01
Sr-90	1.70E-01	1.10E+04	1.42E-09	2.E-05	7.95E-02
Th-230	2.61E-02	1.69E+03	1.48E-10	3.E-07	7.63E-01
H-3	1.10E+00	7.11E+04	1.44E-13	1.E-08	7.84E+02
U-238	1.01E-02	6.55E+02	8.66E-11	6.E-08	1.30E+00
Total Cancer Risk				3.E-05	

g = gram
pCi = picocurie
Sf = slope factor
RG = Remedial Goal
RME = Reasonable Maximum Exposure

APPENDIX K.2
NON-RADIOLOGICAL DISCHARGE LIMITS

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ACRONYMS

AWQC	ambient water quality criteria
BCK	Bethel Creek kilometer
BCV	Bethel Creek Valley
CL	concentration limit
DOE	U.S. Department of Energy
EF	exposure frequency
EMDF	Environmental Management Disposal Facility
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FFS	Focused Feasibility Study
FI	fraction ingested
FY	fiscal year
NT	North Tributary
PRG	preliminary remediation goal
RER	Remediation Effectiveness Report
ROD	Record of Decision
RSL	Regional Screening Level
TDEC	Tennessee Department of Environment and Conservation
Y-12	Y-12 National Security Complex

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K.2 NON-RADIOLOGICAL DISCHARGE LIMITS

K.2.1 EXISTING CONDITIONS

This Focused Feasibility Study (FFS) is being prepared to evaluate the management of landfill wastewater generated from the Environmental Management Waste Management Facility (EMWMF) and the proposed Environmental Management Disposal Facility (EMDF). Non-radiological discharge limits were developed to meet the Tennessee Department of Environment and Conservation (TDEC) recreational ambient water quality criteria (AWQC) (TDEC 0400-40-03-.03, *General Water Quality Criteria*, "Criteria for Water Uses") and antidegradation requirements (TDEC 0400-40-03-.06, *General Water Quality Criteria*, "Antidegradation Statement"). In addition, while uranium radionuclides are described in Chap. K.1, an AWQC-like discharge limit was calculated to address the toxicity of uranium as a metal.

As described in the 2021 Recommendation Effectiveness Report (RER), the Bear Creek Valley (BCV) watershed contains closed and active waste disposal facilities. When the initial evaluation was performed for the D1/D2 FFS, Bear Creek was not listed for several contaminants that were expected to be causing stream impairments. As a result, previous versions of this appendix of the FFS (Appendix K) described conditions as most likely impaired for certain chemicals and evaluated potential anti-degradation requirements based on fish and surface-water data, somewhat as a replacement for the listing process.

Following the original versions of the FFS, Bear Creek became listed for many of these evaluated contaminants. Bear Creek is now officially listed as impaired in the Year 2016 303(d) List for nitrate+nitrite, cadmium, mercury, and polychlorinated biphenyls (PCBs). Therefore, this evaluation was superseded by the listing process and is no longer necessary. This section has been replaced by a brief discussion of the potential source for these contaminants based on the EMWMF inventory and expected EMDF inventory, and information provided in the *2021 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee* (DOE/OR/01-2869&D2) (2021 RER).

K.2.1.1 Mercury

As shown on Fig. K.2.1, the Bear Creek watershed begins at the eastern edge of the Y-12 National Security Complex (Y-12) and is east of the primary area impacted by mercury operations and in a different watershed (Bear Creek vs Poplar Creek). In the past, the Bone Yard Burn Yard east of EMWMF was a source of mercury contamination in Bear Creek. Mercury concentrations decreased rapidly after completion of the *Phased Construction Completion Report for the Bear Creek Valley Boneyard/Burnyard Remediation Project at the Y-12 National Security Complex, Oak Ridge, Tennessee* in 2002 (DOE/OR/01-2077&D2). Since December 2006, mercury concentrations at North Tributary (NT)-3 generally have been below the recreational AWQC of 0.051 ug/L, except for the elevated mercury sample of 147 ng/L collected on August 6, 2020, which was two orders of magnitude higher than any other recent sample. This sample was evaluated and determined to be a statistical outlier using Rosner's Outlier Test (2021 RER).

While mercury concentrations in the Bear Creek water column are below the recreational AWQC of 0.051 ug/L, fish contain measurable amounts of mercury above the U.S. Environmental Protection Agency (EPA)-recommended levels of 0.3 µg/g (Table K.2.2). Therefore, mercury is considered to be of concern for landfill wastewater discharges.

Mercury is present in small quantities in waste disposed at EMWMF but is anticipated to be present in somewhat larger quantities in EMDF because more waste will be received from Comprehensive Environmental Response, Compensation, and Liability act cleanup at Y-12. EMWMF wastewater is typically below 0.051 ug/L. Therefore, a mercury strategy was developed for EMDF by the Federal Facility Agreement (FFA) parties that contain the following key points for wastewater discharges:

- Resource Conservation and Recovery Act (D009) mercury characteristic hazardous waste is prohibited from onsite disposal, along with elemental mercury. These limitations decrease the mercury concentration in leachate.
- The recreational AWQC of 0.051 µg/L will be applied at the point of discharge (no assimilative capacity will be credited). Anti-degradation requirements for the EMDF will be met through the tri-party mercury agreement attached in Appendix N.

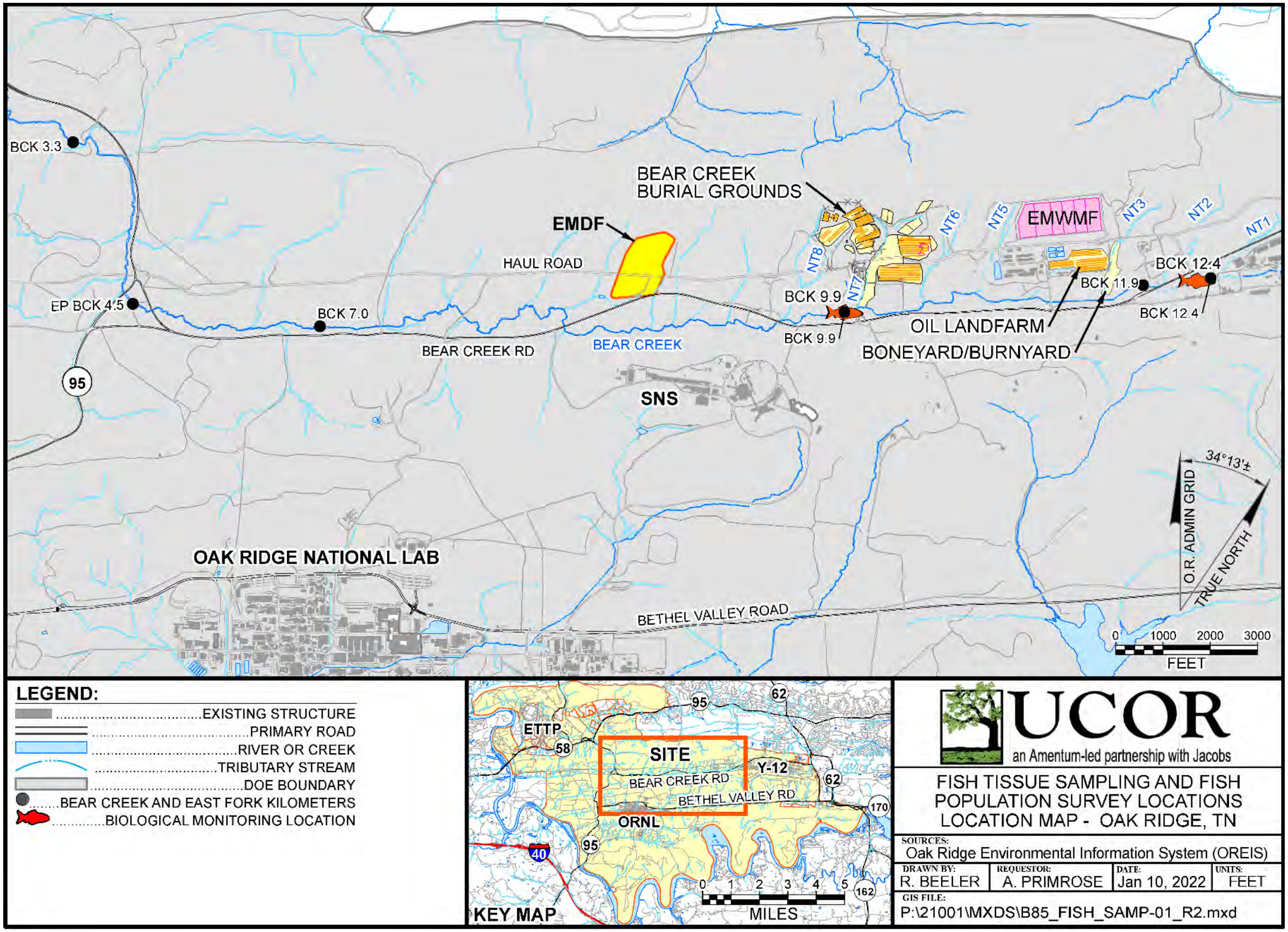

Fig. K.2.1. Bear Creek Valley locations (from 2015 RER).

K.2.1.2 Nitrate and Nitrite

The principal source of nitrate and nitrite is the S-3 Ponds area (2021 RER). The EMWMF does not have significant quantities of these contaminants, and these are not projected to be in the EMDF inventory in significant quantities either.

The concentrations of nitrate at Bear Creek kilometer (BCK) 9.2 from fiscal year (FY)2004 to FY2020 are below the 10 mg/L maximum contaminant level and have not exceeded the risk-based Hazard Quotient of 1 for residential exposure concentrations (2021 RER). No additional restrictions are required for EMWMF/EMDF discharges.

K.2.1.3 PCBs

PCBs are occasionally above the analytical detection limits in downstream tributary NT-8, but are at non-detectable levels in the tributaries near EMWMF and, in general, in Bear Creek (2021 RER). PCBs in fish continue to be above levels recommended in TDEC stream evaluation criteria.

The PCB wastes disposed in EMWMF and planned for the proposed EMDF are primarily painted surfaces on demolition debris, not mobile waste forms. As a result, PCBs are not seen in EMWMF contact water above detection limits, and there have been very minor detects in leachate. Therefore, PCBs are not key contaminants of concern and are not evaluated further as an antidegradation parameter. In the event that PCBs are seen above the historical levels, additional controls will be considered.

As described in the EMDF Record of Decision (ROD), the U.S. Department of Energy (DOE) will ensure applicable and relevant and appropriate requirements are met (or waived consistent with terms of any waivers). PCB levels in Bear Creek from EMWMF are currently below reported detection limits. Since DOE anticipates significantly less PCB disposal at EMDF than EMWMF, DOE does not anticipate additional loading of PCBs.

DOE will continue PCB monitoring efforts, utilizing sufficiently sensitive analytical test methods approved under 40 CFR Part 136 that are capable of detecting and measuring the pollutants at, or below, the applicable water quality criteria limits. In the event PCBs are detected in EMDF effluent, a compliance program and schedule will be implemented.

K.2.1.4 Cadmium

Cadmium is present in the upper stretches of Bear Creek at NT-01 and at BCK 12.34 (Fig. K.2.1), and levels predominantly exceed the 0.72 ug/L AWQC. The principal source of cadmium is disposed liquids from the S-3 ponds (DOE/OR/01-2869&D2).

Cadmium from the S-3 Ponds is strongly attenuated before Bear Creek reaches BCK 9.2.

