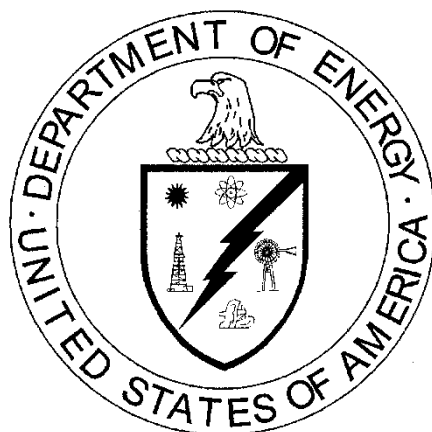


**Phase 1 Field Sampling Plan for the Proposed
Environmental Management Disposal Facility for Comprehensive
Environmental Response, Compensation, and Liability Act
Oak Ridge Reservation Waste Disposal,
Oak Ridge, Tennessee**



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James D. Faucher

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DOE/OR/01-2739&D2

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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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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.

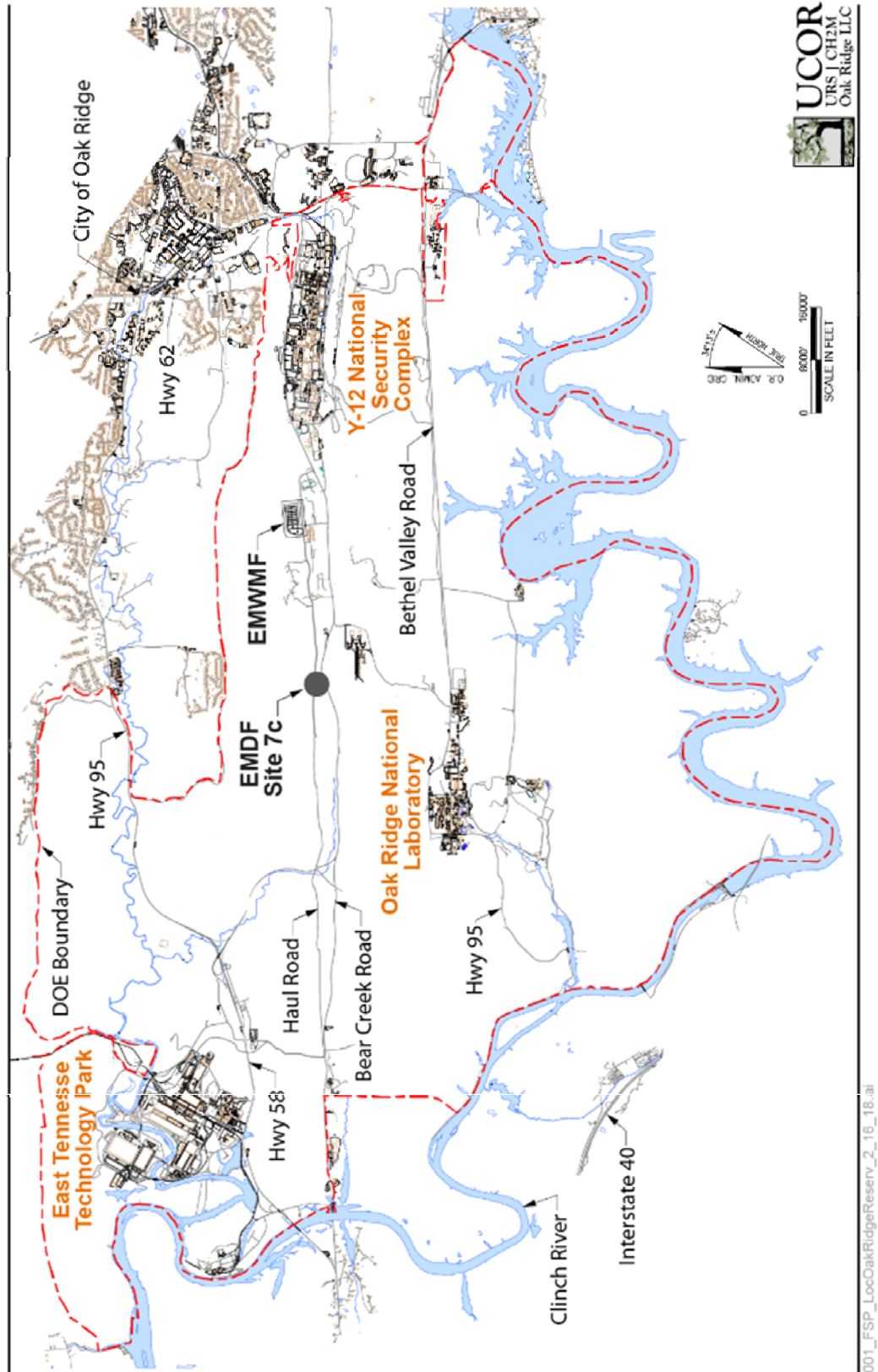


Fig. 1. ORR—proposed EMDF CBCV site location.

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.

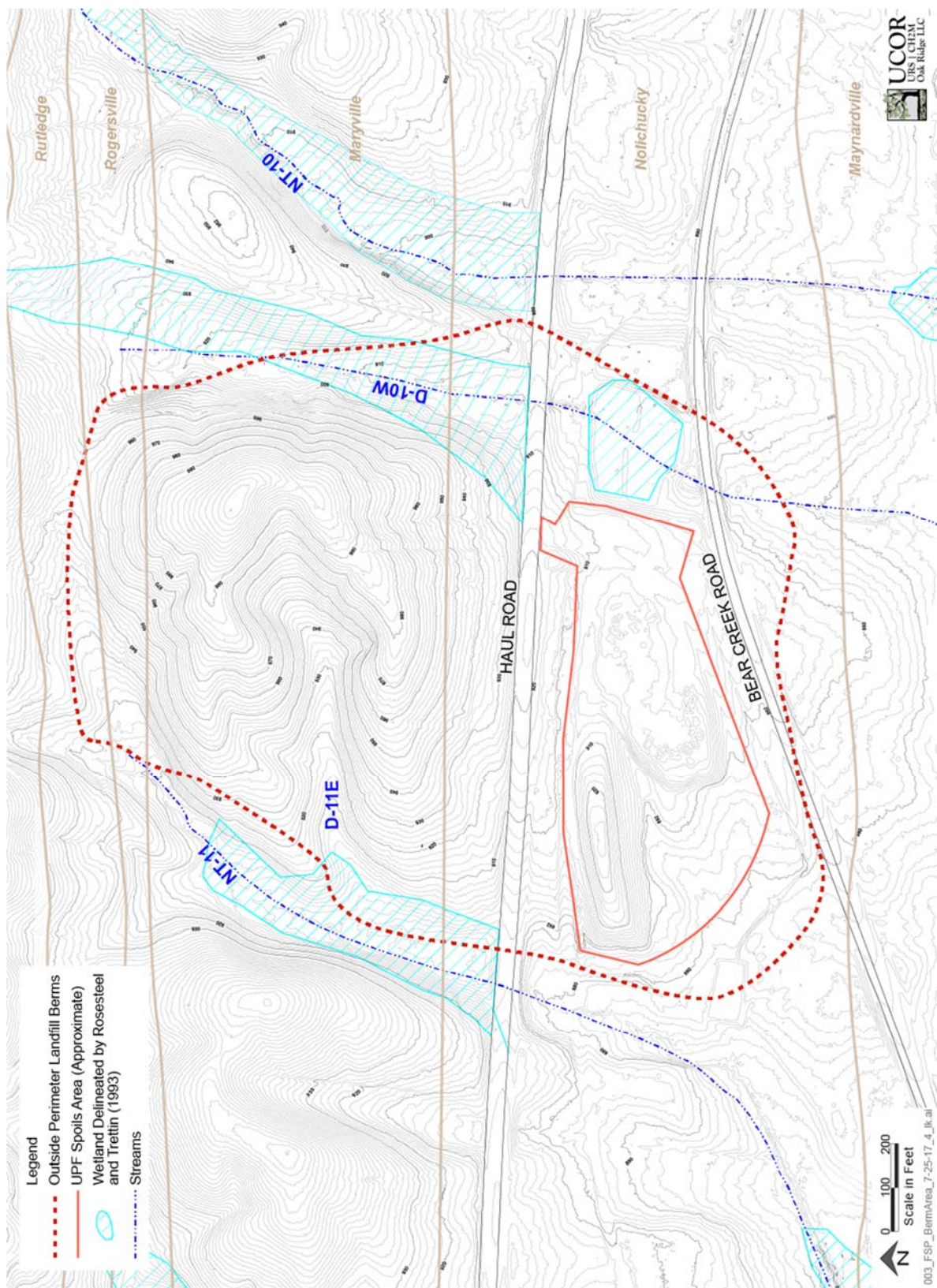


Fig. 2. CBCV site topographic setting.

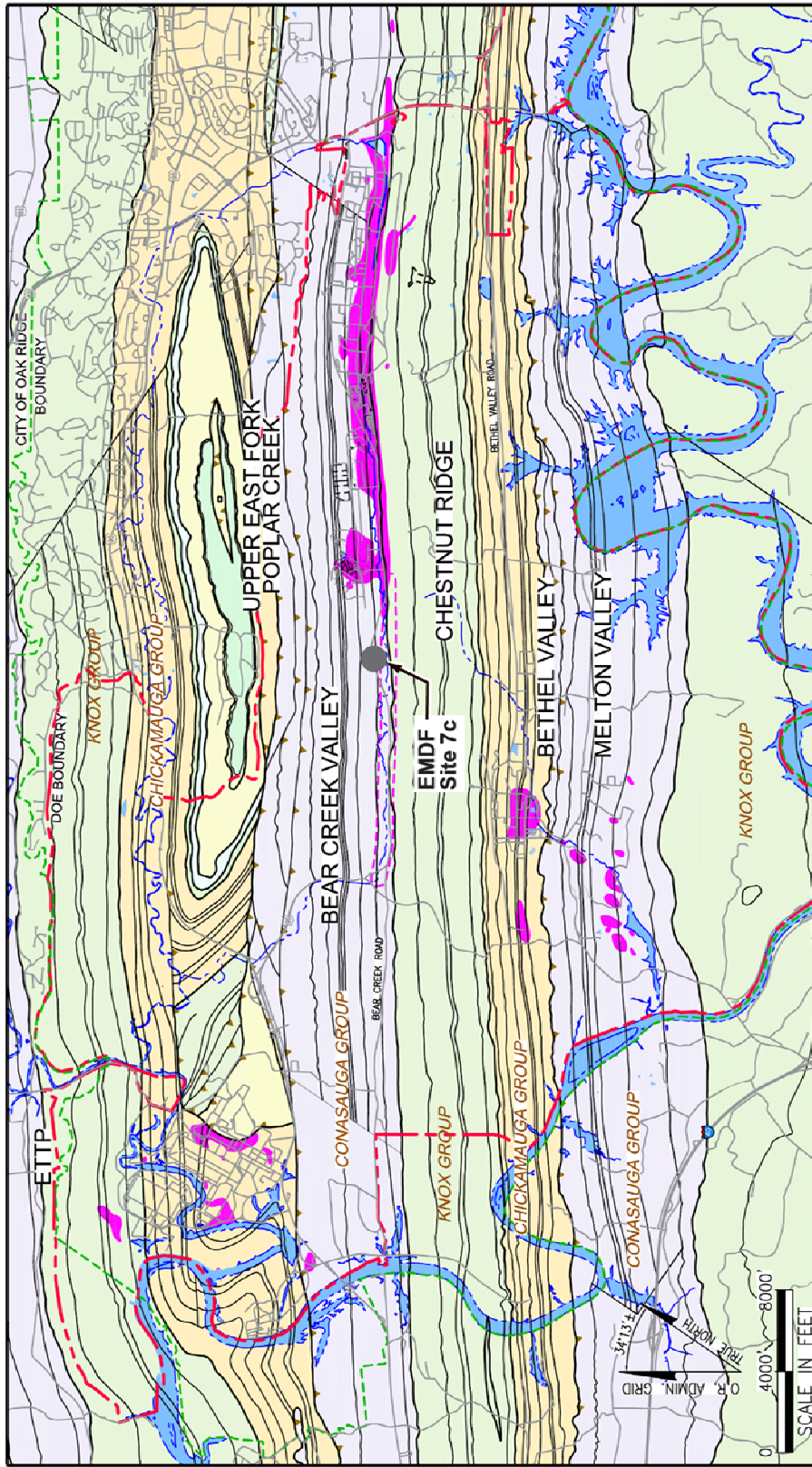


Fig. 3. General geology of the Bear Creek Valley.

