CRESP

Consortium For Risk Evaluation with Stakeholder Participation

Consortium Universities: **Vanderbilt University**, Georgia Tech, Howard University, New York University, Oregon State University, Rutgers University, University of Virginia

HANFORD SITE-WIDE RISK REVIEW PROJECT - FINAL REPORT

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Acknowledgements and Disclaimer

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[7] Dr. Powers retired in November 2015 during the development of this report.

Abstract

Beginning in World War II and continuing through the Cold War, Hanford played a major role in the production of plutonium for the nation's defense. During Hanford's peak years, nine nuclear reactors were operational along the Columbia River in southeastern Washington. Hanford's defense mission ended in 1989. Now, Hanford's mission is the treatment and disposal of radioactive wastes along with cleanup of soil, groundwater, and facilities contaminated from the defense work. This effort is massive and has proven to be technically challenging and very costly. About forty percent of the Department of Energy's (DOE) nationwide cleanup budget or about $2.5 billion is directed each year toward Hanford's cleanup. Despite the challenges and cost, considerable progress has been made in reducing the risks that the site poses to the public, worker safety and health, and the environment.

Even so, cleanup is not expected to be completed at Hanford for another 50 years and perhaps longer. Future cleanup costs are projected to exceed $100 billion. To better understand the substantial work that lies ahead, the Department of Energy (DOE) asked an independent group of university researchers - the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) - to conduct a comprehensive evaluation of current and future risks and impacts on people and the environment arising from the former defense work that took place at Hanford. In addition to providing the DOE with a better understanding of the risks associated with the remaining waste disposal and cleanup, the results of the risk evaluations are intended to provide insights on the order and timing of future cleanup activities and the selection, planning and execution of specific actions to be taken.

This report contains the results of all evaluations conducted and the observations made during the execution of the risk review project. This includes ratings of the risks and impacts to people and protected resources (groundwater and the Columbia River and ecological resources) during the current time period and also during active cleanup and after cleanup has been completed. An overall rating has not been provided for cultural resources. Instead, information about cultural resources was gathered, described, and analyzed as a planning guide for future cleanup activities.

Risks from different types and forms of contamination have the potential to be realized at very different time scales. Contamination releases associated with stored wastes or contamination in facilities that are subject to earthquakes, fires, collapse or loss of active engineered controls, albeit low probability, have the potential at unpredictable times to result in rapid dispersion of contamination requiring urgent responses. In contrast, migration of remaining contamination from waste sites to the vadose zone to groundwater and from groundwater to the Columbia River in most locations present risks that may be realized only slowly over many decades to centuries.

The report's major results include the following:

1. **RISKS TO THE PUBLIC ARE MINIMAL OR LOW:** Current risks and impacts to the public are considered extremely unlikely. Public access to the Hanford Site is prohibited except under very limited circumstances, such as tours, which do not include contaminated areas or areas undergoing active cleanup. Contaminated groundwater also is not considered a current threat to the public because groundwater is not being withdrawn for use or consumption. The only current risk to the public is from atmospheric dispersion of radioactive contaminants that may be released during a major fire or external event such as a severe earthquake. However, the probability of a contaminant release occurring that would threaten the public is remote. There are two reasons for this and both must apply. First, any risks to the public from airborne contaminants would occur **only** from facilities having large amounts of dispersible radioactive contaminants. Second, the risks would be realized **only** when the fire or event is so extreme that the extensive and monitored controls put in place to prevent the contaminant from becoming

airborne or to contain the extent of the contamination traveling large distances to public areas, do not mitigate the risk. In the Plutonium Uranium Extraction Plant (PUREX) tunnels example, the risk to the public would only occur if a tunnel collapse was accompanied by fire. A fire may then lead to the widespread dispersal of radioactive contaminants in the air.

2. **RISKS TO ONSITE WORKERS ARE HIGHER THAN TO OTHER PEOPLE:** The highest current risks to persons physically located within Hanford's controlled access boundary are to workers (described as facility workers[8] and co-located persons[9] in this risk review project). Worker risks arise from (i) external or natural events (e.g., earthquakes or fire) affecting facilities that require active engineering controls, (ii) structural deterioration or failure of engineered facilities with high inventories of readily dispersible radioactive contaminants (e.g., Plutonium Uranium Extraction Plant (PUREX) tunnels), and (iii) accidents during remediation of subsurface contamination (e.g., Building 324) or retrieval of wastes (e.g., 618-11 vertical pipe units retrieval of buried radioactive transuranic waste/ tank wastes). In addition to workers, accidents that may occur during retrieval of subsurface contamination at Building 324 have the potential to affect people, who are located offsite. Accidents that may occur during retrieval of buried wastes at 618-11 legacy source site have the potential to impact people located at or near the Columbia Generating Station. DOE has measures in place to minimize or mitigate these potential threats.
3. **RISKS FROM TANK WASTES VARY DEPENDING ON WASTE COMPOSITION IN EACH TANK:** There is considerable range in the composition and risks posed by wastes stored in tanks – thus, tank farms and tanks should be considered individually for waste retrieval sequencing, waste treatment and the extent of retrieval necessary to reduce risk. Wastes from defense material production accumulated in single shell and double shell tanks (i.e., "tank wastes") collectively represent the largest inventory of radioactivity at the Hanford site. Treating tank wastes is important for reducing the long-term risk to people and the environment, but the radionuclide inventory is not what drives the urgency. What drives the urgency are two attributes of the waste that remain in some tanks – (i) the potential for hydrogen accumulation in the event of loss of active ventilation (leading to fire or deflagration), and (ii) content of key radionuclides (technetium-99 and iodine-129) that are mobile in the subsurface and could contaminate large quantities of groundwater, which is a protected natural resource. Additionally, during waste retrieval and processing, potential exposure to waste vapors and accidents are worker risk concerns.
4. **RISKS TO THE COLUMBIA RIVER AND ECOLOGICAL RESOURCES ARE LIMITED:** Risks to the Columbia River and ecological resources associated with the River are very limited. These risks are focused in the (i) riparian zone (ecologically sensitive zone immediately adjacent to the river) and arise from physical disruption during cleanup activities (e.g., destruction of high value habitat) and (ii) benthic zone (gravel and sediment zone within the river bed), specifically in those areas of the zone that are vulnerable to the discharge of contaminants from groundwater. In the river corridor, DOE is addressing contamination through remediation actions including removal actions and groundwater remediation.

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[8] Facility Worker is any worker or individual within the facility (or within the activity geographic boundary as established for the Documented Safety Analysis) and located less than 100 m from the potential contaminant release point.

[9] Co-Located Person is a hypothetical onsite individual (who may be a site worker not associated with the specific facility or activity, or may be a site visitor) located at a point equal to 100 m from the boundary of the facility (or activity or from the point of potential contaminant release), or beyond 100 m from the point at which maximum dose hypothetically occurs. or from the point of potential contaminant release).