Cadmium does not require additional controls because it is not expected in the waste inventory in amounts that contribute to wastewater contamination but will continue to be evaluated and monitored as an EMWMF and future EMDF contaminant of concern.

K.2.1.5 Uranium as a Metal

In accordance with the Dispute Resolution Decision, the human health exposure scenario for the human health-based surface water discharge limits is a recreational fisherman, with the exposure media being fish in Bear Creek. This scenario is consistent with the stream use classification for Bear Creek (TDEC 0400-40-04), which identifies Bear Creek as recreational. EMWMF is located in the DOE-controlled industrial end use area designated in the approved BCV ROD. Land use for the EMDF will also be DOE-controlled industrial use.

Figure K.2.2 illustrates the conceptual site model under a recreational exposure scenario indicating surface water and fish as the exposure media. Exposure routes include incidental ingestion and dermal exposure during wading for surface water and ingestion for fish.

The in-stream numbers were calculated using the EPA Radionuclide preliminary remediation goal (PRG) calculator and the EPA Chemical Contaminants Regional Screening Level (RSL) calculator. Both the PRG calculator and the RSL calculator are appropriate approaches for calculating discharge limits since both calculators have multiple modules that represent different exposure scenarios and use both EPA-approved input parameters, including agency-approved carcinogenic slope factors (from *Cancer Risk Coefficients for Environmental Exposure to Radionuclides, Federal Guidance Report 13*, EPA/402-R-99-001) and the option to include site-specific input parameters.

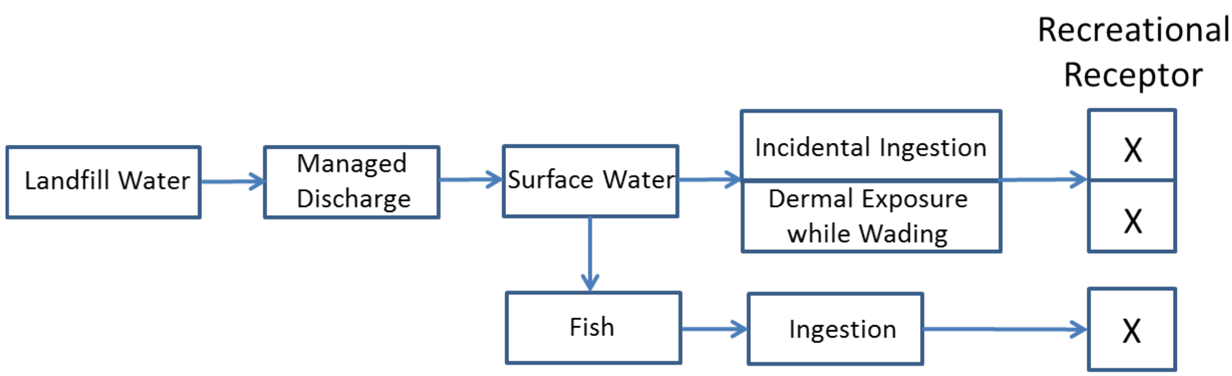

Fig. K.2.2. Conceptual site model for recreational land use.

Surface Water Exposure Pathways

Input parameters for the surface water pathway used in the PRG calculator and the RSL calculator are shown in Table K.2.1. The sources of the values are shown in the third columns.

Table K.2.1. Input parameters for recreator surface water exposure pathways

Variable	Value	Source
TR (target cancer risk) unit less	1×10^{-5}	Default
THQ (target hazard quotient) unit less	1	Default
ED_{rec} (exposure duration - recreator) year	30	Default
ED_{rec-a} (exposure duration - adult) year	26	Site-specific
ED_{rec-c} (exposure duration - child) year	4	Site-specific
THQ (target hazard quotient) unit less	1	Default
LT (lifetime - recreator) year	70	Default
EF (exposure frequency) day/year	45/1	EPA recommended Site-specific
EF_{rec-a} (adult exposure frequency) day/year	45/1	EPA recommended Site-specific
EF_{rec-c} (child exposure frequency) day/year	45/1	EPA recommended Site-specific
$ET_{rec-adj}$ (age-adjusted exposure time) hour/event	1	Site-specific
ET_{rec-a} (adult exposure time) hour/event	1	Site-specific
ET_{rec-c} (child exposure time) hour/event	1	Site-specific
EV_{rec-a} (adult) events/day	1	Site-specific
EV_{rec-c} (child) events/day	1	Site-specific
BW_{rec-c} (body weight - child) kg	15	Default
BW_{rec-a} (body weight - adult) kg	80	Default
SA_{rec-c} (skin surface area - child) cm^2	2690	EPA Exposure Factors Handbook
SA_{rec-a} (skin surface area - adult) cm^2	6032	EPA Exposure Factors Handbook
$IFW_{rec-adj}$ (age-adjusted water intake rate) L/kg	1.331	model calculated
$DFW_{rec-adj}$ (age-adjusted dermal factor) cm^2-event/kg	120498	model calculated
$DFW_{rec-adj}$ (age-adjusted immersion factor) hr	150	model calculated
IRW_{rec-a} (water intake rate - adult) L/day	0.05/0.11	Default
IRW_{rec-c} (water intake rate - child) L/day	0.05/0.12	Default
l_{sc} (apparent thickness of stratum corneum) cm	0.001	Default

Below is a brief explanation of each of the parameters used for the surface water exposure medium.

Exposure Frequency. EPA recommends under a recreator swimming scenario an exposure frequency (EF) of 45 days/yr (*Region 4 Human Health Risk Assessment Supplemental Guidance*. Technical Services Section, Superfund Division, EPA Region 4, Section 4.10, January 2014 Final Draft). An EF of 45 days/yr was used in the approved *Final Sitewide Remedial Investigation and Feasibility Study for East Tennessee Technology Park, Oak Ridge, Tennessee, Sitewide Baseline Human Health Risk Assessment for Residual Contamination at Mitchell Branch and in Groundwater at the East Tennessee Technology Park* (DOE/OR/01-2279&D3). Further, the EF used in this analysis (45 days/yr) is consistent with that used in the approved *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, Baseline Human Health Risk Assessment Report* (DOE/OR/01-1455/V5&D1), which used 45 days/yr and 1 hour/day exposure time (total 45 hours/yr exposure).

Exposure Duration. The exposure duration used in this analysis is that which is generally accepted in EPA risk assessments (30 years). This default value is consistent with the 90th percentile estimate of time spent at a single residence from *Exposure Factors Handbook: 2011 Edition* (EPA/600/R-090/052F). A site-specific fish ingestion exposure frequency (1 meal/yr) was selected based on the limited number of edible fish that can be caught while still retaining a viable fishery in the reach of Bear Creek between BCK 3.3 and 4.5.

Exposure Time. The exposure time used in this analysis is from *Dermal Exposure Assessment: Principals and Applications* (EPA/600/8-91/011B), Table 8-6; upper bound value (1 hour/event) is a default value.

Water Intake Rate. The water intake rate used in this analysis (0.05 L for the RSLs and 0.11 and 0.12 L for radionuclides) is from *Exposure Factors Handbook: 2011 Edition* (EPA/600/R-090/052F), Table 3-5, which assumes an exposure time of 45 minutes while swimming, scaled to 60 minutes (i.e., 0.037 L/45 minutes × 60 minutes = 0.0493 L; with the value rounded to 0.05 L). The water intake rate for radionuclides is the default value in the radionuclide PRG calculator.

Skin Surface Area. Incidental exposure to surface water is considered because the fisher is fishing from the bank or bridge and may get water on their hands and/or arms. Under the recreational scenario, it is assumed that wading occurs with potential exposure to the legs and arms. Thus, the surface areas for these extremities from the EPA memorandum *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors,* OSWER Directive 9200.1-120, are used. Additionally, contact with surface water may result in exposure to radionuclides; therefore, the age-adjusted immersion factor (150 hr) derived by the PRG calculator was used to evaluate this potential exposure.

Table K.2.2 presents the output from both the PRG calculator and the RSL calculator for the radioisotopes and soluble uranium associated with incidental contact with surface water associated with the two exposure pathways calculated at the specific risk level (i.e., excess lifetime cancer risk of 1×10^{-5}) or at the reference dose (i.e., hazard quotient = 1).

Table K.2.2. Recreator scenario surface water risk-based discharge limits

	Risk-based concentration in surface water (mg/L)
	Incidental water contact
Constituent	Hazard index = 1
Uranium (soluble salts)	69

Fish Ingestion Pathway

Input parameters for the fish ingestion pathway used in the PRG calculator and the RSL calculator are shown in Table K.2.3, along with whether these are default values from the calculators or site-specific values. These factors are reasonable since other nearby water bodies are much larger and thus more supportive of a viable fishery than Bear Creek. Therefore, it is plausible that fish caught at alternate locations may be consumed.

Table K.2.3. Input parameters for recreational fish consumption exposure pathway

Variable	Value	Source
TR (target cancer risk) unit less	1×10^{-5}	Default
FI (fraction ingested) unit less	1	Default
EF_f (exposure frequency) days/yr	1	Site-specific
ED_f (exposure duration) yr	30	Default
IRFa (fish consumption rate) mg/day	170,097	Assumes a single 6-ounce meal

According to Sect. 4.12 of *Region 4 Human Health Risk Assessment Supplemental Guidance*, Technical Services Section, Superfund Division, EPA Region 4, January 2014 Final Draft, a fraction ingested (FI) of 1 (i.e., 100%) should be used. However, it is further stated that for exposure evaluations associated with intermittent streams (which the upper reaches of Bear Creek are), adjustments to the FI may be acceptable, pending consultation with EPA. The default FI was retained for this analysis.

Table K.2.4 presents the results from the PRG calculator. Note that the RSL calculator results in values for fish flesh, respectively. Applying the respective radioisotope-specific bioconcentration factor (values from the ORNL PRG calculator) results in the associated water concentration (i.e., mg/L).

Table K.2.4. Recreator scenario fish ingestion surface water risk-based concentration limits

Constituent		Risk-based concentration limits in surface water based on fish ingestion only
		Hazard index = 1 (mg/L)
Uranium (soluble salts)	0.96	37

Table K.2.5 presents the integrated exposure pathway risk-based concentration limits (total CLs) calculated for the recreational exposure scenario. To arrive at the total discharge limits, the following equation is used:

$$Total\ CL = 1/((1/SWdl) + (1/Fishdl))$$

Table K.2.5. Total recreational risk-based concentration limits

Constituent	Total risk-based concentration limits based on incidental water contact and fish ingestion
	Hazard index = 1 (mg/L)
Uranium (soluble salts)	24

K.2.2 FUTURE NON-RADIOLOGICAL DISCHARGE LIMITS

Similar to development of Radiological Discharge Limits (Chap. K.1), future non-radiological discharge limits, including uranium as a metal, will be developed, taking into consideration technically justified site-specific information, including the discharge location, stream conditions at that location, stream classification, and additional observed factors.

These discharge limits will achieve a 10^{-5} risk goal for hypothetical recreational fishing in Bear Creek and will be documented in a post-ROD primary document, such as the Remedial Action Work Plan, that is reviewed and approved by the FFA parties.

However, because Bear Creek is listed as impaired for mercury, and this contaminant is present in the EMWMF waste and expected to be present in the EMDF waste, the discharge limit will be the recreational AWQC of 0.051 ug/L to reduce potential additional impacts to the stream.

Compliance with these non-radiological discharge limits will be determined by the average discharge over a specific time period. There are significant differences in landfill wastewater generated and Bear Creek streamflow over the wet and dry seasons, and averaging provides the best indication of chronic conditions in the stream that would impact a recreational fisher.