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).

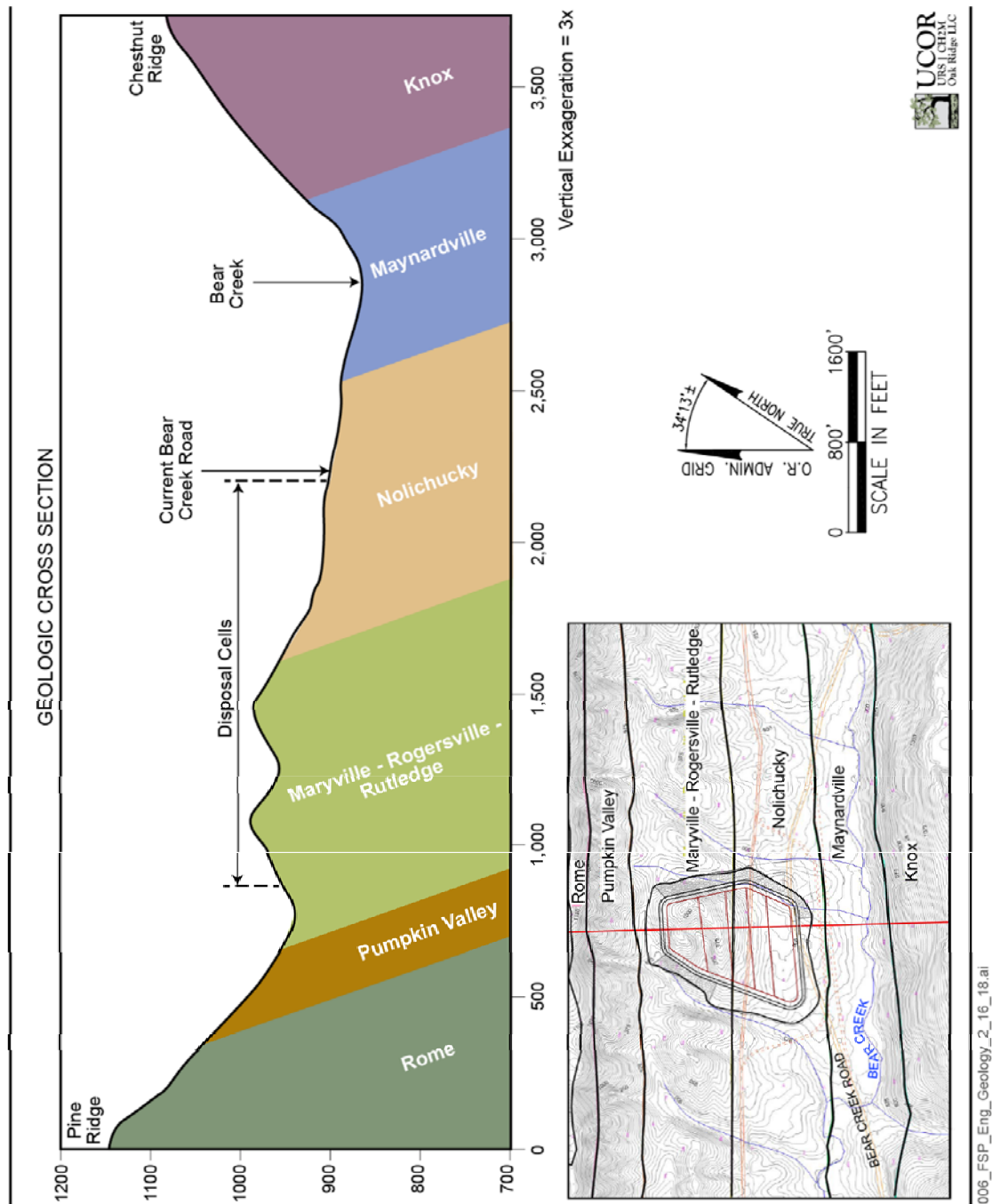


Fig. 4. Generalized cross-section of the CBCV site.

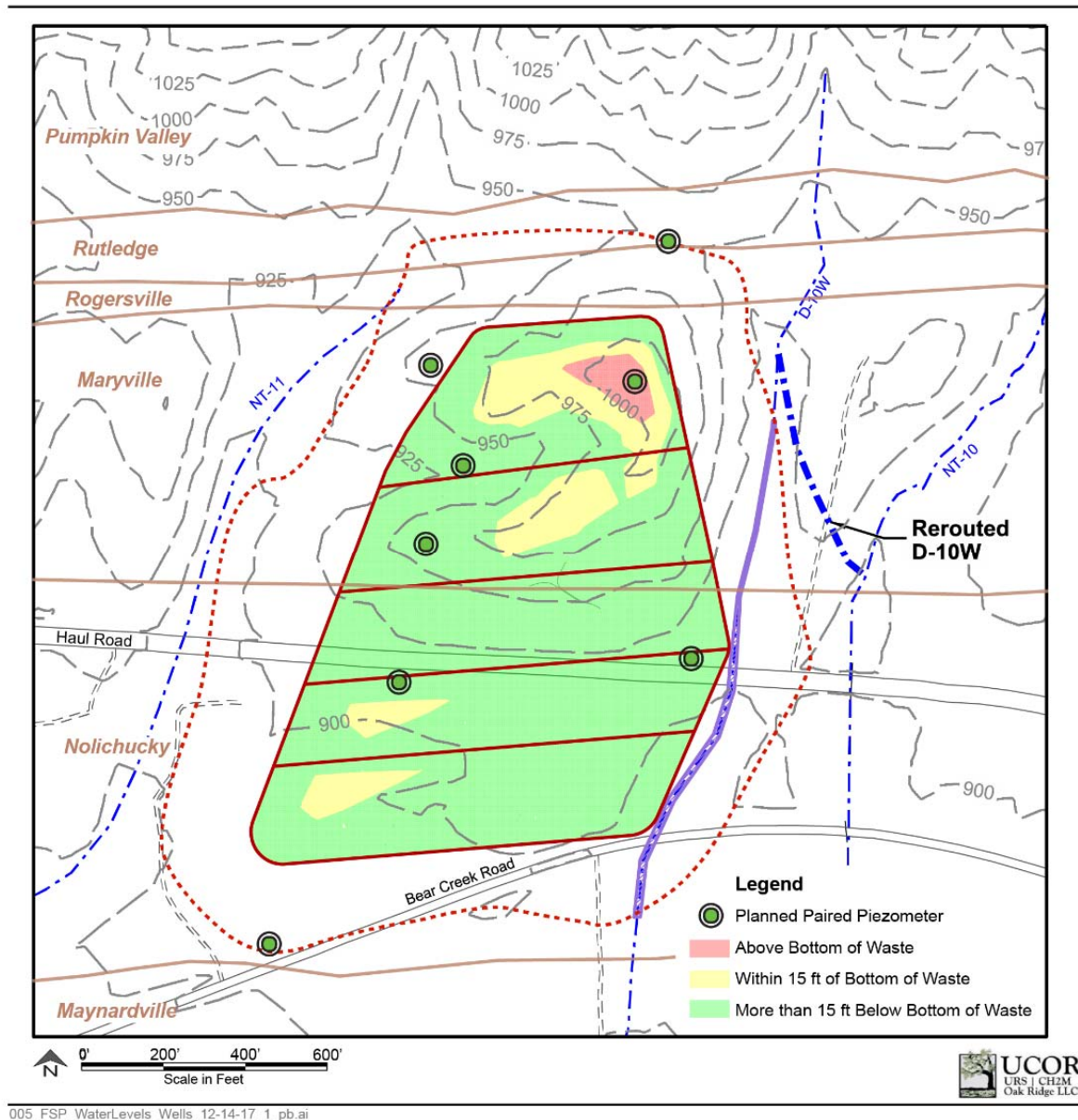


Fig. 5. Projected pre-construction groundwater elevations beneath the EMDF waste cells.

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.

