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RDWP/RAWP for the Groundwater Field Demonstration at the Environmental Management Disposal Facility, Oak Ridge, Tennessee

This document is approved for public release per review by:

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RDWP/RAWP for the Groundwater Field Demonstration at the Environmental Management Disposal Facility, Oak Ridge, Tennessee

Date Issued—April 2023

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

United Cleanup Oak Ridge LLC
under contract 89303322DEM000067

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FIGURES

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
BCV	Bear Creek Valley
BMP	best management practice
CO	Contracting Officer
CBCV	Central Bear Creek Valley
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D	Drainage
dbh	diameter at breast height
DOE	U.S. Department of Energy
EMDF	Environmental Management Disposal Facility
EMWMF	Environmental Management Waste Management Facility
ESP	Early Site Preparation
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
GWFD	groundwater field demonstration
NT	North Tributary
OREM	Oak Ridge Office of Environmental Management
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
ORRL	Oak Ridge Reservation Landfill
QA	quality assurance
QC	quality control
RAD	remedial action objective
RCRA	Resource Conservation and Recovery Act of 1976
RDR	Remedial Design Report
RDWP/RAWP	Remedial Design Work Plan/Remedial Action Work Plan
ROD	Record of Decision
TDEC	Tennessee Department of Environment and Conservation
UCOR	United Cleanup Oak Ridge LLC
W	West

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EXECUTIVE SUMMARY

The *Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal at the Environmental Management Disposal Facility, Oak Ridge, Tennessee* (Environmental Management Disposal Facility [EMDF] Record of Decision) (DOE/OR/01-2794&D2/R2) presents the selected remedy of construction and operation of an onsite waste disposal site for Oak Ridge Reservation (ORR) Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) waste. (Note that the EMDF is also referred to as the Onsite Waste Disposal Site.) EMDF supports the U.S. Department of Energy Oak Ridge Office of Environmental Management's mission to decommission and demolish facilities and conduct remedial actions under CERCLA on the ORR in Oak Ridge, Tennessee. This effort requires an estimated 2.2 million cy of additional landfill disposal capacity for the disposal of wastes from CERCLA cleanup actions. As such, the EMDF will be constructed in Central Bear Creek Valley.

This Remedial Design Work Plan/Remedial Action Plan (RDWP/RAWP) was prepared to present the plan for the groundwater field demonstration (GWFD) as described in the EMDF ROD. This RDWP/RAWP describes the GWFD design and implementation approach. The GWFD is not part of the remedy, but will inform the final landfill design.

The GWFD is designed to approximate the elimination of recharge to groundwater from construction of the EMDF landfill in the knoll area. The key elements are:

1) Upgradient stormwater interceptor channel to reduce lateral recharge into the area—also part of the landfill design,
2) Temporary cover system designed to approximate the conditions of the final landfill liner system configuration, such that infiltration and recharge is cut off to the GWFD footprint, and
3) Stormwater controls to divert runoff from the cover away from the GWFD area.

Where effective in supporting the GWFD goals, design elements of the landfill are incorporated into the GWFD, such as the upgradient stormwater interceptor ditch and the sediment ponds as also to be used during landfill construction and operation.

Existing shallow piezometers will be used for the GWFD, along with three additional piezometers to be installed in the knoll area. Following construction of the GWFD, monitoring will be performed for one wet season to determine the expected post-landfill-construction seasonal high groundwater elevation in the knoll area at the 80^{th} percentile of water levels in the month with the maximum monthly median during the evaluation period. These data will be used to determine whether the design elevation of the geologic buffer in the knoll area is appropriate. Monitoring will continue for a second wet season to obtain additional data. Results will be provided in a Technical Memorandum following each wet season.

A detailed natural resource evaluation and wetland delineation study was performed, and the results are included.

A Stormwater Management Requirements document will be implemented to protect surface water during implementation of this scope.

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1. INTRODUCTION AND PURPOSE

This Remedial Design Work Plan/Remedial Action Plan (RDWP/RAWP) was prepared to present the plan for the groundwater field demonstration (GWFD) as described in the *Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal at the Environmental Management Disposal Facility, Oak Ridge, Tennessee* (ROD) (DOE/OR/01-2794&D2/R2). This RDWP/RAWP describes the GWFD design and implementation approach. (Note that the Environmental Management Disposal Facility [EMDF] is also referred to as the Onsite Waste Disposal Site.) EMDF supports the U.S. Department of Energy (DOE) Oak Ridge Office of Environmental Management's (OREM's) mission to decommission and demolish 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. This effort requires an estimated 2.2 million cy of additional landfill disposal capacity for the disposal of wastes from CERCLA cleanup actions. As such, EMDF will be constructed in the Central Bear Creek Valley (CBCV).

This RDWP/RAWP was prepared to present the plan for the GWFD, as described in the EMDF ROD. This RDWP/RAWP describes the GWFD design and implementation approach. The GWFD is not part of the remedy, but will inform the final landfill design.

The landfill design will meet the remedial action objective (RAO) to maintain a 15-ft separation between the bottom of emplaced wastes and the seasonal high water table of the uppermost unconfined aquifer, which includes 5 ft of liner system and 10 ft of geologic buffer, consistent with TDEC 0400-11-01-.04(4)(a)(2), *Solid Waste Processing and Disposal*, "Specific Requirements for Class I, II, III, and IV Disposal Facilities.

The objective of the GWFD is to verify the post-construction groundwater surface is below the design base of the geologic buffer in the knoll area where the seasonal high groundwater elevations sometimes exceed this design base. The GWFD will be accomplished by placing a temporary, impermeable cover system over the EMDF knoll area, then directly measuring seasonal high (wet season) groundwater elevations to estimate post-landfill construction groundwater elevations. These seasonal high groundwater elevation measurements will be used to verify the groundwater surface is below the design base of the geologic buffer, or if changes to the design are necessary.

In accordance with the ROD, results of the field study will be incorporated into the Remedial Design Report (RDR) for the landfill design; the RDR is a primary document that requires approval by the Federal Facility Agreement (FFA) parties before landfill construction.

As described in the ROD, the significant elements of the GWFD include:

- Study area sized to sufficiently approximate the groundwater recharge conditions of the constructed landfill cells in the knoll area.
- Use of existing shallow piezometers to collect groundwater elevation data for evaluation to determine the post-construction seasonal high water table.
- Installation of additional piezometers to provide groundwater elevation data to minimize interpretation between existing piezometers.
- Clearing of the study area, and excavation (as needed) to remove unsuitable material, to provide a competent subgrade for installation of the temporary cover, and to ensure worker safety.

- Installation of a temporary cover system over the study area to divert precipitation and runoff to approximate the elimination of infiltration into the ground expected from the constructed landfill cells.
- Excavation (as necessary) to divert stormwater flow from the demonstration area toward the tributaries; an upgradient stormwater flow interceptor ditch will be necessary to facilitate movement of water around the study area.
- Installation of stormwater controls will be designed and incorporated into the GWFD to minimize impacts to the North Tributaries (NTs) and Bear Creek, such as construction of the sediment ponds that will also be used for landfill construction and operation.
- Engineered features (as necessary) to support temporary cover construction in the study area.
- Monitor groundwater elevations in selected piezometers to evaluate the seasonal high groundwater elevation at the geologic buffer depth, defined as the potentiometric surface based on the 80th percentile of water levels in the month with the maximum monthly median during the evaluation period (the wettest month, where wettest refers to highest groundwater level and not necessarily the month with the most precipitation).
- Duration will include monitoring for two wet seasons; after the first wet season, final landfill design will begin based on the available data, and data collection will continue in the second wet season to refine the design, if needed.
- If deemed necessary due to a demonstration period that is not representative of historical rainfall (significantly wetter or drier), an adjustment may be warranted. The determination of the method used to calculate the adjustments will be completed by an FFA triparty technical team. The adjustment process will include comparison of rainfall amount, duration, and frequency to historical measurements, and responses measured in surrounding piezometers to historical groundwater information. The representative criteria and adjustment method will be determined by the FFA triparty technical team.
- Evaluations will use linear interpolation between piezometers to the extent practical.

The purpose of this RDWP/RAWP is to describe the components to be designed and to describe how the temporary cover system and other features required for the GWFD will be installed. As described in the ROD, the design of the GWFD will be included in the RDR for the landfill. The results of the GWFD will be presented in a Technical Memorandum to support development of the EMDF RDR.

Because fill material will be necessary to complete the GWFD, this RDWP/RAWP also includes development of the Site 7B Borrow Area, located adjacent to the GWFD site, as a potential fill source area.

2. PROJECT ORGANIZATION AND SCHEDULE

2.1 PROJECT ORGANIZATION

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

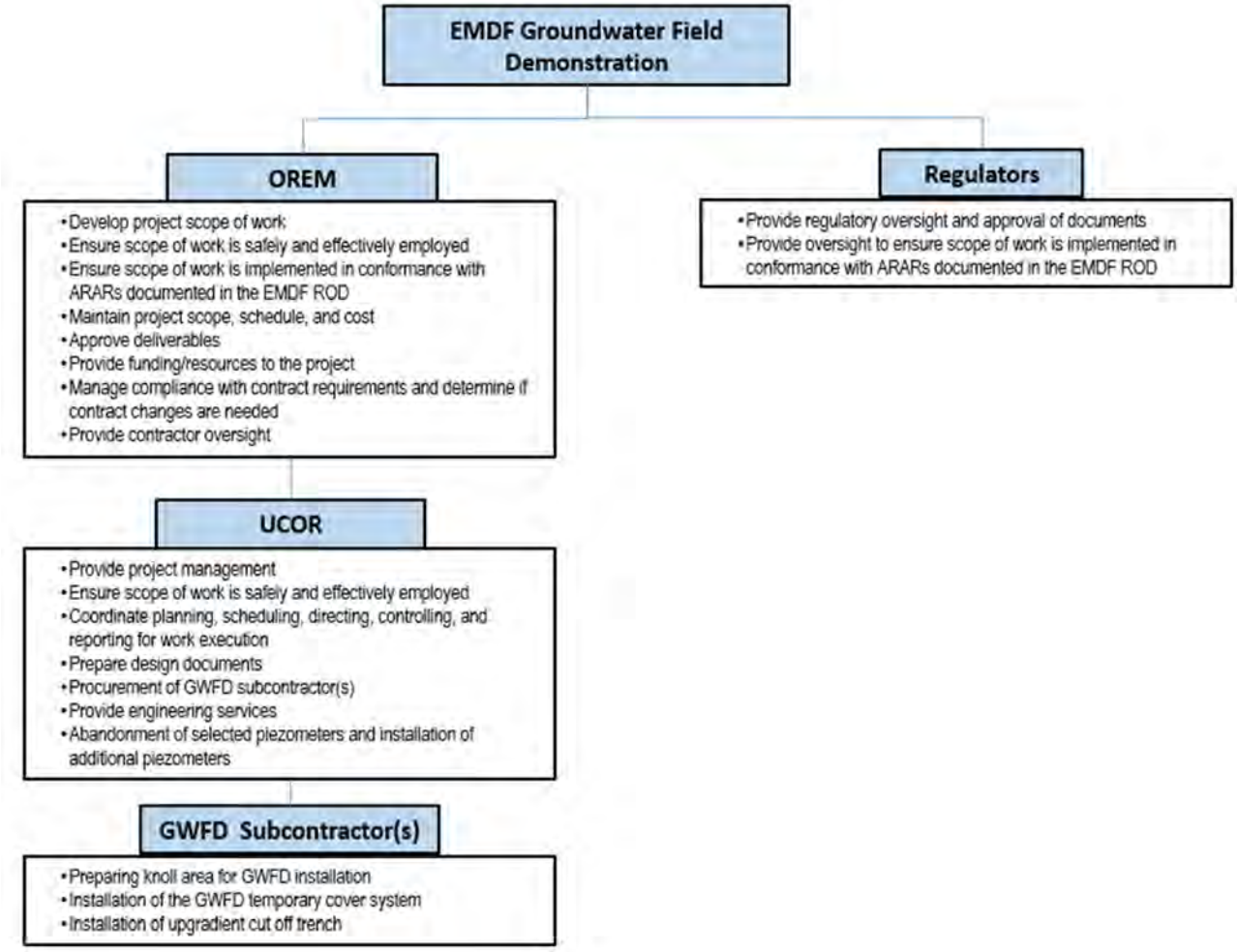

Fig. 1. EMDF GWFC Project organization.

2.1.1 OREM

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

The OREM Federal Project Director (or Deputy) is responsible for maintaining the overall scope, schedule, and costs. The OREM Contracting Officer (CO) and CO Representative are responsible for managing compliance with contract requirements and determining if changes to contracts are necessary or required. OREM staff, including subject matter experts and facility representatives, are responsible for providing general oversight of the contractor's safety and compliance performance.

2.1.2 Regulators

The Tennessee Department of Environment and Conservation (TDEC) and the U.S. Environmental Protection Agency (EPA) have review/approval authority over this scope through reviewing this RDWP/RAWP under FFA protocols. TDEC and EPA will also provide regulatory oversight of activities.

2.1.3 UCOR

United Cleanup Oak Ridge LLC (UCOR) is responsible for working with OREM to develop the project scope of work; ensuring the work scope is performed in a safe, compliant, and effective manner; and maintaining the project scope, schedule, and costs.

UCOR will provide additional project management and support oversight for the project, which includes coordination of overall planning, scheduling, directing, controlling, and reporting for the execution of the work. UCOR has prepared the design documents for the road reroute, utilities extensions, borrow area preparations, and the installation of a construction support area.

UCOR will procure services of construction subcontractor(s) for the GWFD activities by preparing draft statements of work, technically reviewing proposals, answering questions, supplying design and site information, and supporting pre-bid meetings, tours, and site access.

UCOR will provide construction oversight for OREM. Oversight will include reviewing submittals, assisting with site access, providing field oversight, conducting construction completion walkdowns, and supporting construction closeout.

UCOR will provide engineering services to OREM for the design.

2.2 PROJECT SCHEDULE

Key activities and dates for the GWFD scope are presented in Table 1.

Table 1. Key activities and dates for GWFD scope

Activity	Date
GWFD RDWP/RAWP D1 submittal	April 2023 (FFA Milestone 5/31/2023)
GWFD Construction start	Fall 2023
GWFD Construction finish	Fall 2024

Note: The landfill RDR will include and document the GWFD design as specified in the EMDF ROD.

3. SITE DESCRIPTION

The EMDF site is located in CBCV within an upland area located between north-south trending valleys of NT-10 and NT-11. The site and surrounding areas are forested, except for areas along the south side between 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 (Y-12) compensatory wetland mitigation. Haul Road and Bear Creek Road are located in the southern part of the site and will be relocated to the south prior to EMDF construction as part of the upcoming Early Site Preparation (ESP) activities (Fig. 2).

3.1 GEOLOGY

The GWFD will take place on the central knoll area of the EMDF site, located in CBCV within an upland area located between north-south trending valleys of NT-10 and NT-11. The knoll area predominantly overlies bedrock of the Conasauga Group, primarily the Maryville Formation (Fig. 2). The Conasauga Group formations are predominantly shales, siltstones, and mudstones with little limestone present in the bedrock underlying the proposed disposal cells. The crest of the knoll below the north center of the footprint is underlain by the erosion-resistant Maryville Formation. The typical weathering profile consists of topsoil, silty/clayey soil residuum, saprolite, and fractured bedrock**.** Recent stream deposits are present along the streams and tributaries throughout EMDF (DOE/OR/01-2819&D1, *Technical Memorandum #2, Environmental Management Disposal Facility, Phase 1 Monitoring, Oak Ridge, Tennessee*).

3.2 GROUNDWATER

Groundwater migrates from the upland areas along Pine Ridge and discharges to stream channels, supporting base flow within the NT streams and Bear Creek. There is also a component of groundwater flow along strike, most notably in the Maynardville Limestone to the south of the EMDF site.

Thirty-two piezometers were installed across the EMDF site between February 2018 and January 2019 to better understand the geology and groundwater elevations at EMDF (Fig. 2). Downhole monitors were installed in each piezometer to collect continuous depth to groundwater, pH, and water temperature data. Note, GW-991 is always dry and no downhole monitor was installed. These have been monitored since installation (excluding periods when individual downhole monitors were not functioning) and many of these are expected to be used for continued monitoring during the GWFD (see Sect. 8.2).

In general, the vertical hydraulic gradients between the shallow and deeper bedrock zones are mostly small (less than 0.03 ft/ft vertical gradient). Three well pairs consistently have a slight downward gradient (GW-978/GW-979, GW-980R/GW-981, and GW-988/GW-989). They are located on the knoll. Slight upward vertical hydraulic gradients have only been observed at well pairs GW-992R/GW-993 and GW-994/GW-995 at the base of the knoll, with a maximum upward gradient of 0.07 ft/ft in the southern part of the proposed EMDF footprint near the existing Haul Road (Fig. 2).

Piezometric surface elevations confirmed that the piezometric surface generally mirrors topography (i.e., is higher topographically beneath knolls/ridges and lower near the tributaries). The piezometric surface responds to rainfall events, indicating recharge is occurring on the site. Seasonal variation is also observed, with higher piezometric surfaces observed during the winter/spring wet season (typically November to March) than in the summer/fall dry season (Fig. 3).

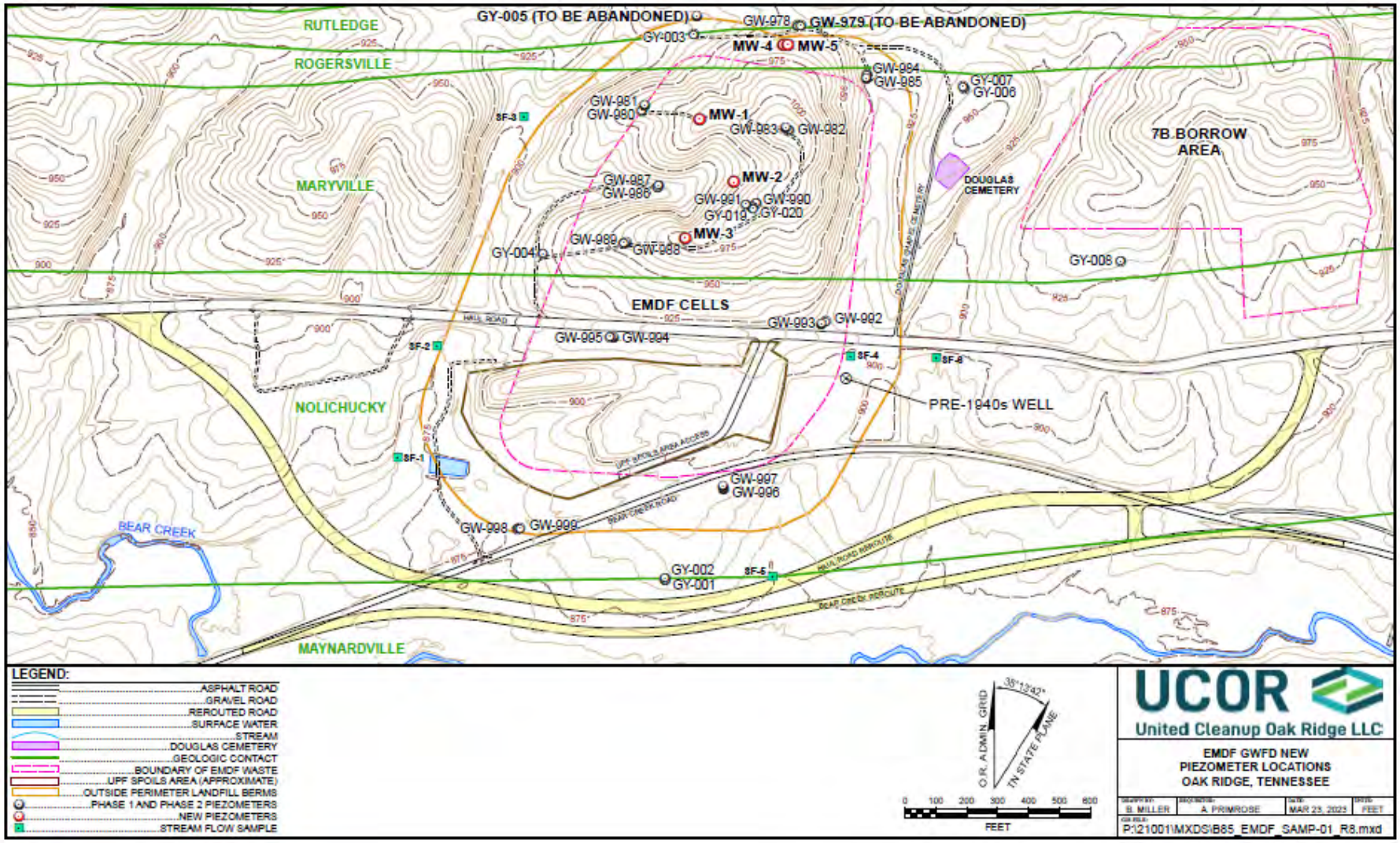

Fig. 2. EMDF area existing piezometers and other features.

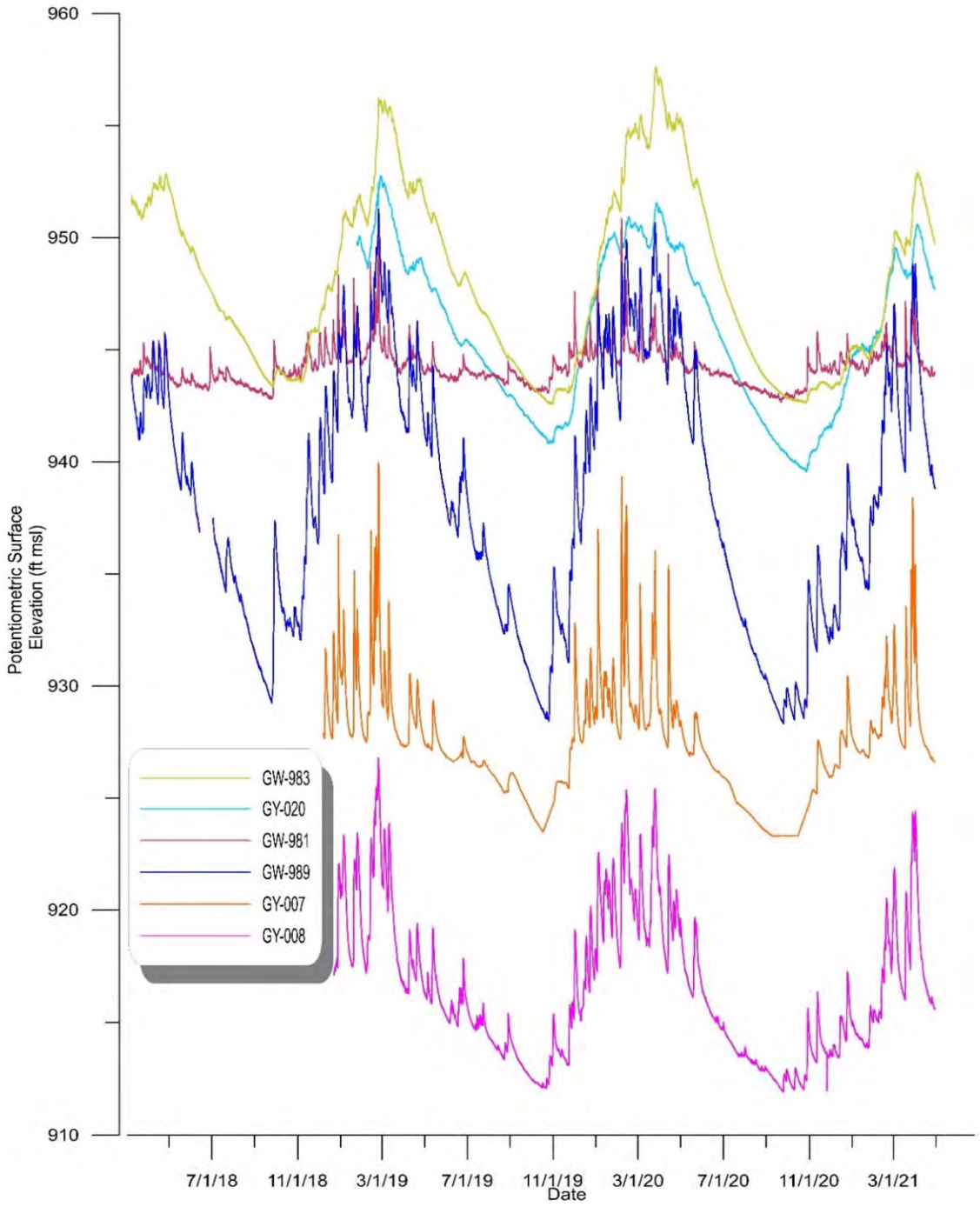

Fig. 3. Seasonal change and response to precipitation in selected shallow piezometers.

As shown in Fig. 3, piezometers respond differently to both seasonal changes and to precipitation based on the location and subsurface conditions. While most piezometers show quick responses to rainfall, GW-981 shows very little seasonal change. GW-981 is surrounded by steep slopes on three sides and infiltration is relatively quickly drained to surface water and does not cause much of a rise in groundwater elevations. In contrast, most of the other piezometers installed at EMDF show a greater response to precipitation and greater seasonal variation (GW-983, GW-989, and GY-020).

The gradients and piezometric surface confirm that shallow groundwater at the site in general results from localized recharge in the higher elevations of the site during precipitation events. The tributaries have some influence on the groundwater flow in their immediate areas acting as localized discharge locations (DOE/OR/01-2819&D1. *Technical Memorandum #2, Environmental Management Disposal Facility, Phase 1 Monitoring, Oak Ridge, Tennessee)*.

3.3 SURFACE WATER

Surface water drainages near the site include NT-10, NT-11, Drainage (D)-10 West (W), and D-11 East, an east–west trending feature that drains westward into NT-11 near the center of the site (Fig. 2). Surface water flow in these drainage channels flows from Pine Ridge to Bear Creek located on the valley floor. The surface water systems are fed by precipitation, surface runoff and shallow stormflow, and groundwater that discharges via springs and seeps.

Stream flow is primarily a result of precipitation events and from subsequent shallow seeps with limited flow or dry stream conditions during the summer months. Shallow soil can act as a stormflow layer when flow is present, with surface water transport through macropores that result from decaying vegetation such as fallen branches or tree roots (Fig. 4). Stormflow emerges as visible flow further downstream (DOE/OR/01-2819&D1, *Technical Memorandum #2, Environmental Management Disposal Facility, Phase 1 Monitoring, Oak Ridge, Tennessee*). Meandering stream channels filled with sediments are present upstream of the Haul Road culverts, and are not typical of other higher gradient streams found across the ORR.

Fig. 4. Macropores examples in the EMDF area.

Continuous flow monitoring data for NT-10, NT-11, and D-10W were collected for one year as part of Phase 1 site characterization (see flume locations on Fig 2). The available U.S. Geological Survey base flow data indicate that base flow is continuous along the D-10W, NT-10 and NT-11 stream channels during the winter/spring non-growing wet season (USGS Open-File Report 95-459). Several seeps are located adjacent to the drainages and tributaries, indicating localized shallow groundwater discharge occurs there at least seasonally.

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 (Robinson and Johnson 1995, *Results*

of a Seepage Investigation at Bear Creek Valley, Oak Ridge, Tennessee, January – September 1994). Flow monitoring for Bear Creek downstream of the EMDF site indicates continuous flow in Bear Creek (DOE/OR/01-2695&D2/R1, *Proposed Plan for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Waste*).

3.4 ECOLOGICAL RESOURCES

A detailed natural resource evaluation and wetland delineation study was performed over most of the EMDF footprint (Fig. 5). The evaluation is documented in *Natural Resource Assessment for the Proposed Environmental Management Disposal Facility (EMDF), Oak Ridge, Tennessee* (ORNL/TM-2018-515). The natural resource assessment included wetland delineation and evaluation, stream surveys, timber assessments, and rare species surveys (Fig. 5). Walkdowns were also conducted in the fall/winter of 2022 to evaluate an extension of Haul Road reroute and the Spoils Area that were not covered by the initial natural resource evaluation. Additional walkdowns were performed in early 2023 to identify potential bat-roosting trees and to evaluate the ESP areas for potential tri-color bat-roosting locations.

Wetland delineations: Potential wetlands were evaluated for the entire EMDF Project site relative to the dominance of wetland vegetation, soils, and hydrological characteristics. Seventeen wetlands, including one created wetland, were identified within the entire EMDF study area, covering 11.8 acres (Fig. 5). The GWFD and balance of landfill scope was designed and will be constructed to minimize impacts to these wetlands. However, it is anticipated that approximately 4.6 acres of wetland will be disrupted and/or eliminated.

Stream surveys: Five tributary streams are present in the EMDF area: NT-9, NT-10, D-10W, NT-11, and an unnamed tributary between NT-9 and NT-10 (Fig. 5). All are considered first- or second-order streams characterized by low flows during non-rain events, shallow pools and riffles. There are multiple road crossings on these streams, including Bear Creek Road, Haul Road, and some historical roads/culverts across the streams. Many of these road crossings present physical barriers for upstream migration of aquatic fauna, in particular fish, by creating large elevation changes in the stream channel just below culverts. In addition, the upstream side of these culverts often create wetlands with meandering stream channels filled with sediments, not typical of other higher gradient streams found across the ORR.

ESP construction activities will require installation of approximately 900 ft of culverts. Existing culverts were used wherever possible, including the existing culverts and bridge used where Bear Creek Road crosses over Bear Creek. The stream channel for NT-9 is unchanged, except for replacement of an undersized culvert where NT-9 crosses under Bear Creek Road. Additional information on culvert placement is provided in Appendix A. GWFD construction will reroute the stream flow in D-10W to NT-10, impacting both of these drainages. Stream flow in the upper reach of NT-11 adjacent to the GWFD temporary cover will be modified to place the temporary cover system, although the stream will remain in its existing channel. NT-11 upper stream channel modifications may increase in this same area during construction of the berms for EMDF. Neither NT-12 nor the unnamed tributary will be modified.

The Bear Creek watershed is home to a strong population of Tennessee dace, the only fish on the ORR listed as “in need of management” by the Tennessee Wildlife Resources Agency. No Tennessee dace were observed in the tributary streams at the EMDF site during the fish surveys; however, EMDF stormwater controls will protect Tennessee dace in streams that may be impacted by EMDF construction activities. Prior to performing construction activities, streams will be walked down and sensitive resources, including Tennessee dace, will be relocated.

Timber assessments: As described in ORNL/TM-2018-515, the GWFD area and the balance of landfill outside of the ESP activities are primarily located in hardwood forest, potentially around 60+ years old. Trees with a diameter at breast height (dbh) greater than 10 in. represent approximately 52% of the total forested area. These trees are primarily tulip poplar (~23%), white oak (~16%), red maple (~14%), and sweet gum (~9%). Trees with dbh between 2 and 10 in. are primarily six species: red maple (15.3%), sweet gum (13.9%), loblolly pine (13.5%), tulip poplar (10.7%), sourwood (8.2%), and dogwood (6.0%).

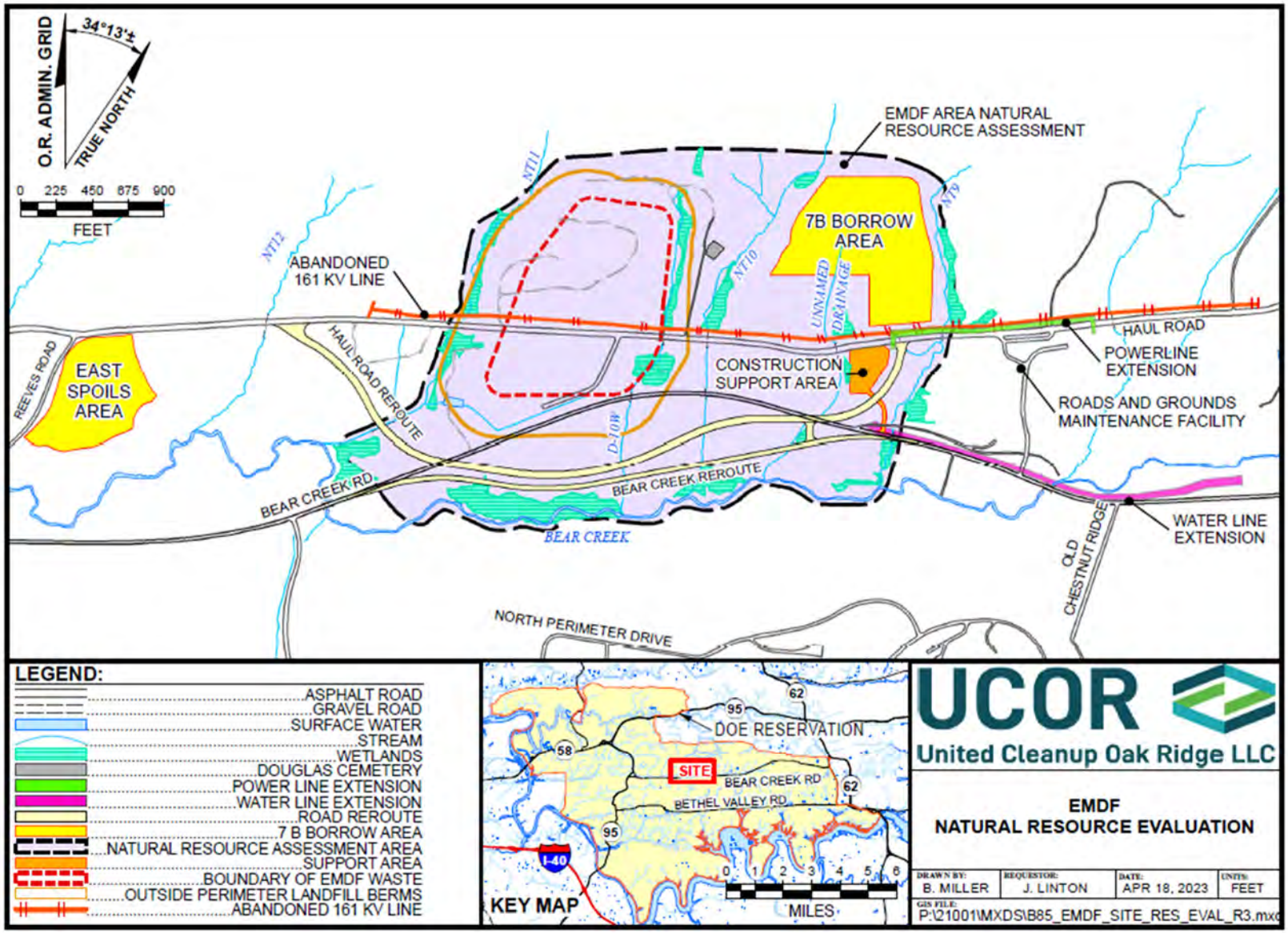

Fig. 5. EMDF natural resource evaluation and EMDF activities.

North of Bear Creek Road, the trees average 508 stems per acre of trees greater than 2 in. dbh with about 48 trees 10 in. dbh or larger per acre. In the 161 acres surveyed for the EMDF Project, 10 trees were identified with a diameter greater to or equal to 30 in. dbh measured at the sample points (tally trees). The tree identified with the greatest dbh in the area was a 38-in. dbh chestnut oak. Of the 10 tally trees identified, six were oak trees.

The EMDF area south of Bear Creek Road was almost entirely subject to timber harvesting during a southern pine beetle outbreak in 2000 and is primarily dense, loblolly pine.

Rare species surveys: Previous investigations to identify threatened and endangered species on the ORR (ORNL/TM-2015/248, *Bat Species Distribution on the Oak Ridge Reservation*), in general, have confirmed the presence of Indiana bats, gray bats, and the northern long-eared bat, all federally listed endangered species; tricolored bats, which are proposed for federal listing; and little brown bats, which are under consideration for federal listing. Results of the bat acoustic surveys indicated that forested portions of the EMDF Project area are used as summer habitat by state- and federally listed bat species. One federally listed endangered species (gray bat) may forage within the site boundaries but does not roost in these areas.

