United States Department of Energy
Environmental Management Program DOE/OR/01-2695&D2

# Proposed Plan for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Waste

**June 2018**

**This Proposed Plan describes:**

- The need for a decision on the disposal of waste from the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) cleanup of the Oak Ridge National Priority List site (referred to as the Oak Ridge Reservation [ORR] in this document)
- Waste disposal alternatives considered
- Onsite disposal locations considered
- Preferred alternative for waste disposal
- How to participate in the selection or modification of the preferred alternative
- Where to get more information

This Proposed Plan presents the Onsite Disposal Alternative located at Central Bear Creek Valley as the preferred remedy for disposal of waste from the U.S. Department of Energy's (DOE's) ORR CERCLA cleanup program. This Proposed Plan presents the following rationale for the preferred alternative:

1. Onsite disposal facilitates timely cleanup of the ORR by providing a cost-effective, protective disposal option. An onsite disposal facility within Central Bear Creek Valley protects human health and the environment and achieves or waives all applicable or relevant and appropriate requirements (ARARs), while obtaining the best balance of the remaining CERCLA remedy selection criterion. This Proposed Plan includes a summary explanation of proposed waivers.
2. Onsite disposal optimizes utilization of government funds available for environmental cleanup efforts at the ORR.
3. The proposed site is located well within the DOE reservation in an area not considered for reindustrialization or reuse.
4. Onsite disposal presents the lowest risks to humans through waste transportation.

## YOUR OPINION IS INVITED

DOE invites you to express your opinion of the presented remedial alternatives and the preferred alternative for disposing of future waste generated from the continued cleanup of the Oak Ridge Site. You are encouraged to read the information in the administrative record, including the Remedial Investigation/Feasibility Study (RI/FS), and any additional reports that follow the RI/FS and precede the Record of Decision, for background and more detailed technical information. A comment form is attached to this Proposed Plan, but you are not restricted to this form. Decision makers will consider any comments received before the end of the public comment period.

Community involvement is critical to the CERCLA process. DOE has established a 30-day public comment period, during which time local residents and interested parties can express their views and concerns on all aspects of this plan. DOE has scheduled a public meeting to discuss cleanup alternatives and to address questions and concerns the public may have. Upon timely request, DOE will extend the public comment period by an additional 30 days.

## INTRODUCTION

This Proposed Plan presents DOE's preferred alternative for the disposal of waste generated from cleanup actions under CERCLA at the DOE ORR for which additional capacity is necessary beyond the currently approved CERCLA disposal facility (Environmental Management Waste Management Facility [EMWMF]). The Proposed Plan is a document that DOE, as the lead CERCLA agency, is required to issue to fulfill the public participation requirement under CERCLA § 117(a) and the National Contingency Plan (40 *Code of Federal Regulations* [*CFR*] 300.430[f][2]). The Environmental Protection Agency Region 4 (EPA) and the State of Tennessee Department of Environment and Conservation (TDEC) support the issuance of this Proposed Plan as Federal Facility Agreement (FFA) (DOE 1992) parties. In accordance with the National Contingency Plan (40 CFR 300.430(9)(iii)(H)), the State Acceptance section addresses the state's positions and key concerns.

It is important to the remedy selection process to obtain public input on all alternatives and on the rationale for the Preferred Alternative. New information or arguments the lead agency receives during the public comment period could result in the selection of a final remedial action that differs from the Preferred Alternative.

This Proposed Plan documents DOE's rationale for the preferred alternative within the framework of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (42 *United States Code* Sect. 96-1 et seq.) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 *CFR* 300). In accordance with the DOE "Secretarial Policy Statement on the National Environmental Policy Act" (DOE 1994), National Environmental Policy Act of 1969 (NEPA) values have been incorporated into the CERCLA documentation prepared for this project.

## BACKGROUND

The 33,477-acre DOE-owned ORR is located within the city limits of Oak Ridge, Tennessee, in Roane and Anderson counties (Figure 1). The three major industrial, research, and production facilities originally constructed on the ORR 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) (Figure 1).

The principal mission of ETTP was uranium enrichment, which ended in 1985. ETTP is now being cleaned up to allow reuse of the land and infrastructure. ORNL has historically hosted and continues to host a variety of research and development facilities, including the use of research nuclear reactors for DOE. Y-12 has served several missions, including uranium enrichment, lithium refining, nuclear weapons component manufacturing, and weapons disassembly, and has a continuing mission in some of these areas. These historical operations on the ORR have led to different types and amounts of contamination in soil, surface water, sediment, groundwater, and buildings, and have resulted in burial of material.

The DOE Oak Ridge Office of Environmental Management Program's focus has been CERCLA remediation at all three facilities. While most

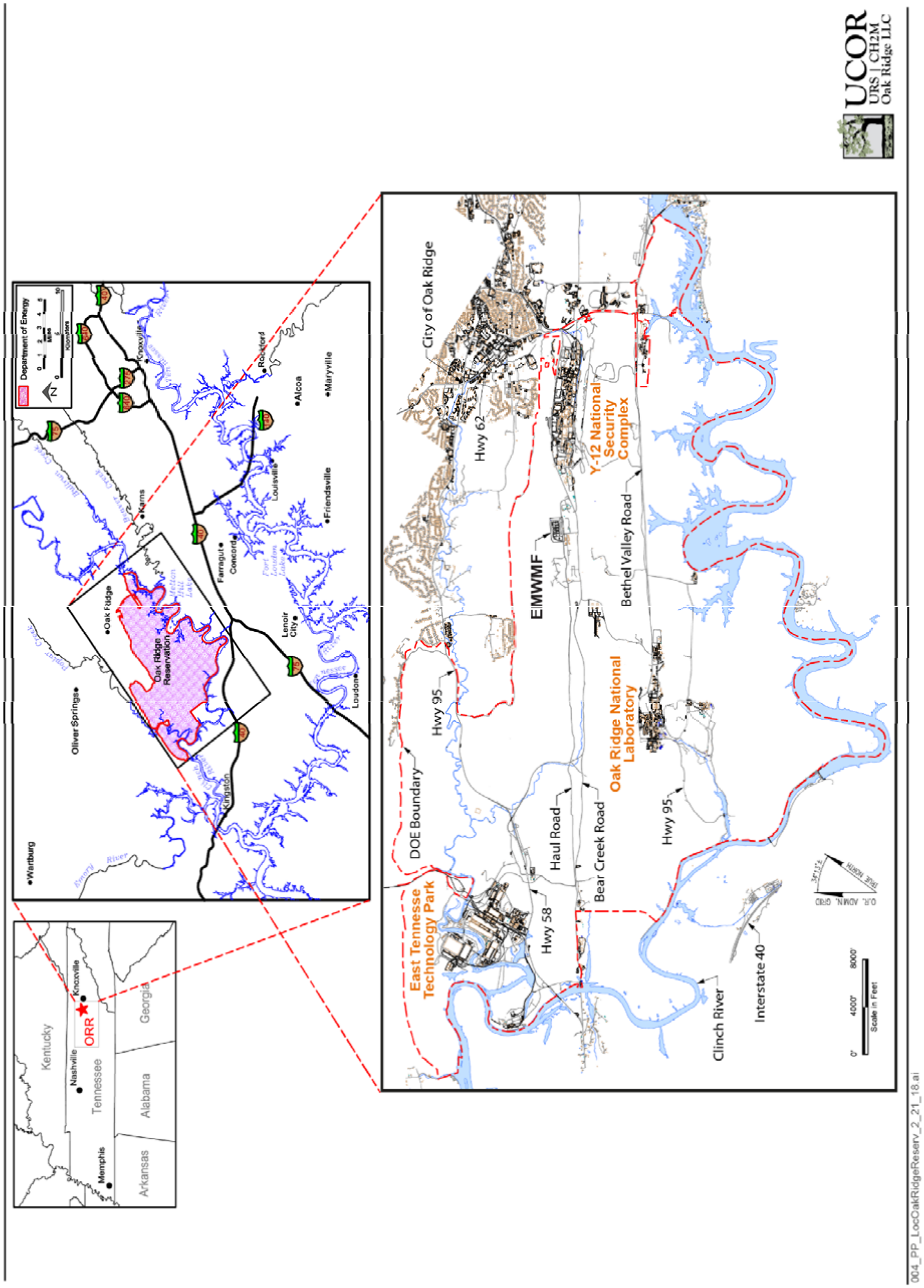


**Figure 1. Location of the Oak Ridge Reservation.**

cleanup activities are complete at ETTP, finishing the cleanup mission at all three facilities is projected to take several decades and is anticipated to result in large volumes of waste requiring disposal. While the most highly contaminated radioactive and chemical waste generated by cleanup activities will be managed at offsite facilities, large volumes of building demolition debris and soil material are anticipated that can be protectively managed in onsite landfills.

In 1997, based upon a State recommendation to expand community involvement, DOE sponsored the establishment of the End Use Working Group (EUWG). The group, composed of citizens from diverse stakeholder organizations, was asked to develop recommendations for end uses of contaminated areas on the ORR and community values that could be used to guide the cleanup decision-making process. As documented in the EUWG Stakeholder Report on Stewardship (DOE 1998a), recommendations on the end use of Bear Creek Valley and for siting an onsite CERCLA waste disposal facility were made. The end use recommendation for Bear Creek Valley included the establishment of a restricted waste disposal zone in the area of existing long-term waste disposal areas. The EUWG recommendation stated that any CERCLA waste facility should be located on or adjacent to an area that is already contaminated and used for long-term waste disposal. Consistent with the EUWG recommendation, the current onsite EMWMF is located in East Bear Creek Valley (Figure 2). The EMWMF began operations in 2002 and has

**Figure 2. Environmental Management Waste Management Facility.**

been receiving radioactive, hazardous, and mixed wastes from CERCLA cleanup activities on the ORR continuously for the last 16 years. The EMWMF consists of six disposal cells with a total capacity of 2.2 million cubic yards. Approximately 95 percent of the volume of wastes associated with cleanup to date has been disposed onsite, with 5 percent of the volume being disposed offsite. Approximately 15 percent of the radioactive curie content has been disposed at EMWMF, with the remaining 85 percent of the activity disposed offsite. Just over 75 percent of the landfill capacity has been used as of January 2018. There have been over 160,000 waste shipments to EMWMF, primarily on the dedicated (non-public) haul road.

## SCOPE AND ROLE OF THE DECISION

The scope of the ORR CERCLA cleanup program has significantly increased since the original waste estimates were developed (DOE 1999). *The Remedial Investigation/ Feasibility Study for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge Tennessee* (DOE 2017) (herein referred to as the RI/FS) was prepared to evaluate several possible alternatives for disposal of CERCLA waste that would be generated during ongoing and future cleanup of the ORR.

The scope of this Proposed Plan is to recommend an alternative for continued disposal of CERCLA waste that would be generated from the cleanup efforts planned for the ORR. If at some future time DOE ORR CERCLA remediation waste off the ORR, but within the state, requires disposal, advance FFA triparty approval would be needed to incorporate that waste in this remedy.

The associated RI/FS analyzed the following primary alternatives: (1) no action, (2) onsite disposal in a newly constructed facility on the ORR, (3) a combination of onsite and offsite disposal, and (4) offsite disposal at authorized facilities. Several possible onsite disposal locations were evaluated in the RI/FS for various siting options in Bear Creek Valley.

This Proposed Plan serves the following four primary purposes:

1. Summarizes the volume projections and waste types/characteristics for waste to be generated from future CERCLA cleanup actions on the ORR.

2. Summarizes alternatives and compares them against the CERCLA remedy selection criteria and relevant NEPA values.

3. Identifies and provides the rationale for the preferred alternative.

4. Facilitates public involvement in the remedy selection process.

This Proposed Plan is based on data and information presented in the RI/FS as well as the Administrative Record, and is being published to solicit public review and comment on all information presented herein, specifically on information pertaining to the preferred action. The lead agency for ORR remedial activities, DOE, is issuing this Proposed Plan as part of public participation requirements under Sect. 117(a) of CERCLA and the NCP 300.430(f)(2).

## WASTE CHARACTERIZATION AND VOLUME

The evaluation of onsite disposal requires the development of assumptions on how much landfill capacity is needed. The final capacity assumed to be needed for completion of ORR cleanup is estimated at 2.2 million cubic yards. Waste types will include soil, sediment, and sludge, along with demolition debris. The majority of the waste (just over two thirds) is anticipated to be debris.

Projections of future waste streams are based on available data for wastes disposed at EMWMF combined with available information on the facilities and environmental media yet to be remediated. An estimate of the amount of radiological and chemical contamination that may be in future waste streams was developed from information about future remedial actions. Information from remedial investigations of soil, scrap, and sediment contamination and information from building sampling efforts were used along with process knowledge of activities that occurred in the buildings. In general, the total amount of radioactivity that may be placed in the landfill is dominated by ORNL wastes, even though ORNL waste is estimated to contribute less than 30 percent of the total forecast waste volume. ORNL waste is projected to account for approximately 80 percent of the radioactivity, and Y-12 debris and soil is projected to contribute the remaining approximately 20 percent. Cesium-137, nickel-63, uranium-234, and strontium-90 account for greater than 50 percent of the total activity. Also significant in terms of relative contributions to total activity are plutonium-238 and -241, uranium-235 and -238, and curium-244. The estimated Environmental Management Disposal Facility (EMDF) hazardous contaminant inventory includes metals such as barium, beryllium, chromium, lead, manganese, mercury, and uranium. Also present are common industrial chemicals such as polychlorinated biphenyls, pesticides, cleaning solvents, and lead paint. Several waste types generated on the ORR will be excluded from disposal at a proposed EMDF because they do not meet the anticipated acceptance criteria (e.g., transuranic waste, liquid waste, and hazardous waste that does not meet land disposal restrictions).

The specific volume and composition of waste that would be generated from the implementation of future CERCLA actions cannot be fully defined at this time. Development of waste volume estimates and waste characteristics rely on reasonable assumptions for proposed remedial actions. Uncertainty is accounted for in the waste volume estimates by adding a straight percentage (25 percent, increase only to be conservative) to the projected volumes. Future CERCLA documents (e.g., Waste Handling Plans) will address the management of the projected wastes for each cleanup activity. These Waste Handling

Plans are reviewed and approved by all three FFA parties for consistency with ARARs and other requirements.

## BASELINE RISK SUMMARY

Under the typical CERCLA RI/FS process, baseline human health risk assessments are conducted to determine the need and extent for specific cleanup action at a remediation site to protect human health and the environment. However, this is not a typical CERCLA remediation action. The purpose of the disposal RI/FS is to evaluate the need for and merits of a comprehensive waste management and disposal process for multiple cleanup projects across the ORR. While cleanup decisions for the remediation sites have been made or will be made in separate, individual CERCLA decision documents, the decision being addressed in this case is the disposal of the projected volume of waste to be generated by these actions. Therefore, a conventional baseline risk assessment does not apply to this evaluation.

## SITE CHARACTERISTICS

Bear Creek Valley is considered to be the most appropriate area on the ORR for locating an onsite disposal facility due its current and planned land use, geology, and groundwater flow conditions. A considerable amount of information is available documenting the environmental conditions of Bear Creek Valley. Much of the available information is based on surface and subsurface investigations and reports of contaminant source areas and groundwater plumes, including the drilling and installation of hundreds of monitoring wells and sampling and analysis of soils, sediment, groundwater, and surface water. Geotechnical investigations and reports and engineering design documents have been developed for proposed waste management sites such as the Low-Level Waste Disposal Development and Demonstration site in West Bear Creek Valley and EMWMF in East Bear Creek Valley. The results of over three decades of investigations, information from the remediation of some sites near Y-12, and ongoing monitoring of surface water and groundwater are all available to support development and planning for the proposed EMDF site in Bear Creek Valley. Findings from available reports have been incorporated into Appendix E of the RI/FS (DOE 2017). The reports referenced in the RI/FS are also available in the Administrative Record.

Bear Creek Valley is approximately 8 miles long and extends from the west end of the Y-12 site southwest to the Clinch River. Bear Creek drains the entire Bear Creek Valley watershed, which includes the potential EMDF sites and historical Y-12 waste sites in the middle and upper portions of the valley (see Figure 3). The valley lies northeast to southwest and is bounded by Pine Ridge on the northwest and Chestnut Ridge on the southeast. Several smaller tributaries, designated as the North Tributaries (numbered sequentially as NT-1, 2, etc. from the Y-12 plant) drain off Pine Ridge to Bear Creek. Elevations range from highs near 1260 ft along the crest of Pine Ridge to around 800 ft at Bear Creek near State Route 95.

The current valley subsurface appears relatively stable. Available satellite images and field reconnaissance at the East Bear Creek Valley site suggest there is no visible evidence of recent large-scale mass movement at the proposed EMDF sites in Bear Creek Valley. None of the potential EMDF locations evaluated in the RI/FS lie directly on the Maynardville Limestone where groundwater flow through karst conduits is well documented. While the evaluated locations lie immediately upstream of the Maynardville Limestone, a buffer area would be maintained between that limestone layer and all waste disposal and wastewater management operations.

Groundwater migrates from the upland areas and discharges along valley floors supporting base flow along the north tributary stream channels and Bear Creek. Although there is contaminated groundwater in Bear Creek Valley, the RI/FS shows that none of the proposed EMDF sites are located over known groundwater contamination plumes (DOE 2017).

## REMEDIAL ACTION OBJECTIVES

CERCLA guidance defines remedial action objectives (RAOs) as “medium-specific or operable-unit-specific goals for protecting human health and the environment” (EPA 1988). According to the NCP (40 *CFR* 300.430[e][2][i]), RAOs should specify the media involved, contaminants of concern, potential exposure pathways, and remediation goals. The scope of this Proposed Plan is limited to evaluating alternatives for the disposition of future-generated CERCLA waste resulting from CERCLA cleanup actions on the ORR. Remediation goals for those cleanup actions are established at the project-specific level in existing CERCLA decision documents or would be made in future CERCLA decision documents.

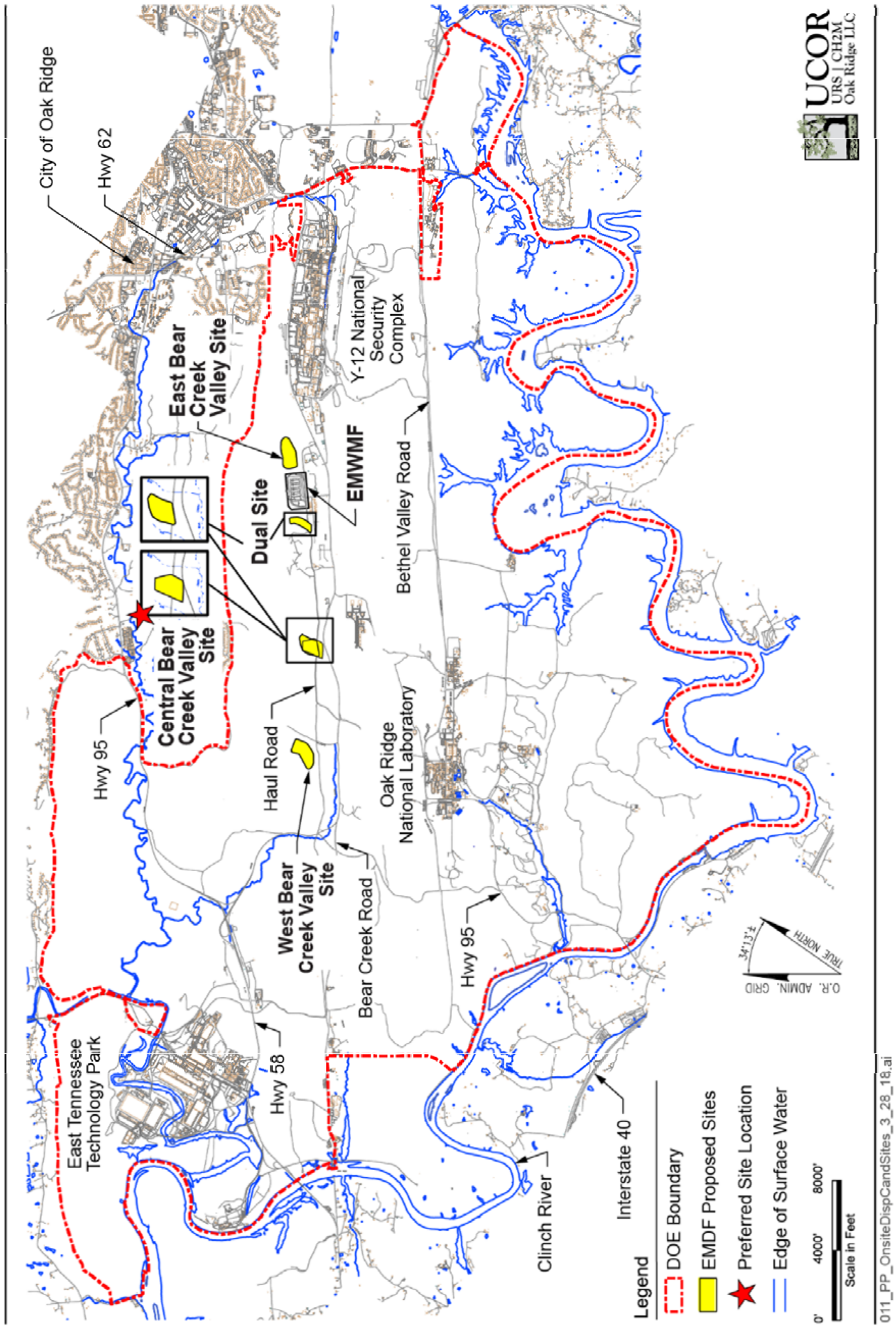


**Figure 3. Proposed sites for the Environmental Management Disposal Facility.**

The following RAOs were employed in the development of this Proposed Plan:

- Prevent exposure of people to CERCLA waste (or contaminants released from the waste into the environment) through meeting chemical-, location-, and action-specific ARARs, and by preventing exposure that exceeds a human health risk of $10^{-4}$ to $10^{-6}$ Excess Lifetime Cancer Risk or Hazard Index of 1.

- Prevent adverse impacts to water resources (surface water and groundwater) from CERCLA waste or contaminants released from the waste through meeting chemical-, location-, and action-specific ARARs, and by preventing exposure that exceeds a human health risk of $10^{-4}$ to $10^{-6}$ Excess Lifetime Cancer Risk or Hazard Index of 1.

- Prevent unacceptable exposure to ecological receptors from CERCLA waste contaminants through meeting chemical-, location-, and action-specific ARARs.

## SUMMARY OF ALTERNATIVES

Seven alternatives were developed and evaluated, including no action, four alternatives using different onsite disposal locations, a hybrid of onsite and offsite disposal, and offsite disposal. Below is a summary of these alternatives. These alternatives are more fully described in the RI/FS (DOE 2017).

### NO ACTION ALTERNATIVE

Under this alternative, no comprehensive site-wide strategy would be implemented to address the disposal of waste resulting from any future CERCLA response actions at the ORR after EMWMF capacity is reached. Future waste streams from site cleanup that require disposal after EMWMF capacity is reached would be addressed at the project level. This alternative provides a baseline for comparison with the action alternatives and is required under CERCLA and NEPA.

### ONSITE DISPOSAL ALTERNATIVES

**Description.** Under these alternatives, a new onsite, engineered, long-term disposal facility would be constructed to provide consolidated disposal of most waste resulting from any CERCLA response actions at the ORR. Waste that does not meet acceptance criteria for protective onsite disposal would be treated to meet requirements or shipped to authorized offsite treatment and/or disposal facilities.

Key elements of this alternative are natural characteristics of proposed site locations, design and construction, operation, waste acceptance criteria (WAC), water management, offsite disposal, and closure and post-closure of the facility.

**Site Locations.** To select a protective and suitable site for EMDF, an evaluation of potential sites was performed. The evaluation of potential sites used a previous 1996 site screening study (DOE 1996) that identified and evaluated 35 sites on the ORR. A thorough examination of 16 sites, including sites from the 1996 site screening study and three from the EMWMF RI/FS (DOE 1998b), was performed. Ultimately, four sites were presented in the EMDF RI/FS. Alternatives were developed around a site in East Bear Creek Valley, a site in Central Bear Creek Valley, a site in West Bear Creek Valley, and a combination of two smaller sites (called the Dual Site) as shown in Figure 3.

All Bear Creek Valley sites considered have some amount of characterization data. Details concerning that data may be found in the RI/FS and Administrative Record for all sites.

**Design and Construction.** Plans for the four onsite disposal locations provide disposal capacities up to 2.8 million cubic yards. The conceptual plans for each location are shown in Figures 4 through 7. Key facility elements include a clean-fill dike to laterally contain the waste, a multilayer base liner system with a double leachate collection/detection system and underlying geologic buffer zone to isolate the waste from groundwater, and a multilayer cover installed over a stable base-contouring layer to reduce infiltration and isolate the waste from people and the environment. Other elements are necessary support facilities (e.g., a landfill wastewater [water that comes in contact with waste] treatment system).

A preliminary cross section of the disposal facility is shown in Figure 8 while typical, preliminary cross sections of the liner and cover are presented in Figure 9. These disposal facility features are common to all onsite locations. The EMDF would be designed to accept the disposal of Resource Conservation and Recovery Act of 1976 (RCRA) hazardous waste, Toxic Substances Control Act of 1976 (TSCA) toxic waste,