5. **RISKS TO PROTECTED RESOURCES VARY (Groundwater, Ecological and Cultural Resources):** The greatest long-term risks to protected resources arise from (i) further migration of contaminants already within groundwater because groundwater itself is a protected resource, and (ii) the disruption or destruction of ecological and cultural resources by cleanup activities. The groundwater areas considered to be at highest risk that are not currently being mitigated are located in the 200 East area of the Central Plateau. The Columbia River currently is not at risk from groundwater contamination, although the ecological and eco-cultural resources in some riparian zones may be impacted from physical disruptions or introduction of invasive species during cleanup.

Five overarching observations emerged from these results. First, risks to members of the public, whether they are located at the official or controlled access boundary or outside the boundary, currently are considered to be low or not discernible. Second, timing of cleanup may reduce worker risk (e.g., by allowing for radioactive decay (reducing potential worker exposure to radiation at a later point)) or increase worker risk (e.g., by facility deterioration, insufficiently trained workforce availability). Third, a major earthquake or other regional catastrophic event may affect multiple facilities simultaneously, and potentially may release significant quantities of radiological contaminants from multiple facilities (e.g., K West Basin, Waste Encapsulation and Storage Facility (WESF), Central Waste Complex (CWC)). The greatest risks arise from low probability events that cause abrupt disruption of facilities with substantial radionuclide inventories resulting in atmospheric dispersion of contaminants (e.g., by fire or earthquake) and require urgent responses. In contrast, under current site hydrologic conditions, transport of contaminants to groundwater and further expansion of existing groundwater contamination are very slow processes that occur over many decades to centuries, allowing for anticipatory monitoring and responses that can be implemented over many years when observed. Groundwater is a protected resource but does not create human or ecological risk unless it is subject to use (currently prevented by government site control) or contamination is brought to the surface by ecological processes (e.g., plants) or is carried in groundwater discharges within the riparian or benthic zones of the Columbia River. Fourth, the ecological resources on the Hanford Site are very important to the Columbia River Basin ecoregion. The Site contains both federal and state threatened and endangered species. DOE stewardship has helped protect and enhance these resources. Fifth, the historical and cultural significance at the Hanford Site stretches over 10,000 years, which the DOE recognizes and actively supports through its stewardship of the site.

At the onset of the project, CRESP, in dialogue with senior officials from the DOE and its regulatory agencies (i.e. Environmental Protection Agency and Washington State Departments of Ecology and Health), divided the risk review project into three parts.

The first part of the project was the development of scientifically sound approaches that distinguish a range of effects (e.g., not discernible, low, high) on people and protected resources (groundwater, the Columbia River, ecological, and cultural) from exposure to contaminants in the areas remaining to be cleaned up. These areas range from buried solid waste sites to contaminated groundwater plumes. Separate and distinct methodologies were developed to assess risks and impacts to people, groundwater, and ecological and cultural resources. Each methodology describes how the risks and impacts are to be rated based on the likelihood of an event occurring that triggers a release of contaminants that in turn threaten people and/or resources.

The project's second part consisted of the development of an interim report, which contains the evaluations and ratings of 25 of the 64 evaluation units[10] (remaining cleanup areas at the Hanford Site) using the methodologies developed for rating risks from contamination on people, groundwater and the Columbia River, and ecological and cultural resources. To conduct the evaluations and make the ratings, publically available information was gathered and analyzed on each evaluation unit. For cultural resources, professional archaeologists thoroughly reviewed cultural resource records to determine whether a resource is or has been present.

The third part of the risk review project was the development of the final report, which contains the evaluations of all the units including those not analyzed for the interim report, results, and observations. Evaluations of some of the units addressed in the interim report were updated for the final report. Appendices to the report contain the completed evaluation templates and underlying documentation supporting ecological and cultural resources.

Both the methodology and interim report documents were reviewed by a group of experts as well as by the DOE and its regulators. The public and stakeholders were provided briefings and also were given the opportunity to provide written comments. Comments made on the methodology informed the interim report. Input received from the public, DOE and its regulated agencies, and other stakeholders on the interim report aided the development of this final report. Finally, this report has undergone technical reviews by the DOE and outside experts.

[10] The Evaluation Unit (EU) concept was developed by the Risk Review Project to provide a tractable basis for reviewing the myriad of cleanup challenges at the Hanford Site. Groupings of facilities, wastes, and existing environmental contamination within each EU are based primarily on geographic location because the potential to impact receptors is fundamentally based on geographic location and spatial relations that may lead to exposure of receptors to hazards from specific sources. Thus, EU groupings are not based on, and may not correspond with, either (1) the process history that produced the wastes or environmental contamination, or (2) the groupings used for regulatory purposes (e.g., operable units).

Executive Summary

Project Goal and Scope

In January 2014, the U.S. Department of Energy (DOE) asked the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) to conduct an independent Hanford Site-wide evaluation of human health, nuclear safety, and environmental and cultural resource risks (hereinafter referred to as the "Risk Review Project") associated with existing hazards, environmental contamination, and remaining cleanup activities. This report provides the results of the evaluations completed for the Project, as well as final observations. To this end, the Risk Review Project is forward looking as it only addresses remaining cleanup at Hanford Site as of October 1, 2015 using an evaluation approach developed by CRESP that screens for current and future risks and impacts to human health and resources.[11] Project results are intended to provide DOE, regulators, Tribal Nations, and the public with a more comprehensive understanding of the remaining cleanup at the Hanford Site. Project results also are intended to help inform (1) decisions on order and timing of future cleanup activities, and (2) selection, planning, and execution of specific cleanup actions, including identifying which areas at the Hanford Site should be addressed earlier for additional characterization, analysis, and remediation.[12]

> **Evaluation Unit**
>
> The evaluation unit concept was developed as part of the risk review project to allow for assessment of geographically co-located sources of contamination or risk that may not normally be considered together because of different regulatory jurisdictions or operational responsibilities.

Sixty-four units, referred to as "evaluation units" (EUs) and composed primarily of geographically co-located areas of existing facilities, waste storage, and environmental contamination, have been evaluated during the execution of the Risk Review Project.[13] These 64 evaluation units represent the remaining cleanup areas at the Hanford Site. The Risk Review Project also provides a description of the inventories of radionuclides and chemicals, including their forms, spatial distribution, and barriers to future environmental contamination that are projected to remain at the end of cleanup (based on current agreements and decisions).[14] DOE, the State of Washington, and the U.S.

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[11] In this Risk Review Project, human health and resources evaluated include groundwater and the Columbia River, Facility Workers, Co-located Persons, Controlled Access Persons, Public, and ecological and cultural resources. Collectively, humans and identified resources also are referred to as "receptors."

[12] It is important to note that while earlier studies have evaluated portions of the Hanford Site, there has never been a comprehensive, Site-wide review of the risks to human health and resources from contamination, waste management, and cleanup activities.

[13] Evaluation Templates for four of the 64 EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3. Two of the EUs (CP-OP-11 and CP-OP-16) were combined and evaluated as CP-OP-11 (LERF + EFT).

[14] For example, decisions have been made that mean some areas of the Hanford Site will be dedicated to long-term waste management.

