Department of Energy
Oak Ridge Office of Environmental Management
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PROGRAM	SITE	PROJECT #	FILE SEQUENCE

ROUTE TO: JBS

December 9, 2019

DEC 10 2019
9:30 a.m

CERTIFIED MAIL

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Superfund and Emergency Management Division
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Mr. Randy C. Young
State of Tennessee
Department of Environment and Conservation
Division of Remediation – Oak Ridge
761 Emory Valley Road
Oak Ridge, Tennessee 37830-7072

Dear Ms. Jones and Mr. Young:

RESPONSE TO TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION COMMENTS RECEIVED AUGUST 27, 2019 ON *TECHNICAL MEMORANDUM #2, ENVIRONMENTAL MANAGEMENT DISPOSAL FACILITY PHASE 1 MONITORING OAK RIDGE, TENNESSEE* (DOE/OR/01-2819&D1)

This letter provides a summary of U.S. Department of Energy (DOE) responses to comments on the subject document provided by the Tennessee Department of Environment and Conservation (TDEC), as well as detailed responses to each comment in the enclosure.

The Phase 1 site investigation (documented in Technical Memorandum #1 [TM-1] and TM-2) consisted of completing the scope of work the U.S. Environmental Protection Agency and TDEC required as part of the dispute resolution process for the Environmental Management Disposal Facility (EMDF) Remedial Investigation/Feasibility Study (RI/FS). All goals of the investigation were met and there were no unexpected conditions encountered. Therefore, data collection activities for this effort are considered complete. The Phase 1 characterization contributed to overall understanding of the hydrogeologic setting of the Central Bear Creek Valley (CBCV) site and determined key assumptions made during the EMDF RI/FS and Proposed Plan regarding the hydrogeologic setting were valid.

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(JONES 7017 2620 0000 6500 7656)
(YOUNG 7017 2620 0000 6500 7649)

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TM-2 contains the full year of groundwater and surface water data, including the monitoring data previously reported in TM-1. These data are in general agreement with the expected site conditions. Data measurements are provided in the Oak Ridge Environmental Information System database, where they are accessible to the public. TM documents are secondary Federal Facility Agreement documents to which revisions based on regulator comments are not required. However, comments previously submitted on TM-1 were addressed in TM-2. Comments on TM-2 are anticipated to be addressed in the Remedial Design Report/Remedial Action Work Plan.

Phase 1 Investigation Scope: While some design information is included in TM-2, such as the preliminary waste cell outline, the purpose of the document was to provide the full year of monitoring data. As part of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 process, the Phase 1 data are being used to develop the design and evaluate protectiveness to evaluate applicable or relevant and appropriate requirement compliance. DOE will use all available information in the Record of Decision to justify any needed applicable or relevant and appropriate requirement waivers. This information will also be utilized to complete the design and ensure the design requirements are met.

Tracer studies were not included in the Phase 1 scope and are not necessary to provide the required information. Of note, several of the older tracer studies referenced in the TDEC comments cannot be considered valid tracer tests by today's standards, either from use of uranium in nitric acid as a tracer or from differences in geologic setting, serious infiltration issues, and/or the method of tracer introduction.

Groundwater Characteristics and Flow Direction: The predominantly shale-rich members of the Conasauga Group at the CBCV site do not demonstrate karst features and do not readily conduct groundwater. Thin limestone beds are frequent but are interbedded with shales. Hydraulic conductivity testing performed at the CBCV site demonstrate low groundwater flow rates.

Many hydrogeology-related comments are consistent with the TM-2 interpretation that groundwater flow is greater in the shallow zones (more fractured rock) and occurs in the direction of the hydraulic gradient and also towards the nearby tributaries (along strike).

No water supply wells are present in the CBCV area. While domestic wells are possible, as noted in TDEC reference 11 (DeBuchanne, G.D., Richardson, R.M., 1956, *Ground-water resources of East Tennessee,* Tennessee Division of Geology Bulletin 58, Part I), "Ground water in the Conasauga shale is restricted to small fractures. The shale has been so deformed by folding that the fractures form an interconnected network." The reference also describes dug wells in topographic lows usually encounter groundwater within the first 20 ft. Dug wells are therefore expected to be within the uppermost weathered bedrock and located near surface water.

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While this 1956 reference is a comprehensive, high-level review of all potential groundwater resources in East Tennessee, additional work has been performed since then by the U.S. Geological Survey. While Part II is available on the TDEC website, the referenced Part I is not available and is not readily available on the internet. DOE recommends that future citations utilize the similar but more recent and readily available U.S. Geological Survey publications or place Part I on the TDEC website.

Surface Water: As noted in several comments, one additional surface water walkdown was conducted than was described in the main body of TM-2 (six instead of the five described). All six of the walkdowns are described in detail in Appendix A.

Continuous flow is not present in the surface water drainages during the dry seasons as evidenced through walkdowns. Recorded measurements of 0.1 gallons per minute were considered no flow, and likely were caused by sediment and/or leaves caught in the flumes.

Text or figure changes, comments, and clarifications: Several comments were received that corrected typographical errors, requested changes to figures (to add or subtract information), or provided alternate wording for text that improved understanding. These comments will be considered for future documents. In other instances, DOE and TDEC used a term differently such as "subdued." Future documents will strive to more thoroughly describe descriptive terms.

If you have any questions, or if we can be of further assistance, please contact Brian Henry at (865) 241-8340 or John Michael Japp at (865) 241-6344.

Sincerely,

Brian T. Henry
Portfolio Federal Project Director

John Michael Japp
Federal Facility Agreement Project Manager

Please see page 4 for cc list.

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Enclosure

cc w/enclosure:
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OSWDF (EMDF) Comment Resolution Matrix

Document Number: DOE/OR/01-2819&D1	Document Title: Technical Memorandum #2, Environmental Management Disposal Facility Phase 1 Monitoring Oak Ridge, Tennessee	Document Dated: May 2019
Organization/Project: EMDF		Comment Due Date:

Reviewer Initials and Name	TDEC

Comment No.	Section, Page, Paragraph	Comment/Suggested Change/Rationale	Resolution
		GENERAL COMMENTS	
1.		**EMDF Comment Resolution Matrix for TDEC Comments on TM-1.** In light of DOE's position that formal comments will be on TM-2 and not TM-1[1], the following TDEC comments address the contents of TM-2. Rather than rebutting responses to TDEC's preliminary comments on the pre-published draft version of TM-1 (received July 5, 2018), TDEC notes that TM-1 comments were developed based on information DOE had provided to TDEC at the time. Furthermore, TDEC prepared the comments in response to DOE's request and provided the comments on July 26, 2019, within one day of DOE's clarification that the pre-published draft version of TM-1 constituted a "final, formal submittal". [1]DOE contractors stated the position during the July 25, 2018 project team meeting.	To clarify the comment, the U.S. Department of Energy's (DOE's) position has been that both technical memoranda (TMs) are secondary Federal Facility Agreement (FFA) documents to which revisions based on regulator comments are not required until the next primary document is produced, according to the FFA. DOE did indicate that instead of waiting for the next primary document to address TM-1 comments, DOE would address them in TM-2.
2.		**Site characterization vs. engineering design.** TM-2 includes numerous references to *engineering design* and the collection of *design data*. TDEC supports efficient data collection, and it is customary for CERCLA[2] projects to collect data for use in the design phase during site characterization, which is part of the remedial investigation phase of the CERCLA process. However, DOE's stated rationale for preparing a second D2 Phase 1 Field Sampling Plan (FSP), after TDEC had already approved the first one to expedite data collection, was to *remove* design data collection from the Phase 1 effort and place those tasks in a separate Phase 2 FSP. It was DOE's decision to prepare extra documents and to collect design data prior to a Record of Decision (ROD) selecting DOE's preferred alternative. From TDEC's perspective, TM-2 is a site characterization report, not a design report. The primary objective of site characterization was to provide the data needed to evaluate ARAR[3] compliance, including relationships between groundwater and streams at the Central Bear Creek Valley (CBCV) site.	DOE acknowledges the Tennessee Department of Environment and Conservation's (TDEC's) perspective.