Following construction of the EMDF landfill wastewater treatment system, landfill wastewater will be discharged to Bear Creek in accordance with the most stringent, applicable AWQC.

K.2.3 REFERENCES

DOE/OR/01-1455/V5&D1. *Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, Baseline Human Health Risk Assessment Report*, 1996, U.S. Department of Energy, Oak Ridge, TN.

———DOE/OR/01-2077&D2. *Phased Construction Completion Report for the Bear Creek Valley Boneyard/Burnyard Remediation Project at the Y-12 National Security Complex, Oak Ridge, Tennessee*, 2003.

———DOE/OR/01-2279&D3. *Sitewide Baseline Human Health Risk Assessment for Residual Contamination at Mitchell Branch and in Groundwater at the East Tennessee Technology Park*

———DOE/OR/01-2869&D2. *2021 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*, 2021

EPA/402-R-99-001. *Cancer Risk Coefficients for Environmental Exposure to Radionuclides, Federal Guidance Report 13*, 1999, U.S. Environmental Protection Agency, Washington, D.C.

———EPA/600/8-91/011B. *Dermal Exposure Assessment: Principals and Applications*, 1992.

———EPA/600/R-090/052F. *Exposure Factors Handbook: 2011 Edition*, 2011.

EPA Region 4 2014. *Region 4 Human Health Risk Assessment Supplemental Guidance*, 2014, Technical Services Section, Superfund Division, U.S. Environmental Protection Agency, Region 4, Washington, DC.

OSWER Directive 9200.1-120. *Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors*, 2014, U.S. Environmental Protection Agency, Washington, D.C.

TDEC 0400-40-03-.03. *General Water Quality Criteria*, "Criteria for Water Uses," latest revision, Tennessee Department of Environment and Conservation, Nashville, TN.

———TDEC 0400-40-03-.06. *General Water Quality Criteria*, "Antidegradation Statement," latest revision.

———TDEC 0400-40-04, *Use Classifications for Surface Water*, latest revision.

APPENDIX L.
PROPOSED SAMPLING APPROACH FOR THE WATER MANAGEMENT FFS

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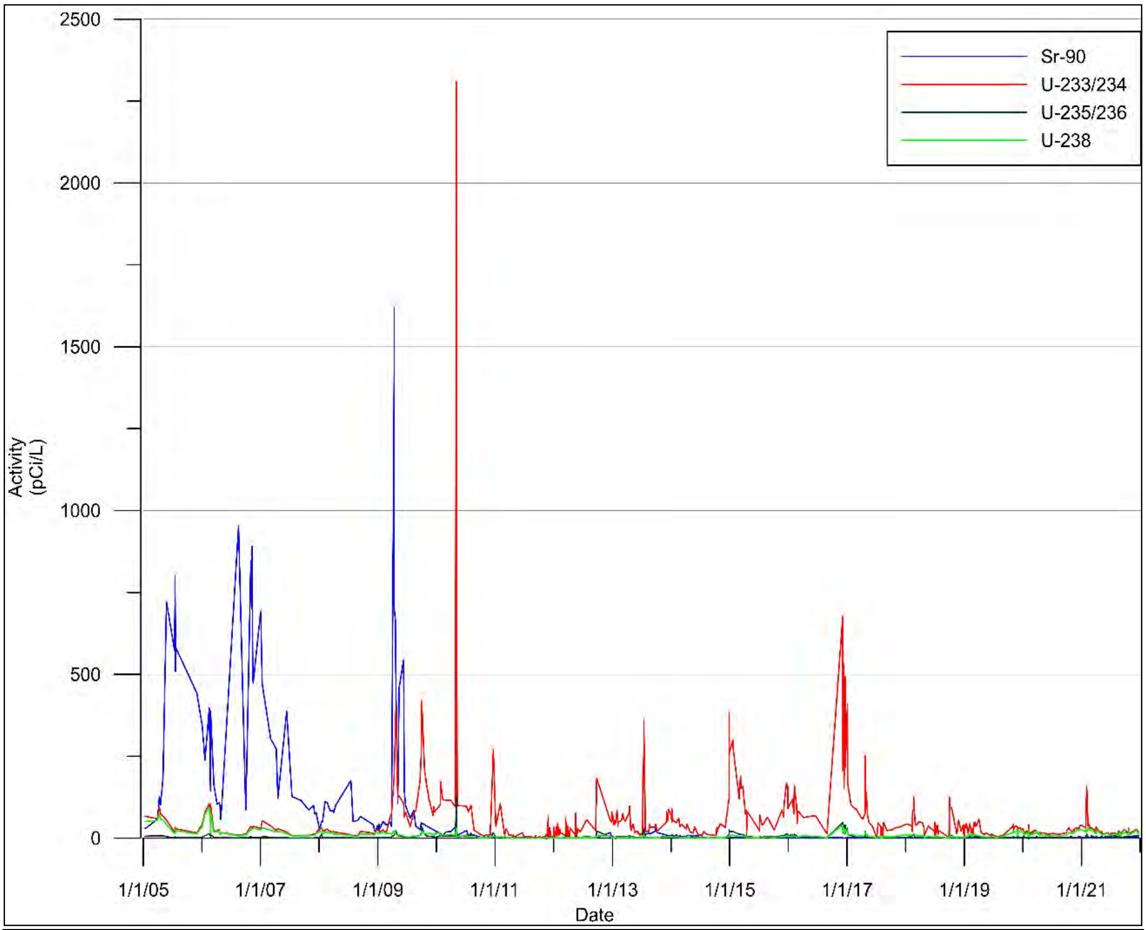
PROPOSED SAMPLING APPROACH FOR THE WATER MANAGEMENT FOCUSED FEASIBILITY STUDY

Appendix C of the Water Management Focused Feasibility Study reviewed the existing Environmental Management Waste Management Facility (EMWMF) contact water and leachate data to select the key contaminants of concern (COCs) that will be used to determine compliance for the Landfill Wastewater Treatment System. As shown below (Fig. L.1), the contaminants in the waste lots, and therefore in the landfill wastewater, change over time as different groups of facilities and projects are remediated.



	2002–2006	2007–2010	2011–2021
Y-12	Boneyard/Burnyard		Old Salvage Yard, Biology Complex, Alpha 5
ORNL	Melton Valley closure soil and sediment, main plant surface impoundments	University of Tennessee-Battelle Bldg. 3026, 2000 complex	2000 complex, including slabs and soils
ETTP	K1070A burial ground, main facilities	K-25, Zone 1 and 2, Poplar Creek process facilities	K-33, K-25
Other	David Witherspoon 901	David Witherspoon 1630	

ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
Y-12 = Y-12 National Security Complex

Fig. L.1 Activity of Sr-90 and uranium isotopes in EMWMF contact water—Jan. 2005 to Dec. 2021.

Prior to 2010, strontium was more prevalent in the contact water, representing the waste streams from the Y-12 National Security Complex (Y-12) and the Oak Ridge National Laboratory (ORNL). After 2010, uranium (U)-233/234 is the prevalent radionuclide, representing a change in waste streams to primarily those originating at the East Tennessee Technology Park (ETTP). U-235/236 was also more common in contact water prior to 2007, representing the portion of waste received from Y-12, including the Boneyard/Burnyard.

Since 2010, the primary source of waste disposed at EMWMF has been from demolition projects at ETTP. Therefore, the contaminants within the landfill wastewater have not changed significantly during that time. However, when demolition of contaminated facilities is completed at ETTP, demolition of facilities at Y-12 and ORNL are scheduled. At that time, the contaminants in the landfill wastewater are expected to change.

The major contaminants expected at all locations are already included as key COCs (Table L.1). Additional water quality or flow parameters that will be monitored are provided in Table L.2. However, to ensure that the key COC is appropriate for the waste disposed, a process was developed to add key COCs as necessary.

Table L.1. Key contaminants of concern in contact water and leachate

Analysis type	Analyte	Analysis type	Analyte
METAL	Arsenic	PPCB	4,4'-DDD
METAL	Cadmium	PPCB	4,4'-DDE
METAL	Chromium	PPCB	4,4'-DDT
METAL	Hexavalent Chromium	PPCB	Aldrin
METAL	Copper	PPCB	beta-BHC
METAL	Lead	PPCB	Dieldrin
METAL	Mercury	RAD	Iodine-129
METAL	Nickel	RAD	Strontium-90
METAL	Uranium	RAD	Technetium-99
Other	Cyanide	RAD	Tritium
Other	Dissolved Solids	RAD	Uranium-233/234
Other	Suspended Solids	RAD	Uranium-235/236
Other	Total Organic Carbon (TOC)	RAD	Uranium-238

PPCB = pesticide/polychlorinated biphenyl
RAD = radiological

Table L.2. Additional water quality or flow parameters to be monitored

Analysis type	Analyte	Explanation
Other	Hardness, as $CaCO_3$	Toxicity of some metals is directly related
Other	Nitrogen, Nitrate total (as N)	Nutrients, important to monitor health of the stream
Other	Nitrogen, total (as N)	Nutrients, important to monitor health of the stream
Other	Phosphorus, total (as P)	Nutrients, important to monitor health of the stream
Other	Total Dissolved Solids or conductivity	Routine performance to determine if a pulse is moving through the system
Other	Total Organic Carbon	Indicates the presence of volatile organic compounds or semi-volatile organic compounds
Other	Total Suspended Solids	Indicates the potential to transport sorbed metals, affects benthics
Other	Whole effluent toxicity, both acute and chronic	Semi-annual, or upon major change in waste characteristics; at least one sample during Sept.–Nov. low-flow period.
Other	Ammonia Nitrogen, total (as N)	Ubiquitous nature in most leachate streams
Other	Stream flow	Required to calculate mixing in stream if upset conditions occur
Other	Wastewater Flow	Required to calculate mixing in stream

$CaCO_3$ = calcium carbonate

Process for Adding Key COCs

Landfill wastewater will be monitored to determine if additional key COCs need to be added to the list. The process uses the following approach:

- Total Organic Carbon will be used as an indicator of the potential presence of volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). Because elevated Total Organic Carbon can also result from other causes, evaluation will be performed to determine why the results are elevated.
- Annual samples of additional waste COCs will be conducted. The first year, a select, more mobile set of COCs will be analyzed. The next year, the full set of waste COCs will be analyzed, including the more mobile COCs. This pattern will continue until no additional changes in key COCs are expected.

Known, new COCs in new waste streams will be evaluated for mobility, persistence, risk, and abundance/volume. Total Organic Carbon will be analyzed for all discharges. Increasing trends will require evaluation, including performing analyses of VOCs and SVOCs that have been identified in the waste lots if a specific, unrelated cause cannot be identified.

If VOCs and/or SVOCs are present in the discharged landfill wastewater at more than 50% of the ambient water quality criteria, then the specific analyte(s) will be added to the key COC list and treatment options will be identified for implementation, if necessary.

Annual samples—more mobile constituents. These samples will be collected from the landfill wastewater discharge every other year and analyzed for the analytes in Table L.3. Selection of these metals and organic compounds was based on their prevalence in wastes disposed in EMWMF; concentration and detection frequency in contact water and leachate; and physical/chemical characteristics, such as toxicity, mobility, and persistence in the environment.