Environmental Protection Agency (EPA) clearly recognize that the Risk Review Project results are only one of many inputs to prioritization of future cleanup activities at Hanford. The Risk Review Project has focused on risk characterization based on analysis and integration of existing information. Risk characterization is essential and must occur as an early and ongoing component[15] of risk management, but it does ***not*** dictate risk management decisions. Further, the results obtained from the risk characterization completed under this project do not provide a rank-ordered priority list of cleanup actions, but rather provide groupings of relative risk (e.g., High, Medium). The development of a priority list of future cleanup actions is a risk management decision. This means development of a priority list is the purview of DOE and its regulators, considering many additional factors. Finally, the cleanup actions for many evaluation units are yet to be determined. As such, reviews of these evaluation units have accounted for a plausible range of cleanup actions for different types of contaminant sources as a way to better understand the scope of potential risks and impacts to receptors that those cleanup actions may cause.

It is also important to be clear about what the Risk Review Project is not. The Risk Review Project is neither intended to be a substitute for, nor preempt, any requirement imposed under applicable federal or state laws or treaties. As important, the Risk Review Project is not intended to make or replace any decisions made under the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) and/or 2010 Consent Order, or amendments to either document. The Risk Review Project is neither a CERCLA (*Comprehensive Environmental Response, Compensation, and Liability Act*) risk assessment nor a Natural Resources Damage Assessment evaluation. The Risk Review Project is not intended to interpret treaty rights that exist between the United States and Native American Tribes.

Project results are intended to provide a more comprehensive understanding of the remaining cleanup and to help inform:

- decisions on order and timing of future cleanup activities, and
- selection, planning, and execution of specific cleanup actions…

This final report presents both the evaluation results and final observations from the Risk Review Project. For each evaluation conducted, available information as of October 1, 2016[16] about hazards (e.g., contaminant inventories, physical chemical forms) and the existing environmental contamination within the evaluation unit has been gathered, described, and analyzed[17]. Consideration was then given to the fact that at certain points in time and as a result of various events (e.g., facility degradation, seismic activity, accidents, or fire), the identified hazards and environmental contamination may move or lead to the movement of radionuclides and chemical contaminants along multiple pathways, potentially creating exposure or impact (referred to as "risk") to human health and resources within an evaluation unit. This actual or potential movement of radionuclides and chemical contaminants and the resulting impact on receptors

[15] Risk characterization needs to be reevaluated as significant new information becomes available that may change outcomes from earlier assessments.
[16] Selected updates were made to Evaluation Units with significant events after October 1 2016 (e.g., PUREX Tunnel collapse).
[17] Evaluations completed for the interim progress report were based on data received as of January 2015 and have not been updated for this report except (1) groundwater evaluations (which have been updated for this report to reflect the 2015 published monitoring data) and (2) as otherwise noted (e.g., Building 324 [RC-DD-1]) because more recent information materially affected the evaluation(s) made in the interim progress report.

are considered the "risks" that have been evaluated and rated for each evaluation unit and which are discussed in this report.

HANFORD SITE BACKGROUND

The Hanford Site is located along the Columbia River in southeastern Washington State and consists of an area 586 square miles (half the size of the State of Rhode Island). For over 40 years, the Site played a major role in the development and production of plutonium and other defense materials as part of the Manhattan Project during World War II and afterwards during the Cold War.

In 1989, Hanford's mission shifted from supporting weapons development to environmental cleanup of facilities, soil, and groundwater. Today, the Hanford Site consists of former weapons production locations, active and closed research facilities, waste management, storage and disposal areas, and huge swaths of natural resources and unique habitats. Maps (Figure ES-1-1, Figure ES-1-2, Figure ES-1-3) of the Hanford Site may be found in the following section of the Executive Summary.

Cleanup at the Site has proven to be more costly, time-consuming, and technically challenging than expected when it began more than 25 years ago. DOE's near-term vision calls for reducing the active cleanup footprint to 75 square miles in the center of the Site, reducing on-going costs associated with maintaining safety, security and infrastructure, and shifting resources that would allow full-scale cleanup of the Hanford Site's Central Plateau. To date, considerable progress has been made toward achieving this vision. For example, many hazards near the Columbia River have been eliminated by completing cleanup of most of the River Corridor and treating contaminated groundwater near the Columbia River. Yet substantial work remains, as evidenced by the more than $100 billion projected to be spent on cleanup over the next 50 years.

APPROACH USED

The Risk Review Project was led by a team of CRESP researchers in dialogue with a Core Team, composed of senior management from DOE, EPA, and the Washington State Departments of Ecology and Health. The Core Team provided advice and guidance on the development and execution of the Risk Review Project through the completion of the interim progress report (CRESP 2015a; www.cresp.org/hanford/).[18] CRESP is a multi-disciplinary consortium of universities with a mission to advance environmental cleanup by finding ways to improve the scientific and technical basis for management decisions, and to engage stakeholders and the public. CRESP has completed risk-informed characterization projects involving complex issues at DOE Office of Environmental Management sites around the country. Pacific Northwest National Laboratory (PNNL) provided research, analytical, and other assistance to CRESP as part of the Risk Review Project.

For the first several months of the project, the focus was on developing an evaluation approach that would accomplish the Risk Review Project's goal of providing DOE, regulators, and the public with a more comprehensive understanding of the current and future risks to receptors and to help inform decisions on order and timing of future cleanup activities, as well as associated selection, planning, and execution of specific cleanup activities. The approach developed for each receptor is described in a

[18] CRESP. 2015a. *Hanford Site-Wide Risk Review Project Interim Progress Report.* Rev. 0, The Consortium for Risk Evaluation with Stakeholder Participation III, Vanderbilt University, Nashville, TN. Available from http://www.cresp.org/hanford/ (1 November 2016).

comprehensive methodology document (CRESP 2015b; www.cresp.org/hanford/).[19] The draft methodology document was made available for agency and public comment in September 2014 and then revised in response to comments received. The methodology used to evaluate the evaluation units discussed both in this report and in the interim progress report (providing evaluations of 25 of the 64 evaluation units) that was completed in 2015 reflects the revisions made in response to input from DOE, regulators, other stakeholders, Tribal Nations, and the public on the draft methodology. The methodology also reflects the lessons learned from the pilot case studies completed in the summer of 2014 to test the draft version of the methodology, as well as input from a review by independent experts. A detailed timeline for the Hanford Risk Review Project that includes stakeholder and public engagement is available at http://www.cresp.org/hanford/.

The screening approach used for this Risk Review Project has limited evaluations to rough order of magnitude factors that distinguish risks between evaluation units and also between receptors because of uncertainties and information gaps. These factors include taking account of current barriers to dispersion of contaminants, including engineered systems, natural systems and institutional controls, the mechanisms of barrier failures, and the likelihood and magnitude of adverse consequences to receptors. Risks have been considered in the context of each evaluation unit's current status, during cleanup activities and after cleanup activities. Figure ES-1-1 shows the locations of all evaluation units evaluated for this report, except groundwater evaluation units; Figure ES-1-2 is a detailed map of the Hanford Site Central Plateau; and Figure ES-1-3 provides an overview and the location of the existing groundwater contamination plumes.

[19] CRESP. 2015b. *Methodology for the Hanford Site-Wide Risk Review Project.* Rev. 0, The Consortium for Risk Evaluation with Stakeholder Participation III, Vanderbilt University, Nashville, TN. Available from http://www.cresp.org/hanford/ (1 November 2016).

