VIA e-mail to

Administrator Michael S. Regan
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue NW
Washington, D.C. 20004
Regan.Michael@epa.gov

Date: February 28, 2024

Subject: Department of Energy (DOE) Oak Ridge Reservation (ORR), Tennessee
Environmental Management Disposal Facility (EMDF)
September 30, 2022, Record of Decision

Dear Administrator Regan:

On September 30, 2022, you, as the Administrator of the Environmental Protection Agency (EPA), signed and approved the Oak Ridge Environmental Management Disposal Facility (EMDF) Record of Decision (ROD).[1] The EMDF ROD selects a remedial action that does not require measures to ensure that EMDF will comply with federal law. The ROD, approved under authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), does not ensure human health protection consistent with requirements of CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The ROD states that the proposed radioactive, toxic, and hazardous waste disposal facility will not pose an unacceptable risk to human health and the environment during operations or after closure. However, the administrative record reveals that CERCLA methodology was not used to impose limits on either waste acceptance or wastewater discharges. Instead, the ROD refers to possible post-ROD studies to demonstrate compliance with CERCLA and the NCP.[2] Since this ROD was signed and approved by the EPA Administrator, it sets a bad precedent of allowing approval of CERCLA decisions without first demonstrating that the chosen remedial actions comply with CERCLA and the NCP including meeting NCP threshold criteria.[3] This precedent applies to both federal facility and non-federal facility CERCLA National Priority List (NPL) sites.[4]

The impetus for this letter is to request that you correct the EMDF ROD you signed, as EPA Administrator, so that it ensures (1) protective wastewater discharge criteria for current and future generations, (2) waste acceptance criteria (WAC) that will protect future generations, and (3) selection and implementation of a remedial action that complies with federal law and regulations. We also request that you end the culture of non-compliance associated with CERCLA waste disposal at the DOE Oak Ridge Reservation (ORR).

---

[1] Record of Decision for Comprehensive Environmental Response, Compensation, and Liability Act Oak Ridge Reservation Waste Disposal at the Environmental Management Disposal Facility, Oak Ridge, Tennessee (DOE/OR/01-2794&D2/R2) signed by EPA Administrator Michael S. Regan on September 30, 2022.

[2] For example, EMDF ROD Section 2.12.2.3, page 2-50 includes: *"DOE has completed the [Performance Assessment (EMDF PA) / Composite Analysis (EMDF CA)] process to demonstrate protectiveness with methodologies described within DOE Orders; a supplemental analysis will be performed to demonstrate protectiveness using CERCLA Methodology."*

[3] 40 CFR § 300.430(f)(1)(i)(A).

[4] CERCLA 120(a)2.

The mercury management approach on ROD pages 2-63 and 2-64 specifies that EPA and Tennessee Department of Environment and Conservation (TDEC) *"concurrence on the final ROD reflects final agreement on the approach."* The mercury management approach in the ROD you signed, as EPA Administrator, violates CERCLA[5] and certain Clean Water Act (CWA) applicable or relevant and appropriate requirements (ARARs), without ARAR waivers or exemptions, at what may be one of the more mercury contaminated sites in the county, if not the world. This establishes a bad precedent for mercury discharges that cannot be undone without amending the EMDF ROD.

Additionally, as discussed in a November 4, 2021, letter[6] to you from retired state of Tennessee employees, the Environmental Management Waste Management Facility (EMWMF), which currently accepts CERCLA generated waste, has already established a precedent of noncompliant disposal practices in Oak Ridge. Ongoing discharges to surface water are illegal under two laws you – as the head of the Agency -- are responsible for. They are illegal because release of pollutants such as mercury and PCBs are not covered by either a Clean Water Act (CWA) permit (so they are in violation of CWA section 301(a)) or authorization in an EMWMF ROD amendment that was functionally equivalent to a CWA permit (per CERCLA section 121(e)(1)). Discharges of radionuclides are also not authorized in an EMWMF ROD amendment that sets compliant and protective discharge criteria. This non-compliance began in 2002 by a DOE contractor discharging landfill wastewater into Bear Creek due to failure of water management during an extreme rain event. In 2006, the EMWMF contractor pled guilty in federal court to unlawfully discharging EMWMF refuse (e.g., landfill wastewater containing radionuclides) into a waterway without a permit.[7] While a focused feasibility study (FFS)[8] process was performed to establish effluent discharge criteria for EMWMF and EMDF under CERCLA, illegal discharges from EMWMF into Bear Creek continue to this day.

EMWMF was also expanded over a gaining tributary to Bear Creek. An underdrain was installed under Cell 3 to transmit groundwater from under the landfill to a surface stream. This violated radioactive[9] and toxic[10] waste applicable or relevant and appropriate requirements (ARARs) specified in the EMWMF ROD and this discharge to surface water continues.

Even though the FFS was approved on September 6, 2022, data collection necessary to support setting water quality-based effluent limits (WQBELs) for CWA pollutants and radionuclides and determining antidegradation requirements for CWA pollutants is not evident in DOE's public environmental database[11] and discharge from the underdrain continues to violate EMWMF ROD ARARs. **We request that EPA promptly bring EMWMF into compliance.**

---

[5] CERCLA 121(d)

[6] The referenced letter is available on the Advocates for the Oak Ridge Reservation (AFORR) website at https://aforr.info/wp-content/uploads/2023/10/Letter-to-EPA-Administrator-Regan-from-former-TDEC-employees-Nov-4-2021.pdf .

[7] This is documented in the EPA Office of the Inspector General, May 2007 Semiannual Report to Congress (EPA-350-R-07-002).

[8] Focused Feasibility Study for Water Management for the Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee, 7/25/2022 DOE/OR/01-2664&D4/R1 (FFS) is the approved version of the FFS.

[9] TDEC 1200-2-11-.17(1)(h) later renumbered TDEC 0400-20-11-.17(1)(h) requiring: *"The hydrogeologic unit used for disposal shall not discharge groundwater to the surface within the disposal site."*

[10] TSCA at 40 CFR § 761.75(b)(3) requiring: "*There shall be no hydraulic connection between the site and standing or flowing surface water."*

[11] Oak Ridge Environmental Information System or OREIS.

The EMDF ROD relies on a flawed dispute resolution decision for the FFS by former EPA Administrator Andrew R. Wheeler (Wheeler Decision)[12] to set in-stream surface water "PRG/Cleanup Levels" for radionuclides in ROD Table 2.9. There are existing levels of PCB-1260 and other carcinogens in Bear Creek that already appear to cause the existing baseline cancer risk to exceed the NCP acceptable 10^{-4} to 10^{-6} cancer risk range without taking into account any future discharges from EMDF.[13] (See Attachment 5 for PCB-1260.) Instead of the February 2017 Remedial Investigation / Feasibility Study (RIFS) for the EMDF remedial action performing a baseline risk assessment, it referred the risk evaluation for the Bear Creek Valley to the outdated, twenty-year-old March 1997 "*Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*" (DOE/OR/01-1455/V1&D2) that predates the EMWMF. Volume 1, Table 5.3 (page T-74) of that report includes mercury, PCB-1254, and PCB-1260 as chemicals of concern for recreational use ingestion of fish. According to that report, PCB-1260 measured in 35 samples had a 95% UCL concentration of 0.89 ug/g in fish and calculated a cancer risk of $2.2X10^{-3}$ from ingestion of fish. The report also included a hazard quotient of 28 from PCB-1254 and a hazard quotient of 9.6 from mercury by the fish ingestion exposure pathway. DOE's annual Remediation Effectiveness Report[14] includes figures with mean concentrations of PCBs in fish and minnows at several locations in Bear Creek but does not include the excess lifetime cancer risk (ELCR) from ingestion of fish contaminated with PCBs calculated with CERCLA methodology or the cumulative ELCR from all carcinogenic chemicals and radionuclides. Bear Creek is listed on the EPA Approved List of Impaired and Threatened Waters (aka, the 303(d) list) and a "Fish should not be eaten" posting of Bear Creek[15] for PCBs by the Tennessee Department of Environment and Conservation (TDEC) also confirms PCBs were identified as posing greater than a 10^{-4} cancer risk from fish consumption[16] prior to the Wheeler Decision.[17]

The Wheeler Decision notes that cleanup levels for discharges of carcinogens cannot be less stringent than the CERCLA risk range and allows setting in-stream ambient water quality equivalent criteria for individual radionuclides at the 10^{-5} cancer risk level but does not specify how other

---

[12] EPA Administrator Andrew R. Wheeler's December 31, 2020, final decision letter to Mr. John A. Mullis II (DOE) and Commissioner David W. Salyers (Tennessee Department of Environment and Conservation or TDEC) resolving the dispute regarding the Focused Feasibility Study for Water Management for the Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee.
https://www.tn.gov/content/dam/tn/environment/remediation/documents/orr/emdf-docs/rem_emdf-ffs-wm-decision-epa-dispute-resolution_12-31-2020.pdf .

[13] An estimate of existing cancer risk in Bear Creek based on PCB-1260 concentrations in fish on the order of $1.2X10^{-4}$ to $3.9X10^{-4}$ is included in Attachment 5. ROD page 3-411 public comment endnote iii also includes that an existing $1.27X10^{-4}$ cancer risk from PCBs was determined with input variables used to calculate ROD Table 2.9. (See Attachment 5.)

[14] *2023 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee, Data and Evaluations*, March 1,2023 (DOE/OR/01-2938&D1) at https://doeic.science.energy.gov/uploads/A.0100.064.2830.pdf.

[15] https://www.tn.gov/content/dam/tn/environment/water/watershed-planning/wr_wq_fish-advisories.pdf

[16] TDEC Rule 0400-40-03-.03(4)(l) *A public fishing advisory will be considered when the calculated risk of additional cancers exceeds 10-4 for typical consumers or 10-5 for atypical consumers (See definition). A "do not consume" advisory will be issued for the protection of typical consumers and a "precautionary advisory" will be issued for the protection of atypical consumers.*

[17] TDEC's March 31, 2016, letter from Mr. Randy Young to DOE's Mr. John Michael Japp invoking informal dispute for the Focus Feasibility Study for Water Management informed DOE that "*TDEC is preparing to post Bear Creek for fish consumption due to levels of mercury and PCBs in fish.*"
A picture of a TDEC sign at a Bear Creek greenway bridge stating "These fish should not be eaten" was taken on February 11, 2020. This picture is included in Attachment 3.
A Knoxville News Sentinel article concerning TDEC posting of Bear Creek, referenced on page 1-4 of the ROD, may be found at:
https://www.knoxnews.com/story/news/local/2016/05/25/state-posts-fish-advisory-on-bear-creek/90988230/

requirements should be met. The Wheeler Decision incorrectly allows DOE to undermine the NCP's cancer risk range provisions by permitting the future EMDF wastewater discharges to ignore the cumulative exposure and cancer risk from those discharges plus existing carcinogens in Bear Creek. The NCP requirement at 40 C.F.R. § 300.430(e)(2)(i)(A)(2) requiring that the 10^{-6} cancer risk level point of departure shall be used to establish remediation goals[18] is applicable to Bear Creek and was not mentioned in the Wheeler Decision. (See Attachment 6 for the 10^{-6} point of departure.) The ROD you signed and approved fails to comply with 40 C.F.R. § 300.430(e)(2)(i)(A)(2) to establish protective in-stream "PRG/Cleanup Levels". **We request that you reconsider the Wheeler Decision and ensure the dispute resolution complies with CERCLA and the NCP.**

The FFS dispute determined that technology based effluent limits (TBELs), WQBELs, and antidegradation are applicable to Clean Water Act (CWA) pollutants like PCBs and mercury, but incorrectly determined that only WQBELs are relevant and appropriate for discharges of radionuclides. Thus, the Wheeler Decision incorrectly determined that neither TBELs nor antidegradation are relevant and appropriate for CERCLA-authorized discharge of radionuclides to surface water.[19]

The ROD includes a basis for setting limits on pollutants in discharges of landfill wastewater but defers the establishment of numerical limits to post-ROD activities. ROD Table 2.9 lists in-stream surface water and fish tissue "PRG/cleanup levels" for 21 radionuclides. As discussed in a public comment beginning on ROD page 3-368 (e.g., #17), the values in Table 2.9 were calculated using assumptions and parameter choices that are subject to much uncertainty. Response to this comment describes DOE defense-in-depth, including treating all landfill wastewater to protective levels. However, discharge limits developed from the in-stream "PRG/cleanup levels" in Table 2.9 to ensure protection of surface water quality (WQBELs) will incorporate these uncertainties. Further, detection limits for some radionuclides are too high to verify compliance with ARARs and the list of 21 radionuclides in ROD Table 2.9 does not account for all radionuclides that may be released. Treating to TBELs would at least ensure protection of human health to levels consistent with the best available demonstrated control technologies. **We request that you reconsider and fix the Wheeler Decision's incorrect and non-protective determination that TBELs and antidegradation are not relevant and appropriate for CERCLA-authorized discharge of radionuclides to surface water.**

The NCP requires that overall protection of human health and environment[20] and compliance with ARARs are threshold criteria that must be met.[21] The ROD does not present convincing evidence or

[18] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure. 40 C.F.R. § 300.430(e)(2)(i)(A)(2).

[19] "The Oak Ridge Cleanup: Protecting the Public or the Polluter" by Charles Openchowski in the journal *Environmental Law Reporter* (Vol. 53, Issue 3 (March 2023), pp. 10188-10211).

[20] ***Overall protection of human health and the environment.*** *Alternatives shall be assessed to determine whether they can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposures to levels established during development of remediation goals consistent with [40 CFR] § 300.430(e)(2)(i). Overall protection of human health and the environment draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs*. 40 CFR § 300.430(e)(9)(iii)(A).

[21] 40 CFR § 300.430(f)(1)(i)(A).

arguments that the remedial action can provide overall protection of human health and the environment and compliance with ARARs. For example, the Mercury Management Approach[22] and the PCB Management Approach[23] violate CWA ARARs and the ROD does not include waivers. (See Attachment 5.) With the large number of carcinogenic CWA pollutants and radionuclides and the ARAR[24] not being sufficiently protective, the NCP requires utilizing a 10^{-6} point of departure to ensure the NCP-required risk range is met.[25] (See Attachment 6.) The ROD misrepresents remedy performance beginning on page 2-52 based on the DOE Performance Assessment (PA).[26] For example, the PA includes a bathtub scenario that does not support the remedy performance conclusion in the ROD. Instead of including it, the ROD defers the bathtub scenario to a post-ROD supplemental analysis.[27] (See Attachments 1 and 2.) Waste lot concentration limits in ROD Table 2.7 based on the intruder analyses are set at $2X10^{-3}$ excess lifetime cancer risk (ELCR). (See Attachment 1.) The ROD ignores protection of young children who may play in Bear Creek. (See Attachment 7.) Etc. **We also request that you prioritize protection of human health and water resources and reconsider your unsupported, incorrect determination that the EMDF ROD complies with CERCLA and the NCP.**

Post-closure overall protection of human health and the environment at Oak Ridge disposal sites will be determined by limits on the nature of the waste to be disposed (Waste Acceptance Criteria or WAC). If DOE's estimate in the EMDF ROD is correct, then release of leachate from EMDF may not begin until about 250 years after landfill closure. Similarly, DOE estimates in the EMDF PA that release of leachate may begin between 310 and 575 years after landfill closure. The EMDF PA also estimates release of leachate to groundwater and/or surface water will increase as the cover deteriorates. Comparing EMDF PA Table C.5 estimates of radionuclides in Bear Creek surface water with "PRG/Cleanup Levels" for radionuclides in surface water in ROD Table 2.9 shows that DOE projects that radionuclides released from EMDF to surface water will exceed recreational use ARARs for protection of human health soon after EMDF begins leaking and that the cancer risk will increase as EMDF continues to deteriorate. PA Table C.5 does not include radioactive decay products. Attachment 2 includes radioactive decay of uranium-234 (half-life of about 246,000 years) and ingrowth of daughter products including radium-226, lead-210, and polonium-210. Justification[28] for the exemption from Tennessee Radiological Health Rule 0400-20-11-.17(1)(h) requires limiting WAC and final radionuclide inventories so that radioactive decay during containment will reduce contamination in the landfill to levels that ensure the eventual migration of radionuclides to groundwater and surface water will not cause CERCLA[29] and NCP protectiveness standards and EMDF Remedial Action Objectives[30] to be exceeded. The example given in the ROD is that there

[22] EMDF ROD pages 2-63 and 2-64.
[23] EMDF ROD pages 2-64 and 2-65.
[24] TDEC 0400-40-03-.03(4)(j) Footnote (c).
[25] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure. 40 C.F.R. § 300.430(e)(2)(i)(A)(2).
[26] Performance Assessment for the Environmental Management Disposal Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee, April 23, 2020 (UCOR-5094/R2).
[27] ROD pages 2-60 and 2-61.
[28] EMDF ROD pages 2-81, 2-82, and 2-83.
[29] CERCLA 121 (d).
[30] EMDF ROD page 2-23. MCLs are also referenced on EMDF ROD pages 1-4 and 2-21.

would be time sufficient for radionuclides with half-lives of 30 years or less to decay 8 half-lives. ROD Table 2.5 presents numerous radionuclides in the estimated radionuclide inventory with half-lives that will undergo little decay during containment. (See Attachment 2.) **We call on you to amend the ROD you signed and issue a new ROD that ensures the EMDF remedial action timely attains and maintains (1) overall protection of human health and environment consistent with the NCP and EPA guidance, (2) compliance with CERCLA, the NCP, ARARs, and EPA guidance, and (3) compliance with grounds specified in the ROD for invoking ARAR waivers or exemptions to the extent you believe, based on sound science, that the waivers or exemptions are protective of human health and the environment.**

DOE has not provided the public with an opportunity to comment on a complete public record consistent with CERCLA, the NCP, and EPA guidance. Public comments to date have been based on incomplete information because decisions about limits on both waste acceptance and wastewater discharge were deferred to post ROD supplemental analysis or future Federal Facility Agreement (FFA) documents. Response to comments did not adequately address key issues of protectiveness that depend on these determinations. (See Attachment 7). Consistent with EPA's longstanding regulations, guidance, and public statements committing the Agency to meaningful public participation in EPA decision-making, **we call on you to ensure complete information is made available to the public and the public is provided an opportunity to review that information and submit comments. If you are sincere about involving interested communities and stakeholders in the decision-making process, we call on you to ensure the FFA parties provide thoughtful responses to the comments and meaningfully address the many concerns that have been raised before effluent limits and waste acceptance criteria are finalized in a process that follows – and doesn't ignore – the NCP and EPA guidance.**

Other than initiating work on a hydrogeologic study - more than a year after the ROD was signed - the DOE November 9, 2023, poster session did not present efforts to perform post-ROD investigations and analyses referenced in the text of the ROD and to which responses to public comments were deferred. We used the administrative record and publicly available environmental data for the Oak Ridge Reservation to undertake several regulatory and technical analyses. Attachments to this letter provide more details of some of the analyses we completed. Several of our more important conclusions from these analyses are listed below:

1. **The EMWMF and EMDF RODs need to be officially updated to bring the landfills into compliance with CERCLA and the NCP. This may dictate implementation of actions required to mitigate the potential long term environmental effects of the EMWMF and may impose additional constraints on the design and operation of EMDF.**
2. **ROD signatories affirm on EMDF ROD page 1-8 that the EMDF remedial action meets threshold criteria without requiring that the remedial action protect human health and the environment after the closure of the facility. Based on hydrologic, geologic, and demographic factors, sites on the Oak Ridge Reservation are not suitable for shallow land disposal of radioactive and hazardous waste. Consequently, long term protection of human health and the environment at Oak Ridge disposal sites depends on limiting the nature of the waste to be disposed. Waste lot concentration limits in ROD Table 2.7 based on the intruder analyses are**

set at 2X10^{-3} excess lifetime cancer risk (ELCR).[31] This exceeds the 10^{-4} to 10^{-6} NCP cancer risk range. Likewise, levels of radionuclides in ROD Table 2.5 (EMDF estimated radionuclide inventory at closure), Table 2.6 (EMDF administrative waste acceptance criteria (WAC)), and Table 2.7 (Summary of EMDF radiological WAC) were not demonstrated protective of human health and water resources (see Attachments 1 and 2)**.**

3. **Deployment of wastewater treatment technologies with very high removal efficiency may be necessary to meet the NCP 10^{-4} to 10^{-6} cancer risk range and CWA ARARs listed in Appendix A of the final ROD for a number of potential contaminants of concern including radionuclides in landfill wastewater discharges. In addition, exclusion of waste containing significant concentrations of certain radioactive and hazardous constituents and operational changes to drastically cut generation of landfill wastewater may be required** (see Attachments 3, 4, 5, and 6)**.**

To evaluate the impact of EMWMF and EMDF on human health, a robust monitoring program is needed. **We therefore call on EPA to establish or require flow monitoring and representative sampling and analyses of surface water and fish downstream of EMDF sufficient to reliably quantify impacts on downstream water uses and people consuming fish. This also includes timely identifying impacts or potential impacts in Bear Creek and/or downstream East Fork Poplar Creek and timely notifying the public of any adverse impacts or potential adverse impacts.**

This letter expresses some of our concerns that the EMDF ROD you signed, as EPA Administrator, fails to comply with CERCLA and NCP requirements including threshold criteria requiring overall protection of human health and environment and compliance with ARARs. This includes failure of the EMDF ROD to include final remediation goals[32] for both (1) landfill wastewater discharges to surface water that are demonstrated to protect current and future generations to CERCLA and NCP human health protectiveness standards, and (2) waste acceptance criteria and waste inventories that are demonstrated to protect future generations and to comply with grounds for ARAR waivers or exemptions. This letter also includes concerns with the history of non-compliance at the EMWMF and your support for the EMDF ROD's continued disregard for CERCLA and NCP requirements.

We look to you to exercise leadership going forward at the DOE Oak Ridge Reservation (ORR) so that all work performed now and, in the future, follows the law and regulations. This includes not only decommissioning and demolition (D&D) of excess buildings and structures, associated waste disposal, and discharges to surface water, but also clean-up of the widespread ORR related contamination necessary to protect current and future generations and that caused ORR to be listed on the EPA National Priority List (NPL) in the first place.

Cosigns for this letter include retired TDEC employees with a cumulative of over 190 years of service to the State of Tennessee, over 230 years of combined environmental experience, and over 120 years of experience with the DOE ORR. Two of the cosigns served as former TDEC Division of Remediation (TnDoR) directors and one cosign served as deputy director of the former TDEC

[31] The intruder analysis is based on 100 mrem/year effective dose. EPA guidance equates 100 mrem/year effective dose to 2X10^{-3} ELCR (Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, August 22, 1997, OSWER No. 9200.4-18, p. 3, at https://semspub.epa.gov/work/HQ/176331.pdf).

[32] 40 CFR § 300.430()(2)(i) requires that: *Final remediation goals will be determined when the remedy is selected*.

Division of Department of Energy Oversight (TnDOEO). TDEC's Division of Remediation is functionally equivalent to EPA's Division of Superfund.

Thank you for your consideration of these requests.