Table L.3. Annual mobile constituent analyte list

Metals	Organic compounds
Antimony	Acetone
Barium	Benzene
Beryllium	Benzoic acid
Cadmium	Carbon tetrachloride
Nickel	Chloroform
Selenium	Tetrachloroethene
Thallium	Trichloroethene
	Vinyl chloride
	1,1-Dichloroethane
	1,1-Dichloroethene
	1,1,1-Trichloroethane

If the analytical results are consistent with the historical results, then no additional action is required. Analytical results that are above the historical results will be evaluated further. If the evaluation determines radionuclides are present at greater than historical values by more than the uncertainty or other constituents are greater than two sigma of the historical values, additional monitoring of the specific analytes will be performed for three months as part of discharge monitoring to determine if these values represent an increasing trend. If an increasing trend is determined, the results will be presented to the Federal Facility Agreement (FFA) Project Team for review and discussion to determine if these specific analytes should be added to the key COCs.

Bi-annual samples—full suite of COCs. These samples will be collected from the landfill wastewater discharge every other year and analyzed for analytes expected to be present in the landfill waste.

If the analytical results are consistent with the historical results, then no additional action is required. Analytical results that are inconsistently higher than the historical results will be evaluated further. If the evaluation determines radionuclides are present at greater than historical values by more than the uncertainty or other constituents are greater than two sigma of the historical values, additional monitoring of the specific analytes will be performed for three months as part of discharge monitoring to determine if these represent an increasing trend. If an increasing trend is determined, the results will be presented to the FFA Project Team for review and discussion to determine if these specific analytes should be added to the key COCs. Pesticide results will be specifically reviewed and evaluated for indications of increasing trends.

New COCs in new incoming waste streams. Known, new COCs in new waste streams will be evaluated for mobility, persistence, risk, and abundance/volume. Based on the results, COC-specific sampling may be performed ahead of the annual sampling, particularly in the contact water, to determine if the COC is, or is not, a soluble discharge issue. Results of the evaluation will be provided to the FFA Project Team for review and discussion to determine if these specific analytes should be added to the key COCs.

The details of the sampling approach will be included in the Sampling and Analysis Plan/Quality Assurance Project Plan.

Reporting

The results of sampling and any additional evaluation will be reported in the Annual Post-Closure Completion Report for EMWMF.

APPENDIX M.
EPA ADMINISTRATOR'S DISPUTE RESOLUTION DECISION LETTER

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

December 31, 2020

THE ADMINISTRATOR

Mr. John A. Mullis II
Oak Ridge Office of Environmental Management
Oak Ridge Reservation
U. S. Department of Energy
P.O. Box 2001
Oak Ridge, Tennessee 37831

Mr. David W. Salyers
Commissioner
Tennessee Department of Environment and Conservation
312 Rosa L. Parks Avenue
Nashville, Tennessee 37243-0435

Dear Mr. Mullis and Commissioner Salyers:

This letter conveys my final decision resolving the dispute among the U.S. Environmental Protection Agency, the Tennessee Department of Environment and Conservation and the U.S. Department of Energy regarding the discharge to surface water of wastewaters generated during a response action under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, as amended, CERCLA at the Oak Ridge Reservation facility (also referred to herein as "Site") listed on the CERCLA National Priorities List.

As described in more detail below, while not legally applicable, regulations that establish water quality based effluent limitations under the *Clean Water Act* National Pollutant Discharge Elimination System program as well as Tennessee's NPDES regulations for establishing water quality-based effluent limitations, certain Tennessee Water Quality Standards regulations and certain Nuclear Regulatory Commission regulations for low-level radioactive waste disposal are relevant and appropriate requirements for purposes of establishing preliminary remediation goals in the disputed Focused Feasibility Study that is being prepared to evaluate remedial alternatives for addressing discharges containing radionuclides from two CERCLA on-site landfills at ORR.[1] This decision applies only to the regulations themselves, not to any implementing guidance

[1] The relevant and appropriate NRC regulations are found at 10 C.F.R. §§ 61.41 and 61.43. For the reasons described below, I have determined that the limits set forth in 10 C.F.R. Part 20 and CWA technology-based standards and anti-degradation policies, while potentially relevant, are not appropriate for addressing releases of radionuclides (which are not CWA pollutants) from landfills at ORR.

documents.[2] Of course, applicable or relevant and appropriate requirements are applicable or relevant and appropriate to the specific remedy that is selected so the final ARARs and final cleanup levels will be identified when the final remedy is selected and a Record of Decision is issued.[3]

Cleanup levels for discharges of carcinogens from a NPL site also cannot be less stringent than the CERCLA risk range.[4] For these CERCLA on-site landfills at ORR, I have determined that the PRGs at a minimum should reflect a risk level of 10^{-5}, based on the Tennessee General Water Quality Criteria regulations that are used to establish Ambient Water Quality Criteria to protect the designated uses established by Tennessee's Water Quality Standards regulations from pollutants that are carcinogens.[5] In applying the relevant and appropriate NRC regulations, the EPA supports the DOE's application of the "as low as reasonably achievable" approach within the relevant and appropriate NRC regulations to ensure that application of a NRC regulation also achieves a risk level no less stringent than 10^{-5}.

As the final decision-maker for a disputed remedy at a federal facility on the NPL, the EPA has the authority to interpret ARARs, including the applicability of any flexibility provided under an ARAR. The EPA will exercise the flexibility provided in the relevant and appropriate state and federal CWA NPDES regulations and the relevant and appropriate NRC regulations to consider site-specific information to evaluate exposure to radionuclides for the purpose of developing the PRGs for water discharged from CERCLA landfills to waterways at ORR to ensure that risk does not exceed the 10^{-5} level.[6]

In exercising those flexibilities, I have determined that at ORR, the EPA will *not* require use of default exposure assumptions from CWA guidance documents regarding fish consumption to develop PRGs, or any other default exposure assumptions that are in dispute, such as ingestion. Instead, the DOE will establish PRGs based on site-specific exposure information and will use that information both to develop CWA effluent discharge limits and to apportion the dose of radionuclides among various sources under the NRC regulations.

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[2] 40 C.F.R. § 300.430(f)(1)(i)(A) (compliance with ARARs "are threshold requirements that each alternative must meet in order to be eligible for selection"). Guidance cannot be considered binding applicable or relevant and appropriate requirements.

[3] 40 C.F.R. §§ 300.430(f)(ii)(B) and 300.430(c).

[4] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. 40 C.F.R. § 300.430(e)(2)(i)(A)(2). *See also* 55 Fed. Reg. 8666, 8717-8718 (Mar. 8, 1990).

[5] TDEC 0400-40-03-.03 *Recreation use* Paragraph (4)(j) fn(c) ("10^{-5} risk level is used for all carcinogenic pollutants"). AWQC are then translated into water quality-based effluent limits applicable to specific dischargers.

[6] *See, e.g.*, 40 C.F.R. § 122.44(d)(1)(vi)(A) (in the absence of a numeric criterion, authorizing establishment of effluent limits using other relevant information, which may include exposure data); 10 C.F.R § 61.41 (concentrations of radioactive material that may be released to the general environment in groundwater, surface water, air, soil, plants or animals must not result in an annual dose exceeding an equivalent of 25 mrem to the whole body of any member of the public with flexibility on apportionment of that dose among exposure pathways and requiring reasonable effort to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable); 10 C.F.R § 61.43 (releases of radioactivity in effluents from a land disposal facility are governed by § 61.41, not the limits set forth in Part 20, and every reasonable effort shall be made to maintain radiation exposures as low as is reasonably achievable).

Default assumptions regarding fish consumption do not represent reasonable maximum exposure at ORR and do not appropriately take reasonably anticipated future land use into account. Other default exposure assumptions may present the same issues. It is longstanding EPA policy to consider reasonably anticipated future land use in conducting a baseline risk assessment.[7] For the purpose of the FFS, given that the state's most restrictive use designation for the receiving water (Bear Creek for the existing landfill) is recreational (including recreational fishing)[8] the individual with the potential maximum exposure to radionuclides in effluent from ORR landfills would be a recreational fisherman who fishes from Bear Creek, if the fish are contaminated by radionuclides. Reasonably anticipated future land use, and thus the location of this exposure, will depend on the DOE's land use designations.[9]

Although the DOE has fish tissue monitoring programs for Bear Creek for polychlorinated biphenyls, mercury and other metals, at present, the DOE has not evaluated the current level of radionuclides in the tissue of fish in Bear Creek or what that level may be if discharges are increased through construction of the new landfill. That fish tissue data (and assumptions based on expected discharges), as well as consumption data if radionuclides are found in fish tissue, are needed before site-specific information on fish consumption can be developed. Accordingly, this decision also provides direction on the collection of fish tissue data and, if needed, fish consumption data.

Background

The ORR Site covers nearly 35,000 acres within and adjacent to Oak Ridge, Tennessee. The EPA placed the site on the NPL in 1989, and the EPA, the DOE and the TDEC entered into a Federal Facility Agreement under CERCLA § 120(e)(2) in 1991 that governs the investigation and cleanup of the ORR Site. The site contains hundreds of contaminated areas, including old waste burial grounds, waste disposal areas and contaminated buildings located primarily in three separate large industrial areas: the Y-12 National Security Complex; the Oak Ridge National Laboratory; and the East Tennessee Technology Park (formerly known as K-25).

In order to facilitate cleanup of the ORR Site, the DOE constructed an on-site landfill, the Environmental Management Waste Management Facility at Y-12 under a 1999 CERCLA remedy

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[7] OSWER Directive No. 9355.7-04 Land Use in the CERCLA Remedy Selection Process, May 25, 1995, at 4; *see also* OSWER Directive No. 9355.7-19 Considering Reasonably Anticipated Future Land Use and Reducing Barriers to Reuse at EPA-lead Superfund Remedial Sites, Mar. 17, 2010, at 5.

[8] TDEC 0400-40-04, *Use Classifications for Surface Waters* (designating Bear Creek for fish and aquatic life, recreation, livestock watering and wildlife and irrigation uses). Bear Creek is not designated for use for water supply so drinking water use of Bear Creek is not reasonably anticipated.

[9] The DOE has designated parts of Bear Creek Valley for unrestricted and for recreational use. *See* Bear Creek Valley Phase I ROD (DOE 2000). The western half of Bear Creek Valley (Zone 1) is designated for unrestricted use. The eastern half of Bear Creek Valley, which includes the confluence of the receiving water for the Environmental Management Waste Management Facility outfall (NT-5) and Bear Creek (Zone 3) is currently designated for "controlled industrial" use. There is a one-mile buffer between Zones 1 and 3 that includes the proposed location of the outfall for the proposed Environmental Management Disposal Facility (Zone 2) that is currently designated for recreational use in the short-term and unrestricted use in the long-term. Unless the DOE decides to change its land use designations and thus change the reasonably anticipated future land use, the EPA will assume recreational fishing could occur in the parts of Bear Creek in Zones 1 and 2. Such a change could be memorialized in the context of the ROD for the new ORR landfill and enforced through the DOE's authority over its reserved federal lands.

decision. That landfill is currently discharging wastewaters with hazardous substances into North Tributary-5, a small tributary of Bear Creek.[10] Due to the DOE's waste-production projections over the next decades, the DOE has proposed building another on-site landfill for CERCLA remediation wastes: the Environmental Management Disposal Facility, that also will discharge wastewaters into Bear Creek (and its tributaries), White Oak Creek at ORNL or Upper East Fork Poplar Creek at Y-12. In 2013, the DOE proposed to prepare an integrated focused feasibility study on the management of wastewaters from EMWMF and EMDF which was submitted to the EPA and the TDEC for review and approval consistent with the ORR FFA.