Additional rare species surveys were performed for the EMDF site in 2018. The EMDF Project surveys noted that there did not appear to be large populations of either the northern long-eared bat or the Indiana bat (ORNL/TM-2018-515). No maternity roosts for the Indiana bat were found in the EMDF area. Less than 50 potential bat-roosting trees were identified in the ESP areas, which are primarily forested with loblolly pine, as these are not the preferred roosting trees for bats. Additional evaluation was performed in 2023 to evaluate for the presence of potential roosts of tricolored bats, such as road culverts and riparian buffer zones, and potential roost areas were identified. The GWFD and balance of landfill areas are expected to have larger numbers of potential bat-roosting trees due to the larger hardwood trees present in these areas.

Other threatened and endangered species surveys were conducted by the Oak Ridge National Laboratory (ORNL) in 2018 (ORNL/TM-2018-515). The tubercled rein orchid, listed as threatened on the Tennessee Rare Plant List, was found in wetlands within the study area, particularly in wetlands along the NT-9 and D-10W streams. D-10W and NT-9 both have large populations of rein orchids. As noted previously, NT-9 will only be minimally impacted by GWFD and the remainder of EMDF activities. Two other plant species of interest found were the American ginseng and pink lady's slipper, which are considered of concern because of commercial harvest. The four-toed salamander and the Wood Thrush (state-listed as In-Need-of-Management) were also confirmed to occur throughout forested portions of the study area. Wetlands and drainages within the area were found to contain the highest densities of four-toed salamander breeding sites known on the ORR (Fig. 6).

Approximately five acres of wetlands will be eliminated by the EMDF Project. During construction of the GWFD and subsequent construction of the balance of the landfill, streamflow in D-10W will be rerouted to NT-10 and the wetlands in D-10W will be eliminated by construction of both the GWFD and balance of landfill. The disrupted wetlands include the engineered wetlands recently constructed in D-10W. The wetlands in NT-11 will also be impacted by these activities (Fig. 6).

No federally listed threatened or endangered bird species were noted during the surveys; however, certain species recorded during the surveys have other state and/or federal management designations. These include dozens of species of birds protected under the Migratory Bird Treaty Act and/or are considered Birds of Conservation Concern by the U.S. Fish and Wildlife Service (USF&WS). The site is on the southern edge of the largest area of contiguous interior forest on the ORR that supports rare bird species. These rare species are not typically found in more fragmented habitats (ORNL/TM-2018-515).

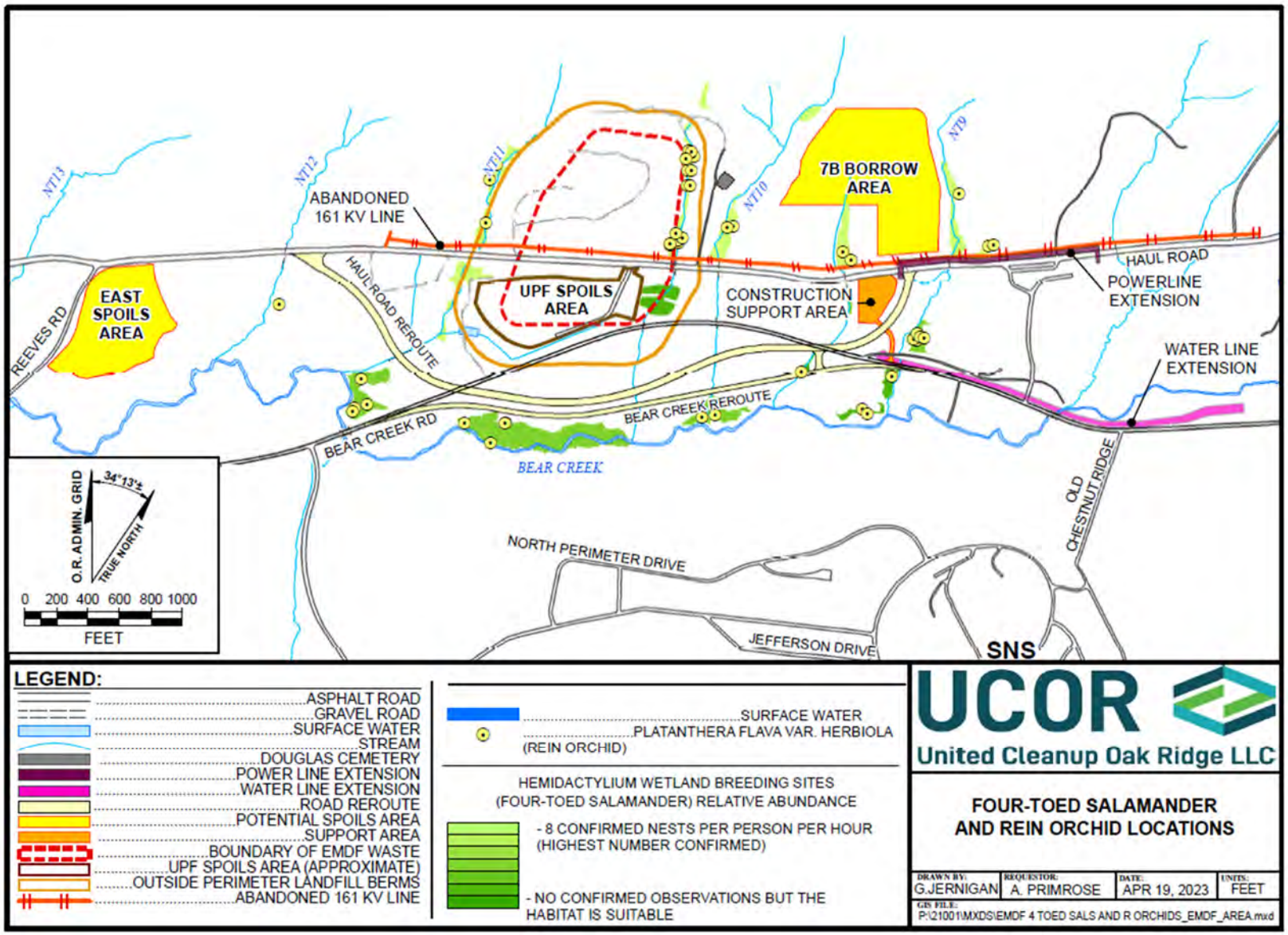

Fig. 6. Four-toed salamander and tubercled rein orchid locations—EMDF area.

The approach to minimize impacts to rare species is as follows:

- UT-Battelle Subject Matter Experts will identify potential bat-roosting trees in the GWFD and balance of landfill areas. These potential bat-roosting trees will be removed prior to start of field work and prior to the start of the foraging season.
- Potential roost areas for tri-colored bats will be identified. Prior to the start of field activities, candidate roosting sites will be fitted with one-way devices to allow bats to exit but not return.
- Fish and aquatic wildlife sweeps and removal will be conducted prior to start of construction activities, including prior to culvert grouting or replacement, given the possible presence of crayfish and four-toed salamanders in all drainages. Although Tennessee dace have not been detected in the EMDF drainages, these will be included in the sweeps and relocated if present.

As part of the approach to minimize impacts, during spring 2023, four-toed salamanders and their nests were identified in the wetlands planned to be impacted by EMDF construction (ESP, GWFD, and balance of landfill). The salamanders and nests were relocated or are planned to be relocated to other suitable habitat that will not be impacted by EMDF construction. Similarly, the tubercled rein orchids are planned to be identified and relocated to suitable habitat in 2023, prior to GWFD construction in the impacted wetlands.

Appendix A contains additional information on the sensitive resources present in the GWFD and balance of landfill areas. Mitigation identification is in progress for both the GWFD and balance of landfill areas. Any mitigation required for the ESP activities will also be performed as part of the overall EMDF GWFD/landfill construction effort. Once finalized, the required mitigation will be documented in the D2 GWFD RDWP/RAWP or as an addendum to this document.

3.5 CULTURAL RESOURCES

The Douglas Chapel Cemetery and four historical home site/structures are present near the EMDF site (*Phase I Archaeological Survey of the Proposed Environmental Management Disposal Facility in Central Bear Creek Valley, Roane County, Tennessee*, CRA 2018). Douglas Chapel Cemetery is located on the knoll between NT-10 and D-10W. DOE intends to avoid and preserve the Douglas Chapel Cemetery, as well as maintain access to the cemetery for visitors.

The four home sites were demolished when the federal government purchased the land for the Manhattan Project. A prehistoric habitation was located near Bear Creek where lithic flakes were found, an indication of prehistoric tool production. All the sites were highly disturbed and appeared to contain no buried cultural deposits. The sites were not recommended for inclusion in the National Register of Historic Places.

No historical sites are located within the GWFD area. The Douglas Chapel Cemetery is located nearby, but will not be disturbed by either GWFD or landfill construction activities (Fig. 6).

4. PROJECT DESCRIPTION

4.1 OVERVIEW AND DESIGN APPROACH

The objective of the GWFD is to verify the post-construction groundwater surface is below the design base of the geologic buffer in the knoll area where the seasonal high groundwater elevations sometimes exceed this design base. The shallow groundwater/potentiometric surface in the knoll area is mounded from local infiltration of precipitation that would be eliminated by construction of EMDF. As described in Sect. 3.2, current groundwater elevations vary considerably between the wet and dry seasons and respond quickly to precipitation events.

Ideally, the GWFD would excavate to the base of the geologic buffer and place the liner system for the most accurate determination of post-construction groundwater levels. However, this approach is not practical as a demonstration. Therefore, the GWFD will be accomplished by placing a temporary, impermeable cover system over the EMDF knoll area, then directly measuring seasonal high (wet season) groundwater elevations to estimate post-landfill construction groundwater elevations. These seasonal high groundwater elevation measurements will be used to verify the groundwater surface is below the design base of the geologic buffer or if changes to the design are necessary.

Precipitation is the primary mechanism for recharging shallow groundwater in the knoll area. The disposal cells will be separated from Pine Ridge by a saddle formed by NT-11. This saddle reduces shallow groundwater recharge from Pine Ridge area from the north. Recharge is expected from Pine Ridge to the shallow groundwater within the stormflow layer within soil and shallow bedrock. Recharge will continue from Pine Ridge to the regional, deeper bedrock groundwater system.

The EMDF disposal cells will be located between NT-10 and NT-11 (Fig. 2). These NTs are lower than the preliminary design base of geologic buffer. D-10W is located slightly higher and adjacent to the disposal area, but the stream channel is still lower than the proposed bottom of the geologic buffer.

The preliminary design of the landfill liner system was based on groundwater modeling that takes into account a decline in shallow groundwater elevations from placing the impermeable liner system over the landfill area, eliminating localized recharge from precipitation. The landfill design assumed that without local recharge to the knoll, shallow groundwater elevations would decrease to levels similar to the elevations of NT-11 and NT-10, lower than the design base of the geologic buffer. The design also includes an interceptor ditch upgradient of the disposal cells to intercept stormflow and eliminate this source of recharge from Pine Ridge through the stormflow layer within soil and shallow bedrock.

As previously noted, the current peak groundwater elevations in the highest areas of the knoll are occasionally higher than the elevation of the base of the geologic buffer in the preliminary design (piezometers locations are shown in Fig. 7). Therefore, as documented in the EMDF ROD, the GWFD is being performed in the knoll area to determine the seasonal high groundwater elevation that will control the final design elevation of the geologic buffer in the knoll area. The GWFD will provide additional characterization information and has the potential to affect the final design of the EMDF disposal cells in the knoll area.

The GWFD will require removal of the soil and weathered rock stormflow zone in the footprint area of the knoll area and covering the area with an impermeable layer to approximate placement of the landfill liner system. The GWFD area is based on the current Phase 1 Preliminary Design layout of the landfill in the knoll area, including the associated berms.

In accordance with the EMDF ROD, the GWFD design and results of the field study will be incorporated into the EMDF landfill RDR, which will present the final landfill design; the EMDF landfill RDR is a primary document that requires approval by the FFA parties before landfill construction. The approved EMDF landfill RDR will serve as the basis for a final landfill design that will meet the RAO to maintain a 15-ft separation between the bottom of emplaced wastes and the seasonal high water table of the uppermost unconfined aquifer, which includes 5 ft of liner system and 10 ft of geologic buffer, consistent with TDEC 0400-11-01-.04(4)(a)(2).

The study area will be modified to approximate the constructed landfill by installing a temporary cover system to shed rainwater that would otherwise infiltrate into the ground to minimize the effects of groundwater recharge in the project area. The temporary cover will direct stormwater into local, existing drainages, as will be done following EMDF disposal cell construction. Groundwater elevations will be measured in key shallow piezometers during two wet seasons (December through March or April). Evaluation of water levels measured during the study's first wet season will be used to support base geologic buffer elevations for the final landfill design, as described in the EMDF ROD (DOE/OR/01-2794&D2/R2).

The major assumptions and requirements used to develop the GWFD are as follows:

- Required for the knoll area where current, peak groundwater levels are higher than the preliminary design base of the geologic buffer.
- Requires excavation of soil and stormflow zone in the knoll area with sufficient excavation to provide a stable and safe working surface.
- Places a temporary impermeable cover system over the knoll area.
- Requires surface water and stormflow cutoff and rerouting of flow from D-10W to NT-10.
- Requires stormwater controls in D-10W, NT-10, and NT-11 to address increased runoff and redistribution of surface water flow and sediment control.
- Requires Haul Road and Bear Creek Road reroute prior to construction of sediment ponds as part of ESP activities. If sediment ponds are not available, then alternative sediment control measures will be used until the sediment ponds are operational.
- Requires existing geophysical boreholes, piezometers within construction zones and other potential sources of surface water migration to groundwater to be abandoned prior to GWFD construction.
- Maintains select existing shallow piezometers in the GWFD area for use after demonstration construction. Existing deeper piezometers will be maintained as possible and practical, but will not be used for the GWFD evaluation.
- Existing piezometers outside the groundwater demonstration area will be maintained and monitored for evaluation of the GWFD groundwater elevation results.
- Additional piezometers will be installed and screened at the base of the geologic buffer to refine and increase lateral coverage and minimize interpretation of results between piezometers. Groundwater elevation monitoring over a minimum of one wet season demonstrate groundwater levels relative to the base of the geologic buffer. Final landfill design will proceed after evaluation of the data from the first wet season. Groundwater elevation monitoring will also be performed for an additional wet season to verify results.

4.2 KEY GWFD-RELATED FEATURES OF THE LANDFILL DESIGN

The GWFD is designed to approximate the effects from construction of the EMDF landfill in the knoll area. The EMDF landfill design includes elements that will remove local recharge from precipitation, intercept stormflow from Pine Ridge, and divert stormwater. The key elements of the landfill design that must be approximated by the GWFD include the following:

- Upgradient stormflow interceptor channel at the northern boundary of the disposal cell that is designed to collect and reroute run-on from Pine Ridge.
- The liner system and the geologic buffer prevent infiltration and eliminate recharge from precipitation and eventually leachate.

The preliminary landfill liner system and geologic buffer design are above the elevation of the surrounding drainages, eliminating the potential for groundwater recharge from surface water and allowing groundwater beneath the disposal cells to stabilize to the adjacent tributary elevations. This design feature is not expected to change as a result of the GWFD. As a note, the base of the geologic buffer in the preliminary design was set 5 ft above the modeled post-construction seasonal high groundwater table to be more conservative.

4.3 GWFD DESIGN

The GWFD will approximate the design approach for the EMDF disposal cells to determine how construction of the landfill will affect groundwater elevations in the knoll area. The upgradient stormflow interceptor channel will be designed and constructed to support both the GWFD and the landfill. However, because the design of the primary and secondary liner systems may be altered as a result of the data collected by the GWFD, it is impractical to excavate and construct the geologic buffer, primary, and secondary liner systems at this time. Therefore, an alternative cover design was selected to simulate the effect of the landfill liner on groundwater in the knoll area by minimizing infiltration in the landfill disposal cell area.

The key elements of the GWFD are (1) upgradient storm interceptor channel and (2) a temporary cover system designed to simulate the conditions of the final landfill liner system configuration, such that infiltration and upgradient lateral recharge is cut off to the GWFD footprint. In addition, stormwater controls will be designed and incorporated into the GWFD to minimize impacts to the NTs and Bear Creek, such as construction of the sediment ponds that will also be used for landfill construction and operation (Fig. 5).

4.4 GWFD AREA

The GWFD is designed to evaluate post-landfill construction groundwater elevations in the EMDF knoll area where current seasonal high shallow groundwater levels are higher than the preliminary design elevation of the geologic buffer.

Upgradient stormflow also must be diverted and infiltration must be limited across the knoll area to approximate the effects from installation of the EMDF landfill liner system, resulting in anticipated higher stormwater flows and stream flow within the adjacent drainages. Therefore, impacts to wetlands and streams must be minimized as much as possible. The cover area was selected to cover the majority of the knoll area from the saddle between the knoll and Pine Ridge to the north to approximately Haul Road in the south, and from immediately adjacent to NT-11 on the west to D-10W on the east (Fig.5). Wetlands will be avoided as much as possible along NT-11, but will be removed within D-10W due to the need to grade the eastern slope of the cover area to provide a stable subgrade for the GWFD temporary cover, and eventually to place the eastern landfill berms.

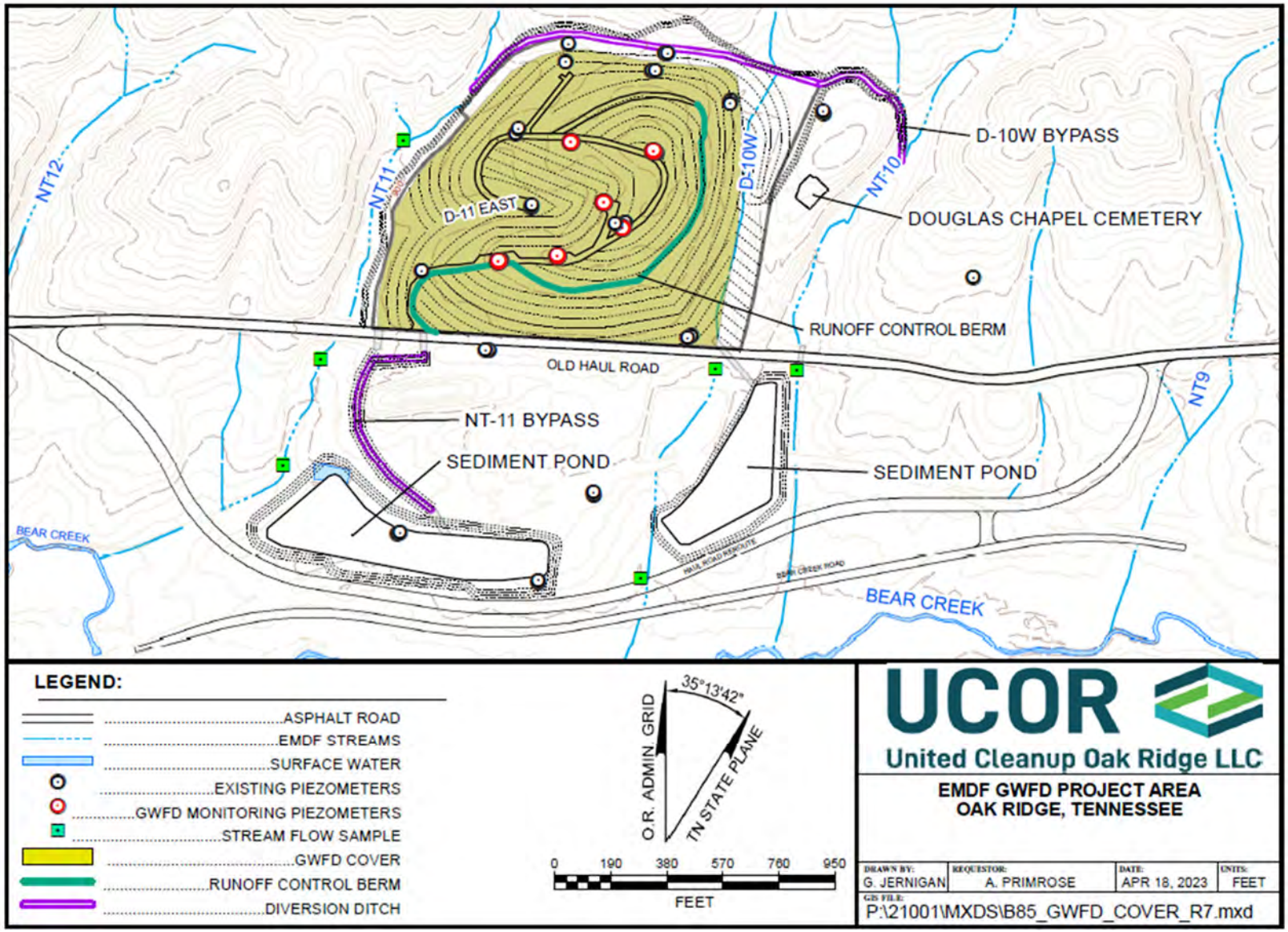

Fig. 7. GWFD Project layout.

5. APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The applicable or relevant and appropriate requirements (ARARs) from the EMDF ROD are those required for natural and cultural resources protection and for the landfill design. Most of the design ARARs are not applicable to the GWFD, because the GWFD is a temporary covers system. The applicable ARARs are provided in Appendix B and were considered and applied during development of the GWFD design.

The approach for implementing the natural resource ARARs is provided in Fig. 8 below.

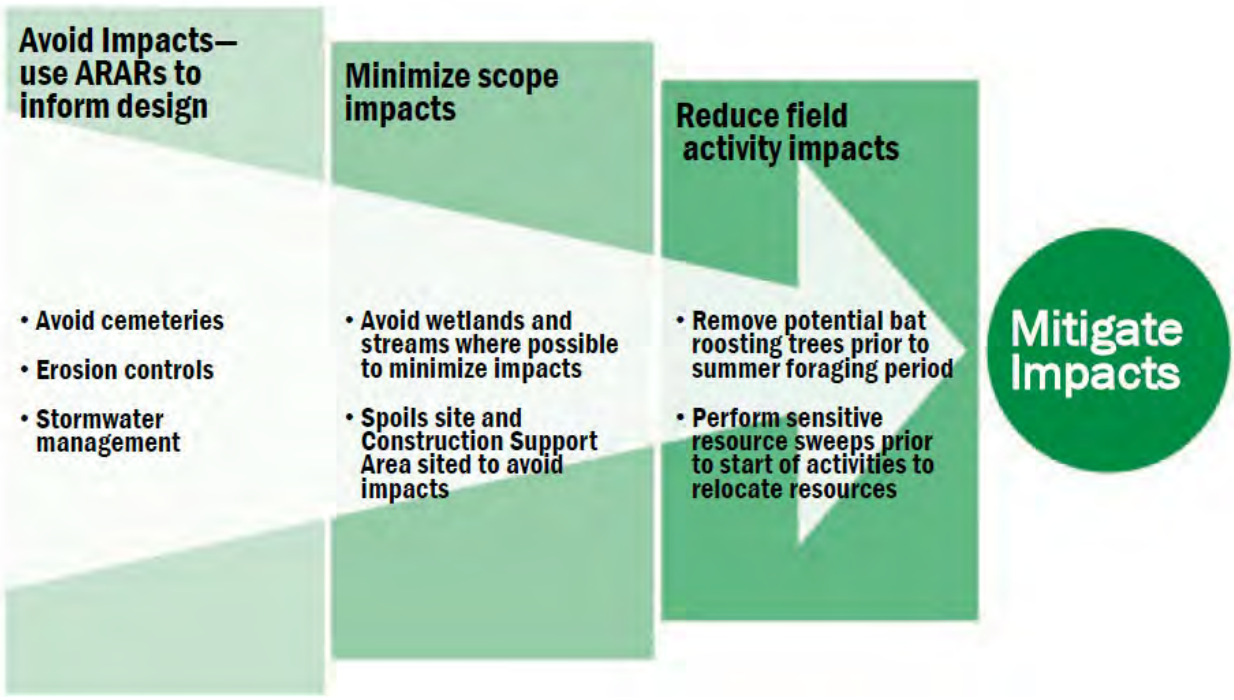

Fig. 8. EMDF GWFD approach to natural resource ARARs.

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6. GWFD IMPLEMENTATION AND APPROACH

Because this action consists of new construction in a clean area, verification, monitoring and operations, and maintenance plans are not required. GWFD activities will be performed under the purview of UCOR's existing programs and procedures, including health and safety, quality assurance (QA)/quality control (QC), and waste management. In addition, GWFD activities will comply with environmental laws and regulations identified in the EMDF ROD as ARARs.

The *Stormwater Management Requirements for Groundwater Field Demonstration for the Onsite Waste Disposal Facility, Oak Ridge, Tennessee* (UCOR-5620) supports the GWFD clearing and grading activities and presents erosion and sediment control best management practices (BMPs). Sediment and erosion control is further discussed in Sect. 6.5. BMPs anticipated to be incorporated include:

- Minimizing disturbed areas
- Controlling stormwater runoff
- Stabilizing disturbed soils as soon as practical
- Protecting slopes and storm inlets downgradient from the work area
- Establishing perimeter controls
- Retaining sediment onsite

Sediment/erosion control measures will be designed in accordance with the guidance presented in the *Tennessee Erosion and Sediment Control Handbook* (TDEC 2012).

Design drawings and specifications for the key design elements are provided in Appendix C. These include site grading, the upgradient stormflow ditch, and the temporary cover system. Field QCs are included with the specifications as appropriate.

6.1 SITE PREPARATION

Prior to construction of the GWFD design features, the initial stormwater controls will be installed. Prior to placement of the temporary cover system, the existing grade in the GWFD area will be stripped to a depth of approximately 4 ft to remove unsuitable materials and provide a safe, stable working surface. Additional cuts will be required in certain areas to develop the appropriate grades (Appendix C).

The uppermost soil unit is a mixed colluvium and residual soil unit with organics that contains unsuitable soils for GWFD subgrade; this material will be stockpiled for later use as topsoil. This upper zone also includes the majority of shallow macropores that increase transmissivity of stormwater and result in an unsafe working environment. The exact depth of stripping will be determined in the field based on the materials encountered, and could be increased in areas where organic, soft/saturated, and highly transmissive materials are present after stripping the upper 4 ft. This material is also unsuitable for subgrade and will be stockpiled for later use as nonstructural fill material.

6.2 UPGRADIENT STORMFLOW INTERCEPTOR CHANNEL

Upgradient stormwater from Pine Ridge will be diverted away from the GWFD area along the course of the current saddle between the knoll and Pine Ridge. The stormflow interceptor channel will be installed at the northern boundary of the GWFD and the D-10W diversion, which will convey flow to dual 48-in. culverts. These features are key to controlling run-on stormwater flows around the facility and maintaining the integrity of the perimeter berms (Figs. 5 and 7). The interceptor channel sides will be sloped at a 2 horizontal to 1 vertical (2H:1V) grade and lined with geotextile covered with riprap to prevent erosion. On the south side of the interceptor channel, the channel serves as an anchor trench for the north side of the GWFD cover system (Figs. 9 and 10).

Grading for the GWFD, and also for the future disposal cells, will cover the former D-10W channel. Therefore, the D-10W headwaters will be diverted to NT-10. The stormflow interceptor channel is adequately sized to reroute run-on through the surficial soil layers north of the site, which is a key element for groundwater management. The stormflow interceptor channel will extend NT-11 to the west, and to the D-10W diversion and NT-10 to the east. The outfall to the D-10W diversion and the stormflow interceptor channel are the dual 48-in. culverts that will convey flow under Haul Road. All run-on controls are designed to convey the 25-year 24-hour storm event with enough capacity to convey the 100-year 24-hour storm event without overtopping.

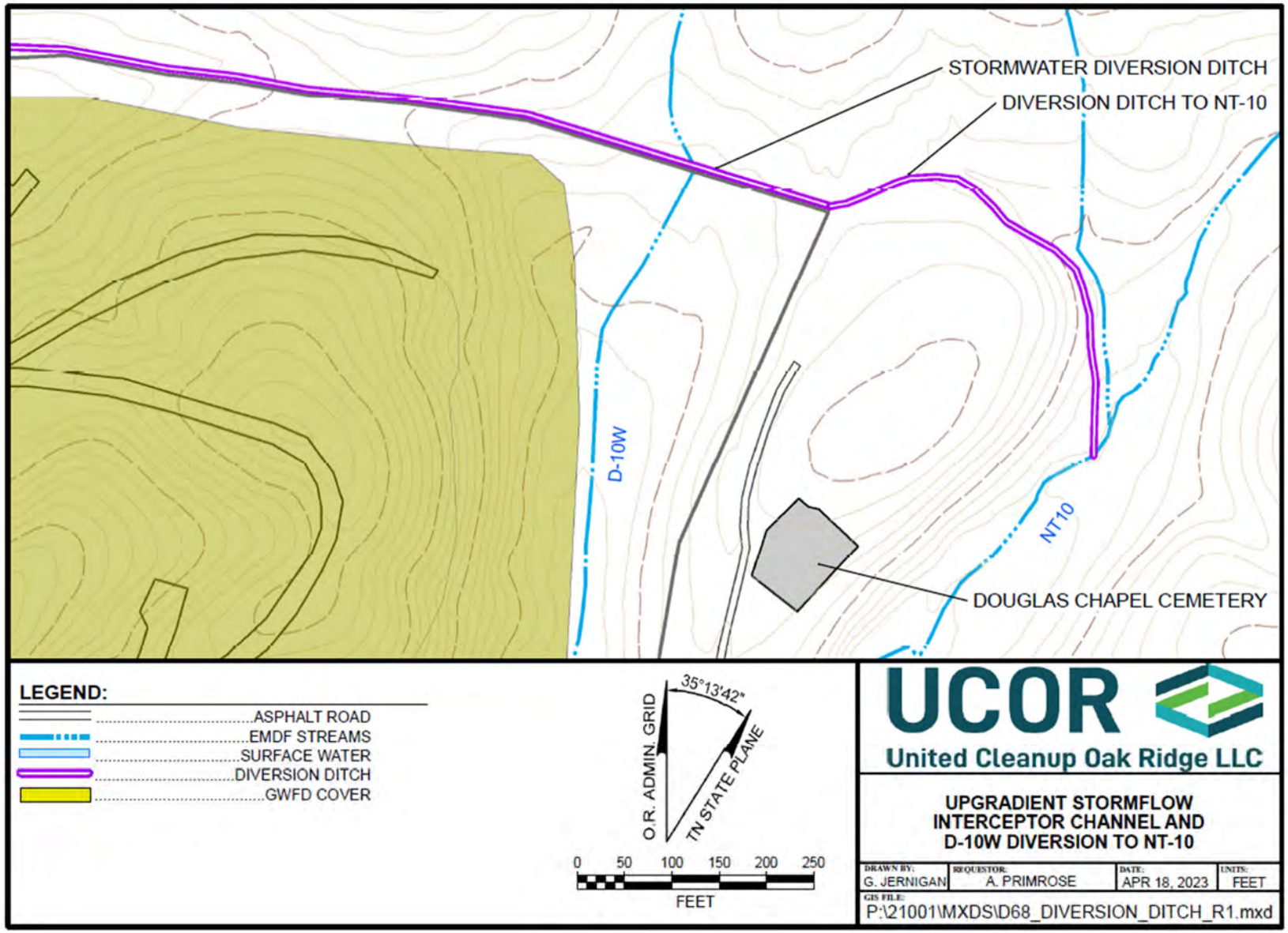

Fig. 9. Upgradient stormflow interceptor channel.

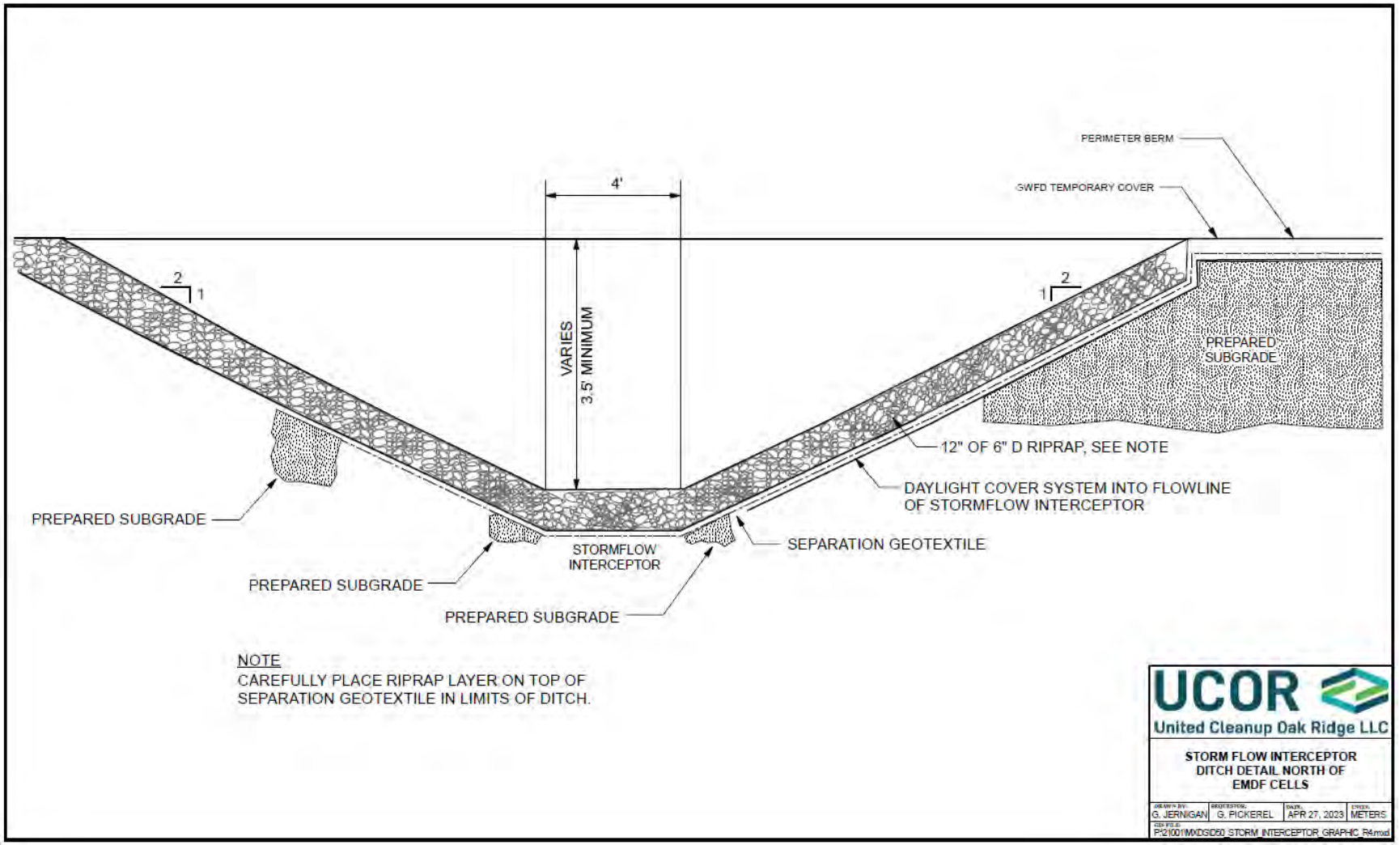

Fig. 10. Design details for the upgradient stormflow interceptor channel.

6.3 TEMPORARY COVER SYSTEM

The civil layout and grading for the temporary cover system were designed with the following requirements:

- Establish a subgrade elevation that removes the high-infiltration stormflow zone and organics layer to support effective cover infiltration control, and removal of additional material below this zone to support an efficient earthwork balance (provide embankment fill for backfill).
- Establish grades such that the final cover system, stormwater features, berms, and access roads are stable, both globally and locally, within the cover system.
- Develop support roads required to access both the existing piezometers to remain and the proposed new piezometers, as well as to support effective cover operations and maintenance.
- Establish grades sufficient to route all overland stormwater to two newly constructed sediment ponds south of the old Haul Road.

Figure 11 provides a cross-section view of the cut and fill required across the knoll to develop a stable, well graded surface to place the temporary cover system.

6.3.1 Design Basis and Requirements

The temporary cover system will be placed over a prepared subgrade to provide a stable working surface. The area will be graded to provide positive drainage away from the cover and to direct stormwater flow to the sediment ponds. In addition, roads for piezometer access and maintenance will be developed as part of the grading.