Sincerely,

Robert (Andy) Binford, P.G.
Former TnDoR Division Director and Environmental Fellow

Steve Goins, CPA
Former TnDoR Division Director

Juan Dale Rector, M.S. Biology, Aquatic
Former TnDOEO Deputy Director

Sid Jones, PhD, P.E., P.G.

Gareth J. Davies, B.Sc., M.Sc., Fellow, Geological Society of America

Michael Higgins, P.E.

Howard Crabtree
Former TnDoR EMWMF/EMDF Project Coordinator

Robert Benfield, P.G.

Copies to:

Secretary Jennifer Granholm, Department of Energy, The.Secretary@hq.doe.gov
Senator Thomas R. Carper, Chairperson, Committee on Environment and Public Works
Senator Jeff Merkley, Chair, Subcommittee on Chemical Safety, Waste Management, Environmental Justice, and Regulatory Oversight
Jeaneanne Gettle, Acting EPA Region IV Administrator, Gettle.Jeaneanne@epa.gov
David Salyers, TDEC Commissioner, David.Salyers@tn.gov
Brenda Mallory, Chair, White House Council on Environmental Quality, Brenda.Mallory@ceq.eop.gov
Matthew Lee-Ashley, Chief of Staff, White House Council on Environmental Quality, Matthew.Lee-Ashley@ceq.eop.gov
Justin Pidot, General Counsel, White House Council on Environmental Quality, Justin.Pidot@ceq.eop.gov
Office of Inspector General, U.S. Environmental Protection Agency, OIG.Hotline@epa.gov
Greg Young, TDEC Deputy Commissioner, Greg.Young@tn.gov
John A. Mullis II, Manager, Oak Ridge Office of Environmental Management, Jay.Mullis@orem.doe.gov
Caroline Freeman, Director, EPA Region IV Division of Superfund, Freeman.Caroline@epa.gov
Randy Young, TDEC Federal Facility Agreement Project Manager, Randy.Young@tn.gov
Roger Petrie, DOE Federal Facility Agreement Project Manager, OakRidgeEM@orem.doe.gov
Samantha Urquhart-Foster, EPA Federal Facility Agreement Project Manager, Urquhart-Foster.Samantha@epa.gov
Amanda Garcia, Southern Environmental Law Center, agarcia@selctn.org
Public Employees for Environmental Responsibility (PEER), info@peer.org
Advocates for the Oak Ridge Reservation, advocates.orr@gmail.com
Tennessee Citizens for Wilderness Planning, contact.us@tcwp.org
Jerry Thornton, Chair, Harvey Broome Group Sierra Club, gatwildcat@aol.com

Attachment Contents:

Attachment 1: Inadvertent Human Intrusion Waste Lot Concentration Limits in ROD Table 2.7

- **$2X10^{-3}$ excess lifetime cancer risk (ELCR)**
- **Misrepresentation of Inadvertent Human Intrusion (IHI) Remedy Performance**

Attachment 2: Future releases of radionuclides to surface water and groundwater

- **ROD grounds for exemption from Tennessee Radiological Health Rule 0400-20-11-.17(1)(h)**
- **Example of radionuclide inventory longer half-life radionuclides**
- **Misrepresentation of Release to Groundwater (RGW) Remedy Performance**
- **ROD failure to include the EMDF PA Appendix C Bathtub Scenario**
- **Illustration of the impact of release from EMDF on surface water 1,000 years after closure**
- **Uranium-234 decay**
- **Five Versions of the Remedial Investigation and Feasibility Study (RIFS) preWAC**

Attachment 3: Radionuclide Discharge to Surface Water During EMDF Operations

- **Requirements relevant and appropriate to discharge of radionuclides and WQBELs must ensure water quality criteria are not exceeded.**
- **It has not been demonstrated that factors and assumptions used to develop surface water "PRG/cleanup levels" in ROD Table 2.9 yield results that comply with 40 CFR §122.44(d)(1)(vi)(A).**
- **Several pictures of lower Bear Creek and lower East Fork Poplar Creek downstream of EMDF at a public greenway where fishing is more likely.**
- **Radionuclide flux during landfill operation**
- **Except for limited exceptions (e.g., uranium isotopes), DOE data in OREIS is not available to quantify existing radionuclide fluxes in surface water for calculation of WQBELs.**
- **Lead-210**
- **Some radionuclides are not reliably measured to levels that would be required to establish WQBELs.**
- **Carbon-14 treatment**

Attachment 4: Uranium Isotopes

- **A water quality based effluent limit (WQBEL) for U-238 developed consistent with ARARs should significantly limit discharge of U-238 to Bear Creek and might determine that no additional U-238 may be discharged from EMDF to surface water.**
- **Disposing waste containing uranium isotopes from "Y-12 D&D Remaining Facilities" into EMDF is not demonstrated to be protective of human health.**

Attachment 5: Clean Water Act Pollutants including Mercury and PCBs

- **Clean Water Act (CWA) Pollutant Discharge to Surface Water During EMDF Operation**
- **Technology based effluent limits (TBELs)**
- **Water quality based effluent limits (WQBELs)**
- **Mercury management approach**

- **Fish analysis for methylmercury in Bear Creek**
- **PCB management approach**
- **Antidegradation**
- **Existing levels of PCB-1260 in fish in Bear Creek and an estimate of resulting cancer risk.**

Attachment 6: Mixture of Carcinogenic Chemicals and Radionuclides and the 10^{-6} Point of Departure

Attachment 7: Several post-ROD supplemental analyses identified in the EMDF ROD.

Attachment 8: USGS StreamStats (https://streamstats.usgs.gov/ss/)

Attachments

Attachment 1: Inadvertent Human Intrusion Waste Lot Concentration Limits in ROD Table 2.7:

EMDF ROD waste lot concentration limits based on inadvertent human intrusion in ROD Table 2.7 are set at an excess lifetime cancer risk (ELCR) of $2X10^{-3}$, yet the ROD misrepresents remedy performance[33] by showing in ROD Figure 2.7 that DOE Performance Assessment (EMDF PA)[34] modeling demonstrates the EMDF will protect inadvertent human intrusion to an ELCR between $1X10^{-6}$ and $2X10^{-6}$.

- **$2X10^{-3}$ excess lifetime cancer risk (ELCR):** Waste lot concentration limits in ROD Table 2.7 based on intruder analysis are identical to inadvertent human intrusion (IHI) chronic post-drilling as-disposed single radionuclide soil guidelines (SRSGs) in EMDF PA Table I.3. SRSGs in the EMDF PA are set at 100 mrem/year effective dose.[35] EPA guidance[36] equates 100 mrem/year effective dose to $2X10^{-3}$ ELCR. This exceeds the 10^{-4} to 10^{-6} NCP cancer risk range.[37]

- **Misrepresentation of Inadvertent Human Intrusion (IHI) Remedy Performance:** The ROD discussion of inadvertent human intrusion (IHI) beginning on ROD page 2-52 does not represent IHI waste lot concentration limits in ROD Table 2.7. For example, landfill averages including 630 pCi/g for uranium-234 and 381 pCi/g for uranium-238[38] were used in EMDF PA modeling instead of ROD Table 2.7 waste lot concentration limits of 39,000 pCi/g for uranium-234 and 41,000 pCi/g for uranium-238. The EMDF PA limiting IHI scenario assumes that future residents living at the landfill drill a water well through the waste and then do not use water from that residential water well. Exposure to groundwater in the EMDF PA is evaluated as release to groundwater (RGW) from a well drilled 100 meters from the edge of the waste. EMDF PA IHI exposure occurs through drill cuttings brought to surface during well drilling, which are mixed with garden soils. Independent expert review evaluated the EMDF PA and the impact of using a water well drilled through the waste and determined drill cutting exposure evaluated in the EMDF PA is relatively unimportant compared to the groundwater exposure pathway.[39]

---

[33] EMDF ROD pages 2-52 and 2-53.
[34] Performance Assessment for the Environmental Management Disposal Facility at the Y-12 National Security Complex, Oak Ridge, Tennessee, April 23, 2020 (UCOR-5094/R2).
[35] 100 mrem/year dose is documented on EMDF PA page 14 Table 1.2 and on page I-29. EMDF PA Review Criteria page A-11 specifies inadvertent human intrusion is total effective dose.
[36] Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, August 22, 1997 (OSWER No. 9200.4-18), https://semspub.epa.gov/work/HQ/176331.pdf .
[37] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. 40 C.F.R. § 300.430(e)(2)(i)(A)(2).
[38] EMDF PA Table G-9, EMDF PA page G-32. Also see ROD Table 2.5 for facility average concentrations.
[39] The Tennessee Department of Environment and Conservation (TDEC) contracted radiological waste disposal experts Neptune and Company, Inc. to review the EMDF PA and EMDF Composite Analysis (CA) and to identify major technical concerns. Neptune prepared a report of their review titled A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee, 12 October 2020 (NAC-0131_R1). Neptune and Company included in Performance Assessment Critical Issue 6 on page 22 that *"[t]here is no logical basis for excluding evaluation of groundwater pathways in a Chronic Post-Drilling residential scenario that includes exposure to cuttings from a groundwater supply well. Both of these exposure pathways should be included in this exposure scenario".* Neptune's report included supplemental analyses of inadvertent human intrusion in Appendix B and Neptune's report page 22 also states: "*Doses related*

ROD page 2-53 also includes Fig. 2.7 which represents 2.95 to 3.56 mrem/year effective dose[40] modeled in the EMDF PA for 1,000 years post closure as an excess lifetime cancer risk (ELCR) between $1X10^{-6}$ to $2X10^{-6}$. If 100 mrem/year effective dose equates to $2X10^{-3}$ ELCR[41] and 12 mrem/year effective dose equates to $3X10^{-4}$ ELCR[42], then a modeled effective dose of 2.95 to 3.56 mrem/year based on landfill arithmetic average radionuclide activity concentrations should represent a landfill arithmetic average IHI cancer risk on the order of 6 $X10^{-5}$ to 9 $X10^{-5}$ not $1X10^{-6}$ to $2X10^{-6}$. The cancer risk from mixing drill cuttings in a garden depends on levels of radionuclides in the drill cuttings, not the overall average of radionuclides in the landfill.

The NCP requires evaluating cancer risk as an excess upper bound lifetime cancer risk to an individual. CERCLA methodology calculates this upper bound lifetime cancer risk using the 95% upper confidence level (UCL) of the mean not arithmetic averages.[43] Using CERCLA methodology and calculation of a reasonable maximum exposure, a different ELCR would likely be calculated.

to exposure to drill cuttings, which are the only exposures evaluated in the [inadvertent human intrusion] evaluation for both the R1 and R2 PA, were found to be relatively unimportant in comparison to groundwater pathways exposures" (NAC-0131_R1- page 22).

[40] EMDF PA Appendix I, Section I.5.3 beginning on page I-27.

[41] Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination, August 22, 1997 (OSWER No. 9200.4-18) https://semspub.epa.gov/work/HQ/176331.pdf .

[42] OSWER 9285.6-20 Distribution of the "Radiation Risk Assessment At CERCLA Sites, Q&A" May 2014, Question 35, page 28, at https://semspub.epa.gov/work/HQ/176329.pdf.

[43] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. 40 C.F.R. § 300.430(e)(2)(i)(A)(2).
Supplemental Guidance to RAGs: Calculating the Concentration Term (Publication 9285.7-081), May 1992. https://rais.ornl.gov/documents/UCLsEPASupGuidance.pdf .
95% UCL concentration values may be calculated with EPA ProUCL software.

Attachment 2: Future releases of radionuclides to surface water and groundwater

Post-closure overall protection of human health and the environment at Oak Ridge disposal sites will be determined by limits on the nature of the waste to be disposed. The ROD estimates release of leachate from EMDF beginning about 250 years after closure and the EMDF PA estimates release of leachate due to the bathtub scenario beginning between 310 and 575 years after closure. The EMDF PA also estimates release of leachate to groundwater and/or surface water will increase as the cover deteriorates. With the estimated inventory of radionuclides to be disposed in EMDF shown in ROD Table 2.5 and leachate concentrations and concentrations of radionuclides in Bear Creek surface water shown in EMDF PA Table C.5 bathtub scenario, it is unreasonable to conclude that EMDF will contain radionuclides estimated in the ROD for disposal in EMDF until radioactive decay reduces radionuclides and daughter products to levels where releases to surface water and groundwater will not pose unacceptable risks to human health.

- **ROD grounds for exemption from Tennessee Radiological Health Rule 0400-20-11-.17(1)(h):** This justification[44] for the exemption requires limiting Waste Acceptance Criteria (WAC) and final radionuclide inventories so that radioactive decay during containment will reduce contamination in the landfill to levels that ensure the eventual migration of radionuclides to groundwater and surface water will not cause CERCLA[45] and NCP protectiveness standards and EMDF Remedial Action Objectives[46] to be exceeded. The example given in the ROD is for radionuclides with half-lives of 30 years or less. ROD page 2-82 states that this would allow sufficient time for 8 half-lives of radionuclides strontium-90[47] and cesium-137[48]. The ROD estimates about 250 years travel time between the bottom of waste and the water table[49] and the EMDF PA Appendix C bathtub scenario estimates release to groundwater or surface water starting 310 to 575 years after closure.[50] Comparing EMDF ROD Table 2.9 with EMDF PA Table C.5 shows that release of about 1 gallon per minute or less of leachate from EMDF to surface water violates surface water "PRG/cleanup levels" in ROD Table 2.9.[51] Independent expert review also determined that release from the bathtub scenario presented in EMDF PA Appendix C would cause exceedance of maximum contaminant levels (MCLs) in groundwater.[52]
- **Example of radionuclide inventory for longer half-life radionuclides:** ROD Table 2.5 presents the estimated radionuclide inventory at landfill closure. A number of radionuclides listed in this table have long half-lives and will undergo little decay during containment. Examples include 186 curies of plutonium-239 with a half-life of 24,100 years; 198 curies of plutonium-240 with a half-

[44] EMDF ROD pages 2-81, 2-82, and 2-83.
[45] CERCLA 121 (d).
[46] EMDF ROD page 2-23. MCLs are also referenced on EMDF ROD pages 1-4 and 2-21.
[47] Strontium-90 estimated inventory in ROD Table 2.5 is 614 curies and strontium-90 has a half-life of about 29.1 years.
[48] Cesium-137 estimated inventory in ROD Table 2.5 is 7,100 curies and cesium-137 has a half-life of about 30 years.
[49] EMDF ROD Page 2-77 and 2-82.
[50] EMDF PA page C-43.
[51] EMDF PA Table C.5 assumes 1.08 gpm release at 1,000 years is diluted in an average Bear Creek flow.
[52] Neptune and Company, Inc.'s 12 October 2020 report titled *A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee* (NAC-0131_R1), Section 2.1.2, pages 15 and 16.

life of 6,560 years; 1.73 curies[53] of carbon-14 with a half-life of 5,700 years; 133 curies of uranium-233 with a half-life of 159,000 years; 2,010 curies of uranium-234 with a half-life of 246,000 years; 127 curies of uranium-235 with a half-life of 704 million years; 28.7 curies of uranium-236 with a half-life of 23.4 million years; and 1,220 curies of uranium-238 with a half-life of 4.47 billion years.

- **Misrepresentation of Release to Groundwater (RGW) Remedy Performance:** The release to groundwater (RGW) scenario analyzed in the EMDF PA assumes that a resident drinks water from a well located 100 meters from the edge of waste. The ROD remedy performance section on page 2-53 evaluates risk due to release of radionuclides to groundwater based on selected portions of the EMDF PA only, not the complete administrative record. Page 2-53 of the ROD reports the results of EMDF PA modeling for release to groundwater, concluding that only carbon-14, technetium-99, and iodine-129 contribute significantly to calculated dose within 10,000 years post-closure. However, the administrative record includes a report generated through an independent expert review of the EMDF PA. This report identifies significant flaws in groundwater and transport modeling in the EMDF PA and cites the results of many field studies done by researchers at Oak Ridge that show much more rapid transport of contaminants through groundwater than EMDF PA modeling predicts.[54] ROD remedy performance fails to acknowledge and address disagreements on modeling results between the EMDF PA and the

[53] EMDF PA Table G.9 and related discussion on page G-33 estimate leaching and release of carbon-14 to surface water during landfill operations. Based on EMDF PA Table B.6 and ROD Table 2.5, an estimated 4.53 curies of carbon-14 from Oak Ridge National Laboratory (ORNL) may be released during landfill operations. Averaged over a 26-year operational period, release of 4.53 curies equates to an average release on the order of 331,490 pCi of carbon-14 per minute.

[54] A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee, 12 October 2020 (NAC-0131_R1) includes for example:

(1) Neptune and Company, Inc.'s report Executive Summary includes: *"The EMDF PA "base case" radionuclide transport and dose assessment modeling is bounded by assumptions rather than structured to evaluate mechanistic modeling of all applicable events and processes. This leads to inaccurate and incomplete modeling based on these constraining assumptions. Natural processes that will compromise the ability of the EMDF to isolate contaminants from the environment are either not incorporated into the base case modeling (e.g. gully erosion, "bathtubbing") or they are artificially constrained without supporting rationale (e.g. a twofold linear increase in infiltration up to year 1000, and no further cover degradation after that time).*

(2) Neptune and Company, Inc.'s report Executive Summary includes: *"Contaminant fate and transport modeling does not adequately represent the natural system. The PA does not address plausible fate and transport pathways including groundwater fracture flow, sheet and gully erosion of the cover, uptake of subsurface radionuclides by deep-rooted plants, and deposition of radon progeny in the cover from the upward diffusion of radon. One example is underprediction of times of travel for contaminants in groundwater. Studies conducted over decades in Oak Ridge have shown that many radionuclides migrate readily through the fractured rocks in Bear Creek Valley. The errors made in solute transport modeling result in the PA's conclusion that a member of the public consuming water or fish in the vicinity of the facility throughout the next millennium would receive a radiation dose from just one isotope, Carbon-14. The transport models should be calibrated using available results from the many field scale tracer tests that have been conducted in Oak Ridge and supplemented with models that incorporate the physics of solute transport in fractured media. Model predictions should be checked against Oak Ridge environmental monitoring data that yield independent estimates of travel times for many radionuclides."*

(3) Neptune and Company, Inc.'s report page 18 includes*: "Likewise, proper assignment of partition coefficients to radionuclides present in waste as different chemical species may require modeling desorption from waste for each chemical species separately or a probabilistic approach rather than using an average value. Uranium is likely to be present in waste both as uranium metal and as uranium salts. While metal pieces of uranium will be quite inert, uranium salts and other uranium compounds can be quite soluble and may migrate readily as hexavalent uranium complexed with anions commonly found in groundwater. The K_d values of 50 ml/g assumed for uranium in the PA will not be appropriate for the fraction of uranium disposed in these more mobile forms."*

independent review. These concerns were submitted by TDEC to DOE about October 15, 2020.[55] Similar concerns were also submitted during public comments on the EMDF. Responses to comments defer addressing these concerns to a supplemental analysis in the WAC Compliance Plan.[56]

- **ROD failure to include the EMDF PA Appendix C Bathtub Scenario:** EMDF PA Appendix C included a release scenario due to bathtubbing of leachate in the landfill. This scenario was not used to evaluate long term protectiveness of EMDF in either the PA or ROD. If it had been included, neither the EMDF PA nor the ROD would have been determined protective of groundwater.[57] Further, the ROD would not have been determined protective of surface water.[58] The ROD excluded the EMDF PA bathtub scenario from determination of remedy performance and deferred the bathtub scenario to a post-ROD supplemental analysis.[59]
- **Illustration of the impact of release from EMDF on surface water 1,000 years after closure.** The EMDF ROD[60] limits post closure protection of human health and environment to 1,000 years consistent with DOE Order 435.1 without listing the 1,000-year compliance period specified in DOE Order 435.1 as an ARAR for EMDF.

  Facility average concentrations in EMDF ROD Table 2.5 and the source as disposed concentrations in EMDF PA Table C.5 are similar. Based on analysis of source leachate concentrations in EMDF PA Table C.5, overall protection of human health and environment for 1,000 years post closure is unlikely.

---

[55] Letter dated October 15, 2020, from Mr. Randy C. Young (TDEC) to Dr. Justin Marble and Mrs. Sherri Ross (DOE) concerning "Review of Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee.
https://www.tn.gov/content/dam/tn/environment/remediation/documents/orr/emdf-docs/rem_emdf-paca-tdec_10-15-2020.pdf .

[56] For example, comment 5 on EMDF ROD pages 3-320 and 3-321 referenced issues identified in Neptune and Company, Inc's report titled *A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee Dated 12 October 2020* (NAC-0131_R1). Response to this comment included: *"The EMDF PA incorporated both sensitivity and uncertainty analyses to address these types of issues. DOE has completed the PA/CA process to demonstrate protectiveness with methodologies described within DOE Orders; a supplemental analysis will be performed to demonstrate protectiveness using CERCLA methodology. The supplemental analysis in the WAC Compliance Plan will address concerns/uncertainties associated with setting WAC derived from the PA."*

[57] Neptune and Company, Inc.'s 12 October 2020 report titled *A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee* (NAC-0131_R1), Section 2.1.2, pages 15 and 16. Using the radionuclide flux and dilution factors given in Appendix C, Neptune determined that if the EMDF PA had included the bathtub results when evaluating facility performance, EMDF PA performance objectives for protection of groundwater resources, including maximum contaminant levels (MCLs), would not have been met.

[58] EMDF PA Table C.5 calculated concentrations of radionuclides in Bear Creek surface water released pursuant to the EMDF PA bathtub scenario at 310 years after closure, 575 years after closure, and 1000 years after closure. Comparison of EMDF PA Table C.5 with EMDF ROD Table 2.9 predicts levels of carbon-14, plutonium-238, plutonium-239, and plutonium-240 in Bear Creek surface water will exceed in-stream surface water "PRG/cleanup levels" listed in EMDF ROD Table 2.9.

[59] EMDF ROD page 2-60 and 2-61.

[60] EMDF ROD pages 2-57 and 2-59 reference a 1,000-year post closure compliance period consistent with DOE Order 435.1. This is inconsistent with EPA National Remedy Review Board (NRRB) Recommendations concerning EMDF in a letter dated April 4, 2017, from Amy R. Legare, NRRB Chair, to Franklin E. Hill, EPA Region 4 Superfund Director. The NRRB specifies that CERCLA protectiveness standards including 10^{-4} to 10^{-6} cancer risk range, hazard index (HI) of 1, or ARARs apply for extended time periods considered part of the CERCLA evaluation.

The following table is an illustration of the radionuclide flux that may be released from EMDF at 1,000 years after closure and the in-stream flux that may equate to $1X10^{-5}$ recreational use cancer risk. Assumptions are included in notes following the table.