Summary of Issues in Dispute

In 2016, TDEC, followed by EPA Region 4, initiated an informal dispute pursuant to the ORR FFA regarding the establishment of PRGs for the development, consistent with the National Contingency Plan, of protective effluent discharge limits for radionuclides and *Clean Water Act* pollutants contained in contact wastewater from the landfills in the *Focused Feasibility Study for Water Management for Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee*. At issue here is the setting of PRGs for radionuclide discharges from the proposed landfill and the need to address such ongoing releases from an existing landfill. For the proposed landfill, final effluent limits will not be set until the Record of Decision is issued by the DOE and the EPA with the concurrence of the TDEC. For the existing landfill, the preliminary goals will inform effluent discharge limits that may be selected in a post-ROD modification to the EMWMF ROD that will govern future effluent discharges.[11]

EPA Region 4 initiated a formal dispute on the Draft FFS in August of 2018. EPA Region 4, the DOE and the TDEC were unable to reach a resolution through the dispute resolution process of the FFA. Accordingly, the Acting Region 4 Regional Administrator issued a decision in March 2019 that concluded that: (1) CERCLA is the appropriate cleanup authority and CERCLA § 120(e)(4) provides the EPA's final remedy selection authority at Federal Facility sites on the NPL; (2) wastewaters discharged from the EMWMF and the proposed EMDF must meet CERCLA § 121(d) threshold requirements for ensuring protectiveness of human health and the environment, including discharges of radionuclides; (3) such discharges must also comply with the other threshold requirement of attaining "applicable requirements" and/or "relevant and appropriate requirements" identified by the EPA; and (4) that, in this case, the EPA and Tennessee's CWA NPDES regulations, as well as Tennessee Water Quality Standards regulations establishing designated uses and criteria to protect those uses, are relevant and appropriate requirements to the development of PRGs for the on-site discharge to surface waters of radionuclides.

On April 5, 2019, the DOE elevated the regional administrator's decision for resolution pursuant to the FFA and CERCLA § 120, and subsequently provided for my consideration formal letters and supplemental materials on June 21, 2019, August 26, 2019, October 18, 2019, April 9, 2020, and in February and March 2020. The TDEC submitted letters on April 5, 2019, in support

[10] No discharge limits were included in that Record of Decision. In 1999 neither the DOE nor the EPA anticipated the volume of wastewater that would be generated by the landfill, and wastewater was anticipated to be mostly leachate. The parties expected that leachate to be sent to the NPDES-permitted Central Neutralization Facility (off-site).

[11] Additional public comment may be necessary in order to meet the public participation requirements for both the current and proposed landfill. *See* 40 C.F.R. § 300.435(c)(2) and 40 C.F.R. § 300.430(f)(3)(ii).

of the regional administrator's position, and responded to the DOE's position on April 18, 2019, and July 5, 2019.

In its elevation of this dispute, the DOE has articulated five overarching issues. First, the DOE raises concerns about the scope of the Region 4 position and how it would impact NRC and DOE implementation of *Atomic Energy Act*-authorized dose-based limits that are considered protective under NRC and DOE programs. Second, the DOE asserts that certain NRC regulations should be considered ARARs for this response action and DOE Orders should be considered. Third, the DOE challenges Region 4's process for identifying ARARs and asserts that the regional administrator's position violates the CWA and the *Administrative Procedure Act*. Fourth, the DOE has stated that there is limited potential for exposures to radionuclide contamination via ingestion of fish caught in the receiving stream due to several site-specific factors. And fifth, the DOE has raised concerns about the cost impact of the regional administrator's position.

As stated in letters sent in April and July 2019, the TDEC supported EPA Region 4's assertion that protective discharge limits for disposal of landfill wastewater should be consistent with CERCLA and established in the ROD for the EMDF. TDEC's Commissioner emphasized that any future on-site disposal facility should comply with the *Tennessee Water Quality Control Act* and state regulations as well as protect downstream surface water users who eat fish sourced from these waters. The TDEC agreed with the EPA that CWA NPDES regulations were appropriately identified as "relevant and appropriate" requirements under CERCLA and reiterated that the current and proposed landfills are CERCLA remedial actions and, therefore, wastewater effluent limits must protect human health and the environment and comply with NCP requirements.

Issue 1: Scope and Applicability of This Decision

CERCLA § 120(e) and Executive Order 12580 specify how remedies are selected under CERCLA at federal facility NPL sites. The legal analyses in this decision apply only to such sites. Those authorities do not apply to NRC or DOE mission-related activities that are not conducted under CERCLA.[12]

My decision is to require PRGs for effluent limits for discharges of radionuclides to be informed by risks associated with identified site-specific exposures. Accordingly, as a factual matter this decision is necessarily limited to ORR. It only addresses the establishment of protective PRGs to be used in the NCP's remedy selection process that will lead to setting final effluent limits in the ROD for the discharge of effluent that includes radionuclides from landfills constructed as CERCLA response actions at ORR, a site on the NPL.

[12] CERCLA controls the remedy selection for the release of hazardous substances at this site. Congress, in enacting CERCLA, included radionuclides as hazardous substances under CERCLA and specifically addressed AEA materials by choosing to exclude only a narrow subset of AEA materials from the CERCLA definition of "release." *See* 42 U.S.C. § 9620(a) and 42 U.S.C § 9601(22)(C) (definition of "release" that includes a qualified exclusion for releases of source, byproduct, or special nuclear material from a nuclear incident, as those terms are defined in the *Atomic Energy Act of 1954* [42 U.S.C. §§ 2011 *et seq.*], if the release is from a nuclear incident, subject to financial protection by the NRC, or from specific uranium tailings facilities, none of which are applicable here).

Thus, in response to the first issue raised by the DOE, this decision does not establish a precedent for setting effluent discharge limits to surface waters at other DOE NPL facilities and does not apply to DOE or NRC facilities outside the CERCLA context.

Issue 2: Whether certain NRC regulations should be considered relevant and appropriate requirements for the discharge of radionuclides from CERCLA landfills at ORR into surface water and whether certain DOE Orders should be considered.

According to Section 121(d) of CERCLA, with respect to any hazardous substance remaining on-site, remedial actions selected under the act must attain legally applicable or relevant and appropriate federal and more stringent state requirements, or ARARs. Such requirements are "cleanup standards, standards of control or other substantive requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance found at a CERCLA site;" or, in the case of relevant and appropriate requirements, that address problems sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site.[13]

The DOE has identified the NRC regulations at 10 C.F.R. § 61.41 and § 61.43 as "relevant and appropriate" requirements for low level radioactive waste disposal.[14] Based on the NCP factors discussed below, the EPA agrees that these regulations also may be relevant and appropriate requirements for the development of PRGs for the discharge of radionuclides in wastewater from EMWMF and from the EMDF.

In assessing whether a requirement is relevant and appropriate, the EPA evaluates the factors in paragraphs 40 C.F.R. § 300.400 (g)(2)(i) through (viii) of the NCP to the extent such factors are pertinent.[15] After careful consideration of the 40 C.F.R. § 300.400(g) factors, the EPA concludes that the NRC's regulations at 10 C.F.R. § 61.41 and § 61.43 are both relevant and appropriate to the discharge of radionuclides in waste water associated with these CERCLA actions because: (1) the purpose of the regulations is to achieve the protection of public health from exposure to radionuclides; (2) § 61.41 addresses all releases of radionuclides to all media, including surface water; (3) § 61.43 addresses releases of radioactivity in effluent from landfills, which is the CERCLA action at issue in the dispute and states that § 61.41 applies to such releases; (4) the substances regulated are CERCLA hazardous substances; and (5) like CERCLA the NRC

[13] *See* 40 C.F.R. § 300.400(g). *See also* 40 C.F.R. § 300.5.

[14]The *RI/FS for CERCLA Waste Disposal of ORR Waste Disposal* (DOE/OR/01-2535) was approved by the EPA Regional Administrator in Formal Dispute Resolution Agreement under the ORR FFA signed by Senior Executive Committee on December 7, 2017. Appendix E of that document identifies 10 C.F.R. § 61.41 and 10 C.F.R. § 61.43 as ARARs for an on-site landfill from which radionuclides are released to the environment.

[15] The eight factors are (i) the purpose of the requirement and the purpose of the CERCLA action; (ii) the medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site; (iii) the substances regulated by the requirement and the substances regulated at the CERCLA site; (iv) the actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site; (v) any variances, waivers or exemptions of the requirement and available for the circumstances at the CERCLA site; (vi) the type of place regulated and the type of place affected by the release or CERCLA action; (vii) the type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action; and (viii) any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resources at the CERCLA site.

regulations aim to address and prevent releases of hazardous substances, pollutants and contaminants into the environment at unacceptable levels in order to ensure protection of human health.[16]

Under these regulations concentrations of radioactive material that may be released to the general environment in groundwater, surface water, air, soil, plants or animals must not result in an annual dose exceeding an equivalent of 25 mrem to the whole body of any member of the public with flexibility on apportionment of that dose among exposure pathways and requiring reasonable effort to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable. These NRC regulations have been identified as a relevant and appropriate requirement at DOE sites where the CERCLA remedial action was construction, operation and closure of an on-site low-level radioactive waste landfill.[17] The EPA has stated that the NRC dose-based limit of 25/75/25 millirems per year (mrem/yr) for radionuclide releases (all pathways) from a low-level radioactive waste disposal unit (i.e., landfill) [18] equates to roughly 10 mrem/yr effective dose equivalent, which the EPA has determined comports with CERCLA's generally accepted cancer risk range.[19]

The NRC dose-based limit of 25/75/25 mrem/yr for radionuclide releases from a low-level landfill such as the EMDF can be apportioned among the exposure pathways such as air, groundwater, soil, plants, animals and surface water considering fish consumption, and used in combination with the NRC process to reduce radiation dose known as ALARA, to result in radionuclide effluent concentrations that would be as stringent as the PRGs derived through application of CWA NPDES regulations for establishing water quality-based effluent limitations and Tennessee Water Quality Standards regulations, ensuring protectiveness of human health and the environment consistent with CERCLA and the NCP.[20]

I also have determined that NRC regulations at 10 C.F.R § 20.1301 (specifying a facility-wide 100 mrem/yr dose limit) and 10 C.F.R § 20.1302 (referencing Table 2 Effluent Concentrations of Appendix B to Part 20 based on a 50 mrem/yr dose limit) are relevant to the ORR landfills but are not appropriate for guiding remedy selection in the FSS. NRC's own

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[16] *CERCLA Compliance with Other Laws Manual, Interim Final, Part I,* OSWER Dir. 9234.1-01, EPA/540/G-89/006, August 1988, General Procedure for Determining if a Requirement is Relevant and Appropriate, p. 1-67.

[17] For example, see *ROD for Disposal of Oak Ridge Reservation CERCLA Waste Oak Ridge, TN, DOE/OR/Ol-l 791&D3* (Sept.1999), *Maxey Flats Nuclear Disposal, KY ROD*, EPA/ROD/R04-91/097 (Sept. 1991), and *U.S. DOE Hanford Environmental Restoration Disposal Facility Hanford Site Benton County, Washington* (Jan. 1995).

[18]10 C.F.R. § 61.41 ("Concentrations of radioactive material which may be released to the general environment in ground water, surface water, air, soil, plants or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."). The NRC dose-based limit of 25/75/25 mrem/yr for radionuclide releases (all pathways) from a low-level radioactive waste disposal unit (i.e., landfill) is included in Appendix G of the Draft RI/FS for the EMDF, and the TN equivalent regulation [currently TDEC 0400-20-11-.16(2)] was included in the 1999 EMWMF ROD as a chemical-specific ARAR.