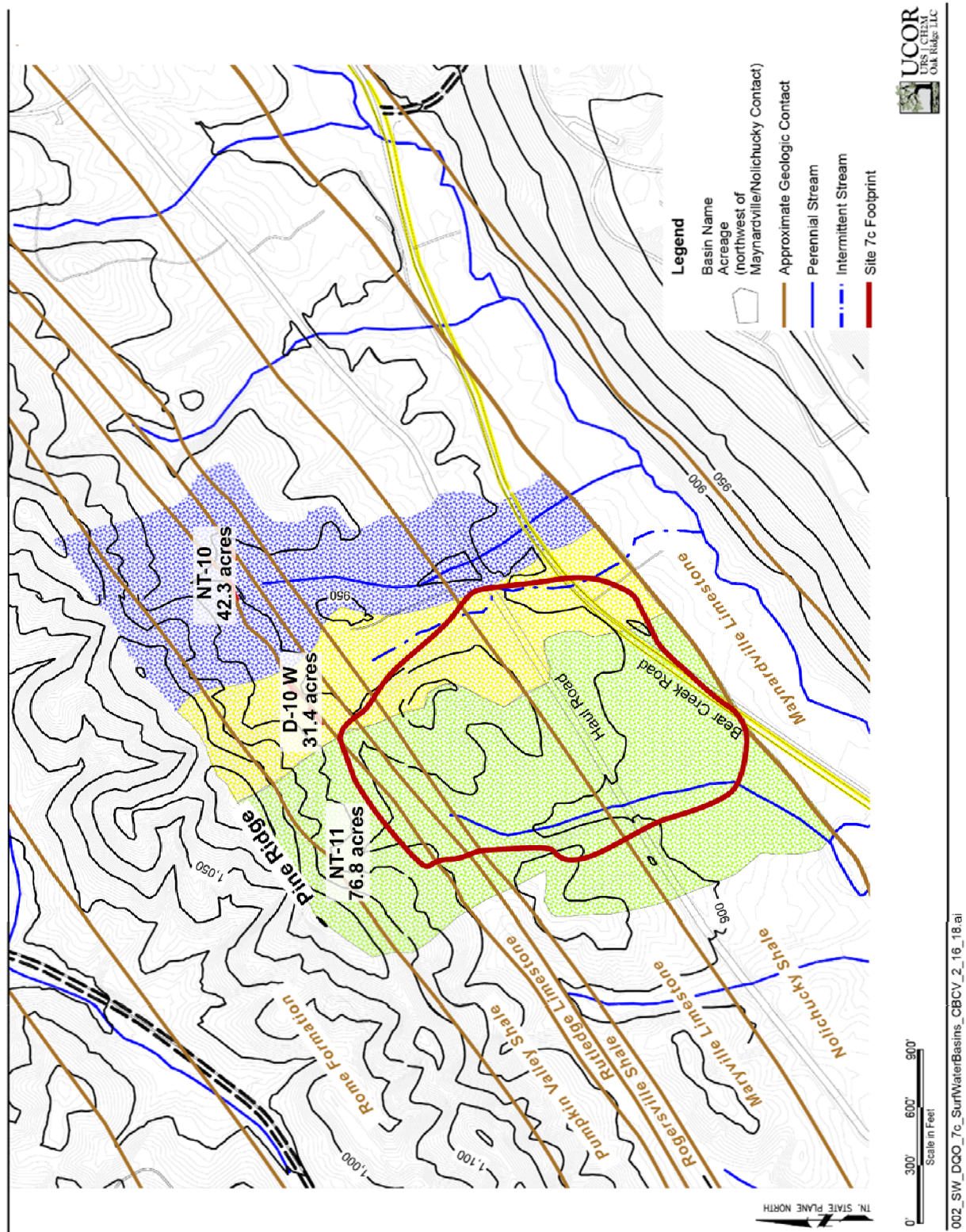


Fig. 6. Surface water capture basins in Central Bear Creek Valley.



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

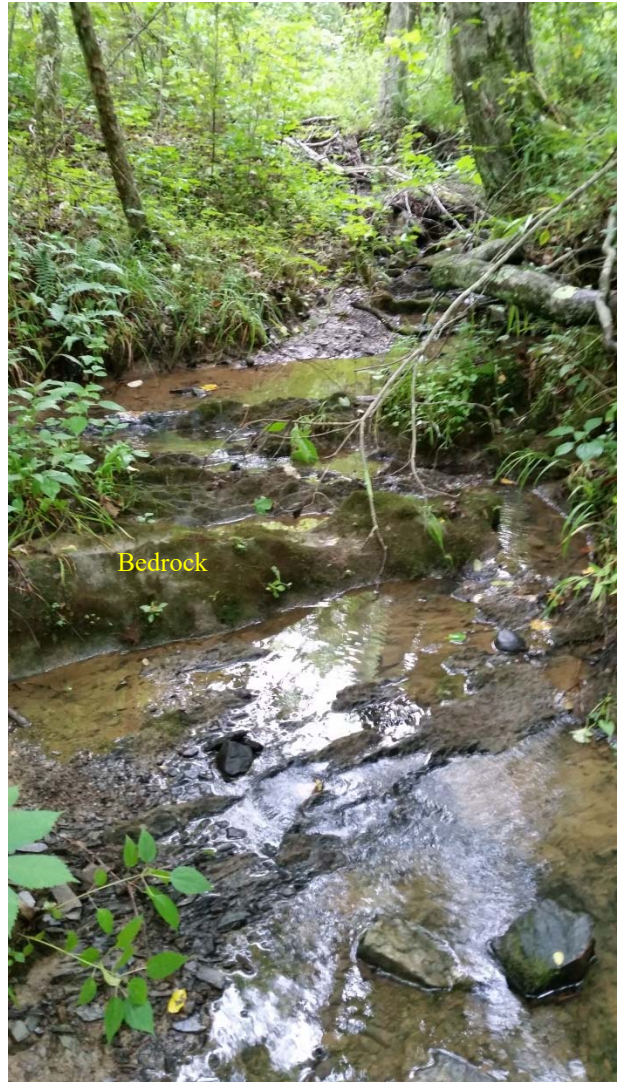


Fig. 8. Nolichucky Shale outcrop in NT-11 stream channel.



Fig. 9. Large macropore channel in soil.

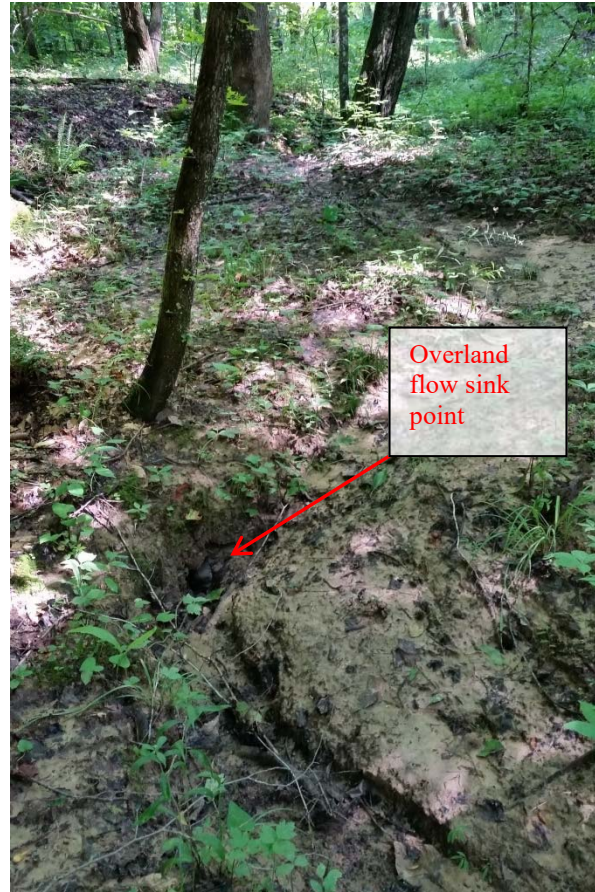


Fig. 10. Overland flow inlet to soil channel.



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.

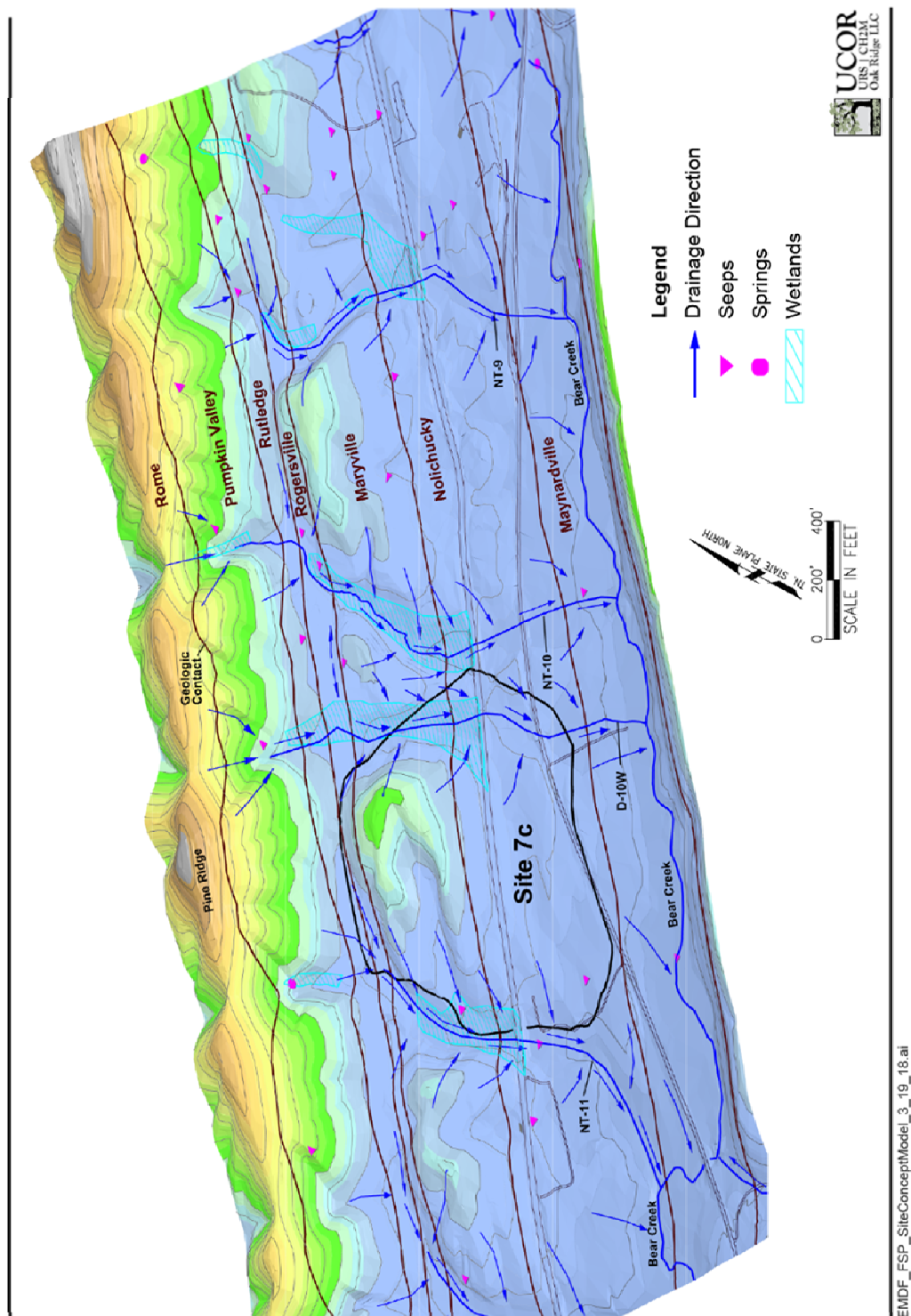


Fig. 12. Generalized flow paths for shallow/intermediate groundwater toward Bear Creek.

3. PROJECT ORGANIZATION

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

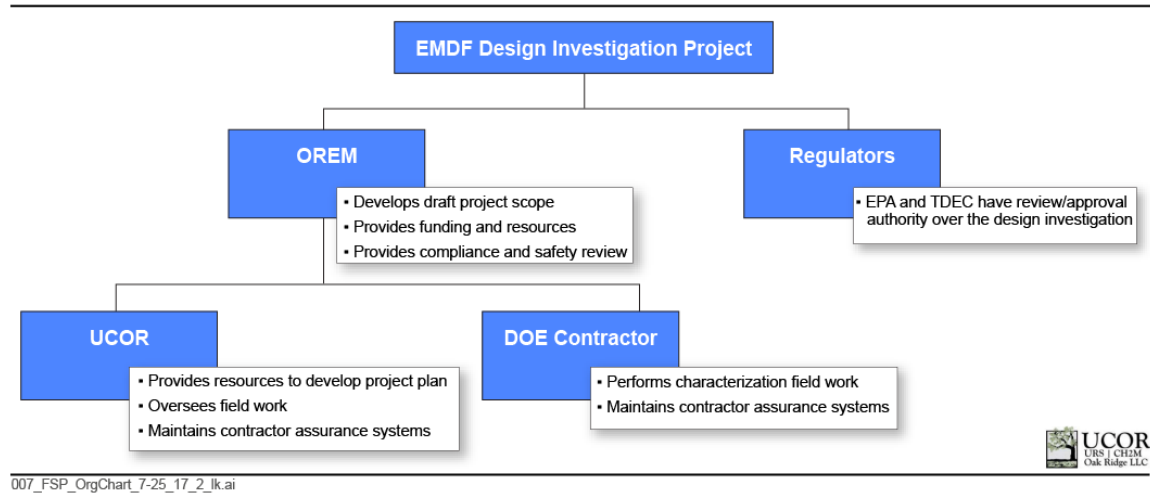


Fig. 13. Project organization.