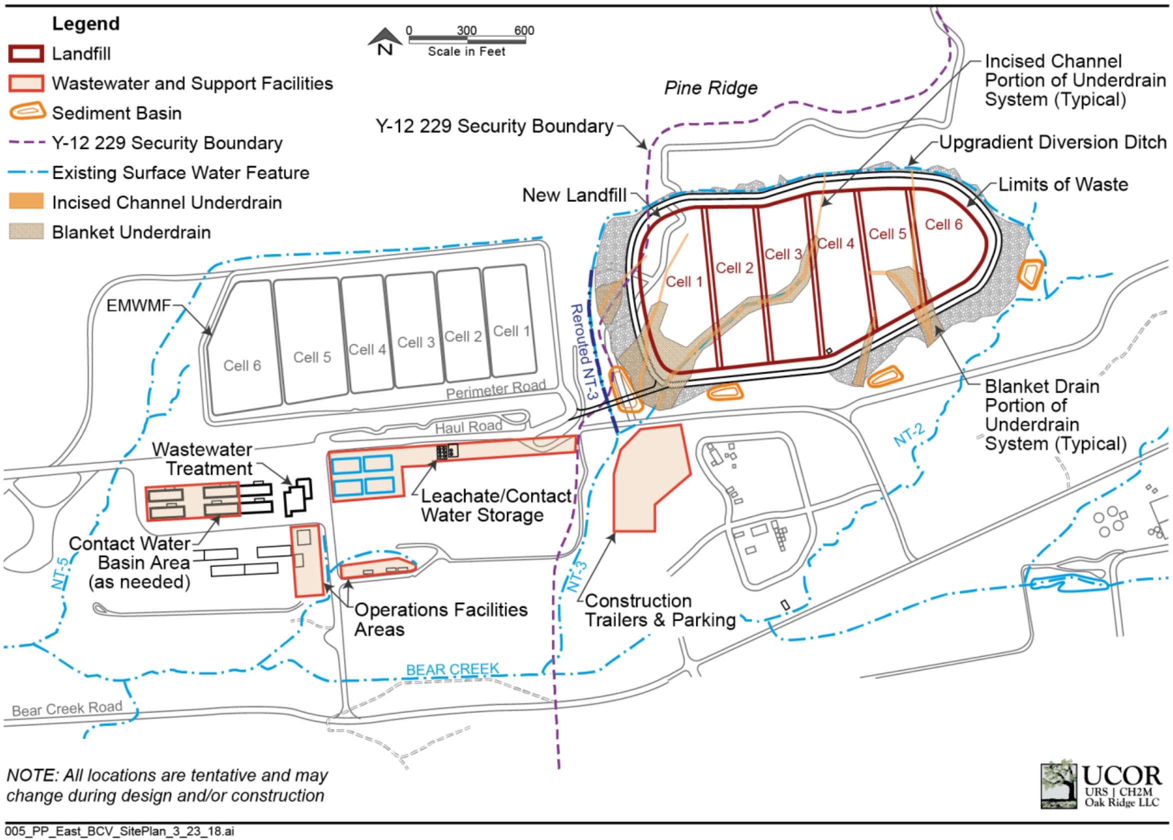


**Figure 4. East Bear Creek Valley EMDF site plan.**

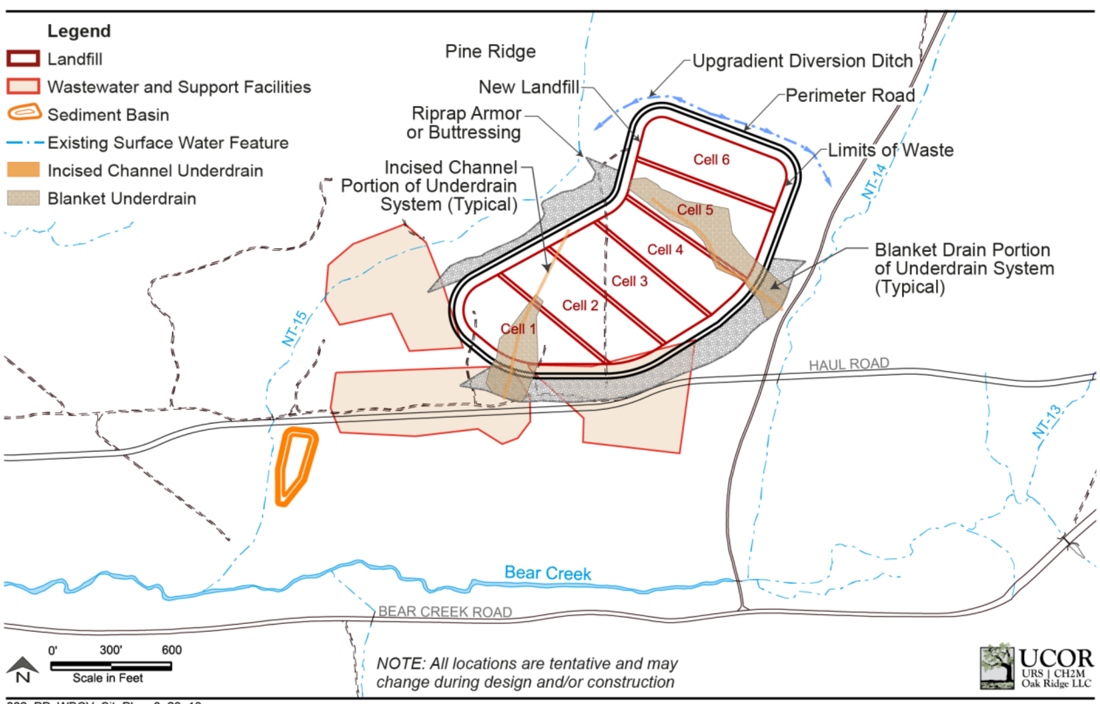


**Figure 5. West Bear Creek Valley EMDF site plan.**

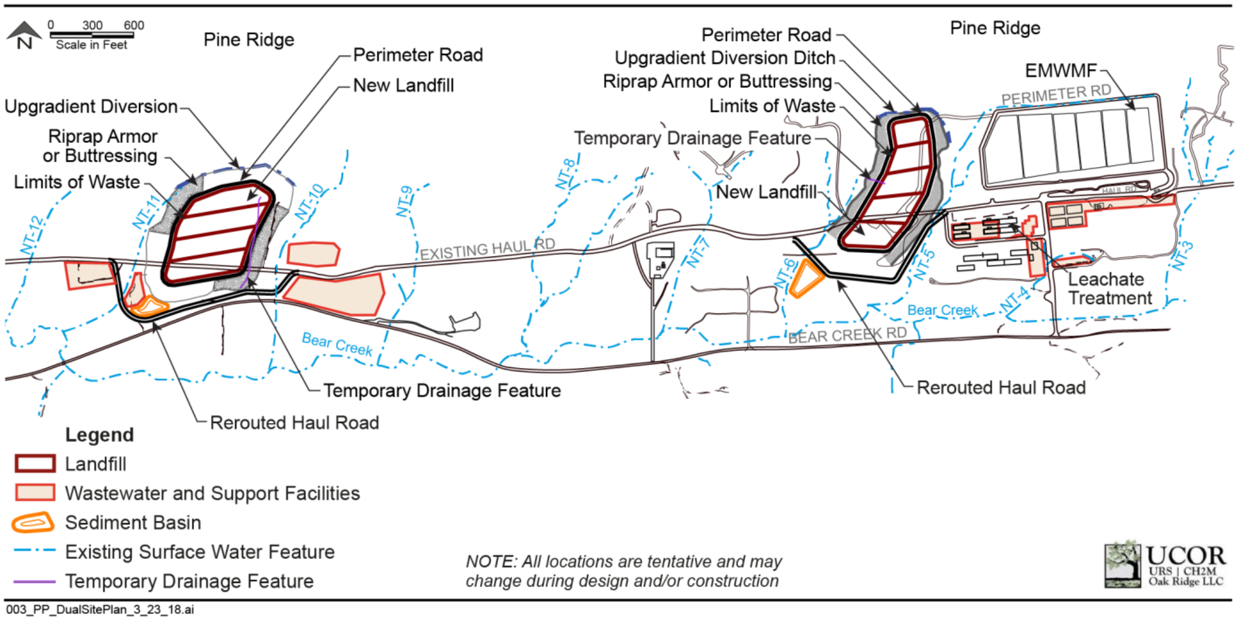


**Figure 6. Dual Site Bear Creek Valley EMDF site plan.**

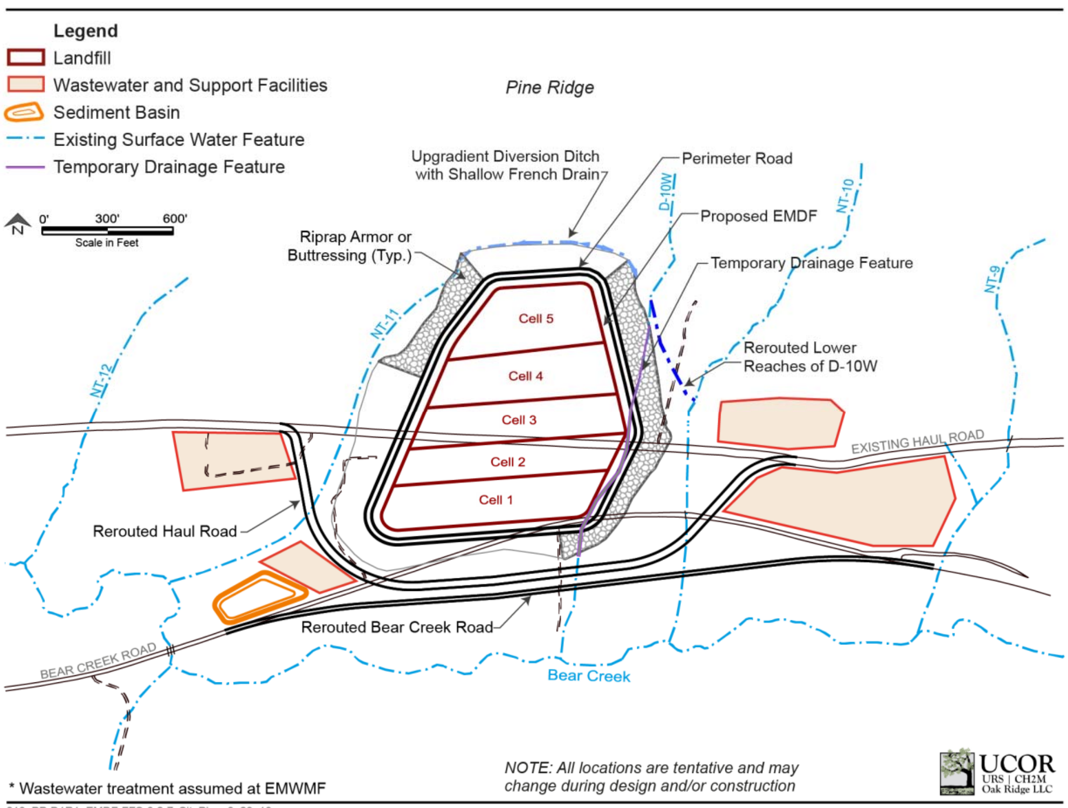


**Figure 7. Central Bear Creek Valley EMDF site plan.**

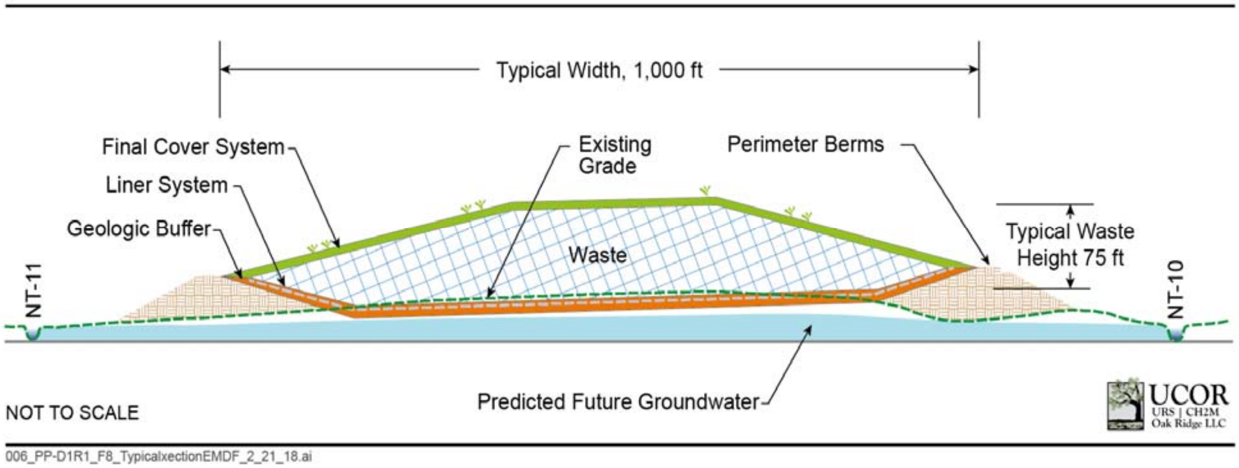


**Figure 8. Typical cross section of EMDF.**

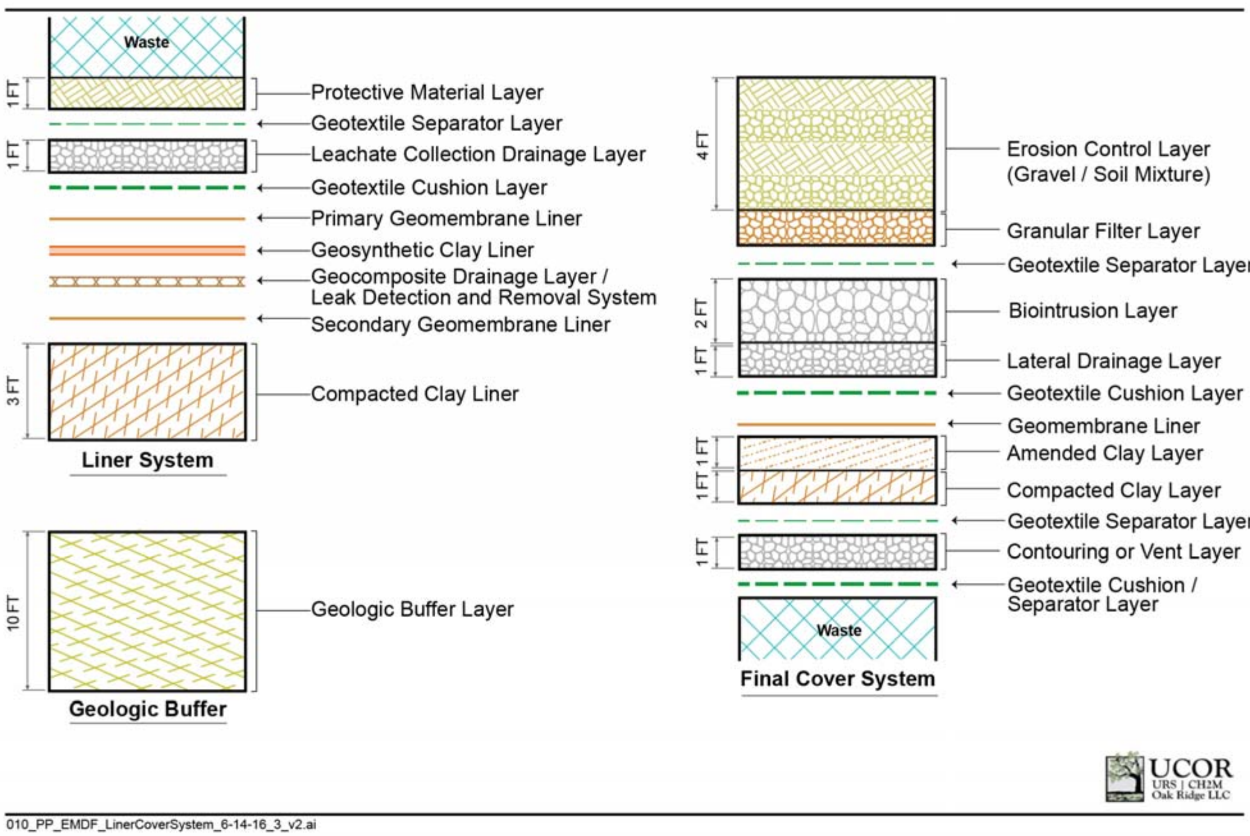


**Figure 9. Preliminary EMDF liner and cover system.**

low-level radioactive waste (LLW), and mixed LLW (hazardous/toxic and LLW).

The EMDF would be constructed in phases, only building the projected capacity needed at that time. The wastewater treatment system and the infrastructure for each proposed landfill location would be constructed in the first phase. For the East and West Bear Creek Valley sites, significant portions of Bear Creek tributaries that cross the landfills would be rerouted to accommodate the landfills. Drain systems would be placed under the liners in the original locations of the tributaries at these two sites.

The Dual Site option and Central Bear Creek Valley site could use temporary drainage features outside the boundaries of the waste footprint to control water flow from seeps or springs.

**Waste Acceptance Criteria.** In addition to siting and designing the facility to minimize environmental impacts, DOE proposes to conservatively evaluate all wastes before acceptance to confirm their eligibility for disposal in the onsite facility. Screening criteria, or WAC, includes physical, administrative, and contaminant limitations for the protection of human health and the environment. The existing landfill, EMWMF, is operating under controls provided by the WAC. These WAC can be found in the *Attainment Plan for Risk/Toxicity-Based Waste Acceptance Criteria at the Oak Ridge Reservation* (DOE 2001) which can be found in the Administrative Record. While the EMDF WAC will be developed independently of the EMWMF WAC, the existing WAC provide examples of what encompasses a disposal facility WAC.

Physical restrictions on waste would be imposed to preserve the integrity of the disposal cell. For example, some wastes may require modification to meet compaction specifications defined to minimize the potential for waste subsidence and size requirements for debris may be defined to facilitate disposal operations.

Administrative WAC are environmental regulations that prevent certain types of waste from being allowed in the disposal facility. These include waste such as liquid waste or waste that does not meet RCRA land disposal restrictions (e.g., ARARs).

Contaminant-specific WAC and/or inventory limits will be established consistent with RAOs and ARARs to ensure protectiveness of human health and the environment.

The purpose of WAC is to allow the disposal of only those wastes that could be protectively managed within the facility and ensure protection of human health and the environment. Wastes that do not meet the WAC will require offsite disposal or receive treatment. The final WAC will be attached to the Record of Decision (ROD) prior to signature and will be one of many factors used by DOE to assure protection of human health and the environment. A process – to be reviewed and approved by DOE, EPA, and TDEC that ensures the wastes generated by CERCLA response action projects meets the EMDF WAC – will be developed before operation of the facility begins.

**Operation.** Initially, it is assumed that both EMWMF and EMDF would be operating, with waste being placed in the last EMWMF cell and in the initial EMDF cells. Once EMWMF is filled to capacity, disposal operations would cease at that facility. A final cover will be constructed to isolate the waste long-term.

Some support systems would be shared between EMWMF and EMDF for those landfill alternatives located near EMWMF. The Central Bear Creek Valley and West Bear Creek Valley alternatives and eventually the Dual Site alternative would require new support systems (meaning all structures outside the landfill that support its operation such as wastewater management ponds, offices, utilities, roads).

Operations at EMDF would include activities such as waste receipt, inspection, WAC attainment verification (e.g., process by which a waste stream is verified to be acceptable for disposal in the facility), recordkeeping, unloading and placing waste into the disposal cells, compacting waste, covering waste, filling void spaces, surveying incoming and outgoing trucks, providing dust control, managing landfill water and storm water, and groundwater and surface water sampling.

**Waste Minimization**. Sequencing of waste generation, as much as possible, would be a priority, to reduce the amount of clean fill required by utilizing soil waste as fill during the disposal of debris waste. Segregating waste at the generator site and maximizing recycling also would be employed. For any onsite location selected for pursuit as the remedy, the ROD will contain a commitment to waste minimization.

**Wastewater Management.** Landfill wastewater from EMDF would be staged and sampled. If sampling results indicate that water quality complies with the RAOs and ARARs (e.g., CERCLA discharge limits) to be agreed to by EPA, DOE, and TDEC, then the water would be directly discharged without treatment to Bear Creek. If the sampling results indicate the water quality is unacceptable for discharge, then the staged water would be treated prior to release. As part of the remedy, a treatment system would be provided adjacent to the EMDF facility. The system would be sized to accommodate the estimated wastewater volume to be treated and designed to remove contaminants projected to exceed discharge limits.

**Offsite Disposal.** Waste that does not meet WAC and cannot be effectively treated to meet acceptance criteria will be shipped to an approved offsite facility for disposal.

**Closure and Post-Closure.** After completion of waste disposal, EMDF closure activities will include construction of the final cover system as shown in Figures 8 and 9. Post-closure activities will also include collection and treatment of landfill wastewater, surveillance and maintenance, environmental monitoring of groundwater and surface water, and land use controls.

Since the Onsite Disposal Alternatives leave hazardous substances in place at levels that do not allow for unrestricted use, land use controls will be required to prevent people and environmental receptors from encountering the residual hazard. The objectives of land use controls during operation and after closure are to:

- Prevent unauthorized excavation into EMDF
- Restrict access to the EMDF site from unauthorized entry
- Preclude alternate use of the EMDF site or underlying groundwater

Table 1 provides the type of controls, purpose of controls, implementation, and affected areas for all of the Onsite Disposal Alternatives. Land use controls would be maintained to ensure long-term protectiveness and maintain integrity of the landfill.

**Key ARARs.** Key location-specific ARARs include those that protect sensitive environments. Construction of EMDF would impact wetlands and streams. These impacts would need to be minimized and mitigated where impacts are unavoidable in accordance with State and Federal regulations.

Action-specific ARARs affect how EMDF will be designed and operated. Key aspects of the RCRA, TSCA, and state radioactive waste regulations are used to determine how to ensure long-term protectiveness of EMDF, both through the design and during operations and closure. There also are ARARs associated with how EMDF would be maintained in the future after closure and how land use controls are required and maintained. The onsite alternatives would meet all ARARs and no CERCLA waivers will be necessary. An exemption under the state radioactive waste disposal rules and a waiver under TSCA will, however, be requested as part of the CERCLA remedy selection process as described further below. The basis of the waivers or exemptions to be requested for onsite locations will be included in the ROD if an Onsite Disposal Alternative is selected.

TSCA requires that there be no hydraulic connection between the site and standing or flowing surface water and that the bottom of the landfill liner system or natural in-place soil barrier of a chemical waste landfill be at least 50 feet above the historical high water table (40 *CFR* 761.75[b][3]). Construction of a disposal facility anywhere in Bear Creek Valley would not meet this requirement. A TSCA waiver from this requirement will be required under that statute for all of the onsite alternatives. Such a waiver is granted through 40 *CFR* 761.75(c)(4) by providing *"...evidence to the EPA Regional Administrator that operation of the landfill will not present an unreasonable risk of injury to health or the environment from polychlorinated biphenyls (PCBs)...."*

A state radioactive waste disposal rule (TDEC 0400-20-11-.17[1][h]) requires that the hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site. At each alternative location in Bear Creek Valley, groundwater discharges to the surface within the proposed disposal site and will not meet this requirement. An exemption under the state rules will be requested by DOE, as allowed through the state rule TDEC 0400-20-04-.08, whereby the Division of Radiological Health (Department) may "*...grant exemptions, variances, or exceptions from the requirements of these regulations which are not prohibited by statute and which will not result in undue hazard to public health and safety or property.*"

## HYBRID DISPOSAL ALTERNATIVE

Hybrid disposal refers to significant disposal at both onsite and offsite disposal facilities using elements of both the Onsite Disposal Alternative and Offsite Disposal Alternative. As with the other alternatives, the starting waste volume for the Hybrid Disposal Alternative is the volume of waste created by CERCLA actions on the ORR that could theoretically be disposed onsite. The Hybrid Disposal Alternative proposes consolidated disposal of CERCLA waste in a newly constructed, much smaller capacity landfill on ORR, still referred

**Table 1. Land use controls for all Onsite Disposal Alternatives**

| Type of control | Purposes of control | Implementation | Affected areas[a] |
|---|---|---|---|
| 1. Property record restrictions[b] | Restrict use of certain property by restricting soil and groundwater use in perpetuity | Drafted and implemented by DOE upon closure of EMDF and/or transfer | EMDF landfill and site |
| 2. Property record notices[c] | Provide information to the public about the existence and location of waste disposal areas and applicable restrictions in perpetuity | General notice of Land Use Restrictions recorded in Roane County Register of Deeds office upon completion of the remedial activity | EMDF landfill and site |
| 3. Access controls (e.g., signs, fences, gates, portals, etc.) | Control and restrict access to the public in perpetuity | Maintained by federal government and its contractors | EMDF landfill and site |

[a]Affected areas – Specific locations will be identified in the completion documents where hazardous waste has been left in place.

[b]Property record restrictions – Includes conditions and/or covenants that restrict or prohibit certain uses of real property and are recorded along with original property acquisition records of DOE and its predecessor agencies.

[c]Property record notices – Refers to any informational document recorded that alerts anyone searching property records to important information about residual contamination/waste disposal areas on the property (TCA requirement).

DOE = U.S. Department of Energy
EMDF = Environmental Management Disposal Facility
TCA = Tennessee Code Annotated

to as EMDF. Waste volumes that exceed the capacity of the facility, regardless of whether those wastes meet the onsite disposal WAC, would be disposed offsite. A single onsite disposal option is analyzed (one of the two sites included in the Dual Site that is located immediately west of EMWMF) with components (e.g., buffer, liner, berms, cells, final cover) the same as that discussed under the Onsite Disposal Alternatives.

The onsite portion of the Hybrid Disposal Alternative includes designing and constructing the landfill, support facilities, and roadways; developing plans and procedures; receiving waste that meets the WAC; unloading and placing waste into the landfill; surveying and decontaminating as needed; and closing the landfill once the capacity is reached. Also included is post-closure maintenance and land use controls for as long as the waste remains a threat to human health or the environment. Due to the limited capacity of the onsite disposal element of this alternative, a size reduction facility to reduce disposal volumes has been added to the onsite portion of the Hybrid Disposal Alternative.

**Onsite Disposal Location.** The onsite landfill location selected for use in the Hybrid Disposal Alternative had to meet the following two criteria:

- Minimum capacity that allows onsite disposal to be more cost effective than offsite disposal (see Figure 10)
- Minimize hydraulic connections between groundwater and surface water (e.g., minimize dependency on underdrains)

A brief analysis was completed to determine the minimum landfill capacity at which onsite disposal is no longer cost effective compared to offsite disposal. Offsite disposal cost (in 2016 present worth dollars) per cubic yard is considered fairly constant, ~$675 per cubic yard (see Figure 10). In contrast, the cost per cubic yard for onsite disposal varies within this range; the greater the volume disposed, the lower the cost per cubic yard. Unit costs were evaluated for a series of as-disposed volumes ranging from 440,000 cubic yards to roughly 2,200,000 cubic yards, with the higher two volumes representing specific evaluated alternatives. The volume at which the offsite and onsite costs are essentially equivalent, i.e., the breakeven volume, is roughly 750,000 cubic yards.

**Volume Reduction.** Volume reduction (mechanical size reduction of waste) is assumed for the onsite portion of the Hybrid Disposal Alternative. An analysis in the RI/FS demonstrated that the use of a centralized volume reduction system at the Hybrid Disposal Alternative EMDF would provide an additional 145,000 cubic yards of disposal capacity in the onsite facility. This additional capacity results in a reduction in the number of offsite shipments necessary under this

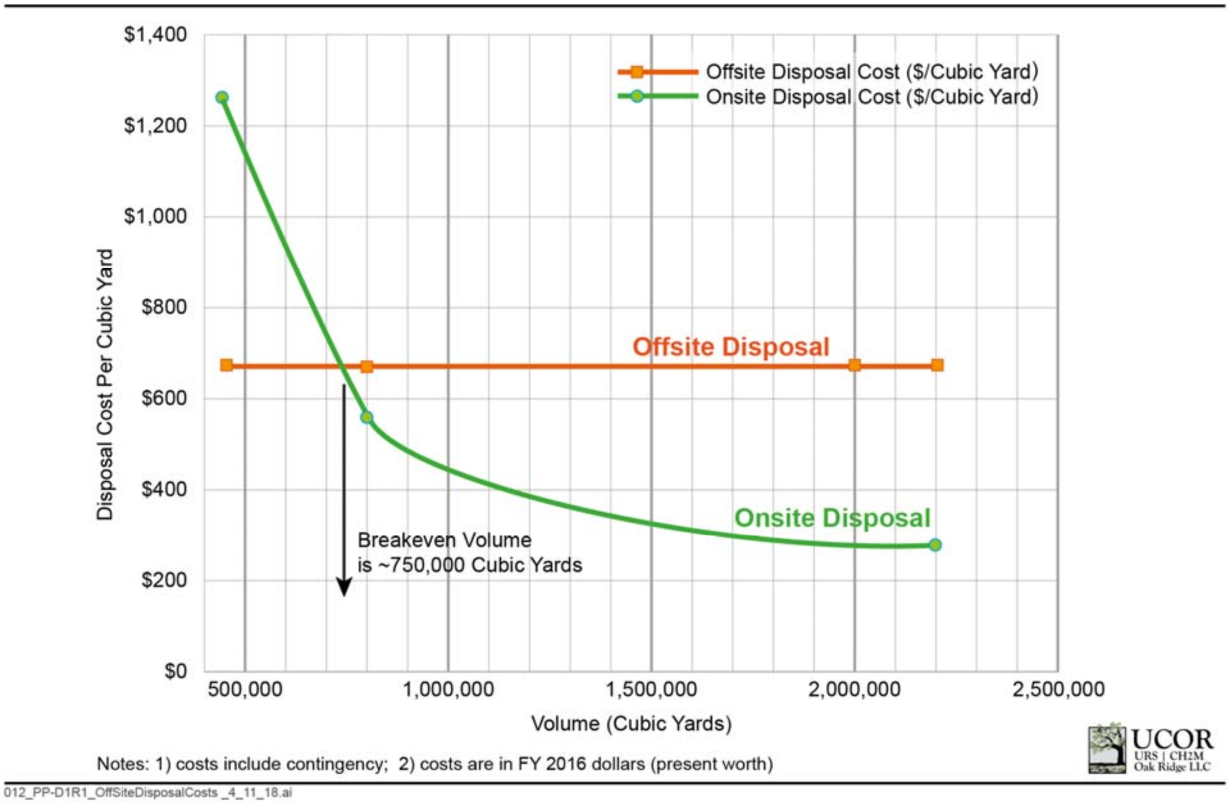


**Figure 10. Estimate of minimum onsite capacity required to reduce unit cost of onsite disposal below offsite disposal.**

alternative, saving overall costs and reducing the risk of transportation accidents.

Regardless of the disposal method used, all onsite remediation activities implement recycling and segregation of waste at the generator site (e.g., prior to the waste entering this disposal facility) to identify non-hazardous/non-radioactive waste that may be able to be disposed in less costly industrial landfills operated by DOE. Projected volumes of industrial waste are not contained in this analysis.

Sequencing of remediation activities to take advantage of using waste soil as fill (to fill voids while disposing of waste debris) is practiced by DOE, and benefits onsite disposal by reducing the need for clean soil to serve as fill during debris disposal (reducing cost and conserving landfill capacity).

## OFFSITE DISPOSAL ALTERNATIVE

Under this alternative, waste resulting from any CERCLA response actions at the ORR and/or associated sites exceeding the capacity of the existing EMWMF would be transported off the reservation for disposal at approved disposal facilities, primarily by rail. Waste disposed under this alternative must meet the WAC of the offsite disposal facility.

**Offsite Disposal Facilities.** For CERCLA actions that treat, store, or dispose of waste offsite, appropriate licenses and/or permits are required by the receiving facility. In general, the following conditions must be met to use an offsite receiving facility in accordance with the Offsite Rule at 40 *CFR* 300.440 and CERCLA Sect. 121(d)(3):

- The proposed receiving facility must be operated in compliance with all applicable Federal, state, and local regulations; there must be no relevant violations at or affecting the receiving facility.
- There must be no releases from the receiving unit and contamination from prior releases at the receiving facility must be addressed as appropriate.
- For mixed LLW/RCRA material, offsite commercial treatment, storage, or disposal facilities must have an approved Nuclear Regulatory Commission license and RCRA Part B permit.

These procedures require confirmation by the regional EPA office with jurisdiction over the chosen disposal facility that indeed the facility is acceptable for the receipt of CERCLA waste.

**Packaging Requirements.** Packaging requirements for waste originating at each generator site would be determined based on waste form (e.g., treated or untreated soil, debris, miscellaneous solids, personal protective equipment/trash, sediment/sludge), waste type (e.g., LLW, mixed waste), transportation mode, and destination.

**Transportation.** All waste would be transported from the generator site to the trans-loading facility. This local transportation would be the responsibility of the generator and is not part of the Offsite Disposal Alternative.

**Onsite Support Facilities.** Onsite facilities required to support the offsite disposal of waste include the following:

- Trans-load facility – Rail transportation of waste is assumed for all waste (except classified) being shipped for offsite disposal. The existing trans-load facility at ETTP would facilitate the transfer and staging of waste containers from trucks to railcars. Waste delivered by truck from generator sites would be staged at an existing docking area for rail shipment. Packages for waste such as intermodals would be loaded onto articulated bulk container railcars or the waste may be placed directly into super gondolas. When ready for shipment, one or more railcars would be transferred from the rail spur to the railroad system and from there would travel by rail to the disposal facility.

- Size-reduction facility – A size-reduction facility would be constructed and operated near the ETTP trans-load station. Waste targeted for size reduction would be transported by dump truck to ETTP and unloaded into the size-reduction unit feed system for processing. Processed material would be loaded by conveyor or excavator into intermodals that would be staged for loading onto railcars. Size reduction was found to be cost effective where packaging/transport methods are not weight limited and reductions in volume affect the number of transportation trips.

## EVALUATION OF ALTERNATIVES

All remediation alternatives must be evaluated against the nine CERCLA evaluation criteria. The first two criteria (overall protection of human health and the environment and compliance with ARARs) are threshold criteria and must be met by any alternative considered for selection in the ROD. The next five criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) are the primary balancing criteria that form the basis for the detailed analysis. The last two criteria (state and community acceptance) are considered modifying criteria as the remedy may be modified as a result of input from the state and the community. Community acceptance will be evaluated after review and consideration of comments received on this Proposed Plan. DOE also evaluated the alternatives against NEPA values consistent with the DOE Secretarial Policy Statement on the National Environmental Policy Act of 1969 (DOE 1994).

The comparative analyses of alternatives are summarized in Appendix A and are discussed below.

### OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The No Action Alternative is the least protective if the lack of a coordinated disposal program results in an increased reliance on management of waste in place at CERCLA remediation sites or if the pace of cleanup were slowed. Selection of any of the action alternatives would be protective of human health and the environment in the long term. The Onsite Disposal Alternatives would be protective primarily through design and construction to required specifications and compliance with the WAC to be established for a new onsite CERCLA waste disposal facility. The Offsite Disposal Alternative also would be protective through design and construction to required specifications and compliance with the WAC for each of the offsite existing authorized facilities. The Hybrid Disposal Alternative would be protective through the design, construction, and WAC of an onsite disposal facility and an offsite disposal facility.

**EXPLANATION OF NINE CERCLA EVALUATION CRITERIA**

***-THRESHOLD CRITERIA-***

1. **Overall Protection of Human Health and the Environment** addresses whether a remedial action provides overall protection of human health and the environment. This criterion must be met for a remedial alternative to be eligible for selection.
2. **Compliance with Applicable or Relevant and Appropriate Requirements** addresses whether a remedial action meets all of the applicable or relevant and appropriate Federal and state environmental requirements, or provides grounds for invoking a waiver of the requirements. This criterion must be met for a remedial alternative to be eligible for selection.

***-BALANCING CRITERIA-***

3. **Long-term Effectiveness and Permanence** considers the ability of an alternative to protect human health and the environment over time.
4. **Reduction of Toxicity, Mobility, or Volume Through Treatment** evaluates an alternative's use of treatment to reduce harmful effects of contaminants, their ability to move in the environment, and the amount of contamination present.
5. **Short-term Effectiveness** refers to potential adverse effects on workers, human health, and the environment during the construction and implementation phases of a remedial action.
6. **Implementability** refers to the technical and administrative feasibility of a remedial action alternative, including the availability of materials and services needed to implement the alternative.
7. **Cost** refers to an evaluation of the capital, operation, and maintenance, and monitoring costs for each alternative, including present-worth costs.

***-MODIFYING CRITERIA-***

8. **State Acceptance** indicates whether the state concurs with the preferred alternative.

*The following is applied after comments are received on the Proposed Plan.*

9. **Community Acceptance** assesses the general public response to the Proposed Plan following a review of public comments received during the public comment period. The remedial action is selected only after consideration of this criterion.

All action alternatives would be protective of human health and the environment in the short term. However, the Onsite Disposal Alternatives, regardless of the location of the landfill, would present the lowest short-term impact to the public primarily due to shipping waste shorter distances. Offsite disposal would require local and long-distance transportation of waste, treatment of some waste streams, and waste handling. Because of the greater volumes of wastes shipped over long distances, transportation risks are significantly higher for the Hybrid and the Offsite Disposal Alternatives.

### COMPLIANCE WITH ARARS

The No Action Alternative has no ARARs. The Offsite Disposal Alternative and the offsite disposal element of the Hybrid Disposal Alternative meet the required chemical-, location-, and action-specific ARARs, and no CERCLA statutory waivers are requested.

No CERCLA statutory waivers are requested for the Onsite Disposal Alternatives. It is important to note that both a TSCA waiver and a Tennessee Department of Radiological Health (TDRH) exemption would be requested for the selected Onsite Disposal Alternative. The parts of TSCA and TDRH that will need to be waived are as follows:

- A TSCA specific waiver for 40 *CFR* 761.75(b)(3) and (b)(5) would be invoked as provided in 40 *CFR* 761.75(c)(4).
- A TDRH specific exemption for TDEC 0400-20-11.17(1)(h) would be invoked as provided for in TDEC 0400-20-04-.08.

These determinations will be made in the ROD based on available data.

For the Offsite Disposal Alternative and offsite component of the Hybrid Disposal Alternative, compliance with ARARs and with facility licenses and/or permits will be determined prior to transport in accordance with the CERCLA offsite rule.

### LONG-TERM EFFECTIVENESS AND PERMANENCE

The No Action Alternative may or may not be effective as it would depend on multiple future individual waste disposal decisions. Because the decisions would be under CERCLA, they would be required to be protective. For the Hybrid and the Onsite Disposal Alternatives, preventing exposure to contaminants placed in EMDF over the long term depends on the success of the facility's waste containment features, characteristics of waste placed in EMDF, and land use controls. The multilayer cover system would be designed to decrease migration of liquids, minimize erosion, accommodate settling and subsidence, and prevent burrowing animals and plant root systems from penetrating the cover system. The cover also would reduce the likelihood of inadvertent intrusion by humans by increasing the difficulty of digging or drilling into the landfill. With proper design and installation of the landfill liner and leachate systems, the bottom of the landfill would contain any contaminants from future unacceptable releases to the environment. During operation when landfill wastewater is generated, that wastewater would be treated as required for removal of contaminants above discharge limits. Upon closure, when the landfill cover is placed, landfill wastewater generation would cease.

The WAC would restrict what waste could be placed in the landfill. These criteria would be set assuming some failure of the manmade components of the underlying liner system and would be determined to ensure that even under these conditions, the release of contamination from the landfill would not harm human health or the environment.

The major difference among the onsite locations would be the long-term land use changes. The sites in Central and West Bear Creek Valley are currently undisturbed forest and both are identified to remain uncontaminated under the Bear Creek Valley ROD (DOE 2000). Use of either of these sites would have the greatest land use change as the forest would be removed and the land use would have to be changed to industrial use. The Dual Site Disposal Alternative also would have a notable land area (one of the two locations) that would be cleared of any forest and be reclassified to a future waste management area where none is currently planned.

Land use controls would restrict access to the site and prohibit actions that could penetrate the cover and expose the waste. Barring extraordinary efforts to penetrate the cover, the landfill would be designed to remain effective for over 1000 years.

The Offsite Disposal Alternative and offsite disposal element of the Hybrid Disposal Alternative also rely on engineering and land use controls at the offsite disposal facilities to prevent inadvertent intrusion, including engineered barriers to intrusion and waste migration. Offsite disposal of waste to locations in the western United States may in the long-term be considered more reliable at preventing exposure than onsite disposal on the ORR. Arid environments reduce the likelihood of contaminant migration or exposure via groundwater or surface water pathways. While the climate in Tennessee is wetter and could be considered less protective, this factor is considered both in determining what waste can be safely placed in a disposal cell to ensure long-term protection and how that cell would be constructed.

## REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

The No Action Alternative does not reduce toxicity, mobility, or volume through treatment.

Onsite Disposal Alternatives would provide landfill wastewater treatment needed to meet ARARs, including portions of the Clean Water Act that address hazardous chemicals. That treatment would reduce contaminants to levels required for discharge.

Waste generators would be required to treat wastes as needed to meet the EMDF WAC and ARARs before onsite disposal; however, that treatment is not part of this onsite remedy.

For waste disposed offsite, size reduction is assumed and results in some volume reduction. Treatment, while provided by offsite facilities to meet their disposal requirements, is not accounted for in the offsite remedy in terms of cost so that equal comparisons may be made to onsite alternatives.

The Hybrid Disposal Alternative also would reduce the volume of waste prior to offsite shipment through assumed size reduction.

## SHORT-TERM EFFECTIVENESS

Short-term effectiveness includes protection of the community and workers during remedial action, short-term environmental effects, and the duration of remedial activities. Because the No Action Alternative includes no activity, there are no short-term impacts.

For the action alternatives, risk to human health is the most differentiating element. Under all disposal alternatives evaluated, risks to workers and the community from actions at the disposal facilities would be controlled to acceptable levels through compliance with regulatory requirements and health and safety plans.

Offsite transportation carries a much higher risk to human health than onsite transportation due to vehicular accidents and emissions associated with public roads/railroads travelled and the long distances involved. Estimates range from 7 to 24 injuries/fatalities depending on the offsite facility where waste is transported for disposal, while onsite disposal risk is less than 1 over the lifecycle of the remedy for the same volume of waste.

Short-term environmental effects would be the greatest for the Onsite Disposal Alternatives. Construction and operation of EMDF would create local short-term environmental effects typically associated with a large construction project. Sensitive human receptors (e.g., residence, church, school) would not be impacted because of the distance of the proposed EMDF sites from these receptors. Disturbance to terrestrial resources would be expected, with land use resulting in losses/changes of habitat and displacement of wildlife from the construction areas. The greatest impact would be installation of the EMDF in Central or West Bear Creek Valley where up to 94 acres of forested land are expected to be impacted. The other onsite alternatives have less, but still notable, impact on environmental habitat.

Environmental effects could result from a spill during transport and handling for the Offsite Disposal Alternative.

**IMPLEMENTABILITY**

Implementability for the No Action Alternative is not applicable, but all disposal alternatives are administratively and technically feasible. Currently, services and materials needed for pre-construction investigations, construction, and operation of the Onsite Disposal Alternatives and transportation and disposal capacity for the Offsite Disposal Alternative are available. No impediments to future operation of the Onsite Disposal Alternatives are likely to arise. The onsite EMDF of both the Onsite Disposal Alternatives and the Hybrid Disposal Alternative is more complex to implement than shipping waste offsite. However, the technology is well proven and onsite disposal capacity has already been constructed at the ORR. Use of both onsite and offsite disposal in the Hybrid Disposal Alternative does introduce operational complexity as decisions about what is disposed onsite versus offsite would be needed. The East Bear Creek Valley site has the most notable implementation issues of the Onsite Disposal Alternatives as it is the steepest of the sites and has little room for support systems. Many other Y-12 facilities and operations are close to the site. However, this site has the greatest use of existing EMWMF infrastructure.

Reliance on offsite disposal facilities introduces an element of uncertainty into the continued availability of offsite disposal during the anticipated operational period. Offsite disposal introduces risks of interruptions caused by events outside the control of DOE. Because CERCLA waste generation on the ORR is projected to continue for roughly three decades, onsite disposal would provide greater certainty that sufficient disposal capacity is actually available at the time the wastes are generated.

**COST**

There are no costs associated with the No Action Alternative since there is no coordinated disposal effort.

The projected cost for the Offsite Disposal Alternative is approximately two times that of the Onsite Disposal Alternatives as seen in Table 2. The estimated total project costs for onsite disposal range from $732M to $928M and $1,567M to $1,799M for the Offsite Disposal Alternative, with the Hybrid Disposal Alternative in between at $1,391M. Both costs have the same assumed uncertainty of 25 percent in waste volumes and account for cost uncertainties. Selection of two smaller sites (the Dual Site Disposal Alternative) is the high range ($928M) onsite disposal estimate. Total estimated costs for capital investment includes planning, construction/closure, and operation as well as long-term maintenance (e.g., maintenance, surveillance, and monitoring for a 100-year period following closure). Costs shown in Table 2 are given in Fiscal Year 2016 dollars along with Present Worth values.

**Table 2. Estimated costs for disposal alternatives**

| | $ million | | | | | |
|---|---|---|---|---|---|---|
| **Cost element** | **East Bear Creek Valley** | **Central Bear Creek Valley** | **West Bear Creek Valley** | **Dual site** | **Hybrid** | **Offsite** |
| Capital cost (construction, operation, to closure) | 733.6 | 732.0 | 750.4 | 928.0 | 1,391 | 1,567 to 1,799 |
| Long-term maintenance[a] | 45.7 | 45.7 | 46.1 | 74.4 | 34.3 | NA |
| Present worth[b] | 538.3 | 537.2 | 553.3 | 667.4 | 1,145 | 1,315 to 1,494 |

[a]Long-term maintenance includes 100 years of maintenance, monitoring, and surveillance.
[b]Present worth calculations use a discount rate of 1.5% per the Office of Management and Budget (OMB 2016).

## STATE ACCEPTANCE

The State of Tennessee recognizes the importance of selecting a waste disposal option to support environmental cleanup and building demolition on the ORR by DOE.