Comparison of EMDF Discharge at 1,000 years with Bear Creek and East Fork Poplar Creek Recreational Use $1X10^{-5}$ Cancer Risk Radionuclide Flux at 30-day 5-year flow

Isotope	Half-Life in Years (EMDF PA Table C.5)	Average Leachate Activity at 1,000 years after closure (EMDF PA Table C.5) Also includes U-234 decay (pCi/L)	Rad flux released to Bear Creek at 1.08 gpm at 1,000 years (pCi/min)	Rad flux released to Bear Creek at 8.6 gpm at 1,000 years (pCi/min)	In-stream Radionuclide Flux in Bear Creek at EMDF equivalent to Recreational Use $1X10^{-5}$ ELCR without daughters except as noted, 2015 IAEA BCF (pCi/min)	In-stream Radionuclide Flux in East Fork Poplar Creek at Poplar Creek equivalent to Recreational Use $1X10^{-5}$ ELCR without daughters except as noted, 2015 IAEA BCF (pCi/min)
Carbon-14 (^{14}C)	5730	2170	8,871	70,643	44	736
Cesium-137 (^{137}Cs)	30				94	1,575
Iodine-129 (^{129}I)	15,700,000	158	646	5,144	151	2,542
Potassium-40 (^{40}K)	1,280,000,000	215	879	6,999	37	622
Lead-210 (^{210}Pb) includes Polonium-210 (^{210}Po)	^{210}Pb 22.3	40.6 Decay of U-234[61]	166	1,322	4	69
Plutonium-238 (^{238}Pu)	87.7	1.72	7	56	251	4,218
Plutonium-239 (^{239}Pu)	24,100	2,800	11,447	91,152	244	4,097
Plutonium-240 (^{240}Pu)	6,540	2,760	11,284	89,850	244	4,097
Plutonium-241 (^{241}Pu)	14.4				18,624	312,920
Radium-226 (^{226}Ra) includes ^{210}Pb and ^{210}Po	1600	0.346 from Table C.5 plus 43.1 from decay of U-234	178	1,414	4	68
Strontium-90 (^{90}Sr)	29.1				578	9,710
Uranium-234 (^{234}U)	245,000	24,900	101,797	810,606	6,226	104,601
Uranium-238 (^{238}U) includes Thorium-234 (^{234}Th)	^{238}U 4,470,000,000	15,100	61,732	491,572	1,205	20,245

[61] Pb-210 and Ra-226 at 1,000 years are calculated from decay of initial activity of U-234 using the decay chain tool at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/chain.pl

Table Notes:

1.0 Recreational use in-stream radionuclide flux was calculated at $1X10^{-5}$ target cancer risk level with an exposure duration of 70 years, exposure frequency of 365 days/year, ingestion rate of 22 grams per day, fraction ingested of 1, and 30-day 5-year stream flow. It is assumed that institutional controls are not viable 1,000 years into the future.

2.0 2015 IAEA BCF refers to International Atomic Energy Agency (IAEA) April 2015 Summary table of freshwater to fish transfer values available at www.wildlifetransferdatabase.org. See ROD public comments page 3-369 and 3-370. These freshwater to fish transfer factors are in L/kg.
The analysis used 2015 International Atomic Energy Agency (IAEA) bioconcentration factors (BCF) or freshwater to fish transfer factors instead of 2010 IAEA BCF values used in development of ROD Table 2.9.

3.0 30-day 5-year flow calculated from USGS StreamStats. See Attachment 8.

4.0 EMDF PA Figure C.12 shows an infiltration rate of about 0.1 inches per year when the bathtub scenario may begin leaking to surface water about 310 years after closure and Figure C.12 and PA page C-45 estimates an infiltraton rate of 0.88 inches per year at 1000 years and after 1,000 years. The EMDF PA page C-43 states that an infiltration rate of 0.88 inches per year yields a discharge rate of 1.08 gpm. An EMDF release at 1.08 gpm was included in the above table.

5.0 EMDF PA page C-37 states: *Uncertainty in using the HELP model to predict long-term hydrologic performance of the EMDF cover system is due in part to the difficulty of specifying representative degraded-condition hydraulic conductivity (K) values based on very limited understanding of the long-term performance evolution of earthen barriers and engineered drainage systems. The degree of degradation of clay barrier performance and increased cover infiltration that could occur due to natural processes over hundreds of years (assuming stable climate conditions) is plausibly bounded by the estimated range of natural annual average rates of recharge to groundwater in BCV, estimated at 7 to 12 in./year (DOE 1997, Volume 2, Appendix F, pages F-36 and F-40).*
The EMDF PA page C-43 states that an infiltration rate of 0.88 inches per year yields a discharge rate of 1.08 gpm. Therefore, an infiltration rate of 7 inches per year yields a discharge of about 8.6 gpm. An EMDF release at 8.6 gpm was also included in the above table.

6.0 EMDF PA Table C.5 includes decay of radionuclides but not ingrowth of daughter products. Ingrowth of daughter products or progeny can significantly change the outcome of the analysis. The above table included decay of uranium-234 at 1,000 years with ingrowth of radium-226, lead-210, and polonium-210 using the decay chain tool at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/chain.pl .
Ingrowth of lead-210 and polonium-210 may pose an increased ELCR from ingestion of fish contaminated with radionuclides and are therefore included in the above table at 1,000 years. Since the ROD includes lead-210 and polonium-210 with radium-226, it is included above both with radium-226 and as lead-210.

- **Uranium-234 decay.**

Radioactive decay of uranium-234 (U-234) in the following table was calculated by the decay chain tool at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/chain.pl. Initial U-234 source leachate concentration from EMDF PA Table C.5 at closure (T=0) is the initial radioactivity. This illustrates levels of uranium daughters' radium-226, lead-210, and polonium-210 will increase after 1,000 years. Releases to surface water containing these radionuclides will likely continue to impact surface water. The impact on surface water is also likely to increase over time as the landfill continues to deteriorate and ingrowth of daughters continue.

DOE OREIS surface water and EMWMF discharge data indicate a disequilibrium between radium-226 and lead-210 with lead-210 potentially greater than radium-226. This is not shown

in the following table. This disequilibrium may be due to radionuclide solubilities with radon-222 being a soluble gas.

Time (yrs)	U-234	Th-230	Ra-226	Rn-222	Po-218	At-218	Rn-218	Pb-214	Bi-214	Po-214	Tl-210	Pb-210	Bi-210	Po-210
0	25000													
100	25000	23	0.49	0.49	0.49	1E-04	9.81E-08	0.49	0.49	0.49	0.0001	0.273	0.273	0.269
126	25000	28.9	0.774	0.774	0.774	0.0002	1.55E-07	0.774	0.774	0.774	0.0002	0.48	0.48	0.475
158	25000	36.4	1.22	1.22	1.22	0.0002	2.44E-07	1.22	1.22	1.22	0.0003	0.829	0.829	0.822
200	25000	45.8	1.92	1.92	1.92	0.0004	3.85E-07	1.92	1.92	1.92	0.0004	1.41	1.41	1.4
251	25000	57.6	3.03	3.03	3.03	0.0006	6.05E-07	3.03	3.03	3.03	0.0006	2.36	2.36	2.35
316	25000	72.5	4.75	4.75	4.75	0.001	9.50E-07	4.75	4.75	4.75	0.001	3.9	3.9	3.89
398	25000	91.3	7.44	7.44	7.44	0.0015	1.49E-06	7.44	7.44	7.44	0.0016	6.37	6.36	6.35
501	25000	115	11.6	11.6	11.6	0.0023	2.32E-06	11.6	11.6	11.6	0.0024	10.3	10.3	10.2
631	25000	144	18.1	18.1	18.1	0.0036	3.62E-06	18.1	18.1	18.1	0.0038	16.4	16.4	16.4
794	24900	182	28	28	28	0.0056	5.60E-06	28	28	28	0.0059	25.9	25.9	25.9
1,000	24900	228	43.1	43.1	43.1	0.0086	8.62E-06	43.1	43.1	43.1	0.0091	40.6	40.6	40.6
1,259	24900	287	66	66	66	0.0132	1.32E-05	65.9	66	65.9	0.0139	62.9	62.9	62.9
1,585	24900	361	100	100	100	0.02	2.00E-05	100	100	100	0.021	96.5	96.5	96.4
1,995	24900	453	150	150	150	0.0301	3.01E-05	150	150	150	0.0316	146	146	146
2,512	24800	569	223	223	223	0.0446	4.46E-05	223	223	223	0.0468	218	218	218
3,162	24800	713	326	326	326	0.0653	6.53E-05	326	326	326	0.0686	321	321	321
3,981	24700	893	470	470	470	0.0941	9.41E-05	470	470	470	0.0988	465	465	464
5,012	24600	1120	666	666	666	0.133	1.33E-04	666	666	666	0.14	660	660	660
6,310	24600	1400	926	926	926	0.185	1.85E-04	926	926	926	0.194	919	919	919
7,943	24400	1740	1260	1260	1260	0.252	2.52E-04	1260	1260	1260	0.265	1260	1260	1260
10,000	24300	2160	1690	1690	1690	0.338	3.38E-04	1690	1690	1690	0.355	1680	1680	1680
12,589	24100	2680	2220	2220	2220	0.443	4.43E-04	2220	2220	2220	0.466	2210	2210	2210
15,849	23900	3310	2860	2860	2860	0.573	5.73E-04	2860	2860	2860	0.601	2860	2860	2860
19,953	23600	4070	3640	3640	3640	0.729	7.29E-04	3640	3640	3640	0.765	3640	3640	3640
25,119	23300	4970	4570	4570	4570	0.914	9.14E-04	4570	4570	4570	0.96	4560	4560	4560
31,623	22900	6020	5650	5650	5650	1.13	1.13E-03	5650	5650	5650	1.19	5650	5650	5650
39,811	22300	7220	6890	6890	6890	1.38	1.38E-03	6890	6890	6890	1.45	6890	6890	6890
50,119	21700	8560	8270	8270	8270	1.65	1.65E-03	8270	8270	8270	1.74	8270	8270	8270
63,096	20900	9990	9750	9750	9750	1.95	1.95E-03	9750	9750	9750	2.05	9750	9750	9750
79,433	20000	11400	11300	11300	11300	2.25	2.25E-03	11300	11300	11300	2.36	11300	11300	11300
100,000	18900	12800	12700	12700	12700	2.54	2.54E-03	12700	12700	12700	2.66	12700	12700	12700
125,893	17500	13900	13900	13900	13900	2.77	2.77E-03	13900	13900	13900	2.91	13900	13900	13900
158,489	16000	14700	14600	14600	14600	2.93	2.93E-03	14600	14600	14600	3.07	14600	14600	14600
199,526	14200	14800	14800	14800	14800	2.96	2.96E-03	14800	14800	14800	3.11	14800	14800	14800
251,189	12300	14200	14200	14200	14200	2.84	2.84E-03	14200	14200	14200	2.98	14200	14200	14200
316,228	10200	12800	12900	12900	12900	2.57	2.57E-03	12900	12900	12900	2.7	12900	12900	12900
398,107	8130	10800	10900	10900	10900	2.17	2.17E-03	10900	10900	10900	2.28	10900	10900	10900
501,187	6070	8410	8460	8460	8460	1.69	1.69E-03	8450	8460	8450	1.78	8460	8460	8460
630,957	4210	5970	6010	6010	6010	1.2	1.20E-03	6000	6010	6000	1.26	6010	6010	6010
794,328	2660	3810	3830	3830	3830	0.766	7.66E-04	3830	3830	3830	0.805	3830	3830	3830
1,000,000	1490	2140	2150	2150	2150	0.431	0.00043	2150	2150	2150	0.452	2150	2150	2150
Activities for U-234 and progeny where initial activity = 25000 pCi														
Timestamp: 2023-10-20 10:39:47														

- **Five Versions of the CERCLA Remedial Investigation and Feasibility Study (RIFS) preWAC**

  There were 5 versions of the EMDF Remedial Investigation and Feasibility Study (RIFS) and analytical waste acceptance criteria (WAC) that achieve CERCLA and NPC human health protectiveness remain unresolved.

Comparison of preWAC proposed in difference versions of the RIFS					
RIFS Version	**Carcinogenic preWAC**			**Non-Carcinogenic preWAC**	**Comment**
	U-238 (pCi/g)	**U-234 (pCi/g)**	**Pu-239 (pCi/g)**	**Uranium Metal (mg/kg)**	
D1 September 2012	**69,400**	**70,900**	**1,040,000**	**377,000**	**Table F-8**
D2 June 2013	**69,400**	**70,900**	**1,040,000**	**377,000**	**Table F-8 Table F-9**
D3 March 2015	**103,000**	**127,000**	**102,000**	**34,800**	**Table H-11**
D4 March 2016	**3,170**	**3,230**	**927**	**HI of 3 = 52.2*** **	**Table H-10 TableH-12**
D4* March 2016	**$5.75X10^{-3}$**	**$5.86X10^{-3}$**	**$2.19X10^{-3}$**		**Cancer Risk at D4 preWAC based on D4 methodology**
D5 ** February 2017	**35 to 1200**	**35 to 1700**	**7.2 to 720**	**Not Found**	**Table 6-5**

* See TDEC's May 16, 2016, comment letter on the D4 RIFS from Mr. Randy Young (TDEC) to Mr. John Michael Japp (DOE) available at https://doeic.science.energy.gov/uploads/F.0615.028.0040.pdf
TDEC's comment letter evaluated D4 RIFS preWAC and found "preliminary administrative limits" for numerous radionuclides calculated cancer risks using D4 RIFS methodology between $2.6X10^{-2}$and $9.8X10^{-4}$ which are greater than the NCP acceptable 10^{-4} to 10^{-6} cancer risk range.

** The D5 RIFS Table 6-5 bounds Analytic WAC for onsite disposal with low and high ranges. (D5 RIFS page 6-86.)

*** A uranium metal HI of 3 at 52.2 mg/kg converts to about 5.8 pCi/g for U-238 at a hazard quotient (HQ) of 1.[62] This is below the low range given in the D5 RIFS for U-238.

The D5 RIFS was not approved on technical merit by EPA and TDEC and the Proposed Plan was issued through dispute resolution. The Proposed Plan references the D5 RIFS and the ROD summarizes and relies on information from the D5 RIFS.[63] The D5 RIFS includes Figure 6-31 that shows final WAC presented in the WAC Compliance Plan including additional EMDF PA scenarios (such as the PA Appendix C bathtub scenario), appropriate documentation under CERCLA, and then WAC codified in the ROD. This was not done.

[62] Remedial Action Objectives (RAOs) on ROD page 2-23 require limiting exposure to a hazard index (HI) of 1. HI is the cumulative of HQs of individual noncarcinogens. This example evaluates the HQ of only ^{238}U. Taking all isotopes of uranium into account to calculate the combined HI of 1 for uranium metal will lower the ^{238}U activity.
[63] EMDF ROD page iii.

Attachment 3: Radionuclide Discharge to Surface Water During EMDF Operations:

The EMDF ROD requires establishing discharge criteria for radionuclides based on in-stream radionuclide "PRG/cleanup levels" that are demonstrated to attain and maintain narrative water quality criteria and will fully protect the designated use. There is significant uncertainty in "PRG/cleanup levels" and a convincing demonstration was not made. Several examples are given below. ARARs require establishing water quality based effluent limits (WQBELs) and treating or reducing effluent so that water quality standards are not exceeded.[64]

This will likely require robust wastewater treatment technologies that achieve very high removal efficiencies. For example, treating a carbon-14 flux of 92,742 pCi/minute to below 25 pCi/minute, or reducing a plutonium-238 flux from 175,643 pCi/minute to 6 pCi/minute would require extremely high removal efficiencies. (See table below.)

- **Tennessee and EPA NPDES regulations that apply to water quality based effluent limits (WQBELs) and water quality standards establishing classified uses and criteria to protect those uses are relevant and appropriate to discharge of radionuclides and WQBELs must ensure water quality criteria are not exceeded.**
  The ROD specifies that EPA and Tennessee rules and regulations applicable for establishing WQBELs for CWA pollutants are also relevant and appropriate for setting WQBELs for radionuclides. ARAR TDEC 0400-40-03-.03(4)(j) Footnote (c) requires that recreational use criteria are established at 10^{-5} excess lifetime cancer risk (ELCR) and ARAR TDEC Rule 0400-40-03-.05(4)[65] specifies required stream flows at which water quality standards are applied. ARARs also require that radionuclide discharge limits are met at the point of discharge[66] or end of pipe. 40 CFR § 122.44(d)(1)(vi)(A)[67] requires that it must be demonstrated that levels of radionuclides in surface water, used to develop discharge criteria, will attain and maintain applicable narrative water quality criteria and will fully protect the designated use.[68] Classified surface water uses apply from Bear Creek mile 0.0 to the origin of Bear Creek and downstream reaches of East Fork

[64] ARAR TDEC Rule 0400-40-03-.05(6) requires "*that all discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards, or state or federal laws and regulations pursuant thereto, and where appropriate will comply with the "Standards of Performance" as required by the Tennessee Water Quality Control Act, (T.C.A., §§ 69-3-101, et seq.).*"

[65] ARAR TDEC Rule 0400-40-03-.05(4) requires that "*Fish and aquatic life water quality criteria shall generally be applied on the basis of stream flows equal to or exceeding the 7-day minimum, 10-year recurrence interval. All other criteria shall be applied on the basis of stream flows equal to or exceeding the 30- day minimum 5-year recurrence interval*" (emphasis added).

[66] TDEC Rule 0400-40-05-.08(1)(k) requires "*All permit effluent limitations, standards, and prohibitions shall be established for each outfall or discharge point of the permitted facility, except as otherwise provided for BMPs where limitations on effluent or internal waste streams are infeasible.*"

[67] 40 CFR 122.44(d)(1)(vi)(A) requires "*Permitting authority must establish effluent limits using a calculated numeric water quality criterion for the pollutant which the permitting authority demonstrates will attain and maintain applicable narrative water quality criteria and will fully protect the designated use*."

[68] For recreational use, TDEC Rule 0400-40-03-.03(4)(j) requires *"[w]ater shall not contain toxic substances that will render the water unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife*."

Poplar Creek and Poplar Creek.[69] Classified uses apply irrespective of land use controls. ARARs require that all discharges shall receive the degree of treatment or effluent reduction to ensure ambient water quality criteria (AWQC) are not exceeded.[70]

- **It has not been demonstrated that factors and assumptions used to develop surface water "PRG/cleanup levels" in ROD Table 2.9 yield results that comply with 40 CFR § 122.44(d)(1)(vi)(A)**. A process[71] was developed to establish surface water and fish "PRG/cleanup levels". These "PRG/cleanup levels" are included in EMDF ROD Table 2.9. This process assumed a 26-year[72] exposure duration instead of the 70-year exposure duration used by EPA and TDEC water programs. EMDF "PRG/cleanup levels" also assume annual fish consumption equates to an average of 17.5 grams per day instead of EPA water program's current fish ingestion rate of 22 grams per day or 37 +/- 6 grams of fish per day[73] from an Oak Ridge Reservation area site-specific study. Each of these assumptions allow increased release of radionuclides from EMDF to surface water and potentially increases radionuclide exposure to people downstream. The EMDF process also assumes people only consume fish muscle and do not eat other parts of fish.[74] A previous site-specific study interviewed people fishing around Oak Ridge Reservation (ORR) and determined that a very small percentage of people who catch fish adjacent to the ORR might eat whole fish.[75] The study also determined that spouses and children of people who fish adjacent to the ORR might also eat the fish.

  The assumption whether people only eat fish muscle or may also eat other parts of fish affects bioconcentration factors (BCF) and conversion of levels in fish to levels in surface water. BCF values, also called freshwater to fish transfer values, add significant uncertainty to the calculation of levels in surface water that correspond to a specific level in fish. This is demonstrated by the following tables including columns comparing results calculated with geometric means of fish muscle from the International Atomic Energy (IAEA) 2010 Technical Report Series No. 472 *Handbook of Parameter Values for the Prediction of Radionuclide Transfer*

[69] Pursuant to TDEC Rule 0400-40-04-.09 both Bear Creek and East Fork Poplar Creek are classified for fish and aquatic life (FAL), recreation (REC), livestock and wildlife watering (LWW), and irrigation (IRR) from mile 0.0 to their origins. Poplar Creek is classified for these same uses from mile 0.0 to its origin plus industrial water supply from mile 0.0 to 0.5.

[70] ARAR TDEC 0400-40-03-.05(6) requires "*that all discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards, or state or federal laws and regulations pursuant thereto, and where appropriate will comply with the "Standards of Performance" as required by the Tennessee Water Quality Control Act, (T.C.A., §§ 69-3-101, et seq.).*"

[71] *"Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee"*, April 28, 2022 (UCOR-5550).

[72] The exposure duration is based on an assumed EMDF operational life of 26 years. See EMDF ROD page 2-69.
TDEC's (Mr. Randy Young) February 26, 2019, letter to DOE (Mr. John Michael Japp) included that the DOE 2019 planning case included operating the landfill 45 years with final cap construction from 2070 through 2074.
It will also take time for radionuclides to decay or to otherwise no longer be available to the aquatic food web.

[73] EMDF ROD comment page 3-362.

[74] Where available, the process to develop EMDF ROD Table 2.9 levels used fish muscle bioconcentration (BCF) values from International Atomic Energy Agency (IAEA) 2010 Technical Report Series No. 472 *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments.*

[75] Fishing and consumption patterns of anglers adjacent to the Oak Ridge Reservation, Tennessee: higher income anglers ate more fish and are more at risk by Joanna Burger & Kym Rouse Campbell, Journal of Risk Research, ISSN: 1366-9877 (Print) 1466-4461 (Online) Journal homepage: https://www.tandfonline.com/loi/rjrr20, Table 1 includes the mean percent fish eaten that is whole was 1.43 +/- 0.92.

in Terrestrial and Freshwater Environments and results calculated with geometric means from the IAEA April 2015 summary table of freshwater to fish transfer values available at www.wildlifetransferdatabase.org.

ROD Table 2.9 assumes secular equilibrium in grouping some radionuclides based on radioactive decay. This allows reducing the number of radionuclides analyzed. In developing Table 2.9, the EMDF ROD discounted public comments and Oak Ridge Environmental Information System (OREIS) data that did not support this grouping for lead-210 with radium-226. For example, public comment beginning EMDF ROD page 3-375 evaluates radium-226 and lead-210 in EMDF PA Table B.5 and demonstrates that some of the waste to be disposed is not in secular equilibrium. This comment concludes that failure to analyze radionuclides produced or used at the Oak Ridge Reservation due to an assumption the radionuclides are only present as daughter products from radioactive decay underestimates the cancer risk. OREIS also includes EMWMF discharge data and surface water data that do not support the conclusion that radium-226 results adequately incorporate cancer risk from lead-210 and polonium-210. Further discussion of lead-210 is included later in this attachment.