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		[2]CERCLA is the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund. [3]ARARs are Applicable or Relevant and Appropriate Requirements. CERCLA requires that onsite remedial actions attain each ARAR unless a waiver is justified by, for example, demonstrating that the action (building EMDF in this case) will attain an equivalent standard of performance.	
3.		Page 2-11 through 2-14. Section 2.5 Site Conceptual Model. Section 2.5 acknowledges the dominance of groundwater flow along fractures oriented parallel to the geologic strike, at least in shallower portions of the saturated zone. Findings of groundwater tracing studies in the saprolite zone on the Oak Ridge Reservation (ORR) reveal important information about flow directions and velocities in settings like the CBCV site. A key finding is that groundwater flow directions are site-specific due to heterogeneity and relict structures, such as folds and fractures leftover from the original bedrock. Groundwater flow at a particular location may be predominantly along geologic strike, parallel to the inferred hydraulic gradient, or between these two ends of the spectrum. In most cases, there is more than one component to the flow direction–i.e., strike and hydraulic gradient both influence flow direction. In such settings, site-specific groundwater tracing is the most appropriate tool for determining groundwater flow rates and directions. Tracing also provides hydraulic conductivity measurements at scales appropriate for groundwater modeling to support design if TDEC and the U.S. Environmental Protection Agency (EPA) approve a ROD for the proposed landfill.	During the scoping of this effort, the U.S. Environmental Protection Agency and TDEC developed the scope of work they wanted DOE to execute as part of a dispute resolution. DOE executed the scope exactly as designed. Tracer studies were not requested by TDEC at the time and are not necessary to provide the required information. Site-specific hydraulic conductivity measurements were collected at each of the piezometers during the investigation. All goals of the sampling were met.
4.		**Shallow and Intermediate Wells/Piezometers.** a) TM-2 appears to use the words *well* and *piezometer* interchangeably. Consider using one or the other for consistency, or at least clarify for the reader whether DOE uses the words to describe the same features. b) It is difficult to follow DOE's comparisons between wells/piezometers of shallow and intermediate depths in many figures and tables. It would help to distinguish shallow and intermediate wells/piezometers in each table or figure by adding "S" or "I" beside each well name or by using color codes for well names, etc. Examples of problematic tables include Table 6.2, 7.1, and 7.2. Figures that are difficult to follow include ES.2, 2.1, 3.1, 5.1, 6.1, 7.1 through 7.15, 7.17 through 7.21, 7.25, and 7.26.	a) While the terms *well* and *piezometer* are interchangeable in this report, the term piezometer was used most often because no water or sample collection is performed at these locations. b) In each pair, the smaller number is the deeper piezometer.

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		SPECIFIC COMMENTS	
1.	ES pg ES-1 2nd para	*"Characterization of the CBCV site began in February 2018…."* Change *February* to *January*. As stated elsewhere in the report, site characterization began during January 2018 with the collection of stream water-quality parameter measurements during "walkdowns".	Characterization began in January 2018 and the text should have reflected this date.
2.	ES pg ES-1 2nd para	*"These initial characterization results have confirmed the CBCV site is acceptable for a new, low-level waste landfill."* Correct the sentence by replacing *low-level waste* with *mixed-waste*. Also, revise the sentence to clarify that it is DOE's interpretation or conclusion that site characterization results confirm site acceptability. As written, the sentence is potentially misleading. First, DOE proposes to build a mixed-waste landfill, not just a low-level radioactive waste landfill. According to the fifth draft (D5) of the Remedial Investigation/Feasibility Study (RI/FS)[4], DOE would use the proposed EMDF for the disposal of toxic, hazardous, and low-level radioactive waste, in addition to mixtures of these waste types. Second, the characterization results presented in TM-2 raise significant questions about how DOE will support the contention that the CBCV site is acceptable for the proposed mixed-waste landfill, as presented conceptually in the RI/FS and Proposed Plan[5]. The Proposed Plan (Appendix A, p. A-3) states that the CBCV site would be protective of human health and the environment, a threshold criterion of CERCLA, in part by application of requirements known as ARARs. One such requirement for a toxic waste disposal facility is a rule in the Toxic Substances Control Act (TSCA) that the bottom of a toxic waste landfill liner system shall be at least 50 feet (ft) from ***[above]*** the historical high water table. The Proposed Plan estimates that the waste (and the underlying liner system) could be within [below] preconstruction groundwater levels. The TM-2 results confirm that estimate. DOE provided data to TDEC and EPA in conjunction with meetings on April 11, June 7, and July 10, 2019. The data show that the planned base of the waste lies ***below*** the historical high water table[6] by 8 ft in the west-central portion of the planned landfill (at GW-989) and by 5 ft in the northeastern part (GW-983). The CERCLA Administrative Record, including TM-2, does not document this information. TDEC staff had to combine information from various DOE documents to calculate these values. The Proposed Plan says DOE would request and justify waivers from this and other requirements in the ROD. Information presented during the meetings mentioned above indicates that DOE anticipates groundwater levels would	The commenter is correct. The current plan is to operate the landfill as a mixed/low-level waste landfill. However, this designation does not change the conclusion. It is inaccurate to impose/overlay existing site conditions (e.g., groundwater levels) onto post-construction facility features (e.g., waste placement elevation) for which the construction of facility features (liners, buffer) and the major cut and fill operations will change the groundwater levels. Post-construction groundwater levels will change notably as a result of this construction. Any comparison of water levels to the design are well beyond the scope of TM-2. DOE will demonstrate long-term protectiveness and justification for waivers in future documents.

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		drop as much as 40 ft beneath some parts of the landfill following construction. Based on experience with the existing landfill, review of groundwater levels measured at the proposed landfill site, and DOE presentations about models projecting future groundwater levels, uncertainties exist regarding the depth at which groundwater would lie below the bottom of the proposed future landfill, particularly during intense rain events and prolonged rainy periods. Even if groundwater levels were to drop as much as DOE projects, it would not be enough to comply with the legal requirement under current conditions, much less future conditions when the landfill cover and liner systems would deteriorate. Therefore, in order to protect human health and the environment and justify waiving the TSCA legal requirement in accordance with CERCLA, the ROD would need to document how DOE will demonstrate that it can maintain a protective, *unsaturated geologic buffer between the bottom of the liner system and groundwater.* [4]*Remedial Investigation/Feasibility Study for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal, Oak Ridge, Tennessee* (DOE/OR/01-2535&D5). [5]*Proposed Plan for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste, Oak Ridge, Tennessee* (DOE/OR/01-2695&D2/R1). [6]Groundwater levels measured at the CBCV site during February 2019 approximate the historical high water table.	
3.	ES.1. pg ES-1 3rd para	**<u>Setting</u>** *"During the summer/fall growing season, the streams within the CBCV site may dry up, although there is still flow during significant rainfall events."* Revise this sentence to be consistent with Section 5.2 and Table 5.1 (p. 5-4). Section 5.2 says, *"There have been periods where flumes SF-1 and SF-3 on NT-11 recorded no flow. However, SF-2, located between SF-1 and SF-3, showed low flows during those same periods."* Although a footnote on Table 5.1 says the minimum flows for two streams (0.1 gallons per minute [gpm]) are "essentially no flow," the minimum flow at the middle station on Northern Tributary 11 (NT-11) is 0.7 gpm. Moreover, the stream walkdown results in Appendix A indicate the presence of water in each tributary, even during the dry season. TDEC acknowledges some locations had no water, or the water was too shallow to measure temperature, pH, and specific conductance. However, Section 5.2, Table 5.1, and Appendix A document that no channel was completely dry during any of the walkdowns.	The flumes were regularly maintained and cleaned. However, because of the flume construction and locations, the presence of leaves or a small amount of sediment at the measuring point can appear to be low flow when in fact there is no flow. The footnote was written to address that issue. As with many of the tributaries in Bear Creek Valley (BVC), water may occur in disconnected pools during the dry season.

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4.	Fig. ES.1 pg ES-2	**Location of the proposed CBCV site** This map (and the similar map on Fig. 1.1) omits the Bear Creek Burial Grounds (BCBG), a major waste disposal area located roughly midway between the existing EMWMF[7] and proposed EMDF landfills. Identification of this nearby disposal site mentioned in the report seems more important than labeling the Spallation Neutron Source (SNS), a landmark unrelated to waste disposal that is not mentioned in the document. However, if DOE elects to show "SNS" on these maps, the full name should be spelled out or defined in a note–or at least in the list acronyms on p. ix. [7]The existing mixed-waste landfill approved under CERCLA is called the Environmental Management Waste Management Facility (EMWMF).	The location map was intended to orient readers to the location of the EMDF and elected to identify well known features such as the Spallation Neutron Source. DOE will consider these requests in developing future location maps.
5.	ES.2 pg ES-4 last para	**Phase 1 Investigation Approach and Results** *"The acquired data are used to verify the CBCV site is appropriate for siting a landfill and will be used to develop the engineering design."* As noted in General Comment 2, the primary objective of data collection was to provide the data needed to evaluate compliance with legal requirements. As discussed in a subsequent comment, compliance with one requirement or justifying a waiver requires that DOE determine the historical high groundwater table.	As noted in Comment 35, TDEC believes that the latest sampling has identified the historical high groundwater table.
6.	ES.2.1 pg ES-4 1st para	**Surface Water Walkdown** *"Two detailed site walkdowns were performed during the wet season (January 30 and February 27, 2018)....Three additional walkdowns, representing drier conditions (May 1, June 4, and October 10, 2018 were also completed."* Correct the second sentence to indicate that there were four stream walkdowns following the wet season, including one on September 12, 2018, as stated elsewhere in the report.	As commented, four dry season walkdowns were performed, for a total of six walkdowns, including the one on September 12, 2018. These are described in Appendix A.
7.	ES.2.2 pg ES-4 3rd and 4th sentences	**Locate the Maynardville Limestone** *"The January 2018 surface walkdown with Subject Matter Experts (SMEs) and TDEC geologists examined this location and revised the Maynardville Limestone contact in CBCV based on observations within NT-10 and D-10W streambeds. The contact location within the NT-11 streambed was found later by the same SME."* DOE should consider clarifying these sentences. The first sentence refers to more than one SME, but the second sentence refers to *"the same SME"*.	Only one subject matter expert (SME), who is very familiar with the BVC regional geology, was involved in the Northern Tributary (NT)-11 investigation.