The State conditionally supports identification of the Central Bear Creek Valley Alternative as the preferred alternative. This conditional support of Central Bear Creek Valley as the preferred alternative is based on its potential to meet the estimated disposal capacity needs without relying on engineered systems for collecting and discharging groundwater under the waste. Until the State has the opportunity to review additional data related to: site characterization, final ARARs identification, and the WAC, the State is unable to provide its unconditional support of Central Bear Creek Valley as the preferred alternative. The State will make its final determination in the ROD.

As with Central Bear Creek Valley as the preferred alternative, the State conditionally supports the Hybrid Option Alternative and the Dual Site Alternative. The State does not support the East Bear Creek Valley Alternative, the West Bear Creek Valley Alternative or the No Action Alternative. The State fully supports the Offsite Disposal Alternative.

## NEPA VALUES

There are no NEPA values to evaluate for the No Action Alternative as the future waste disposal decisions are unknown and would be addressed for NEPA compliance as appropriate.

NEPA values were evaluated for the disposal alternatives. Those values associated with sensitive resources were discussed in the RI/FS (DOE 2017) under compliance with ARARs or Short-term Effectiveness and are not key differentiating values.

NEPA impacts on land use are summarized in Table 3 for the Onsite Disposal Alternatives.

**Table 3. NEPA considerations for Onsite Alternatives**

| | Onsite EMDF locations | | | | |
|---|---|---|---|---|---|
| **NEPA element (impacted areas)** | **East Bear Creek Valley[a]** | **Central Bear Creek Valley** | **West Bear Creek Valley** | **Dual Site** | **Hybrid[a]** |
| Acreage for development | 71 | 82 | 94 | 127 | 53 |
| Footprint of disposal facility | 48 | 47 | 52 | 68 | 27 |
| Area of permanent commitment | 70 | 67 | 71 | 109 | 50 |

[a]These locations assume some use of existing facilities/committed acreage; therefore, acreage for development/permanent commitment is lower.

Land use within the permanent institutional control boundary of all disposal locations, both onsite and offsite, would be restricted. Support areas used during construction and operations of disposal facilities could be released for other uses after facility closure. The Onsite Disposal Alternatives would cause a permanent loss of land for alternate uses of up to 109 acres (for the Dual Site Disposal Alternative).

All disposal alternatives would irreversibly and irretrievably use resources. The Hybrid and Onsite Disposal Alternatives would use material for the construction of the landfill; however, none of the material is considered difficult to replace. Fuel would be used for all alternatives, but to a much greater extent with the Hybrid and the Offsite Disposal Alternative.

Implementation of the Offsite Disposal Alternative would have a lower socioeconomic impact in East Tennessee compared to the Onsite Disposal Alternatives. However, the additional truck and/or rail traffic through the area may be a detriment to the quality of life of some residents. The perception that there is an increased local traffic risk may be an issue for future development, but this is likely to be a small impact.

Onsite disposal would have the greatest effect on local socioeconomic factors. From design and engineering to construction and 20 plus years of operation, and then to closure and many years of post-closure care, local jobs would be created in the east Tennessee area.

The East Bear Creek Valley location adjacent to existing waste disposal sites minimizes the potential impact of the presence of a new facility on future development nearby in Oak Ridge or on the ORR. There would be increased potential negative perception as the site is moved down the valley toward West Bear Creek in areas originally deemed to be uncontaminated.

Programmatic cost savings in implementing onsite disposal instead of offsite disposal would enable quicker remediation progress at individual sites, allowing reuse of property at Y-12 and ORNL and resulting in additional benefits to the local community.

The areas immediately surrounding the proposed EMDF sites are currently unpopulated DOE-controlled property. The nearest residential area is approximately 0.8 mile (Country Club Estates) from the Dual Site or Central Bear Creek Valley sites and approximately 1 mile from the West Bear Creek Valley site. The Scarboro Community, located approximately 1.5 miles northeast of the East Bear Creek Valley site would not be impacted by the construction, operation, or closure of EMDF. All nearby communities are separated by a large ridge (Pine Ridge) from the proposed EMDF sites. Additionally, surface water and groundwater originating in the proposed disposal areas in Bear Creek Valley move away from these residential areas. The mile plus distance, and Pine Ridge, provide a visual and sound barrier between the residents and the waste disposal construction and operational activities. The surrounding communities would not be affected by construction traffic since access to Bear Creek Valley is restricted by ORR security. Waste is shipped to the disposal facilities on dedicated haul roads operated on the ORR, so there is no interaction between the public and the transport trucks. These dedicated haul roads also would minimize public interaction with trucks transporting waste to the trans-load facility for offsite disposal.

Environmental justice is the fair treatment and meaningful involvement of all communities with respect to the planning, development, and siting of the preferred alternative for onsite CERCLA waste disposal. Environmental justice concerns have been raised regarding communities immediately north of the main Y-12 industrial area. Based on the proposed locations for alternatives, coupled with the proximities and locations of these proposed locations when compared with surrounding communities, it is demonstrated that no community is disproportionately affected by the potential environmental consequences presented by the onsite alternatives.

## PREFERRED ALTERNATIVE AND RATIONALE

Based on the considerations and the information currently available, the Onsite Disposal Alternative located in Central Bear Creek Valley is the preferred alternative to manage remediation waste generated by future CERCLA actions at the ORR. Wastes under consideration for disposal include any waste generated under a CERCLA action on the ORR. If at some future time DOE ORR CERCLA remediation waste off the ORR (but within the state) requires disposal, advance FFA triparty approval would be needed to incorporate that waste in this remedy.

The preferred alternative meets CERCLA threshold criteria and provides the best balance of all other criteria (see Appendix A). DOE has determined that the preferred alternative satisfies the requirements of CERCLA 121(b) to: (1) be protective of human health and the environment, (2) appropriately comply with ARARs, (3) be cost effective, (4) use permanent solutions and resource recovery technologies to the extent practicable, and (5) satisfy the preference for treatment as a principal element of the remedy. Element 5 would be addressed through treatment required on individual waste lots generated under CERCLA decision documents, as needed, to meet the EMDF WAC before onsite disposal. For example, waste containing mercury above regulatory limits must be treated to meet ARARs prior to disposal.

DOE is proposing the Central Bear Creek Valley site as the preferred site location for the following reasons:

1. The site facilitates timely CERCLA remediation of the ORR by providing a dedicated onsite disposal location that is protective of human health and the environment, cost-effective, compliant with all Federal and State requirements, and effectively balances the CERCLA remedy selection criteria.

2. The site is located in a secure location (under DOE control) within the ORR in an area not considered for reindustrialization or reuse.

3. The site minimizes short-term risks to humans through transportation or industrial accidents.

4. The site is adjacent to an existing area designated as a future CERCLA waste management area (i.e., EMWMF) along with several other CERCLA areas in Bear Creek Valley.

5. The overall terrain is not as steep as other proposed locations and there is room for collocated support systems installation as there are no other activities nearby.

6. The need for underdrains is minimized. Any/all underdrains in use during disposal operations are conceptualized as not necessary or operational following closure.

The site offers distinct advantages in relation to the management of technical challenges related to surface water and groundwater in Bear Creek Valley. As part of the evaluation of the suitability of this particular location, EPA, TDEC, and DOE agreed that collection and analyses of additional field data would be important to inform this Proposed Plan and ultimately the selection of the preferred alternative for future remediation waste management at the ORR (see Appendix B). The additional data supplements data contained in the RI/FS (available as part of the Administrative Record). The additional field data focuses on the Central Bear Creek Valley site to help define the location-specific hydrologic properties (both surface and subsurface) and support the determination in the ROD whether key ARARs (identified in previous the *Key ARARs* section) can be complied with or whether regulatory exemptions/waivers will be required as part of the remedy selection documented in the ROD. The additional data also will be used to evaluate the ability of the remedy to meet CERCLA statutory requirements. Attached to this Proposed Plan (Appendix B) is an approved copy of the Field Sampling Plan used in the data collection effort that occurred between the conclusion of the RI/FS and this Proposed Plan. The results of the Field Sampling Plan activities are contained in Technical Memorandum #1 (discussed in the Field Sampling Plan) which provides DOE's analysis of the data in relation to the hydrologic properties of Central Bear Creek Valley. Technical Memorandum #1 is available in the Administrative Record.

Surface water and groundwater data would continue to be collected and reported (Technical Memorandum #2) to support remedy selection in the ROD and to ensure that the design protects human health and the environment and complies with ARARs. All data collected to support the ROD or design will be available to the public.

Other activities that will be implemented as the ROD is being developed include an assessment of the long-term performance of the landfill as required by DOE Order 435.1. While this assessment is not required under CERCLA, DOE is required to develop two documents that complement those developed during the CERCLA process. The first document, a Performance Assessment, evaluates the potential for releases of radioactivity from a LLW disposal facility and resultant impacts on future members of the public and the environment. The second document, a Composite Analysis, evaluates the impact of a new LLW disposal facility in aggregate with other sources of radioactivity in the area on members of the public and the environment. These documents will be reviewed under DOE's independent regulatory authority, and approval to proceed with construction will be granted before signature of the ROD. Additionally, development of the final WAC with EPA and TDEC will occur while DOE is drafting the ROD, and the final WAC (approved by the three FFA parties) will be attached to the ROD prior to signature and will be one of many factors used by DOE to assure protection of human health and the environment.

The preferred alternative can change in response to public comments on this Proposed Plan or based on new information collected prior to the ROD. Any new information collected after this Proposed Plan and prior to the signature of the ROD will be placed in the Administrative Record. Selection of the Central Bear Creek Valley site for long-term waste disposal in the ROD will necessitate a change to the future land use designation of the location and surrounding area, from the current recreational and future unrestricted use designation to DOE-industrial use designation.

## NATURAL RESOURCE DAMAGES

Hazardous substances known to be above health-based levels based on residential use will remain in the disposal cell after landfill closure. It is recognized by DOE, TDEC, and EPA that natural resource damage claims, in accordance with CERCLA, may be applicable. Neither DOE nor TDEC waive any rights or defenses they may have under CERCLA Sect. 107(1)4(c).

## COMMITMENT TO LONG-TERM STEWARDSHIP

This proposed remedy will result in leaving hazardous material at the EMDF site that will remain hazardous in perpetuity. DOE is committed to long-term stewardship to protect future users of the site.

DOE will be responsible for maintaining, reporting, and enforcing, as necessary, land use controls. DOE will retain ultimate responsibility for the integrity and protectiveness of the remedy. Monitoring of the approved land use controls will be conducted annually and any identified issues will be reported in the annual ORR remediation effectiveness reports.

## COMMUNITY PARTICIPATION

DOE, EPA, and TDEC encourage the public to review this document and other relevant documents in the Administrative Record to gain an understanding of the proposed waste disposal action. A copy of this Proposed Plan, as well as the entire Administrative Record, is located at the DOE Information Center, at the Office of Scientific and Technical Information, 1 Science.gov Way, Oak Ridge, Tennessee 37830. The Center is open Monday through Friday, 8 a.m. to 5 p.m.; the telephone number is (865) 241-4780.

Community involvement is critical to the CERCLA process. A public meeting has been scheduled by DOE to discuss cleanup alternatives and address questions and concerns the public may have about all alternatives. DOE has established a 30-day public comment period, which allows the public time to review the document and submit comments on the preferred and other alternatives. DOE will document, evaluate, and respond to comments as part of the subsequent ROD. Upon request, DOE will engage the public in additional public outreach efforts. Comments may be addressed to John Michael Japp, FFA Project Manager, Oak Ridge Environmental Management, DOE Oak Ridge Operations, Post Office Box 2001, Oak Ridge, Tennessee 37831.

The preferred alternative identified in this Proposed Plan represents the recommended alternative for the disposal of future waste generated from cleanup actions under CERCLA at the DOE ORR. This Proposed Plan provides stakeholders the information necessary to determine if action is warranted and to provide comments on the potential alternatives. DOE may modify the preferred alternative or select a different alternative in response to public input. Therefore, the public is encouraged to review and comment on all information in this Proposed Plan. After considering public comments, DOE will prepare a ROD that presents the selected remedy. Following the approval of the ROD, DOE will prepare plans and implement the selected action.

## REFERENCES

DOE 1992. *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, January, U.S. Environmental Protection Agency Region 4, Atlanta, GA; U.S. Department of Energy Office of Environmental Management, Oak Ridge, TN; and Tennessee Department of Environment and Conservation, Nashville, TN, January.

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## GLOSSARY

**Administrative Record –** The administrative record is the set of non-deliberative documents that the decision-maker considered, directly or indirectly (e.g., through staff), in making the final (CERCLA ROD) decision. The record includes all the factual, technical, and scientific material or data considered in making the decision, whether or not those materials or data support the decision.

**Applicable or relevant and appropriate requirement (ARAR)** – Those cleanup standards and other substantive requirements, criteria, or limitations promulgated under federal or more stringent state environmental or facility siting laws that are either legally "applicable" or "relevant and appropriate" to the hazardous substances, pollutant, contaminant, remedial action, location, or other circumstance found at the CERCLA site.

**Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)** – The federal law that establishes, among other requirements, a program for parties (including federal agencies) to identify, investigate, and, if determined necessary, remediate inactive site facilities contaminated with a hazardous substance, pollutant, or contaminant. It is also known as the "Superfund law."

**Excess Lifetime Cancer Risk** – Excess Lifetime Cancer Risk considers the cumulative probability of humans developing cancer as a result of a lifetime of exposure to a particular level of a contaminant, above the normal cancer rates from the natural environment. Cumulative means adding the carcinogenic risk from all contaminants and ways a person can be exposed.

**Feasibility Study (FS)** – The step in the CERCLA process in which alternatives for remediation of a contaminated site or of other remediation decisions are developed and evaluated.

**Hazard Index** – The ratio of the level of exposure to an acceptable level of exposure for contaminants that may cause adverse health effects to humans. A cumulative hazard index greater than 1 indicates that there may be a concern for adverse health effects. The hazard index is used to assess contaminants that may cause health effects other than cancer. Some contaminants (e.g., uranium, arsenic) can have both carcinogenic and non-carcinogenic effects.

**National Environmental Policy Act of 1969 (NEPA)** – A federal law that requires federal agencies to consider and evaluate environmental impacts associated with any significant proposed actions or activities. For CERCLA actions undertaken by DOE, any impacts to NEPA values associated with the proposed action are considered along with other factors required to be evaluated.

**Present Worth** – Present worth costs reflect the quantity of money that would need to be placed in a bank today at a set interest rate, termed the discount rate, to pay for the remedial action over the life of the project. The present worth approach for cleanup decision making and comparison of alternatives is recommended by EPA in its cost estimating guidance for Superfund sites (EPA 2000).

**Proposed Plan** – The formal document in which the lead agency identifies its preferred alternative for remedial action, explains why this alternative was preferred, and solicits comments from the public.

**Record of Decision (ROD)** – The formal document in which the lead agency sets forth the selected remedial action and the reasons for its selection.

**Remedial Investigation (RI)** – A CERCLA environmental study that identifies the nature and extent of contamination. The RI also provides an assessment of the potential risks associated with the contaminants.

**Waste Acceptance Criteria (WAC)** – Requirements that waste must meet before being placed in a disposal cell to ensure protection of human health, safety, and the environment. The criteria include limits on the amount of chemical and radiological contamination that can be present in the waste, requirements for size and shape of waste, and lists of wastes prohibited from disposal based on regulations or agreements. The WAC take into consideration the design of the disposal facility, the underlying geologic conditions, and the nature of the contamination.

## ACRONYMS

| | |
|---|---|
| ARAR | applicable or relevant and appropriate requirement |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act of 1980 |
| *CFR* | *Code of Federal Regulations* |
| DOE | U.S. Department of Energy |
| EMDF | Environmental Management Disposal Facility |
| EMWMF | Environmental Management Waste Management Facility |
| EPA | U.S. Environmental Protection Agency |
| ETTP | East Tennessee Technology Park |
| EUWG | End Use Working Group |
| FFA | Federal Facility Agreement |
| LLW | low-level (radioactive) waste |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NEPA | National Environmental Policy Act of 1969 |
| ORNL | Oak Ridge National Laboratory |
| ORR | Oak Ridge Reservation |
| RAO | remedial action objective |
| RCRA | Resource Conservation and Recovery Act of 1976 |
| RI/FS | Remedial Investigation/Feasibility Study |
| ROD | Record of Decision |
| TDEC | Tennessee Department of Environment and Conservation |
| TDRH | Tennessee Department of Radiological Health |
| TSCA | Toxic Substances Control Act of 1976 |
| WAC | waste acceptance criteria |
| Y-12 | Y-12 National Security Complex |

**Proposed Plan for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Waste**
**Public Comment Sheet**

DOE is interested in your comments on the alternatives being considered in the *Proposed Plan for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Waste,* including the preferred alternative. The mailing address is preprinted on the back of this form. You may use this form to submit your comments. We must receive your comments on or before the close of the public comment period. If you have questions, please contact Mr. John Michael Japp, FFA Project Manager; Oak Ridge Environmental Management; DOE Oak Ridge Operations; P.O. Box 2001, Oak Ridge, TN 37831; (865) 576-6344.

Name: ______________________________

Address: ______________________________

City: ______________________ State/Zip: ______________

Phone: ______________________________

---

## MAILING LIST ADDITIONS:

Please add my name to the Environmental Management Program mailing list to receive additional information on the progress at the Oak Ridge Reservation: ☐ Yes ☐ No

Place
stamp
here

**Mr. John Michael Japp, FFA Project Manager**
**Oak Ridge Environmental Management**
**DOE Oak Ridge Operations**
**P.O. Box 2001**
**Oak Ridge, TN 37831**

## RECORD COPY DISTRIBUTION

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# APPENDIX A.
# SUMMARY OF CERCLA EVALUATION CRITERIA FOR DISPOSAL ALTERNATIVES

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# APPENDIX A. SUMMARY OF CERCLA EVALUATION CRITERIA FOR DISPOSAL ALTERNATIVES

<table>
<tr><th rowspan="2">Evaluation Criterion</th><th rowspan="2">No Action Alternative</th><th colspan="4">Onsite Alternatives</th><th rowspan="2">Offsite Alternative</th><th rowspan="2">Hybrid Disposal Alternative</th></tr>
<tr><th>East Bear Creek Valley</th><th>Central Bear Creek Valley</th><th>West Bear Creek Valley</th><th>Dual Site</th></tr>
<tr><td rowspan="2">Overall protection of human health and the environment</td><td rowspan="2">• May not be protective of human health and the environment if remediation not accomplished due to extensive time frames to complete remediation and extensive funding required.</td><td colspan="4">• Would meet all remedial action objectives.<br>• Protective because waste would be disposed of in a landfill designed for long-term containment to be protective of human health and the environment through application of land use controls, application of waste acceptance criteria, and application of ARARs.</td><td rowspan="2">• Would meet all remedial action objectives.<br>• Protective because waste would be disposed of in a landfill designed for long-term containment, application of waste acceptance criteria, and must meet CERCLA offsite rule.<br>• More protective than the Onsite or Hybrid Disposal Alternatives in preventing releases on the ORR because waste is permanently removed and disposed in unpopulated regions with greater depths to groundwater.<br>• Less protective in the short term because of increased transportation risks.</td><td rowspan="2">• Would meet all remedial action objectives.<br>• Protective because waste would be disposed of in a landfill (either onsite or offsite) designed for site-specific conditions to be protective of human health and the environment through application of land use controls, application of waste acceptance criteria, and application of ARARs or CERCLA offsite rule.<br>• Site-specific conditions relevant to siting consideration and potentially affecting design at the onsite location are:<br>- Hydrologic buffer (i.e., depth of waste to pre-construction groundwater levels) is estimated based on wells adjacent to the landfill footprint and within the same subsurface formations to range from ~ 0 ft (waste within pre-construction water levels) to ~30 ft bgs.<br>- Groundwater flow direction is predominantly south to southwest. This analysis is based on identified topography and multiple Bear Creek Valley well results.<br>- Distance to 500 year floodplain is ~ 600 ft.<br>- Distance to karst formation is ~ 600 ft.<br>- Constructed with berm over seeps- would be addressed through engineered structure.<br>• Shortest distance to the DOE property line is ~ 4,400 ft.<br>• Size of permanent commitment for landfill footprint: up to 50 acres.</td></tr>
<tr><td>• Site-specific conditions relevant to siting consideration and potentially affecting design at this candidate site are:<br>- Hydrologic buffer (i.e., depth of waste to pre-construction groundwater levels) within landfill footprint ranges from 0 ft (waste within pre-construction water levels) to ~80 ft bgs based on wells characterized within the footprint in 2015.<br>- Distance to 500-year floodplain is ~1,300 ft.<br>- Distance to karst formation is ~1,270 ft.<br>- Constructed with waste over stream; would be addressed through engineered structure.<br>• Shortest distance to the DOE property line is ~1,200 ft.<br>• Size of permanent commitment for landfill footprint: up to 70 acres.</td><td>• Site-specific conditions relevant to siting consideration and potentially affecting design at this candidate site are:<br>- Hydrologic buffer (i.e., depth of waste to pre-construction groundwater levels) is estimated to range from ~0 ft (waste within pre-construction water levels) to ~30 ft bgs based on wells characterized within the footprint in 2018.<br>- Distance to 500-year floodplain is ~500 ft.<br>- Distance to karst formation is ~300 ft.<br>- Constructed with berm over stream; would be addressed through engineered structure.<br>• Shortest distance to the DOE property line is ~4,200 ft.<br>• Size of permanent commitment for landfill footprint: up to 67 acres.</td><td>• Site-specific conditions relevant to siting consideration and potentially affecting design at this candidate site are:<br>- Hydrologic buffer (i.e., depth of waste to pre-construction groundwater levels) within landfill footprint ranges from 10-30 ft bgs based on wells characterized within the footprint in 1988.<br>- Distance to 500-year floodplain is ~1000 ft.<br>- Distance to karst formation is ~660 ft.<br>- Constructed with waste over stream; would be addressed through engineered structure.<br>• Shortest distance to the DOE property line is ~3,900 ft.<br>• Size of permanent commitment for landfill footprint: up to 71 acres.</td><td>• Site-specific conditions relevant to siting consideration and potentially affecting design at this candidate site are:<br>- Hydrologic buffer (i.e., depth of waste to pre-construction groundwater levels) is estimated based on wells adjacent to the landfill footprint and within the same subsurface formations to range from ~0 ft (waste within pre-construction water levels) to ~60 ft bgs.<br>- Distance to 500-year floodplain is ~600 ft (smaller site) and 500-800 ft (larger site).<br>- Distance to karst formation is ~600 ft (smaller site) and 450-600 ft (larger site).<br>- Constructed with berm over seeps; would be addressed through engineered structure.<br>• Shortest distance to the DOE property line is ~4,000 ft.<br>• Size of permanent commitment for landfill footprint: up to 109 acres (combined sites).</td></tr>
<tr><td>Compliance with ARARs</td><td>• No action, therefore, no ARARs apply. ARARs for remedial actions at individual sites are specified in separate CERCLA documents.</td><td colspan="4">• Would comply with all ARARs. No CERCLA waivers invoked. A TSCA specific waiver for 40 *CFR* 761.75(b)(3) and (b)(5) would be requested as provided in 40 *CFR* 761.75(c)(4). A Tennessee Division of Radiological Health exemption for TDEC 0400-20-11.17(1)(h) may be invoked as provided in TDEC 0400-20-04-.08. These determinations will be made in the Record of Decision based on available data.</td><td>• Would comply with all chemical-, location-, and action-specific ARARs.</td><td>• Same as Onsite Alternatives.</td></tr>
</table>

<table>
<tr><th rowspan="2">Evaluation Criterion</th><th rowspan="2">No Action Alternative</th><th colspan="4">Onsite Alternatives</th><th rowspan="2">Offsite Alternative</th><th rowspan="2">Hybrid Disposal Alternative</th></tr>
<tr><th>East Bear Creek Valley</th><th>Central Bear Creek Valley</th><th>West Bear Creek Valley</th><th>Dual Site</th></tr>
<tr><td rowspan="2">Long-term effectiveness and permanence</td><td rowspan="2">• As the no action remedy does not meet one CERCLA threshold criterion (protection of human health and the environment), no additional summary analysis will be provided.</td><td colspan="4">• Provides long-term effective and permanent waste disposal because of landfill design (designed to RCRA and TSCA) standards and use of waste acceptance criteria consistent with DOE Orders and ARARs.<br>• Potential non-acute residual hazards may be slightly greater for the waste disposed of onsite than for that disposed of offsite because of higher regional population, wetter climatic conditions, and shallower depth to groundwater. However, land use controls and monitoring at the onsite disposal location would mitigate this risk.</td><td rowspan="2">• The offsite facility locations in arid environments reduce the likelihood of contaminant migration, and fewer receptors exist in the vicinity of EnergySolutions and NNSS than near the ORR.</td><td rowspan="2">• Provides long-term effective and permanent waste disposal onsite because of landfill design and use of risk-based WAC. Also provides long-term effective and permanent waste disposal for waste meeting the offsite facility WAC.<br>• Potential non-acute residual hazards may be slightly greater for the waste disposed onsite than for that disposed offsite because of higher regional population, wetter climatic conditions, and shallower depth to groundwater. However, land use controls and monitoring at the onsite disposal location should mitigate this risk.<br>• The offsite facility locations in arid environments reduce the likelihood of contaminant migration, and fewer receptors exist in the vicinity of EnergySolutions and NNSS than near the ORR.<br>• Destruction of up to 50 acres of woodland habitat within facility footprint.<br>• No wetlands are affected.<br>• Temporary drainage features are not expected to be used long-term. Temporary drainage features are as shown in the smaller of the two footprints shown in Figure 6.</td></tr>
<tr><td>• Destruction of up to approximately 70 acres of woodland habitat within facility footprint.<br>• Up to approximately 1.6 acres of wetlands impacted. Impacts would be minimized through use of Best Management Practices or mitigated in accordance with ARARs.<br>• Surface water features, including a tributary creek, would require relocation; however, impacts would be minimized through use of Best Management Practices or mitigated in accordance with ARARs.<br>• Impacts to environmental features would be minimal as the site is located within the secured portion and industrial area of Y-12.<br>• Underdrains are permanent as shown in Figure 4.</td><td>• Destruction of up to approximately 67 acres of woodland habitat within facility footprint.<br>• Up to approximately 4.9 acres of wetlands impacted. Impacts would be minimized through use of Best Management Practices or mitigated in accordance with ARARs.<br>• Surface water features, including a tributary creek, would require relocation; however, impacts would be minimized through use of Best Management Practices or mitigated in accordance with ARARs.<br>• Temporary drainage features are not expected to be used long-term. Temporary drainage features are as shown in Figure 7.</td><td>• Destruction of up to approximately 71 acres of woodland habitat within facility footprint.<br>• Up to approximately 2.5 acres of wetlands impacted. Impacts would be minimized through use of Best Management Practices or mitigated in accordance with ARARs.<br>• Surface water features, including a tributary creek, would require relocation; however, impacts would be minimized through use of Best Management Practices or mitigated in accordance with ARARs.<br>• Underdrains are permanent as shown in Figure 5.</td><td>• Destruction of up to approximately 109 acres of woodland habitat within facility footprint.<br>• Up to approximately 5.8 acres of wetlands impacted. Impacts would be minimized through use of Best Management Practices or mitigated in accordance with ARARs.<br>• Surface water features would not require relocation.<br>• Temporary drainage features are not expected to be used long-term. Temporary drainage features are as shown in Figure 6.</td></tr>
<tr><td rowspan="2">Short-term effectiveness</td><td rowspan="2"></td><td colspan="4">• All onsite facilities require management of landfill wastewater through collection in the leachate collection system.<br>• Transportation risks are significantly lower for the public than those under the offsite alternatives (onsite < 1.0 fatality/injury) over the disposal life cycle (DOE 2017).</td><td rowspan="2">• No notable environmental effects would occur at the existing offsite facilities from increased ORR waste disposal.<br>• Transportation risks are significantly greater for the public than for the Onsite Alternatives. Injuries/fatalities from transportation accidents estimated to range from 7 to 24 over the disposal life cycle (DOE 2017).<br>• Offsite facilities are located in arid regions and have minimal wastewater management requirements.</td><td rowspan="2">• Adverse environmental effects during construction are much lower than for other onsite facility options if the onsite location is used because it was used as a borrow area previously.<br>• Transportation risks to the public and workers are greater than onsite facility alternatives, but less than those encountered for the Offsite Disposal Alternative. Up to 3 injuries/fatalities from transportation accidents may occur over the disposal life cycle.<br>• Onsite facility requires management of landfill wastewater through collection in the leachate collection system. Less wastewater volume due to smaller footprint than full size onsite facilities.</td></tr>
<tr><td>• Wetland mitigation of up to approximately 1.6 acres.</td><td>• Wetland mitigation of up to approximately 4.9 acres.</td><td>• Wetland mitigation of up to approximately 2.5 acres.</td><td>• Wetland mitigation of up to approximately 5.8 acres.</td></tr>
</table>

# APPENDIX A. SUMMARY OF CERCLA EVALUATION CRITERIA FOR DISPOSAL ALTERNATIVES (cont.)

| Evaluation Criterion | No Action Alternative | Onsite Alternatives | | | | Offsite Alternative | Hybrid Disposal Alternative |
|---|---|---|---|---|---|---|---|
| | | East Bear Creek Valley | Central Bear Creek Valley | West Bear Creek Valley | Dual Site | | |
| Reduction of toxicity, mobility, or volume through treatment | | • Landfill wastewater treatment would reduce contaminants to levels required for discharge. | | | | • Reduction in volume provided for disposal at NNSS. | • Reduction of volume is provided through mechanical volume minimization. |
| Implementability | | • Implementation is technically feasible; landfill design and construction of the type presented in this conceptual design is commonly carried out.<br>• Services and materials required for design, construction, and operation of the landfill are readily available, as are qualified personnel, specialists, and vendors. Construction would involve the use of standard construction equipment, trades, and materials; no new technology development is required. | | | | • Administrative and technical requirements are implementable as demonstrated by the current offsite shipment effort from ORR.<br>• However, disposal of waste at commercial and DOE facilities relies on continued availability of offsite disposal capacity. Future changes in the states' acceptance of waste transport and disposal could challenge implementation of the alternative. Travel through multiple states could raise challenges. | • Implementation of the onsite disposal portion is technically feasible; landfill design and construction of the type presented in this conceptual design is commonly carried out.<br>• Less new construction is required. The landfill is smaller and much of the existing infrastructure at EMWMF may be usable.<br>• Services and materials required for design, construction, and operation of the landfill are readily available, as are qualified personnel, specialists, and vendors. Construction would involve the use of standard construction equipment, trades, and materials; no new technology development is required. |
| | | • Greater use of underdrain system required at this site.<br>• Construction on steeper slopes.<br>• Some new construction is required including support facilities. | • Reliance on drainage systems expected to be required only during construction.<br>• No reliance on underdrains beneath waste footprint required.<br>• Slopes less pronounced than those at East Bear Creek Valley, so construction easier.<br>• New construction is required, including support facilities. | • Greater use of underdrain system required at this site.<br>• Slopes less pronounced than those at East Bear Creek Valley, so construction easier.<br>• New construction is required, including support facilities. | • Reliance on drainage systems expected to be required only during construction.<br>• No reliance on underdrains beneath waste footprint required.<br>• Slopes less pronounced than those at East Bear Creek Valley, so construction easier.<br>• Some new construction is required for support facilities and through construction of two landfills. | | |
| Cost | | • Cost per cubic yard of as-generated waste disposed is $276 (present worth 2016 dollars).<br>• Total cost $538.3M (present worth 2016 dollars). | • Cost per cubic yard of as-generated waste disposed is $276 (present worth 2016 dollars).<br>• Total cost $537.2M (present worth 2016 dollars). | • Cost per cubic yard of as-generated waste disposed is $284 (present worth 2016 dollars).<br>• Total cost $553.3M (present worth 2016 dollars). | • Cost per cubic yard of as-generated waste disposed is $343 (present worth 2016 dollars).<br>• Total cost $667.4M (present worth 2016 dollars). | • Cost per cubic yard of as-generated waste disposed of is $675–$767 (present worth 2016 dollars).<br>• Total cost is $1,315–$1,494M (present worth 2016 dollars). | • Cost per cubic yard of as-generated waste disposed is $587 (present worth 2016 dollars).<br>• Total cost is $1,145M (present worth 2016 dollars). |
| State Acceptance | • The State does not support the no action alternative. | • The State does not support the East Bear Creek Valley Alternative based on the understanding that a greater reliance on an underdrain system is required at this site. | • The State conditionally supports identification of the Central Bear Creek Valley site as the preferred alternative. This conditional support of Central Bear Creek Valley is based on its potential as the preferred site to meet DOE's estimated disposal capacity needs without relying on engineered systems for collecting and discharging groundwater beneath the waste footprint. | • The State does not support the West Bear Creek Valley Alternative based on the understanding that a greater reliance on an underdrain system is required at this site. | • The State conditionally supports identification of the Dual Site Alternative. This conditional support of the Dual site is its potential to meet DOE's estimated disposal capacity needs without relying on engineered systems for collecting and discharging groundwater beneath the waste footprint. | • The State supports the offsite disposal alternative, because the offsite facilities have approved permits that comply with applicable regulations and are located in relatively flat, dry, unpopulated locations with deep water tables. | • The State conditionally supports the Hybrid Alternative. This conditional support of the Hybrid Disposal Alternative is based on: 1) the potential to meet DOE's estimated disposal capacity needs without relying on engineered systems for collecting and discharging groundwater beneath the waste footprint; and 2) the offsite facilities have already been permitted in relatively flat, dry, unpopulated locations with deep water tables. |
| Public Acceptance | To be determined upon submittal of the Proposed Plan | | | | | | |

# APPENDIX A. SUMMARY OF CERCLA EVALUATION CRITERIA FOR DISPOSAL ALTERNATIVES (cont.)

| Evaluation Criterion | No Action Alternative | Onsite Alternatives | | | | Offsite Alternative | Hybrid Disposal Alternative |
|---|---|---|---|---|---|---|---|
| | | East Bear Creek Valley | Central Bear Creek Valley | West Bear Creek Valley | Dual Site | | |

ARAR = applicable or relevant and appropriate requirement
bgs = below ground surface
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
*CFR = Code of Federal Regulations*
DOE = U.S. Department of Energy
EMWMF = Environmental Management Waste Management Facility
M = million
NNSS = Nevada Nuclear Security Site
ORR = Oak Ridge Reservation
RCRA = Resource Conservation and Recovery Act of 1976
TDEC = Tennessee Department of Environment and Conservation
TSCA = Toxic Substances Control Act of 1976
WAC = waste acceptance criteria

# APPPENDIX B.
# FIELD SAMPLING PLAN

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**DOE/OR/01-2739&D2**

# Phase 1 Field Sampling Plan for the Proposed Environmental Management Disposal Facility for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge, Tennessee

This document is approved for public release per review by:

UCOR Classification & Information Control Office

3/20/18
Date

DOE/OR/01-2739&D2

# Phase 1 Field Sampling Plan for the Proposed Environmental Management Disposal Facility for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge, Tennessee

Date Issued—March 2018

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

URS | CH2M Oak Ridge LLC
Safely Delivering the Department of Energy's Vision
for the East Tennessee Technology Park Mission
under contract DE-SC-0004645

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# CONTENTS

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# FIGURES



# TABLES

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# ACRONYMS

| | |
|---|---|
| BCV | Bear Creek Valley |
| CBCV | Central Bear Creek Valley |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act of 1980 |
| D | Drainage |
| DOE | U.S. Department of Energy |
| DQO | data quality objective |
| E | East |
| EMDF | Environmental Management Disposal Facility |
| EMWMF | Environmental Management Waste Management Facility |
| EPA | U.S. Environmental Protection Agency |
| FLUTe | Flexible Liner Underground Technologies, LLC |
| FFA | Federal Facility Agreement |
| NT | North Tributary |
| OREIS | Oak Ridge Environmental Information System |
| OREM | Oak Ridge Office of Environmental Management |
| ORNL | Oak Ridge National Laboratory |
| ORR | Oak Ridge Reservation |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| RDWP | Remedial Design Work Plan |
| RI/FS | Remedial Investigation/Feasibility Study |
| SME | subject matter expert |
| TDEC | Tennessee Department of Environment and Conservation |
| UCOR | URS \| CH2M Oak Ridge LLC |
| UPF | Uranium Processing Facility |
| USGS | U.S. Geological Survey |
| W | West |

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# 1. INTRODUCTION

The mission of the U.S. Department of Energy (DOE) Oak Ridge Office of Environmental Management (OREM) is to decommission and demolish numerous facilities and conduct remedial actions under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) on the Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee, and associated sites. This effort requires an estimated 2.2 million cy of landfill disposal capacity beyond what is available in the existing Environmental Management Waste Management Facility for the disposal of wastes from CERCLA cleanup actions. The *Remedial Investigation/Feasibility Study for the Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge, Tennessee* (RI/FS) (DOE 2017) evaluated several alternatives for the disposal of this waste, including no action, off-site disposal, and onsite disposal.