[19] *See Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination,* OSWER Dir. 9200.4-18, Aug. 22, 1997, Attachment B, *Analysis of what Radiation Dose Limit is Protective of Human Health at CERCLA Sites (Including Review of Dose Limits in NRC Decommissioning Rule)*, Aug. 22, 1997, p.2; *Radiation Risk Assessment at CERCLA Sites: Q & A*, Directive 9200.4-40, EPA 540-R-012-13, May 2014.

[20]A remedial action must comply with the most stringent requirement that is ARAR to ensure that all ARARs are attained. 55 Fed. Reg. at 8741.

regulation at 10 C.F.R. § 61.43, which I have found to be relevant and appropriate, specifies that effluent from landfills containing radioactivity should be addressed under 10 C.F.R. § 61.41, not the standards for radiation protection set out in Part 20. Further, 10 C.F.R. § 61.41 is more stringent. I also have determined that there is no need to consider (under the "to be considered" category in 40 C.F.R. § 300.400(g)(3)) DOE Order 458.1 Radiation Protection of the Public and the Environment, Section 1.4(b) (specifying a facility-wide 100 mrem/yr dose limit) because 10 C.F.R. § 61.41 is more stringent and I have determined that it is relevant and appropriate. Finally, NRC's Part 20 regulations and DOE Order 458.1 are not appropriate to consider in the FFS because any PRG must be protective against at least a 10^{-5} level of risk to be as stringent as the requirements of the Tennessee water quality standards for carcinogens that I have determined are relevant and appropriate.[21]

Issue 3: Whether federal and state CWA regulations should be considered relevant and appropriate requirements for the discharge of radionuclides from CERCLA landfills at ORR into surface water.

In its elevation of the dispute, the DOE argues that, since AEA materials are excluded from the NPDES regulatory definition of "pollutant," there is no jurisdictional basis for the determination that the CWA regulations are relevant and appropriate to the discharge of these materials because those regulations are not "applicable" to AEA materials. The DOE posited that the EPA's proposal would violate the CWA and circumvent the APA by using the CWA to *regulate* discharges of AEA materials into surface waters without going through notice and comment rulemaking to change the NPDES regulatory definition of pollutant. That assertion is legally incorrect. First, the plain language of the NCP requires the EPA to consider "applicable ***or*** relevant and appropriate requirements" when identifying preliminary remediation goals, not applicable ***and*** relevant and appropriate requirements.[22] Second, a limitation on the EPA's authority to regulate under the CWA is not a limitation on the EPA's CERCLA authority to respond to releases of hazardous substances. As the lead agency for remedy implementation at ORR, the DOE is required by Section 120 of CERCLA and Executive Order 12580 to implement remedial actions that comply with ARARs in accordance with Section 121(d) of CERCLA.[23]

One issue before me is whether the CWA NPDES regulations and Tennessee Water Quality Standards, including narrative water quality criteria associated with the designated uses for Bear Creek under TDEC Water Quality Criteria regulations, are "relevant and appropriate" to discharges of wastewater containing radionuclides for purposes of the FFS.[24]

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[21] *See supra*, note 19.

[22] 40 C.F.R. § 300.430(e)(2)(i)(A). CERCLA § 121(d) (42 U.S.C. 9621(d)) reflects Congressional direction to the EPA (and the DOE) that in developing CERCLA remedial goals, the "remedial actions shall be ***relevant and appropriate*** under the circumstances" (emphasis added).

[23] *See also* ORR FFA Section III, Section XXI.F, and Section XVI.

[24] While the DOE does not appear to be challenging the "applicability" of these same CWA regulations to pollutants (e.g., mercury), certain requirements were inadvertently omitted from the FFS that may also be applicable to setting PRGs for the discharge of pollutants, and the FFS must be revised to include these omitted regulations. My staff will provide you shortly with a table that identifies the EPA and Tennessee CWA NPDES regulations applicable to CWA pollutants to be added to the existing ARARs/TBC tables in the Wastewater FFS.

The state of Tennessee has adopted its own NPDES regulations and the EPA has authorized those regulations to apply in Tennessee. Under CERCLA Section 121(d), ARARs include federal environmental laws and promulgated regulations or state promulgated standards, requirements, criteria or limitations that are more stringent than the federal requirements.[25] Further, CERCLA Section 121(d)(2) specifies that water quality criteria established under Section 304 or 303 of the *Clean Water Act* are ARARs where such criteria are relevant and appropriate under the circumstances of the release or threatened release. CERCLA Section 121(d)(2) also specifies that "[i]n determining whether or not any water quality criteria under the *Clean Water Act* is relevant and appropriate under the circumstances of the release or threatened release, the President shall consider the designated or potential use of the surface or groundwater, the environmental media affected, the purposes for which such criteria were developed and the latest information available."

Accordingly, for purposes of establishing PRGs for the discharge of wastewater from ORR landfills, I find that the R4 Regional Administrator properly applied the NCP factors to determine that the Tennessee and the EPA NPDES regulations that pertain to water-quality based effluent limitations and the Tennessee Water Quality Standards regulations establishing designated uses and criteria to protect those uses are relevant and appropriate requirements to the discharge of radionuclides in wastewater from EMWMF and such future discharge from EMDF.[26] Water quality criteria also are relevant and appropriate under Section 121(d)(2) because (1) the state has designated Bear Creek for recreation uses; (2) these requirements address discharges into surface water; and (3) their purpose is to protect the designated use of the surface water from risks associated with hazardous substances. This decision means that under the relevant and appropriate Tennessee Water Quality Standards[27] established to protect waters designated for "*Recreation Use*" the AWQC for such surface waters must meet a 10^{-5} target risk level for all carcinogens (including radionuclides) and water quality based effluent limitations must ensure that such AWQC are not exceeded.[28]

[25] 42 U.S.C. § 9621(d)(2)(A); CERCLA § 121(d)(2)(A).

[26] In assessing whether a requirement is relevant and appropriate, the EPA evaluates the factors in paragraphs 40 C.F.R. § 300.400(g)(2)(i) through (viii) of the NCP to the extent such factors are pertinent. The eight factors are (i) the purpose of the requirement and the purpose of the CERCLA action; (ii) the medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site; (iii) the substances regulated by the requirement and the substances found at the CERCLA site; (iv) the actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site; (v) any variances, waivers or exemptions of the requirement and their availability for the circumstances at the CERCLA site; (vi) the type of place regulated and the type of place affected by the release or CERCLA action; (vii) the type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action; and (viii) any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resources at the CERCLA site. In this circumstance, EPA Region 4 considered factors i-iv and viii to be pertinent to the evaluation of relevance and appropriateness for the CWA NPDES regulations evaluated by the EPA considering the scope of the response action.

[27] TDEC 0400-40-03-.02(1). Tennessee water quality standards consist of the *General Water Quality Criteria* and the *Antidegradation Statement* found in Chapter 0400-40-03, and the *Use Classifications for Surface Waters* found in Chapter 0400-40-04. *See also* TDEC 0400-40-03-.05(6). *Interpretation of Criteria.*

[28] TDEC 0400-40-03-.03 *Recreation use* Paragraph (4)(j) ("The waters shall not contain toxic substances, whether alone or in combination with other substances, that will render the waters unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife.") and fn(c) (10^{-5} risk level is used for all carcinogenic pollutants.").

The determination that certain state water quality standards regulations are ARARs is not novel or precedent-setting. State water quality standards and the EPA and/or the state CWA NPDES requirements have been identified as relevant and appropriate requirements for the cleanup under CERCLA of radionuclide-contaminated wastewaters at other Superfund sites.[29]

For the reasons discussed under Issue 4, below, I also have determined that the disputed default exposure assumptions, particularly those regarding fish consumption, in CWA guidance documents should not be used to develop PRGs fo r effluent limits for discharges from ORR landfills.

Further, I have determined that the regional administrator erred in determining that technology-based effluent limitations under the EPA and Tennessee regulations are relevant and appropriate to discharges of radionuclides from ORR landfills. Technology-based effluent limitations are potential ARARs when applicable.[30] However, in exercising the EPA's discretion to identify relevant and appropriate requirements,[31] and through my evaluation of the NCP's eight factors, I have determined that technology-based effluent limitations are not appropriate requirements to apply to a discharge of radionuclides from this CERCLA site.

Factor 1 requires consideration of "[the purpose of the requirement and the purpose of the CERCLA action." 40 C.F.R. § 300.400(g)(2)(i). The CWA is a regulatory statute and includes a goal of eliminating the discharge of pollutants.[32] Technology-based standards for toxic pollutants under the CWA are based on best available technology economically achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants.[33] In contrast, CERCLA is a remedial statute which provides the President broad, discretionary authority to take response actions to reduce risks to human health and the environment. It does not include a goal of eliminating all exposure to hazardous substances or eliminating all risk.[34] As demonstrated by the statutory definition of a CERCLA remedy (which includes actions "to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment"[35]) CERCLA's purpose is not aligned with the purpose of the CWA's technology-

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[29] For example, the *Rocky Flats Plant, Operable Unit 4 ROD, CO*, EPA/ROD/R08-92/064 (Apr. 1992) included CWA ARARs. Because Rocky Flats Plant surface waters had been designated by Colorado for drinking water and aquatic life protection, the more stringent of MCLs or the Water Quality Control Commissions standards were identified as chemical-specific ARARs for radionuclides, p. 4-4 to 4-6. The *Maxey Flats Nuclear Disposal, KY ROD*, EPA/ROD/R04-91/097 (Sept. 1991) identified Kentucky Surface Water Quality Standards regulations including specific limits for radionuclides as ARARs. The *ROD Amendment West Lake Landfill Site (OU-1) Bridgeton, Missouri* (Sept. 2018) identified Missouri Water Quality Standards and Effluent Limit regulations as ARARs including for discharges of radionuclides.

[30] Technology-based standards generally will be ARARs for the discharge of CWA pollutants.

[31] NCP preamble, 55 Fed. Reg. at 8726 ("EPA has discretion to determine whether any, all, or only a portion of a requirement is relevant and appropriate….").

[32] CWA section 101(a)(1).

[33] CWA section 301(b)(2).

[34] NCP Preamble, 55 Fed. Reg. at 8752.

[35] CERCLA section 101(24).

based standards so consideration of Factor 1 does not support identification of CWA technology-based standards as relevant and appropriate here.[36]

Factor 3 requires consideration of "the substances regulated by the requirement and the substances found at the CERCLA site." 40 C.F.R. § 300.400(g)(2)(iii). The hazardous substances in dispute here are radionuclide materials regulated under the *Atomic Energy Act of 1954* (42 U.S.C. § 2011). These materials are excluded from the CWA regulatory definition of pollutants regulated under the CWA (40 C.F.R. §122.2). Accordingly, consideration of Factor 3 does not support identification of CWA technology-based standards as relevant and appropriate here.

Factor 5 requires consideration of "any variances, waivers or exemptions of the requirement and their availability for the circumstances at the CERCLA site." 40 C.F.R. § 300.400(g)(2)(v). As noted above, the hazardous substances at issue in this dispute are exempted from the CWA. Accordingly, consideration of factor 5 does not support identification of CWA technology-based standards as relevant and appropriate here.

Based on the consideration of factors 1, 3 and 5 described above, I also have determined that, for radionuclides only, Tennessee's antidegradation policy is not relevant or appropriate to apply to the CERCLA remedy for discharges of radionuclides from the ORR landfills. Bear Creek is currently impaired due to PCBs and mercury and is not an outstanding natural resource water. And, as provided in this decision, no discharges from an ORR landfill subject to CERCLA will impair water quality. Accordingly, the antidegradation policy is neither relevant nor appropriate to discharges of radionuclides. Of course, it remains legally applicable to discharges of CWA pollutants, such as mercury.