The cover system will meet the following performance objectives and design bases:

- Approximate the conditions of the final landfill liner system to cut off infiltration and lateral recharge to the GWFD footprint.
- The material must be capable of being welded where panels overlap to maintain consistent engineering properties across the liner, which will minimize leakage.
- The cover system must remain intact with frequent inspection and repairs to reduce infiltration to the GWFD area for a minimum of 2 years. However, the cover system is expected to remain until construction of the landfill.
- The cover must be durable and resistant to damage from environmental conditions, including ultraviolet deterioration, chemical degradation, wind, and stormwater runoff for a minimum period of 5 years.
- The cover must support construction of overlying system components for stormwater management, erosion control, and roadway access for operations, maintenance, and monitoring activities.

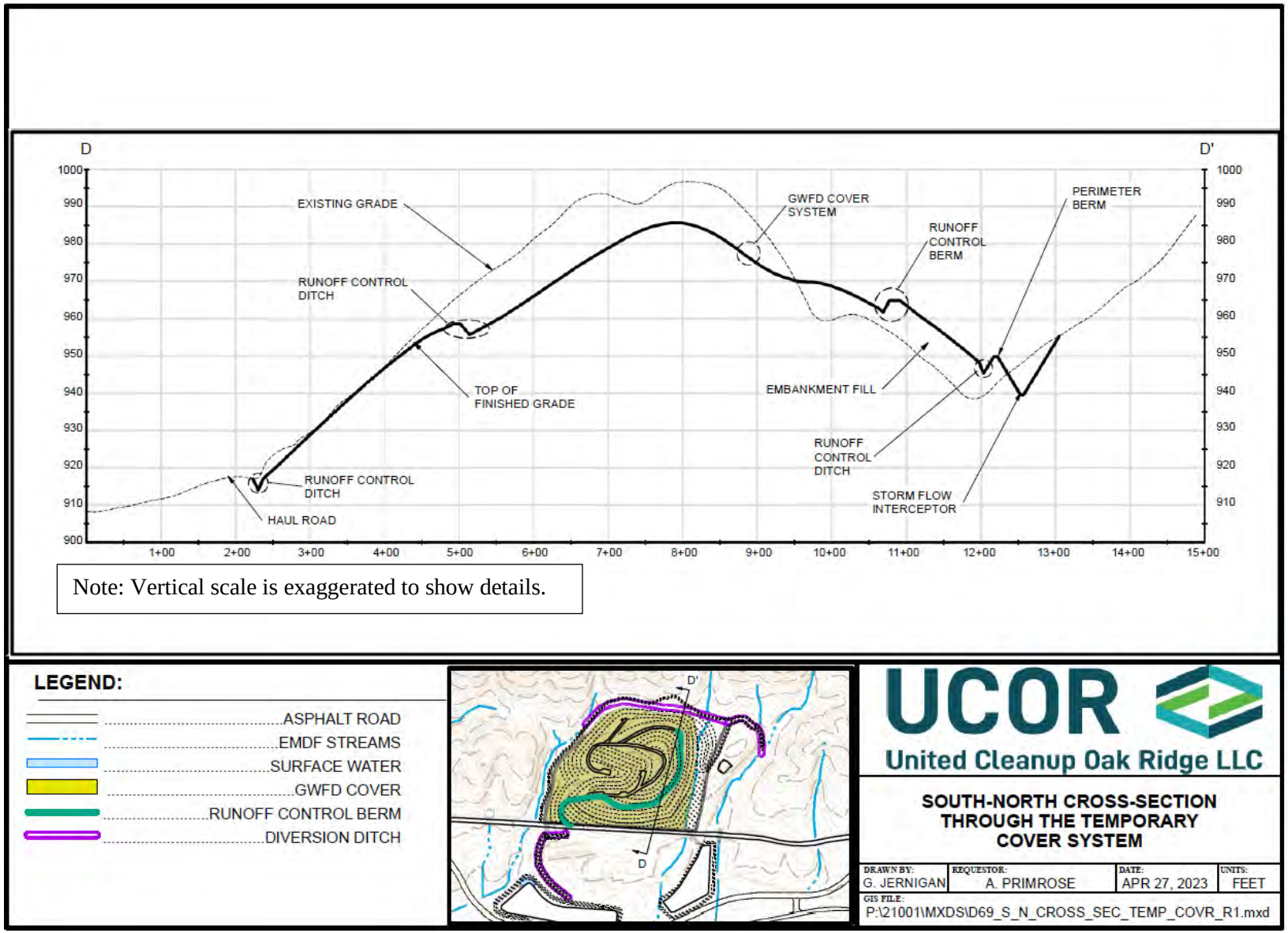

Fig. 11. GWFD south-north cross-section through temporary cover.

The following key design bases were used to develop the design for the temporary cover:

- Maintaining the Douglas Chapel Cemetery in its current state
- Ensure seismic design of the project follows TDEC *Earthquake Evaluation Guidance Document* (TDEC 1994) for design and operation of Class I and Class II solid waste landfills in Tennessee and Resource Conservation and Recovery Act of 1976 (RCRA) Subtitle C/D guidance (40 *CFR* 258.14).
- Use the seismic hazard mapping (2014) incorporated in ASCE 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, and ICC 2018, *International Building Code (IBC)*. Use of the 2014 instead of the updated 2018 seismic hazard mapping is slightly more conservative and therefore appropriate for this design. The design seismic event for ASCE 7-16 corresponds to an event with a 2% probability of exceedance in 50 years (2500-year return period), which is similar to the recurrence interval of approximately 2373 years as required by TDEC and RCRA.
- Static global stability and veneer stability design criteria are based upon recommendations used in standards of practice for slope stability evaluations, including USACE 2003 (*Slope Stability*), USBR 2011 (*Embankment Dams*), and Koerner and Soong 2005, ("Analysis and Design of Veneer Cover Soils." Seismic stability criteria are defined by TDEC (1994) guidelines.

6.3.2 Site Clearing and Grubbing

Initially, sweeps of the area will be conducted to relocate sensitive resources such as four-toed salamanders and tubercle rein orchids. Trees, brush, and other vegetation will be removed from the GWFD area. If possible, merchantable trees will be harvested by an ORR contractor for beneficial reuse. Potential bat-roosting trees will be removed prior to the bat foraging season. If the timing is acceptable, these will be removed at the same time as the remaining trees. Stumps, tree root balls, slash piles, and other unsuitable materials will be removed. This material will be removed and turned into wood chips for future use on the GWFD or other projects.

Topsoil will be stripped from areas that will be disturbed by excavation, filling, or compaction and will be stockpiled/staged in an area such as the Spoils Area. Topsoil will be reused for the project areas or placed into the Spoils Area. Where practical, wetlands soils will be reused for other sites and projects. Soils unsuitable for fill material will be stripped from the project site and staged in the Spoils Area for future use as possible nonstructural fill material.

6.3.3 Subgrade preparation

The civil and grading layout requirements are:

- Develop subgrade elevation that removes the high-infiltration stormflow zone and organics layer to support effective cover infiltration control, and remove additional material below this zone to support an efficient earthwork balance (provide embankment fill for backfill) and safe working surface.
- Develop grades such that the final cover system, stormwater features, berms, and access roads are stable, both globally and locally, within the cover system.
- Develop grades sufficient to route all overland stormwater to two newly constructed sediment ponds south of the old Haul Road.
- Develop support roads required to access both existing and proposed new piezometers, as well as support effective cover operations and maintenance.

The maximum finished grade will be 3H:1V, except in stormwater drainage ditches as described in Sect 3.2. Access roads will be constructed as 2-lane roads with 10-ft lanes. Spur roads will be 12 ft wide with a turnaround point.

The finished grade is shown in Fig. 7 and Fig. 11 (cross-section). While the graded surface reflects a cut of about 4 ft to remove highly transmissive material, due to the knoll configuration, excavation as deep as 30 ft below existing grades will be required in some areas prior to construction of the cover system, as well as embankment construction as high as 24 ft above existing grades. Unsuitable soils may be removed, staged in the Spoils Area, then the area will be backfilled with competent soil. Use of explosives for excavation is not allowed.

After reaching grade, ground surface will be uniformly compacted and prepared for placement of the cover system. Cut slopes will be designed and constructed to drain stormwater with precautions to control erosion and prevent sediment releases.

6.3.4 Cover System Anchor Trenches

Anchor trenches will be excavated into the prepared subgrade after the perimeter embankments and prepared subgrade are complete.

6.3.5 Temporary Cover System

The GWFD temporary cover system consists of (from bottom to top) an HDPE geomembrane, an engineered turf, and overlying sand infill of the turf layer for the ballast (Fig. 12).

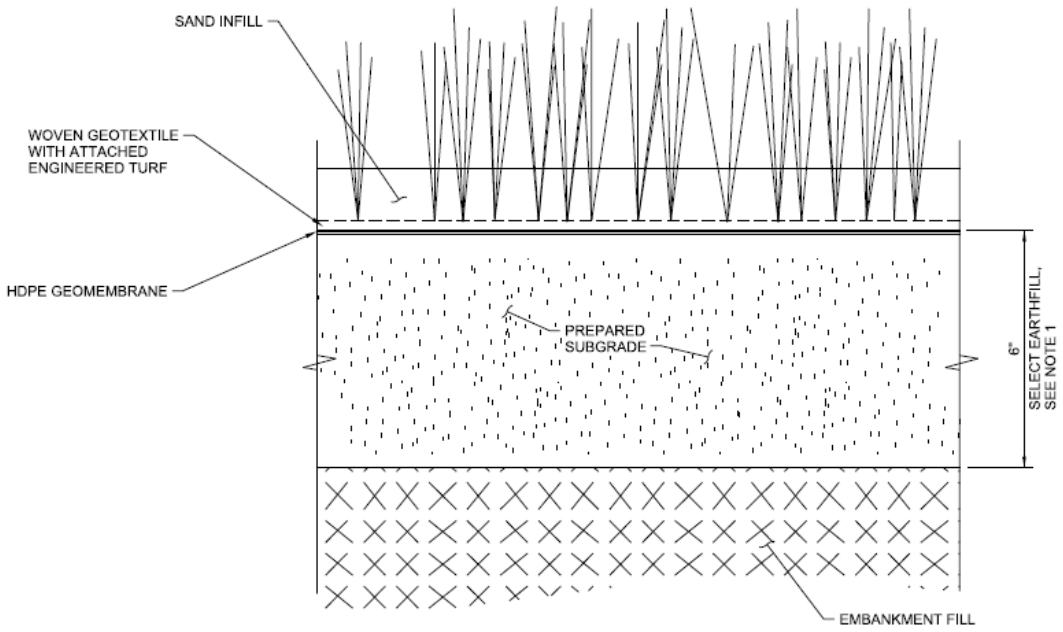

Fig. 12. Design details for the temporary cover system.

The temporary cover system will be installed from the upgradient stormflow interceptor trench southward to Haul Road and from NT-11 eastward to D-10W (Fig. 7). The HDPE geomembrane will be installed over prepared subgrade generated from earthwork activities as shown on Fig. 12.

The key design requirements for the GWFD cover system were as follows:

- Approximate the conditions of the final landfill liner system configuration such that infiltration and lateral recharge is prevented within the GWFD footprint.
- Perform as designed for a period of 2 years during the monitoring period, with inspection and repairs to reduce infiltration. However, the cover system will remain in place until construction of the landfill.
- Include a geosynthetic liner material that forms a low permeability barrier. The geosynthetic liner must be capable of deployment on a prepared subgrade and must be capable of being sealed around piezometer penetrations.
- Material must be capable of being welded where panels overlap to maintain consistent engineering properties across the liner, which will minimize leakage.
- Materials must be durable and resistant to damage from environmental conditions, including ultraviolet deterioration, chemical degradation, wind, and stormwater runoff for a minimum period of 5 years.
- The cover must support construction of overlying system components for stormwater management, erosion control, and roadway access for operations, maintenance, and monitoring activities.

6.3.5.1 HDPE geomembrane

The 50-mil HDPE geomembrane selected will meet the following requirements:

- No manufacturing defects, deterioration from ozone, ultraviolet, or other exposure to elements for 20 years
- No defects in material and factory seams for 2 years
- No defects from installation for 2 years

The selected HDPE will contain no plasticizers, fillers, extenders, reclaimed polymers, or chemical additives, except 2% carbon black to provide ultraviolet resistance and not more than 1.5% antioxidants and heat stabilizers, as required for manufacturing. The HDPE will be smooth, with no ridges of textured geomembrane, and no factory seams.

The HDPE will come in rolls with a width of approximately 22 ft and lengths selected to reduce field seams. The minimum requirements are provided in Table 2. Seams will be welded and quality tested as described in Appendix C.

Table 2. HDPE geomembrane properties

Property	Requirement (MARV)	Test Method
Thickness (min. avg.)	47.5 mil	ASTM D5199, Modified Note 1, or ASTM D5994
Asperity Height (min. avg) 1. Drainage Stud 2. Friction Spike	 130 175	ASTM D7466
Density	0.94 g/cc	ASTM D792, Method B
Tensile Properties (avg. both directions) 1. Tensile Stress @ Break 2. Tensile Stress @ Yield 3. Elongation @ Break 4. Elongation @ Yield	 110 lb./in width 110 lb./in width 200% 12%	ASTM D6693, Type IV
Puncture Resistance	80 lb.	ASTM D4833
Tear Resistance	38 lb.	ASTM D1004, Die C
Carbon Black Content (%)	2 to 3	ASTM D4218
Oven Aging at 200°C Standard OIT (min. ave.) - % retained after 90 days	 140	ASTM 3895
Environmental Stress Crack Resistance	500 hours	ASTM D5397 Single Point NCTL Test

6.3.5.2 Engineered turf component

Overlying the HDPE geomembrane will be a synthetic structure material consisting of geotextiles tufted with polyethylene yarns to resemble grass blades. The color of the polyethylene yarns has not been selected, but is expected to be a color that resembles partially dried grass to better blend in with the environment (expected to be brownish green).

The engineered turf is expected to come in 14-ft-wide rolls. The lengths will be selected to reduce field seams. The minimum requirements are provided in Table 3.

Table 3. Engineered turf properties

Property	Requirement (MARV)	Test Method
Total Product Weight (minimum)	20 oz/sq. yd.	ASTM D5261
CBR Puncture	1500 lb.	ASTM D6241
Tensile Strength of Product	1,600 lb./ft	ASTM D4595
Tensile Strength of Yarn	15 lb.	ASTM D2256
Interface Friction Between Engineered Turf and Textured Geomembrane (min. Peak)	35°	ASTM D5321
UV Stability (retained strength at 100 years projected)	>60%	ASTM G147

The engineered turf will be installed similarly to the geomembrane, except that seams are expected to have a minimum 5-in. overlap. Seams will be fused and quality tested as described in Appendix C.

6.3.6 Sand Infill

A fine-grained uncompacted sand infill shall be placed over the engineered turf and consist of competent washed material less than 3/8 in. in diameter. The sand infill will be ½ to ¾ in. thick as measured with a digital caliper or equivalent.

6.4 BORROW AREA 7B DEVELOPMENT

Installation of the GWFD cover system requires both additional fill material and storage for the topsoil and unsuitable material removed from the GWFD area. While excavated material will be used for fill material if suitable, additional fill material is required to bring the surface to an acceptable grade for placing the temporary cover. Therefore, the Site 7B Borrow Area (Fig. 2) will be developed to support the GWFD, and will continue to operate to support EMDF construction following completion of the GWFD.

Initial site preparation at the Site 7b Borrow Area will be performed as part of the ESP activities and will be completed prior to start of the GWFD Project. The previously constructed features include construction of an access road, a staging area, and stormwater management measures (sediment pond and ditches). The access road will extend approximately 75 ft from the existing Haul Road to the staging area. The staging area will be an area approximately 65 by 285 ft, sufficient to provide for parking of approximately 15 personal vehicles and 5 bays for heavy equipment parking, as well as room for an operations trailer, or similar, and chemical toilets.

Trees identified as potentially used for bats to roost during the summer will be removed during the fall/winter months prior to development of the borrow area. No aquatic resources are anticipated in this area. The initial area of the borrow area will be cleared and grubbed prior to the start of borrow operations, including removal of marketable timber. Topsoil will be removed and staged in a prepared area, either at the 7bBorrow Area or a nearby location.

A newly constructed sediment basin will be approximately 1.1 acre in size, built in an existing swale, to allow sediment control for the entire 15-acre borrow area based on a 5-year, 24-hour design storm. Construction of the sediment basin will require excavation of significant quantities of borrow soil due to

the slopes present at the borrow area. The excavated material is expected to be used for structural fill for the GWFD.

Sediment and erosion controls will be developed for both the active borrow area and the topsoil pile, as described in Sect 6.5.

6.5 SEDIMENT AND EROSION CONTROL

The *Stormwater Management Requirements for Groundwater Field Demonstration for the Onsite Waste Disposal Facility, Oak Ridge, Tennessee* (UCOR-5620, in progress) supports the GWFD clearing and grading activities and presents erosion and sediment control BMPs. Sediment and erosion control BMPs anticipated to be incorporated include:

- Minimizing disturbed areas
- Controlling stormwater runoff
- Stabilizing disturbed soils as soon as practical
- Protecting slopes and storm inlets downgradient from the work area
- Establishing perimeter controls
- Retaining sediment onsite

Sediment/erosion control measures will be designed in accordance with the guidance presented in the *Tennessee Erosion and Sediment Control Handbook* (TDEC 2012).

GWFD construction activities are to be phased to minimize the amount to disturbed areas exposed at any given time. Perimeter runoff controls, including silt fences, straw wattles, and construction exits will be installed prior to clearing and grubbing. Clearing, grubbing, stripping, and grading will only occur in designated construction areas where improvements are planned. Natural features and vegetative soil cover outside of the construction areas will be protected to avoid disturbance to trees or vegetative cover and to minimize soil erosion.

The following erosion and sediment control BMPs will be applied for the GWFD construction activities:

- Control of stormwater flowing onto and through project area
  - Straw wattles: serve as run-on diversion, runoff filtration, water velocity dissipation
  - Check dams: installed in swales and ditches to reduce velocity in channels and thereby reduce erosion
  - Diversion berm: divert rainwater away from the cut slopes and control stormwater flowing onto the project
- Stabilization of soils
  - Hydromulching: protect exposed soils. Wood chips may be used as available and effective.
  - Seeding and straw mulch: lawn areas will be seeded and stabilized with straw or similar mulching material
  - Roadway gravel/road base: placed on all areas receiving vehicular traffic (access roads and staging areas)

- Protection of slopes
  - Erosion-control blankets: used to stabilize slopes in swales, cut slopes, and sediment basin
- Protection of storm drain inlets
  - Straw wattles: protection for storm drain inlets (catch basins) until permanent vegetation has been established
- Perimeter controls and sediment barriers
  - Silt fences: installed along the toe of fill slopes and around topsoil stockpiles
- Stabilized construction exits
  - Anti-tracking pads: installed at project egress locations to prevent the offsite transport of sediment by construction vehicles
- Dust control: use of a water truck to apply water to disturbed areas to control dust

Additional BMPs not presented here may be incorporated as needed. Impacts to waterbodies will be minimized through implementation of BMPs.

Erosion and sedimentation control during construction will be through use of silt fences, inlet and outlet protection at culverts and catch basins, grass-lined and riprap-lined ditches, filter rings, and other erosion- and sedimentation-control measures. Erosion-control matting will be installed on slopes steeper than 4:1 and all ditches not lined with riprap. Straw wattles will be installed along the contour (across the slope) to intercept water running down a slope. Completed slopes, ditches, and other areas will be seeded and mulched within 15 days of completion of site grading.

Stormwater ponds will be placed for sediment control for the GWFD and the landfill disposal cells. These stormwater ponds are expected to be placed in the vicinity of the existing Haul Road, which will be rerouted as part of the ESP activities for the EMDF landfill (Fig. 7).

Run-on to the GWFD from the cemetery hill east of the GWFD will be controlled by a drainage ditch that is located over the cover in the in-filled former D-10W channel and routed to discharge into the newly constructed Pond 2 south of the old Haul Road.

Stormwater runoff control ditches and two culverts will direct runoff to a series of culverts, conveying stormwater flow under Haul Road. All runoff controls are designed to convey the 25-year, 24-hour storm with enough capacity to convey the 100-year 24-hour storm event without overtopping.

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7. WASTE MANAGEMENT

This section identifies the sanitary and industrial waste streams that are expected to be generated during the GWFD activities. The GWFD activities will occur in uncontaminated areas; therefore, waste materials are expected to be disposed at the Oak Ridge Reservation Landfills (ORRLs). A summary of waste stream characterization during GWFD activities is provided in Table 4, which describes, quantifies, and defines waste streams, and identifies the expected disposal outlet(s). While contaminated waste streams are not anticipated, if discovered or generated, DOE will notify EPA and TDEC and those waste streams will be evaluated and characterized for disposal at the Environmental Management Waste Management Facility or other suitable disposal facility.

Vegetation removed during GWFD activities is not expected to be waste. Marketable timber will be harvested as possible and practical, segregated, and removed. The remaining vegetation is expected to be used at the EMDF site for mulch and/or erosion control (some of which may be chipped). Vegetation removal and management will be in accordance with the Stormwater Management Requirements Plan and BMPs. The remaining vegetation will be evaluated for other beneficial use as practical. Secondary waste generated during the primary waste-generating activities is expected to be disposed with the primary waste streams.

Table 4. Summary of wastes generated by GWFD activities

Waste Stream	Expected waste type	Estimated volume	Characterization basis	Planned disposition site
Construction debris, bags/containers and PPE,	Sanitary	50 cy	PK, radiological surveys	ORRL
Misc. trash and organic garbage (e.g., food waste)	Sanitary	10 cy	PK, radiological surveys	ORRL
Hydraulic line spill cleanup material	Sanitary	<5 cy	PK, radiological surveys	ORRL
Associated secondary waste (PPE, plastic sheeting, tools, rags, wipes)	Sanitary	10 cy	PK, radiological surveys	ORRL

ORRL = Oak Ridge Reservation Landfills
PK = process knowledge
PPE = personal protective equipment

It is assumed that unused materials (e.g., surplus materials) from the construction of the temporary cover system will be removed from the site by the subcontractor performing the work and will not be a waste stream managed during this activity. If it is disposed onsite, it will be disposed at the ORRLs.

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8. SAMPLING AND ANALYSIS PLAN

8.1 OBJECTIVES

The GWFD will be performed in an area undisturbed by ORR activities. As described in Chap. 1, seasonal groundwater elevations will be measured following construction of the GWFD cover system to demonstrate the seasonal high post-construction groundwater surface will be below the base of the geologic buffer. Where practical, straight line interpolation between data points will be performed to eliminate the need to interpret or model results.

8.2 PIEZOMETERS

Due to upward gradients at several deeper piezometers reflecting potentially confining conditions, shallow piezometers will provide the best representation of post-construction seasonal high groundwater elevations at the geologic buffer depths. Where possible, the existing shallow piezometers will be maintained during construction of the GWFD to allow ready comparison to pre-GWFD conditions.

There are three existing shallow piezometers where the seasonal high potentiometric surface is higher than the projected bottom of the geologic buffer. The shallow piezometers were selected because these most accurately reflect shallow groundwater elevations closest to the elevation of the geologic buffer. These piezometers are shown in Table 5 and on Fig. 11 and are:

- GW-983—at the top of the knoll
- GW-989—further down the knoll
- GY-020—located between GW-983 and GW-989

The shallow piezometers to be used for the GWFD are in the knoll area. These are provided in Table 5 and shown in Fig. 13. These existing piezometers will be protected during GWFD construction, with casing extended or shortened, as necessary. Following completion of GWFD construction activities, protective surface casing and well pads will be reinstalled, and the piezometers will be protected, as necessary. Methods to protect piezometers will avoid penetrating the liner system.

Deeper piezometers will also be protected and maintained, as practical, but will not be used for determining the post-construction groundwater elevation at the base of the geologic buffer.

Table 5. EMDF average seasonal high and low groundwater elevations—shallow piezometers/GWFD area

Piezometer	Formation	Current seasonal high groundwater elevation higher than bottom of geologic buffer (Y/N)	GWFD monitoring status	Comments
GW-979	Rutledge/ Rogersville	N/A	To be abandoned	Outside landfill cells, within upgradient cut-off trench
GW-981	Maryville	No	To remain	Outside landfill cells, projected geologic buffer
GW-983	Maryville	Yes	To remain	Within landfill cells, screened below geologic buffer
GW-985	Maryville	N/A	To remain	Outside landfill cells
GW-987	Maryville	No	To remain	Significant fill area (D-11E)
GW-989	Maryville	Yes	To remain	Within landfill cells, screened near geologic buffer
GW-990	Maryville	Yes	To remain	
GW-991	Maryville	N/A	To remain	Dry
GW-993	Nolichucky	No	To remain	
GW-995	Nolichucky	No	To remain	
GY-003	Rutledge/ Rogersville	N/A	To remain	Outside landfill cells
GY-004	Maryville	N/A	To remain	Outside landfill cells
GY-005	Rogersville/ Rutledge		To be abandoned	Outside landfill cells, within upgradient cut-off trench
GY-007	Maryville	N/A	To remain	Outside landfill cells
GY-008	Maryville/ Nolichucky	N/A	To remain	Outside landfill cells
GY-020	Maryville	Yes	To remain	Within landfill cells, screened near geologic buffer, shallow pair to GW-990

Note: Shallow piezometers were selected as most representative of groundwater elevations closest to the elevation of the geologic buffer

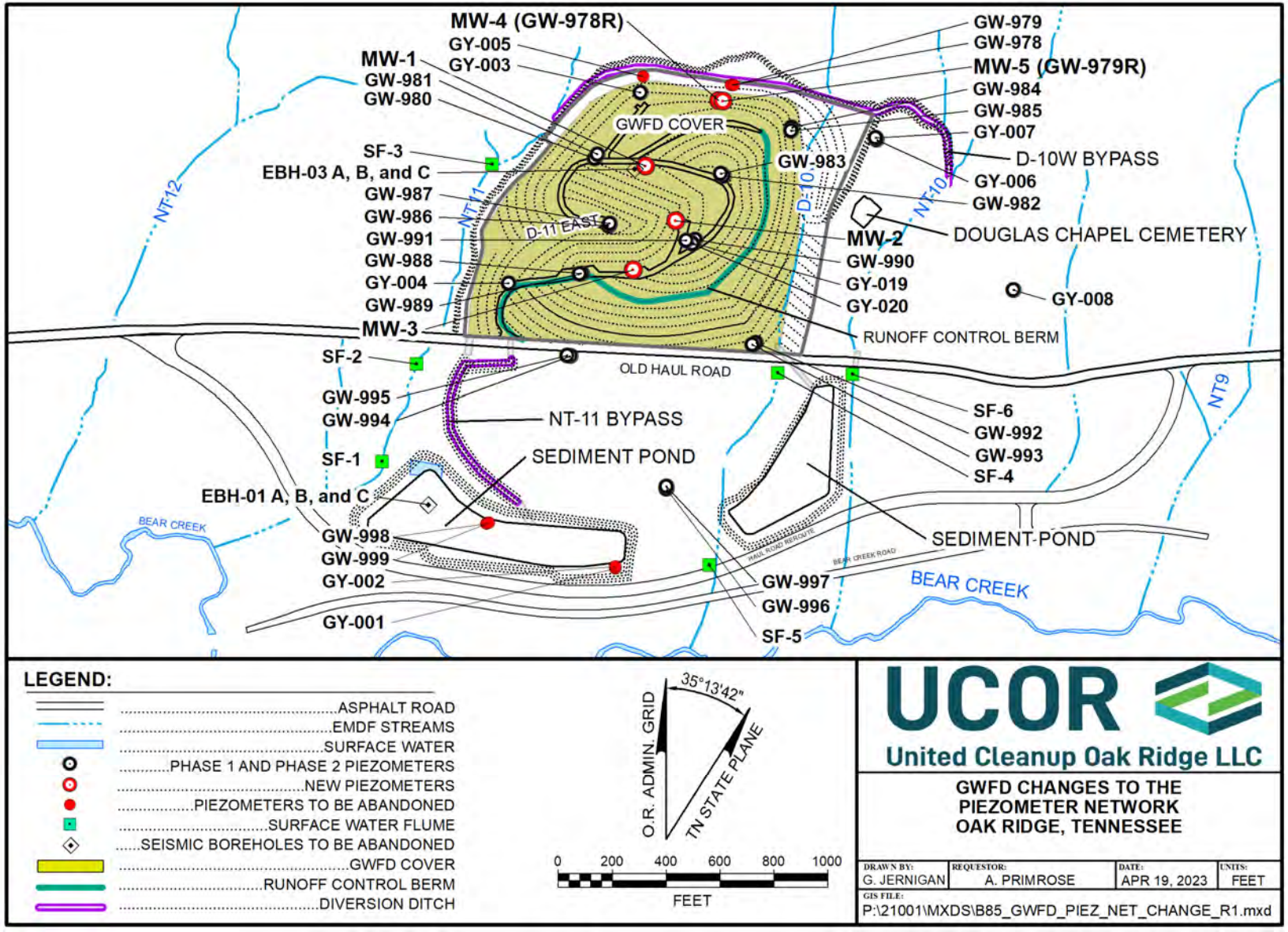

Fig. 13. Changes to piezometer network.

8.2.1 New Piezometers to be Installed

Three new piezometers are expected to be installed to allow more straight-line interpolation of data between existing piezometers to define the seasonal high groundwater table (Fig. 13). An additional two piezometers are being added to replace a piezometer pair to be removed during the upgradient stormflow trench construction.

- New piezometer MW-1, lower on the knoll to the west
- New piezometer MW-2, lower on the knoll between GW-983 and GY-020
- New piezometer MW-3, lower on the knoll to the southeast
- MW-4 and -5, shallow/deep pair replacements for abandoned piezometers GW-978 and -979

The approximate piezometer locations are presented in Fig. 13. Actual investigation locations will be determined in the field, based on accessibility or site conditions encountered at the time of drilling. Locations will be surveyed by a licensed land surveyor (including horizontal position and ground surface elevation at each new piezometer within 0.1 ft and the top-of-casing elevation of each piezometer within 0.01 ft).

Lithologic information will be obtained from the boreholes at each location. The shallow piezometers will be constructed of 2-in. PVC pipe with the base of the well screens at the approximate elevation of the bottom of the geologic buffer zone. Boreholes and piezometers will be constructed by Tennessee-qualified monitoring well drillers in accordance with ORR requirements, as specified in *Standard Specification for Well Drilling, Installation, and Abandonment* (SPG-00000-A005).

Selected construction details are provided in Table 6. Note, a 5-ft screen interval was selected to ensure that groundwater elevations measured were targeted to the base of the geological buffer that is critical to the design and reduce the possibility of having to interpret results.

Table 6. GWFD additional piezometer construction information

Piezometer	Formation	Projected ground surface elevation (ft amsl)	Elevation of base of geologic buffer	Total depth (ft)	Screened interval (ft bgs)	Comment
MW-1	Maryville	975.7	940.4	35	29.5-34.5	
MW-2	Maryville	966.5	931.2	40	34.5 - 39.5	
MW-3	Maryville	967.6	970.0	52.5	47 - 52	
MW-4	Rogersville	955.0	n/a	70	59.5 - 69.5	Replaces GW-978
MW-5	Rogersville	954.8	n/a	40	34.5-39.5	Replaces GW-979

amsl = above mean sea level

Following construction, measures will be taken to protect the piezometers until the final configuration of the GWFD cover is reached. Bollards are not expected to be placed to avoid penetrating the cover. Other methods may be selected to protect the piezometers such as jersey barriers. 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. Following development and similar to the other EMDF piezometers, dedicated downhole monitors will be placed in each piezometer to measure pH, temperature, and groundwater elevation. Data will be collected continuously and recorded every hour.

8.2.2 Piezometer, Seismic Boreholes, and Well to be Abandoned

Three piezometers on the north side of the knoll will be abandoned. These are located within the area that will be disturbed by installation of the upgradient stormflow cutoff trench. Four additional piezometers located in the western sediment pond area will be abandoned (Table 7). Piezometers will be abandoned in accordance with the ORR requirements as specified in *Standard Specification for Well Drilling, Installation, and Abandonment.*

Table 7. GWFD piezometers to be abandoned

Piezometer	Shallow/ Deep	Reason
GY-005	Shallow	Within upgradient cut-off trench
GW-978	Deep	Within upgradient cut-off trench
GW-979	Shallow	Within upgradient cut-off trench
GW-998	Deep	Within western sediment pond area
GW-999	Shallow	Within western sediment pond area
GY-001	Deep	Within western sediment pond area
GY-002	Shallow	Within western sediment pond area

While remaining piezometers will be protected, if additional piezometers are damaged beyond repair during construction activities, these will be abandoned in accordance with *Standard Specification for Well Drilling, Installation, and Abandonment.*

Six seismic boreholes will be abandoned as part of the GWFD Project. These are located in sets of three at two different locations (Fig. 13):

- On the knoll midway between GW-981 and GW-983 in the vicinity of new piezometer MW-1
- West of SF-1

In addition, the pre-ORR settler-era water well on the EMDF footprint will be abandoned at this time. This well is approximately 32 ft deep and is located south of SF-4 (Fig. 2). The well represents a potential pathway to groundwater. A groundwater level will be collected prior to abandonment and the data will be provided to EPA and TDEC.

8.3 INTERPRETATION OF MONITORING RESULTS

Based on the comparison between existing potentiometric data monitoring during wetter periods and the preliminary design elevation of the geologic buffer, piezometers demonstrate groundwater below the elevation of the geologic buffer, except in the knoll area. Piezometers in the knoll area currently demonstrate mounding in groundwater due to recharge from the knoll, with elevations above the bottom of the proposed geologic buffer.

The following piezometers either have current (pre-construction) wet season groundwater elevations/potentiometric surfaces higher than the base of the geologic buffer or are anticipated to have current (pre-construction) wet season groundwater elevations/potentiometric surfaces higher than the base of the geologic buffer. These piezometers are shown on Fig. 14 and will be used to determine whether the

preliminary design elevation of the base of the geologic buffer is appropriate to maintain 15 ft separation between the seasonal high groundwater elevations, or whether design changes are warranted:

- GW-983, high point of knoll
- GW-989, southern part of knoll area
- GY-020, south of GW-983 on knoll
- New piezometer MW-1, lower on the knoll to the west
- New piezometer MW-2, lower on the knoll between GW-983 and GY-020
- New piezometer MW-3, lower on the knoll to the southeast

Because the demonstration is for average seasonal high groundwater elevations, the median monthly groundwater elevations measured in the wettest month (the month with the highest groundwater elevations) will be used to determine the seasonal high groundwater elevation based on the 80th percentile of groundwater elevations. While the highest groundwater levels typically occur in February, during the GWFD, the wet season month with the highest groundwater levels will be used for the average seasonal high groundwater elevation. This calculated average seasonal high groundwater elevation is considered more conservative (i.e., higher) than the average of measurements collected in the wettest month.

If seasonal variation is suspected to be influencing the results from the listed piezometers, then an approach to correcting for seasonal variation will be discussed and agreed upon by the triparty technical team. The agreed-upon approach will be documented as an erratum to this RDWP/RAWP.

Please note, although not required to determine impacts from EMDF construction on the knoll area water levels, the other piezometers in the EMDF area will continue to be monitored, as possible and practical. These will provide comparison data for consideration of seasonal variation outside the influence of the GWFD, if necessary.

8.4 PERFORMANCE/ACCEPTANCE CRITERIA

Groundwater elevations will be collected and analyzed per *URS | CH2M Oak Ridge LLC Quality Assurance Plan for Environmental Characterization and Monitoring, Oak Ridge, Tennessee* (UCOR-4189; QA Plan).

8.5 REPORTING OF MONITORING RESULTS

Monitoring results and the associated evaluation/interpretation will be provided in a Technical Memorandum after the first wet season monitoring period and in a follow-on Technical Memorandum after the second wet season monitoring period. These results will also be included in the landfill RDR.