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8.	ES.2.2 pg ES-4 last sentence	**Locate the Maynardville Limestone** *"The contact was confirmed to be approximately 50 ft further south of the proposed landfill location than was originally mapped (Fig.ES.2)."* TDEC agrees and appreciates DOE's effort to identify the location of the karstic Maynardville Limestone more precisely at the CBCV site. TDEC also notes that TM-2 identifies the presence of limestone at all eight Phase 1 drilling locations (all 16 Phase 1 borings) on the CBCV site, including the presence of 12 to 13 ft of limestone in GW-998. Although these limestone beds do not comprise a laterally extensive karst aquifer like the Maynardville Limestone, they do provide zones of increased groundwater flow, such as the zone of higher transmissivity associated with one of the deeper limestone layers in GW-998.	We appreciate your support of this effort. As noted in the Flexible Liner Underground Technologies, LLC (FLUTe™) test profiles, in conjunction with the boring logs, the transmissive zones occur with fracturing, irrespective of the lithology. For example, in the FLUTe™ profile for GW-998, while the thin limestone at 31.5 to 32.8 ft below ground surface (bgs) is the most transmissive zone, the fractured shale in the approximately 33 to 35 ft zone is similar. The deeper limestone starting at 37 ft bgs did not exhibit any transmissive zones. DOE believes the FLUTe™ test results are a more accurate indicator of transmissivity than geologic descriptions.
9.	ES.2.3 pg ES-5 1st full para	**Determine Surface Water Flow** *"The flumes were sized to accommodate the reasonably expected flow rates based on historical information and additional field observations."* Specify the "historical information" source discussed in this sentence. Does historical information exist regarding stream flow rates at the CBCV site?	No historical stream flow data was available for the Central Bear Creek Valley (CBCV) site but is available in BCV. The size of each flume was based on the experience of the UCOR surface water monitoring group and BCV SME, the channel size at each location, and flow rates in the nearby monitored NTs in BCV.
10.	ES.2.3 pg ES-5 last sentence	**Determine Surface Water Flow** *"Minimum to no flow rates were observed at all flumes during dry periods."* Per Specific Comment 3, revise this sentence to be consistent with Table 5.1 (p. 5-4).	Please see the response to Specific Comment 3.
11.	ES.2.4 pg ES-5 2nd para	**Drill and Install Piezometers** *"Piezometric surface data show responses to precipitation events, as would be expected, with more subdued responses at the well pairs located at the higher elevations (i.e., GW-980R/ GW-981 and GW-982/GW-983)."* Revise the sentence for factual accuracy. The statement is correct with respect to GW–980R/GW-981, but not GW-982/983. The data presented in TM-2 do not appear to support the apparent conclusion that responses to precipitation events are more subdued at wells where the ground is higher, as explained below. • Table 6.2 shows that GW-980R/GW-981 has the second highest ground elevation (963.50 and 963.20 ft above mean sea level [amsl], respectively) and some of the most subdued responses ("difference from min to max") of 5.21 and 8.26 ft, respectively.	DOE and TDEC are using the term "subdued" differently. For TM-2, the term subdued was used to describe responses to individual precipitation events rather than the trends over the period of measurement. In that context, GW-982/GW-983 does not show the same response to a precipitation event as other piezometers. The overall groundwater level rises, but without the sharp increases observed in other piezometers during or immediately following the precipitation events. Therefore, the response is considered subdued.

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		• Table 6.2 shows that GW-982/983 is the location with the highest ground elevation (1015.60 ft amsl for both piezometers), but Table 7.2 shows that both the shallow and deep piezometers have responses of 12.49 and 12.89 ft, respectively, that are *not* subdued, but slightly above average (12.20 ft, based on the values in Table7.2). • The only other piezometer location with responses as subdued as GW-980R/981 is GW-992R/GW-993, which is the second *lowest* piezometer location with ground elevations of 908.90 and 909.70 ft amsl, respectively.	
12.	ES.3 pg ES-6 1st para	**Phase 1 Characterization Conclusions** *"Site walkdowns conducted in January, February, May, June, September, and October 2018 found numerous cases where surface water entered and exited the soil through decayed trees and other types of features."* Consider clarifying this observation by adding the underlined words, as follows: "...where surface water entered and exited the soil through voids left by decayed trees...."	Agree that the suggested text improves understanding.
13.	ES.3 pg ES-6 3rd para	**Phase 1 Characterization Conclusions** *"Results of the Phase 1 site monitoring continue to validate acceptability of the CBCV site for a new, low-level waste landfill and support final site selection based on the following conclusions."* Correct the sentence by replacing *low-level waste* with *mixed-waste*. Also, revise the sentence to clarify that it is DOE's interpretation or conclusion that monitoring results validate site acceptability. See Specific Comment 2 for additional explanation.	Please see response to Specific Comment 2.
14.	Sect. 1 pg 1-1 4th para	**Introduction** *"These key assumptions were validated and were used to confirm the acceptability of the CBCV for a new, low-level waste landfill and to support a final site selection."* Correct the sentence by replacing *low-level waste* with *mixed-waste*. Also, revise the sentence to clarify that it is DOE's interpretation or conclusion that key assumptions were used to confirm site acceptability. See Specific Comment 2 for additional explanation.	Please see response to Specific Comment 2.

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15.	Sect. 1 pg 1-1 1st bullet	**Introduction** *"...there are no major karstic features in the Maryville, Nolichucky, or Rogersville formations underlying the CBCV site."* TM-2 should clarify whether there are any karstic features and distinguish any differences they may have with *"major karstic features"*. DOE should make similar clarifications in Section 2.2 (pp. 2-1 and 2-2) and Section 8 (p. 8-3).	No karstic features, such as those that occur in the Maynardville Formation, were identified during drilling in the Maryville, Nolichucky, or Rogersville Formations. No change to the text is necessary.
16.	Sect. 2.1 pg 2-1 2nd para	**General Site Location** *"Note: The figures in this TM illustrating a disposal facility boundary have used the boundary information from the 2017 RI/FS."* Revise the text to clarify the relevance of this statement. Is the proposed facility boundary different from that shown by the figures in this TM?	The boundary of the facility is not yet defined, although there is a revised version being evaluated that considers the latest data. The final boundary will be defined during the engineering design process.
17.	Sect. 2.3 pg 2-8 2nd para	**Surface Water Hydrology** *"The available U.S. Geological Survey (USGS) base flow data indicated that base flow was present...."* Cite the source (reference) of the USGS base flow data.	The cited reference (DOE 2017) Appendix E, Section 5.3, contains the additional references to Robinson and Johnson (1995) *Results of a Seepage Investigation at Bear Creek Valley, Oak Ridge, Tennessee January – September 1994*. U.S.G.S. Open-File Report 95-459.
18.	Sect. 2.4 pg 2-8 2nd para last sentence	**Groundwater** *"In general, the seasonal range of potentiometric surface elevations tends to span the transition between the saprolite zone and the underlying bedrock, suggesting that the weathering profile reflects the complexity of variably-saturated flow dynamics."* Revise this sentence for clarity. Is the sentence saying that the zone where fractured bedrock transitions to saprolite with relict fractures is saturated at some times because the potentiometric surface rises and falls seasonally? If variably-saturated flow has such a strong influence on the transition zone (between saprolite and underlying bedrock), how can the use of Modflow for simulating groundwater conditions be justified?	As noted, the transition zone between the lower saprolite and upper bedrock transition zone is at times saturated and lies within the range of seasonal groundwater fluctuation. Discussions concerning modeling are outside the scope for TM-2. However, the material properties of the hydrostratigraphic units in the model are a simplified representation of the vertical structure of the weathering profile. The purpose of the groundwater model for facility design is to represent long-term average saturated zone flow conditions, not to capture seasonal dynamics or variably saturated flow phenomena.
19.	Sect. 2.4 pg 2-11 1st complete sentence under Fig. 2.5	**Groundwater** *"Karst features and fractures within the Maynardville Limestone provide the principal conduits for groundwater movement within BCV."* Revise this sentence for clarity. While most groundwater flow through conduits (small caves) happens in the Maynardville Limestone, studies in Bear Creek Valley (BCV) have shown that groundwater migrates rapidly through fractures in other rock units. As written, this sentence appears to imply there is little (or	A more complete description of the groundwater flow in the predominantly clastic formations in BCV can be found on pgs 2-8 through 2-10. The text and associated figures note that the majority of the estimated groundwater flux occurs within the uppermost parts of the subsurface hydrogeologic profile, in the saprolite and upper bedrock. There is no evidence of rapid, long-distance migration of groundwater through fractures outside of the Maynardville Limestone Formation.