My decision that CWA technology-based standards and antidegradation policies do not apply to discharges of radionuclides from landfills at ORR does not reverse any existing policy or precedent. I am not aware of any CERCLA record of decision that applies these requirements as applicable or relevant and appropriate to the discharge of radioactive materials regulated under the *Atomic Energy Act of 1954*, as amended (42 U.S.C. §2011) that are afforded a CWA regulatory exemption from the definition of pollutants (40 C.F.R. §122.2). I decline to make a new policy and set a new precedent on this point at ORR.

Issue 4: Whether site-specific factors are relevant to an evaluation of the potential for exposures to radionuclides via ingestion of fish caught in the receiving stream.

The DOE has asserted that site-specific factors are relevant to an evaluation of the potential for exposure to radionuclides via ingestion. I agree. Thus, I have determined that the process for identifying the PRGs will *not* use default exposure assumptions from CWA guidance documents to determine exposures to radionuclides discharged from landfills at ORR, particularly through fish consumption. These default exposure assumptions do not take into account the site-specific

[36] In contrast, as noted above, CERCLA's objective of protecting human health and the environment is aligned with the objectives of CWA water-quality standards, which I have determined are relevant and appropriate to establishing effluent limits for discharges of radionuclides from ORR landfills. Further, under the CWA's regulatory regime, more stringent limitations must be adopted if the application of a technology-based standard fails to meet water-quality standards. CWA Section 301(b)(1)(C).

risks associated with the reasonably anticipated future land uses at ORR. Reasonably anticipated future land use can be considered when determining the baseline risk. At ORR there is a significant risk that default exposure assumptions could lead to the establishment of effluent limitations in a final remedy that are not closely tied to addressing substantial danger to present or future public health or welfare or the environment and thus may not result in a cost-effective remedy.[37]

Instead of using disputed default assumptions regarding exposures, particularly through fish consumption, the DOE, in applying the relevant and appropriate state and federal CWA regulations and NRC regulations, will establish PRGs for effluent discharge limitations based on site-specific exposure information. This approach is consistent with the NCP.[38] Further, nothing in the federal and state CWA regulations and NRC regulations that I have determined are relevant and appropriate precludes consideration of site-specific exposure information. Under 40 C.F.R. § 122.44(d)(vi), "[w]here a State has not established a water quality criterion for a specific chemical pollutant … the permitting authority *must* establish effluent limits using one or more of the following options: (A) *Establish effluent limits using a calculated numeric water quality criterion* for the pollutant which the permitting authority demonstrates *will attain* and maintain applicable *narrative water quality criteria* and will *fully protect the designated use*, such criterion *may be* derived using … an explicit State policy or regulation interpreting its narrative water quality criterion, *supplemented with other relevant information . . . risk assessment data, exposure data* … and current EPA criteria documents." (Emphasis added).

Tennessee has no explicit state policy interpreting Tennessee's narrative water quality criterion for *recreation* use.[39] Per the NCP, there may be consideration of other pertinent information in developing PRGs which could include a study to determine exposure and risk. Similarly, in apportioning the dose of radiation among exposure pathways and using reasonable efforts to maintain releases of radioactivity in effluents to the general environment as low as reasonably achievable under NRC regulations, nothing precludes the EPA or the DOE from taking site-specific exposure and risk into account.

The existing landfill, EMWMF, is currently discharging wastewaters with hazardous substances into North Tributary-5, a small tributary of Bear Creek. The proposed wastewater discharge locations for the new landfill, EMDF, are Bear Creek and its tributaries, White Oak Creek at ORNL or Upper East Fork Poplar Creek at Y-12. While the location of the proposed landfill has not been selected, the DOE's Proposed Plan calls for it to be located near the existing

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[37] Under Section 121 of CERCLA, all remedies must protect human health and the environment, be permanent to the maximum extent practicable and be cost-effective.

[38] *See* 40 C.F.R. § 300.430(e)(2)(i) ("Initially, preliminary remediation goals are developed based on readily available information, such as chemical-specific ARARs or other reliable information. Preliminary remediation goals should be modified, as necessary, as more information becomes available during the RI/FS…. Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment and shall be developed by considering the following: (A) Applicable or relevant and appropriate requirements under federal environmental or state environmental or facility siting laws, if available, and the following factors:… (5) Other pertinent information.") (emphasis added).

[39] TDEC Rule 0400-04-03.03(4)(j) ("The waters shall not contain toxic substances, whether alone or in combination with other substances, that will render the waters unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will pose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife. Human health criteria have been derived to protect the consumer from consumption of contaminated fish and water….").

landfill where it may also discharge wastewaters into Bear Creek or its tributaries. For the purpose of the FFS, given that the most restrictive use designation for these receiving waters is recreational (including recreational fishing)[40] the individual with the potential for reasonable maximum exposure to radionuclides in effluent from ORR landfills would be a recreational fisherman who fishes at a location downstream from the discharge. Radionuclides bioaccumulate so the fact that only small minnows exist at NT-5 does not mean exposure cannot occur.[41] The exact location of this point of reasonable maximum exposure will be determined based on where recreational fishing occurs or is reasonably anticipated to occur based on reasonably anticipated future land use, considering the DOE's land use designations.[42]

Fish are present in Bear Creek and the DOE has fish tissue monitoring programs for Bear Creek for PCBs, mercury and other metals. However, at present, the DOE has not evaluated the current level of radionuclides in the tissue of fish in Bear Creek or what that level may be if discharges are increased through construction of the new landfill. That fish tissue data (and assumptions based on expected discharges), as well as consumption data if radionuclides are found in fish tissue, are needed before site-specific exposures can be estimated. The DOE may conduct such a study (or studies), scoped in consultation with the TDEC and the EPA and finalize it as a primary document in accordance with the ORR FFA.[43]

Once the PRGs are established applying relevant and appropriate requirements in a manner that considers site-specific risks, they shall be used to derive the specific final effluent limitations that are identified in the ROD for the discharge of radionuclides from the EMWMF and the future discharge from the EMDF in a manner consistent with the NCP and in compliance with the most stringent of the EPA and Tennessee CWA regulations and the NRC regulations that I have determined are relevant and appropriate. While the point of exposure to radionuclides used for identifying risk and setting appropriate effluent limits may be downstream of the discharge point (which has not yet been determined), the point of compliance for meeting the final effluent limits must be at the point of discharge.[44]

[40] TDEC 0400-40-04 (designating Bear Creek for fish and aquatic life, recreation, livestock watering and wildlife and irrigation uses).

[41] See RI/FS Risk Assessment Work Plan Addendum, Fernald Environmental Management Project, Fernald, Ohio (June 1992), at 5.3.1 (including ingestion of fish as an exposure pathway and noting the presence of minnows in Paddy's Run on the site and shad, drum and carp in the Great Miami River near the site).

[42] The DOE has designated parts of Bear Creek Valley for unrestricted and for recreational use. See Bear Creek Valley Phase I ROD (DOE 2000). The western half of Bear Creek Valley (Zone 1) is designated for unrestricted use. The easter half of Bear Creek Valley, which includes the confluence of the receiving water for the Environmental Management Waste Management Facility outfall (NT5) and Bear Creek (Zone 3) is currently designated for "controlled industrial" use. There is a one-mile buffer between Zones 1 and 3 that includes the proposed location of the outfall for the proposed Environmental Management Disposal Facility (Zone 2) that is currently designated for recreational use in the short-term and unrestricted use in the long-term. Unless the DOE decides to change its land-use designations and thus change the reasonably anticipated land uses, the EPA will assume recreational fishing could occur in the parts of Bear Creek in Zones 1 and 2. Such a change could be memorialized in the context of the ROD for the new ORR landfill and enforced through the DOE's authority over its reserved federal lands.

[43] Predicting radionuclide levels in fish tissue may also require data on radionuclide levels in the sediments and the water column.

[44] 55 Fed. Reg at 8713 ("For surface waters, the selected levels should be attained at the point or points where the release enters the surface waters.").

Issue 5: Cost implications of identifying the CWA as an ARAR.

The EPA understands and appreciates the DOE's concerns regarding the issue of cost in remedial actions. CERCLA §121(b) includes cost effectiveness as a factor to be taken into account during the remedy selection process. Consistent with the NCP, cost estimates are developed for each of the remedial alternatives at the FS stage (which is the current stage of this dispute) in order to conduct a comparative analysis that informs the remedy selection decision process.[45] To the extent sufficient information is available, the costs of construction and any long-term costs to operate and maintain the alternatives are considered in developing these estimates.[46] The estimated cost of wastewater treatment will depend in large part on the specific effluent discharge limits that must be met in order for the remedy to be protective. These effluent discharge limits are dependent on the establishment of PRGs. However, since the initial PRGs and effluent limits for discharges of radionuclides have not been determined, reliable cost information is not yet available. The estimated cost of treating wastewater with radionuclides will also depend on the concentrations of radionuclides in the various wastewaters generated by landfill operations, and the volume of the discharge as managed by the DOE. In summary, once initial PRGs and effluent discharge limits are developed, the cost considerations can be evaluated by the agencies in a manner that is consistent with the NCP.

Summary of Major Findings

Based on the foregoing analysis and the record that has led to this decision, the following is a summary of my findings, discussed in more detail above:

1) This decision applies only to ORR.
2) NRC regulations at 10 C.F.R. § 61.41 and 10 C.F.R. § 61.43 are relevant and appropriate for purposes of developing PRGs in the ORR FFS for effluent limits for radionuclide-contaminated wastewater discharges from the EMWMF and EMDF.
3) The EPA and Tennessee's NPDES regulations relating to water quality based effluent limitations and Tennessee Water Quality Standards regulations establishing designated uses and criteria to protect those uses (including the risk level of 10^{-5} for AWQC) are relevant and appropriate requirements for purposes of developing PRGs in the ORR FFS for radionuclide-contaminated wastewater discharges from the EMWMF and EMDF.
4) Site-specific factors shall be used to evaluate the potential for exposure to radionuclides via ingestion of fish and flexibility exists in the relevant and appropriate federal and state CWA regulations as well as the relevant and appropriate NRC regulations to consider site-specific exposure.
5) Consideration of site-specific factors will require site-specific information, including conducting a fish study to assess radionuclides in fish tissue and other media in Bear Creek, and evaluate fish consumption, exposure and risk assessment data, to help inform the development of PRGs for radionuclides at this site.

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[45] *Id*. at 8712 ("The primary objective of the FS is to ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning the waste management options can be presented to a decision-maker and an appropriate remedy selected.").

[46] 40 C.F.R. § 300.430(e)(7)(iii).

6) The consideration of cost estimates associated with PRGs is preliminary, but remedial alternatives in the revised FFS will need to include estimates to meet any final effluent limits to perform a meaningful comparative analysis. Consideration of cost will be weighed by the agencies later in the remedy selection process.

In accordance with Section XXVI.J of the FFA, the DOE is directed to incorporate this resolution and final determination into and to revise the FFS as necessary to conform with this decision. It is my expectation that fish tissue studies and development of PRGs for effluent limitations for radionuclides will occur in parallel with Region 4's review of the draft ROD to continue progress on the remedial actions for establishing additional landfill capacity at ORR.

I appreciate your efforts in identifying and discussing your concerns. The EPA looks forward to working closely with both the DOE and the state of Tennessee as we move this project forward.