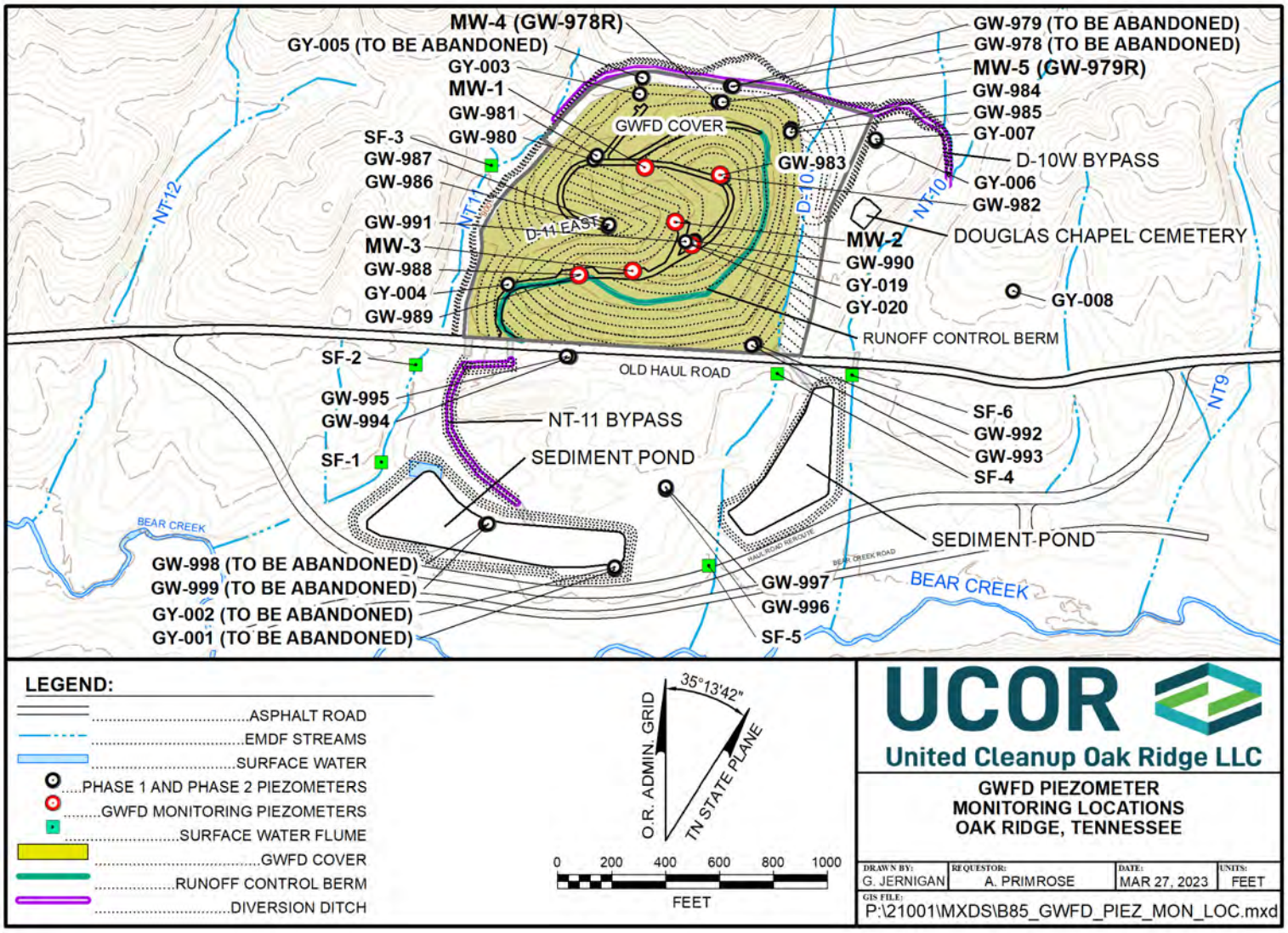

Fig. 14. GWFD piezometer monitoring locations.

8.6 PUMPING TEST

A pumping test will be completed in Fall 2023 prior to installation of the GWFD to provide additional hydrogeologic information for interpretation of the GWFD results and hydrogeologic parameters to be used in the EMDF final design.

The results of the testing will be used to establish hydraulic characteristics in saturated zones within the EMDF footprint. The testing is focused in those areas where current groundwater level measurements indicate groundwater mounding due to precipitation and shallow groundwater recharge, and to refine estimates of groundwater-specific capacity, recovery, and recharge.

The pumping test will be performed within the knoll area of the proposed EMDF in existing piezometers. The piezometers are currently equipped with groundwater level measurement transducers and data loggers, which will be used for data collection during the testing. These data loggers are set at 60-minute measurement intervals and will be reset to measure 1-minute intervals during the testing and recovery time period. Manual groundwater level measurements will be collected in the pumping and observation piezometers to provide more frequent groundwater level measurements during the initial start of pumping, and at less frequent intervals as data validation and for comparison to transducer measurements. More frequent manual groundwater level measurements will be collected after pumping is discontinued to measure recovery.

If practical, the testing should be completed during periods that are not influenced by precipitation and surface recharge to groundwater. The groundwater in the knoll areas show relatively quick and large responses to local precipitation events in the weathered and fractured rock. Indications are that the shallow hydrostratigraphic unit has relatively low storativity, is unconfined, and under normal conditions, has a downward vertical gradient.

Goals of the pumping test are to provide refined estimates of saturated rock storage, hydraulic parameters based on longer and greater area of influence testing, and influence of recharge boundaries on dewatering. These data will be used to support the ongoing GWFD implementation and evaluation, and design parameters for incorporation into the EMDF design.

8.6.1 Scope

Two minimum 72-hour pumping tests will be performed at piezometers GW-983 and GW-990 (Fig. 10). The pumping test will consist of performing a step-drawdown test in each piezometer prior to the long-term pumping tests to determine the long-term pumping rate. The pumping tests are expected to be conducted in parallel, with monitoring at observation points to observe conditions indicating potential lateral and vertical boundary effects within the saturated zone. The duration of the pumping tests will depend on the response observed.

Piezometer GW-983 is located on the highest topographic point within the EMDF area, with the highest shallow groundwater levels measured historically on the site. This piezometer is screened near the bottom of the proposed EMDF geologic buffer. The testing will provide information regarding the storage of groundwater in this area, hydraulic characteristics, and application of this information in interpretation of the response to the GWFD and piezometer measurements.

Piezometer GW-990 is located along the ridgeline to the south of GW-983, with a screen interval below the geologic buffer, but with sufficient drawdown available for pumping and stress of the hydrostratigraphic unit. Piezometers GY-019 and GY-020 are located relatively close to the pumping piezometer GW-990 and will be used as observation points. These are screened at shallower depths within the elevation range of the

geologic buffer. While less drawdown is available at the observation piezometers, observed drawdown in response to the deeper pumping will provide information regarding the shallower geologic buffer zone. Pumping groundwater from GW-990 will provide data to extend the lateral and vertical area for interpretation and for comparison with results from GW-983 testing.

Table 8 shows the selected wells for the testing. This table includes the pumping locations, the observation piezometers, and depths related to total piezometer depth, screen intervals, and approximate groundwater levels. The depth to the proposed EMDF bottom of the geologic buffer have also been included for future evaluation of results to the design.

Table 8. Pumping test piezometers construction details

Piezometer location	Type	Top of casing elevation (ft-MSL)	Ground elevation (ft-MSL)	Total depth of well (ft-TOC)	Top of screen (ft-TOC)	Bottom of screen (ft-TOC)	Approximate depth of groundwater (ft-TOC)	Available drawdown mid-screen (ft)	Bottom of geologic buffer (ft-TOC)
GW-983	Pumping	1018.07	1015.60	92.99	81.67	91.67	73	14	82.27
GW-982	Observation	1018.02	1015.60	115.82	104.52	114.52	73	37	82.65
GW-990	Pumping	996.22	993.95	107.45	100	105	58	44	68.53
GY-019	Observation	994.6	992.29]	87.5	74.5	84.5	53	27	67.13
GY-020	Observation	994.52	992.36	65.5	52.75	62.75	53	5	67.36

MSL = mean sea level
TOC = Top of Casing

8.6.1.1 Pre-test setup

A Grundfos 5SQ-05-90, or equivalent pump capable of pumping up to 7 gal per minute (gpm) should be used for testing. A pump should be installed in each well on a 1/2-in. polyethylene tubing with a tubing length that allows for groundwater removed to be discharged at the surface into an adjacent existing drainage. The tubing will include a foot valve located near the pump so that water from the discharge line does not flow back into the well during the recovery test. The 1/2-in. discharge tubing will be connected to a manifold with a flow-control valve and flowmeter. The flowmeter will have a measurement range that includes 0.4 to 7 gpm, and totalizer volume discharged. The flow-control valve will allow for adjustment to the desired range of flow rates.

The piezometers are currently equipped with transducers and data loggers that measure groundwater levels at a frequency of 60 minutes, as part of the EMDF piezometer monitoring for the site. These transducers will be reprogrammed for 1-minute intervals and replaced in piezometers to allow for continuous monitoring during the testing. The observation piezometers were selected for proximity to the pumping locations.

Manual water level measurements will be collected from the pumping and observation piezometers during the initial step-drawdown and minimum 72-hour testing. These manual measurements will be used for the step-drawdown data analysis, and then for measuring recovery in the piezometers prior to starting the pumping test. Baseline groundwater level monitoring will be provided through the existing piezometer transducer and data logging activities.

8.6.1.2 Mobilization and setup

The testing will be completed from the existing access roads and gravel pads located on the EMDF site. All equipment necessary for operation of the pumping will be mobilized to the site. It is anticipated that generators will be required and refueling performed during the testing. Once equipment has been mobilized

onsite, it should be set up and located so that it can continue operations without onsite staffing between fueling.

The groundwater will not be containerized and will be discharged 50 ft, or preferably 100 ft, away from the piezometer into an existing surface-water drainage. An erosion-control geofabric, or similar erosion-control material, will be placed at the end of the discharge hose to mitigate potential erosion and provide for lateral spread of the water into the drainage.

8.6.1.3 Step-drawdown test

The purpose of the step-drawdown testing is to determine the optimal rate for performing the longer, minimum 72-hour pumping test at each of the locations. The selected rate is one that places enough stress on the saturated zone to produce observable response in the observation piezometers and determines a specific capacity within the pumping piezometer (flow per foot of drawdown). The selected pumping rate should not exceed the available drawdown in the pumping piezometer over the duration of the 72-hour test, but should provide sufficient drawdown that an estimate of the hydraulic properties of the formation are measured. If a steady-state-specific capacity is not determined during the step-drawdown test, a flow rate that has available drawdown to allow 72-hours of pumping without dewatering may be selected.

Initial manual data collection during the step-drawdown should be on minimum 3- to 5-minute intervals. The step test will include a minimum of 3 steps from lower to increasing flow rate. The proposed flow rate and steps are 0.5 gpm for 30 minutes, followed by 2 gpm for 30 minutes, followed by 4 gpm for 30 minutes, and at greater rates for additional steps if the yield is sufficient. The actual rates and duration will be dependent on the actual drawdown measured within the pumping wells, and if steady-state conditions with an equilibrated depth to groundwater is established quickly within each step.

The groundwater levels observed over the step test will be extrapolated using the specific yield (gpm/ft drawdown) over 72 hours to provide a pumping rate that would provide the maximum drawdown without dewatering the piezometer. The pumping piezometer will be allowed to recover to within 0.5 ft of the starting static water level prior to initiating the 72-hour pump test, or until at least the duration of the step-drawdown testing has elapsed if levels do not return to initial (pre-pumping) levels.

8.6.1.4 72-hour test

The initial depth to groundwater will be measured prior to the start of the 72-hour test, with increased frequency of manual measurements collected in the pumping and observation piezometers. Initial manual groundwater level measurements will be collected at a minimum of 3- to 5-minute intervals for the first 30 minutes of the 72-hour testing, then every 10 minutes for the next 60 minutes, followed by every 30 minutes for the following 120 minutes. After the increased manual measurement frequency during the initiation of the pumping, the drawdowns will be reviewed and confirmed that available drawdown is sufficient to continue the testing, or the duration may be adjusted down, as needed. Additional manual groundwater level measurements will be collected at least 2 times per day during testing. At the completion of the pumping, manual measurements will be collected at an increased interval to measure the recovery in the pumping and observation piezometers. Manual measurements will be collected at 3- to 5-minute intervals until the wells have recovered to within 0.5 ft of the initial water level, or 60 minutes past discontinuation of pumping regardless of recovery.

8.6.1.5 Demobilization and transducer measurements

After completion of the testing, step-drawdown, 72-hour constant-rate testing, and recovery measurements, the pumps will be removed from the piezometers, and piezometers caps and covers will be put back in place. The manual measurements from handbooks will be entered into MS Excel spreadsheets for use with the transducer data logger data.

Following testing, testing equipment will be removed from the site. The site is located outside previously disturbed areas of the Oak Ridge Facility and is not within an area of groundwater contamination. The equipment used in the testing will be decontaminated prior to use at this location, but does not require decontamination onsite, or contain investigation-derived wastes.

8.6.2 Duration

The field work is anticipated to be completed over a 5-day period, but could be completed over 10 days if the 72-hour testing is completed sequentially, or if one of the test periods is extended. The work needs to be completed during a period of relatively no or low precipitation so that the shallow groundwater is not impacted by surface water recharge during the testing. While the 72-hour testing includes pumping operations continuously during the 3 days, the equipment and operations should be set up so that staff are only required onsite for a period of not more than 10 hours per day.

8.6.3 Reporting

Results of the pumping tests will be included in the Technical Memorandum that presents the results of the GWFD monitoring. The pumping test results are expected to support and add clarity to the GWFD monitoring results.

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9. SCHEDULE

The pumping tests are currently planned to be completed in fall 2023 prior to construction of the GWFD. As noted in Sect. 2.2, construction for the 7B Borrow Area is expected to begin in fall 2023. The GWFD construction activities are currently planned to begin in February 2024 and are planned to be completed in fall 2024, in time to monitor the 2024/2025 wet season.

Following construction of the GWFD cover, monitoring will be performed for one wet season to determine the expected post-landfill-construction seasonal high groundwater elevation in the knoll area. Following the first wet season, final landfill design will begin, based on the monitoring data. Monitoring will continue through the second wet season to obtain additional information and will refine the design, if needed. As described in Sect 8.3, the highest groundwater elevations in any given year are typically observed in February. However, precipitation varies by year and every attempt will be made to monitor during the wettest winter month of the year for the GWFD.

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APPENDIX A.
SENSITIVE RESOURCES

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A.1 GROUNDWATER FIELD DEMONSTRATION SCOPE

The Groundwater Field Demonstration (GWFD) is designed to approximate the elimination of recharge to groundwater from construction of the Environmental Management Disposal Facility (EMDF) landfill in the knoll area. The key elements are:

1) Upgradient stormwater interceptor channel to reduce lateral recharge into the area
2) Temporary cover system designed to approximate the conditions of the final landfill liner system configuration, such that infiltration and recharge are cut off to the GWFD footprint
3) Stormwater controls to divert runoff from the cover away from the GWFD area
4) Development of the 7B Borrow Area to provide fill material for construction of the GWFD and for the balance of landfill.

The GWFD will require clearing of the northern part of the landfill area and the support areas. Because of the large area to be cleared and the amount of wetlands to be disturbed, the description and mitigation of these sensitive resources will be performed together.

The major EMDF components are shown on Fig. A.1.

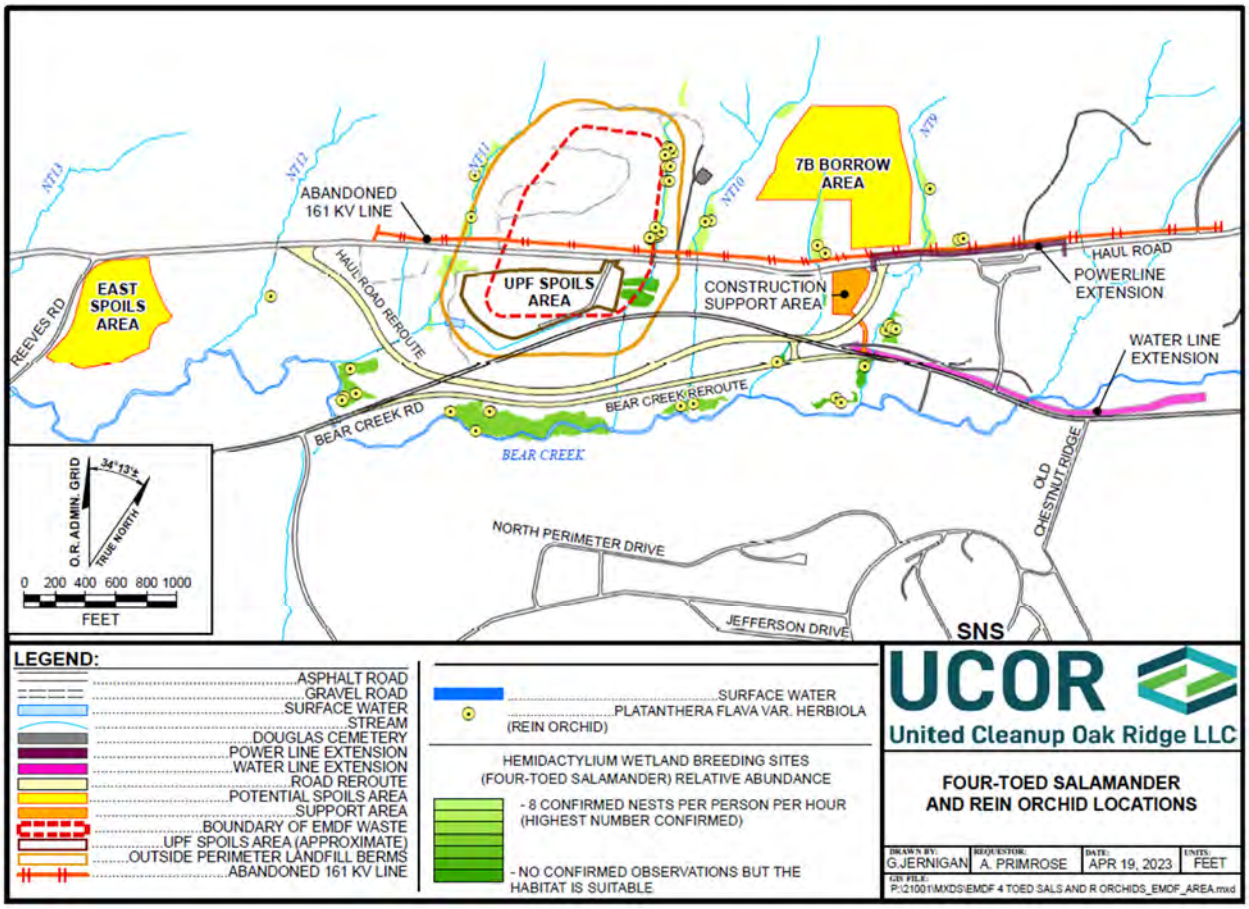

Fig. A.1. Location of EMDF activities.

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A.2 ECOLOGICAL RESOURCES

A detailed natural resource evaluation and wetland delineation study was performed over most of the EMDF footprint (Fig. F.2). The evaluation is documented in *Natural Resource Assessment for the Proposed Environmental Management Disposal Facility (EMDF), Oak Ridge, Tennessee* (ORNL/TM-2018-515). Additional evaluations in 2022-2023 covered the remaining small areas:

- Westernmost extension of Haul Road
- Water line extension outside of the EMDF footprint and along Bear Creek Road
- Power line extension outside of the EMDF footprint and along Haul Road
- Removal of the abandoned power line outside of the EMDF footprint along Haul Road
- Spoils Areas

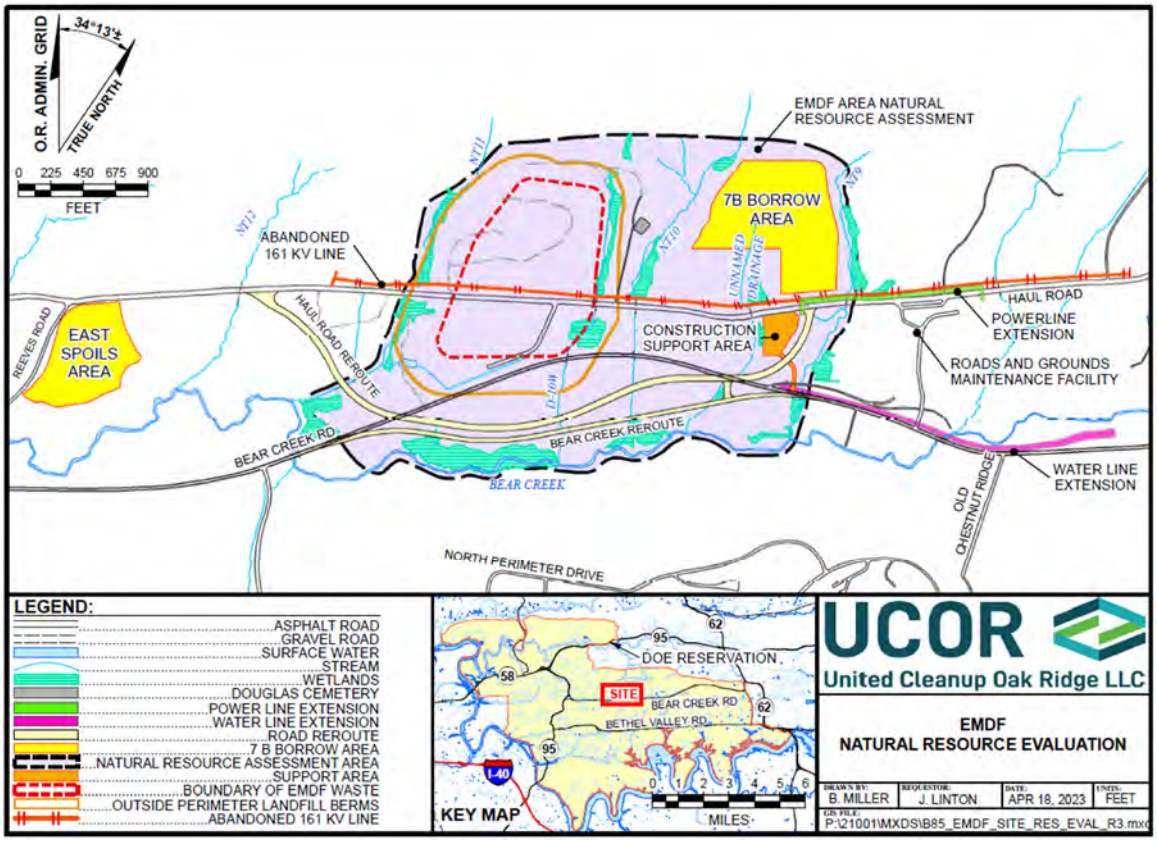

Fig. A.2. Location of natural resource evaluation and EMDF activities.

The natural resource assessment included wetland delineations, stream determinations, timber assessments, and rare species surveys. Evaluations using the Tennessee Rapid Assessment Method for wetlands and the Tennessee Stream Quantification Tool were not conducted. In addition, walkdowns were conducted in the fall/winter of 2022 to evaluate the extension of Haul Road that was not covered by the initial natural resource evaluation (Fig. F.2). The results of the natural resource evaluation are summarized below.

Wetland delineations: Potential wetlands were evaluated for the entire EMDF Project site relative to the dominance of wetland vegetation, soils, and hydrological characteristics. Seventeen wetlands, including one created wetland, were identified within the entire EMDF study area, covering 11.8 acres. The GWFD and balance of landfill scope was designed and will be constructed to minimize impacts to these wetlands. However, based on re-evaluation of the impacts to GWFD activities based on newly provided design information, it is anticipated that approximately 3.6 acres of wetland will be disrupted and/or eliminated as a result of EMDF activities. (Fig. A.1). Table A.1 provides the wetland acreage in the EMDF area and the acreage impacted. Direct impacts include a wetland area that is removed (filled with soil or a change in water flow). Indirect impacts are the result of changes in stream hydrology, runoff, percolation, water temperature, or vegetation cover. Note, wetlands are named first by the tributary in which they occur, and then are assigned a letter based on their relative position.

Table A.1. EMDF wetlands and impacted acreage

Wetland ID	Wetland size (ac.)	Acres directly impacted*			Indirectly impacted	Comments
		ESP	GWFD	Landfill const.		
NT9-A	0.92				✓	
NT9-B	0.41				✓	Construction Support Area access road rerouted away from this wetland, direct impacts were avoided.
NT9-C	0.28	0.1			✓	Impacted by culvert replacement for ESP road reroutes
NT9-D	0.2				✓	
UT-A	0.66			0.66		Possible impacts from increased drainage from borrow area. Possibly removed by landfill.
UT-B	0.1			0.1		Possibly removed by landfill
UT-C	0.1	0.1				Impacted by culvert placement for ESP road reroutes
NT10-A	0.19				✓	
NT10-B[(1)]	0.63		0.63			Possible impacts from increased flow from rerouting D-10W
NT10-C	0.68	0.1			✓	0.1 acre impacted by culvert placement for ESP road reroutes
D10W-A	0.14				✓	Indirectly impact by potential increased drainage
D10W-B	0.78		0.78			Removed by GWFD construction
UPF W11	0.81			0.81		Removed by landfill construction
NT11-A	0.77		0.04		✓	Wetlands on the east side of NT-11 will be removed by GWFD construction. West side wetlands will be retained but are likely to be impacted by increased drainage.
NT11-B	0.72		0.36		✓	Partially removed by GWFD and landfill construction
NT11-C	1.06				✓	
BCK-A	3.36	0.1				Bear Creek Rd reroute clips two sections of wetland.
Spoils	Unknown				✓	Spoils area was selected to avoid direct impacts to nearby wetlands. Acreage unknown for indirect impacts.
Totals	**11.81**	**3.78**				

D = Drainage ESP = Early Site Preparation NT = North Tributary

The most impacted wetland is in Drainage (D)-10W. The wetland from the saddle from the upgradient diversion ditch to Bear Creek Road (D-10WB) will be completely removed by GWFD and balance of landfill construction activities and will be replaced with structural fill material. This results in a loss of almost 0.8 acres of wetlands. D-10WA is located north of the upgradient diversion ditch and will not be impacted.

Uranium Processing Facility (UPF)-11, the engineered wetlands constructed along D-10W as mitigation for the Y-12 National Security Site UPF, will remain during the GWFD activities, but will be removed by the balance of landfill construction for a loss of 0.81 acres of wetland.

The wetlands in North Tributary (NT)-11 will also be impacted by the construction of GWFD and balance of landfill berms. The NT-11 course was maintained as much as possible, but the northern portion was modified slightly to maintain a stable slope for the GWFD activities. The western bank of NT-11 was maintained, with neither cut nor fill required. Wetlands west of NT-11 will be protected and maintained during construction activities. Wetlands along NT-11 north and south of EMDF will be preserved. Wetland NT-11B will be slightly impacted by GWFD activities, resulting in a loss of 0.14 acres of wetlands from construction of the NT-11 interceptor ditch. However, the landfill's western berm will overlie the northern part of the wetland, resulting in a loss of approximately 0.36 acres.

No construction will occur in the NT-9 drainage, except for replacement of a culvert at NT-9C. The access road to the Construction Support Area was rerouted during design with guidance from the Oak Ridge National Laboratory (ORNL) Natural Resources to avoid direct impacts.

Stream surveys: Five tributary streams are present in the EMDF area: NT-9, NT-10, D-10W, NT-11, and an unnamed tributary between NT-9 and NT-10 (Fig. A.2). All are considered first or second order streams characterized by low flows during non-rain events, shallow pools, and riffles. There are multiple road crossings on these streams, including Bear Creek Road, Haul Road, and some historical roads/culverts across the streams. Many of these road crossings present physical barriers for upstream migration of aquatic fauna, in particular fish, by creating large elevation changes in the stream channel just below the culverts. In addition, the upstream side of these culverts often create wetlands with meandering stream channels filled with sediments, not typical of other higher gradient streams found across the Oak Ridge Reservation (ORR).

Early Site Preparation (ESP) construction activities will require installation of approximately 900 ft of culverts. Existing culverts were used wherever possible, including the existing culverts and bridge used where Bear Creek Road crosses over Bear Creek.

The stream channel for NT-9 will not be changed, except for replacement of an undersized culvert where NT-9 crosses under Bear Creek Road (Fig. A.3)

A section of the D-10W channel will be rerouted to NT-10. The upper channel of D-10W will remain intact; however, the channel segment adjacent to EMDF disposal cells will be rerouted to NT-10 (Fig. A.4). The lower portion of D-10W channel will remain, but with reduced stream flow. Culverts will be placed in the lower section of D-10W to support Haul Road and Bear Creek Road reroutes during ESP activities (Fig. A.3). This results in removal of approximately 1657 ft of the D-10W channel.

The stream channel for NT-10 will not be changed. However, rerouting a portion of D-10W flow to NT-10 increases flow in this drainage. Culverts will be placed in the lower section of NT-10 to support Haul Road and Bear Creek Road reroutes during ESP activities (Fig. A.3)

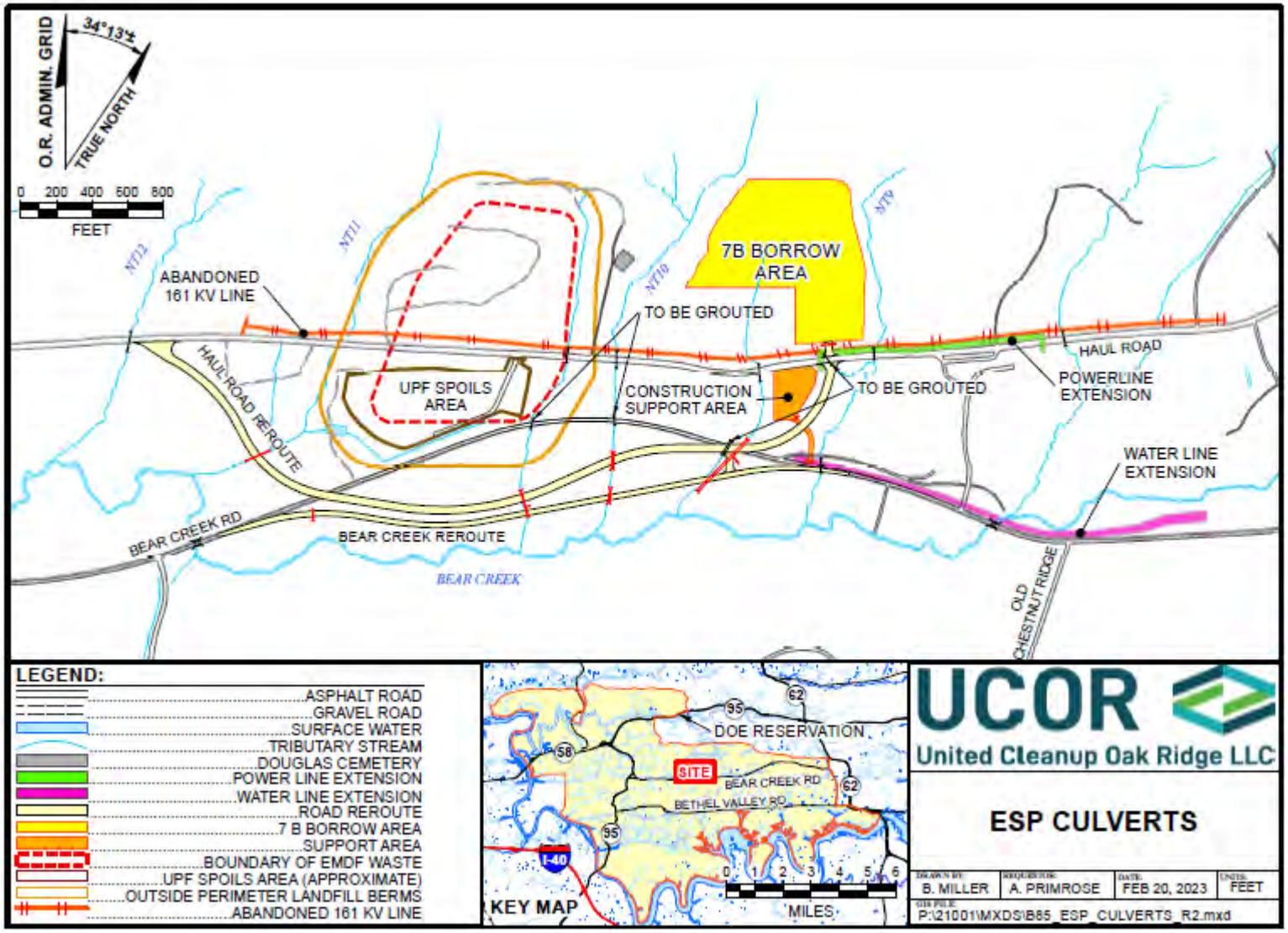

Fig. A.3. Culverts added or modified for ESP activities.

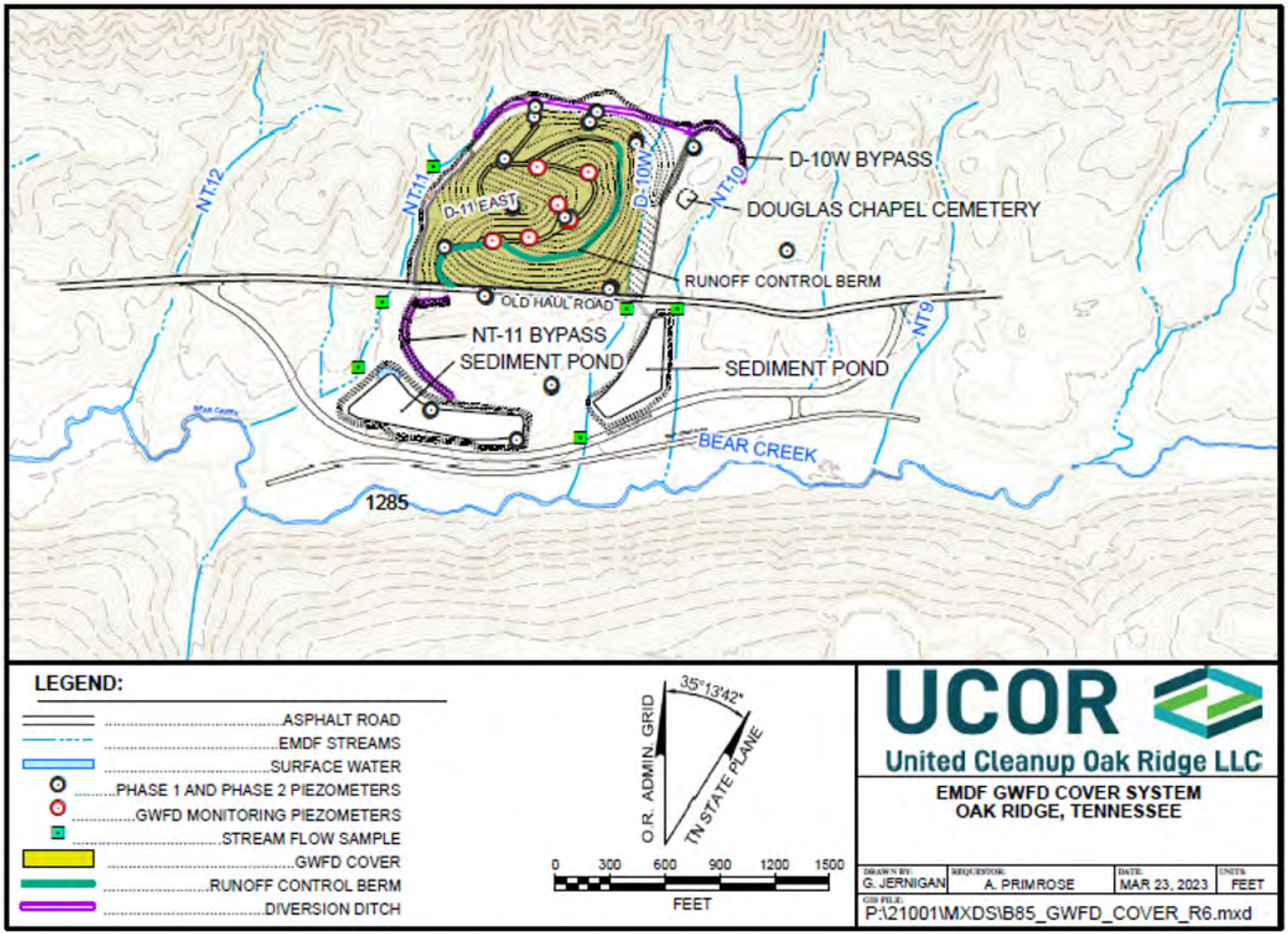

Fig. A.4. GWFD Project layout and stream modifications.