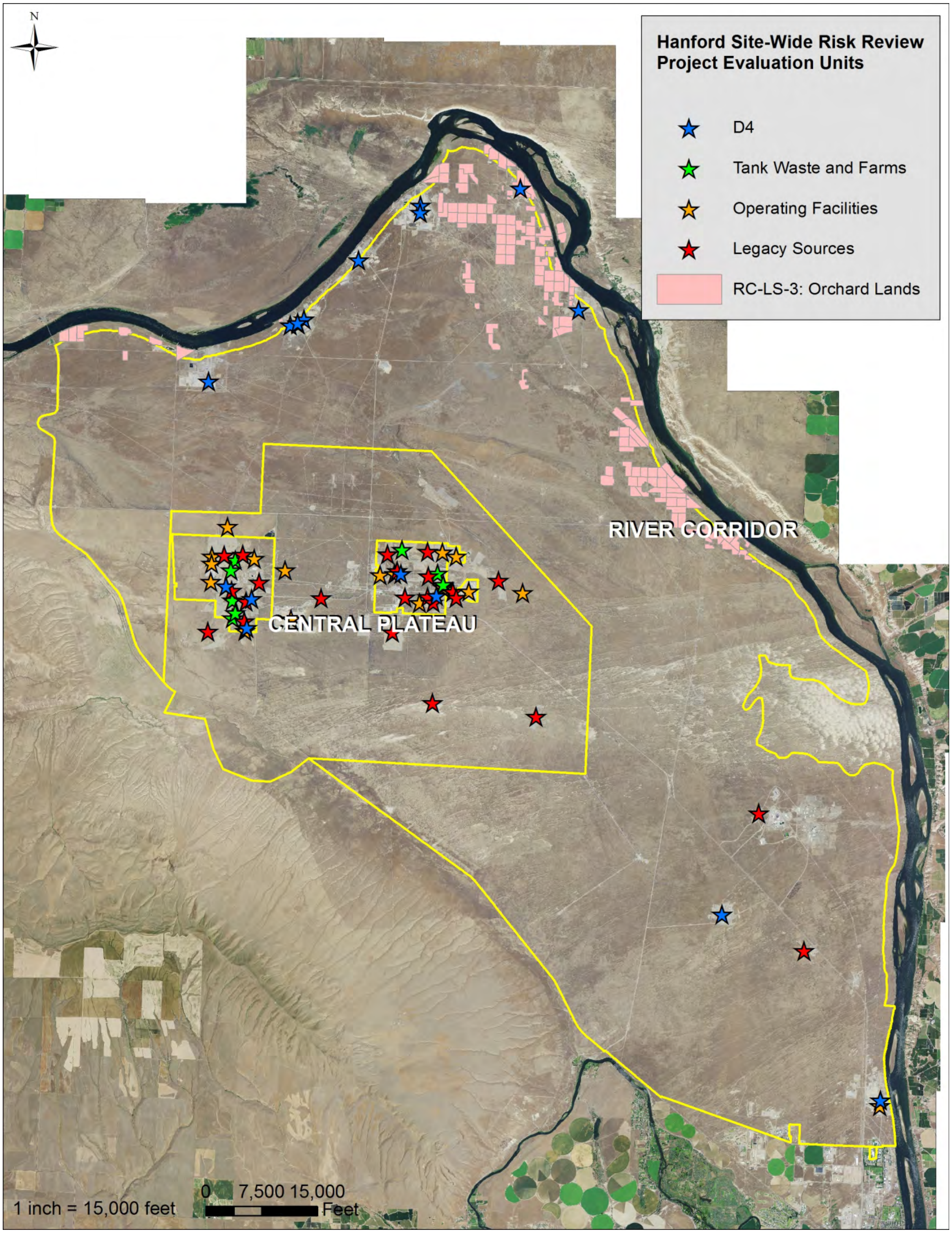

Figure ES-1-1. General location of all evaluation units included in this final report except groundwater plumes (See Figure ES-1-3). (*(D4) Inactive facilities undergoing decommissioning, deactivation, decontamination and demolition)*

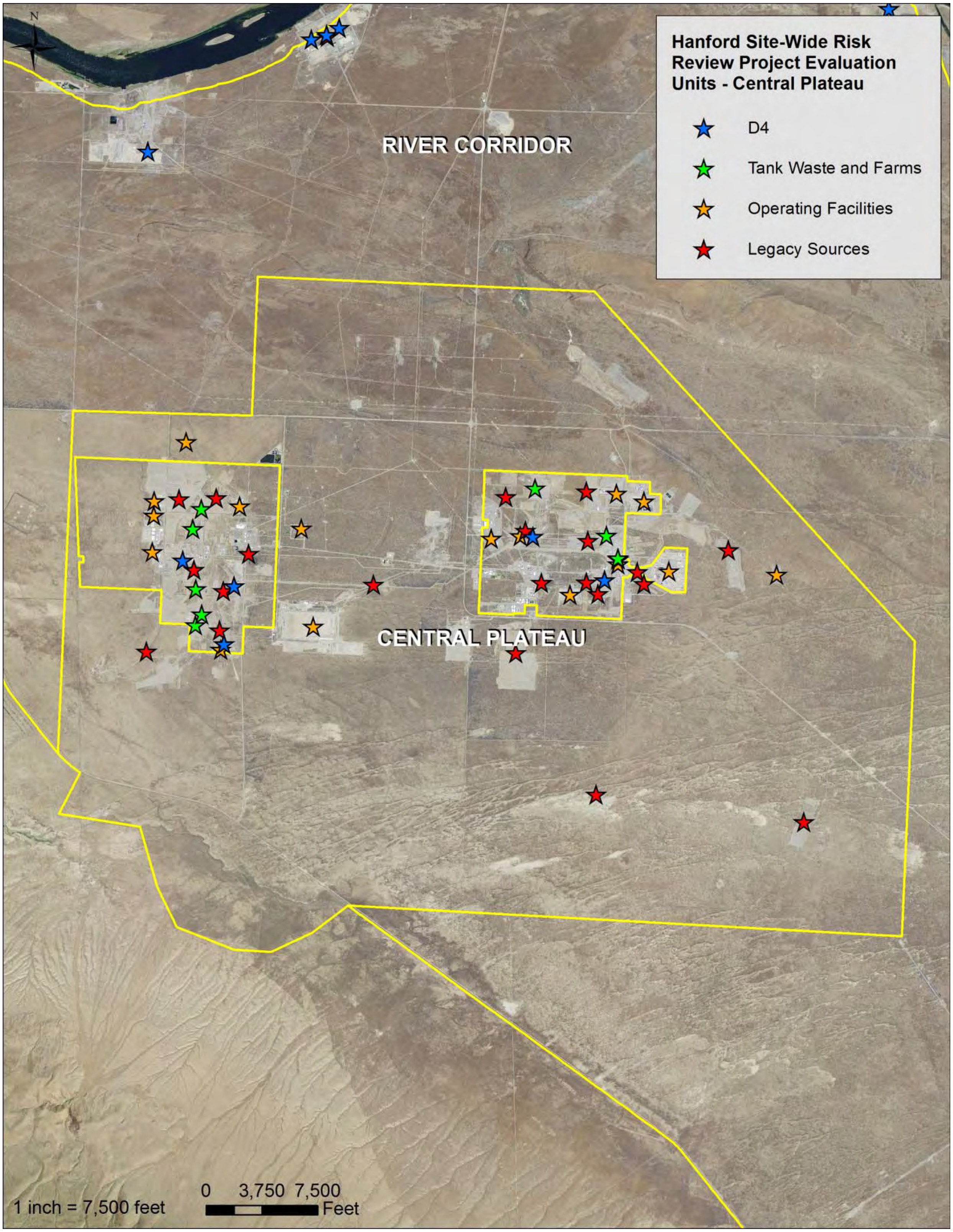

Figure ES-1-2. General location of all evaluation units located at the Hanford Site Central Plateau included in this final report except groundwater plumes (See Figure ES-1-3). ***((D4) Inactive facilities undergoing decommissioning, deactivation, decontamination and demolition)***