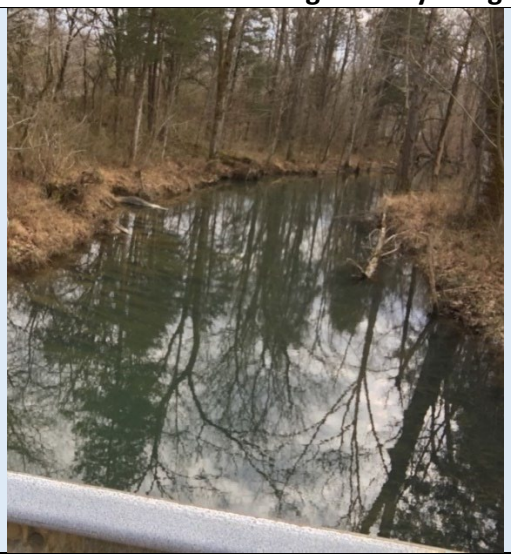
40 CFR § 122.44(d)(1)(vi)(A) requires that it must be demonstrated that levels of radionuclides in surface water, used to develop discharge criteria, will attain and maintain applicable narrative water quality criteria and will fully protect the designated use. This should include all downstream surface water impacted by EMDF discharges. Public comment on EMDF ROD page 3-362 is concerned that EMDF ROD Table 2.9 "PRG/cleanup levels" might be applied to East Fork Poplar Creek, Poplar Creek, and the Clinch River and that assumptions used in developing Table 2.9 are not appropriate to downstream surface water. Response to this comment incorrectly quoted the flawed Wheeler Decision which deemed, without risk assessment, that the *"individual with the potential maximum exposure to radionuclides in effluent from ORR landfills would be a recreational fisherman who fishes Bear Creek, if the fish are contaminated with radionuclides."* The response to comments also references an "applicable Tennessee ARAR" that is not included in the ROD ARAR Table and to our knowledge is not a currently promulgated standard. This response to comments is nonresponsive. The comment references an Oak Ridge Reservation area site-specific-specific study[76] and based on that site-specific study, EMDF ROD Table 2.9 "PRG/cleanup levels" are inappropriate to downstream surface water. Other DOE sources could potentially add to the radionuclide flux in East Fork Poplar Creek (EFPC) downstream of its confluence with Bear Creek. PRG/clean-up levels in the downstream public greenway reaches of Bear Creek and in EFPC should incorporate increased ingestion rates and exposure duration and account for additional sources to demonstrate that the requirements of ARAR 40 CFR § 122.44(d)(1)(vi)(A) are met.

- **Several pictures of lower Bear Creek and lower East Fork Poplar Creek downstream of EMDF at a public greenway where fishing is more likely**. It has not been demonstrated that assumptions

[76] Joanna Burger & Kym Rouse Campbell (2008) Fishing and consumption patterns of anglers adjacent to the Oak Ridge Reservation, Tennessee: higher income anglers ate more fish and are more at risk, Journal of Risk Research, 11:3, 335-350, DOI:10.1080/13669870701795560

used to develop ROD Table 2.9 will attain and maintain applicable narrative water quality criteria and will fully protect the designated use in this area. This area is also subject to other uses and pathways of exposure (e.g., incidental ingestion of uranium as a metal by young children[77] playing in Bear Creek) that were not included in the determination of surface water levels in ROD Table 2.9.

"These Fish Should Not Be Eaten" sign at the first greenway bridge over Bear Creek. Picture taken on February 11, 2020.	**For Public Use and Enjoyment.**
	

Bear Creek from the first greenway bridge.	**Bear Creek from second greenway bridge.**
	

[77] ROD comment page 3-363.

Bear Creek downstream from third greenway bridge.	East Fork Poplar Creek from the greenway.
	

East Fork Poplar Creek upstream of the greenway bridge at Poplar Creek.	East Fork Poplar Creek confluence with Poplar Creek downstream from greenway bridge.
	

- **Radionuclide flux during landfill operation:** The following table illustrates that radionuclide flux discharged from EMDF to surface water during landfill operation could greatly exceed in-stream radionuclide flux equivalent to recreational use $1X10^{-5}$ ELCR[78] and very effective treatment for radionuclides will be needed so that radionuclides discharged from EMDF do not cause

[78] Risk-based water quality standards are calculated at $1X10^{-5}$ cancer risk at stream flows required by ARAR TDEC Rule 0400-40-03-.05(4).

exceedance of ambient water quality criteria (AWQC).[79] The table includes in-stream risk-based radionuclide flux for several radionuclides calculated in Bear Creek near EMDF using EMDF Table 2.9 assumptions and downstream in East Fork Poplar Creek upstream of the confluence with Poplar Creek using standard EPA assumptions. Assumptions are further clarified in the following tables. These risk-based radionuclide fluxes were calculated both assuming people only eat fish filets (ROD Table 2.9 and IAEA 2010 muscle values[80]) and with IAEA 2015[81] updated bioconcentration (freshwater to fish transfer) values. Average landfill leachate activity concentrations at EMDF closure given in EMDF PA Table C.5 are also included in the table and are used to calculate radionuclide fluxes released from EMDF to surface water at the FFS estimated average month discharge flow rate for one landfill cell of 10 gpm[82]. If 3 landfill cells are open, the flux discharged to surface water might be 3 times the flux in the following table. Likewise, the FFS estimates the maximum month discharge rate might be 20 gpm per open cell. East Fork Poplar Creek upstream of the confluence with Poplar Creek receives radionuclides from other sources including Y-12 and the City of Oak Ridge wastewater treatment plant in addition to sources in Bear Creek Valley and identified radionuclide fluxes are not all available to EMDF. The EMDF WQBEL should also ensure the EMDF discharge does not cause exceedance of the in-stream flux downstream in East Fork Poplar Creek downstream of the Bear Creek confluence considering other sources of radionuclides.

Comparison of Radionuclide Flux Released from EMDF with In-stream Radionuclide Flux at 1X10^{-5} cancer risk and ARAR Required Flow. Bear Creek at EMDF is based on EMDF ROD Table 2.9 assumptions. East Fork Poplar Creek at the Confluence of East Fork Poplar Creek and Poplar Creek used alternative assumption specified below. 2010 IAEA BCF assumes people only consume fish muscle (i.e., filets).							
Isotope	**Half-Life in Years (EMDF PA Table C.5)**	**Average Leachate Activity at Closure (EMDF PA Table C.5) pCi/L**	**Rad Flux Released to Bear Creek at 10 gpm at the average leachate activity at closure (pCi/min)**	**In-stream Radionuclide Flux* in Bear Creek at EMDF using ROD Table 2.9 In-stream "PRG/cleanup levels" and 2010 IAEA BCF (pCi/min)**	**In-stream Radionuclide Flux* in Bear Creek at EMDF using ROD assumptions and 2015 IAEA BCF (pCi/min)**	**In-stream Radionuclide Flux* in East Fork Poplar Creek at Poplar Creek without daughters except as noted, 2010 IAEA BCF (pCi/min)****	**In-stream Radionuclide Flux* in East Fork Poplar Creek at Poplar Creek without daughters except as noted, 2015 IAEA BCF (pCi/min)****
Carbon-14 (^{14}C)	**5730**	**2450**	**92,742**	**25**	**148**	**125**	**736**

[79] ARAR TDEC 0400-40-03-.05(6) requires "*that all discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards, or state or federal laws and regulations pursuant thereto, and where appropriate will comply with the "Standards of Performance" as required by the Tennessee Water Quality Control Act, (T.C.A., §§ 69-3-101, et seq.).*"

[80] International Atomic Energy Agency (IAEA) 2010 Technical Report Series No. 472 *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments.*

[81] International Atomic Energy Agency (IAEA) April 2015 Summary table of freshwater to fish transfer values available at www.wildlifetransferdatabase.org .

[82] Focused Feasibility Study for Water Management for the Disposal of CERCLA Waste on the Oak Ridge Reservation, Oak Ridge, Tennessee, 7/25/2022 DOE/OR/01-2664&D4/R1 (FFS) page 14 estimates an average month discharge rate of 10 gpm and maximum month discharge rate of 20 gpm for each open cell. The FFS also estimates a peak day discharge rate of 756 gpm for EMDF Cell 1.

Cesium-137 (^{137}Cs)	**30**	**787 based on 1,180 pCi/g, ROD Table 2.5 (2,220 pCi/g)**	**29,791**	**216**	**317**	**1,071**	**1,575**
Iodine-129 (^{129}I)	**15,700,000**	**158**	**5,981**	**3,414**	**512**	**16,946**	**2,542**
Potassium-40 (^{40}K)	**1,280,000,000**	**215**	**8,139**		**125**	**914**	**622**
Lead-210 (^{210}Pb) includes Polonium-210 (^{210}Po)	**^{210}Pb 22.3**	**73.3**	**2,775**	**182**	**14**	**905**	**69**
Plutonium-238 (^{238}Pu)	**87.7**	**4,640**	**175,643**	**6**	**849**	**28**	**4,218**
Plutonium-239 (^{239}Pu)	**24,100**	**2,880**	**109,020**	**6**	**827**	**27**	**4,097**
Plutonium-240 (^{240}Pu)	**6,540**	**3,070**	**116,212**	**6**	**827**	**27**	**4,097**
Plutonium-241 (^{241}Pu)	**14.4**	**10,100**	**382,325**		**63,116**	**2,086**	**312,920**
Radium-226 (^{226}Ra) includes ^{210}Pb and ^{210}Po	**1600**	**0.534**	**20**	**179**	**14**	**889**	**68**
Strontium-90 (^{90}Sr)	**29.1**	**12,600**	**476,960**	**16,032**	**1,756**	**502,256**	**9,710**
Uranium-234 (^{234}U)	**245,000**	**25,000**	**946,350**	**106,101**	**21,139**	**1,089,595**	**104,601**
Uranium-238 (^{238}U) includes Thorium-234 (^{234}Th)	**^{238}U 4,470,000,000**	**15,100**	**571,595**	**70,288**	**4,076**	**348,578**	**20,245**

*Recreational use In-stream Radionuclide Flux is calculated at 1X10^{-5} excess lifetime cancer risk level at 30-day minimum 5-year recurrence flow required by ARAR TDEC Rule 0400-40-03-.05(4). This flow is estimated from USGS StreamStats in Attachment 8.

(ARAR TDEC Rule 0400-40-03-.05(4) requires that "*Fish and aquatic life water quality criteria shall generally be applied on the basis of stream flows equal to or exceeding the 7-day minimum, 10-year recurrence interval. All other criteria shall be applied on the basis of stream flows equal to or exceeding the 30- day minimum 5-year recurrence interval*.")

** East Fork Poplar Creek upstream of the confluence with Poplar Creek receives radionuclides from Y-12, the City of Oak Ridge wastewater treatment plant (POTW), and potentially other sources in addition to sources in Bear Creek Valley. Y-12 is also likely authorized to discharge into the POTW and there may be infiltration of groundwater into the sewer at Y-12. All In-stream Radionuclide Flux for East Fork Poplar Creek is NOT available to Bear Creek and EMDF.

	Bear Creek ROD Assumptions	Bear Creek ROD Assumption Reference	East Fork Poplar Creek In-Stream Radionuclide Flux Assumptions	East Fork Poplar Creek In-Stream Radionuclide Flux Reference
Target Risk	**$1X10^{-5}$**	**UCOR-5550***	**$1X10^{-5}$**	**TDEC 0400-40-03-.03(4)(j) Footnote C**
Exposure Pathway	**Fish Ingestion**		**Fish Ingestion**	
Exposure Duration	**26 years**	**UCOR-5550***	**70 Years**	**TDEC 0400-40-03-.03(4)(l)**
Exposure Frequency	**365 days/year**	**UCOR-5550***	**365 days/year**	**TDEC 0400-40-03-.03(4)(l) (EPA Assumption)**
Fish Ingestion Rate	**17.5 grams/day**	**UCOR-5550***	**Current risk calculation factors and assumptions used by EPA: 22 grams/day**	**TDEC 0400-40-03-.03(4)(l) (Current EPA Factors and Assumption)**
Contaminated Fish Fraction Ingested (FI)	**1**	**Calculated ROD values with a FI of 1.**	**1**	
Slope Factors	**Radionuclide Specific**	**https://rais.ornl.gov**	**Radionuclide Specific**	**https://rais.ornl.gov**

**"Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee"*, April 28, 2022 (UCOR-5550)

Variable	Resident Contaminated Fish Default Value	Site-Specific Value
$CF_{res\text{-}fish}$ (contaminated fish fraction) unitless	1	1
ED_{res} (exposure duration - resident) yr	26	70
EF_{res} (exposure frequency - resident) day/yr	350	365
$IRFI_{res\text{-}a}$ (fish ingestion rate - adult) mg/day	54000	22000
TR (target cancer risk) unitless	0.000001	0.00001

Output generated 18OCT2023:09:33:48

Site-specific

Resident PRGs for Contaminated Fish - No progeny (with decay)

Isotope	Food Ingestion Slope Factor (risk/pCi)	Fish Consumption PRG TR=1.0E-05 (pCi/g)	Fish Consumption PRG TR=1.0E-05 (mg/kg)
C-14	2.00E-12	**8.90E+00**	1.99E-06
Cs-137	3.74E-11	**4.76E-01**	5.51E-09
I-129	1.97E-10	**9.04E-02**	5.13E-04
K-40	3.42E-11	**5.20E-01**	7.29E-02
Pb-210	1.18E-09	**1.51E-02**	1.97E-10
Po-210	2.25E-09	**7.90E-03**	1.76E-12
Pu-238	1.69E-10	**1.05E-01**	6.14E-09
Pu-239	1.74E-10	**1.02E-01**	1.65E-06
Pu-240	1.74E-10	**1.02E-01**	4.50E-07
Pu-241	2.28E-12	**7.79E+00**	7.55E-08
Ra-226	5.14E-10	**3.46E-02**	3.50E-08
Sr-90	6.88E-11	**2.59E-01**	1.88E-09
Th-230	1.19E-10	**1.49E-01**	7.25E-06
Th-234	3.39E-11	**5.24E-01**	2.27E-11
U-234	9.55E-11	**1.86E-01**	3.00E-05
U-238	8.66E-11	**2.05E-01**	6.12E-01

Output generated 18OCT2023:09:33:48

Factors used to calculate concentrations or activities in freshwater from concentrations or activities in fish		
Element	**International Atomic Energy Agency (IAEA) 2010 Technical Report Series No. 472 *Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Terrestrial and Freshwater Environments* Bioconcentration Factors (BCF) in L/kg**	**International Atomic Energy Agency (IAEA) April 2015 Summary table of freshwater to fish transfer values available at www.wildlifetransferdatabase.org (See ROD comments page 3-369 and 3-370) Freshwater to fish transfer factors in L/kg**
Carbon	**400,000**	**68,000**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**4.0 E+05**	**6.8E+04**
Max	**3.2 E+06**	**4.0E+06**
Min	**1.9 E+05**	**1.0E+03**
N	**6**	**85**

Cesium	**2,500**	**1,700**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**2.5 E+03**	**1.7E+03**
Max	**1.5 E+04**	**8.2E+04**
Min	**1.4 E+02**	**1.3E+01**
N	**106**	**752**
Iodine	**30**	**200**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**3.0 E+01**	**2.0E+02**
Max	**4.0 E+02**	**1.3E+03**
Min	**1.1 E+01**	**9.0E+00**
N	**50**	**165**
Potassium	**3,200**	**4,700**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**3.2E+03**	**4.7E+03**
Max	**9E+03**	**4.7E+04**
Min	**1.2E+03**	**2.4E+02**
N	**97**	**312**
Lead	**25**	**100**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**2.5E+01**	**1.0E+02**
Max	**2.7E+02**	**9.3E+03**
Min	**1.0E-1**	**2.0E+00**
N	**39**	**606**
Polonium	**36**	**590**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**3.6E+01**	**5.9E+02**
Max	**1.7E+02**	**3.7E+04**
Min	**6**	**4.9E+01**
N	**5**	**203**
Plutonium	**21,000**	**140**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**2.1E+04**	**1.4E+02**
Max	**5.0E+04**	**4.7E+04**
Min	**7.7E+03**	**4.0E-01**
N	**3**	**106**
Radium	**4**	**61**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**4**	**6.1E+01**
Max	**1.5E+02**	**4.8E+03**
Min	**6.0E-02**	**1.4E-01**
N	**21**	**295**
Strontium	**2.9**	**150**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**2.9**	**1.5E+02**
Max	**6.9E+01**	**1.2E+05**
Min	**1.4E-01**	**3.8E+00**
N	**99**	**925**

Thorium	**6**	**120**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**6**	**1.2E+02**
Max	**6**	**3.7E+04**
Min	**6**	**3.3E+01**
N	**3**	**73**
Uranium	**0.96**	**10**
Fish	**Freshwater Fish Muscle**	**Freshwater Fish, Otherwise Not Specified**
Geomean	**9.6E-01**	**1.0E+01**
Max	**2.0E+01**	**5.0E+03**
Min	**2.0E-02**	**5.1E-01**
N	**9**	**1334**

- **Except for limited exceptions (e.g., uranium isotopes), DOE data in OREIS is not available to quantify existing radionuclide fluxes in surface water for calculation of WQBELs.**

- **Lead-210**: The ROD assumes radium-226, lead-210, and polonium-210 are in secular equilibrium in surface water and in fish and that the cancer risk from lead-210 and polonium-210 can be incorporated by only measuring radium-226. This assumption is not supported by the administrative record including the EMDF PA, OREIS surface water and EMWMF discharge data, public comments on EMDF,[83] and EMDF ROD Table 2.5. Assuming secular equilibrium and analyzing only radium-226 without analyzing lead-210 and polonium-210 allows undetected discharges of lead-210 and polonium-210 to surface water, underestimates cancer risks to people consuming fish, and is inconsistent with 40 CFR § 122.44(d)(1)(vi)(A).

  Further, even though EMWMF has illegally discharged radionuclides to Bear Creek for over 20 years, lead-210 surface water analyses are only reported in OREIS[84] for samples collected on or about 6/29/2021 and several of the locations sampled exceeded a $1X10^{-5}$ ELCR. The ambient water quality criteria (AWQC) in the following table for radium-226 (Ra-226) is the Ra-226 surface water "PRG/cleanup level" in ROD Table 2.9. The AWQC for lead-210 (Pb-210) was derived from the reference[85] used to develop Table 2.9. This table shows that analyzing Ra-226 without also analyzing for Pb-210 should not be expected to either reliably demonstrate compliance with ARARs or reliably determine cancer risk from Pb-210 and Po-210. There is insufficient data to evaluate whether Pb-210 may be a reliable indicator of polonium-210 (Po-210) in surface water.

[83] For example, public comment 24) on ROD pages 3-375 through 3-379 include decay of radium-226 for 160 years calculated by the decay chain tool at https://epa-prgs.ornl.gov/cgi-bin/radionuclides/chain.pl . Based on these decay chain tool results, if radium-226 and lead-210 were in secular equilibrium in Oak Ridge National Laboratory (ORNL) D&D waste, then 2.92 pCi/g of radium-226 may have a lead-210 daughter concentration on the order of 2.82 pCi/g. This is not observed. EMDF PA Table B.5 reports ORNL D&D waste with an average of 2.92 pCi/g of radium-226 and 46.8 pCi/g of lead-210. The public comment states that mischaracterization of isotopes generated or used at ORR as daughter products and not accounting for them separately likely mischaracterizes the cancer risk.

[84] Oak Ridge Environmental Information System (OREIS) data downloaded on 6/24/2023.

[85] *Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee*, 4/28/22, UCOR-5550.

June 29, 2021 Comparison of Radium-226 (Ra-226) and Lead-210 (Pb-210) in Surface Water									
Sample Location	Date Sampled	Ra-226 Result	Ra-226 AWQC Table 2.9	Ra-226 DL	Ra-226 > DL and AWQC?	Pb-210 Result	Pb-210 AWQC	Pb-210 DL	Pb-210> DL and AWQC?
BCK 0.5	6/29/2021	0.327	0.534	0.335	No	-0.258	0.545	0.497	No
BCK 3.3	6/29/2021	0.111	0.534	0.298	No	0.847	0.545	0.484	**Yes**
BCK 9.9	6/29/2021	0.335	0.534	0.16	No	0.73	0.545	0.499	**Yes**
BCK 12.4	6/29/2021	0.183	0.534	0.253	No	-0.0495	0.545	0.488	No
EFK 0.0	6/29/2021	0.327	0.534	0.224	No	0.783	0.545	0.441	**Yes**
BFK 7.6	6/29/2021	0.024	0.534	0.388	No	0.367	0.545	0.491	No

BFK 7.6 is the reference location.
DL means Detection Limit.

- **Some radionuclides are not reliably measured to levels that would be required to establish WQBELs.**
  Carbon-14: The carbon-14 surface water "PRG/cleanup level" in EMDF ROD Table 2.9 is 0.0753 pCi/L. For calendar years 2020 through 2022, the lowest carbon 14 detection limit measured in either Bear Creek surface water or the EMWMF discharge is about 4 pCi/L and carbon-14 detection limits in the EMWMF discharge to surface water range from 4.4 to 55.9 pCi/L.
  Plutonium-238: The plutonium-238 surface water "PRG/cleanup level" in EMDF ROD Table 2.9 is 0.0169 pCi/L. For calendar years 2020 through 2022, the lowest plutonium-238 detection limit for either Bear Creek or EMWMF was about 0.0356 pCi/L and plutonium-238 detection limits in the EMWMF discharge to surface water ranged from 0.117 to 0.88 pCi/L.
  Plutonium-239/240: The plutonium-239/240 surface water "PRG/cleanup level" in EMDF ROD Table 2.9 is 0.0165 pCi/L. For calendar years 2020 through 2022, the lowest plutonium-239/240 detection limit for either Bear Creek or EMWMF was about 0.0361 pCi/L and plutonium-239/240 detection limits in the EMWMF discharge to surface water ranged from 0.117 to 0.965 pCi/L.

- **Carbon-14 treatment**: Relevant and appropriate requirement TDEC 0400-40-03-.05(6) requires treating the EMDF discharge for carbon-14 to levels that ensure ambient water quality criteria (AWQC) in Bear Creek and downstream is not exceeded.
  The carbon-14 in-stream flux in Bear Creek near EMDF representing a $1X10^{-5}$ ELCR applied at the stream flow required by ARARs (estimated from USGS StreamStats) is 25 pCi/minute. The carbon-14 flux at the EMWMF V-Weir during CY 2022 needed to exceed the detection limit plus rad error ranges from 188 pCi/minute to 60,490 pCi/minute with a median of 6,350 pCi/minute. EMDF PA Table G.9 and related discussion on page G-33 estimate significant leaching and release of carbon-14 to surface water during landfill operations. EMDF PA Table B.6 shows an estimated 1.17 curies of carbon-14 in Y-12 D&D Biology waste. With this waste disposed in EMWMF, there is a potential for the 25 pCi/minute carbon-14 flux calculated from ROD Table 2.9 to be exceeded undetected. Based on carbon-14 levels in Oak Ridge National Lab waste shown

in EMDF PA Table B.6 proposed for disposal in EMDF and carbon-14 remaining at landfill closure in ROD Table 2.5, an estimated release on the order of 4.53 curies of carbon-14 during EMDF landfill operations is estimated. Averaged over a 26-year operational period, release of 4.53 curies equates to a release on the order of 331,490 pCi of carbon-14 per minute. If less carbon-14 is released during operations, then additional carbon-14 may be in the landfill after closure to impact surface water in the future.