Stream flow in the upper reach of NT-11 adjacent to the GWFD area will be modified to place the temporary cover system, although the stream will remain in its existing channel as much as possible. NT-11 upper stream channel modifications may increase in this same area during construction of the berms for the EMDF. Approximately 371 ft of NT-11 channel will be removed/modified by GWFD and landfill construction.

NT-12 will not be modified by EMDF construction activities. The unnamed tributary will be modified by placing culverts along the lower stretch to support Haul Road and Bear Creek Road reroutes during ESP (Fig. A.3). Stream flow in the unnamed tributary may increase due to increased run-off from the 7b Borrow Area. Approximately 730 ft of the unnamed tributary may be removed/modified by landfill construction.

Sediment controls will be placed to prevent and control sediment release to streams, drainages, and wetlands. Erosion controls will include placing a double row of silt fences between the Construction Support Area and the drainages/wetlands. Sediment release will also be controlled by placing geotextile and aggregate over the area and controlling drainage by use of temporary culverts.

The Bear Creek watershed is home to a strong population of Tennessee dace, the only fish on the ORR listed as "in need of management" by the Tennessee Wildlife Resources Agency. No Tennessee dace were observed in the tributary streams at the EMDF site during the fish surveys; however, EMDF stormwater controls will protect Tennessee dace in streams that may be impacted by EMDF construction activities. Prior to performing construction activities, streams will be walked down and sensitive resources, including Tennessee dace, will be relocated.

Timber assessments: As described in ORNL/TM-2018-515, the GWFD area and the balance of landfill outside of the ESP activities are primarily located in hardwood forest, potentially around 60+ years old. Trees with a diameter at breast height (dbh) greater than 10 in. represent approximately 52% of the total forested area. These trees are primarily tulip poplar (~23%), white oak (~16%), red maple (~14%), and sweet gum (~9%). Trees with dbh between 2 and 10 in. are primarily six species: red maple (15.3%), sweet gum (13.9%), loblolly pine (13.5%), tulip poplar (10.7%), sourwood (8.2%), and dogwood (6.0%). Figure A.5 illustrates the canopy height for forested parts of EMDF.

North of Bear Creek Road, the trees average 508 stems per acre of trees greater than 2 in. dbh with about 48 trees 10 in. dbh or larger per acre. In the 161 acres surveyed for the EMDF Project, 10 trees were identified with a diameter greater to or equal to 30 in. dbh measured at the sample points (tally trees). The tree identified with the greatest dbh in the area was a 38-in. dbh chestnut oak. Of the 10 tally trees identified, six were oak trees.

The EMDF area south of Bear Creek Road was almost entirely subject to timber harvesting during a southern pine beetle outbreak in 2000 and is primarily dense, loblolly pine. Much of the GWFD and balance of landfill areas consists of potentially marketable timber.

Timber is a U.S. Department of Energy (DOE) real estate asset and will be dispositioned as an asset through a standing timber sale agreement. Non-marketable woody debris is anticipated to be chipped and used for mulch throughout the EMDF Project.

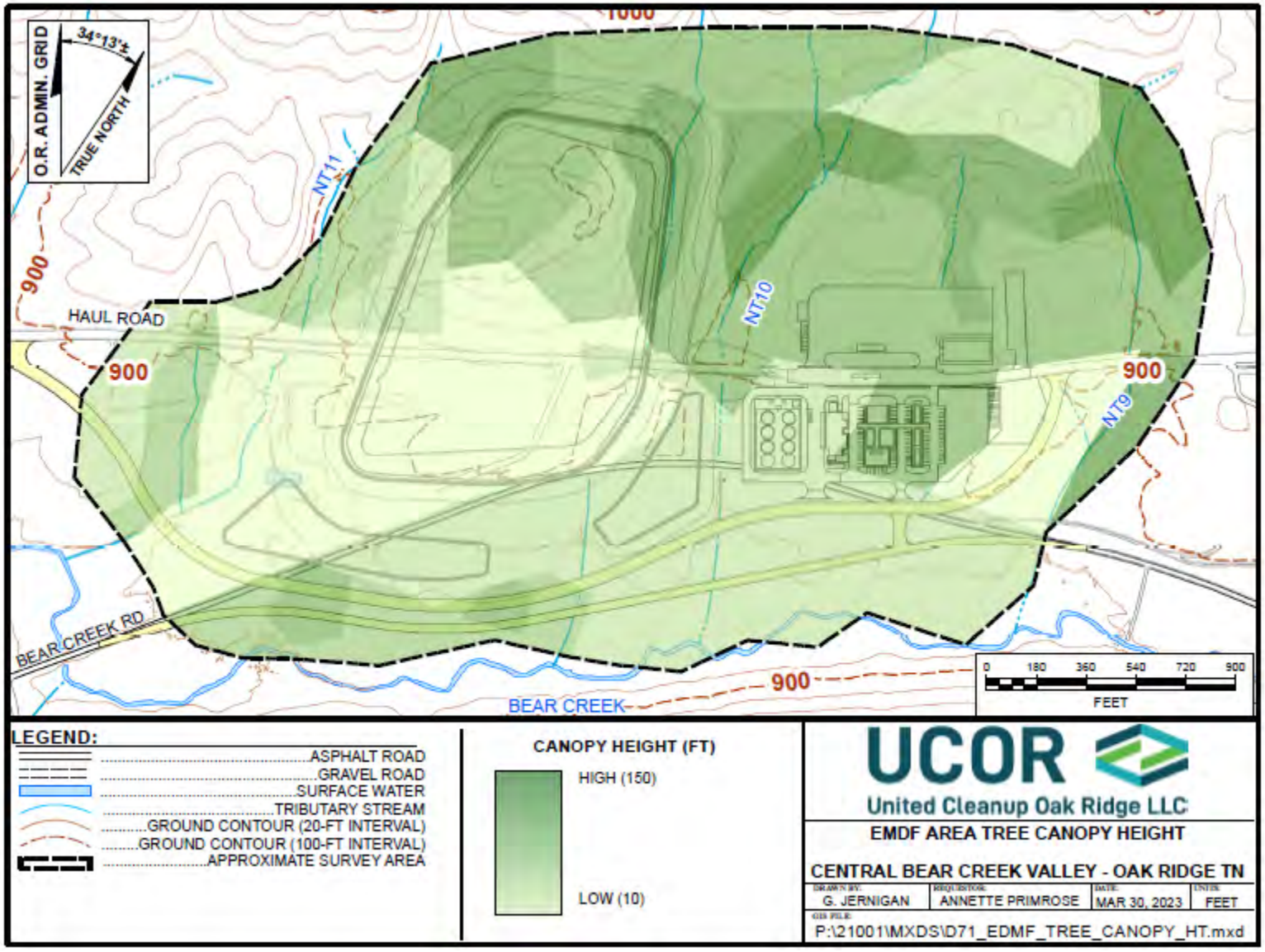

Fig. A.5. Forest canopy height of EMDF and vicinity (from ORNL/TM-2018-515).

Rare species surveys: Previous investigations to identify threatened and endangered species on the ORR (ORNL/TM-2015/248), *Bat Species Distribution on the Oak Ridge Reservation,* in general, have confirmed the presence of Indiana bats, gray bats, and the northern long-eared bat, all federally listed endangered species; tricolored bats, which are proposed for federal listing; and little brown bats, which are under consideration for federal listing. Results of the bat acoustic surveys indicated that forested portions of the EMDF Project area are used as summer habitat by state- and federally listed bat species. One federally listed endangered species (gray bat) may forage within the site boundaries, but does not roost in these areas. Consultation with the U.S. Fish and Wildlife Service (USF&WS) will be conducted in 2023 and is expected to be documented in the D2 Remedial Design Work Plan (RDWP)/Remedial Action Work Plan (RAWP) or an addendum.

Acoustic surveys conducted in 2018 also indicate the presence of two federally listed endangered bat species: Indiana bat and northern long-eared bat (ORNL/TM-2018-515). Recorded call numbers for these two species were very low; however, presence cannot be ruled out. Presence of little brown bat and tricolored bat are indicated by the high number of acoustic calls recorded throughout the EMDF Project area. A survey for potential suitable roost trees for forest-dwelling bat species was conducted in March 2023. Results show that higher elevations on the north facing slope of Pine Ridge within the EMDF Project area have abundant potential roost trees with peeling bark and snags with peeling bark and protected crevices. White oak is a dominant species in this location (ORNL/TM-2018-515).

Much of the GWFD and balance of landfill activities will take place in areas forested with mature hardwoods, including preferred roosting trees for bats. Additional evaluation will be performed in 2023 to evaluate for the presence of potential roosts for bats, including the tricolored bats that may roost in road culverts and riparian buffer zones. Potential roost areas will be identified prior to the start of GWFD activities.

Other threatened and endangered species surveys were conducted by ORNL in 2018 (ORNL/TM-2018-515). The tubercled rein orchid (*Platanthera flava var. herbiola*), listed as threatened on the Tennessee Rare Plant List, was found in wetlands within the study area, particularly in wetlands along the NT-9, NT-10, and D-10W streams. D-10W and NT-9 both have large populations of rein orchids (Fig. A.6). Two other plant species of interest found were the American ginseng and pink lady's slipper, which are considered of concern because of commercial harvest.

The four-toed salamander and the Wood Thrush (state-listed as In-Need-of-Management) occur throughout forested portions of the study area. Wetlands and drainages within the area were found to contain the highest densities of four-toed salamander breeding sites known on the ORR (Fig. A.6).

No federally listed threatened or endangered bird species were noted during the surveys; however, certain species recorded during the surveys have other state and/or federal management designations. These include dozens of species of birds protected under the Migratory Bird Treaty Act and/or are considered Birds of Conservation Concern by the USF&WS. The site is on the southern edge of the largest area of contiguous interior forest on the ORR that supports rare bird species. These rare species are not typically found in more fragmented habitats (ORNL/TM-2018-515).

The approach to minimize impacts to rare species is as follows:

- The GWFD and landfill designs avoided areas with rare species to the extent practical. However, impacts to four-toed salamanders and tubercled rein orchids are unavoidable (Fig. A.6). ORNL Natural Resources subject matter experts are coordinating the relocation of both salamanders and tubercled rein orchids to nearby, similar habitats in 2023 to minimize the impacts to these populations.

- ORNL Natural Resources subject matter experts will identify potential bat-roosting trees in the GWFD and balance of landfill areas. These potential bat-roosting trees will be removed prior to the start of field work, and prior to the start of the bat-foraging season, expected to be March 31.
- Potential roost areas for tri-colored bats will be identified in the GWFD and balance of landfill areas. Prior to the start of field activities, candidate roosting sites will be fitted with one-way devices to allow bats to exit but not return.
- Fish and aquatic wildlife sweeps and relocations will be conducted prior to construction in D-10W and NT-11, and prior to culvert placement, grouting or replacement, given the possible presence of crayfish and four-toed salamanders in all drainages. Although Tennessee dace have not been detected in the EMDF drainages, these will be included in the sweeps and relocated if present.

Identification of the mitigation approach for both the GWFD and balance of landfill areas is in progress. Any mitigation required for the ESP activities will also be performed as part of the overall EMDF mitigation effort. The required mitigation will be documented in the D2 GWFD RDWP/RAWP or addendum.

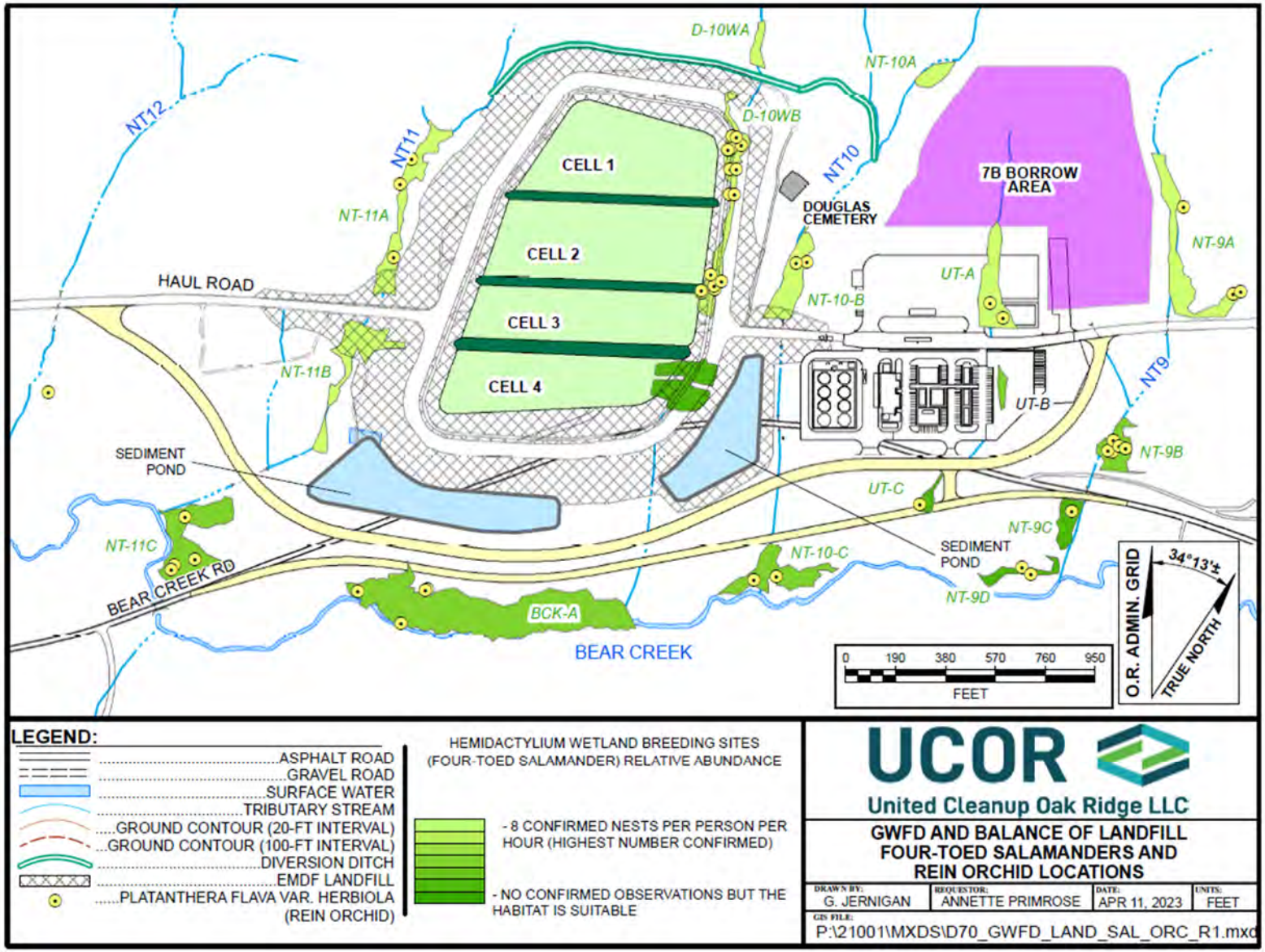

Fig. A.6. EMDF Project layout with current locations of rein orchids and four-toed salamanders.

A.3 CULTURAL RESOURCES

The Douglas Chapel Cemetery and four historical home site/structures are present near the EMDF site (Cultural Resource Analysts, Inc. 2018, *Phase I Archaeological Survey of the Proposed Environmental Management Disposal Facility in Central Bear Creek Valley, Roane County, Tennessee*). Douglas Chapel Cemetery is located on the knoll between NT-10 and D-10W. DOE intends to avoid and preserve the Douglas Chapel Cemetery, as well as maintain access to the cemetery for visitors.

The four home sites were demolished when the federal government purchased the land for the Manhattan Project. A prehistoric habitation was located near Bear Creek where lithic flakes were found, an indication of prehistoric tool production. All the sites were highly disturbed and appeared to contain no buried cultural deposits. The sites were not recommended for inclusion in the National Register of Historic Places.

No historical sites are located within the GWFD area. The Douglas Chapel Cemetery is located nearby, but will not be disturbed by either GWFD or landfill construction activities (Fig. A.6).

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A.4 GWFD/BALANCE OF LANDFILL EVALUATION OF IMPACTS TO SENSITIVE RESOURCES

While the design minimized impacts to sensitive resources as practical, construction of the GWFD and balance of landfill will impact streams, wetlands, and sensitive species (Fig. A.6). Approximately 900 ft of culvert will be placed in streams and wet weather conveyances, D-10W will be rerouted, up to 4.6 acres of wetlands will be destroyed, and sensitive species, primarily tubercled rein orchids and four-toed salamanders will be displaced. Roosting and foraging habitat for several species of bats will be reduced, including threatened or endangered bat species.

Measures to Reduce Impacts to Sensitive Resources

Potential bat-roosting trees will be identified and removed in advance of the foraging season. The remaining trees will be offered for timber sales through the DOE Real Estate Office. Trees that are not marketable are expected to be chipped and used as mulch throughout the project site.

ORNL Natural Resources subject matter experts are coordinating the relocation of both salamanders and tubercled rein orchids to nearby, similar habitats in 2023 to minimize the impacts to these populations.

Fish and aquatic wildlife sweeps and relocations will be conducted prior to construction in D-10W and NT-11, and prior to culvert placement, grouting, or replacement, given the possible presence of crayfish and four-toed salamanders in all drainages. Although Tennessee dace have not been detected in the EMDF drainages, these will be included in the sweeps and relocated if present.

Erosion and sediment controls will be placed to minimize impacts to streams and wetlands. The *Stormwater Management Requirements for Groundwater Field Demonstration for the Onsite Waste Disposal Facility, Oak Ridge, Tennessee* (UCOR-5620, in progress) supports the GWFD clearing and grading activities and presents erosion and sediment control best management practices (BMPs). Sediment and erosion control BMPs anticipated to be incorporated include:

- Minimizing disturbed areas
- Controlling stormwater runoff
- Stabilizing disturbed soils as soon as practical
- Protecting slopes and storm inlets downgradient from the work area
- Establishing perimeter controls
- Retaining sediment onsite

Sediment/erosion control measures will be designed in accordance with the guidance presented in the *Tennessee Erosion and Sediment Control Handbook* (Tennessee Department of Environment and Conservation 2012).

GWFD construction activities are to be phased to minimize the amount to disturbed areas exposed at any given time. Perimeter runoff controls, including silt fences, straw wattles, and construction exits will be installed prior to clearing and grubbing. Clearing, grubbing, stripping, and grading will only occur in designated construction areas where improvements are planned. Natural features and vegetative soil cover outside of the construction areas will be protected to avoid disturbance to trees or vegetative cover and to minimize soil erosion.

The following erosion and sediment control BMPs will be applied for the GWFD construction activities:

- Control of stormwater flowing onto and through project area
  - Straw wattles: serve as run-on diversion, runoff filtration, water velocity dissipation
  - Check dams: installed in swales and ditches to reduce velocity in channels and thereby reduce erosion
  - Diversion berm: divert rainwater away from the cut slopes and control stormwater flowing onto the project
- Stabilization of soils
  - Hydromulching: protect exposed soils
  - Seeding and straw mulch: lawn areas will be seeded and stabilized with straw or similar mulching material
  - Roadway gravel/road base: placed on all areas receiving vehicular traffic (access roads and staging areas)
- Protection of slopes
  - Erosion-control blankets: used to stabilize slopes in swales, cut slopes, and sediment basin
- Protection of storm drain inlets
  - Straw wattles: protection for storm drain inlets (catch basins) until permanent vegetation has been established
- Perimeter controls and sediment barriers
  - Silt fences: installed along the toe of fill slopes and around topsoil stockpiles
- Stabilized construction exits
  - Anti-tracking pads: installed at project egress locations to prevent the offsite transport of sediment by construction vehicles
- Dust control: use of a water truck to apply water to disturbed areas to control dust

Additional BMPs not presented here may be incorporated, as needed. Impacts to waterbodies will be minimized through implementation of BMPs.

Erosion and sedimentation control during construction will be through use of silt fences, inlet and outlet protection at culverts and catch basins, grass-lined and riprap-lined ditches, filter rings, and other erosion- and sedimentation-control measures. Erosion-control matting will be installed on slopes steeper than 4:1 and all ditches not lined with riprap. Straw wattles will be installed along the contour (across the slope) to intercept water running down a slope. Completed slopes, ditches, and other areas will be seeded and mulched within 15 days of completion of site grading.

Stormwater ponds will be placed for sediment control for both for the GWFD and the final landfill disposal cells. These stormwater ponds are expected to be placed in the vicinity of the existing Haul Road, which will be rerouted as part of the ESP activities for the EMDF landfill (Fig. A.6). An additional stormwater pond will be placed for sediment control for the 7B Borrow Area.

Run-on to the GWFD from the cemetery hill east of the GWFD will be controlled by a drainage ditch that is located over the cover in the in-filled former D-10W channel and routed to discharge into the newly constructed Pond 2 south of the old Haul Road.

Stormwater runoff-control ditches and two culverts will direct runoff to a series of culverts, conveying stormwater flow under Haul Road. All runoff controls are designed to convey the 25-year, 24-hour storm with enough capacity to convey the 100-year, 24-hour storm event without overtopping.

Mitigation Requirements

Mitigation planning for the GWFD and balance of landfill is in progress. The planning process will include any mitigation required for the ESP activities as part of the overall EMDF mitigation effort. The required mitigation will be documented in the D2 GWFD RDWP/RAWP or addendum.

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A.5 SUMMARY

A natural resource survey of the EMDF site was conducted and identified sensitive resources (ORNL/TM-2018-515). While the design avoided these as much as practical, construction of the GWFD and balance of landfill will adversely and permanently impact streams, wetlands, and sensitive species as follows:

- Approximately 900 ft of culvert will be placed in streams and wet weather conveyances
- D-10W will be rerouted to NT-10
- Up to 3.78 acres of wetlands will be directly impacted
- Sensitive species, including tubercled rein orchids and four-toed salamanders, will be displaced
- Roosting and foraging habitat for several species of bats will be reduced, including threatened or endangered bat species.

The following approach will be taken to minimize damages:

Potential bat-roosting trees will be identified and removed in advance of the foraging season. The remaining trees will be offered for timber sales through the DOE Real Estate Office. Trees that are not marketable are expected to be chipped and used as mulch throughout the project site.

Salamanders and tubercled rein orchids will be relocated to nearby, similar habitats in 2023 to minimize the impacts to these populations.

Fish and aquatic wildlife sweeps and relocations will be conducted prior to construction in D-10W and NT-11, and prior to culvert placement, grouting, or replacement, given the possible presence of crayfish and four-toed salamanders in all drainages. Although Tennessee dace have not been detected in the EMDF drainages, these will be included in the sweeps and relocated if present.

Erosion and sediment controls will be placed to minimize impacts to streams and wetlands. The *Stormwater Management Requirements for Groundwater Field Demonstration for the Onsite Waste Disposal Facility, Oak Ridge, Tennessee* (UCOR-5620, in progress) supports the GWFD clearing and grading activities and presents erosion and sediment control BMPs. Sediment and erosion control BMPs anticipated to be incorporated include:

- Minimizing disturbed areas
- Controlling stormwater runoff
- Stabilizing disturbed soils as soon as practical
- Protecting slopes and storm inlets downgradient from the work area
- Establishing perimeter controls
- Retaining sediment onsite

Additional mitigation measures are in the planning stage and will be described in the D2 RDWP/RAWP or an addendum.

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APPENDIX B.
GWFD APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

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Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative

Location Resource	Requirements	Prerequisite	Citation
	Wetlands		
Presence of wetlands as defined in 10 *CFR* 1022.4	Incorporate wetland protection considerations into its planning, regulatory, and decision-making processes, and, to the extent practicable, minimize the destruction, loss, or degradation of wetlands; and preserve and enhance the natural and beneficial values of wetlands.	DOE actions that involve potential impacts to, or take place within wetlands— **applicable**	10 *CFR* 1022.3(a)(7) and (8)
	Undertake a careful evaluation of the potential effects of any proposed wetland action.		10 *CFR* 1022.3(b), (c), (d)
	Avoid, to the extent possible, the long- and short-term adverse impacts associated with the destruction of and occupancy and modification of wetlands. Avoid direct and indirect development in a wetland wherever there is a practicable alternative.		
	Identify, evaluate, and, as appropriate, implement alternative actions that may avoid or mitigate adverse wetland impacts.		
	Project Description. This section shall describe the proposed action and shall include a map showing its location with respect to the floodplain and/or wetland. For actions located in a floodplain, the nature and extent of the flood hazard shall be described, including the nature and extent of hazards associated with any high-hazard areas.		10 *CFR* 1022.13(a)(1)
	Floodplain or Wetland Impacts. This section shall discuss the positive and negative, direct and indirect, and long- and short-term effects of the proposed action on the floodplain and/or wetland. This section shall include impacts on the natural and beneficial floodplain and wetland values (§ 1022.4) appropriate to the location under evaluation. In addition, the effects of a proposed floodplain action on lives and property shall be evaluated. For an action proposed in a wetland, the effects on the survival, quality, and function of the wetland shall be evaluated.		10 *CFR* 1022.13(a)(2)
	***Alternatives*.** Consider alternatives to the proposed action that avoid adverse impacts and incompatible development in a wetland area, including alternate sites, alternate actions, and no action. DOE shall evaluate measures that mitigate the adverse effects of actions in a wetland, including but not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas.		10 *CFR* 1022.13(a)(3)
	If no practicable alternative to locating or conducting the action in the wetland is available, then before taking action design or modify the action in order to minimize potential harm to or within the wetland, consistent with the policies set forth in Executive Order 11990.		10 *CFR* 1022.14(a)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Presence of jurisdictional wetlands as defined in 40 *CFR* 230.3, 33 *CFR* 328.3(a), and 33 *CFR* 328.4	No discharge of dredged or fill material into waters of the U.S., including jurisdictional wetlands, is permitted if there is a practical alternative that would have less adverse impact on the wetland or if it will cause or contribute significant degradation of waters of the U.S. Except as provided under CWA Sect. 404(b)(2), no discharge of dredged or fill material shall be permitted unless appropriate and practicable steps (in accordance with 40 *CFR* 230.70 *et seq*, *Actions to Minimize Adverse Effects*) have been taken, which will minimize potential adverse impacts of the discharge on the aquatic ecosystem. No discharge of dredged or fill material shall be permitted if it: Causes or contributes, after consideration of disposal site dilution and dispersion, to violations of any applicable State water quality standard; Violates any applicable toxic effluent standard or prohibition under Sect. 307 of the CWA: Jeopardizes the continued existence of species listed as endangered or threatened under the Endangered Species Act of 1973, as amended, or results in likelihood of the destruction or adverse modification of a habitat that is determined by the Secretary of Interior of Commerce, as appropriate, to be critical habitat under the Endangered Species Act of 1973, as amended. If an exemption has been granted by the Endangered Species Committee, the terms of such exemption shall apply in lieu of this subparagraph. Violates any requirement imposed by the Secretary of Commerce to protect any marine sanctuary designated under Title III of the Marine Protection, Research, and Sanctuaries Act of 1972.	Actions that involve discharge of dredged or fill material into waters of U.S., including jurisdictional wetlands—**applicable**	40 *CFR* 230.10(a), (b), (c) and (d) 40 *CFR* 230, Subpart H 40 *CFR* 230.10(d) CWA Regulations – Sect. 404(b) Guidelines 40 *CFR* 230.10(b)
Mitigation of impacts to state wetlands as defined under TDEC 0400-40-07-.03	If an activity in a wetland results in an appreciable permanent loss of resource values, mitigation must be provided that results in no overall net loss of resource values from existing conditions. To the extent practicable, any required mitigation shall be completed, excluding monitoring, prior to, or simultaneous with, any impacts. Acceptable mitigation mechanisms include any combination of in-lieu fee programs, mitigation banks, or other mechanisms that are reasonably assured to result in no overall net loss of resource values from existing conditions. Acceptable mitigation methods are prioritized in the following order: restoration, enhancement, preservation, creation, or any other measures that are reasonably assured to result in no net loss of resource values from existing conditions. Compensatory measures must be at a ratio of 2:1 for restoration, 4:1 for creation and enhancement, and 10:1 for preservation, or at a best professional judgment ratio agreed to by the state.	Activity that would cause loss of wetlands as defined in TDEC 0400-40-07-.03—**applicable**	TDEC 0400-40-07-.04(7)(a) TDEC 0400-40-07-.04(7)(c)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Presence of wetlands	Shall take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance beneficial values of wetlands. *NOTE:* Federal agencies required to comply with Executive Order 11990 requirements. Shall avoid undertaking construction located in wetlands unless: (1) there is no practicable alternative to such construction and (2) the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use.	Federal actions that involve potential impacts to, or take place within, wetlands - **TBC**	Executive Order 11990 Section l.(a) *Protection of Wetlands* Executive Order 11990, Section 2.(a) *Protection of Wetlands*
Presence of Wetlands (as defined in 44 *CFR* 9.4)	The Agency shall minimize[1] the destruction, loss, or degradation of wetlands. The Agency shall preserve and enhance the natural and beneficial wetlands values. The Agency shall minimize: • Potential adverse impact the action may have on wetland values.	Federal *actions affecting or affected by Wetlands* as defined in 44 *CFR* 9.4 - **relevant and appropriate**	44 *CFR* 9.11(b)(2) and (b)(4) *Mitigation* 44 *CFR* 9.11(c)(3) *Minimization provisions*
General Compensatory Mitigation for Wetlands	Compensatory mitigation required to offset unavoidable impacts to waters of the United States authorized by DA permits. Compensatory mitigation requirements must be commensurate with the amount and type of impact that is associated with a particular DA permit. • Amount of required compensatory mitigation must be, to the extent practicable, sufficient to replace lost aquatic resource functions. • Compensatory mitigation may be provided through mitigation banks or in-lieu fee programs. • Implementation of the compensatory mitigation project shall be, to the maximum extent practicable, in advance of or concurrent with the impact-causing activity. *NOTE*: Although permits are not required per CERCLA Section 121(e)(1), consultation with the USACE recommended to determine mitigation of any adverse impacts. Such mitigation would be performed as part of the remedial action. Compensatory mitigation may be performed using the methods of restoration, enhancement, establishment, and in certain circumstances preservation. Restoration should generally be the first option considered because the likelihood of success is greater and the impacts to potentially ecologically important uplands are reduced compared to establishment, and the potential gains in terms of aquatic resource functions are greater, compared to enhancement and preservation.	Alteration of wetlands requiring compensatory mitigation to replace lost aquatic resource functions – **relevant and appropriate** Alteration of wetlands requiring compensatory mitigation to replace lost aquatic resource functions – **relevant and appropriate**	40 *CFR* 230.93(a)(1) *General compensatory mitigation requirements* 40 *CFR* 230.93 (a)(2)

[1] *Minimize* means to reduce to smallest amount or degree possible. 44 *CFR* 9.4, *Definitions.*

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
General Compensatory Mitigation for Wetlands (cont.)	All compensatory mitigation projects must comply with the standards in this part (40 *CFR* Part 230), if they are to be used to provide compensatory mitigation for activities authorized by DA permits, regardless of whether they are sited on public or private lands and whether the sponsor is a governmental or private entity. *NOTE:* Although permits are not required per CERCLA Section 121(e)(1), consultation with the USACE recommended to determine mitigation of any adverse impacts. Such mitigation would be performed as part of the remedial action.		40 *CFR* 230.93 (a)(3)
	Required compensatory mitigation should be located within the same watershed as the impact site and should be located where it is most likely to successfully replace lost functions and services, taking into account such watershed scale features as aquatic habitat diversity, habitat connectivity, relationships to hydrologic sources (including the availability of water rights), trends in land use, ecological benefits, and compatibility with adjacent land uses.		40 *CFR* 230.93 (b) *Type and location of mitigation*
	Project site must be ecologically suitable for providing the desired aquatic resource functions. In determining the ecological suitability of the compensatory mitigation project site, the district engineer must consider, to the extent practicable, the factors in subsections (i) thru (vi). Applicants should propose compensation sites adjacent to existing aquatic resources or where aquatic resources previously existed.		40 *CFR* 230.93 (d)(1) and (3) *Site selection*
	In general, in-kind mitigation is preferable to out-of-kind mitigation because it is most likely to compensate for the functions and services lost at the impact site. Except as provided in paragraph (e)(2) of this section, the required compensatory mitigation shall be of a similar type to the affected aquatic resource.		40 *CFR* 230.93 (e)(1) *Mitigation type*
	The amount of required compensatory mitigation must be, to the extent practicable, sufficient to replace lost aquatic resource functions. Where appropriate functional or condition assessment methods or other suitable metrics are available, these methods should be used where practicable to determine how much compensatory mitigation is required. If a functional or condition assessment or other suitable metric is not used, a minimum one-to-one acreage or linear foot compensation ratio must be used.		40 *CFR* 230.93 (f)(1) *Amount of compensatory mitigation*
	Implementation of the compensatory mitigation project shall be, to the maximum extent practicable, in advance of or concurrent with the activity causing the authorized impacts. The district engineer shall require, to the extent appropriate and practicable, additional compensatory mitigation to offset temporal losses of aquatic functions that will result from the permitted activity.		40 *CFR* 230.93 (m) *Timing*

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Compensatory Mitigation Planning	Prepare a mitigation plan addressing objectives, site selection, site protection, baseline information, determination of credits, mitigation work plan, maintenance plan, performance standards, monitoring requirements, long-term management, and adaptive management. *NOTE:* Plan would be part of CERCLA document, such as a Remedial Action Work Plan. Plan to include items described in 40 *CFR* 230.94(c)(2) through (c)(14).[2]	Alteration of wetlands requiring compensatory mitigation to replace lost aquatic resource functions – **relevant and appropriate**	40 *CFR* 230.94(c) *Mitigation Plan*
Compensatory Mitigation Performance Standards	The approved mitigation plan must contain performance standards that will be used to assess whether the project is achieving its objectives. Performance standards should relate to the objectives of the compensatory mitigation project, so that the project can be objectively evaluated to determine if it is developing into the desired resource type, providing the expected functions, and attaining any other applicable metrics (e.g., acres). Performance standards must be based on attributes that are objective and verifiable. Ecological performance standards must be based on the best available science that can be measured or assessed in a practicable manner. Performance standards may be based on variables or measures of functional capacity described in functional assessment methodologies, measurements of hydrology or other aquatic resource characteristics, and/or comparisons to reference aquatic resources of similar type and landscape position. The use of reference aquatic resources to establish performance standards will help ensure that those performance standards are reasonably achievable, by reflecting the range of variability exhibited by the regional class of aquatic resources as a result of natural processes and anthropogenic disturbances. Performance standards based on measurements of hydrology should take into consideration the hydrologic variability exhibited by reference aquatic resources, especially wetlands.	Alteration of wetlands requiring compensatory mitigation to replace lost aquatic resource functions – **relevant and appropriate**	40 *CFR* 230.95 (a) E*cological Performance Standards* 40 *CFR* 230.95 (b) *Ecological Performance Standards*
Compensatory Mitigation Project Monitoring	Monitoring the compensatory mitigation project site is necessary to determine if the project is meeting its performance standards, and to determine if measures are necessary to ensure that the compensatory mitigation project is accomplishing its objectives. Compensatory mitigation project monitoring period shall be sufficient to demonstrate that project has met performance standards, but not less than 5 years.	Alteration of wetlands requiring compensatory mitigation to replace lost aquatic resource functions – **relevant and appropriate**	40 *CFR* 230.96 (a) and (b) *Monitoring*

[2] If mitigation obligations will be met by securing credits from approved mitigation banks or in-lieu fee programs, mitigation plan needs to include only items described in Sect. 230.94(c)(5) and (c)(6), and name of mitigation bank or in-lieu fee program. 40 *CFR* 230.94(c)(1).