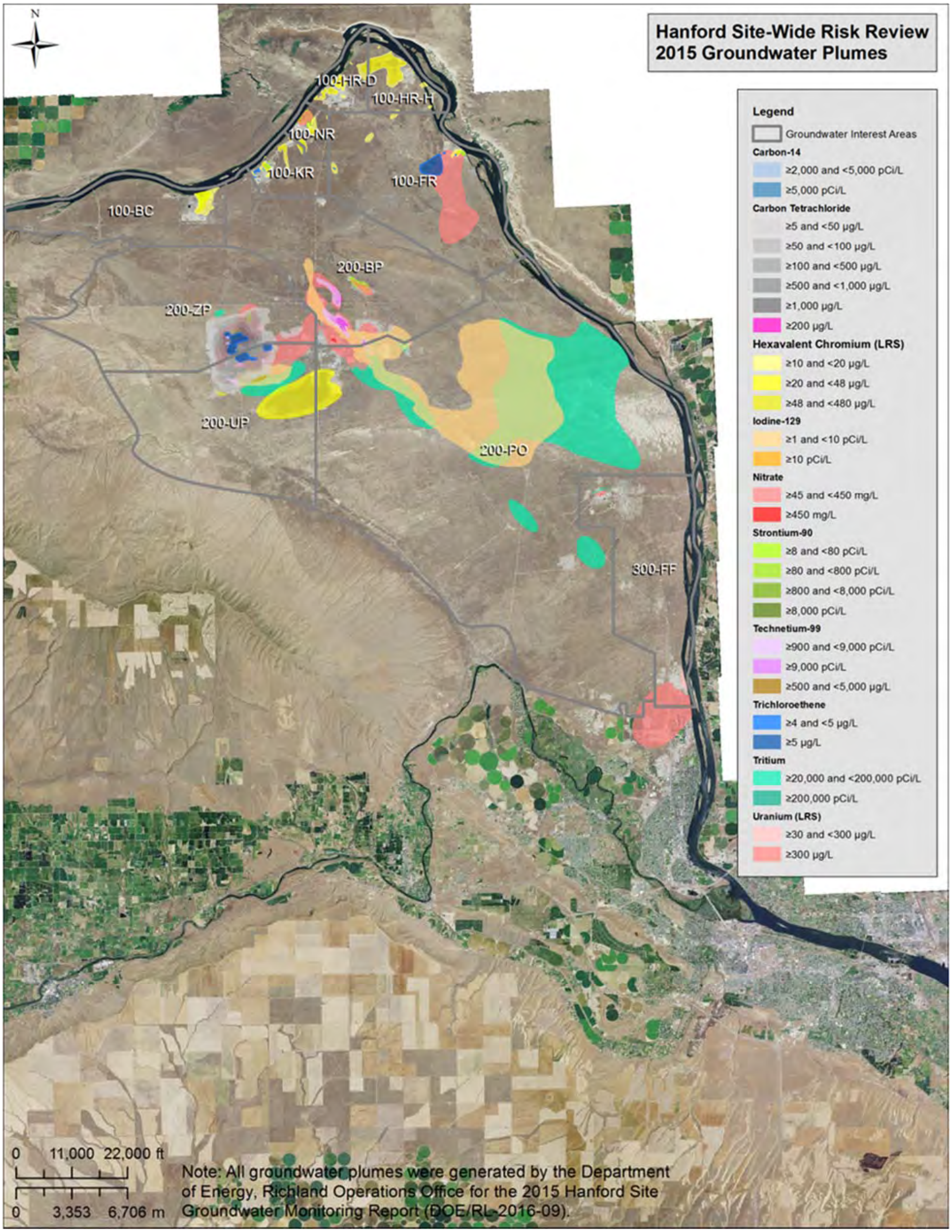

Figure ES-1-3. Hanford Site-wide Risk Review Project 2015 groundwater plumes.

The methodology used to execute this Risk Review Project consists of the following elements:

1. **Identification of Evaluation Units.** The remaining cleanup sites at Hanford as of October 1, 2015, have been divided into 64 evaluation units, which are composed of geographically co-located sites to the extent possible, considering commonality among source types and the overlapping of impacts and risks to receptors.[20] There are five categories of evaluation units[21]: (1) legacy source sites, such as past practice liquid waste disposal and buried solid waste sites[22]; (2) tank waste and farms and associated legacy contamination sources; (3) groundwater plumes; (4) inactive facilities undergoing decommissioning, deactivation, decontamination and demolition (D4); and (5) operating facilities used as part of the cleanup process. *See Chapter 2 for a complete list of all evaluation units and maps of their locations; also Chapter 3 of the methodology (CRESP 2015b).*

   Summary Evaluation Templates. Evaluations completed for the final report are based on data received as of October 2016. Each evaluation template includes information gathered on each evaluation unit as well as the unit description and history; an inventory of waste and contamination history; selected or the potential range of cleanup approaches; and the ratings of risks to human resource and environmental receptors. Each evaluation unit is described in detail using existing information, including regulatory documents, maps, and studies.[23] The Risk Review Project has relied primarily on previously obtained primary data, safety analyses, risk analyses, environmental impact assessments, remedial investigations, and other sources of information. Tens of thousands of pages of information and electronic databases have been reviewed and integrated to form the basis for this report.

   Methodology consists of:
   - identification of evaluation units
   - summary evaluation templates
   - risk ratings
   - temporal evaluation periods
   - initiating events

   Evaluations completed for the interim progress report were based on data received as of January 2015 and have not been updated for this report except (1) groundwater evaluations (which have been updated for this report to reflect the 2015 published monitoring data) and (2) as otherwise noted (e.g., Building 324 [RC-DD-1]) because more recent information materially

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[20] The Evaluation Unit (EU) concept was developed by the Risk Review Project to provide a tractable basis for reviewing the myriad of cleanup challenges at the Hanford Site. Groupings of facilities, wastes, and existing environmental contamination within each EU are based primarily on geographic location because the potential to impact receptors is fundamentally based on geographic location and spatial relations that may lead to exposure of receptors to hazards from specific sources. Thus, EU groupings are not based on, and may not correspond with, either (1) the process history that produced the wastes or environmental contamination, or (2) the groupings used for regulatory purposes (e.g., operable units).

[21] The EU groupings used here were developed by the Risk Review Project to understand potentially overlapping risks and are not common practice at the Hanford Site.