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		less significant) groundwater flow in the fractured rock units that comprise most of BCV and Pine Ridge. It is understood that groundwater may flow through a karstic aquifer like the Maynardville Limestone at rates similar to streams on the ground surface. However, flow rates have been measured at rates of 0.5 ft per day, generally along strike in the Maryville Limestone [Dismal Gap Formation] (Lomenick and Gera, 1964)[8]. Such flow rates are significant, given that contaminant transport would be a long-term concern at the proposed EMDF indefinitely. Moreover, McKay et al. (2005)[9] report that colloids can travel 5 to 200 meters per day through the fractured saprolite, presumably because they do not diffuse into the saprolite between the fractures like dissolved tracers/contaminants. [8]Lomenick, T.J., and Gera, F, 1964, Evaluation of fission-product distribution and movement in and around chemical waste seepage pits 2 and 3, in Waste treatment and disposal quarterly progress report, November 1963-January 1964: U.S. Atomic Energy Commission, Oak Ridge National Laboratory (Report) ORNL/TM-830, p. 120-125. [9]McKay, L.D., Sanford, W.E., and Strong, J.M., 2005, Field-scale migration of colloidal tracers in a fractured shale saprolite: Groundwater, v. 38, no. 1, p. 139-47.	Reference 8 (Lomenick, T.J., and Gera, F, 1964) briefly describes a flawed tracer test using high activities of tritium. The results did not agree with the original assumption that the tracer would primarily flow along strike. In addition, the tracer was injected (not passively placed into the formation), and there was precipitation infiltration during the test through leaking well casings.
20.	Fig. 2.6 pg 2-13	**BCV Groundwater flow patterns** Clarify the map and the associated text in Section 2.4 to explain that the arrows labeled "generalized direction of groundwater flow" are merely hypothetical approximations of the overall groundwater flow direction. Actual groundwater flow directions at a particular location, such as the CBCV site, may be influenced not only by the hydraulic gradient, but also by the orientation and nature of fractures and bedding planes. As noted in General Comment 3, groundwater usually flows in a direction between the strike trend and the hydraulic gradient in settings like the CBCV site. Given these findings, groundwater does not simply flow perpendicular to potentiometric contours, as depicted on Fig. 2.6.	TM-2 provides the projected flow directions, both down gradient and along strike. The arrows in Figure 2.6 reflect the lateral hydraulic gradients based on the potentiometric surface that controls the general groundwater flow direction. As noted in the text in Section 2.4, a significant portion of the shallow groundwater flow may be parallel to geologic strike and discharge into the nearest NT stream.
21.	Sect. 3.1 pg 3-1 1st sentence	**Approach** *"Two detailed site walkdowns were performed during the wet season (January 30 and February 27, 2018), and three walkdowns, representing drier conditions (May 1, June 4, and October 10, 2018) were also completed…."* Correct this sentence to indicate that there were six stream walkdowns, including one on September 12, 2018, as stated elsewhere in the report.	Please see response to Specific Comment 6.

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22.	Sect. 3.2 pg 3-1 2nd para	**Results** *"The site walkdowns determined that D-11E, the east-west valley draining to NT-11, located on the western slope of the high knoll in the Maryville Formation, contained no defined surface water channel."* For completeness and accuracy, add language similar to that in Appendix A (p. A-10): *"No surface flow was present in D-11E; however, groundwater was visible within a soil macropore, D11E-1, that was established as a sampling location. Standing water was present in the area, indicating that at that time, surface water was equivalent to shallow groundwater."* Although there is no stream channel on the surface, a stream was observed flowing through the macropore, as described in the excerpt above, and into NT-11, where the subsequent paragraph and the caption of Fig. A.1 accurately describe the intersection of the two streams as a *"confluence of NT-11 and D-11E"*. Also, in the quotation from p. A-10 and elsewhere, consider changing "sampling" to "measurement" unless DOE collected water samples for analysis.	Groundwater observed in a macropore does not rise to the level of designation as a "stream". The confluence was intended to describe the drainage features, not stream flow. While "sampling" is acceptable, the term measurement would have been more appropriate to more clearly describe that no discrete samples were collected.
23.	Sect. 3.2.1 pg 3-1 2nd sentence	**Parameter Results** *"Based on the number of dry data points or areas of low flow observed during the dry season walkdowns, it can be concluded that groundwater influence is minimal in the tributaries and drainages, especially in D-10W and NT-10 along the eastern side of the site."* Clarify how this statement is consistent with other statements in the report, including, but not limited to, the following on p. 2-10: *"Groundwater within the saturated zone converges and discharges into stream channels along the tributary valley floors, supporting dry-weather base flow, primarily during the wetter portions of the year. During drier periods, groundwater may support little or no stream base flow, but may continue to slowly migrate southward toward Bear Creek along the tributary valley floor areas within alluvium, saprolite, and bedrock fractures below the active stream channels."* Is the minimal groundwater influence along each of the tributaries uniform, or is there greater influence along some segments?	These states are consistent. Please note that in the second quote, the second sentence supports the first quote. A detailed evaluation of the groundwater influence along each drainage and tributary was not conducted.

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24.	Sect. 3.2.2 pg 3-3 1st and 2nd sentences	**Seep Locations** *"Seep locations at the CBCV site are identified on Fig. 3.1. All but one of the previously identified seeps were located and no additional seeps were located during the site walkdowns."* a) The locations of NT11-SEEP1 and NT11-SPEEP2 are not labeled on Fig. 3.1 (or Fig. 4.1), but the symbols appear to be in the wrong locations, based on Figs. A.21 through A.26. TDEC observations are consistent with the locations on Figs. A.21 through A.26. b) DOE identified an additional seep, called D10W-SEEP1 on Figs. A.21 through A.26, but Figs. 3.1 and 4.1 do not show a seep symbol at that location.	a) As noted, these seep locations are closer to the NT-11 channel than shown on Figure 3.1. b) This seep is not shown on Figures 3.1 and 4.1, but is shown on the figures in Appendix A as noted.
25.	Sect. 3.2.3 pg 3-3 2nd sentence	**Conclusions** *"Based on the number of dry data points or areas of low flow observed during the dry season walkdowns, it can be concluded that groundwater influence is minimal in many of the tributaries and drainages, especially in D-10W and NT-10 along the eastern side of the site."* Clarify how this statement is consistent with other statements in the report, including, but not limited to, the quotation from p. 2-10 cited in Specific Comment 23.	Please see the response to Specific Comment 23.
26.	Sect. 3.2.3 pg 3-3 3rd sentence	**Conclusions** *"...however, NT11-SEEP1 and NT11-SEEP2 (the seeps identified in the past by the USGS) were dry during all six walkdowns, suggesting the stream relies primarily on surface water for recharge."* Correct this statement. As noted on p. A-14, *"no measurements were taken at NT11-SEEP1 due to insufficient water depth."* It is not entirely true to say the seeps were always dry just because the water was not deep enough to submerge a measurement probe. DOE provided the following photograph of NT11-SEEP1, which shows the large seep area was wet during the stream survey on January 30, 2019.	The text is correct as reworded. Future documents will contain the revised text. However, please note that the picture was taken during the wet season following a rain storm. The conclusion in the quote is still valid.

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27.	Sect. 4.2 pg 4-1 1st two sentences	**Findings** *"The Maynardville/Nolichucky geologic contact was observed in the field at three locations. The contact was located in the drainage channel of NT 10, D-10W, and near the confluence of NT-11 and Bear Creek (Fig. 4.1)."* For completeness, revise the preceding section, Section 4.1 (Approach), to include the date and any other relevant information describing when and how the contact was located near the confluence of NT-11 and Bear Creek. As written, Section 4.1 only documents that the contact was identified in two locations, not three.	A more complete description is found in ES.2.2, pg ES-4, 3rd and 4th sentences.