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Compensatory Mitigation Project Management	The aquatic habitats, riparian areas, buffers, and uplands that comprise the overall compensatory mitigation project must be provided long-term protection through real estate instruments or other available mechanisms, as appropriate. For government property, long-term protection may be provided through federal facility management plans or integrated natural resources management plans. *NOTE:* Plan would be part of CERCLA document, such as a Remedial Action Work Plan and/or Operations and Maintenance Plan. Projects shall be designed, to the maximum extent practicable, to be self-sustaining once performance standards have been achieved. This includes minimization of active engineering features (e.g., pumps) and appropriate siting to ensure that natural hydrology and landscape context will support long-term sustainability. Where active long-term management and maintenance are necessary to ensure long-term sustainability (e.g., prescribed burning, invasive species control, maintenance of water-control structures, easement enforcement), the responsible party must provide for such management and maintenance.	Alteration of wetlands on *government property* requiring compensatory mitigation to replace lost aquatic resource functions – **relevant and appropriate**	40 *CFR* 230.97 (a)(1) *Site Protection* 40 *CFR* 230.97 (b) *Sustainability*
Minor alterations to wetlands	Minor alteration to wetlands must be conducted in accordance with the requirements of the ARAP Program (TDEC 0400-40-07). The substantive general permit requirements for minor alteration to wetlands include the following: • Excavation and fill activities associated with wetland alteration shall be kept to a minimum • Wetlands outside of the impact areas shall be clearly marked with signs, high visibility fencing, or similar structures so that all the work performed by the contractor is solely within the permitted impact area. • Wetland alterations shall not cause measurable degradation to resource values and classified uses of hydraulically connected wetlands or other waters of the state, including disruption of sustaining surface or groundwater hydrology. • Temporary impacts to wetlands shall be mitigated by the removal and stockpiling of the first 12 in. of topsoil, prior to construction. Temporary wetland crossings or haul roads shall utilize timber matting. Gravel, riprap, or other rock is not approved for construction of temporary crossings or haul roads across wetlands. Upon completion of construction activities, all temporary wetland impact areas are to be restored to pre-construction contours, and the stockpiled topsoil spread to restore these areas to pre-construction elevation. Other side-cast material shall not be placed within the temporary impact locations. Permanent vegetative stabilization using native species of all disturbed areas in or near the wetland must be initiated within 14 days of project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established.	Minor alterations of up to 0.10 acre of moderate resource value wetlands or of up to 0.25 acre of degraded and of low resource value wetlands — **applicable**	*TCA* 69-3-108(l) TDEC 0400-40-07-.01 TDEC ARAP General Permit for Minor Alterations to Wetlands (effective April 7, 2020) (**TBC**)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Minor alterations to wetlands (cont.)	• Erosion prevention and sediment-control measures such as fences shall be removed following completion of construction. • The amount of fill, stream channel and bank modifications, or other impacts associated with the activity shall be limited to the minimum necessary to accomplish the project purpose. Shall utilize the least impactful practicable method of construction. • Clearing, grubbing, or other disturbance to wetland vegetation shall be kept at the minimum. Unnecessary native vegetation removal, including tree removal, and soil disturbance is prohibited. Native wetland vegetation must be reestablished in all areas of disturbance outside of any permanent structure after work is completed. • Activity may not result in a disruption or barrier to the movement of fish or other aquatic life and wetland dependent species upon project completion. • Blasting within 50 ft of any jurisdictional stream or wetland is prohibited. • Where practicable, all activities shall be accomplished during drier times of the year or when recent conditions have been dry at the impact location. All surface water flowing towards or from the construction activity shall be diverted using cofferdams and/or berms constructed of sandbags, steel sheeting, or other non-erodible, non-toxic material. All such diversion materials shall be located outside the wetland and removed upon completion of the work. Activities may be conducted in the water if working in the dry will likely cause additional degradation. If work is conducted in the water, it must be of a short duration and with minimal impact. • All activities must be carried out in such a manner as will prevent violations of water quality criteria or impairment of the designated uses of the waters of the state • Erosion and sedimentation control shall be in place and functional before earthmoving operations begin and shall be designed according to the department's Erosion and Sediment Control Handbook. Permanent vegetation stabilization using native species of all disturbed areas in or near the stream channel must be initiated within 14 days of the project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established. • The use of monofilament-type erosion-control netting or blanket is prohibited in the stream channel, stream banks, or any disturbed riparian areas within 30 ft of top of bank.		

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
	Aquatic Resources		
Waters of the state as defined in *TCA* 69-3-103(45) – Bank stabilization	Bank-stabilization activities along state waters must be conducted in accordance with the requirements of the ARAP Program (TDEC 0400-40-07). The substantive general permit requirements for stream-bank stabilization include the following: • Any spraying, mowing, or other disturbance of the stabilization treatment that interferes with its ability to naturalize is prohibited. • Work performed by vehicles and other related heavy equipment may not be staged within the stream channel. Work performed by hand and related hand-operated equipment is allowed within the stream channel. • Materials used for bank stabilization shall consist of rock, wood, or products made specifically for use in earthen slope stabilization. Other salvaged materials not found in the natural environment cannot be used for bank stabilization. • The amount of fill, stream channel and bank modifications, or other impacts associated with the activity shall be limited to the minimum necessary to accomplish the project purpose. Shall utilize the least impactful practicable method of construction. • Clearing, grubbing, or other disturbance to riparian vegetation shall be kept at the minimum necessary for slope construction and equipment operation. Unnecessary native riparian vegetation removal, including tree removal, is prohibited. Native riparian vegetation must be reestablished in all areas of disturbance outside of any permanent structure after work is completed. • Activity may not result in the permanent disruption to the movement of fish or other aquatic life upon project completion. • Blasting within 50 ft of any jurisdictional stream or wetland is prohibited. • Backfill activities must be accomplished in the least impactful manner possible that stabilizes the streambed and banks to prevent erosion. The completed activities may not disrupt or impound stream flow. • The use of monofilament-type erosion-control netting or blanket is prohibited in the stream channel, stream banks, or any disturbed riparian areas within 30 ft of top of bank.	Bank-stabilization activities affecting waters of the state— **applicable**	*TCA* 69-3-108(l) TDEC 0400-40-07-.01 TDEC ARAP General Permit for Bank Armoring and Vegetative Stabilization Activities (effective January 6, 2021) (**TBC**)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Waters of the state as defined in *TCA* 69-3-103(45) – Bank stabilization (cont.)	• Where practicable, all activities shall be accomplished in the dry. All surface water flowing towards the work shall be diverted using cofferdams and/or berms constructed of sandbags, clean rock (no fines or soils), steel sheeting, or other non-erodible, non-toxic material. All such diversion materials shall be removed upon completion of the work. Any disturbance to the stream bed or banks must be restored to its original condition. Activities may be conducted in the water if working in the dry will likely cause additional degradation. If work is conducted in the water it must be of a short duration and with minimal impact and conform to the Division-approved methodology. • All activities must be carried out in such a manner as to prevent violations of water quality criteria or impairment of the designated uses of the waters of the state • Erosion and sedimentation control shall be in place and functional before earthmoving operations begin and shall be designed according to the department's Erosion and Sediment Control Handbook. Permanent vegetation stabilization using native species of all disturbed areas in or near the stream channel must be initiated within 14 days of the project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established. • Temporary stream crossings shall be limited to one point in the construction area and erosion-control measures shall be utilized where stream bank vegetation is disturbed. Stream beds shall not be used as linear transportation routes for mechanized equipment, rather, the stream channel may be crossed perpendicularly with equipment provided no additional fill or excavation is necessary. • Hard armoring bank stabilization treatment shall not exceed 300 linear ft for the treatment of one bank, or 200 linear ft per bank if the treatment includes both banks.		
Waters of the state as defined in *TCA* 69-3-103(45) – Culvert maintenance activities	The maintenance of existing serviceable structures or fills along waters of the state must be conducted in accordance with the requirements of the ARAP Program (TDEC 0400-40-07). The substantive general permit requirements for maintenance activities include the following: • The length of the pipe or culvert structure may not be increased in a manner that encapsulates any additional length of open stream or wetland. • The capacity or diameter of the culvert may be increased during replacement, providing it does not result in channel widening or other channel destabilization. • Dewatering of impoundments to conduct dam maintenance must be performed in a controlled manner designed to prevent the release of accumulated sediments into downstream waters.	Maintenance activities affecting waters of the state— **applicable**	*TCA* 69-3-108(l) TDEC 0400-40-07-.01 TDEC ARAP General Permit for Maintenance Activities (effective April 7, 2020) (**TBC**)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Waters of the state as defined in *TCA* 69-3-103(45) – Culvert maintenance activities (cont.)	• All riprap associated with maintenance activities shall be placed to mimic the existing contours of the stream channel. Riprap shall be countersunk and placed at grade with the existing stream substrate. Voids in the riprap shall be filled with suitable bedload substrate to prevent stream flow loss within riprap areas. Suitable substrate does not include soil. • Work performed by vehicles and other heavy equipment may not be staged within the stream channel. Work performed by hand and related hand-operated equipment is allowed within the stream channel. • The amount of fill, stream channel and bank modifications, or other impacts associated with the activity shall be limited to the minimum necessary to accomplish the project purpose. Shall utilize the least impactful practicable method of construction. • Clearing, grubbing, or other disturbance to riparian vegetation shall be kept at the minimum necessary for slope construction and equipment operations. Unnecessary native riparian vegetation removal, including tree removal is prohibited. Native riparian vegetation must be reestablished in all areas of disturbance outside of any permanent structure after work is completed. • Widening of the stream channel is prohibited. • Activity may not result in a permanent disruption to the movement of fish or other aquatic life upon project completion. • Blasting within 50 ft of any jurisdictional stream or wetland is prohibited. • Backfill activities must be accomplished in the least impactful manner possible that stabilizes the streambed and banks to prevent erosion. The completed activities may not disrupt or impound stream flow. • The use of monofilament-type erosion-control netting or blanket is prohibited in the stream channel, stream banks, or any disturbed riparian areas within 30 ft of top of bank. • Where practicable, all activities shall be accomplished in the dry. All surface water flowing towards the work shall be diverted using cofferdams and/or berms constructed of sandbags, clean rock (no fines or soils), steel sheeting, or other non-erodible, non-toxic material. All such diversion materials shall be removed upon completion of the work. Any disturbance to the stream bed or banks must be restored to its original condition. Activities may be conducted in the flowing water if working in the dry will likely cause additional degradation. If work is conducted in the flowing water it must be of a short duration and with minimal impact and conform to the Division-approved methodology. • All activities must be carried out in such a manner as to prevent violations of water quality criteria or impairment of the designated uses of the waters of the state		

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Waters of the state as defined in *TCA* 69-3-103(45) – Culvert maintenance activities (cont.)	• Erosion and sedimentation control shall be in place and functional before earthmoving operations begin and shall be designed according to the department's Erosion and Sediment Control Handbook. Permanent vegetation stabilization using native species of all disturbed areas in or near the stream channel must be initiated within 14 days of the project completion. Non-native, non-invasive annuals may be used as cover crops until native species can be established. • Temporary stream crossings shall be limited to one point in the construction area and erosion-control measures shall be utilized where stream bank vegetation is disturbed. Stream beds shall not be used as linear transportation routes for mechanized equipment, rather, the stream channel may be crossed perpendicularly with equipment provided no additional fill or excavation is necessary.		
Alteration of a Wet Weather Conveyance	Wet-weather conveyances may be altered provided the following conditions are met: • The activity must not result in the discharge of waste or other substances that may be harmful to humans or wildlife. • Material must not be placed in a location or manner so as to impair surface water flow into or out of any wetland area. • Sediment shall be prevented from entering other waters of the state. • Erosion/sediment controls shall be designed according to size and slope of disturbed or drainage areas to detain runoff and trap sediment and shall be properly selected, installed, and maintained in accordance with manufacturer's specifications and good engineering practices. • Erosion/sediment-control measures must be in place and functional before earthmoving operations begin, and must be constructed and maintained throughout the construction period. Temporary measures may be removed at the beginning of the work day, but shall be replaced at end of the work day. • Checkdams must be utilized where runoff is concentrated. Clean rock, log, sandbag, or straw bale checkdams shall be properly constructed to detain runoff and trap sediment. Checkdams or other erosion-control devices are not to be constructed in stream. Clean rock can be of various type and size depending on the application and must not contain fines, soils, or other wastes or contaminants. • Appropriate steps must be taken to ensure that petroleum products or other chemical pollutants are prevented from entering waters of the state. All spills shall be reported to the appropriate emergency management agency and TDEC. In event of a spill, measures shall be taken immediately to prevent pollution of waters of the state, including groundwater.	Activities that alter wet-weather conveyances— **applicable**	TCA 69-3-108(q)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Location encompassing aquatic ecosystem as defined as 40 *CFR* 230.3(c)	No discharge of dredged or fill material into an aquatic ecosystem is permitted if there is a practical alternative that would have less adverse impact on the aquatic ecosystem or if it will cause or contribute significant degradation of waters of the U.S. Except as provided under CWA Sect. 404(b)(2), no discharge of dredged or fill material shall be permitted unless appropriate and practicable steps (in accordance with 40 *CFR* 230.70 *et seq*, *Actions to Minimize Adverse Effects*) have been taken that will minimize potential adverse impacts of the discharge on the aquatic ecosystem. No discharge of dredged or fill material shall be permitted if it: Causes or contributes, after consideration of disposal site dilution and dispersion, to violations of any applicable State water quality standard. Violates any applicable toxic effluent standard or prohibition under Sect. 307 of the CWA: • Jeopardizes the continued existence of species listed as endangered or threatened under the Endangered Species Act of 1973, as amended, or results in likelihood of the destruction or adverse modification of a habitat that is determined by the Secretary of Interior of Commerce, as appropriate, to be critical habitat under the Endangered Species Act of 1973, as amended. If an exemption has been granted by the Endangered Species Committee, the terms of such exemption shall apply in lieu of this subparagraph. • Violates any requirement imposed by the Secretary of Commerce to protect any marine sanctuary designated under Title III of the Marine Protection, Research, and Sanctuaries Act of 1972.	Action that involves the discharge of dredged or fill material into "waters of the U.S.," including jurisdictional wetlands—**applicable**	40 *CFR* 230.10(a), and (c) CWA Regulations – Sect. 404(b) Guidelines 40 *CFR* 230.10(d) CWA Regulations – Sect. 404(b) Guidelines 40 *CFR* 230.10(b)
Mitigation of impacts to a stream as defined in TDEC 0400-40-07-.03, which includes all surface water except wetlands and wet weather conveyances	If an activity in a stream results in an appreciable permanent loss of resource values, the applicant must provide mitigation that results in no overall net loss of resource values from existing conditions. To the extent practicable, any required mitigation shall be completed, excluding monitoring, prior to, or simultaneous with, any impacts. Acceptable mitigation mechanisms include any combination of in-lieu fee programs, mitigation banks, or other mechanisms that are reasonably assured to result in no overall net loss of resource values from existing conditions. Acceptable mitigation methods are prioritized in the following order: restoration, enhancement, preservation, creation, or any other measures that are reasonably assured to result in no net loss of resource values from existing conditions. Mitigation for impacts to streams must be developed in a scientifically defensible manner that demonstrates a sufficient increase in resource values to compensate for impacts. At a minimum, all new or relocated streams must include a vegetated riparian zone, demonstrate lateral and vertical channel stability, and have a natural channel bottom. All mitigation watercourses must maintain or improve flow and classified uses after mitigation is complete.	Activity that would result in an appreciable permanent loss of resource value of a stream as defined in TDEC 0400-40-07-.03 —**applicable**	TDEC 0400-40-07-.04(7)(a) TDEC 0400-40-07-.04(7)(b) 2019 Tennessee Stream Mitigation Guidelines (**TBC**) TDEC Stream Quantitative Tool Workbook (**TBC**)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Within area impacting stream or any other body of water -*and*- presence of wildlife resources (e.g., fish)	The effects of water-related projects on fish and wildlife resources and their habitat should be considered with a view to the conservation of fish and wildlife resources by preventing loss of and damage to such resources.	Action that impounds, modifies, diverts, or controls waters, including navigation and drainage activities— **relevant and appropriate**	Fish and Wildlife Coordination Act [16 *USC* 662(a)]
	Cultural Resources		
Presence of historical resources on public land	Federal agencies must take into account the effects of their undertakings on historic properties.	Federal agency undertaking that may impact historical properties listed or eligible for inclusion on the National Register of Historic Places— **applicable**	36 *CFR* 800.1(a)
	Determine whether the proposed federal action is an undertaking as defined in §800.16(y) and, if so, whether it is a type of activity that has the potential to cause effects on historic properties.		36 *CFR* 800.3(a)
	Determine and document the area of potential effects, as defined in §800.16(d).		36 *CFR* 800.4(a)(1)–(2)
	Review existing information on historic properties within the area of potential effects, including any data concerning possible historic properties not yet identified.		
	Take the steps necessary to identify historic properties within the area of potential effects.		36 *CFR* 800.4(b)
	Apply the National Register criteria (36 *CFR* 63) to properties identified within the area of potential effects that have not been previously evaluated for National Register eligibility. If the agency official determines any of the National Register criteria are met and the SHPO/THPO agrees, the property shall be considered eligible for the National Register for Sect. 106 purposes.		36 *CFR* 800.4(c)(1)–(2)
	Shall apply the criteria of adverse effect to historic properties within the area of potential effects.		36 *CFR* 800.5(a)
	Shall ensure that a determination, finding, or agreement under the procedures in this subpart is supported by sufficient documentation to enable any reviewing parties to understand its basis.		36 *CFR* 800.11(a)
Presence of archaeological resources on public land	No person may excavate, remove, damage, or otherwise alter or deface, or attempt to excavate, remove, damage, or otherwise alter or deface any archaeological resource located on public lands or Indian lands unless such activity is pursuant to a permit issued under §7.8 or exempted by §7.5(b) of this part.	Action that would cause the irreparable loss or destruction of significant historic or archaeological resources or data on public land— **applicable**	43 *CFR* 7.4(a)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Presence of human remains, funerary objects, sacred objects, or objects of cultural patrimony	Intentional excavation of human remains, funerary objects, sacred objects, or objects of cultural patrimony from federal or tribal lands may be conducted only if: • The objects are excavated or removed following the requirements of the ARPA (16 *USC* 470aa et seq.) and its implementing regulations, and • The disposition of the objects is consistent with their custody as described in §10.6.	Action involving alteration of terrain that might cause irreparable loss or destruction of any discovered significant scientific, prehistoric, historic, or archaeological resources—**applicable**	43 *CFR* 10.3(b)(1) and (3)
	Must take reasonable steps to determine whether a planned activity may result in the excavation of human remains, funerary objects, sacred objects, or objects of cultural patrimony from federal lands.		43 *CFR* 10.3(c)
	If inadvertent discovery occurred in connection with an on-going activity on federal or tribal lands, in addition to providing the notice described above, must stop activities in the area of the inadvertent discovery and make a reasonable effort to protect the human remains, funerary objects, sacred objects, or objects of cultural patrimony discovered inadvertently.	Excavation activities that inadvertently discover such resources on federal lands or under federal control—**applicable**	43 *CFR* 10.4(c)
	Must take immediate steps, if necessary, to further secure and protect inadvertently discovered human remains, funerary objects, sacred objects, or objects of cultural patrimony, including, as appropriate, stabilization or covering.		43 *CFR* 10.4(d)(ii)
Presence of a cemetery	Intentional desecration of a place of burial without legal privilege or authority to do so is prohibited.	Action that would alter or destroy property in a cemetery—**applicable**	*TCA* 39-17-311(a)(1)
	Disinterment of a corpse that has been buried or otherwise interred, without legal privilege or authority to do so, is prohibited.		*TCA* 39-17-312(a)(2)
Endangered, Threatened, or Rare Species			
Presence of federally endangered or threatened species, as designated in 50 *CFR* 17.11 and 17.12 or critical habitat of such species	Actions that jeopardize the existence of a listed species or results in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken.	Action that is likely to jeopardize fish, wildlife, or plant species or destroy or adversely modify critical habitat—**applicable**	16 *USC* 1531 et seq., Endangered Species Act Sect. 7(a)(2)
Presence of Tennessee-listed endangered or rare plant species as listed in TDEC 0400-06-02-.04	May not knowingly uproot, dig, take, remove, damage, destroy, possess, or otherwise disturb for any purposes any endangered species.	Action impacting rare plant species, including, but not limited to federally listed endangered species—**applicable**	16 *USC* 1531 et seq. *TCA* 70-8-309(a) TDEC 0400-06-02-.04 Tennessee Natural Heritage Program Rare Plant List (2016) (**TBC**)

Table B.1. Location-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Location Resource	Requirements	Prerequisite	Citation
Presence of Tennessee non-game species as defined in *TCA* 70-8-103 and listed in TWRA Proclamations 00-14 and 00-15	May not take (i.e., harass, hunt, capture, kill or attempt to kill), possess, transport, export, or process wildlife species. May not knowingly destroy the habitat of such species. Certain exceptions may be allowed for reasons such as education, science, etc., or where necessary to alleviate property damage or protect human health or safety. Upon good cause shown and where necessary to protect human health or safety, endangered or threatened species or "in need of management" species may be removed, captured, or destroyed.	Action impacting Tennessee non-game species, including wildlife species which are "in need of management" (as listed in TWRA Proclamations 00-14 and 00-15 as amended by 00-21)—**applicable**	*TCA* 70-8-104(b) and (c) *TCA* 70-8-106(e) TWRA Proclamations 00-14, Sect. II and 00-15, Sect. II, as amended by Proclamation 00-21 **(TBC)**
Presence of migratory birds as defined in 50 *CFR* 10.13, and their habitats	Unlawful killing, possession, and sale of migratory bird species, as defined in 50 *CFR* 10.13, native to the U.S. or its territories is prohibited.	Action that is likely to impact migratory birds—**applicable**	16 *USC* 703-704
	Requirements are as follows: • Avoid or minimize, to the extent practicable, adverse impacts on migratory bird resources when conducting agency action • Restore and enhance the habitats of migratory birds, as practicable • Prevent or abate the pollution or detrimental alteration of the environment for the benefit of migratory birds, as practicable.	Federal agency action that is likely to impact migratory birds**—TBC**	Executive Order 13186

ARAP = aquatic resource alteration permit
ARPA = Archaeological Resources Protection Act
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR = *Code of Federal Regulations*
CWA = Clean Water Act of 1972
DA = Department of the Army
DOE = U.S. Department of Energy
SHPO = State Historic Preservation Officer
TBC = to-be-considered (guidance)
TCA = *Tennessee Code Annotated*
TDEC = Tennessee Department of Environment and Conservation
THPO = Tennessee Historic Preservation Officer
TWRA = Tennessee Wildlife Resources Agency
U.S. = United States
USACE = U.S. Army Corps of Engineers
USC = *United States Code*

Table B.2. Action-specific applicable or relevant and appropriate requirements for selected alternative

Action	Requirements	Prerequisite	Citation
	General Landfill Design		
Site design for a LLW disposal facility	Surface features must direct surface water drainage away from disposal units at velocities and gradients that will not result in erosion that will require ongoing active maintenance in the future.	Design of a LLW disposal facility**—relevant and appropriate**	TDEC 0400-20-11-.17(2)(e)
	Construction Requirements		
Activities causing fugitive dust emissions	Shall take reasonable precautions to prevent particulate matter from becoming airborne. Reasonable precautions shall include, but are not limited to, the following: • Use, where possible, of water or chemicals for control of dust in demolition of existing buildings or structures, construction operations, grading of roads, or the clearing of land. • Application of asphalt, water, or suitable chemicals on dirt roads, materials stockpiles, and other surfaces that can create airborne dusts. • Shall not cause or allow fugitive dust to be emitted in such a manner to exceed 5 minute/hour or 20 minute/day beyond property boundary lines on which emission originates.	Use, construction, alteration, repair, or demolition of a building, or appurtenances or a road or the handling, transport, or storage of material**—applicable**	TDEC 1200-3-8-.01(1) TDEC 1200-3-8-.01(1)(a) TDEC 1200-3-8-.01(1)(b) TDEC 1200-3-8-.01(2)
Activities causing stormwater runoff	Shall develop and implement stormwater-management controls to ensure compliance with the terms and conditions of *General Permit No. TNR050000* ("Stormwater Multi-Sector General Permit for Industrial Activities") or any applicable site-specific permit. Shall develop and maintain a stormwater pollution prevention/control plan prepared in accordance with good engineering practices and with the factors outlined in 40 *CFR* 125.3(d)(2) or (3), as appropriate, and any additional requirements listed in Part 11 for the particular sector of industrial activity. The plan shall identify potential sources of pollution that may reasonably be expected to affect the quality of stormwater discharges associated with industrial activity. Stormwater pollution prevention plans shall include, at a minimum, the items identified in *General Permit No. TNR050000 Sector K.3*, including a description of potential pollution sources, stormwater-management measures and controls, preventive maintenance, spill prevention and response procedures, and sediment and erosion controls.	Existing and new stormwater discharges associated with industrial activity—**applicable** Stormwater discharges associated with industrial activity at hazardous waste treatment, storage or disposal facilities—**TBC**	*TCA* 69-3-108(e) through (j) *TCA* 69-3-108(l) TDEC 0400-40-10-.03(2)(a) *General Permit No. TNR05-0000,* Sector K (effective July 20, 2020) (**TBC**) *General Permit No. TNR050000,* Sect. 4 (**TBC**) *General Permit No. TNR050000 Sector K.3* (**TBC**)

Table B.2. Action-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Action	Requirements	Prerequisite	Citation
Activities causing stormwater runoff (e.g., clearing, grading, excavation)	Implement good construction management techniques (including sediment and erosion, vegetative controls, and structural controls) in accordance with the substantive requirements of *General Permit No. TNR10-0000* and *TNR05-0000*, to ensure stormwater discharge is properly managed and: • Does not violate water quality criteria as stated in TDEC 0400-40-03-.03, including, but not limited to, prevention of discharge that cause a condition in which visible solids, bottom deposits, or turbidity impairs the usefulness of waters of the state for any designated uses for that water body by TDEC 0400-40-04. • Does not contain distinctly visible floating scum, oil, or other matter. • Does not cause an objectionable color contrast in the receiving stream. • Results in no materials in concentrations sufficient to be hazardous or otherwise detrimental to humans, livestock, wildlife, plant life, or fish and aquatic life in the receiving stream. • Discharges that would cause measurable degradation of waters with unavailable parameters are not authorized. To be eligible to obtain and maintain coverage, must satisfy, at a minimum, the following additional requirements for discharges into waters with unavailable parameters for siltation and habitat alterations due to in-channel erosion: o Measures used at the site must be designed to control stormwater runoff generated by a 5-year, 24-hour storm event at a minimum. Additional physical or chemical treatment of stormwater runoff, such as use of treatment chemicals, may be necessary to minimize the amount of sediment being discharged when clay and other fine particle soils are found on sites.	Stormwater discharges associated with construction activities that disturb ≥ 1 acre total—**relevant and appropriate**	*TCA* 69-3-108(1) Tennessee General Permit No. TNR10-0000, Sects. 5.3.2 and 5.4.1 (effective October 1, 2016) **(TBC)**
Emissions and Effluents			
Activities causing stormwater runoff (e.g., during operations)	Shall develop and implement stormwater management controls to insure [sic] compliance with the terms and conditions of *General Permit No. TNR050000* ("Stormwater Multi-Sector General Permit for Industrial Activities") or any applicable site-specific permit and with TDEC 0400-40-10-.03(2)(c). Shall develop and maintain a stormwater pollution prevention/control plan prepared in accordance with good engineering practices and with the factors outlined in 40 *CFR* 125.3(d)(2) or (3), as appropriate, and any additional requirements listed in Part 11 for the particular sector of industrial activity. The plan shall identify potential sources of pollution that may reasonably be expected to affect the quality of stormwater discharges associated with industrial activity.	Stormwater discharges associated with industrial activity—**applicable**	*TCA* 69-3-108(e) through (j) *TCA* 69-3-108(l) TDEC 0400-40-10-.03(2)(a) TDEC 0400-40-10-.03(2)(c) *General Permit No. TNR050000*, Sector K (effective July 20, 2020) (**TBC** guidance) *General Permit No. TNR050000*, Sect. 4

Table B.2. Action-specific applicable or relevant and appropriate requirements for selected alternative (cont.)

Action	Requirements	Prerequisite	Citation
	Stormwater pollution prevention plans shall include, at a minimum, the items identified in *General Permit No. TNR050000 Sector K.3*, including a description of potential pollution sources, stormwater management measures and controls, preventive maintenance, spill prevention and response procedures, and sediment and erosion controls.	Stormwater discharges associated with industrial activity at hazardous waste treatment, storage, or disposal facilities**—TBC**	*General Permit No. TNR050000* Sector K.3
Secondary Waste and Waste Acceptance Criteria Attainment			
Management and storage of used oil	Used oil generators shall not store used oil in units other than tanks, containers, or units subject to regulation under TDEC 0400-12-01-.05 or -.06.	Generation and storage of used oil [as defined in TDEC 0400-12-01-.11(1)(a)] and possible release—**applicable**	40 *CFR* 279.22(a) TDEC 0400-12-01-.11(3)(c)(1)
	Containers and aboveground tanks used to store used oil at generator facilities must be in good condition (no severe rusting, apparent structural defects, or deterioration) and not leaking (no visible leaks).		40 *CFR* 279.22(b)(1) and (2) TDEC 0400-12-01-.11(3)(c)(2)(i) and (ii)
	Containers and aboveground tanks used to store used oil at generator facilities must be labeled or marked clearly with the words "Used Oil."		40 *CFR* 279.22(c)(1) and (2) TDEC 0400-12-01-.11(3)(c)(3)(i) and (ii)
	Upon detection of a release of used oil to the environment, a generator must stop the release; contain, clean up, and properly manage the released used oil; and, if necessary, repair or replace any leaking used oil storage containers or tanks prior to returning them to service.		40 *CFR* 279.22(d) TDEC 0400-12-01-.11(3)(c)(4)
Pre-construction activities	Prior to excavation, all bore holes drilled or dug during subsurface investigation of the site, piezometers, and abandoned wells that are either in or within 100 ft of the areas to be filled must be backfilled with a bentonite slurry or other sealant approved by the Commissioner to an elevation at least 10 ft greater than the elevation of the lowest point of the landfill base (including any liner), or to the ground surface if the site will be excavated less than 10 ft below grade.	Construction of a solid waste disposal facility— **relevant and appropriate**	TDEC 0400-11-01-.04(2)(l)

CFR = *Code of Federal Regulations*
LLW = low level (radioactive) waste
TBC = to-be-considered (guidance)
TCA = *Tennessee Code Annotated*
TDEC = Tennessee Department of Environment and Conservation

APPENDIX C.
KEY GWFD DESIGN DRAWINGS AND SPECIFICATIONS

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KEY DESIGN DRAWINGS

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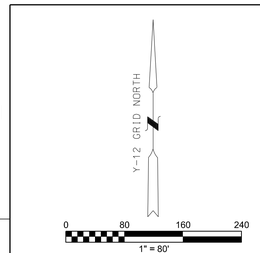

Contour Interval = 2 Feet

GENERAL NOTES

A. THIS OVERALL SITE PREPARATION AND TEMPORARY EROSION AND SEDIMENT CONTROL PLAN IS INTENDED FOR GENERAL INFORMATION AND FOR SUBCONTRACTOR TO ESTABLISH MINIMUM STORMWATER AND EROSION CONTROL MEASURES.

B. CONTOURS ARE DISPLAYED ON 2 FOOT INTERVALS.

C. GRAY CONTOURS REPRESENT EXISTING GRADE AND BLACK CONTOURS REPRESENT FINISHED GRADE.

D. SEE SHEET G2E-OSWDF-I268 FOR GENERAL NOTES, LEGEND AND ABBREVIATIONS.

KEYNOTES

1. SEDIMENT FENCE; SEE DETAIL 6/I287
2. CHECK DAM; SEE DETAIL 5/I287
3. ENERGY DISSIPATION BASIN; SEE DETAIL 2/I289
4. INLET PROTECTION; SEE DETAIL 9/I287
5. SEDIMENT FENCE WITH J HOOKS.

DRW BY	C CONNER										
ORG	F PARTON PE										
ENGR CHK	D MATLOCK PE										
DM	D MATLOCK PE										
PROJ ENGR	G PICKEREL PE										
		A	12/30/22	ISSUED FOR 90% REVIEW	CC	FP	DM	DM			GP
ELECTRONIC SIGNATURES		REV	DATE	DESCRIPTION	DRW BY	ORG/ ENGR	ENGR CHK	DM			PROJ ENGR
DRAWING REVISIONS											

SHEET NUMBER 6

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OAK RIDGE RESERVATION
MANAGED FOR THE DEPARTMENT OF ENERGY
UNDER CONTRACT DE-M-00067
OAK RIDGE TN 37830

PROJECT RECORD NUMBER	CONFIGURATION MANAGEMENT LEVEL
N/A	N/A

PROJECT NAME: OSWDF GROUNDWATER FIELD DEMONSTRATION

TITLE: TEMPORARY EROSION AND SEDIMENT CONTROL PLAN

CAD FILENAME	BUILDING	SITE	CLASS
C2EOSWDFI273.dgn	OSWDF	ORR	U

SCALE	TYPE	DRAWING NUMBER	REV
AS SHOWN	ID	C2E-OSWDF-I273	A

005-C-102_GWFD.dgn

PLOT TIME 8:17:45 AM
PLOT DATE 1/17/2023
MICROSTATION FILE

GENERAL NOTES

A. REFER TO SITE PREPARATION AND TEMPORARY EROSION & SEDIMENT CONTROL PLAN FOR STORMWATER AND EROSION CONTROL MEASURES.

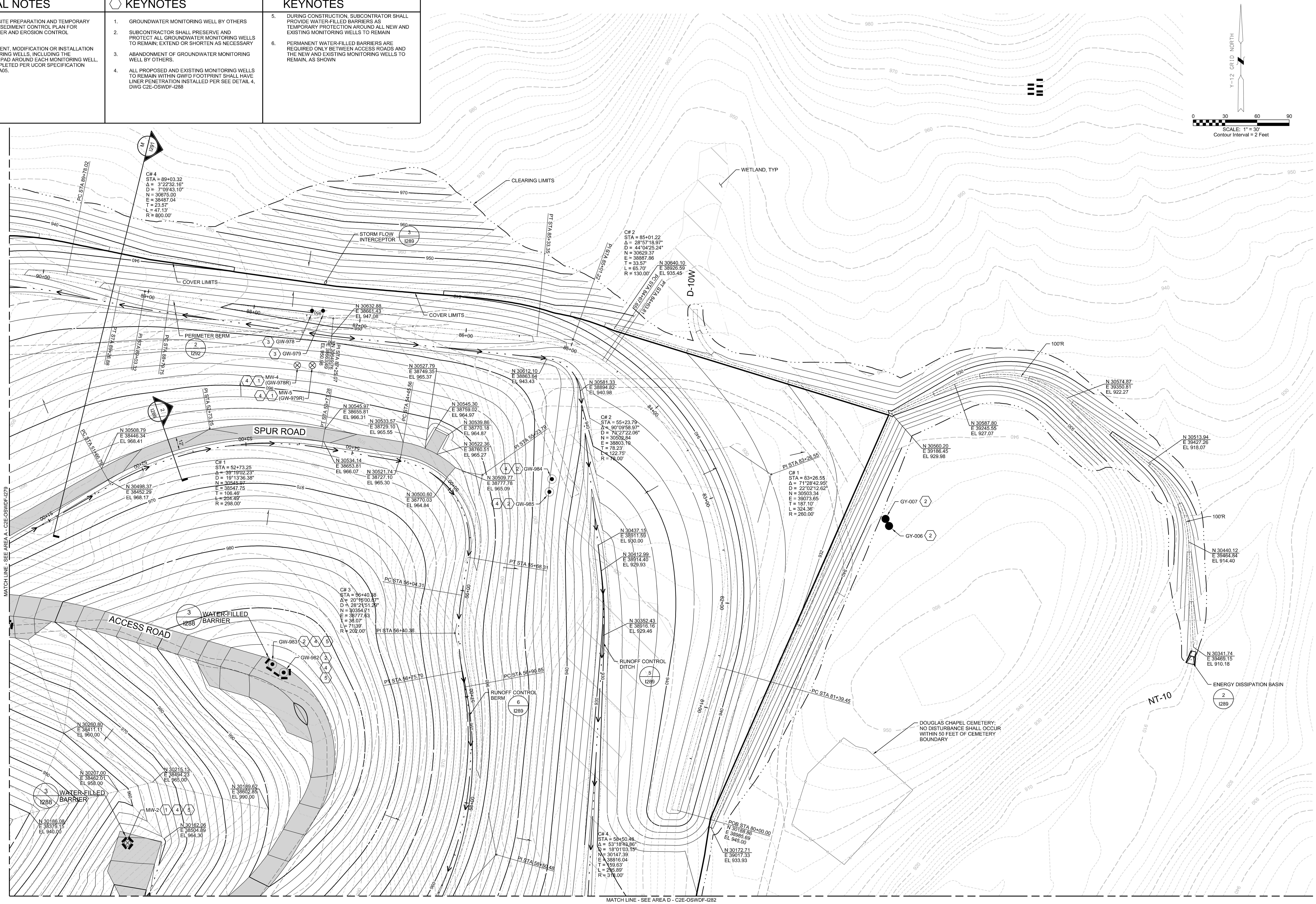
B. ABANDONMENT, MODIFICATION OR INSTALLATION OF MONITORING WELLS, INCLUDING THE CONCRETE PAD AROUND EACH MONITORING WELL, TO BE COMPLETED PER UCOR SPECIFICATION SPG-00000-A05.