An approximately 70-acre tract in the Central Bear Creek Valley (CBCV) site appears to be the best site in terms of available capacity and location. This site is used as the basis for the planned characterization efforts.

This Field Sampling Plan describes the objectives, requirements, and approach to collecting groundwater elevations and surface water flow data, and conducting geotechnical testing and exploration to characterize Site 7c, the current preferred location for the proposed Environmental Management Disposal Facility (EMDF) (Fig. 1) on the DOE ORR. This Field Sampling Plan presents the site characterization activities (Phase 1) identified in the Statement of Work provided by the U.S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC) for Site 7c/CBCV site. The Federal Facility Agreement (FFA) parties have agreed that the results of this Field Sampling Plan will be documented in Technical Memorandum 1 and included in the Administrative Record prior to the public comment period on the preferred EMDF alternative (prior to completion of the Proposed Plan).

Additional investigations will be conducted in the future to obtain additional hydrogeological, geotechnical, and geophysical data for the EMDF design, including data collection to support design of the support facilities and required relocation of the Haul Road and Bear Creek Road. In addition, baseline sampling to determine the baseline analytical data will be performed as part of a future investigation phase. Longer-term monitoring of groundwater and surface water monitoring locations identified in this Field Sampling Plan also will be conducted in the May 2018 through February 2019 timeframe and documented in Technical Memorandum 2.

The data collection described in this Field Sampling Plan will contribute to understanding the hydrogeologic setting for the CBCV site during the planning process and preferred alternative selection. These data will be used to better understand and validate the underlying groundwater assumption for this site to support the FFA parties (EPA, TDEC, and DOE) in selecting and codifying a decision in a Record of Decision.

This plan uses the results of the data quality objective (DQO) process as specified in *Guidance on Systematic Planning Using the Data Quality Objectives Process - EPA QA/G-4* (EPA 2006). The DQO process focused on the use of the data for engineering design. The FFA parties agreed that subsets of this data could be used to validate underlying assumptions used for selecting the remedy.

The project-specific Quality Assurance Project Plan (QAPP) for the Proposed EMDF Design Investigation (Appendix A) identifies the procedures that will be followed in the collection, custody, sample handling, data management, and quality control (QC) activities for all anticipated EMDF investigation activities, including future design investigation activities not described in this document.

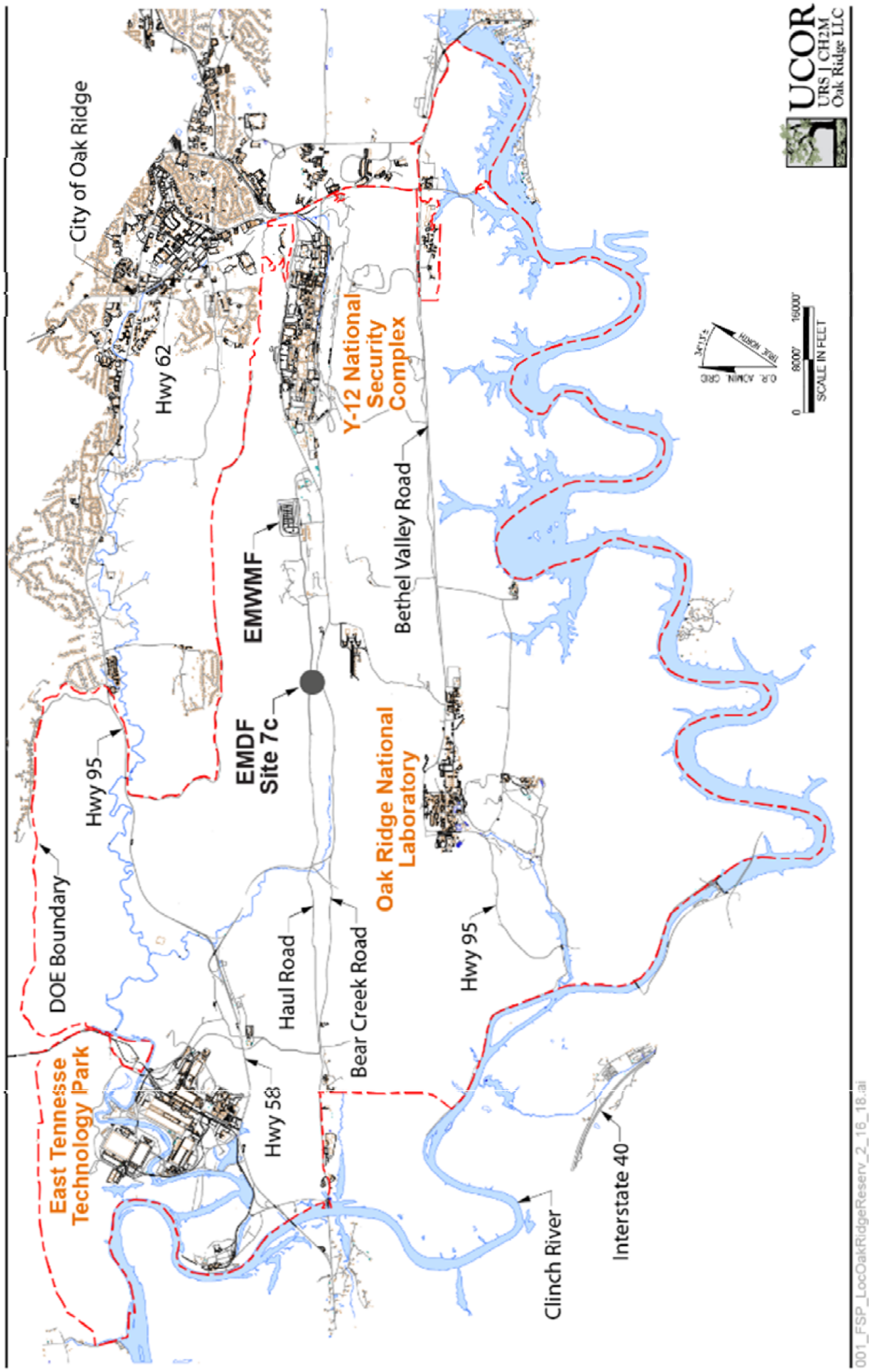


**Fig. 1. ORR—proposed EMDF CBCV site location.**

Safety concerns associated with the sampling will be addressed in contractor-prepared, task-specific work packages that will be approved by the appropriate disciplines. These work packages and contract documents will contain the detailed work scope for implementing this work.

This plan intends to deliver usable data within current constraints posed by physical site conditions and contractual obligations. The overall objective of this plan is to provide the strategy to collect sufficient representative data to address the DQOs. The specific scope of this plan is to obtain the following data:

- Groundwater elevation data
- Surface water flow data
- Geotechnical data

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# 2. HYDROGEOLOGIC SETTING

## 2.1 GENERAL SITE CONDITIONS

The CBCV site is situated within an upland area located between north-south trending valleys of North Tributary (NT)-10 and NT-11. Drainages within the site are Drainage (D)-10 West (W), parallel to and just west of NT-10, and D-11 East (E), an east-west trending feature that drains westward into NT-11 near the center of the site (Fig. 2).

An additional shallow east-west trending drainage was present in the southern part of the area prior to construction of the Uranium Processing Facility (UPF) wet spoils pile. This drainage was noted as dry when previously observed. The drainage is now covered by the UPF wet spoils pile; however, there is a downgradient seep within this drainage area.

The CBCV site and surrounding area are forested, except for areas along the south side between the Haul Road and Bear Creek Road, where the area has been cleared. The cleared area includes a recent soil staging area along the southern margin and two wetland basins completed in 2015 for the Y-12 National Security Complex compensatory wetland mitigation. The Haul Road and Bear Creek Road are located at the southern edge of the site and will need to be relocated prior to EMDF construction.

The Bear Creek Valley (BCV) has been extensively investigated. Geologic, hydrogeologic, and groundwater contamination conditions have been characterized extensively and there is routine monitoring of surface water conditions. There also have been additional investigations conducted for BCV to identify wetlands, ecological species of concern, and cultural resources. However, no CBCV site-specific investigations have been conducted.

The available hydrogeologic data for various potential EMDF sites in BCV are described in Appendix E and Sects. 2 and 5 of the RI/FS (DOE 2017). The information available for BCV was used to summarize various potential CBCV site conditions discussed below.

## 2.2 GEOLOGY/HYDROGEOLOGY

The general subsurface hydrogeological conditions at the CBCV site are known from previous characterization performed of the BCV watershed (DOE 2014). The general hydrogeological setting is provided in Fig. 3.

The waste footprint at the CBCV site predominantly overlies bedrock of the Conasauga Group (Fig. 3), including the Rogersville Shale, Dismal Gap/Maryville Formation, and Nolichucky Shale. Recent alluvium is present on the valley floor along D-10W (eastern side of the site).

These formations are dominantly shales, siltstones, and mudstones. There is little limestone present in the bedrock underlying the proposed disposal cells, even in the Maryville Formation. The crest of the knoll below the north center of the footprint is underlain by the erosion-resistant Dismal Gap/Maryville Formation. The typical weathering profile of topsoil, silty/clayey soil residuum, saprolite, and fractured bedrock are expected across the undisturbed site areas.

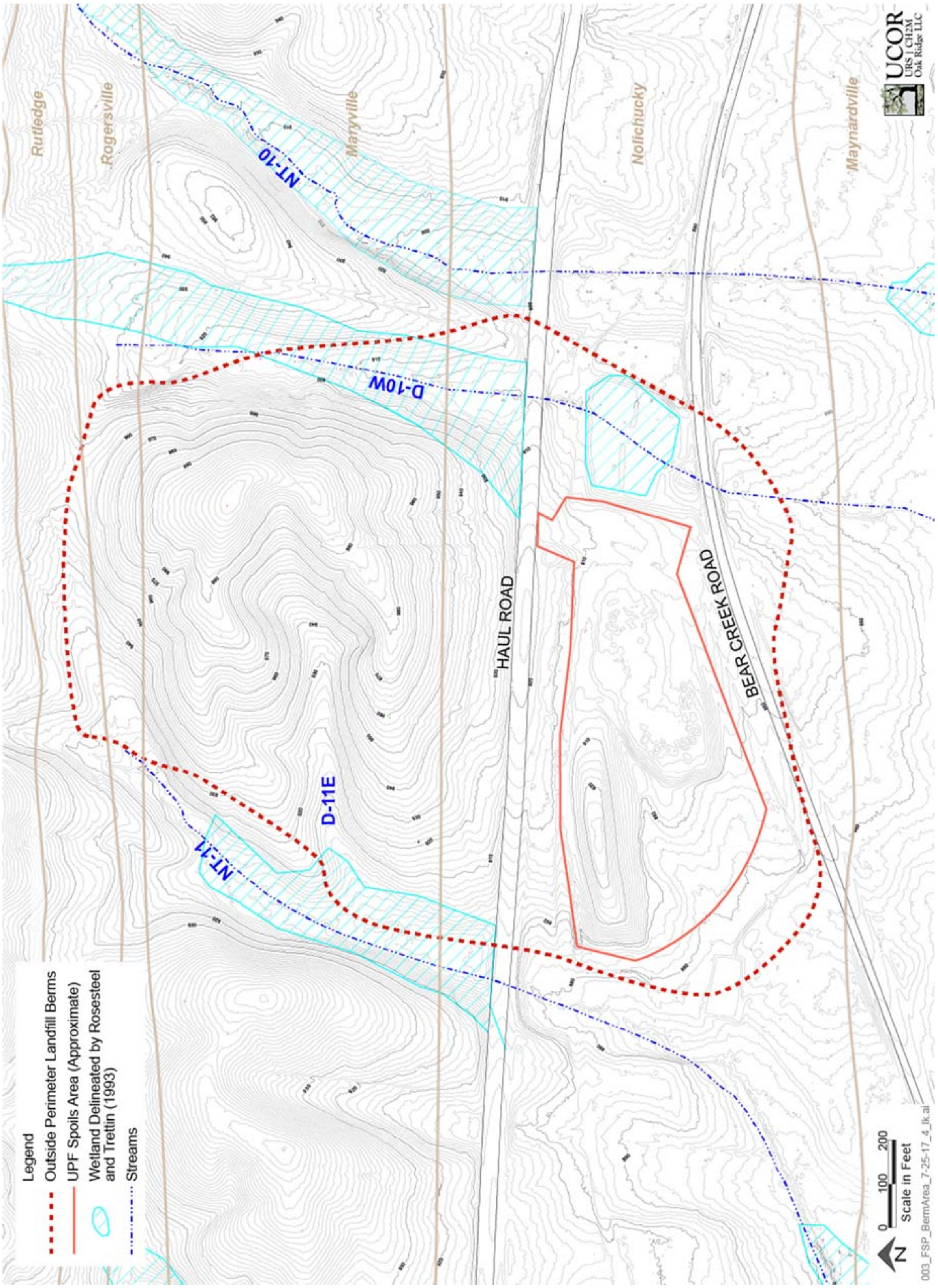


**Fig. 2. CBCV site topographic setting.**

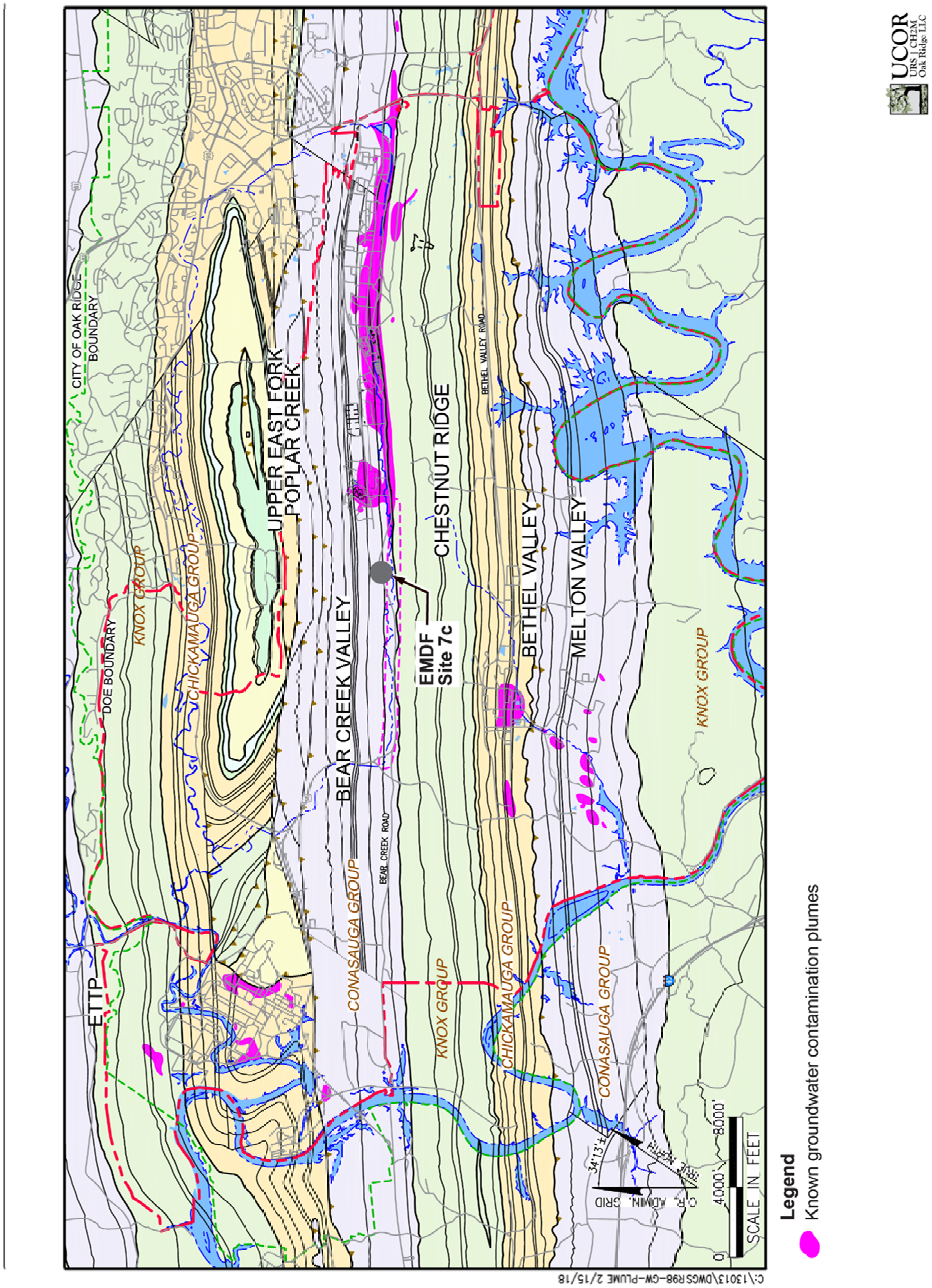


**Fig. 3. General geology of the Bear Creek Valley.**

In BCV, the average dip of the formations is 45° southeast (Fig. 4). Some microfolds to mesofolds are present. Fractures are present within the bedrock and control the location of the NTs. These fractures and macro/micropores within the remaining soils/saprolite and bedrock provide the primary routes for groundwater flow (and contaminant transport) below and downgradient of the CBCV site footprint (DOE 2016).

Thin layers of alluvial and colluvial soils may be present along streams, drainage ways, and the base of steeper slopes. These soils may be looser, more compressible, and more permeable than the underlying residual soils or saprolite. As noted in *Geology of the West Bear Creek Site* (Oak Ridge National Laboratory [ORNL] 1989):

> "The soils are underlain by a comparatively thick saprolite zone which varies from 10 to 20 ft thick. The saprolite is composed of weathered bedrock which has lost its rock cement but retained its bedding features. Its upper portions can be readily penetrated with a hand auger. The saprolite/bedrock contact is gradational due to decreasing weathering with depth but is typically defined as the depth of machine auger refusal."

#### 2.2.1 Groundwater Elevation

There are no current groundwater elevation data available for the CBCV site. Available groundwater elevation data were projected to this site from adjacent areas with similar hydrogeologic conditions. The current projected groundwater elevations and relation to the geologic buffer and projected bottom of waste are shown in Fig. 5. However, as the landfill is constructed, the surface water and groundwater flow regime will be modified.

Construction of the landfill may initially result in elevated groundwater elevations if heavy precipitation is encountered following vegetation and topsoil removal. However, the completion of landfill construction will reduce the area available for groundwater recharge from precipitation. Topsoil materials will be removed and replaced with engineered fill and geologic buffer clays that will reduce infiltration. While groundwater within undisturbed in situ natural materials will continue to migrate downgradient, the elimination of significant portions of the former natural recharge area will greatly reduce the overall groundwater flux. As a result, the groundwater elevation will be reduced and will be maintained lower than the geologic buffer, including reduction to the elevation of the groundwater mound below the central knob/spur ridge (DOE 2017, Appendix E).

#### 2.2.2 Potential for Karst Features

Karst features such as sinkholes, sinking streams, and resurgent springs have not been documented within the formations underlying the proposed footprint of the CBCV site. Karst features are documented within the Maynardville outcrop belt south of the CBCV site. Contact between the Nolichucky Shale and Maynardville Limestone is located approximately 300 ft from the proposed southernmost waste limit (DOE 2017).

### 2.3 SURFACE WATER HYDROLOGY

The CBCV site surface water systems are fed by precipitation, surface runoff and shallow stormflow, and both shallow and deeper groundwater that discharges via springs and seeps. In areas underlain by Conasauga Group shales, as much as 90 percent of the water entering the groundwater system flows rapidly through highly porous, shallow soil. In areas underlain by soluble, massive carbonate bedrock of the Maynardville Limestone, a larger fraction of the water enters the groundwater system by conduit flow through deeper flow pathways (DOE 2016).

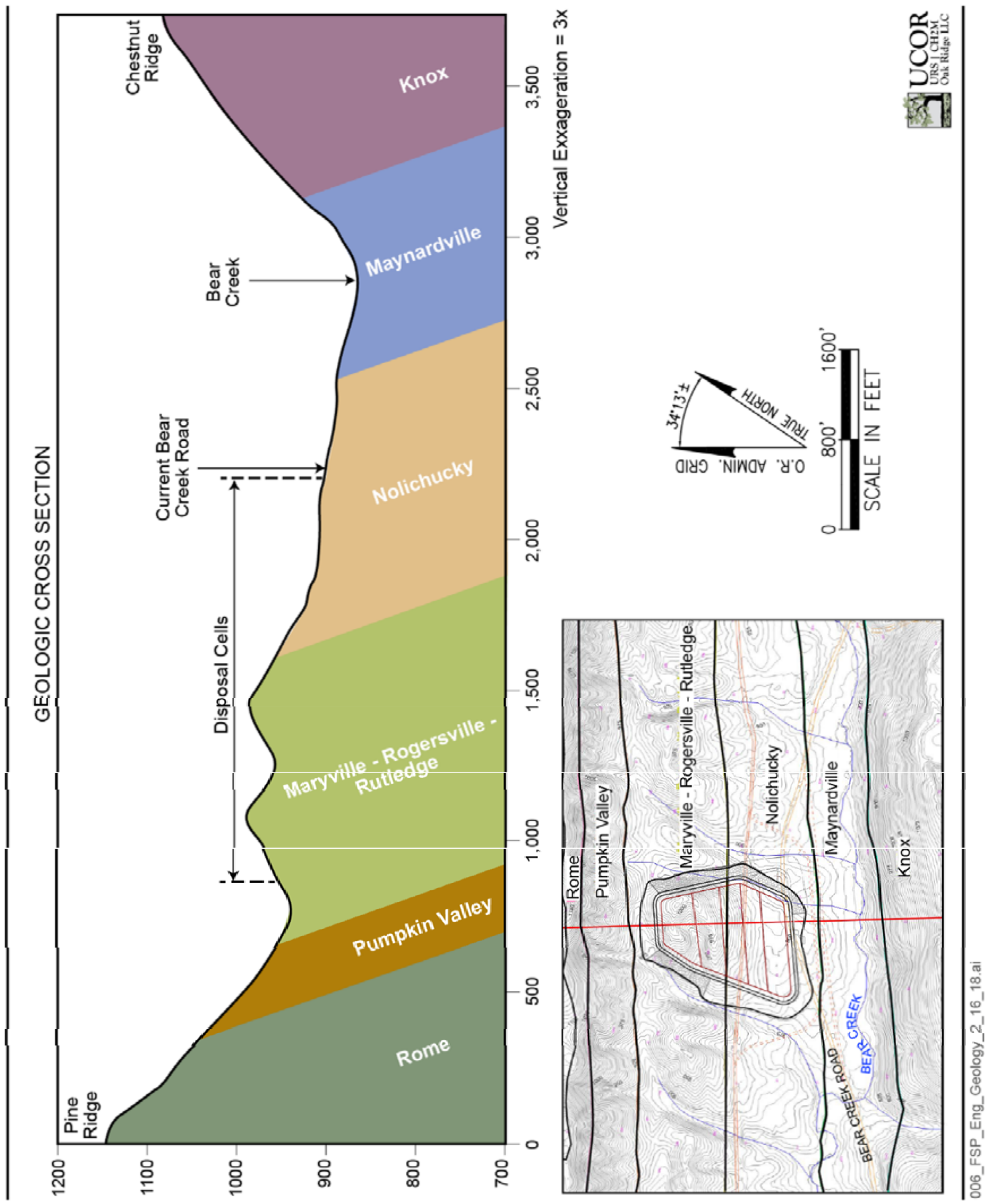


**Fig. 4. Generalized cross-section of the CBCV site.**

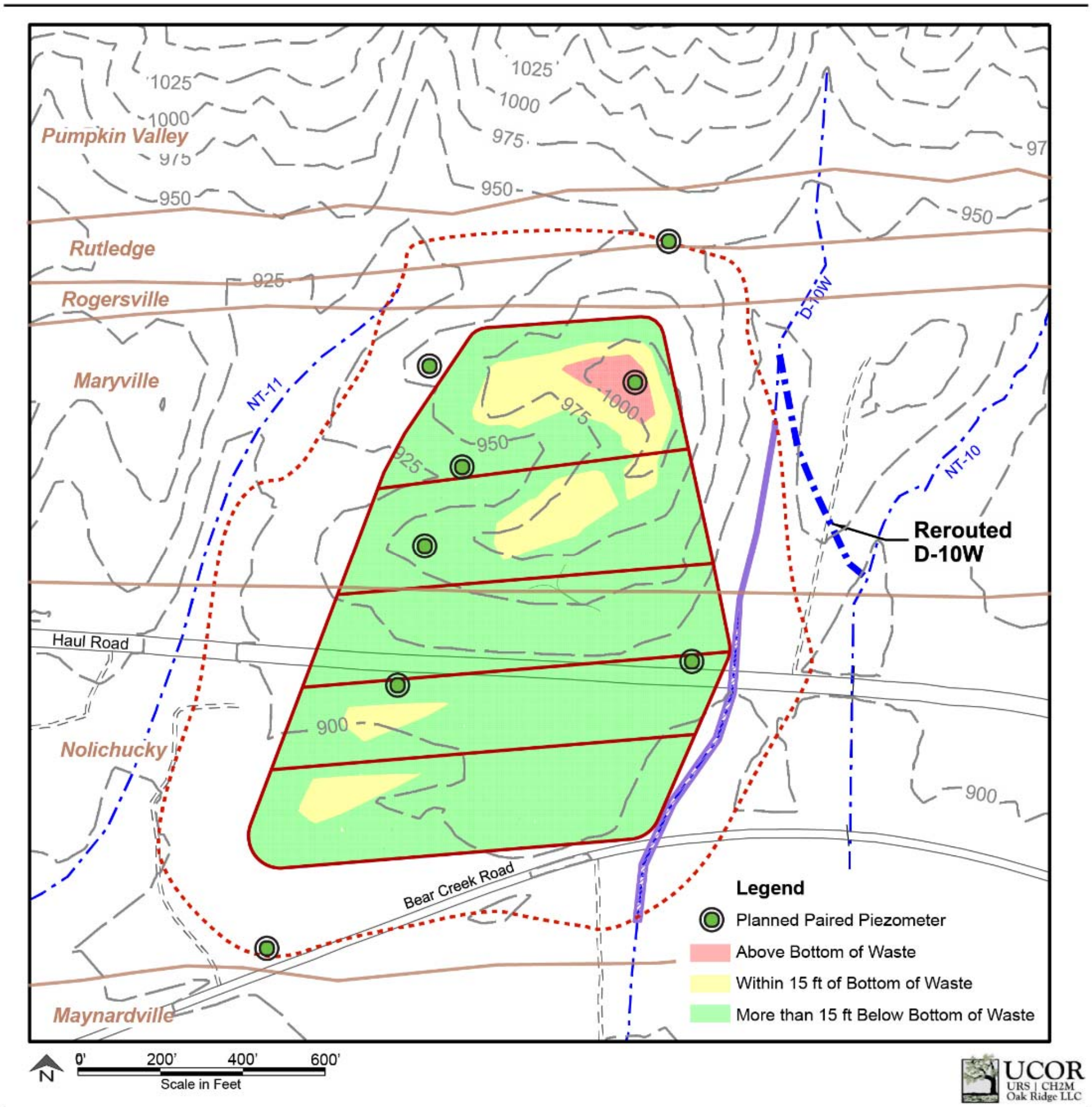


**Fig. 5. Projected pre-construction groundwater elevations beneath the EMDF waste cells.**

Based on existing U.S. Geological Survey (USGS) topographic maps, NT-10 and NT-11 are considered blue line streams. In addition, as part of the RI/FS process, D-10W was evaluated by a Qualified Hydrologic Professional and met the definition of a stream. Supporting information will be provided in the Remedial Design Work Plan (RDWP). The RDWP also will provide the results of any wetlands determinations for this area.

### 2.3.1 Surface Flow Data

Continuous flow monitoring data are not available for NT-10, NT-11 or D-10W. The available USGS base flow data indicate that base flow is continuous along the D-10W and NT-11 stream channels during the winter/spring non-growing wet season. During the summer/fall growing season with warm and often dry conditions, base flow is negligible and limited to pulsed flow associated with significant storm rainfall events. Flow monitoring for Bear Creek downstream of CBCV site indicates continuous flow in Bear Creek (DOE 2017).

Wet season base flows are relatively low along D-10W and vary from 0.01 cfs (4.5 gpm) at a headwater location to a maximum rate 0.04 cfs (18 gpm) southeast of the site. Wet season base flows along NT-11 are slightly higher ranging from 0.01 cfs (4.5 gpm) at a headwater spring location to 0.14-0.16 cfs (63-72 gpm) southwest and downstream of CBCV site (DOE 2017).

### 2.3.2 CBCV Site Preliminary Investigation

A limited site walkover of surface water conditions at the CBCV site was conducted on July 7, 2016, by a subject matter expert (SME) from the URS | CH2M Oak Ridge LLC (UCOR) Water Resources Restoration group to observe stream channels and other relevant features of NT-10, D-10W, and NT-11. The site visit occurred approximately 2-3 hours after a thundershower and following approximately 0.8 in. of rain the previous day.

The areas of the three surface water basins between the crest of Pine Ridge on the northwest and the geologic contact between the Maynardville Limestone and the Nolichucky Shale on the southeast are shown in Fig. 6. The Maynardville/Nolichucky geologic contact is recommended as the most downstream flow measurement location because further downstream surface water tends to sink into the Maynardville karst, causing a low bias to the flow data.

The NT-11 stream channel in the Nolichucky Shale outcrop area typically has a discontinuous outcrop of somewhat weathered bedrock (Figs. 7 and 8).

The walkover included NT-11 from approximately the “dog-leg” bend in the Nolichucky Shale to its head of flow in the Rogersville Shale. Next, the walkover route crossed the saddle to D-10W and proceeded southeast to approximately the Haul Road, across the weak ridge in the Maryville Limestone, and into the lower NT-10 basin above the Haul Road. Surface water features in these areas were difficult to see due to the heavy vegetation that covers much of the area to the southeast and along the Haul Road.

The CBCV site area slopes to the south-southeast. As described in the *Oak Ridge Reservation Physical Characteristics and Natural Resources* (ORNL 2006), sloping land surfaces on the ORR exhibit the characteristics of hillslope hydrology. In undisturbed, naturally vegetated areas such as the CBCV site, an estimated 80 to 90 percent of precipitation is captured and discharged from the 3- to 6.5-ft (1- to 2-m) storm-flow zone/root zone and does not infiltrate into the groundwater table. During November through March when plants are not consuming water and shallow soils are saturated, lateral drainage of water occurs on slopes through macropores (e.g., holes left by the decay of dead plant roots and animal burrows) as well as through vertical seepage to the water table through pervious zones (Clapp 1997).

Several noteworthy soil macropore and channel features were observed in the upper 3 ft of soil in the Nolichucky Shale. A shallow macropore/soil channel that transmits percolation water from soils on the east to the NT-11 stream channel in the Nolichucky Shale outcrop area is shown in Fig. 9. Overland surface water flow into a soil macropore/channel is shown in Fig. 10. The location where that subsurface channel is daylighted a short distance downstream due to collapse and downstream transport of shallow soils is shown in Fig. 11. There was a small amount of water flow emanating from the channel as shown in Fig. 11. This feature joined another branch of subsurface flow from an unnamed western valley. These types of soil drainage features are common in undisturbed ORR soils and are a part of the stormflow system that rapidly conducts percolation water laterally downslope to stream channels.