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)	<p>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?</p> <p>Note: The FS design assumes that groundwater is uncontaminated and may be discharged directly to surface water without treatment.</p>
Identify Inputs to the Decision (to the Design Calculations)	<p>For determining where the seasonal high groundwater table may encroach into the design elevations, the following design information is needed:</p> <ul style="list-style-type: none"> Seasonal high groundwater table (potentiometric surface, piezometric levels, or static groundwater pressures) across the site Adjustment for post-construction conditions <p>For determining the location of the Maynardville Formation sufficiently for the design:</p> <ul style="list-style-type: none"> Bedrock stratigraphy at the surface and beneath the site Field walkdowns to identify contact between the Nolichucky and Maynardville Formations <p>For determining the predicted groundwater elevation and flow to surface water diversions sufficient for the design purposes, the following is needed:</p> <ul style="list-style-type: none"> 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	<p>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).</p> <p>The vertical subsurface boundary extends into the uppermost bedrock below the proposed liner to assess vertical gradients.</p> <p>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.</p>
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.)	<p>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.</p> <p>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.</p> <p>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.</p>
Specify Performance/Acceptance Limits (Error Range)	<p>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.</p> <ul style="list-style-type: none"> • 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. • 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). • 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. <p>Hydraulic conductivities need to be determined within one order of magnitude since the natural variations within the formations are likely high.</p> <p>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.</p> <p>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.</p>
Optimize the Design	<p>The regolith (soils/saprolite) stratigraphy will be characterized within the EMDF design area:</p> <ul style="list-style-type: none"> • 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. • 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. • 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.)	<ul style="list-style-type: none"> • 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). • Piezometer installations will be completed in accordance with UCOR procedures or equivalent. • Water-level measurements will be obtained in accordance with UCOR procedures or equivalent.
<div> <div> 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 </div> <div> FS = Feasibility Study NT = North tributary PCB = polychlorinated biphenyl UCOR = URS CH2M Oak Ridge LLC USCS = Unified Soil Classification System </div> </div>	

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)	<p>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:</p> <ul style="list-style-type: none"> • 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. • 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)	<p>The following design information is needed to determine the design for surface water controls:</p> <ul style="list-style-type: none"> • Surface water capture basin areas, surface water budgets, and potential runoff volumes for NT-10, D-10W, and NT-11 • Location of groundwater seeps, springs, or other sources of groundwater contribution in the channels • Current and predicted groundwater elevations • Site topography and features • 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 • 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	<p>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.</p> <p>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.</p> <p>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.</p>
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	<p>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.</p> <p>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).</p> <p>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.</p>

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)	<p>The following is used to determine the geotechnical characteristics to support the decisions:</p> <ul style="list-style-type: none"> • 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. • Geotechnical properties of bedrock, including bedrock strength, compressibility, interface strength, rock type, fracture size and spacing, and RQD. • Groundwater levels and spatial and temporal variations in the soil and bedrock.
Define the Study Boundaries	<ul style="list-style-type: none"> • 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. • The vertical subsurface boundary extends into bedrock approximately 10–50 ft below the current ground surface.
Develop a Decision Rule	<p>Design criteria include the following:</p> <ul style="list-style-type: none"> • 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. • 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. • 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)	<ul style="list-style-type: none"> • Data collection and analyses shall be as established using the ASTM guidance/test methods provided in Appendix B, Sect. B.5.2. • 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). • 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	<ol style="list-style-type: none"> 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. 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. 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. 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. 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. 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. 7. Laboratory consolidated-undrained triaxial testing will be performed on both recompacted and undisturbed samples (Appendix B, Sect. B.5.2). 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). 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. 10. The number of tests may be adjusted depending on the type and condition of materials encountered and the location of bedrock. 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.)	<ol style="list-style-type: none"> 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. <ul style="list-style-type: none"> • Disturbed samples obtained from auger cuttings and representative of each unique soil type will be selected for testing for compaction and specific gravity. • The number of tests may be adjusted depending on the type and condition of materials encountered and the location of bedrock. 13. Obtain properties of bedrock as follows: <ul style="list-style-type: none"> • Rock type, hardness, weathering, bedding, discontinuities, fracturing, percent core recovery, and RQD will be obtained during core logging and borehole logging. • 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. 14. Sample packaging and shipping will follow the ASTM guidance/test methods provided in Appendix B, Sects. B.5.1 and B.5.2. 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

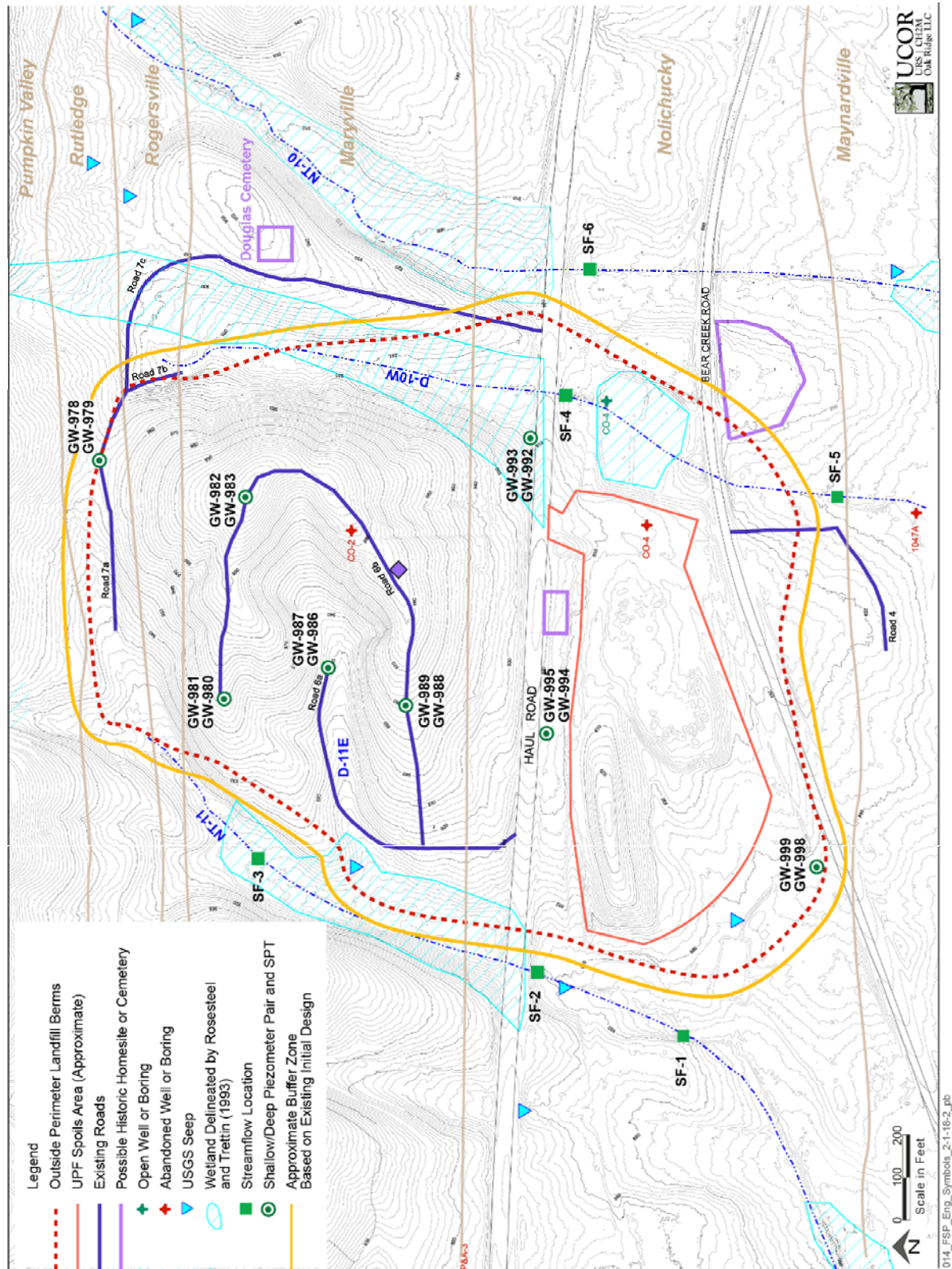


Fig. 14. Approximate Phase 1 measurement and testing locations for CBCV site.

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.)

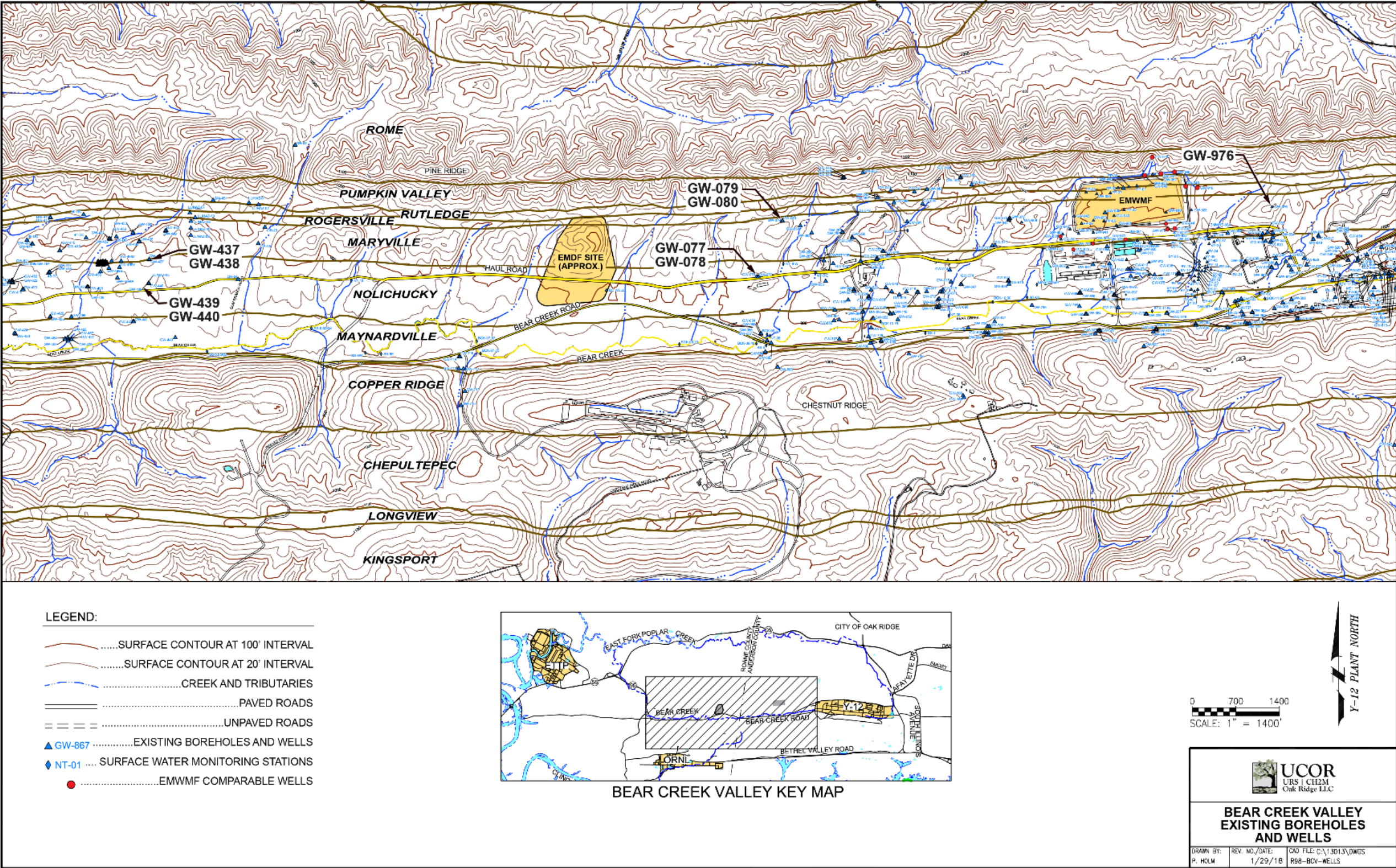
Well No.	Location	Formation	Depth (ft bgs)	Screened interval	Historical data	Frequency/ downhole monitor?	Description of comparable conditions
GW-079	BCBG – west side	Rogersville	60	59.9-64.9	From 1991	2/years	Equivalent to EMDF well cluster on the saddle (GW-978/979), close to EMDF, and similar precipitation 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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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
<i>CFR</i>	<i>Code of Federal Regulations</i>
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.