KEYNOTES

1. GROUNDWATER MONITORING WELL BY OTHERS
2. SUBCONTRACTOR SHALL PRESERVE AND PROTECT ALL GROUNDWATER MONITORING WELLS TO REMAIN; EXTEND OR SHORTEN AS NECESSARY
3. ABANDONMENT OF GROUNDWATER MONITORING WELL BY OTHERS.
4. ALL PROPOSED AND EXISTING MONITORING WELLS TO REMAIN WITHIN GWFD FOOTPRINT SHALL HAVE LINER PENETRATION INSTALLED PER SEE DETAIL 4, DWG C2E-OSWDF-I288

KEYNOTES

5. DURING CONSTRUCTION, SUBCONTRATOR SHALL PROVIDE WATER-FILLED BARRIERS AS TEMPORARY PROTECTION AROUND ALL NEW AND EXISTING MONITORING WELLS TO REMAIN
6. PERMANENT WATER-FILLED BARRIERS ARE REQUIRED ONLY BETWEEN ACCESS ROADS AND THE NEW AND EXISTING MONITORING WELLS TO REMAIN, AS SHOWN



DRW BY	J ASHWORTH		
DRG	F PARTON PE		
ENGR CHK	D MATLOCK PE		
DM	D MATLOCK PE		
PROJ ENGR	G PICKEREL PE		
B	3/20/23	ISSUED FOR 100% REVIEW	JA FP DM DM GP
ELECTRONIC SIGNATURES	REV / DATE	DESCRIPTION	DRW BY / ORG/ENGR / ENGR CHK / DM / PROJ ENGR

DRAWING REVISIONS

SHEET NUMBER 13

UCOR — OAK RIDGE RESERVATION
MANAGED FOR THE DEPARTMENT OF ENERGY UNDER CONTRACT DE-M-0006T
OAK RIDGE TN 37830

PROJECT RECORD NUMBER	CONFIGURATION MANAGEMENT LEVEL
N/A	N/A

PROJECT NAME: OSWDF GROUNDWATER FIELD DEMONSTRATION

TITLE: FINISHED GRADING PLAN - AREA B

CAD FILENAME	BUILDING	SITE	CLASS
C2EOSWDFI280.dgn	OSWDF	ORR	U

SCALE	TYPE	DRAWING NUMBER	REV
AS SHOWN	ID	C2E-OSWDF-I280	B

PLOT DATE 3/28/2023 PLOT TIME 3:25:18 PM

MICROSTATION FILE

KEY TECHNICAL SPECIFICATIONS

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Specification Cover Sheet

SPECIFICATION

FOR

SECTION 31 11 00

SITE CLEARING AND GRUBBING

GROUNDWATER FIELD DEMONSTRATION (GWFD)

		JOB NO.	
		SPECIFICATION NO.	SPC-OSWDF-I299
		SHEET	1 of 7
	Name	**Signature**	**Date**
Originator	Ken Oliver, PE		1/17/2023
Checker	David Matlock, PE		1/17/2023
Additional Reviewer	Butch Parton, PE		
Project Engineer	Greg Pickerel, PE		

Revision History

Rev. No.	Reason For Revision	Date
A	Issued for 60% prelim review	1/15/2022
B	Issued for 60% backcheck review	5/04/2022
C	Issued for 90% review	1/17/2023

Form-362 (6/19) Rev. 2
PROC-DE-1007

SECTION 31 11 00
SITE CLEARING AND GRUBBING

PART 1: GENERAL

1.01 DESCRIPTION

A. This section addresses the clearing and grubbing of trees, brush, and other vegetation from the project site. Clearing limits are shown on construction drawings.

B. The project site has merchantable timber that will have been previously harvested by others. The project site will have tree stumps, root balls, tree trunks and limbs, and slash piles that remain from the timber harvesting operations. Subcontractor will finish the clearing activities, perform grubbing operations, and generally turn all woody debris into wood chips for use on site.

1.02 DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; and topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2 inch caliper to a depth of 6 inches below subgrade.

D. Stripping: Removal of top 4 feet of soil profile measured from existing ground surface after applicable clearing and grubbing is completed.

E. Clearing Limits: Areas, as shown or specified, within which Work is to be performed.

F. Unsuitable Material: As defined under Section 31 23 16, Excavation.

1.03 REFERENCES

A. International Fire Code, Section 2808 (2018), International Code Council.

1.04 SUBMITTALS

A. The following documents shall be submitted to the Subcontract Technical Representative (STR) in accordance with the requirements of Exhibit I of the Subcontract.

B. Clearing and Grubbing Plan (prior to implementation) that includes: Procedures to be used, protection methods for nearby existing wetlands and vegetation, descriptive list of equipment that includes wood chipping and stump grinding, and approximate work extent for each phase of site clearing.

1.05 SCHEDULING AND SEQUENCE

A. Perform site clearing work only after adequate erosion and sediment controls are in place. Limit the bare earth areas that are exposed to uncontrolled erosion to manageable sizes. Install adequate erosion and sediment control measures for each area of bare earth.

B. The Subcontractor shall keep detailed records of all activities, correspondence, and related documents until the Subcontract Technical Representative (STR) has accepted the clearing and grubbing as required by the contract and construction drawings.

PART 2: PRODUCTS

2.01 MATERIALS

A. The Subcontractor shall furnish all materials, tools, equipment, facilities, and services as required for performing site clearing, grubbing and other site preparation work.

PART 3: EXECUTION

3.01 PROTECTION OF TREES AND SHRUBS OUTSIDE OF LIMITS

A. Protect nearby trees and vegetation to remain from any damage incidental to the clearing, grubbing, and construction operations.

3.02 PROTECTION OF UTILITY LINES

A. Protect from damage existing utility lines that are indicated to remain. Suspend work and notify the Subcontract Technical Representative (STR) immediately of damage to an existing utility line. The Subcontractor is responsible for the repairs of any damage to existing utility lines that are indicated or made known to the Contractor prior to start of clearing and grubbing operations.

3.03 WORK LIMITS FOR CLEARING, GRUBBING, AND STRIPPING

A. Site clearing limits:

1. Excavation: 5 feet beyond top of cut slopes.
2. Fill:
   a. Clearing and Grubbing: 8 feet beyond toe of embankment fill.

b. Stripping: 5 feet beyond toe of embankment fill.

3. Roadways: 5 feet from roadway shoulders.

4. Overhead Utilities:

a. Clearing and Grubbing: Entire width of easements and rights-of-way.

b. Stripping: Wherever grading is required.

5. Other Areas: 5 feet from new work.

B. Remove rubbish, trash, and junk from entire area within the project limits.

3.04 CLEARING

A. Merchantable timber will be previously harvested by others. Removal of remaining stumps and slash piles will be the responsibility of the Subcontractor.

B. Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including downed timber, snags, brush, and rubbish occurring within the areas to be cleared. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface.

C. Clear areas within limits shown or specified. Fell trees in a direction so that nearby facilities and vegetation-to-remain are not damaged.

D. For trees that are outside the clearing limits by 10 feet or less, cut off stumps flush with ground surface but grubbing is not necessary. The 10-ft limit may require adjustment at locations where the clearing limits approach environmentally sensitive natural resources, or if felling of a large mature tree near the clearing limit needs to be assessed by the Subcontract Technical Representative (STR). In these cases, more precise removal of trees near the clearing limit may be necessary to minimize impacts to natural resources.

E. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.05 GRUBBING

A. Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Remove grubbed material to a depth of not less than 18 inches below the original surface level of the ground in areas indicated to be grubbed and in areas indicated for project construction under this subcontract. Fill depressions with suitable material and compact to make the surface conform with the original adjacent ground surface.

B. Do not start earthwork operations in areas where clearing and grubbing are not complete, except that stumps and large roots may be removed concurrently with excavation when allowed by the Contractor. The Subcontractor shall immediately segregate stumps and large roots to a separate pile from excavated material.

C. Topsoil shall only be stripped from areas that will be disturbed by excavation, filling, paving, or compaction by equipment. Topsoil shall be stripped and stockpiled onsite before grading activities are commenced in any new area of the site. Contractor will designate locations suitable for temporary storage of soil. The tockpiled topsoil shall be stabilized using BMPs in accordance with Section 31 25 00.

3.06 DISPOSAL OF MATERIALS

A. Chipping: Trees, brush, logs, stumps, roots, rotten wood, and other refuse from the clearing and grubbing operations, shall be chipped onsite and placed into stockpiles at locations designated by the Subcontract Technical Representative (STR). The stockpiles containing wood chips shall be stabilized and protected similar to topsoil stockpiles and as directed by the STR.

B. Wood Chip Piles: Woody debris may be chipped onsite to provide a supply of wood chips for use in enhancement of sediment and erosion controls. Wood chip pile sizes and spacing shall be in accordance with the 2018 International Fire Code, Section 2808, which is attached as page 7 of this specification section.

C. Disposal:

1. Remove and dispose of excess or poor-quality wood chips as directed by the Subcontract Technical Representative (STR).
2. When directed by STR, wood chips may be used for project site erosion and sediment control. Place wood chips in a nominal 4-inch layer in lieu of seeding or straw mulch, in locations that will not block drainage patterns or affect existing tree roots.
3. Burying of trash and debris at the site will not be permitted. Burning of trash and debris at the site will not be permitted.
4. Remove trash and debris from the site at frequent intervals so that its presence will not delay the progress of the work, cause hazardous conditions for workers or the traveling public, or become unsightly.
5. Excess/unwanted materials, waste, trash, and debris shall be removed from the project site by the Subcontractor. Subcontractor shall dispose of waste, trash, and debris at the ORR Construction/Demolition Landfill VII or Industrial Landfill V or as directed by the STR. Waste disposed at the ORR Construction/Demolition Landfill VII or at Industrial Landfill V must meet Contractor's acceptance criteria and must have advance approval from the Contractor's Waste Certification Representative.

D. Stripped Soils

1. Dispose of stripped soils that are unsuitable for topsoil or that exceed quantity required for topsoil where directed onsite by STR.

2. Stockpile topsoil in sufficient quantity to meet the project needs, at onsite locations determined by STR.

3.07 ATTACHMENT

A. The attachment listed below, following "End of Section," is a part of this specification.

1. Section 2808. Storage and Processing of Wood Chips, Hogged Materials, Fines, Compost, Solid Biomass Feedstock and Raw Products Associated With Yard Waste, Agro-Industrial, Recyling Facilities.

International Fire Code (2018), page 28-3, International Code Council.

END OF SECTION

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SPECIFICATION

FOR

SECTION 31 23 23

FILL MATERIAL AND PLACEMENT

GROUNDWATER FIELD DEMONSTRATION (GWFD)

		JOB NO.	
		SPECIFICATION NO.	SPC-OSWDF-I302
		SHEET	1 of 15
	Name	**Signature**	**Date**
Originator	Ken Oliver, PE		1/17/2023
Checker	David Matlock, PE		1/17/2023
Additional Reviewer	Butch Parton, PE		
Project Engineer	Greg Pickerel, PE		

Revision History

Rev. No.	Reason For Revision	Date
A	Issued for 60% prelim review	1/15/2022
B	Issued for 60% backcheck review	5/04/2022
C	Issued for 90% review	1/17/2023

Form-362 (6/19) Rev. 2
PROC-DE-1007

SECTION 31 23 23
FILL MATERIAL AND PLACEMENT

PART 1: GENERAL

1.01 DESCRIPTION

A. This section covers the requirements for soils fill material, placement, and compaction.

1.02 DEFINITIONS

A. Geosynthetics: Geotextiles, geogrids, geomembranes, artificial turf, or a composite of these materials.

B. Lift: Loose (uncompacted) layer of material.

C. Optimum Moisture Content:

1. Determined in accordance with ASTM D698 to determine optimum moisture content.

2. Determine field moisture content per the pertinent ASTM method.

D. Prepared Subgrade: Ground surface after completion of required demolition, clearing and grubbing, stripping of topsoil, excavation to grade, and subgrade preparation.

E. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698.

2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Contractor's Engineer.

F. Satisfactory Materials: Satisfactory materials include any materials classified by ASTM D2487 as GW, GP, GM, GC, SW, SP, SM, SC, ML, CL, or CH. Satisfactory materials for grading may include minor quantities of rock less than 3 inches in any dimension that will not affect soil compaction requirements.

G. Unsatisfactory Materials: Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include excessively wet soil, man-made fills, trash, refuse, backfills from previous construction, and material which contains root and other organic matter or frozen material. Notify the Subcontract Technical Representative (STR) when encountering any unsatisfactory materials.

1.03 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO):

1. AASHTO R 18, Standard Practice for Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories

B. ASTM International (ASTM):

1. ASTM C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

2. ASTM C117, Standard Test Method for Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing

3. ASTM C131, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

4. ASTM C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates

5. ASTM D75, Standard Practice for Sampling Aggregates

6. ASTM D448, Standard Specification for Sizes of Aggregate for Road and Bridge Construction

7. ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3)

8. ASTM D1556, Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method

9. ASTM D2216, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

10. ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

11. ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)

12. ASTM D2937, Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method

13. ASTM D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

14. ASTM E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

C. Tennessee Department of Transportation (TDOT):

1. Standard Specifications for Road and Bridge Construction, Latest edition

1.04 SUBMITTALS

A. The following documents shall be submitted to the Subcontract Technical Representative (STR) in accordance with the requirements of Exhibit I of the Subcontract.

1. Pre-Construction Submittals:

a. Qualifications and certifications for Testing Laboratory.

b. Qualifications, certifications and documentation experience for Geotechnical Engineer and Geotechnical Field Technician.

c. Documentation of current Nuclear Regulatory Commission radioactive material license, current calibration, and current leak test certification for each nuclear density gauge.

d. Sand Infill Placement Plan - to include materials, placement method, list of construction equipment, and protection of work.

2. Test and Inspection Reports:

a. Soil classification tests for fill materials and Select Granular Materials.

b. Tests for moisture-density relation.

c. Density and moisture tests.

d. Inspection reports of proof-rolling (and undercutting and backfill if required).

e. Weekly letter reports by Geotechnical Engineer/Technician.

f. Daily inspection reports for excavations requiring worker and/or equipment access per OSHA regulations.

g. Certification that backfill for undercut meets the specification.

3. Closeout Submittals:

a. As-built topographic drawings.

1.05 QUALITY CONTROL INSPECTION AND TESTING

A. The Subcontractor shall retain a licensed Testing Laboratory, Geotechnical Engineer, and Geotechnical Field Technician, qualified per the requirements of this specification and approved by STR to perform inspections and testing.

B. Qualifications of Testing Laboratory: Shall be accredited per AASHTO R 18, ASTM D3740, and ASTM E329 and meeting the requirements for all testing standards and methods per this specification. The Testing Laboratory shall establish, maintain, and implement a program to identify, control, and calibrate test equipment.

C. Qualifications of Geotechnical Engineer: Shall be a Tennessee-Registered Professional Engineer (PE) with active registration and appropriate experience to verify that work by the Subcontractor meets the specification requirements. The Geotechnical Engineer shall have a minimum of five years of experience in field oversight of civil earthworks and geotechnical engineering projects

D. Qualifications of Geotechnical Field Technician: Shall be certified by the National Institute for Certification in Engineering Technologies (NICET) at Level II or III in Construction Materials Testing for Soils, or be able to demonstrate equivalency through an alternative certification program. Field technicians shall have a minimum of two years of experience performing field quality control for asphalt, concrete, and soil. Field technicians operating nuclear density gauges shall submit certification of training and records of participation in a dosimetry program.

E. The Geotechnical Engineer and/or Geotechnical Field Technician shall be onsite to perform inspections of excavations, proof-rolling and fill placement, and compaction testing throughout construction. The Geotechnical Engineer and/or Geotechnical Field Technician shall provide weekly letter reports of inspections and reports of all test results at the beginning of the following week to the STR.

F. The Geotechnical Engineer and/or Geotechnical Field Technician shall be the "Competent Person" required by OSHA regulations to perform daily inspections and assessments of excavations.

G. The Subcontractor shall provide access to work areas and shall coordinate for inspections and testing by the Geotechnical Engineer/Technician. The Subcontractor shall provide the equipment and operator for proof-rolling.

H. Access by Other Testing Firms – When requested by the STR, the Subcontractor shall provide immediate access to work areas for independent soil inspections or soil testing by other firms.

1.06 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.07 SEQUENCING AND SCHEDULING

A. Complete the applicable work specified in Section 31 11 00, Site Clearing and Grubbing; Section 31 23 16, Excavation; and Section 31 23 13, Subgrade Preparation, prior to the placement of fill or backfill.

B. Do not place embankment fill, select earth fill, structural fill, or mineral aggregate base until after subgrade has been prepared as specified in Section 31 23 13, Subgrade Preparation.

PART 2: PRODUCTS

2.01 MATERIALS

A. The Subcontractor shall furnish all materials, tools, and equipment as required for performing excavation work.

B. Fill material for compacted fill and trench backfill above the pipe section shall be natural fill material from offsite or shall be excavated onsite soil free of debris, foreign objects, large rock fragments, organics, and other deleterious materials. Visible rock particles shall be maximum dimension of 3 inches in any direction for 8-inch thick loose lifts. Smaller lifts shall have visible rock particles no larger than one-half of the lift thickness. Material for compacted fill shall conform to GC, SC, SM, ML, CL, or CH according to the Unified Soil Classification System per ASTM D2487.

C. Select Granular Material: Select granular material shall consist of materials classified as GW or SW in accordance with ASTM D2487 where indicated. Not more than 10% by weight may be finer than No. 200 sieve when tested in accordance with ASTM D1140.

D. Backfill for replacement of undercut soft soils shall be satisfactory material or shot rock or rubble stone riprap in accordance with TDOT Section 709.02.A.

E. Construction water for moisture conditioning of the compacted fill shall be obtained from the onsite water source designated by the STR.

F. Construction safety fence for activities shall be orange, high-density polyethylene, 4 feet in height, opening size approximately 4 inches by 1 inch, minimum tensile

strength of 2,000 pounds per foot of width. Posts shall be T-shaped (T-post) or as approved by the STR.

G. Topsoil: Soil containing organic material excavated onsite from the ground surface or near surface, or soil containing organic material obtained from an offsite source.

2.02 STRUCTURAL FILL

A. Crushed gravel or crushed rock material consisting of excavated or imported granular material and free from dirt, clay balls, and organic matter. Limestone or shale bedrock may be used from required excavations provided it is crushed and sorted so as to be well graded from coarse to fine with 1-inch maximum size and 8 percent maximum passing the No. 200 sieve.

2.03 SELECT EARTH FILL

A. Excavated lean clay, silt, and/or sand material from required excavations and designated borrow sites, free from rocks larger than 1 inch, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

B. Liquid Limit less than 45 percent, Plasticity Index less than 25 percent.

C. Gradation shall be as specified in accordance with ASTM C136.

Sieve Size	Percent Passing by Weight
1 inch	100
No. 4	85 – 90
No. 200	30 – 60

2.04 EMBANKMENT FILL

A. Excavated lean clay, silt, sandy silt, and/or sandy lean clay material from required excavations or designated borrow areas, free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials. Shall meet the following requirements:

1. Liquid Limit less than 45 percent.

2. Plasticity Index less than 25 percent.

2.05 SAND INFILL

A. Fine aggregate angularity uncompacted void content shall be greater than or equal to 40 percent in accordance with ASTM C125, Method A.

B. Bulk oven-dry specific gravity shall be greater than or equal to 2.40 in accordance with ASTM C128.

C. Gradation shall be as specified in accordance with ASTM C136.

Sieve Size	Percent Passing by Weight
3/8 inch	100
No. 4	90 – 100
No. 8	50 – 85
No. 16	25 – 65
No. 30	10 – 45
No. 50	0 – 30
No. 100	0 – 10
No. 200	0 – 5

2.06 GRANULAR DRAIN MATERIAL

A. A. Round, competent, washed rock.

B. B. Free from clay, organic matter, or other deleterious material.

C. C. Gradation shall be as specified in accordance with ASTM C136.

Sieve Size	Percent Passing by Weight
1 1/2 inch	100
3/4 inch	80 – 100
3/8 inch	50 – 70
No. 4	20 – 40
No. 200	0 – 2

2.07 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

PART 3: EXECUTION

3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

D. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:

1. Fill or backfill to an elevation 2 feet above top of item to be laid.
2. Excavate trench for installation of item.
3. Install bedding, if applicable, as specified in Section 31 23 33, Trenching and Backfill.
4. Install item.
5. Backfill envelope zone and remaining trench, as specified in Section 31 23 33, Trenching and Backfill, before resuming filling or backfilling specified in this section.

E. Tolerances:

1. Final Lines and Grades: Within a tolerance of 0.15 foot unless dimensions or grades are shown or specified otherwise.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

F. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

3.02 EMBANKMENT AND SELECT EARTH FILL MATERIAL

A. Material Placement (General):

1. Do not place embankment fill materials on any part of the prepared subgrade until the area has been inspected and approved by Contractor or assigned representative.
2. Place and spread materials in horizontal lifts of uniform thickness.
3. Do not place material in the embankment area, if the material moisture content is outside the specified limits.
4. Do not place embankment material on damaged material. Damaged material includes:
   a. Ponded water.
   b. Cracked soil from drying or freezing conditions.
5. Remove damaged material. Disk and compact the surface of the previously placed embankment.
6. Do not place frozen material in the embankment.
7. Do not place material on frozen subgrade.

8. Maintain the surface of the embankment level in both parallel and transfers directions of the control line, except to allow for surface drainage.

9. Key new embankments constructed on existing slopes steeper than 4:1 (Horizontal Run: Vertical Rise) with horizontal benches of sufficient width to accommodate the operation of placing and compacting equipment. Slope each bench to drain. Incorporate material excavated from the benches into the embankment fill or waste the material if directed by the Contractor.

B. Maximum Loose Lift Thickness:

1. 12 inches for material compacted with self-propelled compaction equipment.

2. 10 inches for materials compacted with hand-operated compaction equipment.

3. Reduce loose lift thickness, as necessary, to achieve compaction criteria.

C. Moisture Content:

1. Determine the optimum moisture content by ASTM D698.

2. Embankment Fill: Place and compact at moisture content at least 2 percentage points higher than the optimum moisture but not greater than 7 percent points higher than the optimum moisture content. Adjustments to moisture content can be made if the Subcontractor can demonstrate to the Contractor that minimum compaction can be achieved.

3. Excavated Limestone or Shale Bedrock: Place and compact at a moisture content between 1 percent below and 3 percentage points higher than the optimum moisture content for the processed material.

4. Moisture condition embankment materials obtained from borrow sites within the borrow area prior to placement within the embankment. No more than 1 percentage point water shall be added to the embankment materials already placed, but not yet compacted, within the embankment limits.

D. Compaction:

1. General:

a. Compact each lift prior to placement of succeeding lifts.

b. When hauling equipment is operated on the embankment lifts, evenly distribute the traffic across the entire embankment width to prevent nonuniform compactive effort.

2. Equipment:

   a. Use compaction equipment of size and type capable of producing the required densities.

   b. Self-propelled rollers shall have functioning speedometers.

   c. Equipment for compacting imported materials shall be clean and shall not contaminate the imported materials.

3. Method and Density Requirements:

   a. Compact to dry density that is greater than or equal to 95 percent of the maximum dry density, as determined by ASTM D698.

   b. Finish the compaction of each lift with a minimum of four passes using a self-propelled tamping-foot roller having a minimum operating weight of 65,000 pounds. The roller shall have chevron-shaped tamping feet with 7-inch minimum length. Roller speed shall not exceed 5 miles per hours when compacting soil.

3.03 SITE TESTING

A. Gradation:

1. One sample from each 175 cubic yards of sand infill to be installed.

2. One sample from each 1,500 tons of structural fill, select earth fill, embankment fill, and granular drain material or more often as determined by Contractor's Engineer, if variation in gradation is occurring, or if material appears to depart from specifications.

3. If test results indicate material does not meet specification requirements, terminate material placement until corrective measures are taken.

4. Remove material placed in Work that does not meet specification requirements.

B. In-Place Density Test Frequency

1. One test per 5,000 square feet, or fraction thereof, of each lift of fill or backfill compacted by heavy equipment.

2. One test per 2,500 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

3. Check Tests on In-Place Densities: If ASTM D6938 is used, check the in-place densities by ASTM D1556 or ASTM D2937 with frequency of one

check test per lift for each 50,000 square feet, or fraction thereof, of each lift of compacted fill or backfill.

C. In-Place Density Test Results

1. In accordance with ASTM D6938. During placement of materials, test as follows:

a. Embankment Fill: 93 percent of maximum dry density per ASTM D698.

b. Structural Fill: 95 percent of maximum dry density per ASTM D698.

c. Select Earth Fill: 95 percent of maximum dry density per ASTM D698.

d. Base Course Rock: 93 percent of maximum dry density per ASTM D698.

3.04 MINERAL AGGREGATE BASE COURSE

A. Place and compact as specified in Section 32 11 23, Aggregate Materials.

3.05 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Contractor's Engineer as follows:

1. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.

2. Trenches:

a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 33, Trenching and Backfill.

b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 33, Trenching and Backfill.

3. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):

a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Earth Fill.

b. Steep Slopes (Steeper than 3:1): Correct overexcavation by transitioning between overcut areas and designed slope adjoining

areas, provided such cutting does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

3.06 BACKFILL FOR COVER SYSTEM ANCHOR TRENCH

A. Cover system anchor trenches shall be backfilled with selected earth fill as shown on Drawings, placed in 8-inch maximum lifts, and compacted to 95 percent relative compaction. HDPE geomembrane seam welds shall extend through the anchor trench to the bottom of the welded sheets. Extend engineered turf also through trench zone as shown.

3.07 PLACING FILL OVER GEOSYNTHETICS

A. General:

1. Prior to placing material over geosynthetics, notify Subcontract Technical Representative (STR). Do not cover installed geosynthetics until after the STR provides authorization to proceed.

2. Do not place materials on geosynthetics where typical height of wrinkles is greater than 2 inches and spacing between wrinkles is less than 10 feet. Also, do not place soil materials in manner that will cause wrinkles to fold over or become confined to form a vertical ridge.

3. Place soil materials when geosynthetics are cool and contracted and wrinkles are minimized.

4. If tears, punctures, or other geosynthetics damage occurs during placement of overlying material, remove overlying products as necessary to expose damaged geosynthetics, and repair damage as specified in Section 32 05 21, Geomembrane and Engineered Turf Cover System.

5. Geosynthetics installer shall remain available during placement of overlying products to repair geosynthetics if damaged.

6. Place fill over geosynthetics with sufficient care so as not to damage them.

7. Place fill only by back dumping and spreading only.

8. Dump fill only on previously placed fill.

9. While operating equipment, avoid sharp turns, sudden starts or stops that could damage geosynthetics.

B. Hauling: Operate hauling equipment on minimum of 3 feet of covering.

C. Spreading:

1. Spreading equipment shall be track mounted , low ground pressure, D 6 or lighter.

2. Operate spreading equipment on minimum of 12 inches of fill over geosynthetics.

3. Spread fill in same direction as unseamed overlaps to avoid separation of seams and joints.

4. Never push fill downslope toward the geosynthetics. Spread fill over sideslopes by pushing up from slope bottom, and allowing the material to fall down the face of spread material. If access to bottom of slope is unavailable, progressively place fill, beginning at toe of slope and working upslope, with backhoe or dragline operated from top of slope. Limit distance material falls onto the geosynthetics to maximum of 2 feet.

5. Always have a thickened layer at the edge of the leading edge of the fill. As the leading edge propagates the thickened lift of material can be cut down to the desire lift thickness.

6. Maintain proper overlap of unseamed geosynthetics.

7. Avoid overstressing geosynthetics and seams.

D. Compaction: Compact fill only after uniformly spread to full thickness shown.

1. Place materials that require density testing in lifts of 8 inch maximum thickness and compact each lift to minimum of 95 percent relative compaction as determined in accordance with ASTM D698.

E. Geosynthetic Damage:

1. Mark punctures, tears, or other damage to geosynthetics, so repairs may be made.

2. Clear overlying fill as necessary to repair damage.

3. Repairs to geosynthetics shall be made by respective installers as specified in respective specification section for each geosynthetic.

3.08 SAND INFILL MATERIAL PLACEMENT

A. No equipment is allowed on slopes steeper than 3:1 (Horizontal Run: Vertical Rise) after placement of engineered turf and prior to placement of sand infill.

B. A low-ground-pressure all-terrain utility vehicle with maximum load of 2000 lbs may travel on side slopes during construction, provided that this vehicle only travels up slope without sudden turns or stops.

C. Do not place sand infill when snow or ice is present on the engineered turf component.

D. Place and spread materials to lines and grades shown and as specified in paragraph 3.07. Sand infill layer will be placed to a 1/2 inch minimum thickness not to exceed 3/4 inch thick, measured with a digital caliper, or alternate measuring device approved by Contractor's Engineer. Final thickness of the sand infill will be checked at a minimum 20 times per acre.

E. Sand infill shall be worked into the engineered turf between the synthetic yarn blades. Placement of sand infill shall be in front of the deployment equipment. Conveyor systems and/or express blowers will be used to place and spread the sand infill. After sand infill placement, use low ground pressure equipment (maximum 4 psi ground pressure) with rake or similar attachment to rake and spread sand infill to a uniform thickness.

F. Verify no geosynthetics are damaged or exposed after installation of sand infill is complete.

3.09 SURVEYING AND INSPECTION

A. Subcontractor shall provide and maintain a means of continuously observing the depth of each material such as by full GPS automatics until placement and spreading is complete. Sharp stakes or methods that could damage the geosynthetics will not be allowed. Subcontractor shall provide and operate suitable equipment to assist Contractor's Engineer's checking of material depths on an approximate 50 foot grid at no additional cost to Contractor.

B. During material placement and spreading operations, the Contractor's Engineer may be monitoring geomembrane movement and integrity. At the Contractor's Engineer's request, the Subcontractor shall uncover and then backfill after approval up to twenty 2-foot square areas over the course of the project at no additional cost to the Contractor.

3.010 ACCESS ROAD MINERAL AGGREGATE BASE COURSE

A. Place and compact as specified in Section 32 11 23, Aggregate Materials.

END OF SECTION

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SPECIFICATION

FOR

SECTION 31 23 13

SUBGRADE PREPARATION

GROUNDWATER FIELD DEMONSTRATION (GWFD)

		JOB NO.	
		SPECIFICATION NO.	SPC-OSWDF-I300
		SHEET	1 of 5
	Name	**Signature**	**Date**
Originator	Ken Oliver, PE		1/17/2023
Checker	David Matlock, PE		1/17/2023
Additional Reviewer	Butch Parton, PE		
Project Engineer	Greg Pickerel, PE		

Revision History

Rev. No.	Reason For Revision	Date
A	Issued for 60% prelim review	1/15/2022
B	Issued for 60% backcheck review	5/04/2022
C	Issued for 90% review	1/17/2023

Form-362 (6/19) Rev. 2
PROC-DE-1007

SECTION 31 23 13
SUBGRADE PREPARATION

PART 1: GENERAL

1.01 DESCRIPTION

A. This section covers the requirements for subgrade preparation.

1.02 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 31 23 23, Fill Material and Placement.

B. Overexcavation of Unsuitable Materials: Materials identified by the Contractor's Engineer during proof-rolling or compaction efforts that require removal and replacement.

C. Prepared Subgrade: Ground surface after completion of clearing and grubbing, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

D. Proof-roll: Testing subgrade and fill material to identify soft areas by driving over an area with a loaded 34 cubic yard scraper > 80 tons gross weight, loaded tandem axle dump truck > 30 tons gross weight, or loaded articulated dump truck > 50 tons gross weight.

E. Relative Compaction: As defined in Section 31 23 23, Fill Material and Placement.

F. Subgrade for Embankment Fill and Select Earth Fill: Layer of prepared subgrade after completion of clearing, grubbing, excavation of unsuitable material prior to placement of embankment fill, select earth fill, or mineral aggregate base.

G. Subgrade for Cover System: Prepared subgrade for placement of cover system.

H. Undercutting: Excavation of soft areas of soil in the subgrade or fill. Soft areas identified by proof-rolling shall be undercut and replaced with rock fill or satisfactory material (as directed by the Geotechnical Engineer or Technician) placed and compacted with heavy equipment until the area has been stabilized.

1.03 REFERENCES

A. ASTM International (ASTM):

1. ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400ft-lbf/ft3)

2. ASTM D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

1.04 SUBMITTALS

A. The following documents shall be submitted to the Subcontract Technical Representative (STR) in accordance with the requirements of Exhibit I of the Subcontract.

1. Test and Inspection Reports:

a. Tests for moisture-density relation.

b. Density and moisture tests.

c. Inspection reports of proof-rolling (and undercutting and backfill if required).

d. Certification that backfill for undercut meets the specification.

e. Weekly letter reports by Geotechnical Engineer/Technician.

1.05 QUALITY CONTROL INSPECTION AND TESTING

A. The Subcontractor shall retain a licensed Testing Laboratory, Geotechnical Engineer, and Geotechnical Field Technician with qualifications and duties as listed in Specification 31 23 23, approved by the Subcontract Technical Representative (STR) to perform inspections and testing.

B. The Geotechnical Engineer/Technician shall be onsite to perform inspections of excavations, fill placement, and compaction testing throughout construction. The Geotechnical Engineer/Technician shall provide weekly letter reports of inspections and reports of all test results at the beginning of the following week.

1.06 SCHEDULING AND SEQUENCING

A. Complete applicable work specified in Section 31 11 00, Site Clearing and Grubbing, and Section 31 23 16, Excavation, prior to beginning subgrade preparation.

B. Prepare subgrade when unfrozen and free of ice and snow.

C. Notify Subcontract Technical Representative (STR) when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

PART 2: PRODUCTS

2.01 MATERIALS

A. The Subcontractor shall furnish all materials, tools, and equipment as required for performing subgrade preparation.

PART 3: EXECUTION

3.01 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper lines, grades and cross-sections, and then uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 SUBGRADE FOR EMBANKMENT FILL AND SELECT EARTH FILL

A. Under Embankment Fill: Compact subgrade using minimum of three passes with a vibratory sheepsfoot roller weighing a minimum of 10 tons to create a firm unyielding surface. Other compaction equipment, including heavy non-vibratory rollers, may be used for subgrade compaction under embankments, when approved by Contractor's Engineer.

B. Under Access Road: Scarify and compact the upper 6 inches to minimum of 95 percent relative compaction as determined in accordance with ASTM D698.

3.03 SUBGRADE FOR COVER SYSTEM

A. After completion of embankment fill or excavation to grades as shown on construction drawings, prepare the subgrade surface for the geomembrane lining system by scarifying and compacting the top 6 inches of excavation to 95 percent relative compaction as determined in accordance with ASTM D698. Moisture condition as necessary to achieve specified compaction. Leave subgrade smooth and without ruts.