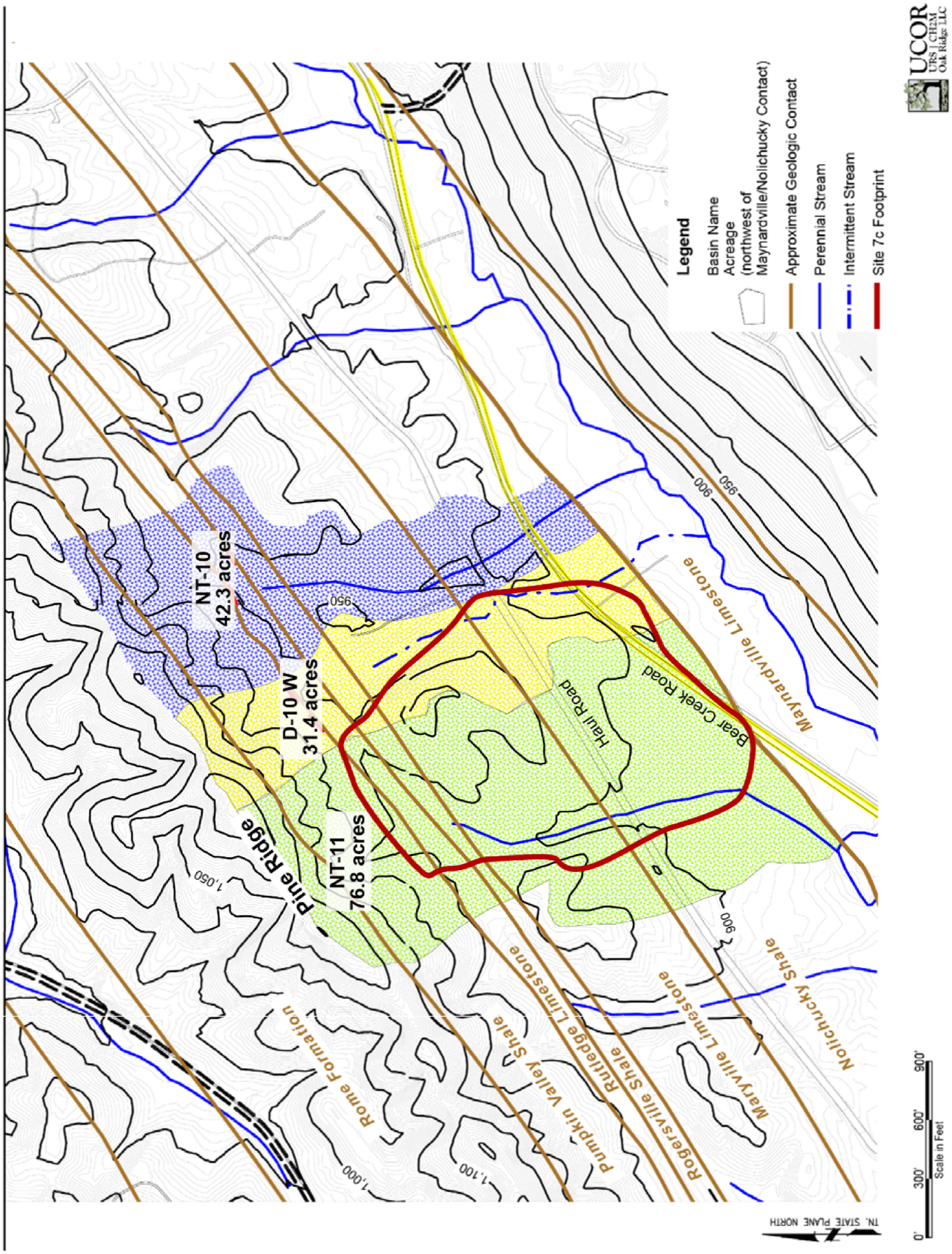


**Fig. 6. Surface water capture basins in Central Bear Creek Valley.**

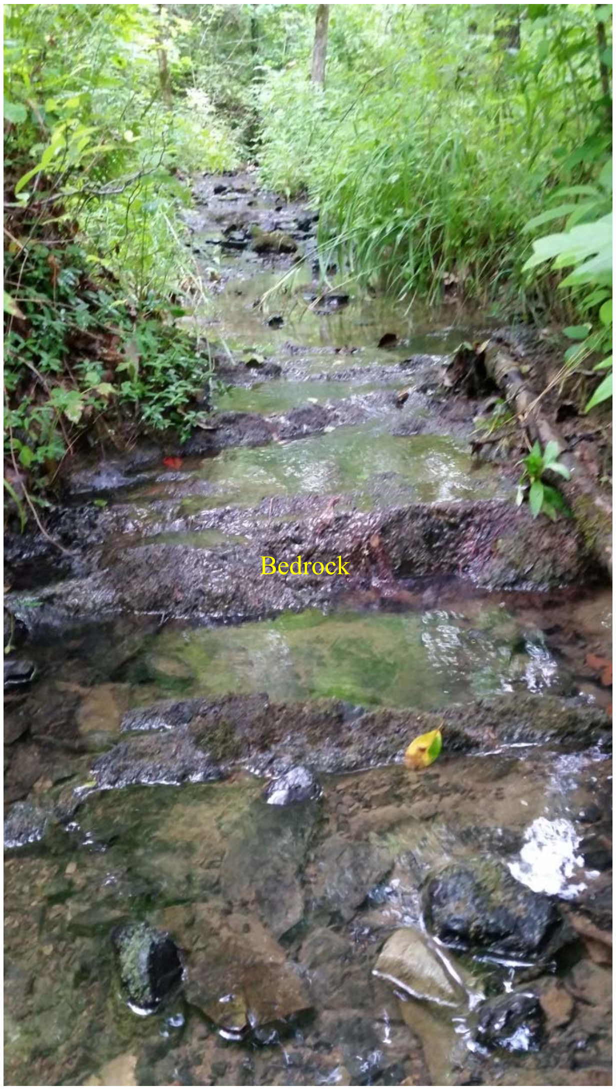


**Fig. 7. Bedrock observed in the Nolichucky Shale outcrop area of the NT-11 stream channel.**

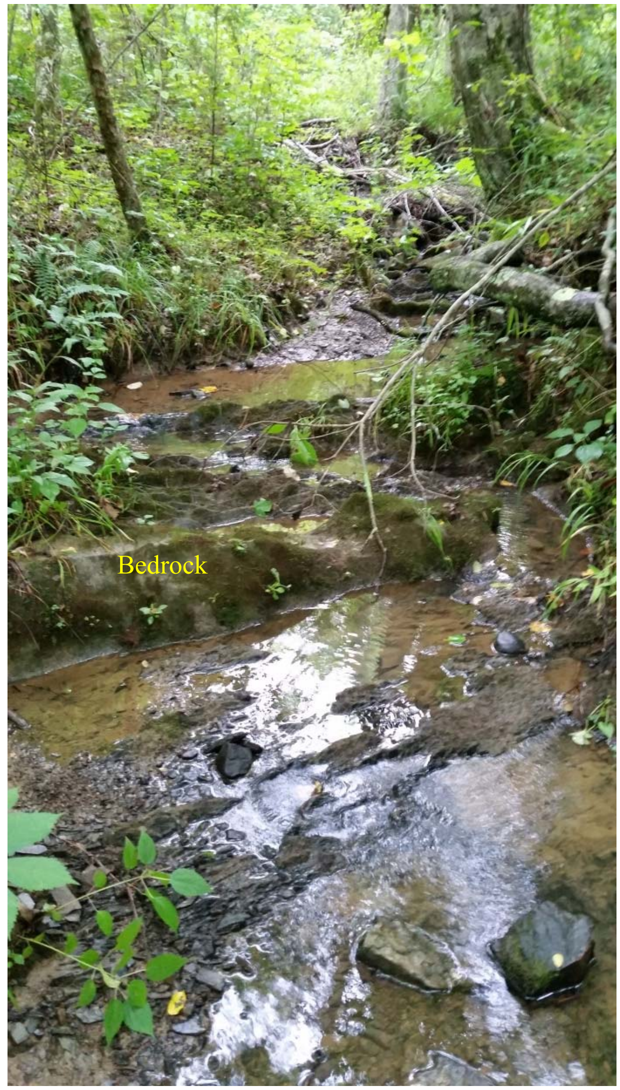


**Fig. 8. Nolichucky Shale outcrop in NT-11 stream channel.**

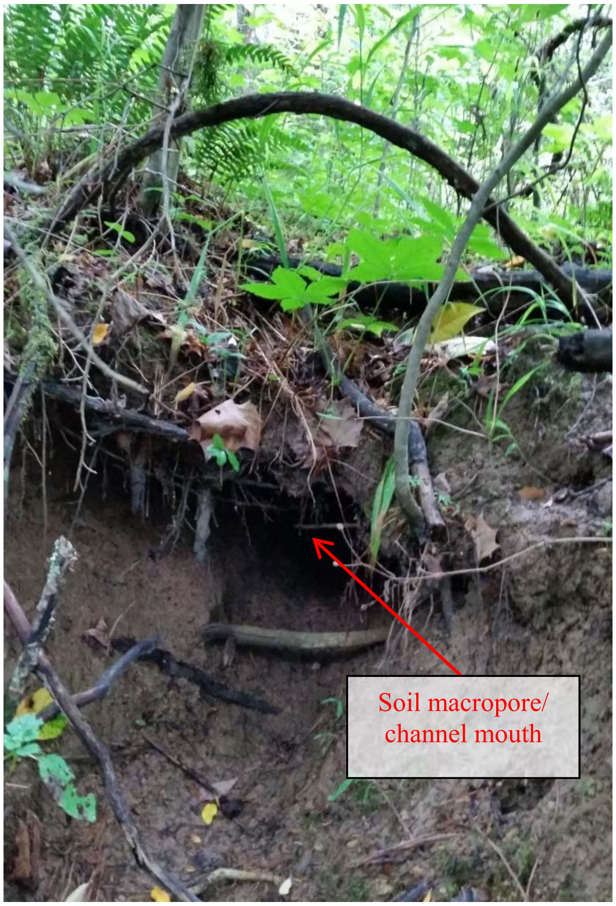


**Fig. 9. Large macropore channel in soil.**

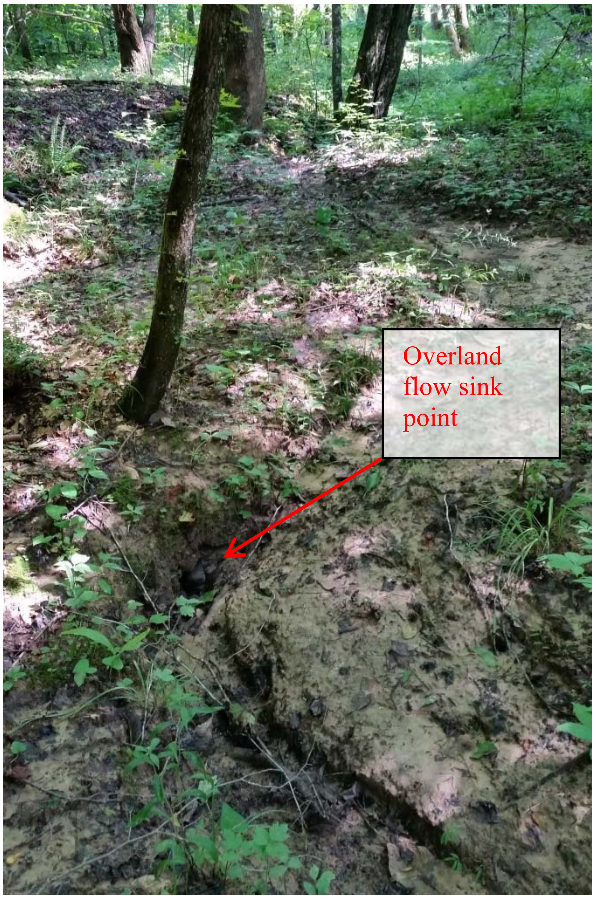


**Fig. 10. Overland flow inlet to soil channel.**

**Fig. 11. Headwater soil channel daylighting point**.

The east-west valley draining to NT-11 (Figs. 2 and 6), also referred to as D-11E, located on the western slope of the high knob in the Maryville Limestone, was inspected for evidence of surface water features. It was apparent that overland flow occurs in the valley, however, no defined surface water channel was observed.

A well-established surface channel approximately 1-ft wide by 1-ft deep was encountered in the D-10W valley. The channel contained isolated pools of standing water, but no flow was occurring. The D-10W valley is approximately 50 percent less incised than the adjacent NT-10 and NT-11 valleys and has a much narrower headwater basin.

## 2.4 SITE CONCEPTUAL MODEL

Key general elements of the site conceptual model for the EMDF CBCV site are shown in Fig. 12.

The majority of flow from upland areas is directed towards the valley axis by the north tributaries. Groundwater in bedrock that does not discharge directly to surface water (e.g., within a confined system) has an upward gradient because of the pressure gradient of recharge from Pine Ridge and discharges into the Bear Creek–Maynardville Limestone drainage system.

Bear Creek flows more or less continuously over non-karst bedrock, but loses flow to subsurface conduits where it crosses karst features in the Maynardville Limestone. Underflow conduits in the Maynardville Limestone continuously convey base flow, while overflow conduits and Bear Creek carry high flows during the wet season and heavy rainfall events.

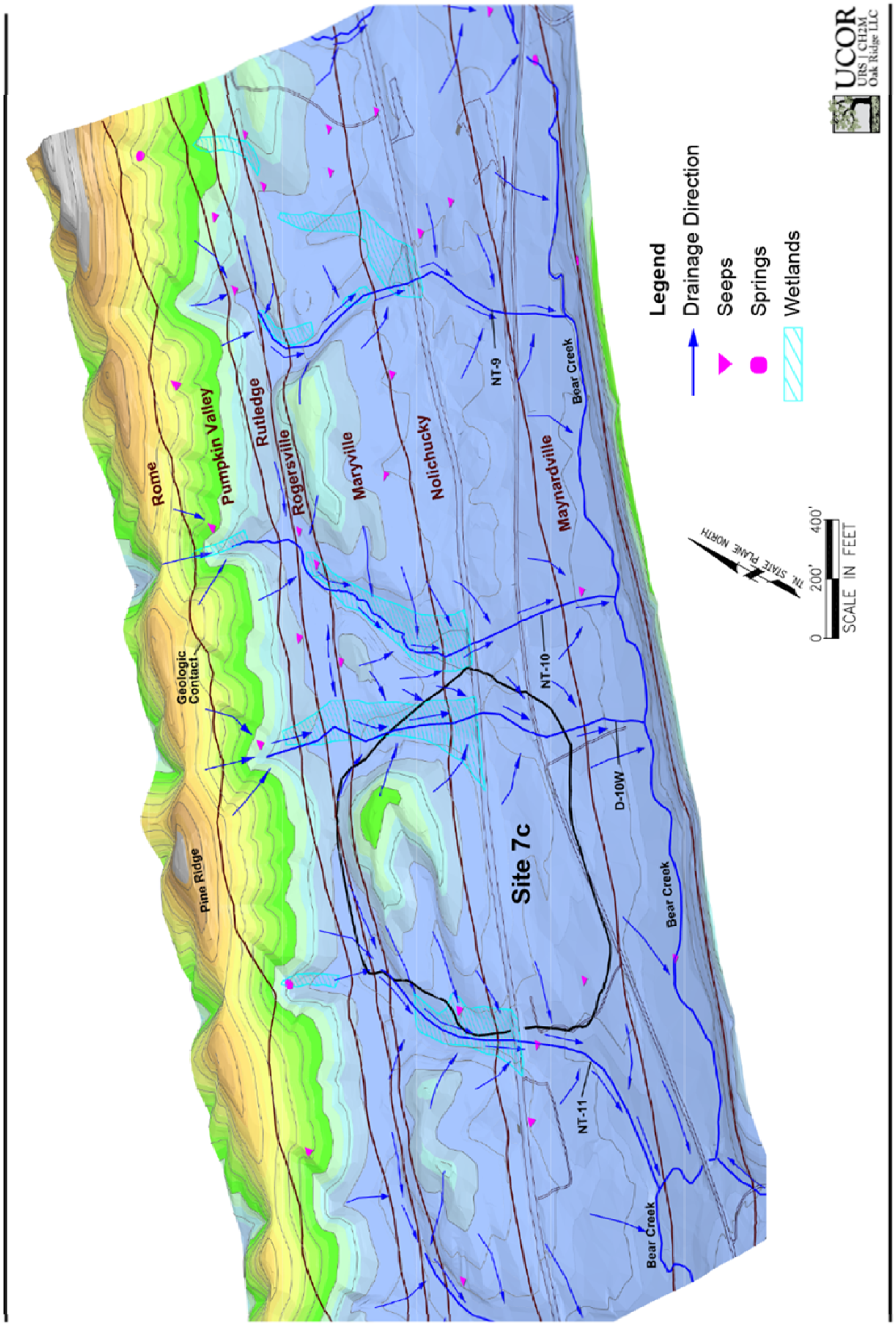


**Fig. 12. Generalized flow paths for shallow/intermediate groundwater toward Bear Creek.**

# 3. PROJECT ORGANIZATION

The organizational structure for this project is presented in Fig. 13.

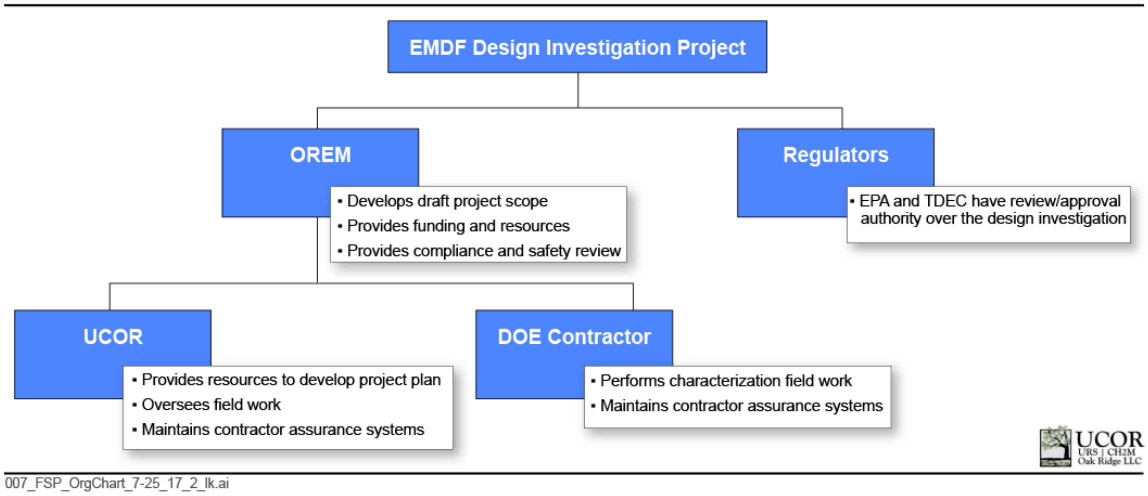


**Fig. 13. Project organization.**

OREM or their designees are responsible for ensuring that the field activities are performed as described in this plan. OREM expects to fulfill these responsibilities through UCOR or other contractor staff, with additional review, oversight, and guidance provided by OREM personnel to ensure these activities are performed safely and compliantly. Additional information on the project organization is provided in the QAPP (Appendix A, Sect. A.2).

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# 4. DATA QUALITY OBJECTIVES

This plan builds upon previous activities and, through the use of the DQO process (EPA 2006), identifies data needs that become the focus for this investigation. The DQOs are summarized in Tables 1 through 3.

**Table 1. DQO summary for groundwater data acquisition**

| DQO step | Groundwater data for design |
|---|---|
| State the Problem | The CBCV site is being proposed for disposal of soils and demolition debris that may contain mixed metals, PCBs, and radioactive constituents (Fig. 1). Additional contaminants (e.g., volatile organic compounds) could also be present in materials disposed in EMDF. If the proposed lined waste disposal facility fails, then those constituents could migrate to groundwater and eventually to surface water in Bear Creek, where they may pose a risk to human or ecological receptors. |
| Identify the Decision (the Design Criteria) | Design criteria for hydrogeologic (groundwater) conditions at the CBCV site include maintaining groundwater elevations beneath a geologic buffer at least 10 ft below the liner system. The FS assumes that the predicted pre-construction groundwater table may be higher than this design criterion. The principal study questions include (1) Where is the natural seasonal high groundwater table and where does it currently encroach into the design elevations? (2) Where groundwater is higher than the design criteria, will design adjustments will be required (e.g., increased elevation of the liner system)? (3) Are subsurface pathways present with relatively higher hydraulic conductivities? (4) Where is the Maynardville contact with the Nolichucky? and (4) Where surface water diversions are used, what is the predicted groundwater flow to be captured and how does the permeability of unconsolidated material above bedrock affect that flow?<br>Note: The FS design assumes that groundwater is uncontaminated and may be discharged directly to surface water without treatment. |
| Identify Inputs to the Decision (to the Design Calculations) | For determining where the seasonal high groundwater table may encroach into the design elevations, the following design information is needed:<br>• Seasonal high groundwater table (potentiometric surface, piezometric levels, or static groundwater pressures) across the site<br>• Adjustment for post-construction conditions<br>For determining the location of the Maynardville Formation sufficiently for the design:<br>• Bedrock stratigraphy at the surface and beneath the site<br>• Field walkdowns to identify contact between the Nolichucky and Maynardville Formations<br>For determining the predicted groundwater elevation and flow to surface water diversions sufficient for the design purposes, the following is needed:<br>• Hydraulic conductivity, soil stratigraphy, and hydraulic gradients/groundwater flow rates (both horizontal and vertical) in the regolith and bedrock beneath the site |
| Define the Study Boundaries | The spatial boundaries of the study are hydraulic divides (e.g., Pine Ridge upgradient of EMDF to the north, NT-10 stream to the east, NT-11 to the west, and Bear Creek to the south).<br>The vertical subsurface boundary extends into the uppermost bedrock below the proposed liner to assess vertical gradients.<br>The temporal boundaries of the study are seasonal hydrologic changes that would affect the groundwater table and groundwater flow, including (1) typical wet precipitation season/anticipated high groundwater season (December-April) and (2) typical dry season (August-October). Piezometers installed in similar conditions at EMWMF, along with associated precipitation data, will be used for long-term monitoring of precipitation and groundwater elevations. Similarly located piezometers at EMWMF will be used to provide input and insight into the conditions at the CBCV site. |
| Develop a Decision Rule | Design criteria include maintaining a geologic buffer of 10 ft above seasonal high groundwater. The geologic buffer must have a maximum saturated hydraulic conductivity of $10^{-5}$ cm/sec. In situ materials may be used as part of the 10-ft-thick geologic buffer layer if these are demonstrated to satisfy the conductivity requirement. |

**Table 1. DQO summary for groundwater data acquisition (cont.)**

| DQO step | Groundwater data for design |
|---|---|
| Develop a Decision Rule (cont.) | If the predicted post-construction groundwater table is above the geologic buffer, then the design elevation must be increased or other groundwater control system must be included in the design.<br>If the predicted post-construction groundwater elevations and flows using the planned groundwater controls are insufficient to lower the groundwater table to this allowable level, then the design must be revised to maintain the geologic buffer layer.<br>If the measured hydraulic conductivity is higher than this allowable level ($10^{-5}$ cm/sec), then the design must be modified by raising the liner grades to provide a compensatory thicker geologic buffer for hydraulic conductivity equivalency, increasing the thickness of the clay liner, or other means. |
| Specify Performance/ Acceptance Limits (Error Range) | Data collection and analyses shall be as established using the ASTM procedures and guidance and UCOR procedures provided in Appendix B, Sect. B.3. The current version of these documents will be used.<br>• Collect core using split spoons or equivalent core collection devices for the deep piezometers continuously throughout the deepest boring at each paired piezometer location, including through the soil and saprolite. Core will be continuously logged/described.<br>• Laboratory samples will provide additional information to correlate with field measurements and recompacted bulk soil samples can be used to replicate as-placed values. Because of the small sample size, these samples may underestimate the permeability of the in situ materials. These sample results will be used in conjunction with the slug tests and FLUTe tests to develop a more complete picture of the hydraulic conductivity present in situ. Potentiometric levels need to be determined to at least 0.1 ft accuracy (objective is 0.05 ft).<br>• FLUTe transmissivity profiling will be used to measure the flow paths from bedrock boreholes that will be developed as piezometers. About 1 percent of the transmissivity remaining below the descending liner at any depth in the hole is the limit of resolution. For that reason, the resolution in the bottom portion of the hole is better than in the upper portion of the hole.<br>Hydraulic conductivities need to be determined within one order of magnitude since the natural variations within the formations are likely high.<br>Spatial variations are not expected to greatly affect design results because of the known low hydraulic conductivities within the residuum. At least 7 locations spatially covering the cell footprint will be appropriate.<br>However, if the measured hydraulic conductivity is variable across the CBCV site, or if there are uncertainties in the hydraulic conductivity due to small sample size, additional protective measures (e.g., a thin layer of low permeability material) may be considered as part of the design in addition to native materials. |
| Optimize the Design | The regolith (soils/saprolite) stratigraphy will be characterized within the EMDF design area:<br>• Complete 8 boreholes within the EMDF footprint (Fig. 14) to characterize regolith lithology, thickness, and uppermost bedrock interfaces by collecting and logging core samples. Boreholes will extend from the surface to approximately at least 10 ft below the top of bedrock. Test borings will be conducted in accordance with UCOR procedures or equivalent.<br>• Characterize temporal variation in water levels in the shallow and intermediate soils/saprolite currently at the projected elevation of the geologic buffer zone. Locations of new water-level measurement locations are shown in Fig. 14. Piezometers will be screened and sand packed.<br>• Perform laboratory hydraulic conductivity tests on representative undisturbed soil samples. Soil samples subjected to laboratory hydraulic conductivity testing also will be tested to determine grain size, Atterberg limits (liquid limit, plastic limit, and plasticity index), USCS, and specific gravity. |

**Table 1. DQO summary for groundwater data acquisition (cont.)**

| DQO step | Groundwater data for design |
|---|---|
| Optimize the Design (cont.) | • FLUTe testing will be performed in accordance with the vendor's specifications and operating procedures for bedrock piezometers to evaluate hydraulic conductivity and detect zones of relatively higher conductivity (if present).<br>• Piezometer installations will be completed in accordance with UCOR procedures or equivalent.<br>• Water-level measurements will be obtained in accordance with UCOR procedures or equivalent. |

ASTM = American Society for Testing and Materials
CBCV = Central Bear Creek Valley
DQO = data quality objective
EMDF = Environmental Management Disposal Facility
EMWMF = Environmental Management Waste Management Facility
FLUTe = Flexible Liner Underground Technologies, LLC
FS = Feasibility Study
NT = North tributary
PCB = polychlorinated biphenyl
UCOR = URS | CH2M Oak Ridge LLC
USCS = Unified Soil Classification System

**Table 2. DQO summary for surface water flow data acquisition**

| DQO step | Surface water data for design |
|---|---|
| State the Problem | The CBCV site is being considered for disposal of soils and demolition debris that may contain mixed metals, PCBs, and radioactive constituents (Fig. 1). Additional contaminants (e.g., volatile organic compounds) could also be present in materials disposed in EMDF. The proposed footprint is located in an area of several surface water features, including two streams (NT-10 and NT-11) and other natural drainages. The landfill design must address these surface water features adequately to prevent potential impacts to the landfill liner and structure and to prevent a pathway for potential leakage migration and potential risk to human or ecological receptors. |
| Identify the Decision (the Design Criteria) | Design criteria for surface water conditions at the CBCV site include controlling the stormwater/surface water flow around the facility. The principal study questions include the following:<br>• Does surface water in NT-10, D-10W, D-11E, and NT-11 (Fig. 14) result from precipitation/overland flow, groundwater, or both? This information will be used to determine the appropriate approach for surface water controls.<br>• Are sections of these streams gaining and losing stretches? This information will be used to design appropriate surface water controls. What are the surface water runoff/flow volumes at NT-10, D-10W and NT-11? The calculated runoff (using the estimated runoff coefficient) will be used in conjunction with the groundwater measurements to address the surface water design criteria. |
| Identify Inputs to the Decision (to the Design Calculations) | The following design information is needed to determine the design for surface water controls:<br>• Surface water capture basin areas, surface water budgets, and potential runoff volumes for NT-10, D-10W, and NT-11<br>• Location of groundwater seeps, springs, or other sources of groundwater contribution in the channels<br>• Current and predicted groundwater elevations<br>• Site topography and features<br>• Analysis and characterization of the current stream channel morphology to provide guidance as to the dimension, pattern, and profile of any planned diversions for long-term stability<br>• Local climate information |

**Table 2. DQO summary for surface water flow data acquisition (cont.)**

| DQO step | Surface water data for design |
|---|---|
| Define the Study Boundaries | The spatial boundaries of the study are the surface water capture basins as shown in Fig. 6. |
| Develop a Decision Rule | If localized storm/precipitation events result in storm flows with the streams/drainages of NT-11, NT-10, and/or D-10W, then the design must consider such storm flows in sizing of diversion or surface water conveyances.<br>If shallow groundwater flow results in gaining conditions in the streams/drainages near the perimeter embankments, then the design must consider the vertical and lateral influences of shallow groundwater flow on diversion or surface water conveyances.<br>The proposed data gathered from the site (primarily in the form of surface vegetation, surface soil conditions, site features, and stream measurements) will be used to support an estimate of the runoff coefficient to use in stormwater generation modeling. No specific measurements are proposed to calculate that coefficient. The calculated runoff (using the estimated runoff coefficient) will be used in conjunction with groundwater measurements to address the surface water design criteria. |
| Develop a Decision Rule (cont.) | If deeper groundwater flow results in encroachment into the geologic buffer, then the design must consider the influences of such deeper groundwater flow on the surface water diversion. |
| Specify Performance/ Acceptance Limits (Error Range) | Data collection and analyses shall be as established using the UCOR procedures provided in Appendix B, Sect. B.4. The current versions of these procedures will be used. |
| Optimize the Design | Place surface water flow measurement stations in the Nolichucky Shale outcrop areas in the lower reaches of NT-11. A second surface water flow measurement station will be placed along NT-11, south of the Haul Road, downstream of the estimated EMDF disposal site buffer zone. A third station will be placed upgradient of the estimated EMDF disposal site buffer zone (Fig. 14). Locations will be selected following a site walkover.<br>Place two surface water flow measurement stations in D-10W: (1) downstream of the Haul Road where there is a well defined channel, and (2) downstream of Bear Creek Road downstream of the estimated EMDF disposal site buffer zone in the Nolichucky Shale near the projected Nolichucky Shale/Maynardville Limestone geologic contact (Fig. 14).<br>Perform two detailed site walkovers during the wet season (December-April) to identify seeps, springs, and other expressions of shallow groundwater in NT-10, D-10W, and NT-11. The walkovers will include a description every 50 ft (as safe access allows) and field measurements of temperature, specific conductivity, and pH. Perform two additional site walkovers (May/June) following the wet season to collect field measurements of temperature, specific conductivity, and pH. |

CBCV = Central Bear Creek Valley
D = drainage
DQO = data quality objective
E = east
NT = North Tributary
PCB = polychlorinated biphenyl
UCOR = URS | CH2M Oak Ridge LLC
W = west

**Table 3. DQO summary for geotechnical data acquisition**

| DQO step | Foundation analysis |
|---|---|
| State the Problem | The CBCV site is being proposed for disposal of soils and demolition debris that may contain mixed metals, PCBs, and radioactive constituents (Fig. 1). Additional contaminants (e.g., volatile organic compounds) also could be present in materials disposed in EMDF. If the proposed lined waste disposal facility fails, then those constituents could migrate to groundwater and eventually to surface water in Bear Creek, where they may pose risk to human or ecological receptors. |
| Identify the Decision (the Design Criteria) | Design criteria for geotechnical foundation and stability analyses at the EMDF site include determining the suitability for construction of the landfill cells, constructed embankments, and support facilities. The analysis principal study questions include (1) What is the bearing capacity of the soils? (2) Where must soil be removed/replaced to support design features? (3) Where can removed soils be used as structural fill? and (4) Will the subsurface conditions support the engineered landfill (embankments) and waste under static loading conditions? |
| Identify Inputs to the Decision (to the Design Calculations) | The following is used to determine the geotechnical characteristics to support the decisions:<br>• Geotechnical soil parameters, including consolidation properties and stress history, shear strength of in-place and recompacted soils, compaction density (Proctor) of embankment components, and index properties, including moisture contents, Atterberg limits, grain-size analyses, unit weights, and specific gravities.<br>• Geotechnical properties of bedrock, including bedrock strength, compressibility, interface strength, rock type, fracture size and spacing, and RQD.<br>• Groundwater levels and spatial and temporal variations in the soil and bedrock. |
| Define the Study Boundaries | • The spatial boundaries of the study are shown in Fig. 14. Geotechnical explorations and tests for facility design will extend across the site. Geotechnical explorations and tests for embankment design will focus on the areas beneath the planned embankments.<br>• The vertical subsurface boundary extends into bedrock approximately 10–50 ft below the current ground surface. |
| Develop a Decision Rule | Design criteria include the following:<br>• If the structural fill meets industry standards (e.g., Tennessee Department of Transportation Standard Specifications) for gradation, plasticity, durability and compactability, then the design is acceptable. If not, then the material must be conditioned or fill must be imported.<br>• If the magnitude and rate of both differential and total settlement of underlying materials meets industry standards, then the design is acceptable. If not, then the material must be conditioned or fill must be imported.<br>• If the static factor of safety against embankment failure is ≥ 1.5 for long-term conditions, then the design is acceptable as proposed. Otherwise, the design or underlying materials must be modified to meet the embankment global stability requirements. |
| Specify Performance/ Acceptance Limits (Error Range) | • Data collection and analyses shall be as established using the ASTM guidance/test methods provided in Appendix B, Sect. B.5.2.<br>• Geotechnical laboratories must be accredited by the U.S. Army Corps of Engineers or American Association of State Highway and Transportation Officials for the specific ASTM laboratory testing procedures referenced in this field sampling plan (Appendix B, Sect. B.5.2).<br>• Vertical variations are expected to affect design results with depth and soil type; test locations on 5-ft intervals are adequate to bound this error. |

**Table 3. DQO summary for geotechnical data acquisition (cont.)**

| DQO step | Foundation analysis |
|---|---|
| Optimize the Design | 1. Characterize soils/saprolite and bedrock stratigraphy within the EMDF design area using subsurface information gathered from the core obtained from the hydrogeologic borings. In addition, historical geotechnical information from previous studies performed for EMWMF and other projects in Bear Creek Valley in similar geology will be used, as appropriate. Proposed locations are shown on Fig. 14.<br>2. SPTs will be performed in piezometer boreholes. Each borehole will be drilled to machine refusal, followed by core drilling to a depth of at least 10 ft into slightly weathered to fresh bedrock. It is anticipated soil drilling depths will vary from about 10-30 ft and the total depths of the geotechnical borings (soil drilling plus rock coring) will vary from about 20-50 ft. The boreholes will be used to characterize the regolith (soils/saprolite) and uppermost bedrock layers.<br>3. Laboratory index tests (e.g., Atterberg limits, grain-size analyses, moisture contents, unit weights, and specific gravities) will be conducted on disturbed and undisturbed soil samples as shown in Appendix B, Sect. B.5.2, including from each distinct soil type. In addition, laboratory corrosion tests will be performed on several representative samples of soil/saprolite.<br>4. Characterize the shear strength and compressibility properties of soils as follows using the ASTM guidance/test methods and UCOR procedures provided in Appendix B, Sect. B.5.2.<br>5. SPT data will be used to estimate shear strength and compressibility properties of the soils/saprolite. In addition, laboratory shear strength and consolidation tests will be performed on representative soil samples.<br>6. Relatively undisturbed samples will be obtained from soil borings using a thin-walled (Shelby) tube sampler (Appendix B, Sect. B.3). Undisturbed soil samples are needed to perform laboratory unit weight, shear strength, hydraulic conductivity (previously described), and consolidation testing of in-place soils. Recovery and sample quality can be poor in harder, rocky residual soils, which will require care and multiple sample attempts to acquire sufficient quantities of undisturbed samples for laboratory testing. Typically, the saprolite is too hard to obtain undisturbed samples by pushing Shelby tubes. Previous experience indicates soil cores of the saprolite obtained by Dennison and Pitcher samplers are not testable in the laboratory because the saprolite retains the structure of the parent bedrock and is very weak along the numerous bedding planes, joints, and fractures. However, the in-place saprolite behaves as a weak rock and is significantly stronger than the overlying soils. Strength and compressibility properties of the saprolite can be determined based on its Geologic Strength Index or other published correlations.<br>7. Laboratory consolidated-undrained triaxial testing will be performed on both recompacted and undisturbed samples (Appendix B, Sect. B.5.2).<br>8. Laboratory testing will be performed to determine if soil compressibility characteristics may be performed on both recompacted and undisturbed samples (Appendix B, Sect. B.5.2).<br>9. Prior to extrusion of undisturbed soil samples, the thin-walled tubes will be subjected to X-ray imaging to identify candidate zones for testing and avoid zones with disturbance, voids, large pieces of gravel (or weathered rock), and natural or induced fissures or shear planes that may interfere with testing.<br>10. The number of tests may be adjusted depending on the type and condition of materials encountered and the location of bedrock.<br>11. Undisturbed soil samples will be collected in offset borings based on review of the SPTs recorded in the geotechnical, hydrogeological, and seismic borings. Based on previous experience in Bear Creek Valley, it is anticipated direct push will only be possible in the upper approximately 5-10 ft bgs. Typically, below these depths, the residual soils are too hard to obtain undisturbed soil samples by pushing thin-walled tubes. Push tubes will not work well in these materials and recoveries are at best 75-85 percent in the upper portions. |

**Table 3. DQO summary for geotechnical data acquisition (cont.)**

| DQO step | Foundation analysis |
|---|---|
| Optimize the Design (cont.) | 12. Characterize moisture-density relationship of sampled soils (compaction, moisture content, specific gravity) as follows using the ASTM guidance/test methods and UCOR procedures provided in Appendix B, Sect. B.5.2.<br>• Disturbed samples obtained from auger cuttings and representative of each unique soil type will be selected for testing for compaction and specific gravity.<br>• The number of tests may be adjusted depending on the type and condition of materials encountered and the location of bedrock.<br>13. Obtain properties of bedrock as follows:<br>• Rock type, hardness, weathering, bedding, discontinuities, fracturing, percent core recovery, and RQD will be obtained during core logging and borehole logging.<br>• Uniaxial compression with measurement of elastic modulus laboratory tests will be performed on selected bedrock cores as described in Appendix B, Sect. B.5. Rock core specimens subjected to compressive strength testing also will be tested to determine unit weight and "as-received" moisture content.<br>14. Sample packaging and shipping will follow the ASTM guidance/test methods provided in Appendix B, Sects. B.5.1 and B.5.2.<br>15. Groundwater levels will be measured in the boreholes during drilling and taken from piezometers as part of the hydrogeologic investigation. |