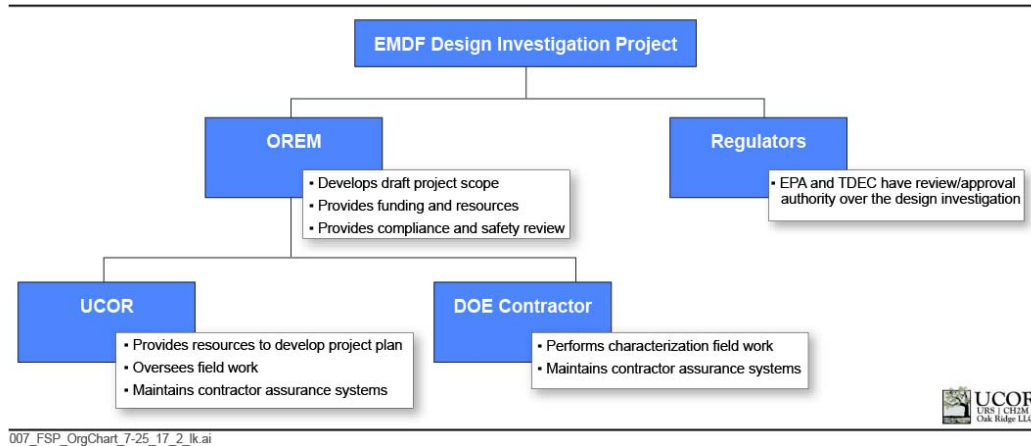


Fig. A.1. Project organization.

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.

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.



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.

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: _____
(Person requesting revision to QAPP)

Date: _____

Approved by: _____
(OREM Landfills Project Manager or authorized designee)

Date: _____

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APPENDIX B.
MEASUREMENT AND TESTING APPROACH AND METHODS

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

^aThe 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	<i>Well Plugging and Abandonment</i> , PROC-ES-2106, latest revision, URS CH2M Oak Ridge LLC, Oak Ridge, TN.

^aThe 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, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i> , 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	<i>Aquifer Testing</i> , PROC-ES-2102, latest revision, URS CH2M Oak Ridge LLC, Oak Ridge, TN.
FLUTe Contractor Manual	Operating manual for specialty contractor performing FLUTe testing.

^aThe 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	<i>Groundwater Level Measurement</i> , PROC-ES-2100, latest revision, URS CH2M Oak Ridge LLC, Oak Ridge, TN.
PROC-ES-2101	<i>Groundwater Sampling Wells or Piezometers</i> , PROC-ES-2101, latest revision, URS CH2M Oak Ridge LLC, Oak Ridge, TN.

^aThe 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	<i>Surface Water Flow Measurements</i> , PROC-ES-2200, latest revision, URS CH2M Oak Ridge LLC, Oak Ridge, TN.

^aThe 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, <i>Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes</i> , ASTM International, West Conshohocken, PA, 2015.	Assume 3 per boring; will be taken in appropriate materials during drilling.
Moisture content	150	ASTM D2216-10, <i>Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass</i> , 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, <i>Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)</i> , 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, <i>Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils</i> , 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, <i>Standard Test Method for Particle-Size Analysis of Soils</i> (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, <i>Standard Test Method for Particle-Size Analysis of Soils</i> (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, <i>Standard Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens</i> , 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, <i>Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer</i> , 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, <i>Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter</i> , 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, <i>Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading</i> , 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, <i>Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils</i> , 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, <i>Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)/ Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN-m/m³), ASTM International, West Conshohocken, PA, 2012.</i>	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, <i>Standard Test Methods for Chloride Ion In Water</i> , ASTM International, West Conshohocken, PA, 2012, or ASSHTO T291, <i>Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil</i> , 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, <i>Standard Test Method for Water-Soluble Sulfate in Soil</i> , 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, <i>Polyethylene Encasement for Ductile-Iron Pipe Systems</i> , 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, <i>Standard Test Method for Measurement of Soil Resistivity Using the Two-Electrode Soil Box Method</i> , 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), <i>Standard Test Method for Measurement of Oxidation-Reduction Potential (ORP) of Soil</i> , 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, <i>Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures</i> , 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, <i>Standard Test Methods for Crosshole Seismic Testing</i> , ASTM International, West Conshohocken, PA, 2014.	

^aThe 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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Comment Resolution Form

Document Number: DOE/OR/01-2739&D1	Document Title: <i>Phase 1 Field Sampling Plan for the Proposed Environmental Management Disposal Facility for Comprehensive Environmental Response, Compensation, and Liability Act, Oak Ridge, Tennessee</i>		
Organization/Project: EPA/EMDF	Comment Due Date: N/A		

Reviewer Initials and Name	CF = Carl R. Froede Jr., P.G.
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Comment No.	Reviewer Initials	Section, Page, Paragraph	Comment/Suggested Change/Rationale	Resolution	Reviewer Concurrence
1.	CF	General	<p>The DOE cover letter transmitting the D1 Field Sampling Plan conveys changes to the D1 document that are consistent with the original expectations of the EPA/TDEC issued <i>Statement of Work to Expedite Groundwater Characterization at Site 7c, Central Bear Creek Valley</i>:</p> <p>A. Modify the frequency of continuous surface water and groundwater measurements to 30-minute intervals (from 1 hour intervals stated in the D1 Field Sampling Plan).</p> <p>B. Clarify the surface water additional walkover effort to include a description every 50 ft (as access allows and is appropriate) and field measurements of temperature, specific conductivity, and pH.</p> <p>C. Regarding the field parameters identified in "B" above, the DOE further clarified:</p> <ol style="list-style-type: none"> Continuous monitoring of groundwater levels and temperature will be conducted. DOE will commit to monitor specific conductivity and pH on a routine, manual basis rather than continuously based on previous difficulties encountered with continuous monitoring of conductivity and on 	<p>A. The Field Sampling Plan (FSP) was modified as stated.</p> <p>B. The FSP was modified as stated.</p> <p>C. After further discussion, it was agreed that specific conductivity and pH are to be collected on a continuous basis. The text was modified to reflect this agreement.</p>	

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			<p>the much higher cost that continuous monitoring of these two parameters would incur.</p> <p>While specific conductivity and pH were originally cited as requiring continuous measurement, the EPA agrees with the DOE to collect these groundwater parameters on a <u>weekly</u> schedule.</p> <p>These changes will need to be made to the revised document.</p>		
2.	CF	Table 1	<p>In Table 1 (Section 4), the problem statement should add wording to indicate that additional contaminants (e.g., volatile organic compounds) also could be present in materials disposed in the EMDF. This comment also has relevance to wording in the "State the Problem" part of Table 1, Table 2, Table 3, and Table 4 on pages 19, 22, 24, and 27.</p>	<p>The following text was added to the description of the proposed EMDF in the problem statements listed in each table:</p> <p><i>"Additional contaminants (e.g., volatile organic compounds) also could be present in materials disposed in the EMDF."</i></p>	
3.	CF	Table 1, pg. 22	<p>The final DQO step for groundwater data acquisition (continuation of Table 1; page 22) indicates that FLUTe testing will be done on bedrock piezometers. Figure 14 shows the locations of proposed deep piezometers (presumably representing bedrock piezometer locations). One location is identified as a "Deep Piezometer/Shallow Well Point" and 12 locations are identified as being "Shallow/Deep Piezometer Pair." The figure shows that an area within the bounds of the "Outside Perimeter Landfill Berms" is lacking any representation by deep or shallow piezometers. This area is roughly defined as the area south of the Haul Road as shown on Figure 1 below.</p> <p>The FSP needs to explain the proposed placement of the shallow and deep piezometers and other test locations shown on Figure 14. The explanation should cover the absence of deep and shallow piezometers in the area shown on Figure 1 below, a lack of deep and shallow piezometers in the vicinity of NT-11, the relatively high density of piezometers in</p>	<p>As agreed to in follow-on discussions, Section 6.1 was modified to include further justification for those sampling locations remaining in the Field Sampling Plan.</p>	

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			the north central part of the proposed landfill area, and the location of piezometers on or near both the northern and southern landfill boundaries with no locations around or along the east and west boundaries.		
4.	CF	App. B, Sect. B.3, pg. B-15,	Table B.4 refers to potential laboratory hydraulic conductivity testing. Some discussion is needed regarding the criteria that will be used to decide whether or not a laboratory hydraulic conductivity test will be done. Within an individual boring, the criteria for selecting a specific zone for laboratory testing needs to be stated. Would there be a single test per location or is there a potential for multiple tests on samples from a location? Sample collection and handling procedures need to be described for earth materials to be laboratory tested for hydraulic conductivity.	<p>The following text was added to the Hydraulic Conductivity section in Section B.3:</p> <p><i>"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."</i></p> <p>Sample collection and handling procedures are described in Appendix A, Section A.5, <i>Sample Collection Procedures</i>. The samples collected for laboratory hydraulic conductivity tests will follow this general approach.</p>	
5.	CF	Table B.5	Referring to Table B.5, ASTM D2434-68 is a withdrawn standard with no replacement. This standard is (or was) probably not appropriate as a method for approximating in-situ hydraulic conductivity of aquifer materials.	ASTM D2434-68 was removed from Table B.5.	
6.	CF	Table B.9	Table B.9 lists a variety of laboratory geotechnical tests to be run on collected soil (and rock?) samples. Sample selection for testing is to be made "... following review of borehole logs and collected samples." The criteria that would be used to select samples for the proposed tests should be described in the Appendix B text.	<p>Section B.5.2 has been revised as follows.</p> <p><i>"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."</i></p>	