3.04 SUBGRADE FOR DITCHES AND POND BOTTOMS

A. Subgrade shall meet requirements of embankment fill.

B. In areas where ditches will be lined, subgrade shall be rolled smooth for geomembrane liner placement.

3.05 MOISTURE CONDITIONING

A. Dry Subgrade: Scarify the surface, add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.06 TESTING

A. Under Embankment Fill and Pond Bottom: Perform proof-roll using loaded dump truck or similar heavy-wheeled vehicle to detect soft or loose subgrade or unsuitable material, as determined by Contractor's Engineer.

B. Under Access Road or Geomembrane Liner: Subcontractor shall provide an independent testing laboratory to conduct in-place density tests in accordance with ASTM D6938 at a minimum rate of one test per every 200 linear feet of prepared subgrade along the access road alignment.

3.07 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact, or

2. Overexcavate as specified in Section 31 23 16, Excavation, and replace with embankment fill or structural fill from the excavation, as specified in Section 31 23 23, Fill Material and Placement.

B. Overexcavation of Unsuitable Material: Overexcavate as specified within Section 31 23 16, Excavation, and replace with embankment fill or structural fill from the excavation, as specified in Section 31 23 23, Fill Material and Placement.

END OF SECTION

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SPECIFICATION

FOR

SECTION 32 05 21

GEOMEMBRANE AND ENGINEERED TURF COVER SYSTEM

GROUNDWATER FIELD DEMONSTRATION (GWFD)

		JOB NO.	
		SPECIFICATION NO.	SPC-OSWDF-I-309
		SHEET	1 of 23
	Name	**Signature**	**Date**
Originator	Ken Oliver, PE		1/17/2023
Checker	David Matlock, PE		1/17/2023
Additional Reviewer	Butch Parton, PE		
Project Engineer	Greg Pickerel, PE		

Revision History

Rev. No.	Reason For Revision	Date
A	Issued for 60% prelim review	1/15/2022
B	Issued for 60% backcheck review	5/04/2022
C	Issued for 90% review	1/17/2023

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SECTION 32 05 21
GEOMEMBRANE AND ENGINEERED TURF COVER SYSTEM

PART 1: GENERAL

1.01 DESCRIPTION

A. This section covers requirements to furnish and install pre-engineered geomembrane and engineered turf components for the cover system as indicated on the construction drawings.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):

a. ASTM D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

b. ASTM D882, Standard Test Method for Tensile Properties of Thin Plastic Sheeting.

c. ASTM D1004, Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting.

d. ASTM D1238, Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer.

e. ASTM D1505, Standard Test Method for Density of Plastics by the Density-Gradient Technique.

f. ASTM D2240, Standard Test Method for Rubber Property-Durometer Harness.

g. ASTM D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

h. ASTM D5199, Standard Test Method for Measuring Nominal Thickness of Geosynthetics.

i. ASTM D5321, Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

j. ASTM D5641, Standard Practice for Geomembrane Seal Evaluation by Vacuum Chamber.

k. ASTM D5994, Standard Test Method for Measuring Core Thickness of Textured Geomembrane.

l. ASTM D6392, Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

m. ASTM D6693, Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.

2. Geosynthetics Research Institute (GRI):

a. GM10, Specification for the Stress Crack Resistance of Geomembrane Sheet.

b. GM13, Standard Specification for Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.

c. GM19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

1.03 DEFINITIONS

A. Boot: Watertight collar fabricated from geomembrane sheet for sealing geomembrane to pipes and other objects that penetrate geomembrane.

B. Film Tearing Bond: Failure in ductile mode of one bonded sheet, by testing, prior to complete separation of bonded area.

C. Engineered Turf: Synthetic turf comprised of polyethylene fibers tufted through a double layer of woven polypropylene geotextile backing.

D. Geomembrane: Essentially impermeable geosynthetic composed of one or more layers of polyolefin materials fusion bonded into single-ply integral sheet.

E. Panel: Piece of geomembrane composed of two or more sheets seamed together.

F. Sheet: Seamless piece of geomembrane.

G. Watertight: Geomembrane installation free of flaws and defects that will allow passage of water and gases, liquids, and solids to be contained under anticipated service conditions.

1.04 SUBMITTALS

A. The following documents shall be submitted to the Subcontract Technical Representative (STR) in accordance with the requirements of Exhibit I of the Subcontract.

1. Pre-Construction Quality Submittals

a. Qualifications for:

1) Geomembrane Manufacturer

2) Geomembrane Installer

3) Geomembrane Independent Testing Agency

b. Qualifications for:

1) Engineered Turf Manufacturer

2) Engineered Turf Installer

3) Independent Testing Agency for Engineered Turf

c. Quality Assurance Program for Geomembrane: Written description of geomembrane Manufacturer's and Installer's formal programs for manufacturing, fabricating, handling, installing, seaming, testing, and repairing geomembrane.

d. Quality Assurance Program for Engineered Turf: Written description of engineered turf Manufacturer's and Installer's formal programs for manufacturing, fabricating, handling, installing, seaming, testing, and repairing engineered turf.

e. Product samples of the geomembrane and engineered turf components.

2. Other Pre-Construction Submittals:

a. Manufacturer's specifications, literature, certificate of compliance for each Geomembrane that is furnished. Include incidental materials and products used to assist and complete installation.

b. Manufacturer's specifications, literature, certificate of compliance for each Engineered Turf that is furnished. Include incidental materials and products used to assist and complete installation.

c. Geomembrane:

1) Compensation allowance calculation and numerical values for temperature-induced geomembrane expansion and contraction.

2) Polymer Resin: Product identification and Supplier.

3) Production dates and factory quality test results.

4) Proposed equipment for material placement.

5) Geomembrane sheet layout with proposed sizes, numbers, position, and sequence of sheet placement, and proposed location of field seams.

6) Factory QC test results for supplied Geomembrane.

7) Certified factory seam test results for Geomembrane.

d. Engineered Turf:

1) Production dates and factory quality test results.

2) Proposed equipment for material placement.

3) Engineered Turf sheet layout with proposed sizes, numbers, position, and sequence of sheet placement, and proposed location of field seams.

4) Factory QC test results for supplied Engineered Turf.

3. Inspections and Test Reports:

a. Documented meeting minutes and procedures agreed upon from project coordination meetings and installation demonstrations.

b. Daily field inspection notes and checklists.

c. Certified field seam test results.

4. Closeout Submittals

a. Special guarantee requirements listed in paragraph 1.08.

b. Geomembrane Installer's Certification of Subsurface Acceptability: Form attached at end of this section.

c. Geomembrane Manufacturer's Certificate of Proper Installation.

d. Geomembrane Record Documents: Include panel and sheet numbers, seaming equipment and operator identification, temperature and speed setting of equipment, date seamed, identify and location of each repair, cap strip, penetration, boot and sample taken from installed Geomembrane for testing.

e. Engineered Turf Record Documents: Include panel and sheet numbers, seam locations, date seamed, identify and location of each repair, cap strip, penetration, and sample taken from installed Engineered Turf for testing.

1.05 QUALIFICATIONS

A. Independent Testing Agency: 5 years' experience in field of geomembrane testing. Laboratory must be certified by an independent agency or organization such as the Geosynthetic Accreditation Institute—Laboratory Accreditation Program for the specified testing and shall maintain calibrated instruments, equipment, and documented standard procedures for performing specified testing.

B. Manufacturer: Successfully manufactured a minimum of 10 million square feet of each type of geomembrane material specified.

C. Installer: Successfully installed a minimum of 10 million square feet of each type of geomembrane product specified in applications similar to the Project.

D. Minimum qualifications stated above will be deemed met if the firm or cumulative experience of key personnel (supervisors and trained installation/testing technicians) proposed for this Project has minimum experience specified. If key personnel provision is used to qualify the firm, submit letter stating key personnel meet the minimum experience requirements and those individuals are available for and will be committed to this Project.

1.06 COORDINATION MEETINGS

A. Meet at least once prior to commencing each of the following activities:
   1. Preconstruction and submittals.
   2. Fabrication of panels and boots.
   3. Installation of Geomembrane.
   4. Installation of Engineered Turf.

B. Attendees:
   1. Subcontractor-designated quality control representative.
   2. Subcontract Technical Representative.
   3. Contractor's Engineer.
   4. Representatives of geomembrane installer.
   5. Others requested by Contractor's Engineer.

C. Topics:
   1. Construction drawings and construction specifications.
   2. Submittal requirements and procedures.
   3. Schedule for beginning and completing geomembrane installation.
   4. Training for installation personnel.
   5. Installation crew size.
   6. Establishing geomembrane marking system, to include sheet identification, defects, and satisfactory repairs, to be used throughout Work.
   7. Quality assurance.

1.07 INSTALLATION DEMONSTRATIONS

A. Seam Installation and Testing Demonstration: Performed by geosynthetic installer, for each type of seam required, a minimum of 3 days prior to placement of product.

B. Attendees: As required for Coordination Meetings.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Geomembrane and Artificial Turf:

1. Individually package each sheet and protect from damage during shipment.
2. Mark each package with identification of material type, size, and weight.
3. Dragging panels on ground surface is not permitted.
4. Do not fold geomembrane component material.
5. Store rolls on a clean, dry surface or on dunnage.

1.09 ENVIRONMENTAL REQUIREMENTS

A. Do not install geomembrane, artificial turf, or perform seaming under the following conditions, unless it can be demonstrated to satisfaction of Contractor's Engineer that performance requirements can be met under these conditions:

1. Air temperature is less than 35 degrees F or more than 90 degrees F.
2. Relative humidity is more than 90 percent.
3. Raining, snowing, frost is in ground, or wind is excessive.

B. Do not place granular materials on geomembrane or artificial turf when ambient temperature is less than 35 degrees F, unless it can be demonstrated to satisfaction of Contractor's Engineer that materials can be placed without damage.

1.10 SEQUENCING AND SCHEDULING

A. Before placing geomembrane on soil surfaces, prepare subgrade as specified in Section 31 23 13, Subgrade Preparation, and Section 31 23 23, Fill Material and Placement.

1.11 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with the Owner (U.S. Department of Energy) named as the beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of the Owner, removal and replacement of Work specified in this specification section that is found defective during the periods below, commencing on date of Substantial Completion.

1. Guarantee the geomembrane against manufacturing defects, deterioration as a result of ozone, ultraviolet, and other exposure to elements for period of 20 years on pro rata basis.
2. Guarantee the geomembrane against defects in material and factory seams for period of 2 years.
3. Guarantee the geomembrane against defects resulting from installation for period of 2 years.

PART 2: PRODUCTS

2.01 MATERIALS

A. The Subcontractor shall furnish all materials, tools, and equipment as required to deliver, install, and protect Geomembranes and Engineered Turf Cover Systems on the project site.

2.02 ACCEPTABLE MANUFACTURERS

A. Geomembrane: AGRU America, Georgetown, SC.

Or manufacturer of equivalent ability, that is approved by the Contractor.

B. Engineered Turf: WatershedGeo, Alpharetta, GA.

Or manufacturer of equivalent ability, that is approved by the Contractor.

2.03 GEOMEMBRANE

A. Product: 50 mil Super Gripnet® textured HDPE geomembrane.

Or an equivalent product, that is approved by Contractor Engineering.

B. Composition:

1. High Density polyethylene (HDPE) containing no plasticizers, fillers, extenders, reclaimed polymers, or chemical additives, except following:
   a. Approximately 2 percent by weight of carbon black to resin for ultraviolet resistance.
   b. Antioxidants and heat stabilizers, not to exceed 1.5 percent total by weight, may be added as required for manufacturing.

C. Furnish in rolled single-ply continuous sheets with no factory seams.

D. Sheet Thickness: Specified nominal thickness is 50 mil. Minimum values determined in accordance with ASTM D5199 and shall not include ridges of textured geomembrane.

E. Sheet Width: Minimum 22 feet.

F. Roll Length: Longest that will be manageable and reduce field seams.

G. Textured HDPE Geomembrane: Manufactured so that surface irregularities that produce specified friction are adequately fused into sheet or are extruded with sheet, on both sides of sheet. Texture is to be in addition to base thickness specified for sheet.

H. Meet manufacturer's most recent specifications and required minimum textured HDPE geomembrane values in Table 1.

Table 1
Textured HDPE Geomembrane Properties

Property	Requirement (MARV)	Test Method
Thickness (min. avg.)	47.5 mil	ASTM D5199, Modified Note 1, or ASTM D5994
Asperity Height (min, avg) 1. Drainage Stud 2. Friction Spike	 130 175	ASTM D7466
Density	0.94 g/cc	ASTM D792, Method B
Tensile Properties (avg. both directions) 1. Tensile Stress @ Break 2. Tensile Stress @ Yield 3. Elongation @ Break 4. Elongation @ Yield	 110 lb./in width 110 lb./in width 200% 12%	ASTM D6693, Type IV
Puncture Resistance	80 lb.	ASTM D4833
Tear Resistance	38 lb.	ASTM D1004, Die C
Carbon Black Content (%)	2 to 3	ASTM D4218
Oven Aging at 200°C Standard OIT (min. ave.) - % retained after 90 days	 140	ASTM 3895
Environmental Stress Crack Resistance	500 hours	ASTM D5397 Single Point NCTL Test

Note 1: Commercially available micrometers may be used that have a 60-degree taper to a point with a radius of 1/32 inch. Subcontractor shall make enough measurements of thinner areas of textured sheet to develop statistical basis for thickness.

I. Geomembrane shall meet the following manufacturer quality control (MQC) requirements:

1. Geomembrane manufacturer shall continuously monitor geomembrane during manufacturing process for inclusions, bubbles, or other defects. Geomembrane that exhibits any defects will not be accepted.
2. Geomembrane manufacturer shall continuously monitor geomembrane thickness during manufacturing process. Geomembrane that fails to meet specified minimum thickness will not be accepted.
3. Geomembrane manufacturer shall sample and test geomembrane in accordance with values specified in Table 1 (manufacturer's specification for 50-mil Super Gripnet geomembrane).

4. Samples of geomembrane shall be taken across the entire width of roll.

2.04 ENGINEERED TURF COMPONENT

A. Product: ClosureTurf®.

Or an equivalent product, that is approved by Contractor Engineering.

B. A synthetic structured material consisting of one or more geotextiles tufted with polyethylene yarns that resemble grass blades.

C. Sheet Width: Minimum 14 feet.

D. Roll Length: Longest that will be manageable and reduce field seams.

E. Yarn Color: Green.

F. Meet the manufacturer's most recent published specifications and required values in Table 2.

Table 2
Engineered Turf Properties

Property	Requirement (MARV)	Test Method
Total Product Weight (minimum)	20 oz/sq. yd.	ASTM D5261
CBR Puncture	1500 lb.	ASTM D6241
Tensile Strength of Product	1,600 lb./ft	ASTM D4595
Tensile Strength of Yarn	15 lb.	ASTM D2256
Interface Friction Between Engineered Turf and Textured Geomembrane (min. Peak)	35°	ASTM D5321
UV Stability (retained strength at 100 years projected)	>60%	ASTM G147

2.05 GEOMEMBRANE EXTRUDATE

A. Extrudate shall be made from the same resin as the geomembrane.

B. Additives shall be thoroughly dispersed in the extrudate.

C. Additives shall be free of contamination by moisture or foreign matter.

2.06 GEOMEMBRANE FIELD SEAMS

A. Approved processes for seaming are extrusion welding and fusion welding.

B. Only apparatus which has been specifically approved by make and model shall be used.

C. Proposed alternate processes shall be documented and submitted for approval.

D. Passing criteria for geomembrane seams are established by GM-19 and shall meet the required values in Table 3.

Table 3
HDPE Geomembrane (Textured) Minimum Seam Properties

Property	Unit	Specified Value	Test Method
Shear Strength	lbs/inch width	100 at FTB	ASTM D6392
Shear Elongation at Break	%	50 at FTB	ASTM D6392
Peel Strength, Fusion Weld	lbs/inch width	75 at FTB	ASTM D6392
Peel Strength, Extrusion Weld	lbs/inch width	60 at FTB	ASTM D6392
Peel Separation	%	25	ASTM D6392
Note: Film Tear Bond (FTB) is defined as failure of one of the sheets by tearing, instead of separating from the other sheet at the weld interface area (such as, sheet fails before the weld fails).			

E. Passing criteria for artificial turf are established by manufacturer installation guidelines and must comply with visual passing criteria. Visual passing criteria shall be established at the preconstruction seam and testing demonstration.

2.07 BOOTS

A. Fabricated of same material as geomembrane sheets to fit around penetrations, without folds, stretching, or unsupported areas.

B. Flanges:

1. Angle: Match slope or bottom where penetration passes through liner.

2. Width: Minimum 2 feet, plus dimension of penetration.

2.08 SEALANT CAULKING

A. Two-component sealant formulated of 100 percent polyurethane elastomer, such as Elastuff 120 Mastic as supplied by United Paint and Coatings, Greenacre, WA. Or an equivalent product, that is approved by Contractor Engineering.

B. Butyl rubber sealant such as Butylgrip Sealant, supplied by the Biddle Company, St. Louis, MO. Or an equivalent product, that is approved by Contractor Engineering.

2.09 STAINLESS STEEL BANDS

A. As manufactured by Breeze Clamp Products, Saltsburg, PA.
Or an equivalent product, that is approved by Contractor Engineering.

2.010 ALUMINUM CLAMP MATERIAL

A. In accordance with ASTM B211, Alloy 5052, Temper H32.

1. Strips: 2 inches wide by 1/4-inch-thick.
2. Channel: 2 inches wide by 1/8-inch-thick.

2.011 NEOPRENE RUBBER PAD

A. Compression Strip Beneath Battens:

1. 2 inches wide by 1/4-inch-thick.
2. 35 durometer to 45 durometer, in accordance with ASTM D2240 hardness.

B. Contact Cement: As recommended by neoprene rubber pad manufacturer.

C. Manufacturer: Aero Rubber Co., Inc., Bridgeview, IL.

2.012 PROTECTIVE FOAM

A. Medium to high-density rigid board.

B. Manufacturers and Products:

1. General Plastics Manufacturing Corp, Tacoma, WA; Polyurethane Last-a-Foam.
2. Dow Chemical Corp., Midland, MI; Polyethylene Ethafoam.
3. Or an equivalent product, that is approved by Contractor Engineering.

2.013 GEOMEMBRANE MANUFACTURER'S CONFORMANCE TESTING

A. Resin Quality Documentation:

1. Prior to geomembrane and engineered turf component delivery and installation, manufacturer shall provide Subcontract Technical Representative (STR) with the following information:

a. Origin (resin supplier's name, resin production plant), (identification brand name, number), and production date of resin.

b. Copy of quality control certificates issued by resin supplier noting results of density and melt index.

c. Reports on tests conducted by manufacturer to verify quality of the resin used to manufacture the geomembrane rolls assigned to the project facility (these tests should include specific gravity (ASTM D792 Method A or ASTM D1505) and melt index (ASTM D1238 Condition 190/2.16).

d. Reports on the tests conducted by the manufacturer to certify the quality of the sheet.

B. Property Conformance Documentation:

1. Prior to liner delivery and installation, manufacturer shall provide Contractor with the following:

a. Properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the specification or equivalent.

b. Contractor's Engineer will verify that:

1) Property values certified by the geosynthetic manufacturer meet all of the requirements in these specifications.

2) Measurements of properties by geosynthetic manufacturer are properly documented and the test methods used are acceptable.

C. Geosynthetic Roll Documentations: Prior to shipment, manufacturer shall provide Subcontract Technical Representative (STR) with one quality control certificate for every roll of geosynthetic provided. Quality control certificate shall be signed by manufacturer's responsible party. Quality control certificate shall include at a minimum:

1. Roll numbers and identification.

2. Results of quality control tests. As a minimum, ASTM test methods shall be used to test for thickness, tensile strength, and tear resistance.

PART 3: EXECUTION

3.01 PREPARATION

A. Geomembrane Inspection: During unwrapping visually inspect and mark each imperfection for repair.

B. Do not place geomembrane until condition of subgrade or geosynthetics installed is acceptable to Contractor's Engineer.

C. Subgrade: Maintain in smooth, uniform, and compacted condition as specified in Section 31 23 13, Subgrade Preparation, during installation of geomembrane.

3.02 WELDING UNITS

A. Double hot-wedge fusion seam welding.

B. Extrusion welding systems.

C. Hot-air welding is not acceptable.

3.03 TENSIOMETER FOR FIELD TESTING

A. Motor-driven with jaws capable of traveling at measured rate of 20 inches per minute.

B. Equipped with gauge which measures force in unit pounds exerted between jaws.

C. As recommended by HDPE geomembrane manufacturer.

D. The field tensiometer must have a valid calibration for the provided model and serial number. The certificate must include the next calibration due date.

3.04 GEOMEMBRANE AND ENGINEERED TURF INSTALLATION

A. Prepare geomembrane liner subgrade as specified in Section 31 23 23, Fill Material and Placement.

B. Do not install geomembrane or engineered turf or seam unless Subcontractor can demonstrate successful performance and test results showing seams meet strength specifications. No seaming shall take place unless environmental requirements are satisfied in accordance with paragraph 1.09.

C. Install the geomembrane and engineered turf cover system in areas shown on Drawings. No geomembrane or engineered turf material shall be seamed unless environmental conditions are as specified in paragraph 1.09, unless the Subcontractor can demonstrate to the Contractor's Engineer's satisfaction that installation techniques compensate for these conditions.

D. Install the geomembrane and engineered turf cover system in accordance with the approved Shop Drawings. Any deviations must be documented in writing and approved by the Contractor prior to field installation.

E. Sheets of geomembrane and engineered turf shall be of such lengths and widths and shall be placed in such a manner as to reduce field seaming to a minimum.

Sheets shall be placed parallel to slopes to minimize horizontal seams. Seams parallel to any toe of slope shall be at least 5 feet from the toe.

F. Factors such as expansion, contraction, overlap at seams, anchorage requirements, seaming progress, and drainage shall be considered. Textured-surface sheets shall be aligned in a manner which maximizes their frictional capabilities along the slope. Maneuver sheets of geomembrane and engineered turf into place in a manner which prevents wrinkles, folds, or similar distress which can damage the geomembrane or prevent its satisfactory alignment or seaming.

G. Sandbags shall be used as necessary to temporarily anchor or hold the geomembrane and engineered turf in position during installation. Sandbag fabric shall be sufficiently close knit to preclude fines from working through the bags. Tires and paper bags, whether or not lined with plastic, shall not be used. Burlap bags, if used, shall be lined with plastic. Bags shall be securely closed after filling to prevent sand loss. Bags that are split, torn, or otherwise losing their contents shall be immediately removed from the work area and any spills immediately cleaned up.

H. Anchor the perimeter of the geomembrane and engineered turf as shown on Drawings, or as otherwise approved in writing by the Contractor. Protect the geomembrane and artificial turf from equipment and other hazards and keep it clean and free of all debris during placement. Protect the geomembrane and artificial turf from uplift by wind and other damage prior to seaming, anchoring, or attachment of the edges of the geomembrane.

I. Anchor and seal the geomembrane to structures, pipes, and other types of penetrations in accordance with details shown on Drawings.

J. Take extreme care during installation of the geomembrane and engineered turf to be certain no damage is done to any part of the liner system. Prohibit smoking at the Site by installation personnel. Handling and installation procedures shall be performed by workers wearing smooth-soled footwear. No vehicular traffic shall be allowed on the geomembrane surface. Motor-driven equipment using fuel shall have spark arresters. No gasoline-driven generators or cans of flammable liquid shall be placed on the lining. Under no circumstances shall the geomembrane surface be used as a work area, for preparing patches, storing tools and supplies, or other uses. If needed, a protective cover shall be spread out as a work surface, to prevent damage to the cover system.

K. Compensation allowance for temperature induced expansion and contraction of geomembrane must be submitted to the Contractor's Engineer prior to placement of operations layer over the geomembrane, as specified herein.

3.05 FIELD SEAMS

A. General:

1. Seam coding system shall be compatible with panel coding system.

2. Seams shall be oriented parallel to the line of maximum slope, for example, oriented up and down, not across, the slope to the maximum extent practical. In corners and odd-shaped geometric locations, the number of seams shall be minimized.

B. Geomembrane:

1. Use lap joints to seal geomembrane sheets together in the field. Field seams shall be made on a supporting smooth surface. Form the seams by lapping the edges of sheets a minimum of 4 inches. Wipe contact surfaces of the sheets clean to remove dirt, dust, moisture, and other foreign materials and prepare in accordance with the installer's seaming method approved by the Contractor's Engineer. Avoid seam intersections involving more than three thicknesses of geomembrane material. Offset seam intersections at least 2 feet. Extend the seams to the ends of the geomembrane sheets through the anchor trench, boots, and mechanical attachments.

2. For seams where extrusion welds are used and where it will be impracticable to perform a vacuum test, insert copper wire for spark test, prior to welding. Position to within 1/8 inch of sheet edge.

3. Seams shall not go through a boot. Locate seams a minimum of 2 feet from boot.

4. Seam the geomembrane sheets together, using the extrusion and/or doublehot-wedge fusion system, equipment, and techniques.

5. Fishmouths or wrinkles at seam overlaps shall be cut to achieve a flat overlap.

6. The cut fishmouths or wrinkles shall be extrusion welded or patched where the overlap is more than 3 inches.

7. When capping of a field seam is required, use a cover strip cap of the same thickness as the geomembrane (and from the same roll, if available) and of 8-inch minimum width. Position the cap strip over the center of the field seam and weld to the geomembrane using a fillet weld each side, including a copper wire as described above for spark testing.

8. Prior to starting the production welding, trial welds must be performed and tested.

9. Trial Weld Testing:

   a. Five 1-inch-wide test strips shall be cut from the trial weld.

   b. Each of the specimens shall be tested in the field for peel and shear using a digital tension meter. Four out of five specimens must meet the minimum requirements for field seam acceptance. The test results shall be verbally reported to the Subcontract Technical Representative

(STR) within 1 hour of testing. The results shall be provided in writing to the Subcontract Technical Representative (STR) within 24 hours of testing.

c. Remaining sample shall be retained for future testing.

d. A trial weld specimen will pass when the results are achieved for both peel and shear tests as specified herein. For double-wedge welding, both welds shall be individually tested and both shall be required to pass in peel.

e. Seaming apparatus or seamer shall not be accepted and shall not be used for seaming until deficiencies are corrected and consecutive full trial seams are achieved.

C. Engineered Turf:

1. Fusion seams require a minimum of 5 inches of overlap.

2. Cut off or remove frayed or loose geotextile strands.

3. Prior to starting the production fusion seaming, perform trial seams.

4. Demonstrate the preparation methods and equipment utilized for removal of the selvage from the outside edge of the rolls of turf (trimming and cutting devices).

5. Mechanical or hot knife trimming and cutting devices will be utilized for selvage trimming.

6. Demonstrate and control the fraying of geotextile strands when performing the removal of selvage.

7. Any damage that occurs due to production seaming will be repaired.

D. Trial Welds and Seams:

1. Trial welds and seams shall be performed on geomembrane and engineered turf samples to verify welding/seaming equipment operations and performance of seaming methods and conditions.

2. Minimum of one trial seam per day or shift per welding/seaming apparatus and operator shall be made, one made prior to the start of work and one completed at mid shift. Results shall be submitted to the Subcontract Technical Representative (STR) at the end of each day.

3. Welds and seams shall be made under the same surface and environmental conditions as the production welds and seams (such as, in contact with geomembrane subsurface and similar ambient temperature).

3.06 PLACING PRODUCTS OVER GEOSYNTHETICS

A. Sand Infill is specified in Section 31 23 23, Fill Material and Placement.

B. Engineered turf shall be placed over the completed portions of the geomembrane cover within 10 work days of geomembrane installation.

C. Do not place engineered turf in a manner that will cause wrinkles to fold over or be confined to form a vertical ridge. Maximum wrinkle height shall be 2 inches and a minimum wrinkle spacing shall be 10 feet prior to placement of operations layer over geomembrane.

3.07 REPAIRING GEOSYNTHETICS

A. Geosynthetics shall be examined for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

B. Geosynthetic surface shall be clean at the time of the examination.

C. Each suspect location shall be repaired and non-destructively tested.

D. Subcontractor shall be responsible for repair of damaged or effective areas. One of the procedures listed below shall be recommended by the Subcontractor and approved by the Contractor's Engineer:

1. Patching: Used to repair large holes (over 3/8-inch diameter), tears (over 2 inches long), undispersed raw materials, and contamination by foreign matter.

2. Abrading and Rewelding: Used to repair small seam sections (less than 12 inches long).

3. Spot Welding: Used to repair small tears (less than 2 inches long), pinholes, or other minor, localized flaws.

4. Capping: Used to repair large lengths of failed seams.

5. Removing unsatisfactory material and replacing with new material.

E. Geosynthetic surfaces to be repaired shall be abraded (extrusion welds only) no more than 1 hour prior to the repair.

1. Patches or caps shall extend at least 6 inches beyond the edge of the defect, and all corners of material to be patched and the patches shall be rounded to a radius of at least 4 inches.

2. Geomembrane below large caps shall be cut to avoid water or gas collection between the two sheets.

F. Prepare contact surfaces and seam patch in accordance with paragraph 3.05.

1. Pull and hold flat receiving surface in area to be patched.

2. Seal each patch by extrusion welding continuous bead along edge, with no free edge remaining. Vacuum box test each patch on completion.

3.08 FIELD QUALITY CONTROL

A. Conformance Testing:

1. Prior to deployment of the geosynthetics, the Subcontractor shall collect samples and perform conformance testing to document conformance to the properties listed in Table 1. The Subcontractor shall submit test results to the Subcontract Technical Representative (STR). The Subcontractor shall submit them to a qualified laboratory of their choice for testing. Samples shall be collected at the project site. Unless otherwise specified, samples shall be taken at a rate of one per lot or one per 100,000 square feet, whichever results in the greater number of tests.

2. Samples shall be taken from any portion of the roll that has not been damaged. Unless otherwise specified, samples shall be 2 feet long by the roll width. Samples may be cut to a minimum size of 2 feet by 1 foot. The pieces of a sample shall be labeled in a manner to correctly identify the location of the piece within the sample. Machine direction shall be marked on each sample piece with an arrow.

3. Collection of the sample shall be performed under the observation of the Contractor's Engineer or designated representative.

B. Nondestructive Field Testing: Nondestructively test all field seams over their full length using an air pressure test or other approved methods. Only use a vacuum box when air pressure testing cannot be performed. Nondestructive testing shall be carried out as the seaming progresses and not at completion of all seaming. Results shall be provided in writing to the Subcontract Technical Representative (STR) by the end of each testing day.

1. Vacuum testing shall conform to the following requirements:

a. Equipment shall consist of two vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, a soapy solution and an applicator.

b. Testing shall conform to the following procedure: Brush soapy solution on geomembrane (approximately 12-inch by 36-inch). Place vacuum box over the wetted seam area. Close bleed valve and open vacuum valve and ensure that a leak-tight seal is created. Apply a vacuum of approximately 5 psi. Examine the geomembrane through the viewing window for the presence of

soap bubbles for not less than 15 seconds. All areas where soap bubbles appear shall be marked and repaired as described in this section. If no bubble(s) appear after 15 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum 3 inches overlap, and repeat process.

2. Air Pressure Testing:

   a. Equipment shall consist of an air pump (manual or motor driven) equipped with a pressure gauge capable of generating and sustaining pressure over 30 psi and mounted on a cushion to protect the geomembrane, a rubber hose with fittings and connections, a sharp hollow needle, or other approved pressure feed device, and a gauge with an accuracy of 1 psi.

   b. Testing shall conform GRI GM6 and the following procedure: Seal both ends of the seam to be tested. Insert needle or other approved pressure-feed device into the channel created by the double-wedge weld. Energize the air pump to a minimum pressure of 30 psi, close the valve, and sustain the pressure for at least 5 minutes. If pressure loss exceeds 4 psi or does not stabilize, locate faulty area and repair as described in this section. Puncture opposite end of the seam to release air. If blockage is present, locate and test seam on both sides of blockage. Remove needle or other approved pressure-feed device and seal penetration holes by extrusion welding.

3. Destructive Field Test Sampling:

   a. The Subcontractor shall collect destructive test samples at a minimum frequency of one test per 500 feet of seam length for geomembrane and engineered turf components. The Contractor's Engineer reserves the right to adjust this testing requirement if other seam tests appear adequate for assuring seam quality. Test locations shall be determined during seaming. Locations may be prompted by appearance of excess heating, contamination, offset welds, or suspected defect. The Contractor's Engineer may choose the locations. The Contractor's Engineer will not notify the Subcontractor in advance of selecting locations where seam samples will be taken.

   b. The Subcontractor shall cut samples at locations designated by the Contractor's Engineer as the seaming progresses to obtain laboratory test results before the geomembrane is covered. The Subcontractor shall number each sample and mark the sample number and location on the panel layout drawing.

c. The Subcontractor shall immediately repair all holes in the geosynthetics resulting from destructive sampling. The continuity of the repair shall be vacuum tested in accordance with this section.

d. The destruction sample shall be 18 inches wide by 36 inches long with the seam centered lengthwise. The sample shall be cut into three equal parts for distribution to the Subcontractor for field-testing, the Geomembrane Testing Laboratory for analytical testing, and the Contractor for archiving. The Subcontractor shall test the piece that he retains for peel and shear in the field in accordance with Table 2 using a digital tensiometer. This shall be performed under the observation of the Contractor's Engineer or designated representative. The results of the field tests shall be provided in writing by Subcontractor to the Subcontract Technical Representative (STR) within 24 hours of testing.

C. Destructive Test Sample Testing:

1. The Subcontractor will submit the destructive test samples for laboratory testing. The Subcontractor will select and retain the geomembrane testing laboratory.

2. Samples shall be tested in peel and shear (ASTM 6392). Minimum acceptable stress to be obtained for these tests shall be as listed in Table 2.

3. All tests shall exhibit a Film Tearing Bond type of separation in which the geomembrane material tears before the weld.

4. At least five coupons shall be tested by each test method.

5. Four of the five coupons shall meet the minimum requirements stated herein.

6. The Subcontractor shall submit test results to the Subcontract Technical Representative (STR) within 48 hours of receipt of the samples by the geomembrane testing laboratory.

D. Destructive Test Failure:

1. One of two options shall be followed:

a. Option 1: Reconstruct the seam between any two passed test locations.

b. Option 2: Trace the weld to an intermediate location at least 10 feet minimum or to where the seam ends, in both directions from the location of the failed test. Check the next seam welded using the

same welding device if required to obtain additional sample (such as, if one side of the seam is less than 10 feet long). Bounding laboratory samples shall be taken, and destructive testing shall be performed per this section. If the bounding samples pass, then the seam shall be reconstructed between the test sample locations. If any additional samples fail, then the process shall be repeated to establish the zone in which the seam shall be reconstructed.

2. Reconstruction methods shall include cap stripping of seam, or replacing seam with a new 1-foot wide panel and welding in place.

E. Acceptable seams shall be bounded by two locations from which samples have passed destructive tests. For reconstructed seams exceeding 50 feet, a sample taken from within the reconstructed seam shall also pass destructive testing. Whenever a sample fails, additional testing may be required for seams that were welded by the same welder and welding apparatus or were welded during the same shift.

3.09 CLEANUP

A. Clean up the work area as the installation work proceeds. Take particular care to ensure that no trash, tools, and other unwanted materials are trapped beneath geomembrane and that scraps of geosynthetics material are removed from the work area prior to completion of installation.

3.10 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification.

1. Geomembrane Installer’s Certification of Subsurface Acceptability.

END OF SECTION

GEOMEMBRANE INSTALLER'S CERTIFICATION
OF
SUBSURFACE ACCEPTABILITY

Geomembrane installer, _____

for On-site Waste Disposal Facility Groundwater Field Demonstration hereby certifies that supporting surfaces are acceptable for installation of geomembrane, undersigned having personally inspected condition of constructed and prepared surfaces. This certification is for areas defined as follows:

_____

_____

_____

_____

_____

_____

_____

_____

Condition of supporting surfaces in defined area meets or exceeds minimum requirements for installation of geomembrane.

Signed: _____

(Representative of Geomembrane Installer)

_____

(Position)

Date: _____

Witness: _____

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