[22] From 1989 through fiscal year 2015, 1303 of 2,028 waste sites had been remediated, with 725 remaining (DOE/RL-2017).

[23] The information available for each EU is variable, depending on documentation of past site practices, the current regulatory status, currently planned near-term cleanup activities, and other factors.

affected the evaluation(s) made in the interim progress report. Updated references also have been provided to key documents (e.g., Tri-Party Agreement) as appropriate.

2. **Risk Ratings.** The primary groupings of risk are Very High, High, Medium, Low, and Not Discernible (ND). The highest rating for risk to people or human health is High. *See Chapter 3 and Appendices D-H for the completed summary evaluation templates for the evaluation units discussed in this report, and Appendix B of the methodology (CRESP 2015b) for the Summary Evaluation Template.* Four evaluation units have not been described in detail using a Summary Evaluation Template format for various reasons, primarily a lack of available pertinent information on that evaluation unit, including contaminant inventory. *See* **Table 2-1** *for a complete listing of evaluation units; see Chapter 3 for a summary of the results of the evaluation unit sources, including the rationale for not rating four of the evaluation units.*

   The receptors rated are people and protected resources. People or human health receptors are Facility Workers, Co-located Persons, Controlled Access Persons, and the Public. Protected resource receptors that are rated are groundwater, the Columbia River, and ecological resources. The groupings of risk ratings (e.g., High, Medium) for each type of receptor are determined by applying the specific methodology developed for that receptor. *See Chapters 5 through 8 of the methodology (CRESP 2015b) for detailed descriptions.* Demarcation between ratings uses recognized regulatory or literature thresholds applicable to the specific receptor, if they exist, as screening levels, as well as other factors. This approach is intended to provide comparative risk ratings *within* receptor categories (i.e., relative binning of risks to the Columbia River, groundwater, ecology, etc.). Risk ratings for each receptor may then be used to inform the urgency of addressing specific hazards (e.g., chromium, uranium or technetium). An overall risk rating is not provided for cultural resources; however, information about cultural resources within each evaluation unit and near (within 500 m) each evaluation unit has been gathered, described, and analyzed as a planning guide and information source for future cleanup activities.

   The risk rating scales were developed for each receptor group based on discipline-specific expertise and judgement, and are meant to compare within, but not between, receptor groups. So, for example, the ratings provided for human receptors such as Facility Workers at a legacy source evaluation unit can be compared to Facility Workers at a tank waste and farms evaluation unit. In contrast, ratings for Facility Workers cannot be compared with ratings for ecological resources (e.g., Level 5, endangered or threatened species) at a particular evaluation unit or between different receptor groups across different types of evaluation units (e.g., between D4 and tank waste and farms). *See Chapter 2 for summaries of each receptor methodology; see Chapters 5 through 8 of the methodology (CRESP 2015b) for detailed descriptions of each receptor group methodology.*

3. **Temporal Evaluation Periods.** Risks are evaluated based on the following distinct time periods: (1) the current status of the evaluation unit, typically prior to cleanup, although cleanup has been initiated for some evaluation units; (2) active cleanup period (or until 2064); (3) near-term post-cleanup (until 2164, or assuming a 100-year duration for institutional controls associated with areas transferred from federal control); and (4) long-term post-cleanup (or until 3064).[24] Each evaluation unit and selected evaluation unit components are evaluated as if cleanup were not to occur for 50 years to provide insights into the potential risks of delay, which in turn will help inform the order and timing of cleanup actions. However, this is not to imply that delay of

[24] Any available information that indicates risks that may be present beyond the year 3064 is noted (such as with slow groundwater migration of contaminants).

cleanup for 50 years is recommended. *See Chapter 2 for a more detailed description of the evaluation periods.*

4. **Initiating Events.** The likelihood of initiating events, both localized and regional, which may occur during any or all of the evaluation periods, such as fire, volcanic eruptions, loss of power, and loss of cooling water, are described. This is to establish a consistent basis for identifying and categorizing phenomena that may remove or degrade barriers, thus placing receptors at risk from contaminants. Nuclear safety is considered in the context of potential initiating events and risks to receptors. *See Chapter 2 for a summary of initiating events; see Chapter 4 of the methodology (CRESP 2015b) for a detailed analysis.*

A diagram of the methodology used is provided in Figure ES-1-4.