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				<i>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, the engineering parameters needed for design, sample quantity and quality, and budget."</i>	

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Document Number: DOE/OR/01-2739&D1	Document Title: <i>Phase 1 Field Sampling Plan for the Proposed Environmental Management Disposal Facility for Comprehensive Environmental Response, Compensation, and Liability Act, Oak Ridge, Tennessee</i>		
Organization/Project: TDEC/EMDF	Comment Due Date: N/A		

Reviewer Initials and Name	TDEC
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Comment No.	Reviewer Initials	Section, Page, Paragraph	Comment/Suggested Change/Rationale	Resolution	Reviewer Concurrence
General Comments					
1.	TDEC	General	<p>As stated in the SOW and pursuant to 40 CFR 761.75(b)(3), OREM must obtain continuous data on water level fluctuations at Site 7c during March/April 2018 and use those data along with water-level and precipitation data collected over longer periods at comparable locations in Bear Creek Valley (BCV) to estimate historical high water table fluctuations at Site 7c.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 3).</p> <p>Section 6.1, Groundwater Evaluation, says that "monitoring will continue for at least one year to ensure seasonal high water levels are captured". TDEC 0400-20-1 1-.17(4)(a) requires a preoperational monitoring program of at least 12 months. TSCA 40 CFR 761.75(b)(3) requires estimating the historical high water table. The SOW required determination of the historical high water table because the historical high water table includes both this year's high water table and past high water tables in determining whether waivers are needed and justifiable.</p> <p>The immediate concern is determining whether there would be a hydraulic connection between the site and standing or flowing surface water and, if so, whether a waiver from this TSCA siting requirement is required and justified. Another</p>	<p>Text was added in Section 6.1.2 as follows:</p> <p><i>"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."</i></p>	

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			<p>immediate concern is determining whether the hydrogeologic unit used for disposal would discharge groundwater to the surface within the disposal site and, if so, whether a waiver from this siting requirement is required and justified.</p> <p>FSP Table 1 also states "If the predicted post-construction groundwater table is above the geologic buffer, then the design elevation must be increased or a French drain or other groundwater control system must be included in the design ... If the predicted post-construction groundwater elevations and flows using the planned French drains are insufficient to lower the groundwater table to this allowable level ..." (text bolded for emphasis). French drains as specified here would provide hydraulic connection between the site and standing or flowing surface water and would discharge groundwater to the surface within the disposal site. Use of French drains as specified here would require ARAR waivers that must be justified.</p> <p>Section 6.1 says that "EMWMF [Environmental Management Waste Management Facility] piezometer data will be used to predict groundwater elevations at the CBCV [site] by noting the magnitude of the change during wet season, and applying a similar factor to EMDF piezometer readings." Analyses of March and April 2018 data will be required to determine whether piezometer data from other BCV locations may be comparable to Site 7c. Further, EMWMF piezometers are newly instrumented and will not characterize the historical high water table. In order to estimate historical high water levels, the FSP should specify that OREM will identify monitoring wells and piezometers in BCV which have or previously had continuous water level monitoring data, the time period such data was collected, the topographic and geologic environment for each monitoring well and piezometer, and the rationale for whether OREM considers the monitoring well or piezometer comparable with piezometers installed at Site 7c. Continuous water level monitoring intervals should be compared with annual rainfall to determine whether</p>	<p>The text in Table 1 and elsewhere has been modified to remove the reference to French drains.</p> <p>Table 6 was added that provides the specific wells in Bear Creek Valley that have been identified for groundwater elevation monitoring, including the EMDF Site 5 piezometers that were continuously monitored for one year. The available monitoring data, topographic and geologic environment and rationale are listed in the new Table.</p>	

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			each data collection period related to drought, normal precipitation, or above-average rainfall. OREM should also consider making the FSP more specific. For example, it might indicate that OREM will overlap graphs from Site 7c and other BCV locations to support decisions regarding whether the locations are comparable and what constitutes a "similar factor".		
2.	TDEC	General	<p>OREM must demonstrate that BCV wells used to support an estimate of historical high water table fluctuations at Site 7c are comparable to Site 7c piezometers.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 3).</p> <p>Analyses of March and April 2018 data will be required to determine whether 2018 wet season piezometer or monitoring well data in BCV may be comparable to Site 7c. This is a different question than identification of the historical high water table. Also, see discussion in General Comment 1.</p> <p>The FSP must specify which wells OREM will use, including depths, screen lengths, geologic formations, and any other information needed to demonstrate that the BCV wells/piezometers are comparable to the planned locations at Site 7c.</p> <p>Site 5 well pair GWM-3 appear to be located on a knob in a similar geologic environment to Site 7c. OREM monitored water levels continuously during the Site 5 phase 1 investigation and should resume monitoring at the GWM-3 well pair unless that effort is already underway.</p> <p>TDEC staff are optimistic that OREM can identify comparable wells/piezometers in BCV with an adequate combination of recent continuous records to characterize short-term fluctuations and older manual measurements to characterize historical seasonal/annual fluctuations. However, OREM must demonstrate that the wells proposed</p>	<p>Table 6 has been added to provide the evaluation of Bear Creek Valley piezometers to determine whether these are comparable to Site 7c piezometers. Table 6 includes depths, screen lengths, geologic formations, and additional information for each selected piezometer.</p> <p>GW-976 was installed as part of the Site 5 investigation and is one of the selected piezometers now presented in Table 6. As noted, this is located on a knob in a similar geologic environment.</p>	

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			for use are comparable and that it has a plan for using data from those wells along with rainfall data to help estimate historical high water table fluctuations at Site 7c.		
3.	TDEC	General	<p>Document precipitation recorded at stations monitored by operations personnel at the Environmental Management Waste Management Facility (EMWMF).</p> <p>The FSP meets this data collection requirement identified in the SOW (page 3). No revision is required.</p> <p>There is a statement in Table 1 that OREM will use precipitation data from EMWMF for long-term monitoring of precipitation.</p>	No changes to the FSP are required.	
4.	TDEC	General	<p>Collect data during drilling and after piezometer installation to understand hydraulic properties (e.g., hydraulic conductivity) relative to the lithology and water bearing/transmission zones within the soil and rock underlying the site.</p> <p>The FSP meets this data collection requirement identified in the SOW (page 3). No revision is required.</p> <p>There are statements in Table 1 Section 6.1 indicating that OREM will collect lithologic and hydraulic conductivity data during and after piezometer installation.</p>	No changes to the FSP are required.	
5.	TDEC	General	<p>Demonstrate how groundwater moves through the site and discharges to the ground surface and surface water, including geotechnical characteristics of natural materials at the site (e.g., horizontal and vertical hydraulic conductivity values).</p> <p>The FSP meets this data collection requirement identified in the SOW (page 3). No revision is required.</p> <p>There is a statement in Table 1 identifying horizontal and vertical hydraulic conductivity as decision inputs.</p>	No changes to the FSP are required.	
6.	TDEC	General	<p>Collect, during drilling of the borings for piezometer installation, standard penetration test (SPT) data.</p> <p>The FSP meets this data collection requirement identified in</p>	No changes to the FSP are required.	

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			the SOW (page 3). No revision is required. Tables 3 and 4 indicate that SPT data will be collected in the deeper boring at each paired piezometer location.		
7.	TDEC	General	Use split spoons and Shelby tubes (or equivalent equipment) to log and sample soils and saprolite continuously throughout the deepest boring at each paired piezometer location. Revise the FSP to reflect this data collection requirement identified in the SOW (page 3). Tables 1, 3, and 4 indicate that residuum core samples will be collected in the deeper boring at each paired piezometer location. However, the FSP must state that soil/saprolite will be logged continuously or clarify any rationale for logging only discrete intervals.	Table 1 was revised as follows: <i>"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."</i> Table 4 (now Table 3) was revised to indicate saprolite and bedrock core would be collected.	
8.	TDEC	General	Describe the material with sufficient detail to identify lithology, chert lenses, fractures, relic bedding, moisture and other features that may bear or transmit water. Revise the FSP to reflect this data collection requirement identified in the SOW (page 3). The FSP must specify OREM will describe all geologic materials (soil, saprolite and bedrock) sufficiently to identify lithology, chert lenses, fractures/voids, relic bedding, moisture and other features that may bear or transmit water.	Section B.2 was revised to state: <i>"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)."</i>	
9.	TDEC	General	Select intervals for geotechnical samples (e.g., horizontal and vertical hydraulic conductivity values) based on observed characteristics. Clarify how D2 FSP meets this data collection requirement identified in the SOW (page 3). In the D1 FSP, Table 4 indicated that geotechnical data would be gathered from geotechnical borings, test pits, and hydrogeological and seismic borings. However, some of	Section B.3 was modified to state: <i>"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</i>	

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			that language has been deleted from the table, which is Table 3 in the D2 FSP.	<p><i>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."</i></p> <p>The Phase 1 FSP fulfills the requirements of the SOW. Scope previously included in the FSP that is not identified in the referenced SOW will be performed in the Phase 2 investigation.</p>	
10.	TDEC	General	<p>Core any bedrock drilled with detailed observations to identify, quantify, and describe areas of fracturing, bedding, dissolution and other features that may transmit water.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW.</p> <p>The FSP indicates that bedrock will be cored to depths of approximately at least 10 feet below the top of bedrock (Tables 1 and 3) at multiple locations (Table 4). However, the FSP must specify that the core samples will be described in detail to identify, quantify, and describe areas of fracturing, bedding, dissolution and other features that may transmit water.</p>	<p>Section B.2 was revised to state:</p> <p><i>"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)."</i></p>	
11.	TDEC	General	<p>Screen piezometers at depths that contain groundwater, based on information and observations made during drilling.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 3).</p> <p>The FSP indicates on page B-15 that the screen setting shall be determined based on lithology, the interception of or lack of fractures, and the location of hydrogeological unit contacts. Revise this statement to clarify that the screen setting shall be at depths where groundwater is encountered, based on the interception of water-bearing fractures and other observations made during drilling.</p>	<p>Section B.3 was revised to state:</p> <p><i>"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."</i></p>	

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12.	TDEC	General	<p>Survey horizontal position and ground surface at each piezometer within 0.1 foot and top-of-casing elevation within 0.01 foot.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>The FSP must include a statement indicating that a Tennessee-licensed land surveyor will survey the horizontal position and ground surface elevation at each piezometer within 0.1 foot and the top-of-casing elevation of each piezometer within 0.01 foot.</p>	<p>Section 6 has been modified to state:</p> <p><i>"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."</i></p>	
13.	TDEC	General	<p>Instrument each piezometer to record hydraulic head (water level), temperature, conductivity, and pH at intervals of at least every 30 minutes.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>In accordance with OREM's October 4, 2017 transmittal letter for the D2 FSP, OREM did modify the frequency of continuous groundwater measurements to 30-minute intervals for groundwater levels and temperature. However, Section 6.1 of the FSP says that conductivity and pH will be measured only twice bi-weekly for four weeks.</p> <p>The October 4, 2017 transmittal letter for the D1 FSP states that OREM will measure conductivity and pH manually because of difficulties and higher cost associated with continuous monitoring of these parameters. TDEC staff believe there is a benefit to measuring these parameters on a continuous basis. Even if the data are not perfectly accurate, the rate of change in values for these parameters over relatively short time intervals can provide valuable semi-quantitative information regarding interactions among precipitation, surface water, and groundwater. Such changes cannot be characterized with daily or weekly measurements.</p>	<p>Section 6.1.1 has been revised to state:</p> <p><i>"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."</i></p>	