ASTM - American Society for Testing and Materials
bgs = below ground surface
CBCV = Central Bear Creek Valley
DQO = data quality objective
EMDF = Environmental Management Disposal Facility
EMWMF = Environmental Management Waste Management Facility
PCB = polychlorinated biphenyl
RQD = rock quality designation
SPT = standard penetration test
UCOR = URS | CH2M Oak Ridge LLC

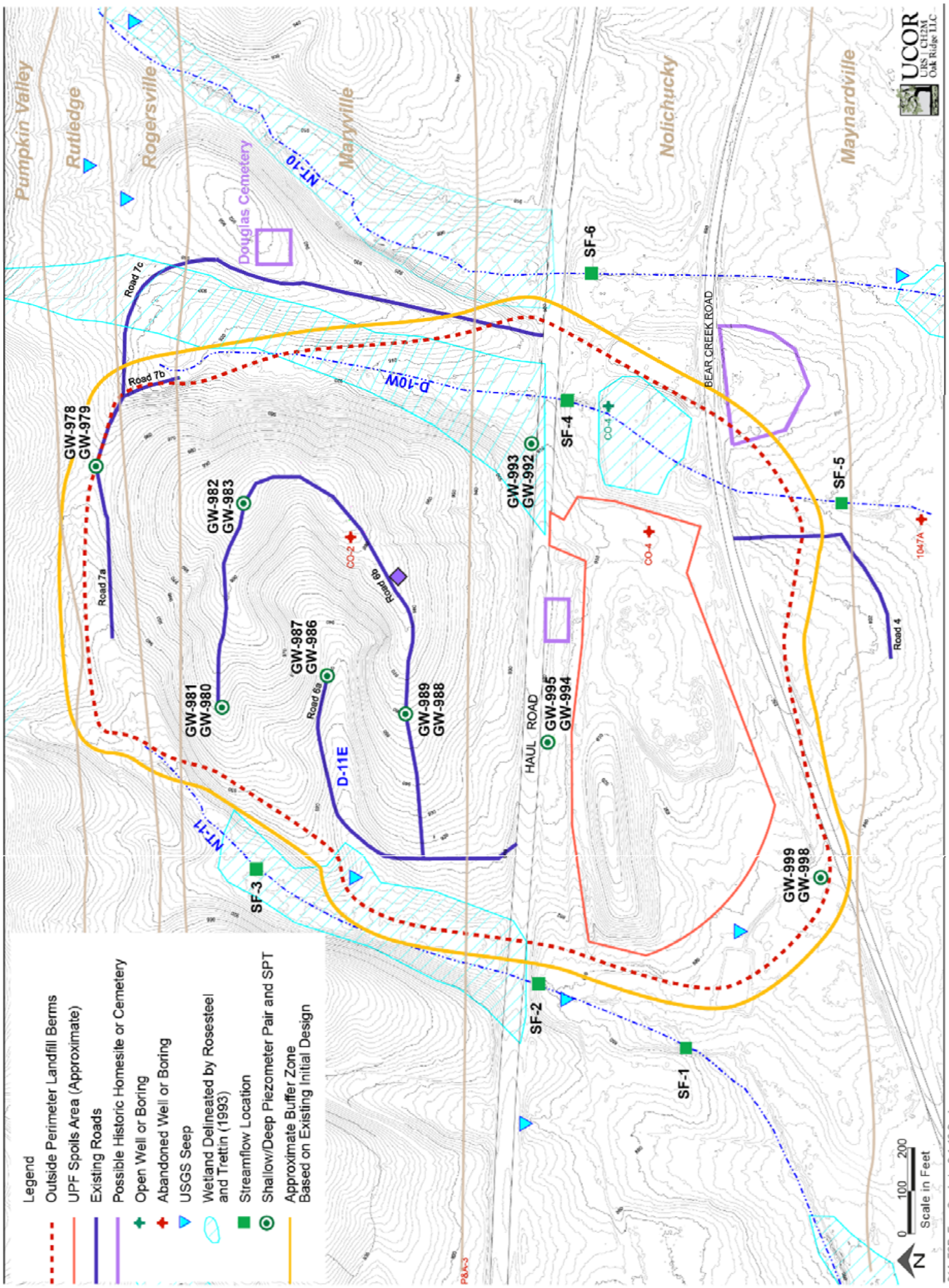


**Fig. 14. Approximate Phase 1 measurement and testing locations for CBCV site.**

# 5. INVESTIGATION SCHEDULE/APPROACH

The investigation schedule will depend on the availability of specialty subcontractors and the site-specific conditions encountered. The field activities can be performed in phases, with only a subset of activities performed at any given time. However, the following sequence is anticipated for Phase 1 work during the first half of calendar year 2018:

- Procurement of specialty contractors (as required for the investigation phase)
- Development of specific project plans, work control documents, and internal work permits (e.g., excavation/penetration permits)
- Hold point – ensure project plans, work control documents, specialty contractors and designated personnel qualifications and training meet the requirements in the Field Sampling Plan and QAPP, including the DQOs, prior to performing specified work scope
- Performance of two walkovers and evaluation of surface water – Winter 2018
- Performance of two walkovers and evaluation of surface water following the wet season– May/June 2018
- Mobilization of specialty contractors (as required for the investigation phase) – Winter 2018
- Installation of surface water flow meters (independent activity from drilling, may occur before, during, or after drilling) – Spring 2018
- Drilling for piezometers and geotechnical samples, and geotechnical samples collected during drilling operations – Winter/Spring 2018
- Downhole hydrogeologic testing (Flexible Liner Underground Technologies, LLC [FLUTe] and slug tests) – Winter/Spring 2018
- Installation of piezometers – Winter/Spring 2018
- Plugging and abandonment of open boreholes (if any) – Spring 2018
- Demobilization – Spring 2018
- Monitoring (following piezometer installation) – March-April 2018 (monitoring will continue through February 2019, with results documented in Technical Memorandum 2 [will be available prior to the RDWP]; preliminary data will be made available to the FFA parties as it becomes available)
- Technical Memorandum 1 – March-April 2018 (data will be added to the Administrative Record prior to completion of the Proposed Plan)

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# 6. SAMPLING REQUIREMENTS AND DOCUMENTATION

The approximate investigation locations are presented in Fig. 14. Actual investigation locations and support facility footprints will be determined in the field based on existing site conditions. The subsurface sampling locations are summarized in Table 4. Locations will be surveyed by a licensed land surveyor, including horizontal position and ground surface elevation at each piezometer within 0.1 ft and top-of-casing elevation of each piezometer within 0.01 ft.

All field activities shall comply with UCOR procedures or equivalents, including, but not limited to, environmental safety and health, radiation control, facility management, access, excavation/penetration permits, and waste management. The project-specific QAPP (Appendix A) developed for both the current planned activities and for future planned activities will implement quality assurance (QA) requirements for use in sample collection, laboratory analysis, and data management of groundwater assessments, geotechnical testing, and geophysical studies needed to support design of the proposed EMDF.

These requirements ensure that appropriate levels of QA and QC are achieved and maintained. This plan identifies the procedures that will be followed in the collection, custody, and handling of samples as well as environmental/laboratory data used in the Field Sampling Plan.

The investigation approach and measurement and testing requirements are provided in Appendix B, along with the procedure, test method, or guidance that will be used to obtain data from the specified location.

Documentation requirements are provided in Sect. 9.

## 6.1 GROUNDWATER EVALUATION

To support the design, groundwater levels and hydraulic conductivity measurements will be required from the uppermost aquifer. Groundwater data acquisition will be performed with oversight by a qualified geologic technician or geologist under the supervision by a senior hydrogeologist.

### 6.1.1 New Piezometers

Eight pairs of shallow/intermediate piezometers will be installed to monitor the geologic buffer zone within the cell boundary (Fig. 14).

The estimated horizontal buffer zone around the EMDF waste cells is provided in Fig. 14. As defined in TDEC 0400-20-11-.03 the buffer zone is "portion of the disposal site that is controlled by the licensee and that lies under the disposal units and between the disposal units and the boundary of the site."

The buffer zone is estimated based on the design presented in the FS and will be refined as the engineering design is developed. As currently drawn, this estimated buffer zone is sufficient for monitoring and future remedial actions (if necessary).

The piezometer along the southern boundary of the disposal cell berms will provide downgradient groundwater elevations. No wells are located within the area south of the Haul Road, currently occupied by the UPF Spoils Area (as designated on Fig. 1), to avoid interfering with ongoing operations.

**Table 4. Summary of subsurface sample collection locations**

| Location | Deep piezometer | Shallow piezometer | Residuum and bedrock core | Slug tests | FLUTe | GW levels | SPTs | Potential geotechnical lab samples |
|---|---|---|---|---|---|---|---|---|
| GW-978 | • | | • | | • | • | • | • |
| GW-979 | | • | | • | | • | | |
| GW-980 | • | | • | | • | • | • | • |
| GW-981 | | • | | • | | • | | |
| GW-982 | • | | • | | • | • | • | • |
| GW-983 | | • | | • | | • | | |
| GW-986 | • | | • | | • | • | • | • |
| GW-987 | | • | | • | | • | | |
| GW-988 | • | | • | | • | • | • | • |
| GW-989 | | • | | • | | • | | |
| GW-992 | • | | • | | • | • | • | • |
| GW-993 | | • | | • | | • | | |
| GW-994 | • | | • | | • | • | • | • |
| GW-995 | | • | | • | | • | | |
| GW-998 | • | | • | | • | • | • | • |
| GW-999 | | • | | • | | • | | |

GW = groundwater
FLUTe = Flexible Linder Underground Technologies, LLC
SPT = standard penetration test

Piezometers will obtain representative lithologic and groundwater data from across the site and in representative formations. Piezometers specifically will be placed to monitor locations where pre-construction groundwater levels are projected to be within the geologic buffer. Because these piezometers could be preferential pathways to groundwater, all piezometers within the footprint of the disposal cells will be plugged and abandoned per UCOR procedures prior to construction of the EMDF (Appendix B, Sect. B.2).

Piezometers will be installed in each designated borehole by Tennessee-qualified monitoring well drillers in accordance with ORR requirements as described in Appendix B, Sect. B.3. Depths and testing requirements for each piezometer are provided in Table 5.

**Table 5. Groundwater-level, location-specific target depths and tests**

| Location | Formation | Shallow/ deep | Estimated ground elevation | Estimated target elevation | Estimated drilling footage | Expected hydrologic tests | Purpose |
|---|---|---|---|---|---|---|---|
| GW-978 | Rutledge | D | 960 | 885 | 75 | FLUTe | Hydrogeologic conditions in the upgradient saddle |
| GW-979 | Rutledge | S | 960 | 930 | 30 | Slug | Hydrogeologic conditions in the upgradient saddle |
| GW-980 | Maryville | D | 955 | 885 | 70 | FLUTe | Establish general hydrogeologic conditions |
| GW-981 | Maryville | S | 955 | 905 | 50 | Slug | Establish general hydrogeologic conditions |
| GW-982 | Maryville | D | 1005 | 885 | 120 | FLUTe | Groundwater levels where projected within waste |
| GW-983 | Maryville | S | 1005 | 905 | 100 | Slug | Groundwater levels where projected within waste |
| GW-986 | Maryville | D | 940 | 885 | 55 | FLUTe | Hydrogeologic conditions along D11-E |
| GW-987 | Maryville | S | 940 | 905 | 35 | Slug | Hydrogeologic conditions along D11-E |
| GW-988 | Maryville | D | 960 | 885 | 75 | FLUTe | Establish general hydrogeologic conditions |
| GW-989 | Maryville | S | 960 | 905 | 55 | Slug | Establish general hydrogeologic conditions |
| GW-992 | Nolichucky | D | 910 | 860 | 50 | FLUTe | Determine groundwater contribution to D-10W |
| GW-993 | Nolichucky | S | 910 | 885 | 25 | Slug | Determine groundwater contribution to D-10W |
| GW-994 | Nolichucky | D | 895 | 845 | 50 | FLUTe | Groundwater levels where projected near waste |
| GW-995 | Nolichucky | S | 895 | 880 | 15 | Slug | Groundwater levels where projected near waste |
| GW-998 | Nolichucky | D | 885 | 845 | 40 | FLUTe | Establish general hydrogeologic conditions |
| GW-999 | Nolichucky | S | 885 | 870 | 15 | Slug | Establish general hydrogeologic conditions |

D = deep (bedrock) or drainage
E = east
FLUTe = Flexible Liner Underground Technologies, LLC
N/A = not applicable
S = shallow (residuum/soil)
West = west

Piezometers shall be developed no sooner than 24 hours after installation and shall continue until the piezometer responds to water-level changes and produces clear, sediment-free water to the extent possible (Appendix B, Sect. B.3).

Hydraulic conductivity (horizontal) will be measured by performing slug tests for piezometers completed in the residuum. FLUTe testing will be performed for bedrock piezometers to maximize the amount of hydraulic conductivity information obtained and obtain more precise data. FLUTe testing will not be as effective in residuum. The procedures and test methods used to collect these data are found in Appendix B, Sect. B.3.

In addition, laboratory analysis of hydraulic conductivity will be performed on select samples. Because of the small sample size, these samples may underestimate the permeability of the in situ materials. These sample results will be used in conjunction with the slug tests and FLUTe tests to develop a more complete picture of the hydraulic conductivity present in situ. The test method used to collect these data are provided in Appendix B, Sect. B.3.

Groundwater elevation, conductivity, pH and temperature data will be collected using downhole monitors placed in each piezometer. Data will be collected continuously and recorded every 30 minutes with downloads every 2 weeks. Technical Memorandum 1 will include continuous monitoring of these 16 piezometers during the March/April timeframe. Monitoring will continue for at least 1 year to ensure seasonal high- and low-water levels are captured.

Groundwater elevations determined from depth-to-water measurements will be used to (1) estimate the groundwater surface elevations across the entire footprint of EMDF (and immediate areas upgradient/downgradient), and (2) assess and design the difference between the water table and the proposed geobuffer beneath all disposal cells.

The results of these tests also will support estimates to be made of hydraulic conductivity, groundwater flow rates, and historical high groundwater levels for use in optimizing the design.

### 6.1.2 Comparable Existing Piezometers

To aid in interpreting the results, long-term monitoring of precipitation and groundwater elevations for similarly located piezometers at the Environmental Management Waste Management Facility (EMWMF), and other BCV locations, will be used to provide input into the conditions at the CBCV site, specifically the groundwater elevations during the wet season. The data from these piezometers will be used to predict groundwater elevations at the CBCV by noting the magnitude of the change during the wet season and applying a similar factor to CBCV piezometer readings.

The specific additional BCV wells that will support forecasting groundwater elevations within the EMDF footprint are provided on Table 6 and the locations of these wells are shown on Fig. 15.

**Table 6. Comparable Bear Creek Valley wells**

| Well No. | Location | Formation | Depth (ft bgs) | Screened interval | Historical data | Frequency/ downhole monitor? | Description of comparable conditions |
|---|---|---|---|---|---|---|---|
| GW-077 | BCBG – west side | Nolichucky | 100.5 | 90.3-100.3 | From 1991 | 2/years | In the same formations and similar topography as EMDF piezometers, closest appropriate wells to the EMDF location, and similar precipitation expected in a given event |
| GW-078 | BCBG – west side | Nolichucky | 21.1 | 16.1-21.1 | From 1991 | 2/years | In the same formations and similar topography as EMDF piezometers, closest appropriate wells to the EMDF location, and similar precipitation expected in a given event |

**Table 6. Comparable Bear Creek Valley wells (cont.)**

| Well No. | Location | Formation | Depth (ft bgs) | Screened interval | Historical data | Frequency/ downhole monitor? | Description of comparable conditions |
|---|---|---|---|---|---|---|---|
| GW-079 | BCBG – west side | Rogersville | 60 | 59.9-64.9 | From 1991 | 2/years | Equivalent to EMDF well cluster on the saddle (GW-978/979), close to EMDF, and similar precipitation expected in a given event |
| GW-080 | BCBG – west side | Rogersville | 30 | 24.7-29.7 | From 1991 | 2/years | Equivalent to EMDF well cluster on the saddle (GW-978/979), close to EMDF, and similar precipitation expected in a given event |
| EMWMF multiple | EMWMF | Maryville Nolichucky | various | various | Yes | Quarterly from ~2002, downhole monitors since 03/17 | In the same formations, although steeper topography, several choices available because of the number of instrumented wells/piezometers; will determine most suitable when EMDF data are available |
| GW-976 | EMDF-Site 5 | Maryville | 101 | 27.8-100.3 | 11/14-11/15 | Continuous data from 11/14-11/15 | Deeper well on the knoll will represent similar conditions at Site 7c and match with GW-982, also in the Maryville; topography is steeper than CBCV site |
| GW-437 | WBCV | Maryville | ~64 | 53.2-63.1 | Very limited | Not monitored | Downhole monitor will be installed if well is viable. Appears in good condition. Maryville near Nolichucky contact, moderate slope. Similar to GW-994/995 area. |
| GW-438 | WBCV | Maryville | ~23 | 13.05-22.95 | Very limited | Not monitored | Downhole monitor will be installed if well is viable, appears in good condition; Maryville near Nolichucky contact, moderate slope, similar to GW-994/995 area |
| GW-439 | WBCV | Nolichucky | ~60 | 49.7-59.65 | Very limited | Not monitored | Downhole monitor will be installed if well is viable, appears in good condition; slight slope similar to GW-998/999 |
| GW-440 | WBCV | Nolichucky | ~27 | 16.5-26.65 | Very limited | Not monitored | Downhole monitor will be installed if well is viable, appears in good condition; slight slope similar to GW-998/999 |

Note: Downhole conditions for the West Bear Creek Valley wells have not been verified. Additional, similar wells were identified to use as replacements for the selected wells if necessary.

BCBG = Bear Creek Burial Ground
CBCV = Central Bear Creek Valley
EMDF = Environmental Management Disposal Facility
EMWMF = Environmental Management Waste Management Facility
WBCV = West Bear Creek Valley

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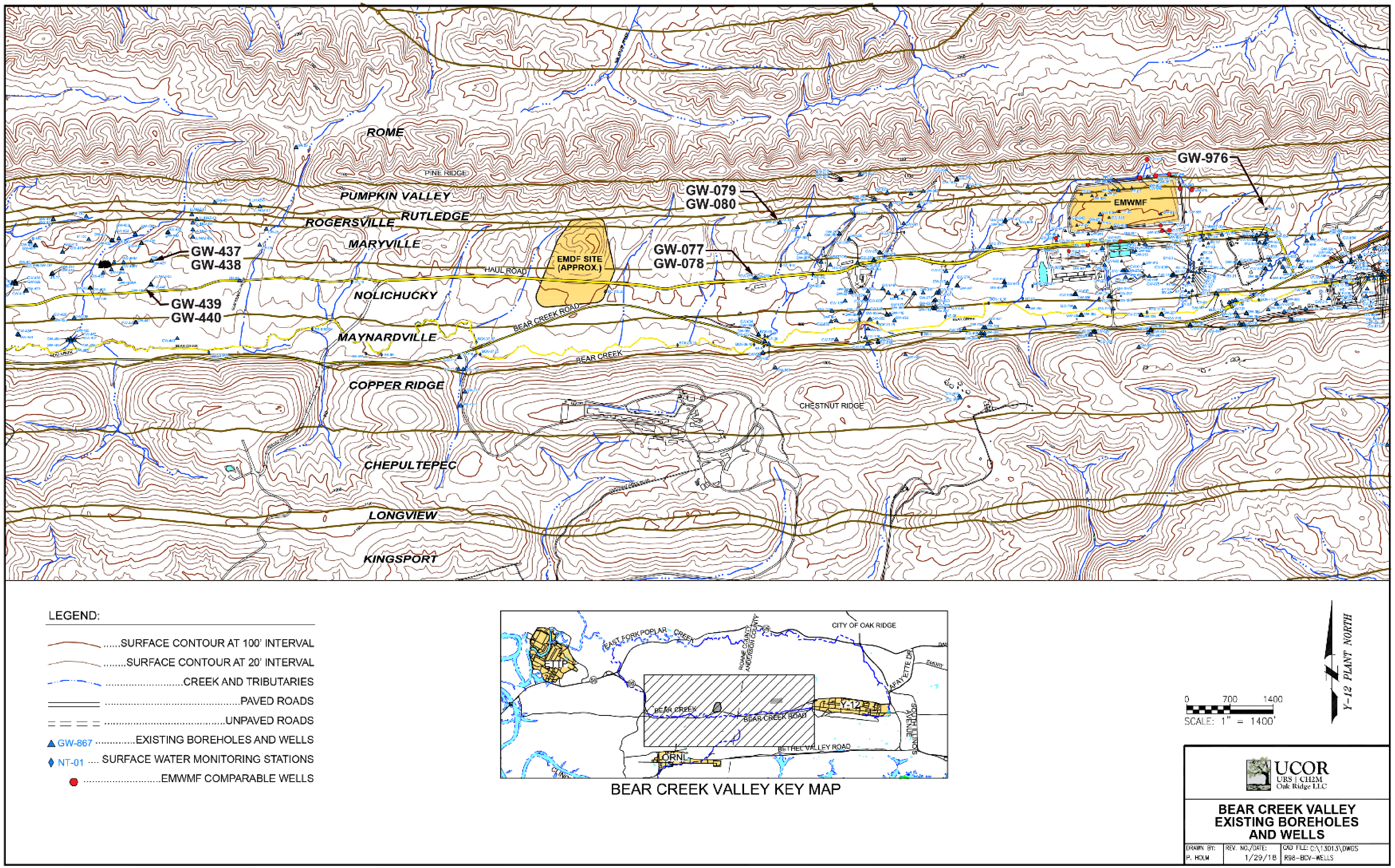


Fig_15_EMDF_FSP_BCV_Wells_2_20_18.ai

**Fig. 15. Comparable Bear Creek Valley wells.**

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Quarterly groundwater elevation data are available for many of the EMWMF wells since 2002 or before, including recent wetter periods. Twice a year groundwater elevations are available for the Bear Creek Burial Ground wells (GW-077 to GW-080). These groundwater elevations will be used to provide the relative magnitude change in groundwater elevations during wetter and drier periods.

Continuous groundwater elevation monitors were installed in March 2017 in EMWMF wells. Therefore, these wells have more specific data to forecast specific responses to precipitation over the year. Specific groundwater elevation data for an appropriate EMWMF well will be matched to the groundwater elevation data for a given EMDF well to predict the wet season data for that well.

Continuous groundwater elevation data for GW-976, located on a knoll in the previous EMDF Site 5 location, is expected to be comparable to the expected groundwater elevations in bedrock piezometers on the knoll in the CBCV site (GW-980, GW-982, and GW-986). This information will augment EMWMF well data for developing projected groundwater elevations for these wells. The shallow piezometer paired with GW-976 is GW-977. This piezometer was dry during drilling and remained dry during the project. It will be checked and groundwater elevations measured (if present) when data are downloaded from GW-976.

No groundwater elevations are available for locations GW-437 through GW-440. However, continuous groundwater elevation monitors will be installed in these (and the other locations noted in Table 4) prior to completion and instrumenting the CBCV piezometers. These wells will provide additional comparable wet season data to augment what is collected for the CBCV piezometers.

## 6.2 SURFACE WATER EVALUATION

### 6.2.1 Field Identification of Surface Water Features

Two detailed site walkovers will be performed during the wet season (winter 2018) to further characterize surface geology, identify geotechnical areas of interest, and identify seeps, springs, and other expressions of shallow groundwater in NT-10, D-10W, D-11E, and NT-11. Observations of flow in macropores and similar features during the wet season also will occur to determine potential impacts on design. The walkover will include a description every 50 ft of NT-10, D-10W, and NT-11 (as safe access allows) and field measurements of temperature, specific conductivity, and pH (seeps/springs to be included). The specific conductivity measurements will be performed to determine the potential influence from groundwater. A qualified hydrologic professional (TDEC 2011) will participate in the walkovers. The results of these wet weather walkovers will be documented in Technical Memorandum 1 along with results of two additional walkovers in May and June. Additionally, two dry season walkovers will be performed during September/October 2018 and documented in the Technical Memorandum 2.

### 6.2.2 Surface Water Flow Measurements

Based on the site walkovers, three surface water flow measurement stations are planned for installation at appropriate locations in the Nolichucky Shale outcrop areas in NT-10 and NT-11. These stations are planned for locations where the tributaries enter or leave the buffer zone (Fig. 14). The specific locations and measurement apparatus sizing will be based on results of the additional fieldwork outlined above.

For the D-10W valley, a surface water flow measurement station is planned for installation upstream of Haul Road in an area where surface water flow diversion may be considered during design. A station is also planned for installation downstream of the existing Bear Creek Road near the Nolichucky

Shale/Maynardville Limestone geologic contact where D-10W leaves the buffer zone (Fig. 14). Another surface water flow measurement station will be placed as indicated by the site walkover.

Surface water flow measurements will be performed as described in Appendix B, Sect. B.4, and will include continuous flow, temperature, pH, and conductivity measurements collected at 30-minute intervals. Phase 1 characterization will begin in the spring 2018 (March-April timeframe).

Because surface water flow is not present/cannot be measured with conventional flow measurement devices in the D-11E area, and subsurface flow merges with NT-11 prior to leaving the site/buffer zone, the already established flume locations located upstream and downstream of the D-11E area discharge into NT-11 will be used to approximate the D-11E discharge as requested.

## 6.3 STABILITY TESTING

Standard penetration test data provides the most typical values used for liquefaction analyses and will be collected as described in Sect. 6.4 and Appendix B, Sect. B.5.2, as the boreholes for the piezometer pairs are drilled.

## 6.4 GEOTECHNICAL EXPLORATION AND LABORATORY TESTING

Geotechnical tests for landfill design will be collected at the piezometer locations (Fig. 14) and will include areas within the landfill footprint. The vertical subsurface boundary extends into bedrock, approximately 30–50 ft below current ground surface (approximately 10 ft into bedrock).

Geotechnical data acquisition will be performed by qualified subcontractors with continuous field oversight by a geotechnical engineer or geologist with geotechnical experience. Geotechnical data will be used for the design, including stability analyses. These data will be collected and analyzed as described in Appendix B, Sect. B.2.1 and Sect. B.5.

## 6.5 SAMPLE COLLECTION, IDENTIFICATION, AND LABELING

Sampling data generated during all phases of this project must be of acceptable quality. The appropriate contractor characterization team lead is responsible for implementation and performance of sample collection, quality checks, and monitoring activities.

The QAPP (Appendix A) contains the requirements for field documentation, sample containers, sample packaging, decontamination of equipment and devices, sample identification and traceability, and field variance systems integral to the collection of samples.

## 6.6 LABORATORY ANALYSIS

Geotechnical sample analysis will be performed by a geotechnical laboratory accredited by the U.S. Army Corps of Engineers or American Association of State Highway and Transportation Officials for the specific American Society for Testing and Materials laboratory testing procedures called out in Appendix B, Sect. B.5.2.

# 7. DATA MANAGEMENT

The Oak Ridge Environmental Information System (OREIS) is the centralized, standardized, quality-assured, and configuration-controlled data management system used as the long-term repository for environmental data (measurements and geographic) for all projects performed pursuant to the FFA. OREIS is comprised of hardware, commercial software, customized integration software, an environmental measurements database, a geographic database, and associated documentation.

OREIS, the primary component of the data management program for restoration projects, provides consolidated, consistent, and well-documented environmental data and data products to support planning, decision making, and reporting activities. OREIS provides a direct electronic link of ORR monitoring and remedial investigation results to EPA Region 4, TDEC Division of Remediation–Oak Ridge, and interested members of the public. Waste characterization data is not included in OREIS.

For applicable numeric data, reports and data will be developed in accordance with the OREIS Ready-to-Load Format Document to allow successful uploading into the OREIS database. Remaining data will be provided in a format suitable for uploading into the OREIS database.

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# 8. DATA VERIFICATION AND REVIEW

The project SME will review the data to verify that the results are reasonable. Results that appear anomalous will be evaluated in greater detail, including discussions with the laboratory as appropriate, to confirm the validity of the results.

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# 9. DATA REPORTING

The results of the March-April field investigation data will be presented in Technical Memorandum 1 and will be submitted to the Administrative Record prior to the public comment period on the EMDF preferred alternative. Technical Memorandum 1 will also include the results of two additional surface water walkovers in May and June. Results from longer-term monitoring (May 2018 through February 2019) and the dry season surface water walkdowns will be documented in Technical Memorandum 2.

The following data, evaluations, calculations, and reports will be included in the Administrative Record.

- Groundwater data, including borehole logs, piezometer construction logs, groundwater table maps, charts of groundwater elevation fluctuations over time, hydraulic conductivity data (including FLUTe borehole transmissivity profiling), soil stratigraphy, groundwater gradients, and groundwater flow rates. Data will be collected during March-April 2018 and will be considered part of the field data collection to be provided in Technical Memorandum 1 prior to the public comment period.
- Surface water data, including surface water flow rates, locations of seeps/springs (as well as temperature, conductivity, and pH in streams and seeps/springs), groundwater elevations impacting surface waters, site topography, stream morphology, and climate information. The March-April 2018 surface water data will be considered part of the field data collection to be documented in Technical Memorandum 1 and provided prior to the public comment period.

In addition, a geotechnical data report will be prepared that will include soil consolidation, shear, density, and index properties (moisture content, Atterberg Limits, grain size, and specific gravity); bedrock strength, interface strength, rock type, fractures, and rock quality; and groundwater elevations and variations.

The QAPP (Appendix A, Sect. A.10) contains the specific requirements for data reporting.

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# APPENDIX A.
# QUALITY ASSURANCE PROJECT PLAN FOR THE PROPOSED EMDF DESIGN INVESTIGATION, OAK RIDGE, TENNESSEE

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# CONTENTS

# FIGURES

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# ACRONYMS

| | |
|---|---|
| AR | Administrative Record |
| AASHTO | American Association of State Highway and Transportation Officials |
| ASTM | American Society for Testing and Materials |
| CBCV | Central Bear Creek Valley |
| *CFR* | *Code of Federal Regulations* |
| CO | Contracting Officer |
| COC | chain-of-custody |
| COR | Contracting Officer Representative |
| DMC | Document Management Center |
| DOE | U.S. Department of Energy |
| DOE O | DOE Order |
| DOT | U.S. Department of Transportation |
| DQO | data quality objective |
| EDD | electronic data deliverable |
| EMDF | Environmental Management Disposal Facility |
| EPA | U.S. Environmental Protection Agency |
| ES&H | Environment, Safety and Health |
| FDF | field data form |
| FFA | Federal Facility Agreement |
| FSP | Field Sampling Plan |
| LCOC | laboratory chain-of-custody |
| LOR | Letter of Receipt |
| NCR | nonconformance report |
| OREIS | Oak Ridge Environmental Information System |
| OREM | Oak Ridge Office of Environmental Management |
| ORR | Oak Ridge Reservation |
| PEMS | Project Environmental Measurements System |
| PM | Project Manager |
| QA | quality assurance |
| QAPP | Quality Assurance Project Plan |
| QC | quality control |
| RADCON | Radiological Control |
| ROD | Record of Decision |
| S/CI | suspect/counterfeit items |
| SOP | standard operating procedure |
| SOW | Statement of Work |
| TDEC | Tennessee Department of Environment and Conservation |
| UCOR | URS \| CH2M Oak Ridge LLC |
| USACE | U.S. Army Corps of Engineers |

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# A.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been developed to identify and implement quality assurance (QA) requirements for use in sample collection, laboratory analysis, and data management of groundwater assessments, surface water flow measurements, geotechnical exploration and testing, and geophysical studies needed to support the design of the proposed Environmental Management Disposal Facility (EMDF) on the U.S. Department of Energy (DOE) Oak Ridge Reservation (ORR) located in Oak Ridge, Tennessee. These requirements ensure that appropriate levels of QA and quality control (QC) are achieved and maintained. This plan identifies the procedures that will be followed in the collection, custody, and handling of samples, as well as environmental/laboratory data used in the Field Sampling Plans (FSPs) generated to support the EMDF project.

This QAPP provides the QA for collection of groundwater elevations, surface water flow measurements and geotechnical exploration in an uncontaminated setting for the Phase 1 and any follow-on design investigations. Samples will be collected for geotechnical laboratory analyses, not for chemical or radiological analyses. In addition, this QAPP establishes requirements and responsibilities applicable to project participants and establishes methods through which project personnel implement the requirements of the URS | CH2M Oak Ridge LLC (UCOR) QA programs. Any changes to this QAPP require completion of the EMDF QAPP Addendum form provided in Attachment 2.

This QAPP meets the requirements of the *EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5)* (U.S. Environmental Protection Agency [EPA] 2001); *URS | CH2M Oak Ridge LLC Quality Assurance Program Plan* (UCOR 2016a); and 10 *Code of Federal Regulations* (*CFR*) 830.122, *Quality Assurance Criteria*.

The stakeholders and data users in the performance of the environmental sampling and analysis effort are Oak Ridge Office of Environmental Management (OREM), the EPA Region 4 and the Tennessee Department of Environment and Conservation (TDEC). The selected characterization contractor is a prime contractor to OREM and has been tasked with implementation of the Phase 1 FSP using the QA requirements in this QAPP. UCOR will provide technical assistance and oversight of the Phase 1 sampling effort, and will be responsible for inputting data into Project Environmental Measurements System (PEMS).

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## A.2 PROJECT ORGANIZATION

The organizational structure for this characterization project is presented in Fig. A.1.

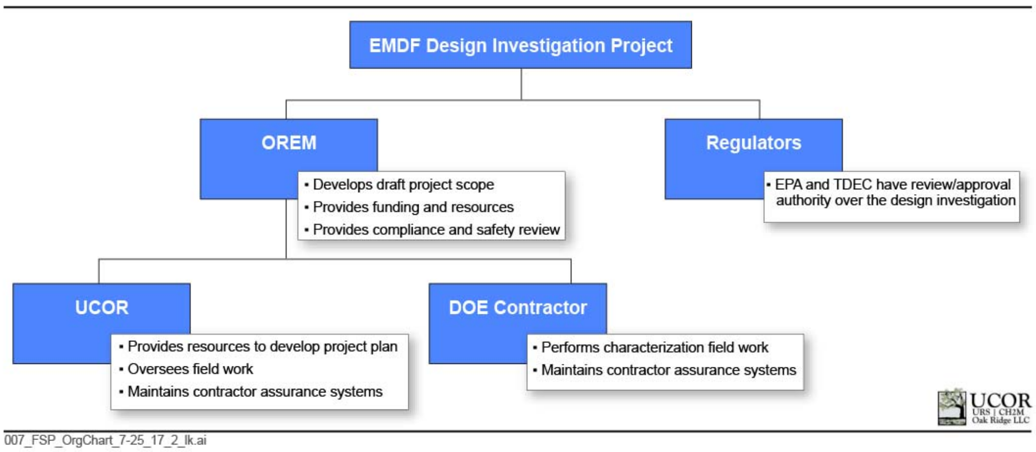


**Fig. A.1. Project organization.**

### A.2.1 ROLES AND RESPONSIBILITIES

In accordance with DOE Order (O) 450.2, CHG 1 (MINCHG), *Integrated Safety Management*, and *Integrated Safety Management System Program Description* (DOE 2017), the authority and expectation to suspend work is extended to all employees of the Characterization Contractor and UCOR. All employees are empowered to refuse to perform work that is unsafe or may cause environmental impact, even if directed to do so by supervisors, customers, or other prime contractors on shared sites, without fear of reprisal. Work that is suspected or proven to place the workers, the public, or the environment at risk is to be stopped until it can be demonstrated that changes have been made and it is safe to proceed with the work.