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28.	Sect. 5.2 pg 5-2 1st para	**Flume Data Findings** *"There have been periods where flumes SF-1 and SF-3 on NT-11 recorded no flow.... The SF-4 and SF-5 locations on D-10W showed periods of no flow in May, June, July, August, September, and October. The SF-6 location on NT-10 also showed periods of no flow in June, July, August, and September."* Revise this sentence to be consistent with Table 5.1 (p. 5-4). Although a footnote on Table 5.1 says the minimum flows for two streams (0.1 gpm) are "essentially no flow," the minimum flow at the middle station on NT-11 is 0.7 gpm. Moreover, the stream walkdown results in Appendix A indicate the presence of water in each tributary, even during the dry season. TDEC acknowledges some locations had no water, or the water was too shallow to measure temperature, pH, and specific conductance. However, Table 5.1 and Appendix A document that no channel was completely dry during any of the walkdowns.	Please see response to Specific Comment 3.
29.	Sect. 5.2 pg 5-2 1st two para	**Flume Data Findings** *"Surface water flow data collected from April 2018 to April 2019 at the flow measurement stations at the CBCV site are illustrated in Fig. 5.1.... Table 5.1 provides a summary of the flow rates recorded from April 2018 to April 2019 at the CBCV weirs."* Revise the text of this section to explain how the flow and precipitation data are summarized for presentation in Fig. 5.1. This information should also be noted on the graphs. Do the graphs present data as collected (every 30 minutes), hourly, or daily?	The graphs contain the complete flow data sets collected (every 30 minutes). These graphs are considered summaries because the individual data points are not readily discernable.
30.	Sect. 5.2 pg 5-2 Last para	**Flume Data Findings** *"Less flow occurs in D-10W in response to the same precipitation events."* Correct this sentence for consistency with the following sentence in the first paragraph on the same page, or clarify the apparent discrepancy: *"However, the peak flow rate during the wet February 2019 period at SF-5 did exceed the flow rate recorded at flume SF-6 on NT-10 during the same period."*	The first sentence is from a summary paragraph. It could have been clearer by inserting the word "typically" after "less flow". However, it is still a valid summary statement and not inconsistent with the following quote.

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31.	Sect. 5.2 pg 5-2 Last sentence	**Flume Data Findings** *"Stormflow bypass flow through macropores (see Fig. 2.4) is assumed to be contributing to surface water flow at the CBCV site."* For clarity, consider revising this sentence as follows (or similar): *"Stormflow through macropores (see Fig. 2.4) is assumed to be contributing to surface water flow at the CBCV site, and some of this flow may bypass the flumes."*	While some local flume bypass may occur, the majority of surface water flow is measured at the flumes. The text as written in TM-2 more clearly represents this finding.
32.	Fig. 5.1 pg 5-3	**Surface water flow measurement flumes at the CBCV site** Show each of the six graphs presented on Fig. 5.1 as separate figures. There is no need to revise Fig. 5.1, but the report should also present the results in a legible format. As presented, the graphs are too small to see the relationships between precipitation and stream flow, and the legend appears to include a gray line that presumably corresponds with the red columns/lines on the graphs. Legibility of the plots can be increased by presenting them in landscape format like Fig. 5.1 or using an 11-by-17-inch like Fig. 7.1. This comment also applies to Figs. 5.2 through 5.4.	These suggestions will be considered when developing future figures.
33.	Sect. 6.3.1 pg 6-7 1st two para	**FLUTe™ Test Results** For clarity, consider presenting much of this information about the test method in Section 6.1.1, FLUTe™ Test [approach], rather than in the "results" section.	Much of this text explains how the measurements collected during FLUTe™ tests (described in Section 6.1.1) can be related to the transmissivity (and/or conductivity) values interpreted from those measurements and therefore is appropriate as written.
34.	Sect. 7 pg 7-1	**Long-term Monitoring Results from Phase 1 Wells–Through April 2019** For accuracy and clarity, revise the title of this section to "Groundwater Monitoring Results from Phase 1 Wells–March 2018 Through April 2019". The phrase *long-term monitoring* (LTM) applies to environmental monitoring that occurs over periods of several years–not a single year. More importantly, LTM occurs after achieving cleanup goals to ensure the remedy remains protective of human health and the environment.	"Long-term" monitoring was used to describe the monitoring as compared with the 8 to 10 weeks of monitoring results presented in TM-1.
35.	Sect. 7 pg 7-1 1st two para	**Long-term Monitoring Results from Phase 1 Wells–Through April 2019** *"Understanding the expected seasonal high groundwater levels is a key element to designing a landfill. The FS phase (DOE 2017) provided conceptual landfill base elevations that would ensure long-term protection from groundwater intrusion based on informed assumptions regarding local conditions at the CBCV site. The purpose of the FS was to determine the plausibility of constructing an on-site disposal facility, based on meeting CERCLA criteria.* *The intent of the engineering design will be to establish the lowest allowable*	Future documents will demonstrate protectiveness and compliance with ARARs. This is outside the scope of TM-2. Design features will be also be discussed and addressed in future CERCLA design documents.

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		elevation of the CBCV site landfill bottom and still maintain a minimum 10-ft buffer between the bottom of the liner system and the estimated seasonal high piezometric surface. It is anticipated that the post-construction piezometric surface will be lower than the current lowest piezometric surface observed in the shallow piezometers due to the elimination of groundwater recharge over the footprint of the landfill because of the placement of the impermeable barriers in the bottom of the landfill. This lack of recharge will also reduce the degree of response in the piezometric surface to precipitation events and seasonal fluctuations from what is currently observed at the site." The EMDF conceptual design in the D5 RI/FS indicates that the buffer zone will be located within the zone of water table fluctuation. Available data indicate that the seasonal high water table would often be within the conceptual buffer zone and the historical high water table would often be within the waste. This fact, coupled with the complex hydrogeology of the site, makes it difficult to determine if the landfill can be constructed and operated in a manner that will meet the two CERCLA threshold criteria for an action to eligible for remedy selection: 1) protection of human health and the environment and 2) compliance with (or a basis for waiving) ARARs. TDEC recommended that DOE consider innovative design solutions to overcome these challenges posed by site conditions. DOE could use conventional engineering technologies, such as mechanically stabilized earth (MSE) walls, to build additional buffer that would elevate and separate the waste from the groundwater while maintaining disposal volume. Such approach could allow vertical elevation of the waste cells without a corresponding lateral expansion of the landfill and supporting berms. In response, DOE proposed proceeding with the current design and deferring consideration of such options until after ROD approval. Any forthcoming draft (D1) ROD needs to justify waivers of the TSCA requirements for a (1) 50-ft distance between the bottom of the landfill liner and the historical [not seasonal] high groundwater table and (2) any hydraulic connection between the site and standing or flowing surface water. CERCLA threshold criteria must be met or waived at the time of ROD signature. Approval of the ROD requires that DOE show the TSCA 50-ft buffer requirement can be waived, in part, by providing a quantitative demonstration that the proposed buffer thickness and hydraulic conductivity meets the TSCA requirement that operation of the landfill will not present an unreasonable risk of injury to health or the environment from PCBs and is protective under CERCLA. The February 2019 water levels provide a reasonable demonstration of the *historical* high water table cited in the TCSA rule because that was one of the wettest months on record for the proposed landfill location. Similarly, the	

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		average of the February 2019 water levels provides a reasonable approximation of the *seasonal* high water table. TDEC sees no practical application of annual average water table conditions, as DOE presented during a meeting on April 11, 2019, or seasonal low conditions, as presented in TM-2. The design should maintain the buffer thickness under the entire landfill, so the base of the designed liner system would be placed such that the seasonal high water table (average February 2019 groundwater level) is not within the buffer at any location. TDEC suggested MSE retaining walls because they are cost effective and can be used to achieve the protective buffer required by the rules while maintaining DOE's proposed disposal capacity (landfill area & volume). MSE walls are used at municipal landfills.	
36.	Fig. 7.1 pg 7-3	**Existing conditions profile location map** a) Remove or revise the erroneous scale information of 1" = 300'. When a map scale is changed for inclusion in a report, it is better to rely on the graphical scale bar because it retains its accuracy when the map is enlarged or reduced. The scale of the printed map can also change due to printer settings. Check the applicability of this comment to other maps in the document. b) The profiles shown on this map (and corresponding profiles in Figs. 7.2 and 7.3) should be adjusted slightly to include data from the omitted piezometers: GW-980R, GW-981, GW-992, and GW-993. c) Alternatively, at a minimum, the text should explain the rationale for excluding data from the profiles, as well as the bend in Profile N/S-2 south of GW-982/983. d) Finally, the geologic formation names on this diagram (e.g., Friendship Formation and Dismal Gap Formation) are not consistent with those shown in Figs. 7.2through 7.4 (e.g., Rutledge [Formation] and Maryville [Limestone]).	a) DOE appreciates the suggestion for future documents. b) and c) Profiles were drawn from point to point and were selected to provide representative north-south and east-west sections. The inclusion of these points would not have changed the overall interpretation of the profiles. d) These are older and newer names for the same geologic formations. The project will standardize the use of the names.
37.	Fig. 7.8 pg 7-12	**Water levels at paired wells GW-986 and GW-987** Revise this graph to present data at the same vertical (y-axis) scale as the comparable plots in Figs. 7.5 through 7.11. The y-axis in Fig. 7.8 has a range of 16 ft (916 to 932 ft amsl), whereas the others have a 50-ft range.	This comment is appreciated and will be considered in developing future hydrographs.