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14.	TDEC	General	<p>Collect the data described above from the following locations:</p> <ul style="list-style-type: none"> • GW-978/GW-979 • GW-982/GW-983 • GW-986/GW-987 • GW-988/GW-989 • GW-992/GW-993 • GW-994/GW-995 • GW-998/GW-999 <p>The FSP meets this data collection requirement identified in the SOW (page 4). No revision is required.</p> <p>These locations are included in FSP tables titled "Summary of subsurface sample collection location"; "Groundwater level, location specific target depths and tests"; and "Summary of subsurface sample collection locations". These locations are also listed in Figures 5 and 14.</p>	No changes to the FSP are required.	
15.	TDEC	General	<p>Estimate the buffer zone boundary which shall not overlie the karstic Maynardville Limestone or its contact with the Nolichucky Shale.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>The FSP includes numerous references to the geologic buffer that would underlie the proposed landfill, but it must also present an estimated boundary for the horizontal buffer zone around the proposed facility. A horizontal buffer zone is critical to reduce the threat of contaminating groundwater in the karstic Maynardville Limestone and to facilitate the detection and remediation of contaminants released to groundwater before they reach that sensitive groundwater unit. Definition of the buffer zone boundary is also critical for satisfying several requirements presented on pages 4 and 5 of the SOW, as reiterated below.</p> <p><i>"The July 20th map (attached) does not identify the boundary of the <u>buffer zone</u> required for monitoring and potential future corrective action. DOE must estimate</i></p>	<p>Section 6.1.1 and Figure 14 were revised to include a buffer zone. Text added to Section 6.1.1 is as follows:</p> <p><i>"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.'</i></p> <p><i>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)."</i></p>	

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			<p><i>the <u>buffer zone</u> boundary which shall not overlie the karstic Maynardville Limestone or its contact with the Nolichucky Shale. [Footnote 2: DOE must identify the Nolichucky-Maynardville contact based on field observations that do not rely on regional geologic maps. It is particularly important to identify locations where the contact underlies any portion of the site, including locations where the contact crosses streams that flow through the site/buffer.] DOE shall measure the flow of surface water using standard flumes or weirs where any stream (e.g., NT-10, D-10W, and NT-11) enters and leaves the <u>buffer zone</u>. For streams originating within the site/buffer area, spring discharge or stream flow shall be measured as close as possible to the spring/seep zone.... DOE must engage a Qualified Hydrologic Professional [QHP] in accordance with TDEC 0400-40-17 to walk the site area, including the <u>buffer zone</u>, during the wet season and identify locations of springs and seeps. For any spring or seep where it is practical, DOE must measure flow, temperature, conductivity, and pH.</i></p> <p><i>DOE must evaluate NT-10, D-1 OW, and NT-11 at intervals of 50 feet or less within the disposal site including <u>buffer zone</u> by describing stream sections, including any observed springs or seeps, and measuring temperature, conductivity, and pH....</i></p> <p><i>This SOW assumes that neither the disposal area nor the associated <u>buffer zone</u> overlies the Maynardville Limestone or the Maynardville-Nolichucky contact. If any portion of the disposal area or buffer zone overlies the Maynardville Limestone or its contact with the Nolichucky shale, additional site characterization will be required to demonstrate compliance with additional ARARs [Applicable or Relevant and Appropriate Requirements] complicated by groundwater movement in a karst environment."</i></p>		
16.	TDEC	General	Identify the Nolichucky-Maynardville contact based on field observations that do not rely on regional geologic maps.	Table 1 was revised to state: "Field walkdowns to identify contact	

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			<p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>The FSP includes numerous references to the Nolichucky-Maynardville contact, but it must state explicitly that the contact will be identified based on field observations rather than relying on regional geologic maps like those on Figures 2 through 6. This is important because, as stated in footnote 2 on page 4 of the SOW, TDEC expects OREM to identify locations where the Nolichucky-Maynardville contact underlies any portion of the site, including locations where the contact crosses streams that flow through the site/buffer.</p> <p>Table 1 identifies that a principal study question is: "<i>Where is the Maynardville contact and does it underlie a buffer zone surrounding the landfill?</i>" Table 1 also identifies bedrock stratigraphy as a decision input for determining "<i>the location of the Maynardville Formation</i>". However, it is not clear how OREM proposes to identify the Nolichucky-Maynardville contact based on field observations.</p> <p>Section 6.1, Groundwater Evaluation, says: "<i>The piezometer along the southern boundary of the disposal cell berms will provide downgradient groundwater elevations and will help locate the contact with the Maynardville Limestone.</i>" Regional geologic mapping like that shown on Figure 14 suggest that the southernmost piezometer location is not likely to intersect the Maynardville Limestone, which dips (slopes) southeastward away from that location as shown on Figure 4.</p>	<p><i>between the Nolichucky and Maynardville Formations"</i></p> <p>The phrase "<i>and will help locate the contact with the Maynardville Limestone.</i>" was deleted.</p>	
17.	TDEC	General	<p>Measure the flow of surface water using standard flumes or weirs where any stream (e.g., NT-10, D-10W, and NT-11) enters and leaves the buffer zone.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>The FSP (Table 2) states that OREM will monitor surface</p>	<p>Section 6.2.2 was revised as follows:</p> <p><i>"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</i></p>	

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			water flow in the lower reaches of NT-10 and NT-11, including a second location along NT-11 south of the Haul Road, and two locations in D-10W. The locations described may be acceptable depending on how OREM defines the horizontal buffer zone. However, the number and/or locations of surface water monitoring stations may need to be revised, particularly for NT-10 and NT-11, to satisfy the SOW requirement. Just like groundwater level monitoring, OREM must characterize wet season stream conditions and continue data collection at least through the ROD.	<p><i>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.</i></p> <p><i>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."</i></p>	
18.	TDEC	General	<p>Measure spring discharge or stream flow for streams originating within the site/buffer area.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>The FSP (Table 1) states, "<i>D-11E drainage will be covered by the landfill and does not require a flow evaluation.</i>" TDEC does not agree because OREM has provided no data to indicate that groundwater discharge to D-11E will cease as a result of landfill construction. The FSP must state that flow and discharge will be measured along D-11E (shown on Figure 14) and any springs identified during the site walkovers along D-11E. Collection of this characterization information is critical for assessing the currently assumed landfill footprint.</p>	<p>The following text was added to Section 6.2.2:</p> <p><i>"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."</i></p>	
19.	TDEC	General	<p>Establish downstream gaging stations locations on the Nolichucky Shale, not the Maynardville Limestone.</p> <p>The FSP meets this data collection requirement identified in the SOW (page 4). No revision is required.</p>	No changes to the FSP are required.	

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			Table 2 and Section 6.2.2 state that OREM will place surface water flow measurement stations in the Nolichucky Shale outcrop areas in the lower reaches of NT-10 and NT-11.		
20.	TDEC	General	<p>Instrument each stream gaging station to record discharge (flow), temperature, conductivity, and pH at intervals of at least every 30 minutes.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>In accordance with OREM's October 4, 2017 transmittal letter for the D2 FSP, OREM did modify the frequency of continuous surface water measurements to 30-minute intervals for flow and temperature. However, Section 6.2.2 of the FSP says that conductivity and pH will be measured only twice-bi-weekly for four weeks.</p> <p>The October 4, 2017 transmittal letter for the D1 FSP states that OREM will measure conductivity and pH manually because of difficulties and higher cost associated with continuous monitoring of these parameters. TDEC staff believe there is a benefit to measuring these parameters on a continuous basis. Even if the data are not perfectly accurate, the rate of change in values for these parameters over relatively short time intervals can provide valuable semi-quantitative information regarding interactions among precipitation, surface water, and groundwater. Such changes cannot be characterized with daily or weekly measurements.</p>	<p>Section 6.2.2 was revised as follows:</p> <p><i>"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)."</i></p>	
21.	TDEC	General	<p>OREM must engage a Qualified Hydrologic Professional (QHP) in accordance with TDEC 0400-40-17 to walk the site area, including the buffer zone, during the wet season and identify locations of springs and seeps.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p>	<p>Section 6.2.1 was revised as follows:</p> <p><i>"A qualified hydrologic professional (TDEC 2011) will participate in the walkovers."</i></p>	

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			<p>During the autumn of 2017, TDEC offered the services of a staff QHP to support the stream characterization, and OREM accepted the offer.</p> <p>Subsequently, on January 10, 2018, OREM notified TDEC by email that a QHP from Oak Ridge National Laboratory (ORNL) will support the effort, along with a hydrogeologist with extensive experience on the ORR. This is consistent with the SOW and needs to be documented in the revised FSP.</p>		
22.	TDEC	General	<p>Measure flow, temperature, conductivity, and pH at each spring/seep.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>The FSP (Sections 6.2.1 and 6.2.2) states that electrical conductivity measurements will be performed to determine the potential influence from groundwater. The FSP must clarify that OREM will measure flow, temperature, conductivity, and pH at each spring/seep in addition to every 50 feet along the streams.</p>	<p>Section 6.2.1 was revised as follows:</p> <p><i>"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)."</i></p>	
23.	TDEC	General	<p>Evaluate NT-10, D-10W, and NT-11 at intervals of 50 feet or less within the disposal site including buffer zone by describing stream sections, including any observed springs or seeps, and measuring temperature, conductivity, and pH twice during the wet season and twice during the dry season.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 4).</p> <p>There are statements in Table 2 and Section 6.2.1 that OREM will identify seeps, springs, and other expressions of shallow groundwater during a wet-season (December-April) site walkover.</p> <p>However, in accordance with the SOW and OREM's October 4, 2017 transmittal letter for the D1 FSP, revise the FSP to reflect OREM's commitment to complete at least</p>	<p>Section 6.2.1 was revised as follows:</p> <p><i>"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"</i></p>	

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			<p>two site walkovers during the wet season and two during the dry season to describe conditions. Also, clarify in Section 6.2.1 that the site walkovers OREM plans to complete southeast of the Haul Road are part of (not in lieu of) the walkovers to characterize conditions along NT-10, D-10W and NT-11.</p> <p>Finally, for consistency with the SOW, delete the phrase "as access allows and is appropriate" or clarify its meaning in Table 2 and Section 6.2.1. TDEC staff understand short reaches of the streams are in culverts under roadways, and description/measurement locations may be adjusted accordingly.</p>	<p>(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 walkdowns in May and June. Additionally, two dry season walkovers will be performed during September/October 2018 and documented in the Technical Memorandum 2."</p>	
24.	TDEC	General	<p>Perform additional site characterization to demonstrate compliance with additional ARARs complicated by groundwater movement in a karst environment if any portion of the disposal area or buffer zone overlies the Maynardville Limestone or its contact with the Nolichucky shale.</p> <p>Revise the FSP to reflect this data collection requirement identified in the SOW (page 5).</p> <p>As discussed in General Comment 15, the FSP must present an estimated boundary for the horizontal buffer zone around the proposed facility. The FSP must also indicate whether any portion of the proposed disposal area or buffer zone overlies the Maynardville Limestone or its contact with the Nolichucky shale. Finally, in accordance with the SOW, the FSP must acknowledge that OREM will work with TDEC and EPA to scope additional characterization to demonstrate ARARs if any portion of the disposal area or buffer zone overlies the Maynardville Limestone or its contact with the Nolichucky shale.</p>	<p>As shown on Figure 14, neither the disposal area nor the buffer zone overlies the Maynardville limestone or the contact with the Nolichucky shale.</p> <p>The estimated boundary of the horizontal buffer zone has been added to Figure 14 as described in the response to General Comment 15.</p>	
Specific Comments					
1.	TDEC	Sect. 1	<p>"This Field Sampling Plan identifies the initial site characterization activities (Phase 1) that have been agreed to by the FFA parties to be included in the Administrative</p>	<p>Section 1 was revised to include the following:</p>	