Attachment 4: Uranium Isotopes:

- **Currently, uranium-238 (U-238) sources in Bear Creek Valley release U-238 at levels that appear to exceed AWQC calculated from ROD Table 2.9 at BCK 9.2. If in-stream U-238 radionuclide flux exceeds AWQC, then ARAR TDEC Rule 0400-40-03-.05(6) requires that EMDF would not add additional U-238 flux to Bear Creek.**
  The allowable U-238 flux in the creek calculated using "PRG/clean-up levels" from ROD Table 2.9 and ROD ARARs is on the order of 70,350 picocuries per minute (pCi/min). As shown in the following tables, the mean uranium flux in Bear Creek based on 156 measurements in OREIS for BCK 9.2 from 7/1/2020 through 6/30/2023 is 70,615 pCi/min and the 95th percentile and 95% upper confidence levels for the mean are substantially higher.
  The U-238 "PRG/cleanup level" in ROD Table 2.9 includes cancer risk from both U-238 and thorium-234. A public comment on ROD pages 3-370 and 3-371 illustrates that the U-238 "PRG/cleanup level"[86] may change from 210 pCi/L (i.e., ROD Table 2.9) to 12 pCi/L based on thorium and uranium BCF or freshwater to fish transfer values. Results of thorium-234 analyses included in OREIS are insufficient to evaluate thorium BCF values and thorium-234 levels in fish. It is undetermined whether the U-238 surface water "PRG/cleanup level" should be closer to 210 or 12 pCi/L.

	Surface Water "PRG/cleanup levels"	USGS StreamStats 30 day 5-year flow (L/minute)	Recreational Use In-stream Flux (pCi/minute)	BCK 9.2 OREIS Data from 7/1/2020 to 6/30/2023	BCK 9.2 OREIS Data from 7/1/2020 to 6/30/2023	BCK 9.2 OREIS Data from 7/1/2020 to 6/30/2023
	(pCi/L)	Bear Creek @ EMDF	Bear Creek @ EMDF	Arithmetic Mean Flux	95 %ile Flux (pCi/minute)	95% UCL Flux (pCi/minute)
	Uranium-238					
ROD Table 2.9	210	335	70,350	70,615	219,425	129,493
ROD Comment page 3-371	12	335	4,076	70,615	219,425	129,493
	Uranium-233/234					
ROD Table 2.9	317	335	106,195	28,506	84,746	52,451

- **Disposing waste containing uranium isotopes from "Y-12 D&D Remaining Facilities" into EMDF is not demonstrated to be protective of human health.**
  - **Most Oak Ridge Reservation uranium proposed for disposal in EMDF is located at "Y-12 D&D Remaining Facilities."** From EMDF PA Table B.6., it can be estimated that "Y-12 D&D Remaining Facilities" contain about 22% of the total waste proposed for disposal in EMDF and over 97% of the uranium-234; 93% of the uranium-235; 97% of the uranium-236; and 89% of the uranium-238 proposed for disposal in EMDF.

[86] Uranium-238 "PRG/cleanup level" includes cancer risk from combined uranium-238 and thorium-234.

- **U-234, U-238, and their daughter products are the main radionuclides of concern for long-term inadvertent human intrusion (IHI).** EMDF PA page I-27 specifies *"Primary contributors to the chronic post-drilling IHI dose prior to 1000 years post closure include U-232, U-234, U-235, U-238, Cs-137, and Th-228. After 500 years, total dose is driven by U-234, U-238, and their associated progeny."* Independent expert review[87] includes a supplemental evaluation using average waste concentrations predicted from the EMDF PA to evaluate groundwater use from the residential water well drilled through the waste. This supplemental analysis also shows that a significant portion of the long-term dose (and resulting cancer risk) is due to uranium isotopes and their progeny.
- **Average uranium isotopes at "Y-12 D&D Remaining Facilities" approach the upper end of the NCP cancer risk range for inadvertent human intrusion (IHI) without ingrowth of daughter products or calculating an upper bound cancer risk required by CERCLA methodology.** Attachment 1 shows that ROD Table 2.7 waste lot concentration limits are set at $2X10^{-3}$ excess lifetime cancer risk (ELCR). Reducing these by an order of magnitude approaches the upper end of the cancer risk range[88] specified in the NCP. Reducing waste lot concentration limits by an order of magnitude would reduce U-238 from 41,000 pCi/gram to 4,100 pCi/gram and U-234 from 39,000 pCi/gram to 3,900 pCi/gram. EMDF PA Table B.5 "Y-12 D&D Remaining Facilities" includes arithmetic average radionuclide waste activities of 5,230 pCi/gram of U-234 and 2,910 pCi/gram of U-238. Utilizing average uranium activity concentrations for "Y-12 D&D Remaining Facilities" and chronic post-drilling as-generated and as disposed Single Radionuclide Soil Guidelines (SRSG) in EMDF PA Table I.3, then an IHI ELCR on the order of $3X10^{-4}$ to $5X10^{-4}$ may be calculated without including daughter products or cancer risk from groundwater use. Methodology consistent with the NCP calculates an upper bound lifetime cancer risk typically using the 95% upper confidence level (UCL) of the mean not arithmetic averages.[89] IHI cancer risk from drilling through "Y-12 D&D Remaining Facilities" wastes incorporating daughter products, groundwater use, and using NCP consistent methodology will likely result in calculating higher ELCR.
- **Radioactive half-lives of uranium isotopes at Y-12 D&D Remaining Facilities" are not protective of surface water and groundwater after landfill closure. (See Attachment 2)** With radioactive decay of uranium-233 with a half-life of 159,000 years; U-234 with a half-life of 246,000 years; uranium-235 with a half-life of 704 million years; uranium-236 with a half-life of 23.4 million years; and U-238 with a half-life of 4.47 billion years, radioactive

[87] A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee, 12 October 2020 (NAC-0131_R1).

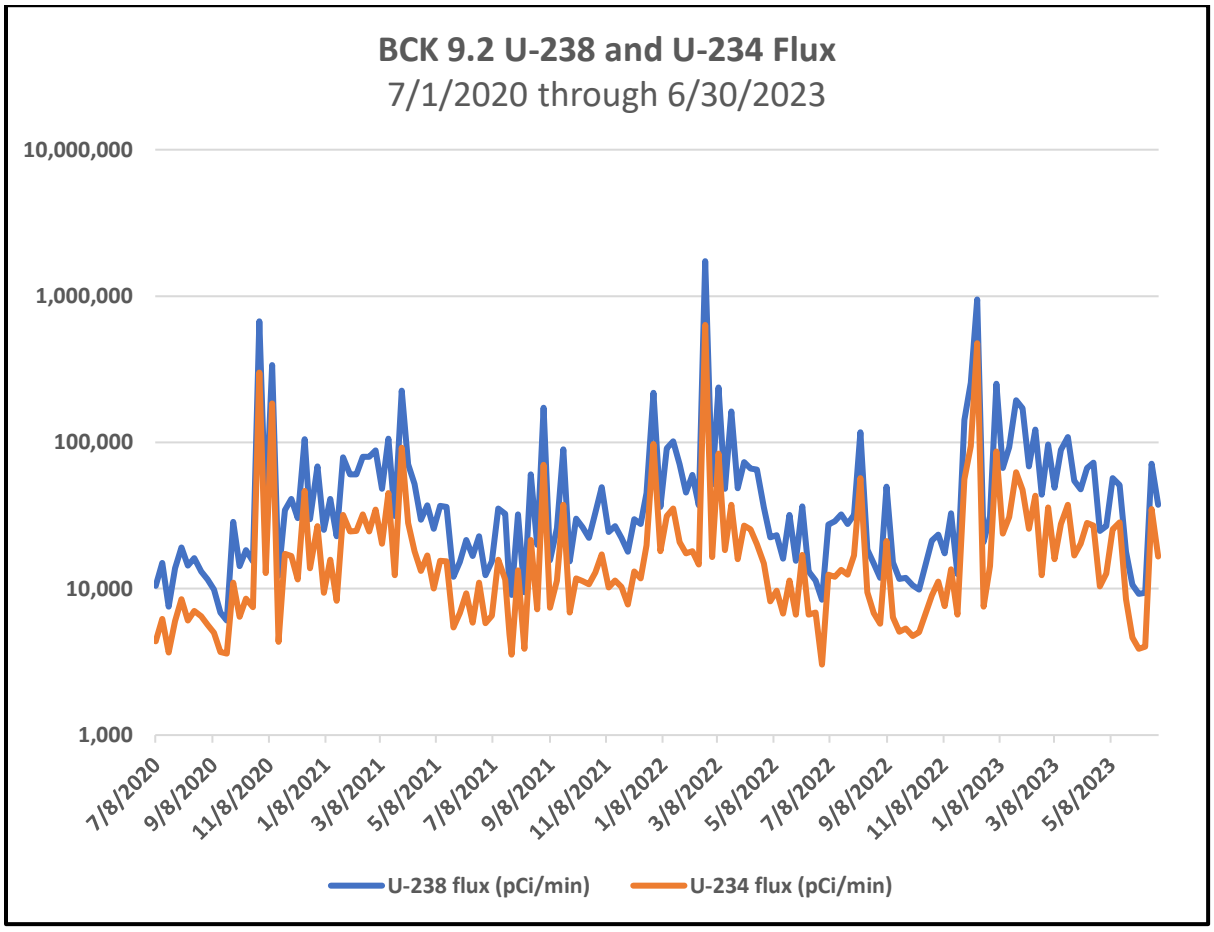
[88] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. 40 C.F.R. § 300.430(e)(2)(i)(A)(2).

[89] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. 40 C.F.R. § 300.430(e)(2)(i)(A)(2).
Supplemental Guidance to RAGs: Calculating the Concentration Term (Publication 9285.7-081), May 1992
https://rais.ornl.gov/documents/UCLsEPASupGuidance.pdf
95% UCL concentration values may be calculated with EPA ProUCL software.

decay during containment in EMDF should not reduce these uranium isotopes estimated in ROD Table 2.5 and their daughters to levels that ensure the eventual migration of radionuclides to groundwater and surface water meet CERCLA and NCP protectiveness standards.

Further, U-234 and U-238 decay to daughter products including radium-226, lead-210, and polonium-210. Attachment 2 shows that U-234 and daughter products likely adversely impact surface water recreational use including consumption of fish by the end of the 1,000-year compliance period and thereafter.[90]

OREIS Data (endnote)[i] and Calculated Uranium-238 Flux and Uranium-234 Flux in Bear Creek at BCK 9.2



[90] Attachment 2 includes output from the decay chain tool for uranium-234 from 100 years to 1 million years. Uranium-234 is a daughter of uranium-238 and uranium-238 decay will add additional uranium-234 and other daughters that are not included in Attachment 2 decay chain tool evaluation.

EPA's ProUCL: Uranium-238 Flux (pCi/min) 7/1/2020 through 6/30/2023

	A	B	C	D	E	F	G	H	I	J	K	L
1				General Statistics on Uncensored Full Data								
2			Date/Time of Computation	ProUCL 5.112/20/2023 9:40:37 AM								
3			User Selected Options									
4			From File	WorkSheet_a.xls								
5			Full Precision	OFF								
6												
7	From File: WorkSheet_a.xls											
8												
9	General Statistics for Uncensored Dataset											
10												
11	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.675	Skewness
12	C0		156	0	6065	1731387	70615	35708	168709	13508	25953	7.501
13												
14	Percentiles for Uncensored Dataset											
15												
16	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile
17	C0		156	0	11617	15295	16627	31886	65294	71208	112735	219425

1	**UCL Statistics for Uncensored Full Data Sets**											
2												
3	User Selected Options											
4	Date/Time of Computation	ProUCL 5.112/20/2023 9:43:15 AM										
5	From File	WorkSheet b.xls										
6	Full Precision	OFF										
7	Confidence Coefficient	95%										
8	Number of Bootstrap Operations	2000										
9												
10												
11	**C0**											
12												
13	**General Statistics**											
14	Total Number of Observations	156					Number of Distinct Observations	156				
15							Number of Missing Observations	0				
16	Minimum	6065					Mean	70615				
17	Maximum	1731387					Median	31886				
18	SD	168709					Std. Error of Mean	13508				
19	Coefficient of Variation	2.389					Skewness	7.501				
20												
21	**Normal GOF Test**											
22	Shapiro Wilk Test Statistic	0.344					**Shapiro Wilk GOF Test**					
23	5% Shapiro Wilk P Value	0					Data Not Normal at 5% Significance Level					
24	Lilliefors Test Statistic	0.351					**Lilliefors GOF Test**					
25	5% Lilliefors Critical Value	0.0713					Data Not Normal at 5% Significance Level					
26	**Data Not Normal at 5% Significance Level**											
27												
28	**Assuming Normal Distribution**											
29	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
30	95% Student's-t UCL	92966					95% Adjusted-CLT UCL (Chen-1995)	101500				
31							95% Modified-t UCL (Johnson-1978)	94318				
32												
33	**Gamma GOF Test**											
34	A-D Test Statistic	8.751					**Anderson-Darling Gamma GOF Test**					
35	5% A-D Critical Value	0.79					Data Not Gamma Distributed at 5% Significance Level					
36	K-S Test Statistic	0.17					**Kolmogorov-Smirnov Gamma GOF Test**					
37	5% K-S Critical Value	0.0776					Data Not Gamma Distributed at 5% Significance Level					
38	**Data Not Gamma Distributed at 5% Significance Level**											
39												
40	**Gamma Statistics**											
41	k hat (MLE)	0.862					k star (bias corrected MLE)	0.85				
42	Theta hat (MLE)	81916					Theta star (bias corrected MLE)	83102				
43	nu hat (MLE)	269					nu star (bias corrected)	265.1				
44	MLE Mean (bias corrected)	70615					MLE Sd (bias corrected)	76604				
45							Approximate Chi Square Value (0.05)	228.4				
46	Adjusted Level of Significance	0.0485					Adjusted Chi Square Value	228.1				
47												
48	**Assuming Gamma Distribution**											
49	95% Approximate Gamma UCL (use when n>=50))	81962					95% Adjusted Gamma UCL (use when n<50)	82075				
50												
51	**Lognormal GOF Test**											

	A	B	C	D	E	F	G	H	I	J	K	L
52					Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk Lognormal GOF Test**					
53					5% Shapiro Wilk P Value	1.0608E-5	Data Not Lognormal at 5% Significance Level					
54					Lilliefors Test Statistic	0.0879	**Lilliefors Lognormal GOF Test**					
55					5% Lilliefors Critical Value	0.0713	Data Not Lognormal at 5% Significance Level					
56	**Data Not Lognormal at 5% Significance Level**											
57												
58	**Lognormal Statistics**											
59					Minimum of Logged Data	8.71				Mean of logged Data	10.48	
60					Maximum of Logged Data	14.36				SD of logged Data	0.981	
61												
62	**Assuming Lognormal Distribution**											
63					95% H-UCL	68670				90% Chebyshev (MVUE) UCL	73796	
64					95% Chebyshev (MVUE) UCL	81170				97.5% Chebyshev (MVUE) UCL	91405	
65					99% Chebyshev (MVUE) UCL	111509						
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data do not follow a Discernible Distribution (0.05)**											
69												
70	**Nonparametric Distribution Free UCLs**											
71					95% CLT UCL	92832				95% Jackknife UCL	92966	
72					95% Standard Bootstrap UCL	92812				95% Bootstrap-t UCL	118127	
73					95% Hall's Bootstrap UCL	180981				95% Percentile Bootstrap UCL	94733	
74					95% BCA Bootstrap UCL	104872						
75					90% Chebyshev(Mean, Sd) UCL	111137				95% Chebyshev(Mean, Sd) UCL	129493	
76					97.5% Chebyshev(Mean, Sd) UCL	154969				99% Chebyshev(Mean, Sd) UCL	205013	
77												
78	**Suggested UCL to Use**											
79					95% Chebyshev (Mean, Sd) UCL	129493						
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL											
82	Recommendations are based upon data size, data distribution, and skewness.											
83	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
84	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
85												

Attachment 5: Clean Water Act Pollutants including Mercury and PCBs

The EMDF ROD Mercury Management Approach[91] and PCB Management Approach[92] violate Clean Water Act (CWA) ARARs and the ROD does not include waivers. The mercury management approach establishes a discharge limit based on a mercury concentration of 51 ng/L at an unspecified flow rate and deems that this is the more stringent of the technology based effluent limit (TBEL) and WQBEL without quantifying either the TBEL or WQBEL. Similarly, instead of the PCB management approach requiring quantification of TBELs and WQBELs and setting a discharge limit that would be the lower of the TBEL and the WQBEL and that complies with antidegradation requirements, it requires that in the event PCBs are detected in EMDF effluent, a compliance program and schedule will be implemented. The ROD mercury and PCB management approaches also do not include strategies that ensure antidegradation requirements in ARARs are met.

ROD mercury management approach on page 2-63 includes the statement that *EPA and TDEC concurrence on the final ROD reflects final agreement on the approach* thereby making noncompliance with certain CWA ARARs ROD requirements.

- **Clean Water Act (CWA) Pollutant Discharge to Surface Water During EMDF Operation:** Discharge of non-radionuclide pollutants under CERCLA and the NCP are required to meet substantive requirements of a National Pollutant Discharge Elimination System (NPDES) permit unless a requirement is waived. No NPDES requirement is waived in the ROD. Applicable requirements include establishing technology based effluent limits (TBELs)[93] and water quality based effluent limits (WQBELs)[94] where the discharge limit would be the lower of the TBEL and the WQBEL. The discharge must also comply with antidegradation requirements.[95] ARARs also specify that since all Waters of the State are classified for more than one use, the most stringent criteria will be applicable[96] and that discharge limits are met at the point of discharge[97] or end of pipe. These requirements are applicable to all CWA pollutants including, and not limited to, PCBs (c)[98], uranium as a metal, nutrients, and CWA pollutants identified in ROD Table 2.8. Key CWA pollutants listed in ROD Table 2.8 include aldrin (c); arsenic (c); arsenic III; b-BHC (c);

[91] EMDF ROD pages 2-63 and 2-64.
[92] EMDF ROD pages 2-64 and 2-65.
[93] TDEC Rule 0400-40-05-.08(1)(b) requires "*[f]or new sources, technology-based effluent limitations shall require the greatest degree of effluent reduction achievable through application of the best available demonstrated control technology, which shall be new source performance standards, if available.*"
[94] ARAR TDEC 0400-40-03-.05(6) requires "*that all discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards, or state or federal laws and regulations pursuant thereto, and where appropriate will comply with the "Standards of Performance" as required by the Tennessee Water Quality Control Act, (T.C.A., §§ 69-3-101, et seq.).*" and
ARAR TDEC Rule 0400-40-03-.05(4) requires that "*Fish and aquatic life water quality criteria shall generally be applied on the basis of stream flows equal to or exceeding the 7-day minimum, 10-year recurrence interval. All other criteria shall be applied on the basis of stream flows equal to or exceeding the 30- day minimum 5-year recurrence interval.*" (emphasis added)
[95] TDEC Rule 0400-40-03-.06.
[96] TDEC Rule 0400-40-03-.02(5).
[97] TDEC Rule 0400-40-05-.08(1)(k) requires "*All permit effluent limitations, standards, and prohibitions shall be established for each outfall or discharge point of the permitted facility, except as otherwise provided for BMPs where limitations on effluent or internal waste streams are infeasible.*"
[98] (c) means the pollutant is identified as a carcinogen.

cadmium; chromium III; chromium VI; copper; cyanide; 4,4-DDT (c); 4,4-DDE (c); 4,4-DDD (c); dieldrin (c); lead, mercury, and nickel.

- **Technology based effluent limits (TBELs):** The Clean Water Act requirement to establish TBELs based on best professional judgment (BPJ) is discussed in the EPA Region 4 Administrator's March 21, 2019, letter.[99] This letter specifies that "*Once the BPJ determination is made, the numerical effluent discharge limits are derived by applying the levels of performance of the selected treatment technology to the wastewater discharge. Because this is a Federal NPL site. any BPJ analysis that is undertaken as part of an ARAR requirement is an enforceable part of a remedy, and as such is included in a Primary Document that is reviewed and approved by EPA and TDEC.*" Even though BPJ is mentioned in relation to TBELs in the mercury management strategy, TBEL numerical discharge limits were neither included nor required to be developed in either the EMDF ROD mercury management approach or PCB management approach. Failure to develop numerical effluent limits for TBELs violates applicable requirements.
- **Water quality based effluent limits (WQBELs)** require at ARAR TDEC 0400-40-03-.05(6)[100] "*that all discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards...*" Further, ARAR TDEC Rule 0400-40-03-.05(4) requires that "*Fish and aquatic life water quality criteria shall generally be applied on the basis of stream flows equal to or exceeding the 7-day minimum, 10-year recurrence interval. All other criteria shall be applied on the basis of stream flows equal to or exceeding the 30- day minimum 5-year recurrence interval*" (underline emphasis added). To comply with ARARs, WQBELs are established so that the pollutant load or radionuclide flux in the discharge plus the pollutant load or radionuclide flux otherwise in the stream will not exceed ambient water quality criteria (AWQC) which may be estimated as the more stringent of fish and aquatic life standards at 7-day 10-year recurrent flow and recreational use standards at 30-day 5-year recurrent flow. These flows were estimated from USGS StreamStats. Attachment 8 includes USGS StreamStats estimates for Bear Creek (BCK 7.87) near the EMDF location and in East Fork Poplar Creek upstream of the confluence of East Fork Poplar Creek with Poplar Creek.

- **Mercury management approach**:
  ROD authorization of the mercury management approach likely violates 40 CFR § 122.4(i).[101] The recreational use mercury water quality standard[102] based on the stream flow required by TDEC

[99] Letter from Acting EPA Region 4 Administrator Mary S. Walker dated March 21, 2019, to Mr. John A. Mullis, Manager OREM, and Commissioner David W. Salyers (TDEC), page 8.
https://www.tn.gov/content/dam/tn/environment/remediation/documents/orr/emdf-docs/rem_emdf-ffs-formal-dispute-epa_03-21-2019.pdf

[100] ARAR TDEC 0400-40-03-.05(6) "*that all discharges of sewage, industrial waste, and other waste shall receive the degree of treatment or effluent reduction necessary to comply with water quality standards, or state or federal laws and regulations pursuant thereto, and where appropriate will comply with the "Standards of Performance" as required by the Tennessee Water Quality Control Act, (T.C.A., §§ 69-3-101, et seq.).*"

[101] The ROD effectively serves as a permit and 40 CFR § 122.4(i) on ROD page A-63 requires that:
No permit may be issued: (i) To a new source or a new discharger, if the discharge from its construction or operation will cause or contribute to the violation of water quality standards….

[102] EMDF ROD Table 2.8 includes recreational and fish and aquatic life water quality criteria for mercury
Recreational Use (TDEC 0400-40-03-.03(4)) Water Quality Criteria for mercury is 51 ng/L (0.051 ug/L)
Fish and Aquatic Life (TDEC 0400-40-03-.03(3)) continuous discharge 0.77 ug/L
Fish and Aquatic Life (TDEC 0400-40-03-.03(3)) non-continuous (batch) discharge 1.4 ug/L

Rule 0400-40-03-.05(4) estimated from USGS StreamStats is on the order of 17,085 ng/minute[103] in Bear Creek near EMDF. Recreational use in-stream mercury load is applicable to Bear Creek near EMDF irrespective of whether mercury is an antidegradation available or unavailable parameter and irrespective of whether the discharge is continuous or batched. Further, DOE's data indicate 17,085 ng/minute of mercury in Bear Creek may be met or exceeded. Using in-stream monitoring data in OREIS for sampling station BCK 9.2 located between the future EMDF and previous Bear Creek Valley disposal areas for the period of Calendar Year (CY) 2017 through CY 2022, a 95th percentile in-stream mercury load on the order of 26,922 ng/minute and a 95% UCL of the mean in-stream mercury load on the order of 18,844 ng/minute can be calculated from 14 measurements. (Data and evaluation with EPA's ProUCL are included below.)