Roles and responsibilities of the major EMDF Project administrative and functional interfaces are discussed below (see Fig. A.1). These positions may be combined and/or performed by one or more individuals.

The project contact list is provided in Attachment 1.

#### A.2.1.1 OREM

The OREM is responsible for developing the project scope of work, ensuring work scope is performed in a safe, compliant and effective manner, and maintaining the project scope, schedule and costs. OREM is responsible for approving deliverables and providing funding/resources to the project.

The DOE Oak Ridge Environmental Management Landfills Project Manager (PM), Contracting Officer (CO), and Contracting Officer Representative (COR) are solely responsible for the project scope and shall approve all changes to the scope baseline in advance of implementation.

**OREM Landfills PM.** Responsible for maintaining overall scope, schedule and costs for this characterization project.

**OREM CO and COR**. Manage compliance with contract requirements and determine if changes to contracts are necessary or required.

**OREM Staff**: Includes subject matter experts and facility representatives responsible for providing general oversight of the contractor's safety and compliance performance.

#### A.2.1.2 OREM Characterization Contractor

The OREM characterization contractor is responsible for providing the resources to complete the designated scope of work as described, including providing the geotechnical laboratory, geophysical subcontractor, and hydrogeologic testing subcontractor. The characterization contractor will report to OREM for overall project direction, scope, cost and schedules.

The characterization contractor will provide field and laboratory data in the appropriate format to support upload into the PEMS/Oak Ridge Environmental Information System (OREIS) systems.

**Characterization PM**. The Characterization PM is responsible for the effective execution of project tasks under this characterization project and serves as the point-of-contact for project activities. The Characterization PM oversees the activities of all contractor personnel, ensures compliance with the statement of work (SOW), and controls project consistency.

The Characterization PM supervises sampling activities and coordinates all planning, data collection, and reporting. The Characterization PM is responsible for ensuring work is performed in accordance with this FSP/QAPP and all applicable and appropriate procedures; coordinating activities of the field sampling personnel; ensuring all FSP/QAPP requirements are met and sampling procedures are followed by the samplers; directing planning and technical implementation of the FSP/QAPP and sampling procedures for all sampling activities; ensuring the proper collection, containerization, and storage/preservation of samples in accordance with the FSP/QAPP and applicable approved methods; ensuring delivery of samples to the laboratory as directed; confirming that training and certification requirements are met for each project; and ensuring adherence to QC requirements identified in this plan.

**Contractor Environment, Safety, and Health Oversight**. The assigned Environment, Safety, and Health (ES&H) Representative independently reports to the Characterization PM on matters concerning project safety and health. The ES&H Representative assists in addressing and resolving health and safety concerns involved in sampling events, provides oversight of controls required for protection from hazards associated with the sampling event, ensures all work is planned and conducted in a safe manner and in accordance with the five core functions of Integrated Safety Management, and reviews and approves applicable Job Hazard Analyses. The ES&H Representative also works with site Radiological Control (RADCON) to ensure safe operations. Work packages shall contain specific safety and health requirements for field activities and will be available to personnel in the field.

**Contractor QA.** The assigned QA Representative independently reports to the Characterization PM on matters concerning QA aspects of the project. The project QA Representative will perform the following functions:

- Review and approve the overall quality of project plans and reports.
- Ensure all measuring and testing equipment is properly maintained and calibrated.
- Coordinate with technical members of the project team to evaluate status, procedures, and nonconformances from a quality program standpoint.

- Coordinate the areas of records management, quality improvement, QA/QC, and quality assessments for the project.

- Compare collected data to the data quality objectives (DQOs) to assure project goals are met. Perform data quality assessments will include thorough reviews of the field and laboratory data for adherence to data collection procedures, protocols, and specifications in applicable SOWs.

The QA Representative is responsible for distributing and controlling procedures, overseeing the maintenance of training records, providing independent oversight for QA pertaining to work performed by the project, reviewing and providing concurrence for release of reports, ensuring data verification is performed, performing or overseeing performance of project file reviews, overseeing archival of critical records, ensuring required data entry to the audit and nonconformance data tracking systems, ensuring complete documentation of performance evaluation activities, and coordinating vendor/provider assessments as deemed necessary by the Characterization PM.

**Contractor Sample Manager**. The project Sample Manager supports planning and executing characterization field activities. The Sample Manager is responsible for maintaining chain-of-custody (COC) forms; field logbooks; coordinating with the Geotechnical Laboratory Manager to ensure sample technicians have the proper labels, containers, preservatives, etc., to satisfy DQOs; and coordinating with the project Transportation Specialist for sample shipment.

The contractor Sample Manager will interface with the project team personnel and provide the following services:

- Ensure planned project objectives are met and all on-site field activities are executed in a technically sound and responsible way with regard to health, safety and quality.
- Review field generated project documentation for completeness and accuracy and ensure field documents are appropriately field and stored.
- Participate in field decisions and prepare field change notices to document variances in the field.

- Ensures proper disposal of samples which includes receiving certificates of disposal.

**Contractor Transportation Specialist**. The project Transportation Specialist coordinates with the Sample Manager and is responsible for providing oversight and support necessary to ensure that sample shipments are conducted according to applicable U.S. Department of Transportation (DOT) procedures; determining the appropriate hazard classifications for sample shipments; directing sample shipments, including appropriate marking, labeling, and placarding in accordance with applicable standards; and ensuring sampling personnel are adequately trained in the applicable sample packaging.

**Contractor Data Manager**. The contractor Data Manager works with the project team and geotechnical laboratory to ensure the complete and accurate transfer of samples and information from the field to the laboratory. The Contractor data management function provides the following services:

- Assists field sampling teams in addressing identified data gaps, implementing DQO/data quality assessments processes, and determining data sufficiency.
- Verifies receipt of incoming field data and geotechnical data from the laboratory in both hard copy and electronic formats.
- Oversees and tracks the data review process and preparation and submittal of deliverables to the OREM CO/COR, OREM PM and UCOR Characterization Technical Lead.

- Identifies and resolves analysis issues and non-conformances.
- Ensures the laboratory is aware of the project DQOs, program goals, and QA/QC objectives.
- Monitors the QA/QC deliverables from the laboratory, ensures conformance with authorized procedures and sound practices, and assists in identifying and resolving non-conformances.
- Communicates the schedule of sample shipments and shipment contents to the laboratory, and provides status of sample shipments to the project team.

#### A.2.1.3 UCOR Project Team

The UCOR Project Team is responsible for providing technical assistance during the characterization process to support completion of the project scope as specified in the FSP.

**UCOR EMDF PM.** The UCOR EMDF PM is responsible for all aspects of the EMDF project and has overall responsibility for ensuring that the sampling effort results in information needed to support the future design of the EMDF.

**UCOR Characterization Technical Lead.** The UCOR Characterization Technical Lead serves as the primary interface between the OREM sampling contractor and UCOR as well as the subject matter expert for technical aspects of the FSP. As changes occur in the field, the UCOR Characterization Technical Lead will be informed by the UCOR representative in the field and then will communicate with the UCOR PM and the OREM PM for concurrence of said changes.

The UCOR Characterization Technical Lead is responsible for arranging inbound/outbound equipment and radiological surveys, and for ensuring radiological release surveys are performed for the samples prior to shipping offsite. The technical lead is also responsible for ensuring the applicable data are uploaded into PEMS and OREIS as needed.

**UCOR Field Representative.** The UCOR representative in the field is responsible for ensuring that the details of the sampling plan are implemented in the field as specified in the FSP/QAPP to ensure that data collected will support the future design efforts. There may be multiple representatives for the various elements of this scope. The UCOR representative will observe boring and other field activities, review field and lab results to verify the appropriate data are collected, and consult with the geotechnical lab on sample location selection and testing parameters. The UCOR field representative will consult with the UCOR Characterization Technical Lead and the OREM Landfills PM when there are or need to be field changes to the sampling design.

### A.2.2 TRAINING AND QUALIFICATION OF PERSONNEL

DOE contractors, UCOR, and UCOR Subcontractors will provide trained and qualified personnel as governed by their contract and DOE O 426.2, *Personnel Selection, Training, Qualification and Certification Requirements for DOE Nuclear Facilities* (DOE 2013). Qualification of personnel is accomplished by consideration of experience, education, training, and by demonstration and testing to verify acquired skills.

The characterization contractor training program focuses on an approach to ensure that employees and subcontractors are trained and qualified commensurate with their responsibilities. Training includes mandatory company, access-specific, functional-specific, project-specific, facility-specific, job-specific, and professional qualification training.

All project personnel must be qualified and experienced in the project task(s) for which they are responsible. For those personnel actively involved in field work, training, at a minimum, will include 40-hour Occupational Safety and Health Administration training, general employee training, and site required orientation. All field personnel will be trained on the applicable work packages and this FSP/QAPP.

Additional training to standard operating procedures (SOPs) and other training that becomes identified as specific to the activities identified in this FSP/QAPP must also be completed before installing any borings or collecting any samples. In addition, site workers will receive training in personal protective equipment, daily tailgate safety meetings, and daily pre-job briefings. Data management personnel will also require training in the use of PEMS. Documentation of all training will be maintained in the contractor's corporate records.

Training may be performed during mobilization. Additional training that may be required for specific equipment or by ES&H, RADCON, and/or Transportation is not addressed in this QAPP, but will be addressed in the task-specific work control documents.

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# A.3 DATA QUALITY OBJECTIVES

The EMDF FSP and this QAPP together describe the data collection and sample analyses requirements.

Quality objectives for data collection and analysis are developed as DQOs for this project in accordance with UCOR's prevailing revision of PROC-ES-1004, *Implementing and Documenting the Data Quality Objective Process* (UCOR 2014). The DQOs are provided in Sect. 4 of the FSP, however, the general quality objectives for the groundwater level, geotechnical, and geophysical data are as follows:

- Data generated will withstand scientific and technical scrutiny.
- Data will be generated using appropriate procedures for analysis, COC, data documentation, and reporting.
- Data will be of known representativeness, comparability, and sensitivity.

QC requirements will be communicated to the contracted laboratory accredited by the U.S. Army Corps of Engineers (USACE) or American Association of State Highway and Transportation Officials (AASHTO) for the specific American Society for Testing and Materials (ASTM) laboratory testing procedures called out in Appendix B of the FSP. Any necessary changes to these requirements will be documented, reviewed, and approved by the OREM CO/COR. Analyses will be scheduled according to program needs and will be consistent with ASTM/AASHTO standards. These requirements will be included in any contractual agreement between the Characterization Contractor and the USACE/AASHTO accredited lab.

Quality objectives for all field and laboratory data are to obtain reproducible, precise, and accurate measurements consistent with the intended use of the data and the limitations of the sampling and laboratory procedures. Project data requirements are identified in detail in the FSP. Geotechnical laboratory data will be provided in electronic and hard copy format as described in Sect. A.10. The data reported will comply with ASTM/AASHTO standards.

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# A.4 PROCUREMENT, SUPPLIES, AND CONSUMABLES

All field instrumentation, sample containers, and other equipment or materials purchased for use in the FSP will be purchased in accordance with DOE G 414.1-3, *Suspect/Counterfeit Items Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1b, Quality Assurance* (DOE 2004) as implemented through the characterization contractor's QA Program Plan/Procurement Plan and applicable procedures. If applicable, all critical elements of the equipment or materials being purchased will be specified in the purchase order to the vendor.

Receipt, inspection, and acceptance of supplies and consumables will be in accordance with the characterization contractor's QA Program Plan/Procurement Plan/Inspection and Acceptance Testing requirements.

Characterization contractor personnel will implement the requirements in accordance with DOE Suspect/Counterfeit Items (S/CI). A standard S/CI clause is also required in procurement documents in accordance with characterization contractor's QA Program Plan/Procurement Plan.

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# A.5 SAMPLE COLLECTION PROCEDURES

Sampling data generated during all phases of this project must be of acceptable quality. The Characterization PM is responsible for implementation and performance of sample collection, quality checks, and monitoring activities.

This section discusses field documentation, sample containers, sample packaging, decontamination of equipment and devices, sample identification and traceability, and field variance systems integral to the collection of samples. Related activities are performed in accordance with ASTM/AASHTO standards as described herein.

The measurement and testing locations are shown on Fig. 14, and a summary of field sampling activities is provided in Table 5 of the FSP. The FSP Appendix B contains the specific sampling approach for the field activities.

## A.5.1 FIELD DOCUMENTATION

An integral part of field exploration and sampling activities will be to maintain current, accurate, and complete field records. Field records include COC forms, field logbooks, field testing reports, and drilling/boring logs. The COC (i.e., laboratory chain-of-custody [LCOC]) form, or equivalent, should document the transfer of sample custody from time of sample collection to laboratory receipt and will be in accordance with ASTM/AASHTO standards. The COC form will accompany the samples from the field to the USACE/AASHTO accredited laboratory. All applicable information on the COC will be filled out completely and legibly using indelible black ink. No blank spaces should appear on completed COC forms.

Field records will be reviewed by a characterization contractor member other than the person completing the record (e.g., boring/drilling logs), and the review will be documented by the reviewer's initials and the date. All field records and documentation will be maintained and controlled in accordance with ASTM/AASHTO standards.

### A.5.1.1 Field Logbook and Field Data Forms

A bound logbook will be used to document all field activities. The logbook will include descriptions of daily progress of the fieldwork for the area of investigation. Field logbooks become part of the project record. Guidelines for the minimum entries to be made in field logbooks are provided in PROC-ES-2700, *Field Logbooks and Field Data Forms* (UCOR 2015a). The field logbooks are used to document a broad range of field activities, including, but not limited to, inspections, sampling, and testing and/or measurements. Field logbooks will be maintained by assigned personnel to document field activities, such as borehole drilling, geotechnical sampling, and geophysical logging/testing.

As electronic logbooks and/or electronic field data forms (FDF) and devices are developed and approved for use, the electronic logging devices may be utilized in lieu of a bound logbook and hard copy FDF. The e-logbook or e-forms and/or devices should be officially approved for use by the project and meet the specified quality requirements.

Borehole and test pit logs will document subsurface information (see Appendix B, Sect. B.2 of the FSP). Sample collection depths will be noted on the logs. Additional information provided in the field logbooks will include the following:

- Project name and location
- Dates and times
- General weather conditions
- Field observations
- Sampling performed, including locations, sample numbers, and analyses
- Deviations from the FSP
- Problems encountered and corrective actions taken
- QC activities

#### A.5.1.2 Field Documentation Checks

Documented quality check reviews of field logbooks are performed daily to ensure collection of the information as outlined in *Field Logbook and Field Data Forms* (UCOR 2015a) or Characterization Contractor equivalent. This review includes a quality check of field logbook entries of sample times and dates to the field logbook or other associated FDFs used for the day’s activity (i.e., groundwater purge/sampling form). Field documentation reviews are conducted by a Quality Check Reviewer, or designee (i.e., peer). If deficiencies are encountered, the Quality Check Reviewer notifies the appropriate author to fully document (e.g., perform a Late Entry to the field logbook) or amend documentation, as appropriate and in accordance with *Field Logbooks and Field Data Forms* (UCOR 2015a).

#### A.5.1.3 Field Variances

Procedures cannot fully encompass all conditions encountered during field activities therefore variances from the field sampling procedures and/or ES&H Plan must be documented in the field logbook. Deviations from the approved scope of the project shall be approved in advance by the DOE PM, CO, and COR with consultation with UCOR. Variances from the characterization contractor ES&H Plan must be approved by the characterization contractor’s ES&H representative.

Controlling and documenting field changes will be in accordance with the ASTM/AASHTO standards. Any deviations from procedural requirements and one-time difficulties will be reported to and authorized by the UCOR Characterization Technical Lead in consultation with the UCOR field representative and UCOR PM. Deviations from the requirement will be sufficiently documented in the field logbook.

If a variance is anticipated (e.g., because of a change in field instrumentation), the procedure will be modified in accordance with ASTM/AASHTO standards, and the changes will be documented in the field logbook or drilling/boring log.

### A.5.2 SAMPLE CONTAINERS

The selection criteria for appropriate sample containers shall be in accordance with ASTM/AASHTO standards. The sample volume to be collected is dependent upon the methodology to be used. The USACE/AASHTO accredited laboratory shall provide this information prior to sample collection. Types of sample containers used will be documented in the drilling/boring log and/or on the COC. Sample containers will be provided or specified by the geotechnical lab in accordance with ASTM/AASHTO standards.

### A.5.3 SAMPLE IDENTIFICATION AND TRACEABILITY

Sample numbers will be generated by the characterization contractor that will include the following information:

- EMDF Project
- Location identifier (e.g., GW-999)
- Depth

Sample containers will be labeled with a unique sample identification prior to sample collection. The sample labels will be completed with indelible black ink and in accordance with ASTM/AASHTO standards. Corrections should be made by drawing a single line through the erroneous information and initialing and dating the correction. Sample identification will be recorded in the drilling/boring log and COC form. Sample identification shall be associated with the sample type and location, thereby ensuring traceability of samples to the specific sample location.

### A.5.4 TYPE AND FREQUENCY OF QC SAMPLES

No field QC samples will be required for this activity. Laboratory QC samples will be in accordance with the specified ASTM standard.

### A.5.5 SAMPLE PACKAGING

Sample containers must comply with ASTM standards. Samples will be handled to avoid contamination from outside sources and to prevent sample moisture evaporation during and after collection. Sample preservation, storage, packaging, shipping, and handling will be in accordance with ASTM/AASHTO standards, the laboratory SOW, and DOT requirements.

After sample collection, the sampling team shall store samples in accordance with ASTM/AASHTO standards until packaging and shipment to an USACE/AASHTO accredited laboratory.

The Transportation Specialist or Sample Shipping Manager packages the samples, completes the required sections on the COC (i.e., records signature, time, date, air bill number), and seals the original COC in a watertight bag inside the shipping container.

### A.5.6 STORAGE AND SHIPMENT OF SAMPLES

Samples will not be stored on site and shall be transported to controlled storage or the appropriate laboratory on the same day. Sample packaging for shipment to a laboratory will follow ASTM D4220/D4220M-14, *Standard Practices for Preserving and Transporting Soil Samples,* (ASTM 2014) to prevent physical damage. Samples collected, packaged, and shipped to the laboratory for analyses will be tracked using the carrier’s tracking system (e.g., United Parcel Service, Federal Express), if not hand delivered.

Samples of material shipped from a site to a laboratory for analysis must be classified and prepared for the carrier in accordance with regulatory requirements found in the International Air Transport Association regulations and the U.S. DOT 49 *CFR*, Parts 100 through 177, *Transportation*, as outlined in PROC-TR-9503, *Shipping Samples from a Company Site* (UCOR 2012).

Samples are not expected to meet the definition of a hazardous material or dangerous goods.

# A.6 SAMPLE CUSTODY

A sample is in custody if it is in the actual possession of a sample custodian, is in the view of a sample custodian after being in their physical possession, was in the physical possession of a sample custodian and then secured to prevent tampering (e.g., affixed with custody/tamper seals), and is placed in a secured area. Custody/tamper seals are placed on the container lid and side of the sample container to guard against and detect any sample tampering between the time of sample collection and receipt by the laboratory. Sample shipment containers (i.e., ice chest or coolers) will have custody/tamper seals placed across the hinge of the lid and opposite side (back and front) of the lid to also guard against or detect tampering.

## A.6.1 CUSTODY SEALS

Custody/tamper seals are affixed to sample containers and sample shipment containers in accordance with the characterization contractor's COC Protocol for Environmental Sampling. The application of custody/tamper seals on shipping containers may be waived if the sample team maintains sample custody as defined in PROC-ES-2708, *Chain of Custody Protocol for Environmental Sampling,* Sect. 4[2] (UCOR 2016b) from the time of collection until the samples are relinquished to the Transportation Specialist. Certain sample containers may be placed in a resealable bag and have a custody seal affixed such that the seal must be broken when the bag is opened (i.e., over the bag opening).

## A.6.2 SAMPLE TRACKING

The COC form documents the transfer of sample custody from the time of sample collection to laboratory receipt (Fig. A.2). The COC custody record will be initiated at the time of sample collection and remain with the sample from the field to storage, and sample shipment to the laboratory.

Upon laboratory receipt, the laboratory custodian will complete the required sections of the COC thereby accepting custody of the samples. Sample shipments will be examined immediately upon receipt by the laboratory to determine damage, loss, or inconsistencies. A Letter of Receipt (LOR) or equivalent will be completed by the laboratory that indicates sample condition, documentation inconsistency, and any problems discovered. If samples are damaged or the shipment has been otherwise compromised, the laboratory will immediately notify the characterization contractor.

Samples will be logged into the laboratory and will be tracked and maintained under conditions appropriate to the specific laboratory methods throughout the laboratory process as described in the laboratory QC manual. After appropriate information and required signatures have been added to the COC form and LOR, the laboratory will return signed copies to the characterization contractor as soon as practicable (e.g., usually within 24 hours). The LOR may be in the form of an electronic confirmation (e.g., email, pdf). The laboratory shall include a copy of the LOR and documentation of the analytical login (project sample number, laboratory sample number, analysis scheduled, etc.) in this sample receiving report.

| CHAIN-OF-CUSTODY FORM | MACTEC Engineering & Consulting, Inc. - Knoxville Branch<br>1725 Louisville Drive - Knoxville, TN 37921-5904 |
|---|---|
| Job Number: | Date: |
| Client Name: | of Samples |
| Job Name: | Rush? Yes or No |
| Building: | |
| Inspectors: | |

| Sample I.D. Number | Location | Source Description | Lab I.D. Number | Comments |
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|---|---|---|
| Friable Material: | Shipped Via: Ground unless other noted | Lab Shipped To: ( If Required) |
| Non-Friable Material | (other: Airborne, Fed-Ex, UPS, US Mail, Etc.) | |
| Field Collection: | 1st Transfer Facility: | 2nd Transfer Facility:<br>Disposal: |
| Name: | Name: | Name: |
| Signature: | Signature: | Signature: |
| Date: | Date: | Date: |

**Fig. A.2. LCOC example.**

The original COC will be returned by the laboratory to the characterization contractor along with the data package. Original COC forms will be stored with the associated data deliverables or electronic data deliverables (EDDs), then provided as records at project completion.

### A.6.3 SAMPLE DISPOSAL

Samples will be held for a minimum of 90 days following reporting. Samples will be stored by the laboratory in appropriate containers and under conditions appropriate to the specific laboratory methods.

The laboratory will be responsible for return of residual samples after the minimum retention period and upon approval by the project. Returns will be coordinated with the characterization contractor.

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## A.7 DECONTAMINATION OF EQUIPMENT AND DEVICES

The Central Bear Creek Valley (CBCV) site is located in an uncontaminated area. All equipment and downhole tools will be steam cleaned prior to mobilization to the CBCV project site. Decontamination will consist of removing adhering soil and subsurface materials from the downhole tools prior to use and between sampling locations and intervals in accordance with the applicable standards. Field decontamination activities will be recorded in the applicable field notebook or on the drilling/boring log.

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# A.8 CALIBRATION PROCEDURES AND FREQUENCY

## A.8.1 FIELD INSTRUMENT CALIBRATION PROCEDURES AND FREQUENCY

Field instrumentation and measurement equipment will be calibrated by qualified individuals and maintained against certified equipment and/or standards having known valid traceability in accordance with ASTM/AASHTO standards. Field logbooks shall be used to record calibration, standardization, and field measurement data associated with field instruments and measurement equipment in accordance with ASTM/AASHTO standards.

Where radiological monitoring is required for samples, personnel, or certain activities, radiological protection personnel shall ensure radiological monitoring equipment is calibrated daily (e.g., daily source checks). Radiological monitoring instrument calibration records are established and maintained by UCOR radiological protection personnel.

If an instrument malfunctions prior to use, remove the device from service, tag the device so it is not inadvertently used, and notify the characterization contractor field personnel. If an instrument is discovered to be out of calibration while in the field, notify the Characterization PM or designee and discontinue related field work until a properly calibrated instrument is obtained. The characterization contractor field personnel will ensure that if an instrument is discovered to be out of calibration, the instrument will be tagged or segregated from other equipment (not to be used) and properly calibrated or disposed as appropriate.

If an instrument is found to be out of calibration and inadvertently used to obtain field measurement data, then a nonconformance report (NCR) will be completed and the sample will be considered null and void, resulting in a retest. The nonconformance will be documented by the appropriate project personnel in the field logbook along with the validity of the previous calibration or inspection with test results and the acceptability of similar equipment previously calibrated or inspected and tested. Any equipment that is consistently found to be out of calibration will be repaired or replaced. Such action(s) will be documented in the field logbook.

## A.8.2 LABORATORY INSTRUMENT CALIBRATION PROCEDURES AND FREQUENCY

Laboratory equipment will be calibrated according to ASTM/AASHTO standards. Calibration frequency will be based on the standard employed, type of equipment, inherent stability, manufacturer's recommendations, values given in the USACE/AASHTO accredited laboratory QC manual, intended use, and experience. All standards used for equipment calibration will be traceable to ASTM/AASHTO standards. The source of the standard used must be documented in the lab records.

For volumetric laboratory measurements, ASTM/AASHTO approved volumetric equipment shall be used by trained and qualified technicians to prepare calibration standards, bench standards, samples for analysis, etc. For gravimetric measurements, calibration of analytical balances must be performed by trained and qualified instrument technicians using weights traceable to the National Institute of Standards and Technology.

It should be noted that other instrumentation (such as thermometers) must be properly maintained and calibrated to ASTM/AASHTO standards. The temperatures of ovens used in sample handling will be recorded, and the control limits shall be defined. When these limits are not met, the sample will be considered null and void, and a retest of the sample must occur.

### A.8.3 CALIBRATION FAILURES

Laboratory equipment failures are addressed in the laboratory QC manual, which is audited by AASHTO. If a laboratory equipment failure occurs, the sample will be considered null and void, and a retest of the sample must occur once adequate equipment is acquired.

### A.8.4 CALIBRATION RECORDS

Calibration data will be recorded in the laboratory records. The information will include the date, calibrator's initials, and standard used during the calibration process. Records that demonstrate traceability of all calibration standards used in calibrations to the certified source will be maintained in accordance with ASTM/AASHTO standards.

The appropriate project personnel will ensure that field calibration data records are kept current. Records for field instruments used will be maintained in the project files.

Records for laboratory equipment will be maintained as specified in the geotechnical laboratory QC manual in accordance with the laboratory's QC system.

## A.9 PROJECT DATA QUALITY ASSESSMENT

The data assessment objectives for laboratory analysis will produce data of known and sufficient quality to support the project and resultant decisions. Appropriate procedures and QC checks will be employed to assess the level of acceptance of these parameters. Applicable QC data will be reported for the project along with the sample results. When the sample set is completed, QC data will be reviewed and evaluated to validate the information. Acceptance criteria and evaluation of laboratory results for the representativeness, comparability, and sensitivity parameters will be determined in compliance with ASTM/AASHTO standards.

The following quality parameters will be used to evaluate data quality:

- Representativeness
- Comparability
- Sensitivity

In determining data usability, especially in the decision-making process, the integrity and authenticity of the data must be evaluated and the measurement uncertainty must be determined. The laboratory analyzing the data must be accredited by the USACE or AASHTO through the certification program involving standard analysis in accordance with AASHTO procedures.

### A.9.1 REPRESENTATIVENESS

Representativeness expresses the relative degree to which the data depict the characteristics of a population, parameter, sampling point, process condition, or environmental condition. The objective of this study is to accurately represent the material properties.

Representative samples for this investigation will be acquired through implementation of ASTM/AASHTO standards that will generate data representative of the sampling point location. Sampling procedures are designed to minimally impact the sample obtained, so that conditions representative of the sampling location will be maintained. Representativeness is also provided through the sample selection for geotechnical analysis by the UCOR field representative and geotechnical laboratory personnel. The combined consultation will ensure that the interval selected for analysis represents the site conditions and provides the most useful information for the future engineering design.

The goal for representative sample data will, therefore, be met through the proper documentation of field and standard protocols as well as through subject matter expert consultation and sample interval selection. Review of the data, documentation, and field information will also be implemented to identify sample population, parameter, or process characteristics relative to representativeness.

### A.9.2 COMPARABILITY

Comparability expresses the confidence with which one data set can be compared with another. Comparability of the data generated in this investigation will be obtained through the implementation of the identified protocols for sampling and analysis of samples. Expression of results in standard units, and successful participation by the laboratories in external performance evaluation programs will enable the data produced through this investigation to be compared with future geotechnical data sets.

### A.9.3 SENSITIVITY

Procedures to attain sensitivity objectives include the following:

- Uniform training and certification for staff
- Standard provisions for inspection, maintenance, and repair
- Provision of SOPs to technical staff
- Reference to SOPs in the field and laboratory QAPPs
- Field/laboratory QA inspections to determine compliance with the items specified in the support plans

# A.10 DATA REPORTING

The results of the field investigation will be presented in a report as described in Sect. 9 of the FSP. Record copy and electronic data will be entered/presented into common, standardized formats. In addition to following field, sample management, data management, and laboratory QC manual specifications, verification of data may be made using a variety of computerized checks (i.e., record copy checked against EDD). These procedures will ensure that data are entered, encoded, processed in a consistent way, and available in a designated and usable format.

## A.10.1 FIELD DATA REDUCTION AND EVALUATION

Data measurements collected during field activities will be evaluated by comparing the data to similar measurements, as applicable. Field measurements are collected in accordance with ASTM/AASHTO standards or procedures. The appropriate project personnel will be responsible for verifying that sampling protocols have been observed.

The COR/UCOR representative may perform a surveillance of the sampling protocols. These reviews may include checking the sample collection date and times, applicable procedures, calibration methods and frequency, COC, field logbook and/or drilling/boring logs, and other applicable information and documentation.

## A.10.2 GEOTECHNICAL LABORATORY DATA REDUCTION AND EVALUATION

In general, the analyst will process the data either manually or by inputting the data into a relevant software program. For manually processed data, all the steps in the computation must be provided, including equations used and the source of input parameters such as response factors, dilution factors, and calibration constants. If calculations are not performed directly on the data sheet, the calculations must be provided on company letterhead paper and attached to the data sheets. All pages of the calculations must be signed and dated by the analyst performing the calculations as well as by the individual verifying the calculations.

For data input by an analyst and processed using a relevant software program, a copy of the input must be kept and uniquely identified with the project number and other pertinent information, as necessary. The samples to which the data processing refers must be clearly stated, and the input must be signed and dated by the analyst performing the input as well as the individual verifying the process. When processing data are acquired from instrumentation, the analyst and the oversight individual must verify that the correct project, sample numbers, calibration constants, response factors, units, equipment numbers, and numerical values used for detection limits are present.

### A.10.2.1 Laboratory Data Review

The laboratory is responsible for ensuring that data reduction and calculations follow correct procedures, are documented, and are checked by qualified personnel, in accordance with the laboratories' internal QC manual. All information, including reduced and summarized data, will be retained with the raw data. Specific calculations used for data reduction will also be included. The laboratory is responsible for maintaining comprehensive documentation for all data produced, including the following:

- Appropriateness of equations employed
- Correctness of numerical input (both record copy and electronic)

- Numerical correctness of all calculations
- Interpretation of laboratory analysis output
- Comparability and correctness of initial and continuing calibration results
- Traceability of samples from receipt to data report by internal custody and tracking procedures
- Evaluation of data deliverable completeness and legibility
- Raw data from drilling/boring logs
- Geotechnical report

#### A.10.2.2 Data Reporting and Deliverables

Geotechnical reports and borehole logs will be loaded into OREIS while groundwater and surface water flow data will be uploaded into PEMS then transferred to OREIS.

A characterization contractor approved geotechnical data report, content and format, will be developed in accordance with the requirements ASTM/AASHTO standards. The geophysical data reports will also be loaded into OREIS.

# A.11 RECORDS AND DOCUMENT CONTROL

## A.11.1 RECORDS CONTROL

All QA records concerning the project (internal and external correspondence, FSP, QAPP, field logbooks, LCOC forms, data packages, audit reports, surveillance reports, NCRs, corrective action reports, management assessments, etc.) and other quality records are submitted to the DOE PM, CO, and COR at the end of each phase of the project. These records will be submitted to the UCOR Document Management Center (DMC) in accordance with PROC-OS-1001, *Records Management, Including Document Control* (UCOR 2017).

The DMC Controlled Document Worksheet, Form-1057 (Fig. A.3), is completed by the UCOR Characterization Technical Lead to identify all recipients of a controlled record copy of the FSP/QAPP. The DMC Supervisor, or designee, issues revised electronically controlled documents (or hard copy upon request) to those on the distribution list (see last page of this QAPP).

## A.11.2 RECORDS RETENTION

Prior to the approval of the Record of Decision (ROD), all primary and secondary documents, decision relevant correspondence, and public notices/presentation materials are entered into the Administrative Record (AR). The AR is approved by the three Federal Facility Agreement (FFA) Parties prior to closing the AR. Post-ROD project/subproject FFA documents and correspondence are stored in post-decision record files maintained by the AR coordinator and are available to the public. All validated characterization sampling data supporting regulatory decisions shall be archived in OREIS and are available online to the FFA parties or in hardcopy upon request. Following receipt of information from external sources and issuance of reports, associated records, including those generated by subcontractors, shall be placed in the AR or the project post-decision record file, as required. Each contractor shall maintain project files as appropriate.

The AR Coordinator is responsible for maintaining evidence files to support the AR and maintaining post decision project files. All environmental characterization and post-remediation sampling and analysis generated, validated data used to support future decisions, decision changes, or used to determine the effectiveness of the remedy are archived in the OREIS database. Documents are initiated, compiled, and transmitted to the ORR AR Coordinator in accordance with PROC-OS-1003, *Administrative Record Program* (UCOR 2015b).

Records are retained and maintained in accordance with the length of time as specified in DOE records retention schedules (i.e., destroy 75 years after termination of the applicable FFA). The DMC obtains authorization for records turnover to the Federal Records Center or records destruction from the OREM contractor DMC Records Manager, Legal, and the originating organization, if different from the originator, during the 6 months before the record's scheduled destruction date. EPA and TDEC are made aware of planned destruction of FFA-related decision and completion materials and seek approval prior to any record destruction.

UCOR
URS | CH2M
Oak Ridge LLC

## DMC Controlled Document Worksheet

| | |
|---|---|
| **General Instructions:** | The following worksheet should be completed and attached to all Documents transmitted to the Document Management Center (DMC) for retention of the Record Copy and Controlled Copy distribution. |

| | | |
|---|---|---|
| Document Number: | Revision Number: | Document Date: |
| Document Title: | | |
| Author/Contact | | |

**Applicable Project and Site:**

Supersedes other Documents? Yes ☐ No ☐
If Yes, Indicate Document Numbers:

Should Previous Versions be Cancelled? Yes ☐ No ☐
If Yes, Indicate Document Number and Revision:

Indicate Recipients:

**Notes or Special Instructions:**

**Submitted By** **Date Submitted**

**Attach the DMC Controlled Document Worksheet to the front of the document and forward to the Document Management Center Distribution.**

**NOTE: This worksheet is not for use with Facility Safety Documents – A Form-554 must be used for those documents.**

Form-1057 (8/11) Rev. 0
PROC-OS-1001

**Fig. A.3. UCOR Form-1057, DMC Controlled Document Distribution.**

### A.11.3 RECORDS STORAGE

Prior to the transmittal of documents to the DMC, Record Copy material will reside with the characterization contractor in suitable storage locations that will ensure the protection of Record Copy (hard copy and electronic) records. The protection includes, but is not limited to, reasonable safeguards against fire, theft, water damage, rodents, insect infiltration, or floods.