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			<p><i>Record prior to the public comment period on the preferred EM DF alternative. Additional investigations will be conducted in the future Longer-term monitoring of groundwater and surface water...are not within the scope of this Field Sampling Plan."</i></p> <p>Revise the FSP to clarify how OREM will comply with the following agreement identified in the DRA (item 3): <i>"The FSP shall reflect mutual agreement of the parties to implement data collection identified in the "Statement of Work" provided by EPA and TDEC for Site 7C. The results and analysis of the field investigation in accordance with the FSP shall be included in the administrative record and the Proposed Plan public comment period shall be provided thereafter. This field investigation and EPA/TDEC's review of the results thereof shall be conducted prior to execution of the Record of Decision (ROD) and shall be used in selecting the remedy."</i></p> <p>The FSP proposes to implement only a very limited "initial" characterization effort. It does not explain how OREM will fully implement data collection identified in the SOW to comply with the agreement.</p>	<p><i>"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).</i></p> <p><i>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</i></p>	

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				<i>timeframe and documented in Technical Memorandum 2."</i>	
2.	TDEC	Sect. 2.3.2	Revision of the section title from "Initial Investigation" in the D1 to "Preliminary Investigation" in the D2 is not consistent with the text inserted in Section 1: <i>"This Field Sampling Plan identifies the initial site characterization activities (Phase 1)..."</i> . What distinction is made by changing "Initial" to "Preliminary"? Regardless, revise the FSP to clarify how OREM will comply with the DRA if this FSP only proposes to implement an "initial" or "preliminary" characterization effort.	This section describes a site walkover conducted in advance of FSP development to guide investigation activities and does not include any activities described in the SOW. It was relabeled as "Preliminary" to avoid confusion with the SOW activities.	
3.	TDEC	Table 1	<i>"If the predicted post- construction groundwater table is above the geologic buffer, then the design elevation must be increased or a French drain or other groundwater control system must be included in the design."</i> It has not been demonstrated that the site would meet CERCLA threshold criteria, if the predicted post-construction groundwater table requires French drains to lower the water table below the geologic buffer.	The text in Table 1 was revised as follows to remove the French Drain as a remedy: <i>"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."</i> <i>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."</i>	
4.	TDEC	Table 1	<i>"Locations of new water level measurement locations are shown in Fig. 14."</i> Locations of existing water-level measurement locations should also be shown on a map. As noted by an OREM representative on December 12, 2017, the FSP must state clearly how data will be evaluated. OREM's use of water-level data from existing wells/ piezometers in BCV will be critical to the evaluation.	Figure 15 has been added to the Field Sampling Plan to provide the locations of the existing Bear Creek Valley wells and piezometers that will be used in the evaluation.	
5.	TDEC	Sect. 5	<i>"However, the following sequence is anticipated for Phase 1 work...."</i> The schedule in Section 5 of the FSP indicates that data	Section 5 was revised in consultation with EPA and TDEC and now reflects mutual agreement on the text and schedule.	

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			collection will be limited to a period of four weeks or less at the end of the 2017-2018 winter wet season. This is not consistent with the SOW and the DRA. Multiple tasks are scheduled very generally as <i>"Spring 2018,"</i> indicating that OREM will collect little or no data during the winter wet-season. Revise the FSP to explain how OREM will comply with the DRA and SOW.		
6.	TDEC	Sect. 5	<i>"Monitoring (following piezometer installation) for 4 weeks".</i> Data collection limited to a period of four weeks or less at/following the end of the 2017-2018 winter wet season is not consistent with the SOW and the DRA. Revise the FSP to comply with the DRA and SOW.	Section 5 was revised in consultation with EPA and TDEC and now reflects mutual agreement on the text and schedule.	
7.	TDEC	Sect. 6.1	<i>"Piezometers are not needed near the main channels for NT-1 1 and D-10W because these are groundwater discharge locations and define the ground water elevation."</i> Delete this sentence, which adds no value to the FSP. Although these TDEC-requested locations were not included in the SOW, the original rationale for these locations was to evaluate groundwater gradients beneath the proposed landfill footprint adjacent to the streams-not to define groundwater elevations at the streams.	This sentence was deleted.	
8.	TDEC	Sect. 6.1	<i>"Groundwater elevation and temperature data will be initially collected by using downhole monitors placed in each piezometer. Data will be collected every 30 minutes and downloaded biweekly during this initial phase to obtain one month of data. In addition, pH and conductivity measurements will be collected on a bi-weekly basis from the piezometers. The initial phase (Phase 1) of site characterization includes 4 weeks of data collection."</i> Data collection limited to a period of one month at the end of the 2017-2018 winter wet season is not consistent with the SOW and the DRA. Revise the FSP to comply with the DRA and SOW, including the SOW requirement to also instrument each piezometer to record conductivity and pH at intervals of at least every 30 minutes, not twice (bi-weekly for four weeks).	As described in the response to General Comment 13, Section 6.1.1 now states: <i>"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."</i> Section 6.1.1 was revised to address data collection timeframe as follows: <i>"Technical Memorandum 1 will include continuous monitoring of these 16 piezometers during the March/April timeframe. Monitoring will continue for at</i>	

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				<i>least 1 year to ensure seasonal high- and low-water levels are captured."</i>	
9.	TDEC	Sect. 6.1	<p><i>"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."</i></p> <p>In accordance with the SOW and 40 CFR 761.75(b)(3), revise the FSP to clarify that decisions are based on the <u>historical</u> high water table. This parameter may be estimated by comparing to longer records throughout the valley, but it cannot be developed only from a limited set of depth-to-water measurements at Site 7c.</p>	<p>As described in response to General Comment 1, text was added in Section 6.1.2 as follows:</p> <p><i>"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."</i></p>	
10.	TDEC	Sect. 6.2.2	<p><i>"In addition, pH and conductivity measurements will be collected on a bi-weekly basis. The initial phase of characterization (Phase 1) will consist of the first 4 weeks of flow measurements."</i></p> <p>Data collection limited to a period of one month at the end of the 2017-2018 winter wet season is not consistent with the SOW and the DRA. Revise the FSP to comply with the DRA and SOW, including the SOW requirement to also instrument each stream gaging location to record conductivity and pH at intervals of at least every 30 minutes, not twice (bi-weekly for four weeks).</p> <p>Further, the SOW includes surface water discharge (flow) monitoring where the northern tributaries (NTs) enter and leave the buffer zone to help quantify groundwater discharge to surface water within the disposal site. The FSP must specify how stream flow (discharge) monitoring locations relate to the buffer zone.</p>	<p>As described in the response to General Comment 20, Section 6.2.2 was revised as follows:</p> <p><i>"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)."</i></p> <p>As described in the response to General Comment 17, Section 6.2.2 was revised as follows:</p> <p><i>"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</i></p>	

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				<p>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.</p> <p>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."</p>	
11.	TDEC	Sect. 9	<p>"Up to 4 weeks of data will be considered part of the Phase 1 data collection to be provided prior to the public comment period.</p> <p>Data collection limited to a period of one month at the end of the 2017-2018 winter wet season is not consistent with the SOW and the DRA. Revise the FSP to comply with the DRA and SOW.</p>	<p>Section 9 was revised as follows:</p> <p>"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."</p>	
12.	TDEC	Sect. 9	<p>"Up to 4 weeks of surface water data will be considered part of the Phase 1 data collection to be provided prior to the public comment period."</p> <p>Data collection limited to a period of one month at the end</p>	<p>Section 9 was revised as follows:</p> <p>"The results of the March-April field investigation data will be presented in Technical Memorandum 1 and will be</p>	

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			of the 2017-2018 winter wet season is not consistent with the SOW and the DRA. Revise the FSP to comply with the DRA and SOW.	<i>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."</i>	
13.	TDEC	Pg. A-9, Sect. A.1	<p><i>"The Phase 1 approach is provided in the attached FSP."</i></p> <p>Delete this sentence because there is no FSP attached. The quoted statement is made in an attachment to the FSP. Moreover, the FSP indicates that the QAPP also applies to unspecified future work phases that are not described in the FSP.</p>	This sentence was deleted.	
14.	TDEC	Pg. B-17, Sect. B.3	<p><i>"Downhole monitors will be placed in each piezometer and will collect groundwater level and temperature data every 30 minutes. Data will be downloaded quarterly and groundwater elevations in the well points will be obtained quarterly. In addition, pH and conductivity measurements will be collected on a bi-weekly basis from each piezometer."</i></p> <p>The phrase <i>"groundwater elevations in the well points will be obtained quarterly"</i> appears to contradict the previous sentence, which states that <i>"monitors...will collect groundwater level and temperature data every 30 minutes"</i>. Clarify if this means that manual measurements will be made quarterly in addition to the continuous measurements at 30-minute intervals. Alternatively, the reference to <i>"well points"</i> may be a relic of planned monitoring locations that OREM removed in revising the FSP to include only the minimum work identified in the SOW.</p> <p>Based on the importance of the planned characterization data, OREM should revise the FSP to indicate that data will be downloaded at least every two weeks so that problems like those encountered with recent (November 2017)</p>	<p>Section B.3 was revised as follows:</p> <p><i>"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."</i></p>	

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			continuous water level monitoring at EMWMF can be corrected in a timely manner.		
15.	TDEC	Pg. B-19, Sect. B.4	<p><i>"In addition, pH and conductivity measurements will be collected on a bi-weekly basis at the surface water flumes."</i></p> <p>Data collection limited to a period of one month at the end of the 2017-2018 winter wet season is not consistent with the SOW and the DRA. Revise the FSP to comply with the DRA and SOW, including the SOW requirement to instrument each stream gaging location to record conductivity and pH at intervals of at least every 30 minutes, not twice (bi-weekly for four weeks).</p>	<p>Section B.4 was revised as follows:</p> <p><i>"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."</i></p> <p><i>Flow, temperature, pH, and conductivity measurements will be collected at the surface water flumes."</i></p>	
16.	TDEC	Pg. B-19, Sect. B.4	<p><i>"The flumes will be monitored on an every 30 minute basis, with data downloaded at least quarterly..."</i></p> <p>Based on the importance of the planned characterization data, OREM should revise the FSP to indicate that data will be downloaded at least every two weeks so that problems can be corrected in a timely manner.</p>	See response to Specific Comment 15 above.	