The mercury WQBEL is the mercury (not methylmercury) load that may be discharged from EMDF for the mercury load in Bear Creek in the vicinity of EMDF to not exceed promulgated mercury water quality criteria at the stream flow required by ARARs.
The mercury management approach establishes a discharge limit based on a mercury concentration of 51 ng/L at an unspecified rate and deems that this is the more stringent of the TBEL and WQBEL without quantifying either the TBEL or WQBEL.[104] The ROD also specifies that the 51 ng/L limit "*shall be met at the point of discharge without allowance of mixing or dilution or consideration of any available assimilative capacity in the creek."* Failure to consider assimilative capacity affects calculation of WQBELs and likely violates ARAR TDEC Rule 0400-40-03-.05(6).

The ROD also includes that if fish meet the methylmercury standard before EMDF operations begin*, "then the wastewater discharge limit for mercury may remain 51 ng/L, expressed as a mass-based number regardless of flow volume in the discharge*."[105] This likely violates ARARs including, and not necessarily limited to, 40 CFR § 122.4(i), TDEC 0400-40-03-.05(6), and TDEC Rule 0400-40-03-.03(4)(j)[106] in addition to CERCLA at 42 U.S. Code 9621(d)(2)(A).

[103] Recreational use mercury water quality standard applied at the 30-day 5-year recurrent flow in Bear Creek at EMDF is calculated by multiplying the mercury recreational use water quality standard of 51 ng/L times 335 liters per minute. 335 L/ minute is the 30-day 5-year recurrent flow estimated from USGS StreamStats. USGS StreamStats in the vicinity of the future EMDF near BCK 7.87 gives a flow of about 0.197 cfs or about 335 liters/minute. See Attachment 8.
[104] EMDF ROD page 2-63.
[105] EMDF ROD page 2-63.
[106] TDEC Rule 0400-40-03-.03(4)(j) requires *Water shall not contain toxic substances that will render the water unsafe or unsuitable for water contact activities including the capture and subsequent consumption of fish and shellfish, or will propose toxic conditions that will adversely affect man, animal, aquatic life, or wildlife*.

Mercury Load in Bear Creek at BCK 9.2 for Calendar Year (CY) 2017 through CY 2022

Mercury Concentration, Flow, and Load in Bear Creek at BCK 9.2.**					
Date Collected	Mercury Results (ng/L)	Date Sample Collection Ended	Date Sample Collection Started	Daily average in L/min	Calculated Mercury Load (ng/min)
5/23/2017	2.07	5/23/2017	5/23/2017	1744.63	3,611
10/30/2017	5.48	10/30/2017	10/30/2017	3640.22	19,948
6/7/2018	3.37	6/7/2018	6/7/2018	1563.43	5,269
10/25/2018	2.46	10/25/2018	10/25/2018	1013.23	2,493
6/3/2019	1.71	6/3/2019	6/3/2019	879.39	1,504
10/3/2019	1.59	10/3/2019	10/3/2019	643.67	1,023
3/5/2020	5.06	3/5/2020	3/5/2020	7879.92	39,872
5/11/2020	2.23	5/11/2020	4/2/2020	8319*	18,551
8/6/2020	3.08	8/6/2020	8/6/2020	915.63	2,820
10/22/2020	2.1	10/22/2020	10/6/2020	1740.8*	3,656
5/20/2021	2.51	5/20/2021	5/20/2021	2204.59	5,533
10/18/2021	4.78	10/18/2021	10/18/2021	3628.43	17,344
4/21/2022	2.8	4/21/2022	4/21/2022	6112.64	17,115
10/18/2022	2.6	10/18/2022	10/18/2022	1077.74	2,802

*Average of Daily Averages from date sample collection started to date sample collection ended.

**Data downloaded from the DOE Oak Ridge Environmental Information System (OREIS) October 22, 2023.

ProUCL: General Statistics, In-stream BCK 9.2 Mercury Load (ng/min)

	A	B	C	D	E	F	G	H	I	J	K	L
1				General Statistics on Uncensored Full Data								
2		Date/Time of Computation		ProUCL 5.110/30/2023 9:49:15 AM								
3		User Selected Options										
4		From File		WorkSheet.xls								
5		Full Precision		OFF								
6												
7	From File: WorkSheet.xls											
8												
9	General Statistics for Uncensored Dataset											
10												
11	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Geo-Mean	SD	SEM	MAD/0.675	Skewness
12	C0		14	0	1023	39872	10110	5820	11110	2969	3653	1.654
13												
14	Percentiles for Uncensored Dataset											
15												
16	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile
17	C0		14	0	1800	2678	2807	4462	17287	17827	19529	26922

ProUCL: BCK 9.2 In-stream Mercury Load in ng/min

1	**UCL Statistics for Uncensored Full Data Sets**										
2											
3	User Selected Options										
4	Date/Time of Computation	ProUCL 5.110/30/2023 9:51:15 AM									
5	From File	WorkSheet.xls									
6	Full Precision	OFF									
7	Confidence Coefficient	95%									
8	Number of Bootstrap Operations	2000									
9											
10											
11	**C0**										
12											
13	**General Statistics**										
14	Total Number of Observations	14			Number of Distinct Observations	14					
15					Number of Missing Observations	0					
16	Minimum	1023			Mean	10110					
17	Maximum	39872			Median	4462					
18	SD	11110			Std. Error of Mean	2969					
19	Coefficient of Variation	1.099			Skewness	1.654					
20											
21	**Normal GOF Test**										
22	Shapiro Wilk Test Statistic	0.765			**Shapiro Wilk GOF Test**						
23	5% Shapiro Wilk Critical Value	0.874			Data Not Normal at 5% Significance Level						
24	Lilliefors Test Statistic	0.303			**Lilliefors GOF Test**						
25	5% Lilliefors Critical Value	0.226			Data Not Normal at 5% Significance Level						
26	**Data Not Normal at 5% Significance Level**										
27											
28	**Assuming Normal Distribution**										
29	**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**						
30	95% Student's-t UCL	15369			95% Adjusted-CLT UCL (Chen-1995)	16397					
31					95% Modified-t UCL (Johnson-1978)	15588					
32											
33	**Gamma GOF Test**										
34	A-D Test Statistic	0.722			**Anderson-Darling Gamma GOF Test**						
35	5% A-D Critical Value	0.759			Detected data appear Gamma Distributed at 5% Significance Level						
36	K-S Test Statistic	0.228			**Kolmogorov-Smirnov Gamma GOF Test**						
37	5% K-S Critical Value	0.235			Detected data appear Gamma Distributed at 5% Significance Level						
38	**Detected data appear Gamma Distributed at 5% Significance Level**										
39											
40	**Gamma Statistics**										
41	k hat (MLE)	1.04			k star (bias corrected MLE)	0.865					
42	Theta hat (MLE)	9719			Theta star (bias corrected MLE)	11688					
43	nu hat (MLE)	29.13			nu star (bias corrected)	24.22					
44	MLE Mean (bias corrected)	10110			MLE Sd (bias corrected)	10871					
45					Approximate Chi Square Value (0.05)	14.02					
46	Adjusted Level of Significance	0.0312			Adjusted Chi Square Value	12.99					
47											
48	**Assuming Gamma Distribution**										
49	95% Approximate Gamma UCL (use when n>=50)	17471			95% Adjusted Gamma UCL (use when n<50)	18844					
50											
51	**Lognormal GOF Test**										

	A	B	C	D	E	F	G	H	I	J	K	L
52					Shapiro Wilk Test Statistic	0.934	**Shapiro Wilk Lognormal GOF Test**					
53					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
54					Lilliefors Test Statistic	0.192	**Lilliefors Lognormal GOF Test**					
55					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
56	**Data appear Lognormal at 5% Significance Level**											
57												
58	**Lognormal Statistics**											
59					Minimum of Logged Data	6.931				Mean of logged Data		8.669
60					Maximum of Logged Data	10.59				SD of logged Data		1.11
61												
62	**Assuming Lognormal Distribution**											
63					95% H-UCL	26926				90% Chebyshev (MVUE) UCL		19969
64					95% Chebyshev (MVUE) UCL	24438				97.5% Chebyshev (MVUE) UCL		30640
65					99% Chebyshev (MVUE) UCL	42824						
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
69												
70	**Nonparametric Distribution Free UCLs**											
71					95% CLT UCL	14994				95% Jackknife UCL		15369
72					95% Standard Bootstrap UCL	14741				95% Bootstrap-t UCL		17366
73					95% Hall's Bootstrap UCL	17118				95% Percentile Bootstrap UCL		15317
74					95% BCA Bootstrap UCL	16865						
75					90% Chebyshev(Mean, Sd) UCL	19018				95% Chebyshev(Mean, Sd) UCL		23053
76					97.5% Chebyshev(Mean, Sd) UCL	28654				99% Chebyshev(Mean, Sd) UCL		39655
77												
78	**Suggested UCL to Use**											
79					95% Adjusted Gamma UCL	18844						
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
82	Recommendations are based upon data size, data distribution, and skewness.											
83	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
84	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
85												

- **Fish analysis for methylmercury in Bear Creek.**

From April 2020 through May 2023 OREIS data shows that about 100 sunfish and rock bass were collected in Bear Creek and analyzed for methylmercury. Breakdown by sample location is included in the following table. BCK 9.9 is upstream of the EMDF site. Locations BCK 3.3 and BCK 0.5 are downstream and outside of the area identified for institutional control (IC) included in the EMDF ROD. Sample locations BCK 3.3 and BCK 0.5 are evaluated using EPA water program default values. BCK 9.9 was evaluated using assumptions consistent with the development of ROD Table 2.9.

95% UCL concentrations of methylmercury in fish were calculated with EPA's ProUCL software.

Hazard quotients (HQ) were calculated with the EPA Regional Screening Level calculator at https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search . N is the number of fish analyzed at that location.

This table shows that there are likely areas conducive to increased methylation downstream in the BCK 3.3 / BCK 0.5 area, that Bear Creek does not meet EMDF ROD Remedial Action Objectives (RAOs) of preventing adverse impact to human health and water resources by preventing exposure above a hazard index (HI) of 1 without discharges from EMDF, and that the highest levels of methylmercury are at BCK 0.5. BCK 0.5 was sampled on October 27, 2021, and fish collected included rock bass and bluegill sunfish.

This table also shows that it is likely not protective of human health to increase mercury levels in Bear Creek above current levels. Further, with 95% UCLs indicating mercury methylation downstream in the area without EMDF ICs and with current HQs in this area greater than 1, mercury levels in Bear Creek likely need to be reduced to meet EMDF Remedial Action Objectives (RAOs).

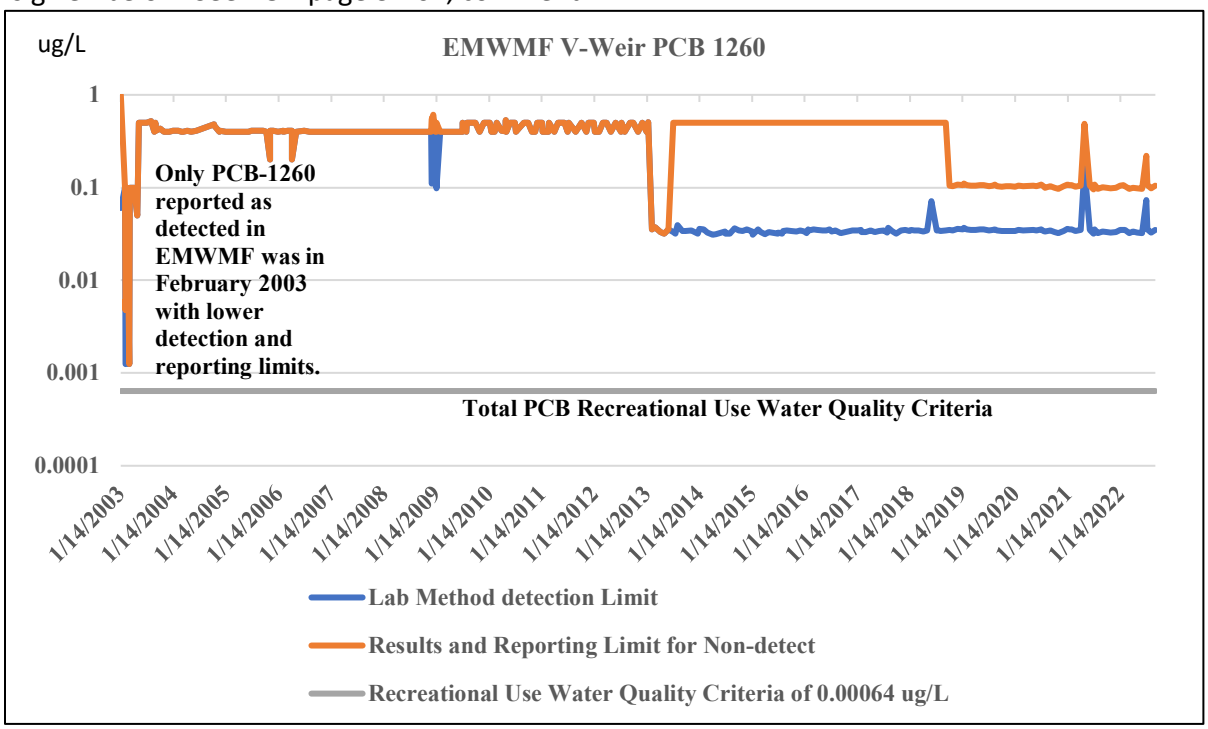
Analysis of methylmercury measured in rock bass and sunfish in Bear Creek from April 2020 through May 2023							
	95% UCL concentration of methylmercury in fish (ug/g)	**n**	**EMDF Institutional Control (IC)**	**HQ =1**	**HQ =1**	**HQ**	**HQ**
BCK 9.9	0.387	28	In IC area.				0.847
BCK 3.3	0.469	54	Downstream of IC			1.29	
BCK 0.5	0.77	18	Downstream of IC			2.12	
Total	0.478	100				1.31	1.05
BCK 3.3 and BCK 0.5	0.531	72	Downstream of IC			1.46	
HQ =1 Screening Level				0.364	0.457		
Fish Ingestion				22000	17500	22000	17500
Exposure Duration				70	26	70	26
Exposure Frequency				365	365	365	365

PCB management approach:

ROD authorization of the PCB management approach likely violates 42 U.S. Code 9621(d)(2)(A) and **40 CFR § 122.4(i) in addition to ARARs related to TBELs and WQBELs. Further, without complying with applicable CWA treatment requirements, it is likely not demonstrated that conditions for waiving TSCA 40 CFR § 761.75(b)(3) are met.**

Instead of the PCB management approach requiring determination of TBELs and WQBELs and setting a discharge limit that would be the lower of the TBEL and the WQBEL and that complies with antidegradation requirements, it requires that in the event PCBs are detected in EMDF effluent, a compliance program and schedule will be implemented.[107] The ROD also fails to identify PCB water quality criteria in ROD Table 2.8 due to PCB detection limits used for the EMWMF discharge to surface water even though EMDF is approved for disposal of PCB wastes and Bear Creek is already impaired for PCBs. ROD page 2-65 also includes a CWA process that may allow establishing monitoring requirements for PCBs that are "sufficiently sensitive."

If the approach to PCB sampling and analysis used at EMWMF is followed at EMDF, detection and reporting limits that exceed water quality criteria will make it impossible to substantiate that EMDF meets NCP threshold criteria. Tennessee recreational use water quality criteria are established at a 10^{-5} cancer risk. Detection and reporting limits for PCBs at EMWMF over the past 20 years have often been 100 to 1000 times greater than recreational use water quality criteria.[108] To illustrate the point, a graphical representation of the PCB detection and reporting limits at EMWMF for PCB 1260 is given below. See ROD page 3-404, comment 4.



[107] EMDF ROD page 2-65.
[108] EMDF ROD page 3-324.

PCB detection and reporting limits used at EMWMF are insufficient to support a determination whether EMWMF is protective of human health to NCP standards.

The EMDF ROD waiver for TSCA requirements in 40 CFR § 761.75(b)(3) also includes treating PCBs to protective levels. The waiver includes "*Since all EMDF landfill wastewater will undergo treatment prior to release, the only contaminants reaching surface water from the site will be those treated to protective levels."*[109]

- **Antidegradation:** Mercury and PCB management approaches in the ROD reference antidegradation[110] for unavailable parameters as applicable requirements yet the ROD does not include strategies to quantify and achieve antidegradation requirements. ARAR TDEC Rule 0400-40-03-.06(2)(a) regulates whether new or increased discharges of unavailable parameters may be authorized, and ARAR TDEC Rule 0400-40-05-.10(4) authorizes effluent limits to ensure compliance with antidegradation requirements. Antidegradation includes multiple requirements. For example, a public comment on ROD page 3-389 identifies that one antidegradation requirement specifies that new or increased discharges of unavailable parameters shall not be authorized if the discharge would cause measurable degradation of surface water for the unavailable parameter. OREIS data of mercury in surface water at Bear Creek sampling stations BCK 9.2 and BCK 07.87 from 2009 through 2020 identified a 95% UCL mercury concentration of 5.17 ng/L (ppt) and a median mercury concentration of 3.3 ng/L (ppt). Increasing these levels for mercury in surface water would represent measurable degradation and would violate antidegradation requirements for unavailable parameters. The ROD response to comments disagrees with this comment.

  Different antidegradation requirements apply depending on whether the parameter is available or unavailable.[111] ROD ARAR table page A-6, footnote 14 specifies that *"[i]f the currently "unavailable" parameters become "available" parameters under the rule, the new ARAR would be TDEC 0400-40-03-.06(3)*." Therefore, TDEC Rule 0400-40-03-.06(3) was timely identified. This rule was not waived and should be applicable to all "available" CWA pollutants.

- **Existing levels of PCB-1260 in fish in Bear Creek and an estimate of resulting cancer risk.**

  Laboratory analyses included in OREIS for rock bass and sunfish collected at Bear Creek locations BCK 3.3 and BCK 9.9 for the period of calendar years 2019 through 2023 reported PCB-1260

[109] EMDF ROD page 2-78.
[110] TDEC 0400-40-03-.06(2)(a).
[111] Care should be taken in making this determination. The 2023 Remediation Effectiveness Report indicates decrease in mercury concentrations in fish may be due to habitat modifications, smaller fish, and overharvesting. See: *2023 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee Data and Evaluations (DOE/OR/01-2938&D1),* 3/01/2023 page 4-45 at https://doeic.science.energy.gov/uploads/A.0100.064.2830.pdf .

concentrations in fish that calculate a 95% UCL on the order of 0.708 ug/g.[112] Fish sampling results reported in OREIS are included in an endnote.[ii]

Depending on assumptions used to calculate the cancer risk, this level of PCB-1260 in fish might exceed the 10^{-4} to 10^{-6} cancer risk range.

Bear Creek is listed on the EPA Approved TDEC 303(d) list of Impaired and Threatened waters for PCBs. Bear Creek is also posted by TDEC with a do not consume fish warning.

ProUCL calculation of the 95% UCL of PCB-1260 concentrations in sunfish and rock bass reported in OREIS at Bear Creek locations BCK 3.3 and BCK 9.9 for calendar years 2019 through 2023.

1	**UCL Statistics for Uncensored Full Data Sets**											
2												
3			User Selected Options									
4			Date/Time of Computation	ProUCL 5.11/13/2024 12:00:10 PM								
5			From File	WorkSheet.xls								
6			Full Precision	OFF								
7			Confidence Coefficient	95%								
8			Number of Bootstrap Operations	2000								
9												
10												
11	**C0**											
12												
13						**General Statistics**							
14					Total Number of Observations	100			Number of Distinct Observations	80		
15									Number of Missing Observations	0		
16					Minimum	0.00785			Mean	0.447		
17					Maximum	3.1			Median	0.19		
18					SD	0.618			Std. Error of Mean	0.0618		
19					Coefficient of Variation	1.384			Skewness	2.504		
20												
21						**Normal GOF Test**						
22					Shapiro Wilk Test Statistic	0.671			**Shapiro Wilk GOF Test**			
23					5% Shapiro Wilk P Value	0			Data Not Normal at 5% Significance Level			
24					Lilliefors Test Statistic	0.261			**Lilliefors GOF Test**			
25					5% Lilliefors Critical Value	0.0889			Data Not Normal at 5% Significance Level			
26						**Data Not Normal at 5% Significance Level**						
27												
28						**Assuming Normal Distribution**						
29					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
30					95% Student's-t UCL	0.549			95% Adjusted-CLT UCL (Chen-1995)	0.565		
31									95% Modified-t UCL (Johnson-1978)	0.552		
32												
33						**Gamma GOF Test**						
34					A-D Test Statistic	1.835			**Anderson-Darling Gamma GOF Test**			
35					5% A-D Critical Value	0.795			Data Not Gamma Distributed at 5% Significance Level			
36					K-S Test Statistic	0.144			**Kolmogorov-Smirnov Gamma GOF Test**			
37					5% K-S Critical Value	0.0929			Data Not Gamma Distributed at 5% Significance Level			
38						**Data Not Gamma Distributed at 5% Significance Level**						
39												
40						**Gamma Statistics**						
41					k hat (MLE)	0.76			k star (bias corrected MLE)	0.744		
42					Theta hat (MLE)	0.588			Theta star (bias corrected MLE)	0.6		
43					nu hat (MLE)	152			nu star (bias corrected)	148.8		
44					MLE Mean (bias corrected)	0.447			MLE Sd (bias corrected)	0.518		
45									Approximate Chi Square Value (0.05)	121.6		
46					Adjusted Level of Significance	0.0476			Adjusted Chi Square Value	121.2		
47												
48						**Assuming Gamma Distribution**							
49					95% Approximate Gamma UCL (use when n>=50))	0.547			95% Adjusted Gamma UCL (use when n<50)	0.548		
50												
51												

[112] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. 40 C.F.R. § 300.430(e)(2)(i)(A)(2).
Supplemental Guidance to RAGs: Calculating the Concentration Term (Publication 9285.7-081), May 1992
https://rais.ornl.gov/documents/UCLsEPASupGuidance.pdf
95% UCL concentration values may be calculated with EPA ProUCL software

	A	B	C	D	E	F	G	H	I	J	K	L
52												
53	**Lognormal GOF Test**											
54					Shapiro Wilk Test Statistic	0.97	**Shapiro Wilk Lognormal GOF Test**					
55					5% Shapiro Wilk P Value	0.134	Data appear Lognormal at 5% Significance Level					
56					Lilliefors Test Statistic	0.0574	**Lilliefors Lognormal GOF Test**					
57					5% Lilliefors Critical Value	0.0889	Data appear Lognormal at 5% Significance Level					
58	**Data appear Lognormal at 5% Significance Level**											
59												
60	**Lognormal Statistics**											
61					Minimum of Logged Data	-4.847			Mean of logged Data	-1.592		
62					Maximum of Logged Data	1.131			SD of logged Data	1.338		
63												
64	**Assuming Lognormal Distribution**											
65					95% H-UCL	0.708			90% Chebyshev (MVUE) UCL	0.75		
66					95% Chebyshev (MVUE) UCL	0.868			97.5% Chebyshev (MVUE) UCL	1.032		
67					99% Chebyshev (MVUE) UCL	1.354						
68												
69	**Nonparametric Distribution Free UCL Statistics**											
70	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
71												
72	**Nonparametric Distribution Free UCLs**											
73					95% CLT UCL	0.548			95% Jackknife UCL	0.549		
74					95% Standard Bootstrap UCL	0.546			95% Bootstrap-t UCL	0.578		
75					95% Hall's Bootstrap UCL	0.563			95% Percentile Bootstrap UCL	0.551		
76					95% BCA Bootstrap UCL	0.57						
77					90% Chebyshev(Mean, Sd) UCL	0.632			95% Chebyshev(Mean, Sd) UCL	0.716		
78					97.5% Chebyshev(Mean, Sd) UCL	0.833			99% Chebyshev(Mean, Sd) UCL	1.062		
79												
80	**Suggested UCL to Use**											
81					95% H-UCL	0.708						
82												
83	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
84	Recommendations are based upon data size, data distribution, and skewness.											
85	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
86	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
87												
88	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**											
89	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**											
90	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**											
91	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**											
92												

PCB-1260 at an exposure point concentration of 0.708 ug/g in fish might cause the excess upper bound lifetime cancer risk to an individual from ingestion of contaminated fish to exceed the NCP required 10^{-4} to 10^{-6} cancer risk range. Response to comment 4 on ROD Page 3-387 specifies that DOE legacy waste sites in Bear Creek Valley are the source of PCBs in fish.