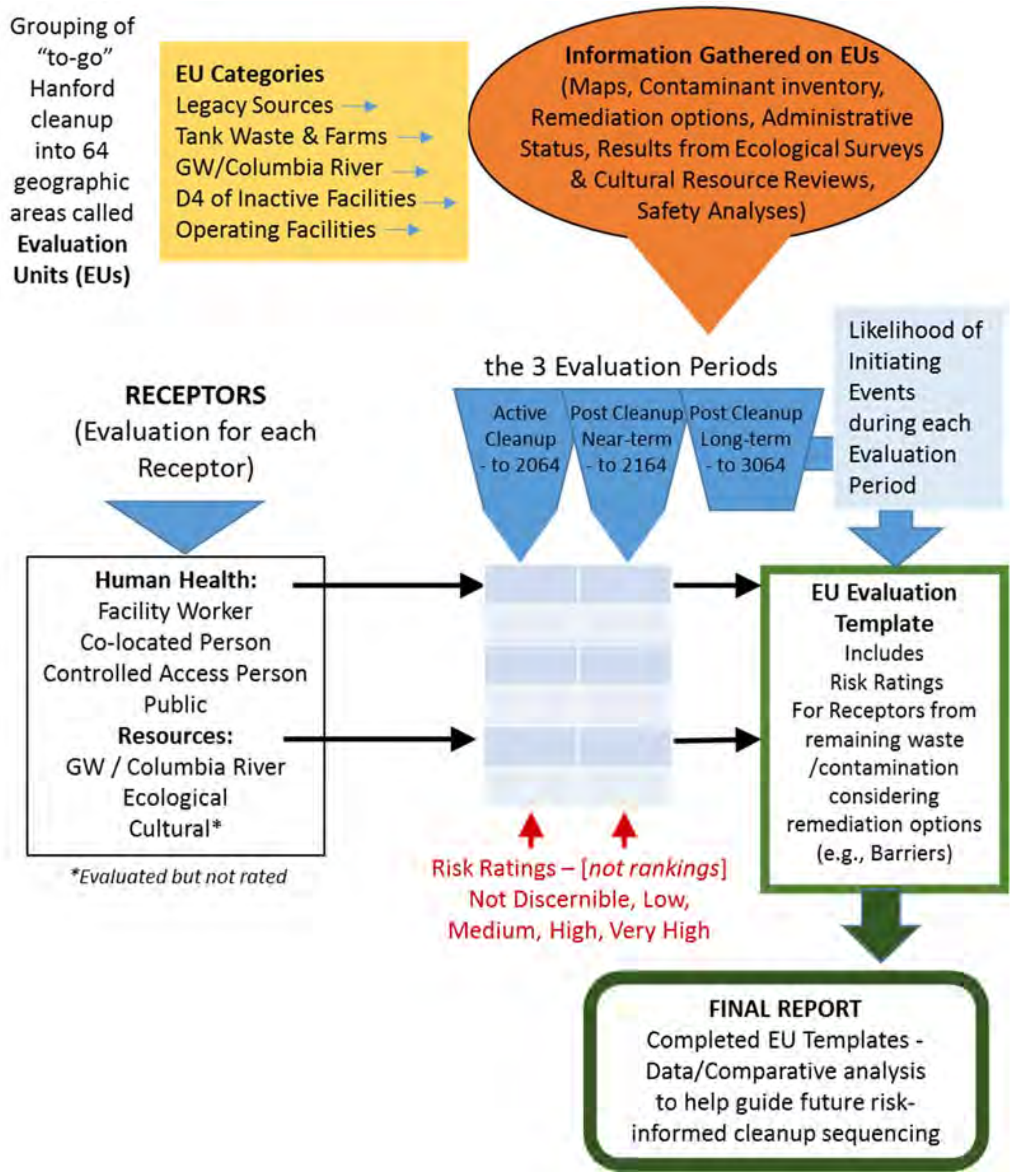

Figure ES-1-4. Methodology overview for the Hanford Site-wide Risk Review Project. Specific cleanup needs were grouped by geographic location into *Evaluation Units* for assessment of risks to human health and resources over three evaluation periods.

RESULTS

Current risks and impacts to the public are considered extremely unlikely. Public access to the Hanford Site is prohibited except under very limited circumstances, such as tours, which do not include contaminated areas or areas undergoing active cleanup.

Contaminated groundwater also is not considered a current threat to human health because groundwater is not being withdrawn for use or consumption. Ecological threats from groundwater contamination in the vicinity of the Columbia River are undergoing active remediation. Current groundwater remedies should be reevaluated to determine if they are efficiently resulting in risk reduction.

The only current risk to the public is from atmospheric dispersion of radioactive contaminants that may be released during a major fire or external event such as a severe earthquake. However, the probability of a contaminant release occurring that would threaten the public is remote. There are two reasons for this and both must apply. First, any risks to the public from airborne contaminants may occur **only** from facilities having large amounts of dispersible radioactive contaminants. Second, the risks would be realized **only** when the fire or event is so extreme that the extensive and monitored controls put in place to prevent the contaminant from becoming airborne or to contain the extent of the contamination found traveling the large distances to public areas, do not mitigate the risk. In the Plutonium Uranium Extraction Plant (PUREX) tunnels example, the risk to the public would be from a tunnel collapse accompanied by fire.[25] A fire may then lead to the widespread dispersal of radioactive contaminants in the air.

Risks from different types and forms of contamination have the potential to be realized at very different time scales. Contamination releases associated with stored wastes or contamination in facilities that are subject to seismic events, fires, collapse or loss of active engineered controls (e.g., active ventilation to prevent hydrogen accumulation, or active cooling pools to maintain temperature and avoid air contact), albeit low probability, have the potential at unpredictable times to result in rapid dispersion of contamination requiring urgent responses if postulated initiating events occur and/or there is a loss of engineering controls. Examples include the Plutonium Uranium Extraction Plant (PUREX) waste storage tunnels B-complex ventilation ducts, cesium and strontium capsule storage, double shell waste tanks requiring active ventilation, etc. In contrast, most buried wastes do not have potential to cause significant impacts for decades or longer if not disturbed by remediation activities (whereby the remediation activities themselves often pose the greatest risks), and migration of remaining contamination from the vadose zone to groundwater and from groundwater to the Columbia River in most locations present risks that may be realized slowly over many decades to centuries. For example, under current and projected hydrologic conditions, release of contaminants currently present in tanks in the Central Plateau would take decades to centuries to reach groundwater, and then additional decades to centuries to reach the Columbia River.

Despite the breadth of information considered, important uncertainties and data gaps remain that required assumptions to be made in order to execute the Risk Review Project. These uncertainties encompass many issues surrounding cleanup, including: (1) the need to stagger projects to avoid workforce disruptions that may lead to additional worker training and infrastructure maintenance; (2) whether funding is sufficient to complete a cleanup project once started; and (3) the flexibility and

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[25] Fortunately, the partial collapse of PUREX Tunnel #1 that occurred in May 2017 did not result in radioactive contaminant dispersion, although the risks of tunnel collapse and concurrent fire were identified in the Risk Review Interim Progress Report (2015a). As of August 2018, PUREX Tunnel #1 has been stabilized with grout and planning is in progress to stabilize PUREX Tunnel #2 with grout.

readiness of the workforce to shift from one project to another as projects are completed, funding becomes available or priorities change. Maintaining a robust, transparent, and ongoing dialogue with the public, other stakeholders, Tribal Nations, and regulators is a key to clarifying and communicating uncertainties as they emerge during cleanup.

Major results of the Risk Review Project evaluations follow.

Tank Wastes

Wastes from defense material production accumulated in single shell and double shell tanks ("tank wastes") represent collectively the largest inventory of radioactivity at the Hanford site. Treating the tank waste is important for reducing the long-term risk to people and the environment, but the radionuclide inventory is not what drives the urgency. What drives the urgency are two attributes of the waste that remain in some tanks – (i) the potential for hydrogen accumulation in the event of loss of active ventilation (leading to fire or deflagration), and (ii) content of key radionuclides (technetium-99 and iodine-129) that are mobile in the subsurface and could contaminate large quantities of groundwater, which is a protected natural resource. Risks from hydrogen accumulation and to groundwater have been to a large extent mitigated by engineering measures, but nevertheless remain. Mitigation measures include redundancy in tank active ventilation systems to meet necessary DOE safety requirements and removal of pumpable liquids (supernatant and drainable liquids that are most likely to leak) from 147 of the 149 single shell tanks to minimize the potential for further leakage. Over the longer term, uncertainty about tank integrity and the need to safely and permanently dispose of the tank wastes drives the mission for waste retrieval, treatment, and disposal. During waste retrieval and processing, potential exposure to waste vapors and accidents are worker risk concerns.

The diverse set of chemical processes used at Hanford to produce defense nuclear materials and the extensive transfer and recovery processes for specific radionuclides (e.g., cesium-137 and strontium-90) carried out on tank wastes has resulted in a wide range of different radionuclide and chemical compositions, as well as physical characteristics, of waste contained in each tank. Thus, diversity in the properties of waste in tanks makes it potentially much more efficient to consider each tank or tank farm individually, rather than considering all tank wastes as a single collective problem with uniform urgency, retrieval, and treatment approaches.

Relative urgency for treating certain tank wastes with respect to potential for hydrogen accumulation can be evaluated based on the time to reach 25 percent of the lower flammability limit (a safety threshold) if a loss of ventilation occurs (Figure ES-1-5). At the time of preparation of this report, three tanks would reach 25% of the lower flammability limit within 14 days and an additional 13 tanks would reach this safety threshold within 30 days. All of these tanks are double shell tanks within the 200 East Area. Ten additional tanks would reach 25% of the lower flammability limit within 180 days, including one double shell tank (SY-103) and one single shell tank (T-201) in the 200-West Area. In addition, at the time of the preparation of this report retrieval of waste from tank AY-102 had not been completed.