QA Records are a subcategory of Category I Records—records that require a rigorous level of protection because of their content or value. Non-lifetime QA records (non-permanent records) are Category II records, which have less stringent requirements. Records storage shall provide control and protection to records.

Category I and II records are maintained with the following storage requirements: (1) records are maintained in a lockable file cabinet or a lockable room that contains file cabinets, open shelving, or racks (in a lockable room, records may be boxed and stored on racks or other means to prevent boxes from residing directly on the floor); (2) access control is established to prevent unauthorized use, disclosure, theft, or destruction; (3) a posted list indicates designated personnel approved for unescorted access to records filing areas; and (4) an index system facilitates ease of records retrieval and accounts for records removed from the storage area.

Category I records include one of the following additional storage requirements: (1) records vault, one-hour fire-rated cabinet, plus smoke detection system; (2) fire suppression system and reasonable safeguards against theft, water damage, rodent or insect infiltration, or floods; (3) duplicate records in an identified duplicate storage area in a separate location (locations shall be sufficiently remote from each other to eliminate the chance of exposure to a single hazard); or (4) duplicate information on other record media stored in a separate location.

Electronic records and databases (i.e., OREIS, PEMS, and Tracker) are protected from damage and loss by full weekly and incremental nightly backups.

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## A.12 REFERENCES


ASTM 2014. *Standard Practices for Preserving and Transporting Soil Samples,* ASTM D4220/ D4220M-14, ASTM International, West Conshohocken, PA, 2014.

DOE 2004. *Suspect/Counterfeit Items Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1b, Quality Assurance*, DOE Guide 414.1-3, U.S. Department of Energy, Washington, D.C., November 3.

DOE 2013. *Personnel Selection, Training, Qualification and Certification Requirements for DOE Nuclear Facilities*, DOE Order 426.2, U.S. Department of Energy, Washington, D.C., July 29.

DOE 2017. *Integrated Safety Management*, and *Integrated Safety Management System Program Description*, DOE Order 450.2, CHG 1 (MINCHG), U.S. Department of Energy, Washington, D.C., January 17.

EPA 2001. *EPA Requirements for Quality Assurance Project Plans (EPA QA/R-5),* EPA/240/B-01/003. U.S. Environmental Protection Agency, Washington, D.C., March.

UCOR 2012. *Shipping Samples from a Company Site,* PROC-TR-9503, URS | CH2M Oak Ridge LLC, Oak Ridge, TN, January 23.

UCOR 2014. *Implementing and Documenting the Data Quality Objective (DQO) Process*, PROC-ES-1004, URS | CH2M Oak Ridge LLC, Oak Ridge, TN, November 25.

UCOR 2015a. *Field Logbooks and Field Data Forms*, PROC-ES-2700, URS | CH2M Oak Ridge LLC, Oak Ridge, TN, July 30.

UCOR 2015b. *Administrative Record Program*, PROC-OS-1003, URS | CH2M Oak Ridge LLC, Oak Ridge, TN, June 15.

UCOR 2016a. *URS | CH2M Oak Ridge LLC (UCOR) Quality Assurance Program Plan*, *Oak Ridge, Tennessee,* UCOR-4141/R4, URS | CH2M Oak Ridge LLC, Oak Ridge, TN, March.

UCOR 2016b. *Chain of Custody Protocol for Environmental Sampling*, PROC-ES-2708, URS | CH2M Oak Ridge LLC, Oak Ridge, TN, November 21.

UCOR 2017. *Records Management, Including Document Control,* PROC-OS-1001, URS | CH2M Oak Ridge LLC, Oak Ridge, TN, February 1.

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## ATTACHMENT 1.
## ENVIRONMENTAL MANAGEMENT DISPOSAL FACILITY QUALITY ASSURANCE PROGRAM PLAN (QAPP) CONTACT LIST

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**EMDF Project Key Personnel Contact List**

| Role | Name | Organization | Telephone | Email |
|---|---|---|---|---|
| OREM Landfills Project Manager | Susan DePaoli | OREM/P2S | (865) 294-6065 | depaolis@p2s.com |
| OREM Contracting Officer | Heather Cloar | OREM | (865) 576-1894 | Heather.Cloar@orem.doe.gov |
| OREM Contracting Officer Representative | Brian DeMonia | OREM | (865) 241-6182 | Brian.DeMonia@orem.doe.gov |
| Characterization Contractor Project Manager | Dirk Van Hoesen | Strata-G | (865) 705-8793 | dvanhoesen@stratag.org |
| Characterization Contractor Health and Safety | David Bratley | CTI and Associates | (361) 548-9164 | dbratley@cticompanies.com |
| Characterization Contractor Quality Assurance | Tammy Phillips | Strata-G | (865) 806-7188 | tphillips@stratag.org |
| Characterization Contractor Sample Manager | Kevin Foye | CTI and Associates | 248-459-4609 | kfoye@cticompanies.com |
| Characterization Contractor Transportation Specialist. | Kevin Foye | CTI and Associates | 248-459-4609 | kfoye@cticompanies.com |
| Characterization Contractor Data Manager | Kevin Foye | CTI and Associates | 248-459-4609 | kfoye@cticompanies.com |
| UCOR EMDF Project Manager | Julie Pfeffer | UCOR | (865) 712-4172 | julie.pfeffer@ettp.doe.gov |
| UCOR Characterization Technical Lead | Annette Primrose | UCOR | (865) 576-9170 | annette.primrose@ettp.doe.gov |
| UCOR Field Representative(s) | Dick Ketelle/TBD | UCOR/RSI | (865) 574-5762 | richard.ketelle@ettp.doe.gov |

EMDF = Environmental Management Disposal Facility
OREM = Oak Ridge Office of Environmental Management
P2S = Professional Project Services, Inc.
RSI = Restoration Services, Inc.
TBD = to be determined
UCOR = URS | CH2M Oak Ridge LLC

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# ATTACHMENT 2.
# ENVIRONMENTAL MANAGEMENT DISPOSAL FACILITY QUALITY ASSURANCE PROGRAM PLAN
# ADDENDUM FORM

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**ADDENDUM FORM**
**ENVIRONMENTAL MANAGEMENT DISPOSAL FACILITY**
**QUALITY ASSURANCE PROJECT PLAN**

**Addendum No.: FY17-__________ Effective Date: __________________**

Type of Change (check all that apply):

☐ Change in project organization
☐ Change in procedure or process for conducting an element of work
☐ Change in personnel listed in Appendix C – Contact List
☐ Other: ____________________________________________________
____________________________________________________

Attach copies of the pages affected by the change for insertion into the QAPP.

Change is: ☐ Permanent (i.e., >1 year) ☐ Temporary (i.e., <1 year)

Reason for Change(s):

Requester: ________________________________________ Date: ______________
(Person requesting revision to QAPP)

Approved by: ________________________________________ Date: ______________
(OREM Landfills Project Manager or authorized designee)

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# APPENDIX B.
# MEASUREMENT AND TESTING APPROACH AND METHODS

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# CONTENTS

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# TABLES

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# ACRONYMS

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| bgs | below ground surface |
| EMDF | Environmental Management Disposal Facility |
| NT | North Tributary |
| OREIS | Oak Ridge Environmental Information System |
| PEMS | Project Environmental Measurements System |
| P-wave | compression wave |
| S-wave | shear wave |
| SPT | standard penetration test |
| UCOR | URS \| CH2M Oak Ridge LLC |

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# B.1 INTRODUCTION

The following procedures and American Society for Testing and Materials (ASTM) methods and guidelines will be used to ensure the appropriate quality of data are collected. The latest available version of these will be used.

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# B.2 DRILLING FOR PIEZOMETERS, GEOTECHNICAL INVESTIGATION AND SEISMIC INVESTIGATION

Phase 1 boreholes as well as boreholes identified for a future investigation will be drilled as shown on Table B.1 and Fig. 14 in this Field Sampling Plan as specified in the latest version of SPG-00000-A005, *Standard Specification for Well Drilling, Installation and Abandonment* (URS | CH2M Oak Ridge LLC [UCOR] 2016). Note that planned future boreholes also are provided in Table B.1 for completeness.

Boreholes will be drilled by Tennessee-qualified monitoring well drillers. Core or representative samples will be collected from boreholes, but the method will vary depending on the material and tests performed as described below. A Boring Log Form or electronic logging device will be used to document soil and rock characteristics and pertinent field data during soil boring activities. Continuous bedrock core will be collected throughout the deepest boring at each paired piezometer location. A geologist or engineer will describe the material with sufficient detail to identify lithology, chert lenses, relic bedding, moisture, and other features that may bear or transmit water (e.g., areas of fracturing, bedding, dissolution).

The specific methods for data collection and logging are provided in Table B.2.

## B.2.1 STANDARD PENETRATION TEST APPROACH

Standard penetration tests (SPTs) will be conducted using a qualified contractor with field oversight by a geotechnical engineer or geologist with geotechnical experience. These data will be collected and analyzed as described in Sect. B.5.

Borings will be installed at the approximate locations as presented in Fig. 14 in this Field Sampling Plan. For boreholes constructed while collecting SPT measurements, SPTs will begin at the ground surface, but beneath any drill pads that are present. This will allow measurement of the topsoil layer thickness. SPTs will be conducted at 2.5-ft intervals in the upper 10 ft of the borehole, then at 5-ft intervals until the top of competent rock is encountered and/or drilling refusal. While vertical variations are expected, testing on 5-ft intervals is adequate to describe this variation sufficiently for design purposes.

Measurements of the efficiency of the SPT hammer will be conducted in accordance with ASTM D4633, *Standard Test Method for Energy Measurement for Dynamic Penetrometers* (ASTM 2016).

All borings should be advanced to drilling refusal or a maximum of approximately 50 ft below ground surface. SPT data will be collected by driving a split-spoon sampler 18-24 in. and recording the blow counts every 6 in. Core will be collected between each SPT interval. Each boring will be cored an additional 10 ft below drilling refusal. The top of bedrock will be noted for each location.

A boring log will be maintained for each borehole that will include a brief description of the soil types encountered and the associated blow counts per depth intervals for SPTs.

Geotechnical samples will be collected from specified depths within offsets of selected boreholes following review of the SPT data and borehole logs by geotechnical engineers. These relatively undisturbed (Shelby tube) samples will target representative cohesive soils for permeability, laboratory shear strength, and consolidation tests.

**Table B.1. Summary of subsurface sample collection locations**

| Location | Deep piezometer | Shallow piezometer | Residuum and bedrock core | Well point | Slug tests | FLUTe | GW levels | SPTs | Test pit | Potential geotechnical lab samples | Crosshole geophysics | Geophysical logging |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW-978 | • | | • | | | • | • | • | | • | | |
| GW-979 | | • | | | • | | • | | | | | |
| GW-980 | • | | • | | | • | • | • | | • | | |
| GW-981 | | • | | | • | | • | | | | | |
| GW-982 | • | | • | | | • | • | • | | • | | |
| GW-983 | | • | | | • | | • | | | | | |
| GW-984 | • | | • | | | • | • | • | | • | | |
| GW-985 | | • | | | • | | • | | | | | |
| GW-986 | • | | • | | | • | • | • | | • | | |
| GW-987 | | • | | | • | | • | | | | | |
| GW-988 | • | | • | | | • | • | • | | • | | |
| GW-989 | | • | | | • | | • | | | | | |
| GW-990 | • | | • | | | • | • | • | | • | | |
| GW-991 | | • | | | • | | • | | | | | |
| GW-992 | • | | • | | | • | • | • | | • | | |
| GW-993 | | • | | | • | | • | | | | | |
| GW-994 | • | | • | | | • | • | • | | • | | |
| GW-995 | | • | | | • | | • | | | | | |
| GW-996 | • | | • | | | • | • | • | | • | | |
| GW-997 | | • | | | • | | • | | | | | |
| GW-998 | • | | • | | | • | • | • | | • | | |
| GW-999 | | • | | | • | | • | | | | | |
| GY-001 | • | | • | | | • | • | • | | • | | |
| GY-002 | | • | | | • | | • | | | • | | |
| GY-003 | | • | • | | • | | • | • | | • | | |
| GY-004 | | • | • | | • | | • | • | | • | | |
| GY-005 | • | | | | | | • | | | | | |
| GY-006 | | | | • | | | • | | | | | |
| GY-007 | | | | • | | | • | | | | | |
| GY-008 | | | | • | | | • | | | | | |
| GY-009 | | | | • | | | • | | | | | |
| EMDFBH-1 a-c | | | 2 | | | | | • | | 2 boreholes | • | • |
| EMDFBH-2 | | | • | | | | | • | | • | | |
| EMDFBH-3 a-c | | | 2 | | | | | • | | 2 boreholes | • | • |
| EMDFBH-4 | | | • | | | | | • | | • | | |
| EMDFBH-5 | | | • | | | | | • | | • | | |
| EMDFBH-6 | | | • | | | | | • | | • | | |
| EMDFBH-7 | | | • | | | | | • | | • | | |
| EMDFPT-1 | | | | | | | | | • | • | | |
| EMDFPT-2 | | | | | | | | | • | • | | |

FLUTe = Flexible Liner Underground Technologies, LLC
GW = groundwater
SPT = standard penetration test

**Table B.2. Specific methods for data collection and logging**

| ASTM standard or UCOR procedure | Citation[a] |
|---|---|
| ASTM D1586 | ASTM D1586-11, *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*, ASTM International, West Conshohocken, PA, 2011. |
| ASTM D2113 | ASTM D2113-14, *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration*, ASTM International, West Conshohocken, PA, 2014. |
| ASTM D2488 | ASTM D2488-09a, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure),* ASTM International, West Conshohocken, PA, 2009. |
| ASTM D7012 | ASTM D7012-14, *Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures,* ASTM International, West Conshohocken, PA, 2014. |
| ASTM D4220/ D4220M-14 | ASTM D4220 / D4220M-14, *Standard Practices for Preserving and Transporting Soil Samples*, ASTM International, West Conshohocken, PA, 2014. |
| ASTM D4633 | ASTM D4633-16, *Standard Test Method for Energy Measurement for Dynamic Penetrometers*, ASTM International, West Conshohocken, PA, 2016. |
| ASTM D5079 | ASTM D5079-08, *Standard Practices for Preserving and Transporting Rock Core Samples (Withdrawn 2017)*, ASTM International, West Conshohocken, PA, 2008. |
| ASTM D6032/D6032M-17 | ASTM D6032 / D6032M-17, *Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core*, ASTM International, West Conshohocken, PA, 2017. |
| PROC-ES-2303 | *Borehole Logging,* PROC-ES-2303, latest revision, URS \| CH2M Oak Ridge LLC, Oak Ridge, TN. |

[a]The most current version of the procedure shall be used.

ASTM = American Society for Testing and Materials
UCOR = URS | CH2M Oak Ridge LLC

Boring logs will be provided to the laboratory with the collected samples for review by a geotechnical engineer to determine the number and types of tests. Sample packaging for shipment to the laboratory will prevent physical damage. The required tests and frequency are provided in Sect. B.5.2.

## B.2.2 BOREHOLE AND TEST PIT ABANDONMENT

Boreholes that will not be converted to piezometers will be abandoned in accordance with *Standard Specification for Well Drilling, Installation, and Abandonment* (UCOR 2016) and the requirement listed in Table B.3.

**Table B.3. Specific method for borehole abandonment**

| Reference | Citation[a] |
|---|---|
| PROC-ES-2106 | *Well Plugging and Abandonment,* PROC-ES-2106, latest revision, URS \| CH2M Oak Ridge LLC, Oak Ridge, TN. |

[a]The most current version of the procedure shall be used.

Additional, follow-on seismic and geotechnical boreholes are expected to be plugged and abandoned:

- EMDFBH-1 a, b, and c (3 boreholes)
- EMDFBH-2
- EMDFBH-3 a, b, and c (3 boreholes)
- EMDFBH-4
- EMDFBH-5
- EMDFBH-6
- EMDFBH-7

Follow-on test pits also will be abandoned following data collection and photographic documentation. The excavated soil will be replaced in lifts not to exceed 3 ft and compacted by tamping with a bucket or tracking across the backfilled soil a minimum of three times. The test pits are expected to be included in a follow-on Field Sampling Plan to include the following:

- EMDFPT-1
- EMDFPT-2

# B.3 HYDROGEOLOGIC INVESTIGATION

Piezometers are shown on Fig. 14. Piezometers, future well points, and the current and future planned tests are shown on Table B.4. Piezometers will be installed in designated boreholes by Tennessee-qualified monitoring well drillers in accordance with Oak Ridge Reservation requirements as specified in the latest version of *Standard Specification for Well Drilling, Installation, and Abandonment* (UCOR 2016). Well points will be installed according to manufacturer's instructions.

Each piezometer will be constructed with commercially fabricated 2-in.-diameter, flush-threaded, carbon steel or polyvinyl chloride conductor casings and well screens. Well screens will be slotted and will have an inside diameter equal to that of the piezometer casing. A minimum 1-ft sump will be installed below the well screens. No fitting (coupling) shall restrict the inside diameter of the jointed casing and/or screen. All screens, casings, and fittings shall be new.

Screen lengths will be a nominal 5 ft in length, where possible, for both the intermediate and shallow piezometers. The actual length of the screened interval and the screen setting shall be determined based on lithology, the interception of fractures (e.g., locations encountering groundwater) or lack of fractures, and the location of hydrogeological unit contacts. Screens will have 0.010-in. machine-cut slots. Screen bottoms shall be securely fitted with a threaded cap or plug of the same composition as the screen. A filter pack of silica sand will be placed around each screen such that no voids are created from the bottom of the borehole to approximately 0.6 m (2 ft) above the top of the screen. A minimum 2-ft seal of sodium bentonite pellets will be installed above the filter pack to ensure no void space and it will be hydrated with potable water for a minimum of 8 hours. Each piezometer will be secured at the surface with a locking, waterproof cap. Permanent surface completions of the piezometer will be decided by the project design team.

**Table B.4. Hydrogeologic investigation current and future locations and planned tests**

| Location | Deep piezometer | Shallow piezometer | Well point | Slug tests | FLUTe | GW levels | Potential laboratory hydraulic conductivity |
|---|---|---|---|---|---|---|---|
| GW-978 | • | | | | • | • | • |
| GW-979 | | • | | • | | • | |
| GW-980 | • | | | | • | • | • |
| GW-981 | | • | | • | | • | |
| GW-982 | • | | | | • | • | • |
| GW-983 | | • | | • | | • | |
| GW-984 | • | | | | • | • | • |
| GW-985 | | • | | • | | • | |
| GW-986 | • | | | | • | • | • |
| GW-987 | | • | | • | | • | |
| GW-988 | • | | | | • | • | • |
| GW-989 | | • | | • | | • | |
| GW-990 | • | | | | • | • | • |
| GW-991 | | • | | • | | • | |
| GW-992 | • | | | | • | • | • |
| GW-993 | | • | | • | | • | |
| GW-994 | • | | | | • | • | • |
| GW-995 | | • | | • | | • | |
| GW-996 | • | | | | • | • | • |
| GW-997 | | • | | • | | • | |
| GW-998 | • | | | | • | • | • |
| GW-999 | | • | | • | | • | |
| GY-001 | • | | | | • | • | • |
| GY-002 | | • | | • | | • | • |
| GY-003 | | • | | • | | • | • |
| GY-004 | | • | | • | | • | • |
| GY-005 | • | | | | | • | |
| GY-006 | | | • | | | • | |
| GY-007 | | | • | | | • | |

**Table B.4. Hydrogeologic investigation locations and planned tests (cont.)**

| Location | Deep piezometer | Shallow piezometer | Well point | Slug tests | FLUTe | GW levels | Potential laboratory hydraulic conductivity |
|---|---|---|---|---|---|---|---|
| GY-008 | | | • | | | • | |
| GY-009 | | | • | | | • | |

FLUTe = Flexible Liner Underground Technology, LLC
GW = groundwater

**Piezometer Development**—Piezometers shall be developed no sooner than 24 hours after installation and shall continue until the piezometer responds to water-level changes and produces clear, sediment-free water to the extent possible. During development, water shall be removed throughout the entire column of water standing in the piezometer by periodically lowering and raising the pump intake or bailer. A minimum of three piezometer volumes will be evacuated, if possible. Temperature, pH, and specific conductivity of evacuated water will be monitored in accordance with PROC-ES-2101, *Groundwater Sampling Wells or Piezometers* (UCOR 2015), or equivalent during development and will be stable, if practical, before each piezometer shall be considered developed.

**Hydraulic Conductivity**—Both laboratory and field hydraulic conductivity measurements will be obtained as shown on Table B.4. The specific methods for hydraulic conductivity measurements are shown on Table B.5.

The total number of tests, specific locations, and depths of the laboratory samples will be determined in consultation with geotechnical engineers and the geotechnical laboratory following review of the borehole logs and collected samples. There is no specific criteria available in advance. The selection of samples for each test will be based on professional judgment by the design team and the laboratory based on the subsurface conditions encountered, sample quantity and quality, and budget.

**Table B.5. Specific methods for hydraulic conductivity measurement**

| Reference | Citation[a] |
|---|---|
| ASTM D5084 | ASTM D5084-16a, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter*, ASTM International, West Conshohocken, PA, 2016. (Provides additional information to correlate with field measurements, and recompacted bulk soil samples can be used to replicate as-placed values. Because of the small sample size, these samples may underestimate the permeability of the in situ materials. These sample results will be used in conjunction with the slug tests and FLUTe tests to develop a more complete picture of the hydraulic conductivity, including vertical conductivity values, present in situ.) |
| PROC-ES-2102 | *Aquifer Testing*, PROC-ES-2102, latest revision, URS \| CH2M Oak Ridge LLC, Oak Ridge, TN. |
| FLUTe Contractor Manual | Operating manual for specialty contractor performing FLUTe testing. |

[a]The most current version of each standard, test method, or procedure shall be used.

ASTM = American Society for Testing and Materials
FLUTe = Flexible Liner Underground Technologies, LLC

**Groundwater elevation measurements**—Qualified field personnel will perform the measurements in accordance with the most recent version of the applicable operating procedure specified in Table B.6 (or a U.S. Environmental Protection Agency-approved technically equivalent procedure).

The procedures listed in Table B.6 will be used to determine groundwater elevations. Downhole monitors will be placed in each piezometer and will collect groundwater level, pH, conductivity, and temperature data every 30 minutes. Data will be downloaded every 2 weeks.

**Table B.6. Specific methods for groundwater elevation measurements**

| Reference | Citation[a] |
|---|---|
| PROC-ES-2100 | *Groundwater Level Measurement,* PROC-ES-2100, latest revision, URS \| CH2M Oak Ridge LLC, Oak Ridge, TN. |
| PROC-ES-2101 | *Groundwater Sampling Wells or Piezometers,* PROC-ES-2101, latest revision, URS \| CH2M Oak Ridge LLC, Oak Ridge, TN. |

[a]The most current version of each procedure shall be used.

Groundwater and surface water field data measurements collected by characterization contractor personnel will be manually entered into an electronic spreadsheet or provided in electronic format. These measurements will be provided to the UCOR characterization technical lead for electronic upload into the Project Environmental Measurements System (PEMS) by the UCOR characterization technical lead or designee. A PEMS report is printed or reviewed on screen and compared to the associated hard copy Field Data Form or the electronic raw data printout. The reviews are performed by sampling personnel or other pertinent personnel. Changes are provided to the characterization contractor to correct the database as appropriate. If data has been sent to Oak Ridge Environmental Information System (OREIS), then the UCOR characterization technical lead will submit a change request in accordance with PROC-ES-1002, *Submitting, Reviewing, and Dispositioning Changes to the Environmental Information Management (EIM) System (OREIS, PEMS, and TRACKER)* (UCOR 2014).

In addition and as possible and observed, groundwater levels will be noted and recorded for the seismic boreholes, SPT boreholes, and test pits.

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## B.4 SURFACE WATER FLOW MEASUREMENT

Four surface water flumes will be placed along Drainage-10 West, North Tributary (NT)-10 and NT-11. The planned locations are shown on Fig. 14, however, field walkovers will be conducted to determine the specific locations for each flume based on the field conditions. Flumes will be installed per manufacturer's instructions. An additional two flumes will be located based on the field walkdown results. Flumes will be located where the streams enter and/or leave the estimated buffer zone or as appropriate.

The flumes will be monitored on an every 30 minute basis, with data downloaded every 2 weeks. The procedure listed in Table B.7 will be used to collect flow measurements.

**Table B.7. Specific method for surface water flume installation**

| Reference | Citation[a] |
| --- | --- |
| PROC-ES-2200 | *Surface Water Flow Measurements,* PROC-ES-2200, latest revision, URS \| CH2M Oak Ridge LLC, Oak Ridge, TN. |

[a]The most current version of the procedure shall be used.

Flow, temperature, pH, and conductivity measurements will be collected at the surface water flumes.

As noted in Sect. B.3, surface water flow data will be provided to the UCOR characterization technical lead for electronic upload into PEMS by the UCOR characterization technical lead or designee.

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## B.5 GEOTECHNICAL AND GEOPHYSICAL DATA COLLECTION

Geophysical and geotechnical data acquisition are used together in the design stability analysis. The Phase 1 and anticipated future locations planned for collection of geotechnical and geophysical data are shown in Table B.8. The Phase 1 locations are shown on Fig. 14.

**Table B.8. Geotechnical and geophysical collection current and future locations**

| Location | SPTs | Test pit | Potential geotechnical lab samples | Crosshole geophysics | Geophysical logging |
|---|---|---|---|---|---|
| GW-978 | • | | • | | |
| GW-979 | | | | | |
| GW-980 | • | | • | | |
| GW-981 | | | | | |
| GW-982 | • | | • | | |
| GW-983 | | | | | |
| GW-984 | • | | • | | |
| GW-985 | | | | | |
| GW-986 | • | | • | | |
| GW-987 | | | | | |
| GW-988 | • | | • | | |
| GW-989 | | | | | |
| GW-990 | • | | • | | |
| GW-991 | | | | | |
| GW-992 | • | | • | | |
| GW-993 | | | | | |
| GW-994 | • | | • | | |
| GW-995 | | | | | |
| GW-996 | • | | • | | |
| GW-997 | | | | | |
| GW-998 | • | | • | | |
| GW-999 | | | | | |
| GY-001 | • | | • | | |
| GY-002 | | | • | | |
| GY-003 | • | | • | | |
| GY-004 | • | | • | | |
| EMDFBH-1 a-c | • | | 2 boreholes | • | • |
| EMDFBH-2 | • | | • | | |
| EMDFBH-3 a-c | • | | 2 boreholes | • | • |
| EMDFBH-4 | • | | • | | |
| EMDFBH-5 | • | | • | | |
| EMDFBH-6 | • | | • | | |
| EMDFBH-7 | • | | • | | |
| EMDFPT-1 | | • | • | | |
| EMDFPT-2 | | • | • | | |

SPT = standard penetration test

### B.5.1 GEOPHYSICAL INVESTIGATION

Geophysical data acquisition in a future phase will be performed by a qualified subcontractor with experience in similar geologic conditions. A qualified geophysical subcontractor with at least 10 years of experience acquiring and interpreting geophysical data for geotechnical applications determinations, including foundation stability, will be used.

Tennessee-qualified monitoring well drillers will be used to construct the boreholes as described in Sect. B.2. Oversight will be provided by either a qualified field engineer or hydrogeologist with geophysical field experience to ensure the appropriate data are collected.

The principal failure areas for the Environmental Management Disposal Facility (EMDF) landfill during an earthquake are anticipated to be the southern earthen embankments and liner cover soils. The site-specific response analysis will provide seismic stability and deformation analysis of the landfill by performing the following in a follow-on investigation:

- Two borehole arrays will be placed to obtain cross-hole shear (S)-wave and compression (P)-wave velocity data. One array will be in the Maryville Limestone and one will be in the Nolichucky Shale, the major formations at the proposed EMDF site. Each array will consist of one source borehole and two data collection boreholes..
- Three boreholes will be drilled for each crosshole seismic testing array to a depth of at least 150 ft bgs, at least 50 ft into bedrock. The arrays will be positioned within the Maryville/Rogersville and Nolichucky formations. The EMDF site is underlain by Conasauga Group shale with similar seismic responses, and the collected data will be representative of the EMDF site area. Seismic borings will include performing SPTs in the soil/saprolite and rock coring below drilling refusal within bedrock.
- The three in-line boreholes in each array will be spaced approximately 10 ft apart from each other, center-to-center, at the ground surface (total spacing approximately 20 ft center-to-center from source borehole to farthest receiver borehole). Borings will be aligned approximately along strike. Actual seismic borehole locations will be adjusted, as required, based on field conditions.
- After rock coring and geophysical logging, boreholes will be enlarged (maximum borehole diameter of 6.5 in.) and 4-in. polyvinyl chloride casing will be installed to provide access for the crosshole seismic testing equipment. Vertical departure shall be maintained less than 1 percent out of plumb throughout the entire borehole depth.
- Boreholes and installed casings will be sized to allow acquisition of the required S-wave velocity and related values (approximately 4-in. inside diameter). Annular backfill grout will be designed to match density characteristics of the adjacent formation for compatibility of the installations for the required geophysical data acquisition.
- Crosshole seismic testing will be performed as per the guidance in Sect. B.5.2. Seismic velocities are to be measured within an accuracy of ± 10 m/s.
- Geophysical profiles will be developed from the bottom of the constructed boreholes to nominally 5 ft bgs.

SPT data (Sect. B.2.1) is used for liquefaction analyses. In addition, geophysical logs will be run in at least one of the uncased seismic boreholes in each array to further evaluate the stratigraphy and presence of higher conductivity zones to aid in geophysical data interpretation. These will include the following:

- Acoustic televiewer
- Natural gamma
- Spontaneous potential

Geophysical logs will be obtained by a specialty contractor in accordance with the contractor's operating instructions.

### B.5.2 GEOTECHNICAL DATA

Table B.9 lists the tests to be performed; the number of tests are approximate. No specific criteria are available for sample selection. The total number of tests, specific locations, and depths will be determined in consultation with geotechnical engineers and the geotechnical laboratory following review of the borehole logs and collected samples. The selection of samples for each test will be based on professional judgment by the design team and the laboratory based on the subsurface conditions encountered and the engineering parameters needed for design, sample quantity and quality, and budget.

**Table B.9. Geotechnical tests to be performed (current and future)**

| Residuum geotechnical tests | Total expected quantity | Applicable ASTM standards[a] | Comments |
|---|---|---|---|
| Thin-walled tube sampling/Shelby tube | 51 | ASTM D1587/D1587M-15, *Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes,* ASTM International, West Conshohocken, PA, 2015. | Assume 3 per boring; will be taken in appropriate materials during drilling. |
| Moisture content | 150 | ASTM D2216-10, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass,* ASTM International, West Conshohocken, PA, 2010. | These lab tests will be performed separately and in conjunction with other laboratory tests (e.g., sieve analysis). |
| Unified soil classification | 25 | ASTM D2487-11, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*, ASTM International, West Conshohocken, PA, 2011. | These lab tests will be performed in conjunction with other laboratory tests (e.g., sieve analysis). |
| Atterberg limits | 12 | ASTM D4318-17, *Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils,* ASTM International, West Conshohocken, PA, 2017. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Sieve analyses and P200 with Hydrometer | 12 | ASTM D422-63(2007)e2, *Standard Test Method for Particle-Size Analysis of Soils* (withdrawn in 2016 and no replacement, latest version will be used), ASTM International, West Conshohocken, PA, 2007. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Sieve analyses and P200 without Hydrometer | 25 | ASTM D422-63(2007)e2, *Standard Test Method for Particle-Size Analysis of Soils* (withdrawn in 2016 and no replacement, latest version will be used), ASTM International, West Conshohocken, PA, 2007. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Density of soil/unit weight | 4 | ASTM D7263-09, *Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens,* ASTM International, West Conshohocken, PA, 2009. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Specific gravity | 4 | ASTM D854-14, *Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer,* ASTM International, West Conshohocken, PA, 2014. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Hydraulic conductivity (permeability) testing | 12 | ASTM D5084-16a, *Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter,* ASTM International, West Conshohocken, PA, 2016. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |

**Table B.9. Geotechnical tests to be performed (cont.)**

| Residuum geotechnical tests | Total expected quantity | Applicable ASTM standards[a] | Comments |
|---|---|---|---|
| 1-D consolidated tests | 8 | ASTM D2435/D2435M-11, *Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading*, ASTM International, West Conshohocken, PA, 2011. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Consolidated undrained triaxial test | 4 | ASTM D4767-11, *Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils,* ASTM International, West Conshohocken, PA, 2011. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Modified and/or standard proctor compaction test | 12 | ASTM D1557-12e1/D698-12e2, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft$^3$ (2,700 kN-m/m$^3$)/ Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft$^3$ (600 kN-m/m$^3$),* ASTM International, West Conshohocken, PA, 2012. | Specific samples (test pit, boring and depth) will be assigned following review of borehole and test pit logs and collected samples. |
| Corrosion testing suite - chlorides | 2 | ASTM D512-12, *Standard Test Methods for Chloride Ion In Water*, ASTM International, West Conshohocken, PA, 2012, or ASSHTO T291, *Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil,* American Association of State Highway and Transportation Officials, 1994. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Corrosion testing suite - sulfates | 2 | ASTM C1580-15, *Standard Test Method for Water-Soluble Sulfate in Soil,* ASTM International, West Conshohocken, PA, 2015. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Corrosion testing suite – sulfides | 2 | AWWA C105A.1.4 Qualitative Test, *Polyethylene Encasement for Ductile-Iron Pipe Systems*, American Water Works Association, 2010. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Corrosion testing suite - soil resistivity | 2 | G187-12a, *Standard Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method*, ASTM International, West Conshohocken, PA, 2012. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Corrosion testing suite - moisture content | 2 | Laboratory methods | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| Corrosion testing suite - redox potential | 2 | ASTM G200-09(2014), *Standard Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil*, ASTM International, West Conshohocken, PA, 2014. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |

**Table B.9. Geotechnical tests to be performed (cont.)**

| Residuum geotechnical tests | Total expected quantity | Applicable ASTM standards[a] | Comments |
|---|---|---|---|
| Corrosion testing suite – pH | 2 | ASTM G51-95(2012), Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing, ASTM International, West Conshohocken, PA, 2012. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| **Bedrock Geotechnical/Geophysical Analysis** | | | |
| Unconfined compression tests on rock with modulus measurements (rock only) | 12 | ASTM D7012-14, *Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures*, ASTM International, West Conshohocken, PA, 2014. | Specific samples (boring and depth) will be assigned following review of borehole logs and collected samples. |
| | 2 | ASTM D4428 / D4428M-14, *Standard Test Methods for Crosshole Seismic Testing*, ASTM International, West Conshohocken, PA, 2014. | |

[a]The most current version of each procedure, standard, or test method shall be used.
AWWA = American Water Works Association
ASTM = American Society for Testing and Materials

## B.5.3 GEOTECHNICAL LABORATORY

Geotechnical sample analysis will be performed by a geotechnical laboratory accredited by the U.S. Army Corps of Engineers or American Association of State Highway and Transportation Officials for the specific ASTM laboratory testing procedures called out in Sect. B.5.2.

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# B.6 REFERENCES


ASTM 2016. ASTM D4633-16, *Standard Test Method for Energy Measurement for Dynamic Penetrometers*, ASTM International, West Conshohocken, PA, 2016.

UCOR 2014. *Submitting, Reviewing, and Dispositioning Changes to the Environmental Information Management (EIM) System (OREIS, PEMS, and TRACKER)*, PROC-ES-1002, latest revision, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

UCOR 2015. *Groundwater Sampling Wells or Piezometers,* PROC-ES-2101, latest revision, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

UCOR 2016. *Standard Specification for Well Drilling, Installation, and Abandonment*, SPG-00000-A005, latest revision, URS | CH2M Oak Ridge LLC, Oak Ridge, TN.

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