With Bear Creek already impaired for PCBs and with this level of PCBs in fish, WQBELs and likely antidegradation requirements would eliminate additional discharge of PCBs to Bear Creek.

The following were calculated with the EPA Regional Screening Level Calculator at: https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Input variables used by the EMDF ROD to calculate "PRGs/Cleanup Levels" in ROD Table 2.9:

Variable	Fish Fish Default Value	Site-Specific Value
AT (averaging time)	365	365
BW_{rec_a} (body weight) kg	80	80
ED_{rec} (exposure duration) yr	26	26
EF_{rec_a} (exposure frequency) days/yr	350	365
THQ (target hazard quotient) unitless	0.1	0.1
$IRFI_{rec\_a}$ (fish consumption rate - adult) mg/day		17500
LT (lifetime) yr	70	70
TR (target cancer risk) unitless	1.0E-06	1.0E-04

$1X10^{-4}$ screening level for PCB-1260 in fish is 0.615 ug/g.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o (mg/kg-day)$^{-1}$	SF_o Ref	RfD (mg/kg-day)	RfD Ref	Ingestion SL TR=0.0001 (mg/kg)	Ingestion SL THQ=0.1 (mg/kg)	Screening Level (mg/kg)
Polychlorinated Biphenyls (high risk)	1336-36-3	No	Yes	Organics	2.00E+00	I	-		6.15E-01	-	6.15E-01 ca

PCB-1260 exposure point concentration of 0.708 ug/g in fish results in about a $1.2X10^{-4}$ excess lifetime cancer risk.

Chemical	SF_o (mg/kg-day)$^{-1}$	SF_o Ref	RfD (mg/kg-day)	RfD Ref	Concentration (mg/kg)	Ingestion Risk	Ingestion HI
Polychlorinated Biphenyls (high risk)	2.00E+00	I	-		0.708	1.15E-04	-
*Total Risk/HI	-		-		-	1.15E-04	-

This is consistent with EMDF ROD pages 3-394 and 3-411 footnote iii which states: *"The 95% Upper Confidence Level of the sum of PCB-1254 and PCB-1260 in fish collected from Bear Creek for the 5-year interval of Calendar Year (CY) 2017 through CY2021 is 0.782 mg/kg. Using the EPA Regional Screening Level Calculator at https://epa-prgs.ornl.gov/cgibin/chemicals/csl_search with 17500 mg/day fish ingestion rate, 365 days per year, for 26 years consistent with assumptions in EMDF PRG Development, an existing excess lifetime cancer risk (ELCR) of 1.27E-04 from ingestion of fish collected from Bear Creek is calculated."*

These footnotes relates to comments on ROD pages 3-389 and 3-406 which state: ***"Waste containing PCBs should not be disposed in a future EMDF. EMDF should not be approved for disposal of TSCA waste, the TSCA waiver requested in the Site Groundwater Characterization fact sheet should not be granted, and TSCA waste containing PCBs should be shipped offsite to a permitted facility.*** *CERCLA at 42 U.S. Code § 9621(d)(1) requires that "Remedial actions*

selected under this section or otherwise required or agreed to by the President under this chapter shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further release at a minimum which assures protection of human health and the environment." (Emphasis added). With an existing 10-4 excess lifetime cancer risk (ELCR) from PCBs [endnote iii] in fish in Bear creek, moving waste containing PCBs from elsewhere on the Oak Ridge Reservation (ORR) to EMDF and releasing additional PCBs to Bear Creek surface water is inconsistent with said control of further release required by CERCLA."

Response to Comments on ROD page 3-389 and 3-406 refer to the response to Part 4 Comment #4.

Response to Part 4, Comment 4 on ROD Page 3-387 states:

"Response: See response to Additional Comment 54 (this comment), Part 1 Comment #14. DOE disagrees that control of PCBs is not a priority. PCB waste disposed in the EMWMF is primarily painted surfaces where PCB was present in the paint. This form of PCBs is not soluble. No PCB liquids are allowed in the EMWMF. As described in the response Additional Comment 54 (this comment), Part 3 Comment #15, AWQC for chemicals with higher risk were sometimes set at concentrations that are not possible to detect using current laboratory methods. Over time, analytical methods are expected to improve to allow detection at these very low levels. Sources of more mobile forms of PCBs are found associated with legacy waste sites in Bear Creek Valley and are the sources for the PCBs found in fish tissue."

Part 1 Comment # 14 on ROD pages 3-324 and 3-325 states:

"Response: DOE disagrees that control of polychlorinated biphenyls (PCBs) is not a priority. PCB waste disposed in the EMWMF is primarily painted surfaces where PCB was present in the paint. This form of PCBs is not soluble. No PCB liquids are allowed in the EMWMF. As described in the response to Additional Comment 54 (this comment), Part 3 Comment #15, ambient water quality criteria (AWQC) for chemicals with higher risk were sometimes set at concentrations that are not possible to detect using current laboratory methods. Over time, analytical methods are expected to improve to allow detection at these very low levels (see Additional Comment 54 [this comment], Part 4 Comment #4). In addition, the EMDF site is planned and designed to be isolated from surface water during operations, closure, and post-closure periods."

Response to comments in the ROD do not address current levels of PCBs in Bear Creek posing an existing 10^{-4} excess lifetime cancer risk.

The following were calculated with the EPA Regional Screening Level Calculator at: https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

Input variables are current EPA Assumptions and Factors required by TDEC Rule 0400-40-03-.03(4)(l).

Variable	Fish Fish Default Value	Site-Specific Value
AT (averaging time)	365	365
BW_{rec_a} (body weight) kg	80	80
ED_{rec} (exposure duration) yr	26	70
EF_{rec_a} (exposure frequency) days/yr	350	365
THQ (target hazard quotient) unitless	0.1	0.1
$IRFI_{rec\_a}$ (fish consumption rate - adult) mg/day		22000
LT (lifetime) yr	70	70
TR (target cancer risk) unitless	1.0E-06	1.0E-04

$1X10^{-4}$ screening level for PCB-1260 in fish is 0.182 ug/g.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o (mg/kg-day)$^{-1}$	SF_o Ref	RfD (mg/kg-day)	RfD Ref	Ingestion SL TR=0.0001 (mg/kg)	Ingestion SL THQ=0.1 (mg/kg)	Screening Level (mg/kg)
Polychlorinated Biphenyls (high risk)	1336-36-3	No	Yes	Organics	2.00E+00	I	-		1.82E-01	-	1.82E-01 ca

PCB-1260 exposure point concentration of 0.708 ug/g in fish results in about a $3.9X10^{-4}$ excess lifetime cancer risk from ingestion of fish.

Chemical	SF_o (mg/kg-day)$^{-1}$	SF_o Ref	RfD (mg/kg-day)	RfD Ref	Concentration (mg/kg)	Ingestion Risk	Ingestion HI
Polychlorinated Biphenyls (high risk)	2.00E+00	I	-		0.708	3.89E-04	-
*Total Risk/HI	-		-		-	3.89E-04	-

Attachment 6: Mixture of Carcinogenic Chemicals and Radionuclides and the 10^{-6} Point of Departure

The cumulative exposure and risk from all carcinogenic chemicals and radionuclides[113] in effluent discharged from a NPL site plus existing carcinogens in surface water cannot be less stringent than the NCP cancer risk range.[114] A large number of carcinogenic chemicals and radionuclides may potentially be in the EMDF discharge to surface water. The ROD has not been demonstrated to maintain the excess upper bound lifetime cancer risk to an individual between 10^{-4} and 10^{-6} for the cumulative of all carcinogenic chemicals and radionuclides and overall protection of human health to NCP protectiveness standards cannot be confirmed. Under these conditions, the NCP at 40 CFR § 300.430(e)(2)(i)(A)(2) requires utilizing a 10^{-6} point of departure for determining remediation goals. This was not done.

- Carcinogenic chemicals identified in ROD Table 2.8 include aldrin; arsenic; b-BHC; 4,4-DDT; 4,4-DDE; 4,4-DDD; and dieldrin. ROD Table 2.9 includes radionuclide "PRG/cleanup levels" for americium-241, carbon-14, chlorine-36, cobalt-60, cesium-137, europium-154, tritium, iodine-129, neptunium-237, plutonium-238, plutonium-239/240, radium-226, radium-228, strontium-90, technetium-99, thorium-228, thorium-230, thorium-232, uranium-233/234, uranium-235/236, and uranium-238. ROD Table 2.5 includes additional radionuclides including, and not limited to, americium-243, curium-244, europium-152, potassium-40, nickel-59, nickel-63, lead-210, plutonium-241, and uranium-232. EMDF is also approved for disposal of waste containing carcinogenic chemicals PCBs.
- Grouping of radionuclides in the ROD and selection of variables in the formulas used to calculate the excess lifetime cancer risk (ELCR) include considerable uncertainty. For example, data is unavailable to evaluate whether the uranium-238 "PRG/cleanup level" in ROD Table 2.9 includes combined uranium-238 and thorium-234 at a 10^{-5} ELCR level. Data does not support the assumption in ROD Table 2.9 that there is a secular equilibrium relationship in surface water for radium-226 and lead-210 and assuming secular equilibrium and analyzing only radium-226 underestimates cancer risks to people consuming fish, and is inconsistent with 40 CFR § 122.44(d)(1)(vi)(A). There is no data to evaluate secular equilibrium of lead-210 with polonium-210 in surface water and whether analyzing for lead-210 levels may reliably incorporate cancer risk from polonium-210.
- Detection limits of some carcinogenic chemicals and radionuclides such as carbon-14, potassium-40, some plutonium isotopes, and PCBs may not allow reliable determination at the 10^{-5} cancer risk level.
- Bear Creek is impaired for PCBs and as shown in pictures in Attachment 3, Bear Creek is posted with a "These fish should not be eaten" advisory.[115] Existing levels of carcinogenic pollutants

[113] OSWER 9285.6-20 Distribution of the "Radiation Risk Assessment At CERCLA Sites, Q&A" Radiation Risk Assessment At CERCLA Sites: Q & A May 2014, Question 29, page 25 at https://semspub.epa.gov/work/HQ/176329.pdf.

[114] For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. 40 C.F.R. § 300.430(e)(2)(i)(A)(2).

[115] TDEC Rule 0400-40-03-.03(4)(l) Fish Consumption Advisories requires that: "*A public fishing advisory will be considered when the calculated risk of additional cancers exceeds 10-4 for typical consumers or 10-5 for atypical consumers (See definition). A "do*

and radionuclides in Bear Creek including PCB-1260 appear to cause the cancer risk from ingestion of contaminated fish to exceed the NCP acceptable 10^{-4} to 10^{-6} cancer risk range. (See Attachment 5.) Instead of the Remedial Investigation / Feasibility Study (RIFS) for the EMDF remedial action performing a baseline risk assessment it referred the risk evaluation for Bear Creek Valley to the March 1997 "*Report on the Remedial Investigation of Bear Creek Valley at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*" (DOE/ORlOl-1455Nl&D2). Volume 1, Table 5.3 (page T-74) of that report includes mercury, PCB-1254, and PCB-1260 as chemicals of concern for recreational use ingestion of fish. PCB-1260 reportedly had a frequency of detections of 35/35, 95% UCL of 0.89 ug/g, and a calculated cancer risk of $2.2X10^{-3}$ from ingestion of fish. PCB-1254 reportedly had a hazard quotient of 28 and mercury reportedly had a hazard quotient of 9.6 due to ingestion of fish.

- EMDF is authorized for disposal of carcinogenic PCBs. Promulgated recreational use water quality criteria of 0.00064 ug/L represents a 10^{-5} cancer risk level for PCBs. This is orders of magnitude below the 0.0355 ug/L detection limit and 0.107 ug/L reporting limit for PCB-1260 reported for 9/28/2023 at the EMWMF VWeir discharge to surface water and the 0.0352 ug/L detection limit and reporting limit last used at Bear Creek sampling location BCK 9.2.[116] Further, with these levels of detection and reporting limits for PCB-1260 reported for the EMWMF VWeir and Bear Creek in OREIS, it is likely discharges that represent cancer risks greater than the NCP acceptable risk range could occur undetected. The ROD failed to include promulgated recreational use water quality criteria for PCBs in Table 2.8 and does not require TBELs and WQBELs for PCBs. Instead, the ROD specifies using “sufficiently sensitive” analytical test methods and that a compliance program will be implemented if PCBs are measured in EMDF effluent. The ROD also includes a process to establish “sufficiently sensitive” detection limits. This PCB management approach neither complies with ARARs nor supports a quantitative determination whether the NCP cancer risk range may be exceeded.

not consume” advisory will be issued for the protection of typical consumers and a “precautionary advisory” will be issued for the protection of atypical consumers.”

[116] OREIS data for PCB-1260 downloaded on1/27/2024 showed that BCK 9.2 was last sampled for PCB-1260 on 8/6/2020.

Attachment 7: Several post-ROD supplemental analyses identified in the EMDF ROD.

A few of the post-ROD supplemental analyses and activities identified in the ROD include the following.

- Comment 11 on ROD page 3-363 is concerned with protecting young children who may play in Bear Creek from incidental ingestion of surface water polluted with uranium as a metal. The response to comment defers limits for uranium as a metal to a future Federal Facility Agreement (FFA) document such as the Remedial Action Work Plan for Operations and incorrectly implies that levels of radionuclides in ROD Table 2.9 account for this pathway of exposure.[117] Protection of young children is not included in the ROD or development of ROD Table 2.9 and, to our knowledge, there is no risk assessment in the administrative record that evaluates the exposure scenario discussed in Comment 11, ROD page 3-363.
- Update Waste Acceptance Criteria (WAC) based on long-term protectiveness after engineering systems and post-closure care have limited efficacy or fail entirely, [118]
- Address public comments associated with WAC derived from the EMDF PA,[119]
- Evaluate potential cancer and non-cancer health risks under a hypothetical "bathtubbing" scenario, [120]
- Establish WAC for hazardous chemicals including inventory limits for uranium as a metal,[121]
- Develop final discharge limits for relevant radionuclides[122] (It is notable that the ROD does not include compliance with ARARs in the discussion to develop final discharge limits.), and

---

[117] The ROD response to this comment includes "*Per previous agreement between the FFA parties, uranium toxicity will be included as a chemical [Contaminant of Concern (COC)] as part of the non-radiological [Ambient Water Quality Criteria (AWQC)] and AWQC-like limits. These will be described in the post-ROD decision documents such as the Remedial Action Work Plan for Operations following approval by the FFA parties*."
The response also states: *The uranium concentrations in EMDF discharge will be limited by instream PRGs/cleanup levels for the uranium isotopes, and are further limited by treatment of all landfill wastewater prior to discharge, as stated in the Water Quality Protection for Bear Creek fact sheet. These PRGs/cleanup levels assume full access to Bear Creek and account for both child and adult exposure. The details are provided in Development of Fish Tissue and Surface Water Preliminary Remediation Goals for Radionuclides of Interest for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee (UCOR 2022)* However, the administrative record (UCOR-5550) shows derivation of "PRG/cleanup levels" for uranium isotopes is based solely on ingestion of fish and does not include incidental ingestion of surface water by young children playing in Bear Creek. Families with young children have been observed on the greenway that crosses Bear Creek.

[118] EMDF ROD Section 2.12.2.3, Page 2-50
"The [waste acceptance criteria (WAC)] are an important element of the total EMDF disposal system that provide added long-term protection (defense in depth) in combination with site characteristics, facility design, operations, and post-closure care for the remedy. The supplemental analysis evaluates long-term protectiveness after other protections fail (such as the aforementioned site characteristics, facility design) and will be used to inform the design and the WAC."

[119] Comment 5 on EMDF ROD pages 3-320 and 3-321 referenced issues identified in Neptune and Company, Inc's report titled *A Review of the Performance Assessment and Composite Analysis for the Proposed Environmental Management Disposal Facility, Oak Ridge, Tennessee Dated 12 October 2020* (NAC-0131_R1). Response to the comment included:
"The EMDF PA incorporated both sensitivity and uncertainty analyses to address these types of issues. DOE has completed the PA/CA process to demonstrate protectiveness with methodologies described within DOE Orders; a supplemental analysis will be performed to demonstrate protectiveness using CERCLA methodology. The supplemental analysis in the WAC Compliance Plan will address concerns/uncertainties associated with setting WAC derived from the PA."

[120] EMDF ROD page 2-61

[121] Response to comments including EMDF ROD page 3-412 and 3-425. Page 3-412 includes:
"These WAC limits will be implemented through the post-ROD, Federal Facility Agreement (FFA) parties-approved primary document, the WAC Compliance Plan."

[122] EMDF ROD page 2-69

- Develop final PCB discharge limits that meet the most stringent of the applicable water quality criteria and antidegradation requirements.[123]

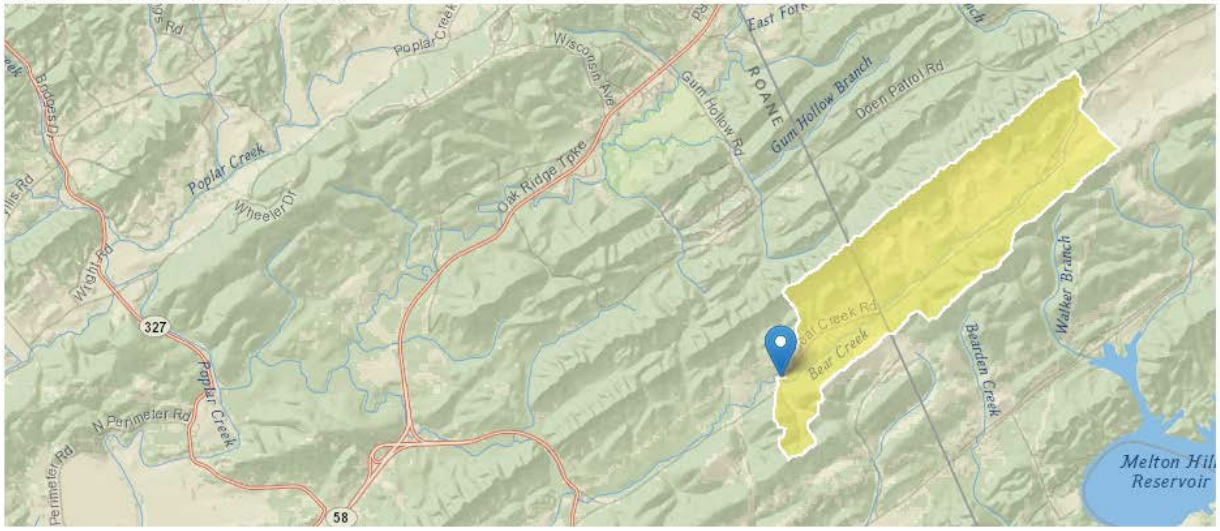
"As the EMDF design progresses, and as additional field studies are conducted, final discharge limits for relevant radionuclides will be developed and documented in a post-ROD FFA primary document (e.g., RAWP) with EPA and TDEC approval, taking into consideration technically justified site-specific information, including the discharge location, stream conditions at that location, and additional observed factors such as bioaccumulation of certain radionuclides within game fish in Bear Creek."
[123] EMDF ROD Response to Comment page 3-385

Attachment 8: USGS StreamStats (https://streamstats.usgs.gov/ss/)

Bear Creek near the EMDF Site.

StreamStats Report for BCK 7.87

Region ID: TN
Workspace ID: TN20210110220011008000
Clicked Point (Latitude, Longitude): 35.95064, -84.31372
Time: 2021-01-10 16:00:28 -0600



Low-Flow Statistics Parameters [Low Flow Central and East Regions 2009 5159]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.17	square miles	1.3	14441
RECESS	Recession Index	65	days per log cycle	32	175
CLIMFAC2YR	Tennessee Climate Factor 2 Year	2.248	dimensionless	2.056	2.46
SOILPERM	Average Soil Permeability	2.712	inches per hour	0.45	9.72
PERMGTE2IN	Percent permeability gte 2 in per hr	23.13	percent	2	100

Low-Flow Statistics Flow Report[Low Flow Central and East Regions 2009 5159]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
7 Day 10 Year Low Flow	0.112	ft^3/s	89
30 Day 5 Year Low Flow	0.197	ft^3/s	70.2

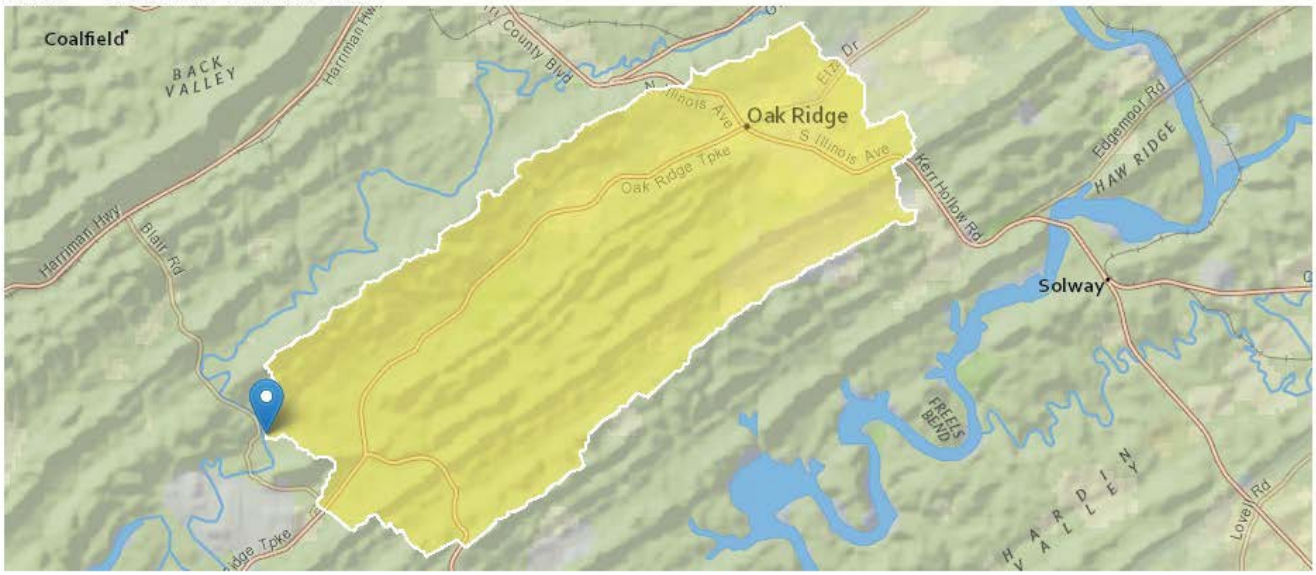
Low-Flow Statistics Citations

Law, G.S., Tasker, G.D., and Ladd, D.E.,2009, Streamflow-characteristic estimation methods for unregulated streams of Tennessee: U.S. Geological Survey Scientific Investigations Report 2009–5159, 212 p., 1 pl. (http://pubs.usgs.gov/sir/2009/5159/)

East Fork Poplar Creek near the Confluence with Poplar Creek.