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38.	Sect. 7.2 pg 7-18 2nd full para	**Potentiometric Surface Fluctuations Over Time** *"...an overall fluctuation of approximately 113.3 ft has occurred in the intermediate zone over the year-long monitoring period."* For accuracy, correct this typographical error: *113.3 ft* should be *13.34 ft*, according to Table 7.2.	This is a typographical error. The correct fluctuation of 13.3 ft for GW-998, the intermediate piezometer, is shown on Fig. 7.12 and in Table 7.2.
39.	Sect. 7.2 pg 7-22 2nd full para	**Potentiometric Surface Fluctuations Over Time** *"Rapid, large fluctuations in temperature at GW-999, located in the lower elevations nearthe valley floor, suggest that contributions from surface water may be impacting the observed temperatures. Spikes in pH greater than 11 at GW-981 in the wet season may indicate impacts from grout used for piezometer construction."* Revise the text to clarify DOE's interpretation that surface water "contributions" cause the observed rapid, large temperature fluctuations at the intermediate-depth piezometer GW-998 (not GW-999). Fig. 7.14 shows the pH spikes at GW-981, as mentioned in the text, but it is unclear how this information relates to temperature fluctuations at GW-998, which lies about 1,200 ft from GW-981. Boring logs (Appendix A) for the paired piezometers GW-998/999 and FLUTe™ results for GW-998 indicate the presence of 12 to 13 ft of limestone with associated and high transmissivities. Presumably, these high-transmissivity zones are associated with solution-enlarged fractures in the limestone, which may provide direct hydraulic connections to one or more nearby streams (D-10W, NT-11, and Bear Creek). However, the presence of high-transmissivity zones does not appear to explain the temperature fluctuations in GW-998, which is screened in a shallower interval. Moreover, the temperature fluctuations are not observed in GW-999.	The text was not meant to relate the temperature at GW-999 to the pH at GW-981. These are independent observations. While the boring logs for GW-998 identified stained fractures in the limestone and shale of the upper bedrock, there were no indications of solution-enlarged fractures in this boring. The GW-998/GW-999 piezometer pair is located in a low lying area that can be affected by standing water during periods of high precipitation. Therefore, a possible explanation for the wide temperature fluctuations in the shallow piezometer is contribution from the surface.
40.	Sect. 7.3 pg 7-22 1st paragraph	**Potentiometric Surface Maps, Gradients, and Flow Rate** *"Figures 7.19, 7.20, and 7.21 show the piezometric surface for the peak high conditions at the CBCV site, from February 24, 2019, the average seasonal high potentiometric surface from February 2019, and the average seasonal low potentiometric surface from the period of late August to early September 2018 in the shallow CBCV site piezometers. The potentiometric surface represented in Fig. 7.19 is based on the potentiometric surface measured in the CBCV piezometers on September 24, 2018, with the exception of GW-999, which did not have data collected on that date. The potentiometric surface for GW-999 is represented by the lowest potentiometric surface measured in that piezometer which occurred on October 15, 2018."*	a) The requested values are provided on the figures as noted. b) and c) The second callout for Fig. 7.19 should have referenced February 24, 2019 not September 24, 2018 as stated in TM-2. The figure callout is correct as Fig. 7.19.

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		a) TM-2 should include a table of measured or calculated water levels used to represent peak high, average seasonal high, and average seasonal low, as depicted on the maps in Figs. 7.19, 7.20, and 7.21. b) Correct the citation of *"Fig. 7.19"* in the excerpt above to *"Fig. 7.21"*. c) Clarify the apparent discrepancy between the text, which says the potentiometric surface in Fig. 7.19 [actually Fig. 7.21] is based on measurements on a specific date (with one exception), and the caption of Fig. 7.21, which says the map shows *"average seasonal low conditions"*.	
41.	Fig. 7.16 pg 7-23	**Bear Creek Valley well locations** a) As explained in Specific Comment 40, TDEC agrees that extrapolation of groundwater levels from "comparable" wells is no longer necessary given the availability of wet-season data from the CBCV site. However, TM-2 is based on the FSP, which includes data collection at those locations. For completeness, Fig. 7.16 should show the locations of the comparable wells (similar to Fig. 15 in the FSP). TM-2 should document that DOE measured the water levels in those wells as agreed. TM-2 should also document the availability of those results on the DOE Oak Ridge Environmental Information System (see p. 1-2). b) Fig. 7.16 shows nine well locations at the CBCV site. This is inconstant with the remainder of the document, which says there are well pairs at eight locations. The southeastern most location on the map appears to be the location where no Phase 1 well exists.	a) Given that these data are no longer necessary, additional changes to document these are not necessary. TM-1 provided sufficient information on the comparable wells. b) Fig. 2.1 provides the piezometer locations. The regional Fig. 7.16 includes an older well, identified as "DC well" on Fig. 15 of the Phase 1 FSP (DOE/OR/01-2739&D1). However, the location should be slightly west of the map location shown in Fig. 7.16. Nevertheless, because this is a map of BCV wells, it belongs.
42.	Fig. 7.19, pg 7-26 Fig. 7.20, pg 7-27 Fig. 7.21, pg 7-28	**Piezometric surface map of the peak high conditions at the CBCV site, February 24. 2019.** **Piezometric surface map of the average seasonal high conditions at the CBCV site, February 2019.** **Piezometric surface map of the average seasonal low conditions at the CBCV site, August to September 2018.** a) The map legends should identify the piezometric surface contours. b) The text should explain why Figs. 7.20 and 7.21 show piezometric surface contours west of GW-986/987 (D-11E) but Fig. 7.19 does not. c) The maps should show all data points and values used to develop the piezometric surface contours. For example, if surface water levels at the stream gages support the contours between GW-986/987 and NT-11, the maps should show those values.	a) Comment noted for future figure development. b) Because Figs. 7.20 and 7.21 are of average piezometric surfaces rather than a date-specific surface as in Fig. 7.19, and the conceptual site model assumes most shallow groundwater discharges to the tributaries, professional judgment was used with the average piezometric surface maps and contours were included west of GW-986 to illustrate the anticipated piezometric surface sloping towards the NT valleys. c) The contours near the NT streams are based on the NT elevations and were not included to simplify the figure. d) Comment noted for future documents.