Sincerely,

Andrew R. Wheeler

cc: Susan Parker Bodine
Peter C. Wright
David Fotouhi
Mary S. Walker
William Cooper

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APPENDIX N.
FFA PARTIES, EMERGING ISSUES TEAM AGREEMENTS

Mercury Management Approach for Discharges to Bear Creek—EMDF ROD

EIT-Developed Adaptive Approach for EMDF Wastewater Management

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Mercury Management Approach for Discharges to Bear Creek—EMDF ROD

Mercury Management Approach. The Federal Facility Agreement (FFA) parties have developed the following mercury-management approach to be implemented for Bear Creek that can adjust effluent limits for mercury. This approach is a path forward on mercury disposal at the Environmental Management Disposal Facility (EMDF) and is intended to be the basis of language included in the Record of Decision (ROD). The U.S. Environmental Protection Agency (EPA) approval and the Tennessee Department of Environment and Conservation (TDEC) concurrence on the Final ROD will reflect final agreement with the approach.

1) The U.S. Department of Energy's (DOE's) goal, in coordination with FFA parties, is to restore Bear Creek prior to the need to discharge wastewater from EMDF. Specifically, the goal is to restore Bear Creek from its status in Tennessee's Clear Water Act (CWA) 303(d) report to attainment of water quality standards for mercury to meet the recreational use designation.

2) DOE shall provide treatment of landfill wastewater, as necessary, to meet an effluent limit based on achieving treatment to a concentration below 51 ng/L (but expressed as a mass-based limit not affected by variations in the flow volume of discharge water) and such other conditions as required by CWA regulations at 40 *CFR* 122.45 (d) and (e), to be included as applicable or relevant and appropriate requirements (ARARs) and based on the type of discharge—continuous or non-continuous. This limit is the more stringent of a water-quality-based effluent limit and a technology-based effluent limit based on Best Professional Judgment, which is not a promulgated limit. The limit shall be met at the point of discharge without allowance of mixing or dilution or consideration of any available assimilative capacity in the creek. Regardless of which of the following conditions apply at the time EMDF commences operation, the limit remains the mass-based limit based on 51 ng/L.

3) Because of several years between the EMDF ROD and the completion of construction and commencement of operation of EMDF, the water quality of Bear Creek may improve. In its current condition, however, the state antidegradation rule, 0400-40-03-.06(2)(a), requiring *no additional loading* of a bioaccumulative pollutant in water with *unavailable parameters,* is included in the EMDF ROD as an ARAR. If before the EMDF is operational, Bear Creek is meeting the water quality standard for methylmercury (based on sampling data in fish tissue) by being consistently below the methylmercury fish tissue residue criterion (as defined in EPA-823-R-01-001, January 2001, *Water Quality Criterion for the Protection of Human Health: Methylmercury*), then this state antidegradation rule sub-paragraph requiring no additional loading will no longer be considered an ARAR for mercury discharges. In this case, the discharge of landfill wastewater from EMDF will be subject to the requirement to not "cause or contribute" to an exceedance of water quality standards per 40 *CFR* 122.4(i) and 122.44(d)(1).

4) DOE shall make efforts to restore Bear Creek to attain full compliance with recreational use designation, including conducting a Remedial Site Evaluation (RSE) (40 *CFR* 300.420) to evaluate mercury methylation in Bear Creek and conduct pilot or treatability studies as needed. The RSE will be scheduled in Appendix E of the FFA prior to approval of the EMDF ROD. Unless the conclusion in the RSE accepted by all parties is for no further action, the RSE shall lead to other milestones for removal or remedial actions, including developing the substantive equivalent to developing load allocations and waste load allocations under 40 *CFR* 130.7(c)(2) and 130.2(g)(h) and (i). These efforts will result in one of two scenarios addressed in paragraphs 5 and 6 below:

5) **<u>Creek meets water quality standards before EMDF operations</u>**: If the creek improves to meet its designated recreational use as measured in fish tissue concentrations below the methylmercury fish tissue residue criterion (as defined in EPA-823-R-01-001, January 2001, *Water Quality Criterion for the Protection of Human Health: Methylmercury*) and satisfies the requirements of 40 *CFR* 130.7(b)(6)(iv), then the wastewater discharge limit for mercury may remain at 51 ng/L, expressed as a mass-based number regardless of flow volume in the discharge. The fish tissue concentrations are documented in the annual Remediation Effectiveness Report reports. The discharge also still must not "cause or contribute" to an exceedance of the water quality standards (consistent with 40 *CFR* 122.44(d)), considering available assimilative capacity for methylmercury. Fish tissue sampling will continue to be performed to verify that *recreational* use attainment is maintained. To prevent the stream from becoming impaired for its designated recreational use again, any action(s) selected under paragraph 4 shall be fully implemented.

6) **<u>Creek does not meet water quality standards before EMDF operations</u>**: If Bear Creek does not meet applicable water quality standards (the methylmercury fish tissue residue criterion as defined in EPA-823-R-01-001, January 2001, *Water Quality Criterion for the Protection of Human Health: Methylmercury*) at the time the landfill begins operations, the antidegradation rule will still apply, and DOE can only discharge subject to approval by EPA and TDEC of a schedule of actions showing the discharge is at a level that will not "cause or contribute" to further violation of the methylmercury standard. EPA and TDEC must review and approve DOE's demonstration based on the following criteria:

   a) DOE will implement a schedule of actions selected and agreed to by the FFA parties under paragraph 4 above to reduce sources of methylmercury to satisfy substantive elements of 40 *CFR* 122.4(i) and bring the creek into compliance with applicable water quality standards. DOE will also re-evaluate the effectiveness of the actions and the rate of progress to consider additions and/or revisions, and any additional actions in or revisions to the schedule, once approved by all FFA parties, shall be placed as milestones in Appendix E; <u>and</u>
   b) All discharged wastewater from EMDF will be treated to meet an effluent limit of 51 ng/L. The limit can remain at 51 ng/L, expressed as a mass-based limit, or be adjusted down at DOE's discretion, allowing DOE the flexibility to attain the standard through the other actions in the Bear Creek Valley watershed to reduce methylmercury based on the earlier study and the re-evaluation required in this paragraph.
   c) The plan providing for reducing mercury loading and restoring the creek may be a phased approach using an enforceable CERCLA-compliance schedule. The approach may recognize nonpoint source reductions to offset the point source discharge at EMDF, following treatment or other measures, to permanently reduce loading and reduce the rate of mercury methylation on such an enforceable schedule.

7) Include 40 *CFR* 122.4(i) and the Tennessee antidegradation rule, 0400-40-03-.06(2)(a), as an ARAR in the EMDF ROD.

8) Revise the <u>Mercury Management Approach</u> portion of the EMDF ROD Sect. 2.12.2.3, ***Waste Acceptance Criteria***, as shown below:

   a) To the extent practicable, all recoverable elemental mercury will not be disposed in any Oak Ridge landfill and will eventually be shipped offsite, subject to availability of a disposition pathway, as specified in project-specific documentation.
   b) Resource Conservation and Recovery Act (D009) mercury characteristic hazardous waste is prohibited from onsite disposal.

9) The use of other potential design and/or operational approaches in the landfill that might further reduce or eliminate mercury mobility in disposed wastes will be evaluated.

10) **Documenting attainment of water quality standards and maintaining compliance:** The current program of fish tissue sampling shall continue to support the determination that the remedial action objective to meet all water quality standards in the EMDF ROD related to wastewater discharges is maintained after the creek is restored.

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EIT-Developed Approach to EMDF Wastewater Management for Radionuclides
May 3, 2022

The Emerging Issues Team (EIT) has determined that the best approach to meet cleanup levels for the Environmental Management Disposal Facility (EMDF) is through a final Record of Decision (ROD). The selected remedy will be primary treatment, and secondary treatment as needed, to meet cleanup levels. If a change to the identified remedy is necessary, the change will be initiated through an Explanation of Significant Differences (ESD) to the ROD, which will include public comment.

The following approach will be included in the ROD:

Twenty-one radionuclides, and associated progeny, which bioaccumulate and have the potential to be present in landfill wastewater at some time during the operational life of EMDF, have been identified as "radionuclides of interest." For the 21 radionuclides of interest, fish tissue and instream water column Preliminary Remediation Goals (PRGs)/Cleanup Levels have been developed to be protective of recreational use (human health), specifically fish ingestion.

PRGs/Cleanup Levels have been established for these radionuclides, inclusive of relevant progeny, using the U.S. Environmental Protection Agency's (EPA's) PRG Calculator tool, based on a target of 10^{-5} excess lifetime cancer risk. Exposure factors used to develop the PRGs/Cleanup Levels include:

17.5 grams/day Fish Consumption Rate and 365 days/year Exposure Frequency (current TN guidance)

26 years Exposure Duration (per Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] guidance and consistent with site-specific factors)

Default Bioconcentration Factors used in EPA's PRG Calculator tool

Derivation of the fish tissue and instream water column PRGs will be outlined in the Focused Feasibility Study (FFS) for Water Management for the Disposal of CERCLA Waste, and the values will be specified in the final ROD for EMDF.

EMDF design information is not yet available, including details such as discharge point, discharge rate, assimilative capacity of the receiving surface water body, etc. As a result, prior to operation, a post-ROD Focused Feasibility Agreement primary document such as the Remedial Action Work Plan will establish details of wastewater and/or receiving water sampling, fish tissue sampling, and other specifics of the monitoring and compliance program. This is consistent with the approach used for non-radiological chemicals with established Ambient Water Quality Criteria and/or Tennessee Water Quality Standards. As needed, compliance criteria that correspond with the PRGs/Cleanup Levels may be documented in an ESD.

The selected remedy for the EMDF's landfill leachate and contaminated stormwater (i.e., contact water), for both radionuclides and non-radionuclides, is primary treatment of all wastewaters, with secondary treatment when required to meet cleanup goals. The primary wastewater treatment will be a flocculation and chemical precipitation process. Secondary wastewater treatment will be determined during the design phase and documented in a post-ROD primary document. As with other RODs, in the event that the selected remedy does not meet the identified protective goals for a pollutant, an ESD or ROD amendment will be used to modify the remedy, such as changing the treatment approach or changing operational methods, so that the identified protective goals are met. When the EMDF effluent limits are calculated, the limits will be made available for public comment through either an ESD or ROD amendment.

Radionuclides of interest and corresponding fish tissue and instream water PRGs are shown below. These PRGs are included in UCOR-5550, *Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee,* which is part of the FFS and is being made available for public comment. The EMDF Water Quality Protection for Bear Creek Fact Sheet includes a link to this technical document, which enumerates these fish tissue and instream water PRGs.

Radionuclide	Instream water PRG/Cleanup Level (pCi/L)	Fish tissue PRG/Cleanup Level (pCi/gm of fish)
Am-241	1.88E+00	4.51E-01
C-14	7.53E-02	3.01E+01
Cl-36	2.89E+02	1.36E+01
Co-60	3.55E+01	2.70E+00
Cs-137	6.45E-01	1.61E+00
Eu-154	3.27E+01	4.25E+00
H-3	4.65E+05	4.18E+02
I-129	1.02E+01	3.06E-01
Np-237	2.34E+01	6.56E-01
Pu-238	1.69E-02	3.55E-01
Pu-239/240	1.65E-02	3.46E-01
Ra-226	5.34E-01	1.52E-02
Ra-228	1.05E+01	4.22E-02
Sr-90	4.79E+01	6.32E-01
Tc-99	1.00E+03	1.51E+01
Th-228	2.19E+01	1.42E-01
Th-230	8.42E+01	5.05E-01
Th-232	7.53E+01	4.52E-01
U-233/234	3.17E+02	5.59E-01
U-235/236	4.55E+02	6.01E-01
U-238	2.10E+02	4.99E-01

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