StreamStats Report East Fork Poplar Creek Upstream of Poplar Creek and Downstream of Bear Creek

Region ID: TN
Workspace ID: TN20201205035041313000
Clicked Point (Latitude, Longitude): 35.94947, -84.38659
Time: 2020-12-04 21:50:58 -0600



Low-Flow Statistics Parameters [Low Flow Central and East Regions 2009 5159]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	29.74	square miles	1.3	14441
RECESS	Recession Index	67	days per log cycle	32	175
CLIMFAC2YR	Tennessee Climate Factor 2 Year	2.249	dimensionless	2.056	2.46
SOILPERM	Average Soil Permeability	2.405	inches per hour	0.45	9.72
PERMGTE2IN	Percent permeability gte 2 in per hr	40.812	percent	2	100

Low-Flow Statistics Flow Report[Low Flow Central and East Regions 2009 5159]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SEp
7 Day 10 Year Low Flow	2.02	ft^3/s	89
30 Day 5 Year Low Flow	3.31	ft^3/s	70.2

Low-Flow Statistics Citations

Law, G.S., Tasker, G.D., and Ladd, D.E.,2009, Streamflow-characteristic estimation methods for unregulated streams of Tennessee: U.S. Geological Survey Scientific Investigations Report 2009–5159, 212 p., 1 pl. (http://pubs.usgs.gov/sir/2009/5159/)

Flow-Duration Statistics Parameters[Low Flow Central and East Regions 2009 5159]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	29.74	square miles	1.3	14441
RECESS	Recession Index	67	days per log cycle	32	175
CLIMFAC2YR	Tennessee Climate Factor 2 Year	2.249	dimensionless	2.056	2.46
SOILPERM	Average Soil Permeability	2.405	inches per hour	0.45	9.72

i

OREIS U-238 and U-234 7/1/2020 to 6/30/2023 data for BCK 9.2						
Station Name	Date Collected	U-238 Results (pCi/L)	U-233/234 Results (pCi/L)	Daily Average Flow (L/min)	U-238 flux (pCi/min)	U-234 flux (pCi/min)
BCK9.2	7/8/2020	12.4	5.16	844	10,467	4,356
BCK9.2	7/15/2020	14.2	5.9	1,058	15,024	6,242
BCK9.2	7/22/2020	11.1	5.4	679	7,537	3,667
BCK9.2	7/29/2020	12.9	5.63	1,069	13,790	6,018
BCK9.2	8/5/2020	10.5	4.68	1,819	19,100	8,513
BCK9.2	8/12/2020	15.2	6.44	945	14,364	6,086
BCK9.2	8/19/2020	15.1	6.6	1,069	16,142	7,055
BCK9.2	8/26/2020	14.4	7.14	912	13,133	6,512
BCK9.2	9/2/2020	14.7	7.23	786	11,560	5,686
BCK9.2	9/9/2020	14.2	7.18	694	9,860	4,985
BCK9.2	9/16/2020	11.1	5.99	619	6,867	3,706
BCK9.2	9/23/2020	10.5	6.23	578	6,065	3,598
BCK9.2	9/30/2020	13.2	5.05	2,178	28,747	10,998
BCK9.2	10/7/2020	17.6	7.92	814	14,332	6,449
BCK9.2	10/14/2020	12.6	5.85	1,457	18,362	8,525
BCK9.2	10/21/2020	17.7	8.61	872	15,440	7,511
BCK9.2	10/28/2020	17.4	7.8	38,517	670,204	300,436
BCK9.2	11/4/2020	18.7	7.5	1,703	31,843	12,771
BCK9.2	11/11/2020	17.1	9.34	19,699	336,845	183,984
BCK9.2	11/18/2020	7.33	2.61	1,667	12,222	4,352
BCK9.2	11/25/2020	19.9	9.94	1,736	34,547	17,256
BCK9.2	12/2/2020	24.8	10.1	1,656	41,060	16,722
BCK9.2	12/9/2020	18.1	6.9	1,675	30,316	11,557
BCK9.2	12/16/2020	19.6	8.65	5,366	105,168	46,413
BCK9.2	12/22/2020	14.8	6.86	2,017	29,851	13,836
BCK9.2	12/30/2020	23.6	9.22	2,893	68,273	26,673
BCK9.2	1/6/2021	13.6	5.05	1,865	25,360	9,417
BCK9.2	1/13/2021	20.7	7.94	1,983	41,041	15,742
BCK9.2	1/20/2021	18	6.54	1,264	22,757	8,269
BCK9.2	1/27/2021	15.1	6.08	5,256	79,365	31,956
BCK9.2	2/3/2021	16	6.54	3,771	60,336	24,663
BCK9.2	2/10/2021	17.9	7.35	3,375	60,420	24,809
BCK9.2	2/17/2021	11.5	4.65	6,945	79,864	32,293
BCK9.2	2/24/2021	15	4.62	5,331	79,965	24,629
BCK9.2	3/3/2021	11.7	4.62	7,530	88,103	34,789
BCK9.2	3/10/2021	14.1	5.94	3,406	48,032	20,235
BCK9.2	3/17/2021	16.6	7.03	6,411	106,415	45,066
BCK9.2	3/24/2021	7.68	3.01	4,102	31,502	12,346
BCK9.2	3/31/2021	5.97	2.44	37,728	225,235	92,056
BCK9.2	4/7/2021	12.2	4.87	5,791	70,644	28,200
BCK9.2	4/14/2021	15.8	5.48	3,301	52,162	18,092
BCK9.2	4/21/2021	13.8	6.13	2,155	29,743	13,212
BCK9.2	4/28/2021	17.3	7.87	2,143	37,082	16,869
BCK9.2	5/5/2021	2.62	1.02	9,830	25,755	10,027
BCK9.2	5/12/2021	7.94	3.36	4,636	36,812	15,578

BCK9.2	5/19/2021	13.3	5.66	2,716	36,123	15,373
BCK9.2	5/26/2021	10.6	4.78	1,140	12,083	5,449
BCK9.2	6/2/2021	16.6	7.4	921	15,295	6,818
BCK9.2	6/9/2021	13.9	6	1,553	21,583	9,316
BCK9.2	6/16/2021	11.1	3.88	1,513	16,789	5,869
BCK9.2	6/23/2021	5.79	2.79	3,947	22,852	11,012
BCK9.2	6/30/2021	12.9	6.09	958	12,356	5,833
BCK9.2	7/7/2021	12	5.1	1,283	15,402	6,546
BCK9.2	7/14/2021	11	4.9	3,208	35,291	15,720
BCK9.2	7/21/2021	14	5	2,318	32,455	11,591
BCK9.2	7/26/2021	12.9	6.07	801	10,326	4,859
BCK9.2	7/28/2021	12	4.7	757	9,079	3,556
BCK9.2	8/4/2021	14	5.8	2,301	32,209	13,344
BCK9.2	8/11/2021	12	4.9	791	9,487	3,874
BCK9.2	8/18/2021	12	4.3	5,023	60,275	21,598
BCK9.2	8/25/2021	14	5.1	1,424	19,937	7,263
BCK9.2	9/1/2021	6.1	2.5	28,225	172,175	70,564
BCK9.2	9/8/2021	12	5.7	1,302	15,622	7,420
BCK9.2	9/15/2021	19	8.3	1,367	25,977	11,348
BCK9.2	9/22/2021	15	6.3	5,962	89,434	37,562
BCK9.2	9/29/2021	15	6.7	1,026	15,394	6,876
BCK9.2	10/6/2021	15	5.9	2,001	30,013	11,805
BCK9.2	10/13/2021	14	6	1,879	26,301	11,272
BCK9.2	10/20/2021	11	5.3	2,023	22,257	10,724
BCK9.2	10/27/2021	21	8.2	1,572	33,012	12,890
BCK9.2	11/3/2021	23	8	2,147	49,374	17,174
BCK9.2	11/10/2021	18	7.5	1,358	24,436	10,182
BCK9.2	11/17/2021	19	8.1	1,404	26,682	11,375
BCK9.2	11/24/2021	14	6.5	1,585	22,188	10,302
BCK9.2	12/1/2021	14	6.1	1,284	17,970	7,830
BCK9.2	12/8/2021	15	6.6	1,985	29,772	13,100
BCK9.2	12/15/2021	11	4.7	2,510	27,612	11,798
BCK9.2	12/21/2021	10	4.4	4,503	45,033	19,815
BCK9.2	12/29/2021	12	5.4	18,124	217,488	97,870
BCK9.2	1/5/2022	5	2.5	7,251	36,257	18,129
BCK9.2	1/12/2022	14	4.8	6,540	91,556	31,391
BCK9.2	1/19/2022	15	5.2	6,783	101,751	35,274
BCK9.2	1/26/2022	18	5.3	3,940	70,928	20,884
BCK9.2	2/2/2022	18	6.9	2,535	45,627	17,490
BCK9.2	2/9/2022	13	3.9	4,618	60,035	18,010
BCK9.2	2/16/2022	14	5.5	2,662	37,274	14,643
BCK9.2	2/23/2022	12	4.4	144,282	1,731,387	634,842
BCK9.2	3/2/2022	7.2	2.3	7,143	51,428	16,428
BCK9.2	3/9/2022	8.2	2.9	29,013	237,906	84,137
BCK9.2	3/16/2022	7.1	2.7	6,809	48,344	18,384
BCK9.2	3/23/2022	25	5.8	6,484	162,088	37,604
BCK9.2	3/30/2022	15	4.9	3,252	48,782	15,935
BCK9.2	4/6/2022	15	5.5	4,895	73,427	26,923
BCK9.2	4/13/2022	7.8	3	8,465	66,026	25,395
BCK9.2	4/20/2022	9.4	2.9	6,920	65,050	20,069
BCK9.2	4/27/2022	9.7	4	3,716	36,049	14,865
BCK9.2	5/4/2022	11	4	2,044	22,481	8,175

BCK9.2	5/11/2022	12	5	1,940	23,277	9,699
BCK9.2	5/18/2022	13	5.5	1,231	16,004	6,771
BCK9.2	5/25/2022	14	5	2,285	31,990	11,425
BCK9.2	6/1/2022	11	4.7	1,414	15,558	6,648
BCK9.2	6/8/2022	14	6.5	2,610	36,538	16,964
BCK9.2	6/15/2022	13	6.6	1,006	13,073	6,637
BCK9.2	6/22/2022	12	7.2	952	11,418	6,851
BCK9.2	6/29/2022	13	4.7	645	8,388	3,032
BCK9.2	7/6/2022	9.7	4.4	2,839	27,541	12,493
BCK9.2	7/13/2022	11	4.6	2,624	28,862	12,070
BCK9.2	7/20/2022	13	5.4	2,483	32,284	13,410
BCK9.2	7/27/2022	13	5.9	2,123	27,600	12,526
BCK9.2	8/3/2022	11	5.8	2,903	31,928	16,835
BCK9.2	8/10/2022	14	6.8	8,369	117,166	56,909
BCK9.2	8/17/2022	8.6	4.4	2,152	18,508	9,469
BCK9.2	8/24/2022	17	7.8	878	14,928	6,849
BCK9.2	8/31/2022	15	7.3	789	11,829	5,757
BCK9.2	9/7/2022	13	5.5	3,844	49,976	21,144
BCK9.2	9/14/2022	14	5.9	1,080	15,118	6,371
BCK9.2	9/21/2022	14	6.1	834	11,674	5,086
BCK9.2	9/28/2022	15	6.8	788	11,820	5,358
BCK9.2	10/5/2022	14	6.3	754	10,556	4,750
BCK9.2	10/12/2022	13	6.6	761	9,894	5,023
BCK9.2	10/26/2022	15	6.3	1,426	21,393	8,985
BCK9.2	11/2/2022	16	7.6	1,467	23,471	11,149
BCK9.2	11/9/2022	14	6.1	1,250	17,505	7,627
BCK9.2	11/16/2022	15	6.2	2,181	32,715	13,522
BCK9.2	11/23/2022	14	7.4	899	12,590	6,655
BCK9.2	11/30/2022	15	5.9	9,509	142,638	56,104
BCK9.2	12/7/2022	12	4.4	21,418	257,011	94,237
BCK9.2	12/14/2022	16	8	59,361	949,770	474,885
BCK9.2	12/21/2022	5.8	2.1	3,593	20,840	7,545
BCK9.2	12/28/2022	13	6	2,387	31,029	14,321
BCK9.2	1/4/2023	20	6.9	12,547	250,933	86,572
BCK9.2	1/11/2023	18	6.4	3,726	67,068	23,846
BCK9.2	1/18/2023	15	5	6,185	92,775	30,925
BCK9.2	1/25/2023	18	5.8	10,737	193,266	62,275
BCK9.2	2/1/2023	17	4.7	10,045	170,767	47,212
BCK9.2	2/8/2023	16	6	4,288	68,605	25,727
BCK9.2	2/15/2023	19	6.7	6,463	122,790	43,299
BCK9.2	2/22/2023	7.8	2.2	5,633	43,940	12,393
BCK9.2	3/1/2023	19	7.1	5,077	96,462	36,046
BCK9.2	3/8/2023	9.3	3	5,289	49,190	15,868
BCK9.2	3/15/2023	17	5.3	5,222	88,768	27,675
BCK9.2	3/22/2023	15	5.2	7,220	108,303	37,545
BCK9.2	3/29/2023	10	3.1	5,444	54,436	16,875
BCK9.2	4/5/2023	9.7	4.1	4,945	47,967	20,275
BCK9.2	4/12/2023	14	5.9	4,771	66,799	28,151
BCK9.2	4/19/2023	13	4.8	5,612	72,955	26,937
BCK9.2	4/26/2023	11	4.6	2,253	24,781	10,363
BCK9.2	5/3/2023	12	5.7	2,234	26,802	12,731
BCK9.2	5/10/2023	13	5.8	4,377	56,901	25,387

BCK9.2	5/17/2023	11	6.1	4,652	51,176	28,379
BCK9.2	5/24/2023	12	5.7	1,492	17,905	8,505
BCK9.2	5/31/2023	13	5.7	816	10,606	4,651
BCK9.2	6/7/2023	13	5.5	709	9,214	3,898
BCK9.2	6/14/2023	10	4.3	936	9,358	4,024
BCK9.2	6/21/2023	12	5.9	5,934	71,208	35,010
BCK9.2	6/28/2023	12	5.3	3,134	37,610	16,611

ii

OREIS PCB-1260 Fish Data Used to Estimate Cancer Risk					
Station Name	Fish Common Name	Date Collected	PCB-1260 Results	Comment	Fish Tag Number
BCK 3.3	rock bass	4/11/2019	0.071		29933
BCK 3.3	rock bass	4/11/2019	0.23		29934
BCK 3.3	rock bass	4/11/2019	0.17		29935
BCK 3.3	rock bass	4/11/2019	0.097		29936
BCK 3.3	rock bass	4/11/2019	0.14		29937
BCK 3.3	rock bass	4/11/2019	0.89	Average	29938
BCK 9.9	rock bass	4/15/2019	1.5		29943
BCK 9.9	rock bass	4/15/2019	0.89	Average	29944
BCK 9.9	rock bass	4/30/2019	1.2		29969
BCK 9.9	rock bass	4/30/2019	0.51		29970
BCK 9.9	rock bass	4/30/2019	1.6		29971
BCK 9.9	rock bass	4/30/2019	0.6		29972
BCK 3.3	rock bass	10/3/2019	0.21		30359
BCK 3.3	rock bass	10/3/2019	0.19		30360
BCK 3.3	rock bass	10/3/2019	0.092		30361
BCK 3.3	rock bass	10/3/2019	0.18		30362
BCK 3.3	rock bass	10/3/2019	0.17		30363
BCK 3.3	rock bass	10/3/2019	0.0775	Average	30364
BCK 9.9	rock bass	10/9/2019	3.1		30369
BCK 9.9	rock bass	10/9/2019	2.9		30370
BCK 9.9	rock bass	10/9/2019	2.4		30371
BCK 9.9	rock bass	10/9/2019	1.2		30372
BCK 9.9	rock bass	10/9/2019	1.2		30373
BCK 9.9	rock bass	10/9/2019	1.01	Average	30374
BCK 9.9	rock bass	4/9/2020	2.7		30766
BCK 9.9	rock bass	4/9/2020	0.51		30767
BCK 9.9	rock bass	4/9/2020	0.88		30768
BCK 9.9	rock bass	4/9/2020	0.72	Average	30769
BCK 3.3	rock bass	5/12/2020	0.42		30813
BCK 3.3	rock bass	5/12/2020	0.3		30814
BCK 3.3	rock bass	5/12/2020	0.31		30815
BCK 3.3	rock bass	5/12/2020	0.48		30816
BCK 3.3	rock bass	5/12/2020	0.26		30817

BCK 3.3	rock bass	5/12/2020	0.405	Average	30818
BCK 9.9	rock bass	10/1/2020	0.073		31271
BCK 9.9	rock bass	10/1/2020	0.097		31272
BCK 3.3	rock bass	10/7/2020	0.26		31273
BCK 3.3	rock bass	10/7/2020	0.12		31274
BCK 3.3	rock bass	10/7/2020	0.24		31275
BCK 9.9	rock bass	10/9/2020	0.46		31282
BCK 9.9	rock bass	10/9/2020	1.4		31283
BCK 9.9	rock bass	10/9/2020	0.675	Average	31284
BCK 3.3	rock bass	11/3/2020	0.19		31309
BCK 3.3	rock bass	11/3/2020	0.13	Average	31310
BCK 3.3	rock bass	5/12/2021	0.077		31696
BCK 3.3	rock bass	5/12/2021	0.14		31697
BCK 3.3	rock bass	5/12/2021	0.19		31698
BCK 3.3	rock bass	5/12/2021	0.17		31699
BCK 3.3	rock bass	5/12/2021	0.21		31700
BCK 3.3	rock bass	5/12/2021	0.11		31701
BCK 3.3	rock bass	5/12/2021	0.17		31701
BCK 9.9	rock bass	5/20/2021	0.32		31708
BCK 9.9	rock bass	5/20/2021	0.31		31709
BCK 9.9	rock bass	5/20/2021	0.13		31710
BCK 9.9	rock bass	5/20/2021	0.69		31711
BCK 9.9	rock bass	5/20/2021	0.67		31712
BCK 9.9	rock bass	5/20/2021	0.78	Average	31713
BCK 3.3	rock bass	10/11/2021	0.16		32118
BCK 3.3	rock bass	10/11/2021	0.1		32119
BCK 3.3	rock bass	10/11/2021	0.25		32120
BCK 3.3	rock bass	10/11/2021	0.076		32121
BCK 3.3	rock bass	10/11/2021	0.15		32122
BCK 3.3	rock bass	10/11/2021	0.125	Average	32123
BCK 9.9	redbreast sunfish	10/25/2021	1.4		32148
BCK 9.9	redbreast sunfish	10/25/2021	1.3		32149
BCK 9.9	redbreast sunfish	10/25/2021	0.76		32150
BCK 9.9	redbreast sunfish	10/25/2021	1.3		32151
BCK 9.9	rock bass	10/25/2021	0.48		32152
BCK 9.9	rock bass	10/25/2021	0.24	Average	32153
BCK 3.3	rock bass	4/4/2022	0.00785	1/2 Detection Limit	32597
BCK 3.3	rock bass	4/4/2022	0.0647		32598
BCK 3.3	rock bass	4/4/2022	0.02		32599
BCK 3.3	rock bass	4/4/2022	0.0862		32600
BCK 3.3	rock bass	4/4/2022	0.008	Average & 1/2 Detection Limit	32601
BCK 9.9	redbreast sunfish	4/6/2022	0.205		32603

BCK 9.9	redbreast sunfish	4/6/2022	0.259		32604
BCK 9.9	redbreast sunfish	4/6/2022	0.173		32605
BCK 9.9	rock bass	4/6/2022	0.0376		32606
BCK 9.9	rock bass	4/6/2022	0.031		32607
BCK 9.9	rock bass	4/6/2022	0.0813	Average	32608
BCK 9.9	redbreast sunfish	10/20/2022	0.158		32906
BCK 9.9	redbreast sunfish	10/20/2022	0.1945	Average	32907
BCK 9.9	rock bass	10/20/2022	0.063		32909
BCK 3.3	rock bass	11/2/2022	0.0128		32922
BCK 3.3	redbreast sunfish	11/2/2022	0.0129		32923
BCK 9.9	rock bass	11/3/2022	0.269		32927
BCK 9.9	rock bass	11/3/2022	0.118		32928
BCK 9.9	rock bass	11/3/2022	0.0462		32929
BCK 3.3	green sunfish	11/17/2022	0.008	Average & 1/2 Detection Limit	32937
BCK 3.3	redbreast sunfish	4/18/2023	0.0352		33248
BCK 3.3	rock bass	4/18/2023	0.106		33249
BCK 3.3	rock bass	4/18/2023	0.048	Average	33250
BCK 9.9	rock bass	5/8/2023	0.403		33289
BCK 9.9	rock bass	5/8/2023	0.053		33290
BCK 9.9	rock bass	5/8/2023	0.0498		33291
BCK 9.9	redbreast sunfish	5/8/2023	0.185		33292
BCK 9.9	redbreast sunfish	5/8/2023	0.228		33292
BCK 3.3	rock bass	5/24/2023	0.0657		33341
BCK 9.9	rock bass	5/24/2023	0.0438		33342
BCK 9.9	redbreast sunfish	5/24/2023	0.0253		33343