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		d) Fig. 7.21 should show the water levels used to represent average seasonal low conditions at GW-998/999, even though the values represent conditions on a different date.	
43.	Sect. 7.3 pg 7-29 1st para	<u>Potentiometric Surface Maps, Gradients, and Flow Rate</u> *"Using the potentiometric map in Fig. 7.20, the average hydraulic conductivity from the shallow piezometers, and an effective porosity of 0.2, a linear groundwater velocity of approximately 0.58 ft/day is obtained for the slopes in the central portion of the site between GW-989 and GW-995 based on the January 2019 water levels. A linear groundwater velocity of 0.25 ft/day is obtained for the southern portion of the site between GW-995 and GW-999 based on the January water levels."* a) Revise the excerpted text and/or Fig. 7.20 for accuracy and consistency. The text says DOE calculated the average hydraulic gradient based on <u>January</u> water levels and the potentiometric map in Fig. 7.20, which shows average water levels in <u>February</u>. b) TM-2 should either 1) present hydraulic gradient based on peak high water levels (Fig. 7.19) and average seasonal low water levels (Fig. 7.21) or 2) provide a rationale for using only average seasonal high water levels (Fig. 7.20).	a) Text should state that the estimated flow rates are based on the average seasonal high conditions (average of February 2019) shown in Fig. 7.20. b) The gradients for seasonal high and peak high (based on Figs. 7.20 and 7.19) at these well pairs are essentially the same (0.11 ft/ft between GW-989 and GW-995 during both periods and 0.05 to 0.06 ft/ft between GW-995 and GW-999 between seasonal high and peak high, respectively). The seasonal high was used over the seasonal low to provide an estimate under "greater" groundwater flow conditions (the gradients measured on Fig. 7.21 during seasonal low conditions are less).
44.	Sect. 7.4 pg 7-30 1st para	<u>Potential for Upwelling Beneath the Knoll</u> *"Hydrographs and groundwater electrical conductivity (EC) were evaluated for the four piezometer pairs constructed in the Maryville Limestone beneath the knoll area on the southern flank of Pine Ridge to determine the potential for groundwater upwelling (Fig. 6.1, GW-980R/981, GW-982/983, GW-986/987, and GW-988/989)."* a) TM-2 should evaluate all locations where data were collected at the CBCV site or provide the rationale for evaluating only the knoll area. TDEC made a preliminary effort to assimilate peak groundwater levels presented in TM-2 with a recent revision of the landfill design that DOE shared during the groundwater modeling session on July 10, 2019. The results of that effort reveal that peak groundwater levels are above the design elevation (e.g., bottom of waste cell or berm surface) or cannot be determined (because TM-2 does not present February 2019 water levels for "Phase 2" wells) at approximately two-thirds of the locations shown on the design drawings. In the remaining cases, water levels are well within the 50-ft buffer zone that should remain unsaturated per 40 CFR 761.75(b)(3). This is also true	a) The upwelling discussion was focused on this area because previous conversations with TDEC indicated this was the area where there were concerns about potential groundwater intrusion. Groundwater elevations are highest in the knoll piezometers and the upper portion of the knoll is expected to be removed to construct the proposed landfill. In addition, DOE believes that understanding the vertical gradients in this area is of significant importance for the design of the facility. It has been recognized since the RI/FS that existing peak groundwater levels would be above conceptual design waste elevations. That is because the post-construction water levels will be notably different than pre-construction levels. The comparison of water levels to design elevations is beyond the scope of TM-2. Additional Phase 2 data will be presented in TM-3 and comparison of post-construction water levels to design elevations will be made in future documents. The conductivity measurements provided a better delineation between intermediate/shallow groundwater,

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		for GW-998/999, which lies off the knoll and where the potentiometric surface peaks within 6 ft of the planned berm *surface.* Why were temperature changes recorded by the downhole instrumentation not considered in this evaluation? Temperature variations can indicate changes related to direct infiltration of precipitation.	surface water and the very deep groundwater.
45.	Sect. 7.4.1 pg 7-30 5th para	**Piezometer Pair GW-982/GW-983** *"Comparison of the vertical gradient between the piezometer pairs with the lateral gradient to the nearest surface water drainage (D-10W) found that the lateral gradient to the D-10W is 5 to 10 times steeper than the vertical gradient for the piezometer pair. This steeper lateral gradient..." (underlining added for emphasis).* For accuracy, replace *"steeper"* with *"greater"*. The magnitude of the lateral gradient may be greater than the vertical gradient, but it cannot be steeper.	The term "greater" would be better usage than "steeper"; however, the meaning is still clear.
46.	Fig. 7.25 pg 7-34	**GW-986/987 gradient evaluation** TM-2 should provide the rationale for presenting this type of graph for the GW-986/987 location only, despite text comparing vertical and lateral gradients at other locations.	This chart was provided solely for GW-986/987 because this is the only piezometer pair evaluated with a change in vertical gradient from weakly downward to weakly upward over the monitoring period.
47.	Fig. 7.26 pg 7-35	**GW-988/989 comparisons** In light of the upper note *("Consistent downward gradient")*, TM-2 should explain or clarify the interpretation in the lower note that *"Shallower zone somewhat inversely responsive to rainfall suggesting deeper groundwater rises with rainfall"*. The text on p. 7-34 makes similar statements.	The electrical conductivity (EC) for the shallow piezometer is relatively constant with little fluctuation related to individual precipitation events. However, a very slight increase in EC can be seen during the wet season.
48.	Sect. 8.1 pg 8-1 3rd para	**Summary and Conclusions** *"The Pumpkin Valley and Rutledge formations provide a low hydraulic conductivity separation between the sandstone of the Rome Formation and the primarily shale bedrock formations that directly underlie the CBCV site. These lower permeability shales effectively confine groundwater in the Rome Formation."* The CBCV site investigation collected no data to address this topic, and TM-2 provides no basis or evidence for this assertion. Historical reports[10] on the hydrogeology of the ORR say the rock units present at the CBCV site, excluding the Maynardville Limestone, comprise an "aquitard," which is an outdated name for a low hydraulic conductivity zone that confines groundwater. However, this element of DOE's conceptual model for the ORR–i.e., that rocks of the Lower Conasauga Group confine groundwater–is not consistent with findings and observations on the ORR and surrounding region.	This statement reflects that at depth beneath the CBCV site, the predominantly shale units overlying the Rome likely have lower permeability and provide a separation between the Rome (deep groundwater zone) and the shallow/intermediate groundwater flow zones. As noted, the term aquitard was used in the referenced 1992 document (Reference 10), not TM-2. However, DeBuchananne and Richardson (Reference 11) point out that the Pumpkin Valley shale is "one of the poorest aquifers in East Tennessee. The shale despite being fractured is almost impervious." As noted in DeBuchananne and Richardson (Reference 11), dug wells in topographic lows [*added note, e.g., such as near streams*] usually encounter groundwater within the first 20 ft. This reference describes "Ground water in the Conasuaga shale is restricted to small fractures. The shale has been so deformed by

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		For example, residential wells in these rock units produce water supplies sufficient for domestic use.[11] In addition, groundwater tracing on the ORR has demonstrated the existence of hydraulic connections through the rock units present at the CBCV site[12,13]. In these cases, lithological changes between adjacent rock units do not confine groundwater because the flow is almost exclusively through fractures, like those visible in the rock cores from the CBCV site (Appendix B).[14] Finally, in light of statements throughout the document that fractures decrease with depth, TM-2 should reconcile the statement in the excerpt above with the sentence on p. 8-3 that says: "*While not observed during the investigation* [presumably because no deep wells were installed], *other investigations in BCV indicate deep groundwater flow from Pine Ridge to Bear Creek and the Maynardville Limestone across bedding planes and geologic contacts, and may have higher potentiometric surfaces (upward gradients) at greater depths (below the investigation depths).*" [10]Solomon, D.K., Moore, G.K., Toran, LE., Dreier, R.B., and McMaster, W.M., 1992, *Status report: A hydrologic framework for the Oak Ridge Reservation,* Oak Ridge National Laboratory ORNL/TM-12026. [11]DeBuchanne, G.D., Richardson, R.M., 1956, *Ground-water resources of East Tennessee,* Tennessee Division of Geology Bulletin 58, Part I. [12]Morton, R.J., 1955, *Radioactive waste disposal, in Health Physics Division semiannual progress report for period ending July 31, 1954:* U.S. Atomic Energy Commission, Oak Ridge National Laboratory (Report) ORNL-1763, p. 14-17. [13]Webster, D.A., 1996, *Results of Ground-Water Tracer Tests Using Tritiated Water at Oak Ridge National Laboratory, Tennessee:* U.S. Geological Survey Water-Resources Investigations Report 95-4182, 50 p. [14]Iron staining indicates natural open fractures with groundwater flow natural rather than fractures formed by the drilling process. Field geologists also identified slickensides, which typically indicate rock movement along faults. Although field logs describe the slickensides as appearing to be depositional, faulting is a more likely explanation in the folded and faulted geology of BCV.	folding that the fractures form an interconnected network." While Bulletin 58 from 1956 (Reference 11) is a comprehensive, high-level review of all potential ground-water resources in East Tennessee, additional work has been performed since then by the U.S. Geological Survey (USGS). While Part II is available on the TDEC website, the referenced Part I is not available and is not readily available on the internet. Recommend future references utilize the similar but more recent USGS publications, or place Part I on the TDEC website. In addition, there are no residential wells in the BCV, including in the Conasauga Group. This reference does not represent more site-specific information or current domestic uses. The test described in Reference 12 cannot be considered a valid tracer test by today's standards. A pit was dug and "Seven hundred and forty one gallons of a solution containing uranium nitric acid and aluminum nitrate were obtained from the Chemical Technology Division and have been discharged to the pit." This material is completely unlike any waste allowed for disposal. Due to the acid present in the solution, dissolution of the limestone occurred, changing flow paths. Reference 13 describes in the abstract that "Results demonstrated that ground water is able to flow through joints in the weathered bedding and that the direction of the water-table gradient is the primary factor governing flow direction." The article continues that bedding plane openings still exert a significant secondary influence on flow direction in the weathered rock. This is a key conclusion that is consistent with TM-2. Because there is permeability in the clastic formations, groundwater flow also occurs at depth, albeit slowly. Reference14 – As a result of the geologic history, fractures, local dip angle changes and slickensides are common in the Conasauga Group formations, particularly in the Maryville and Nolichucky Formations which underlie the CBCV site (Lee, R. R and Ketelle, R. H., *Geology of the West Bear Creek Site,* ORNL/TM-10887, 1989). Generally bed parallel slickensides are thought to be in part a result of bedding plane slip as a result of thrust faulting (Hatcher, et. al., *Status Report on the Geology of the Oak Ridge Reservation*, ORNL/TM-12074, 1992).

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49.	Sect. 8.1 pg 8-1 4th para	**Summary and Conclusions** *"The permeability of both the saprolite and the bedrock is approximately 1×10^{-3} to 1×10^{-5} cm/sec [centimeters per second], resulting in slow groundwater movement. Fractures are present in the bedrock and decrease with depth, resulting in decreased permeability and slower groundwater movement with depth (Fig. 2.5)."* TM-2 should reconcile the first sentence in the excerpt above, which says that groundwater movement is slow, with the second sentence, which says the bedrock is fractured. TM-2 should also reconcile the first sentence in the excerpt above, which says that groundwater movement is slow, with the sentence on p. 8-2 that says groundwater migration in competent bedrock beneath the CBCV site is expected to occur through the fracture network. Finally, TM-2 should reconcile the claim of slow groundwater movement with statements throughout the document indicating that groundwater pH and electrical conductivity have a flashy response to rainfall.	As noted at the top of pg 7-29, using the potentiometric map in Fig. 7.20, the average hydraulic conductivity from the shallow piezometers, and an effective porosity of 0.2, a linear groundwater velocity of approximately 0.58 ft/day is calculated for the slopes in the central portion of the CBCV and a linear groundwater velocity of 0.25 ft/day is obtained for the southern portion of the CBCV site. The measures of permeability mentioned in this statement are based on the hydraulic testing performed in Phase 1 (slug tests in shallow piezometers and FLUTe™ testing of open boreholes). The FLUTe™ testing provides a measurement of the transmissivity of the fracture zones in the bedrock. Therefore, these sentences are not inconsistent. The site-specific information, even in fractured intervals, does not support rapid groundwater flow. As noted on pg 8-2, 3rd paragraph: "*In competent, shale-rich bedrock zones, groundwater flow occurs primarily through fractures because the rock matrix has extremely low permeability.*" While slower, groundwater flow also occurs through the porous medium, as noted above, fractures decrease with depth with slower groundwater movement. Page 7-2, 3rd paragraph describes: "*In general, the shallow piezometers show a more flashy response of all three parameters to precipitation events than occurs in the intermediate zone piezometers.*" This demonstrates the relatively quick infiltration of precipitation into the shallow groundwater, as described previously in this section. This response decreases with depth, supporting the conclusion of decreasing groundwater flow rates with depth.
50.	Sect. 8.1 pg 8-2 1st full para	**Summary and Conclusions** *"At the CBCV site...there is one interconnected groundwater zone at shallow and intermediate depths, not distinct aquifers separated by unsaturated bedrock zones."* TM-2 should reconcile the sentence in the excerpt above with the statement on p. 8-1 that lower permeability shales of the Pumpkin Valley and Rutledge formations confine groundwater in the Rome Formation.	The conclusion refers to the similar potentiometric surfaces observed in the shallow and intermediate piezometer pairs that demonstrates interconnection between these zones (see pg 8-2). The next paragraph on pg 8-2 describes the much deeper Rome Formation beneath the CBCV site (at depths estimated to be greater than 500 ft) which is confined by the Pumpkin Valley and Rutledge Formations.
51.	Sect. 8.1 pg 8-2 1st full para	**Summary and Conclusions** *"The higher the degree of rock weathering, or the more fractures that are present, the more similar to a porous media the matrix material becomes with*	DOE stands behind this summary statement. As with any summary, there are exceptions at the detail level but the summary more accurately reflects conditions than the comment suggests.

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		observed groundwater flow similar to porous media flow (Darcy flow)." This theoretical generalization may not apply at the BCV site. The basis for assuming groundwater flow through fractured rock is similar to flow through porous media is the assumption that weathering causes more fractures which interconnect in a relatively uniform manner. On the other hand, the porous-media assumption does not adequately represent groundwater flow through fractures if weathering simply enhances existing fractures, such as those produced by tectonic forces that folded and faulted the rock layers in BCV. Springs discharge groundwater from the rock units present at the CBCV site. In fact, TDEC geologists observed a spring on Pine Ridge in the D-10W channel immediately above the CBCV site. The spring was flowing on September 27, 2016 after several months of drought. The presence of springs demonstrates the existence of convergent flow. Convergent flow suggests the porous-media assumption may not adequately represent groundwater conditions at the BCV site, as explained above. As rocks alter/weather, groundwater flows more through individual fractures, becoming **less** similar to "porous media flow (Darcy flow)". This natural process involves a positive feedback loop in which widening of a fracture allows it to pirate water from adjacent fractures, causing preferential widening of that fracture, increased water flow, etc.[15] Statements that pH and specific conductivity increase from north (upstream) to south (downstream) along the streams that flow through the site suggest that this natural process is active at the CBCV site.[16] Tracer tests on the ORR[17] found that groundwater flows preferentially through strike-parallel fractures in rock units present at the CBCV site[18], not in the direction of the hydraulic gradient. This demonstrates the CBCV rock units are not a porous medium, and TDEC urges caution in attempting to apply the "equivalent porous medium" modeling concept to fractured-rock aquifers at small scales like the CBCV site. [15]Worthington, R.H., Davies, G.J., and Alexander, Jr., E.C., 2016, *Enhancement of bedrock permeability by weathering,* Earth Science Reviews 160, p. 188-202. [16]Examples include Sections ES.2.1 and 3.2.1. [17]Vaughn, N.D., Haase, C.S., Huff, D.D., Lee, S.Y., and Walls, E.G., 1982, *Field demonstration of improved shallow land burial practices for low-level radioactive solid wastes: preliminary site characterization and progress report:* [U.S.] Department of Energy, Oak Ridge National Laboratory (Report) ORNL/TM-8477, 112 p. [18]Nolichucky Shale and Maryville Limestone.	Where is the referenced spring located on Pine Ridge? A response cannot be provided without additional information. As noted in Reference 15, in silicate aquifers, such as the clastic formations underlying the CBCV site, "slower dissolution kinetics and incongruent dissolution make it more difficult to predict permeability enhancement." Reference 16 – ES.2.1 simply notes a general increase in pH from north to south. Section 3.2.1 notes the same general increase in pH from north to south, "*...suggesting that more carbonate is present in the lower reaches as one approaches the Maynardville contact.*" Reference 17 – This in-depth demonstration noted "These tracer tests thus indicate the importance of both rapid migration pathways associated with fractures as well as slower intergranular flow paths that are controlled by the bulk hydraulic properties of the deep residuum and bedrock." This is consistent with TM-2.

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52.	Sect. 8.1 pg 8-2 last para	**Summary and Conclusions** *"The investigation included...conducting seven walkdowns (both wet and dry season) of surface water drainages within the CBCV site."* Correct this sentence and the one on p. 8-3 to indicate there were six walkdowns.	As noted in the responses to Specific Comments 6 and 21, the six stream walkdowns are described in Appendix A.
53.	Sect. 8.1 pg 8-3 3rd full para	**Summary and Conclusions** *"D-10W...exhibits no flow approximately 25 percent of the year. However, all drainages had periods of no flow during the dry season."* Revise these sentences to be consistent with Section 5.2 and Table 5.1 (p. 5-4). Section 5.2 says, *"There have been periods where flumes SF-1 and SF-3 on NT-11 recorded no flow. However, SF-2, located between SF-1 and SF-3, showed low flows during those same periods."* Although a footnote on Table 5.1 says the minimum flows for two streams (0.1 gpm) are "essentially no flow," the minimum flow at the middle station on NT-11 is 0.7 gpm. Moreover, the stream walkdown results in Appendix A indicate the presence of water in each tributary, even during the dry season. TDEC acknowledges some locations had no water, or the water was too shallow to measure temperature, pH, and specific conductance. However, Section 5.2, Table 5.1, and Appendix A document that no channel was completely dry during any of the walkdowns.	Please see response to Specific Comment 3. As noted, continuous flow is not present in drainages at all times of the year.