Urgency for treating certain tank wastes with respect to potential for groundwater contamination can be evaluated based on the amount of groundwater that could potentially be contaminated by the technetium-99 and iodine-129 content in a tank should all of these two radionuclides become dispersed in groundwater (referred to as the groundwater threat metric (GTM), in millions of cubic meters, Mm^3, of groundwater). The greatest GTM is associated with the double shell tanks located in the 200 East Area (Figure ES-1-6). In addition, wastes in 40 single shell tanks are included in the set of both single shell and double shell tanks containing wastes that account for 90 percent of the total GTM from all tank wastes (Figure ES-1-7). Current focus on treating Low Activity Waste (LAW) is consistent with addressing the groundwater threat to Technetium (Tc-99) and Iodine (I-129) because both of these radionuclides are present predominately in the LAW fraction of tank waste. Thus, both the potential for hydrogen accumulation and the threat to groundwater emphasize the urgency of retrieval and treatment of wastes from 66 of the 177 single shell and double shell tanks (Figure ES-1-7). In addition, waste in only 55 single shell tanks (including 15 assumed leakers) comprises 90 percent of the groundwater threat metric posed by all the single shell tanks.

> Groundwater Threat Metric (GTM)
>
> GTM was developed as part of the risk review project and allows for comparison of threats to groundwater from different sources of potential contamination (e.g., tank wastes, contaminated soils, buried wastes).
>
> GTM is the maximum volume of water that could be contaminated by the source amount of the primary contaminant if that contaminant was present in the groundwater at the water quality standard.

The extent of waste retrieval from each tank is also an important consideration for achieving risk reduction. Retrieving the same fraction of waste from 55 of the single shell tanks achieves much greater risk reduction with respect to groundwater threat than retrieving the same fraction of waste from the remaining single shell tanks. For example, retrieving 90 percent of the waste from the indicated 55 single shell tanks reduces groundwater threat by 81 percent, while the same extent of retrieval from the remaining single shell tanks only achieves an additional 8 percent reduction in groundwater threat.

Further factors that play a role in the residual risk from waste remaining in a tank after retrieval include: (i) the potential for remaining contaminants to migrate from the closed tank to groundwater, and (ii) the extent of contamination within the specific tank farm already in the vadose zone external to tanks. Currently, tank closure by filling with grout, remaining tank integrity, and final closure covers over a tank farm are not fully accounted for in assessments with respect to reducing or preventing radionuclides and other contaminants remaining in tanks after retrieval from impacting groundwater. Figure ES-1-8 compares by tank farm the groundwater threat from technetium-99 and iodine-129 contamination currently in tanks to the groundwater threat from the same contaminants currently in the co-located vadose zone. For example, retrieval of less than 90 percent of the waste would be needed from tanks in the T, TX-TY, and B-BX-BY tank farms to reduce the threat from residuals remaining in the tanks to less than the threat from contamination in the adjacent vadose zone.

A more risk informed approach to tank waste retrieval and treatment may result in more rapid retrieval and risk reduction, including by reducing the risks to workers from accidents and vapors.

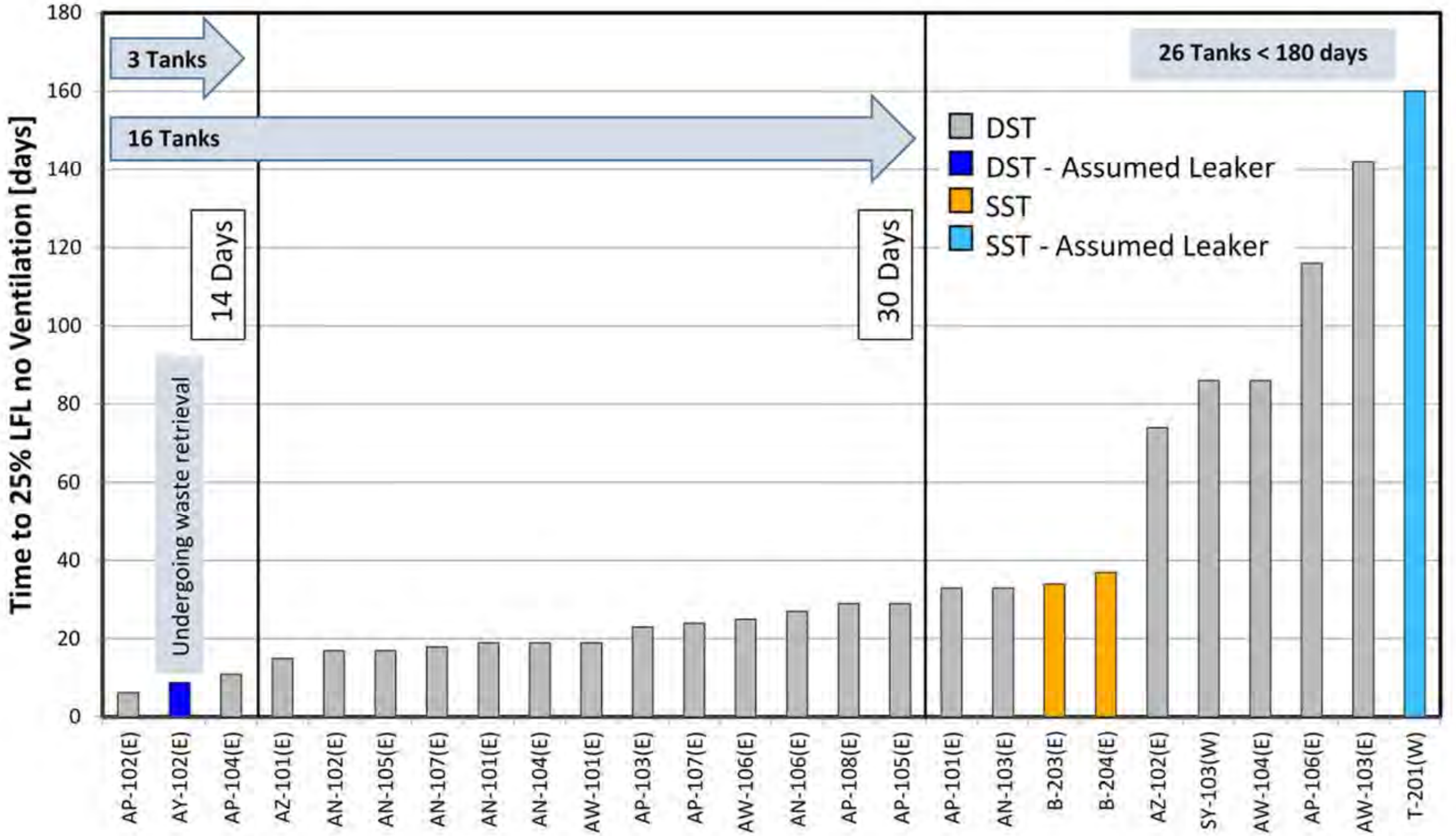

Figure ES-1-5. Currently, 3 waste tanks can exceed the safety threshold of 25 percent of the lower flammability limit (LFL) from hydrogen production within 14 days and 16 tanks within 30 days, if there is a loss of ventilation (after RPP-5926, Rev. 17). The location (E = 200 East and W = 200 West) is provided after each tank name.

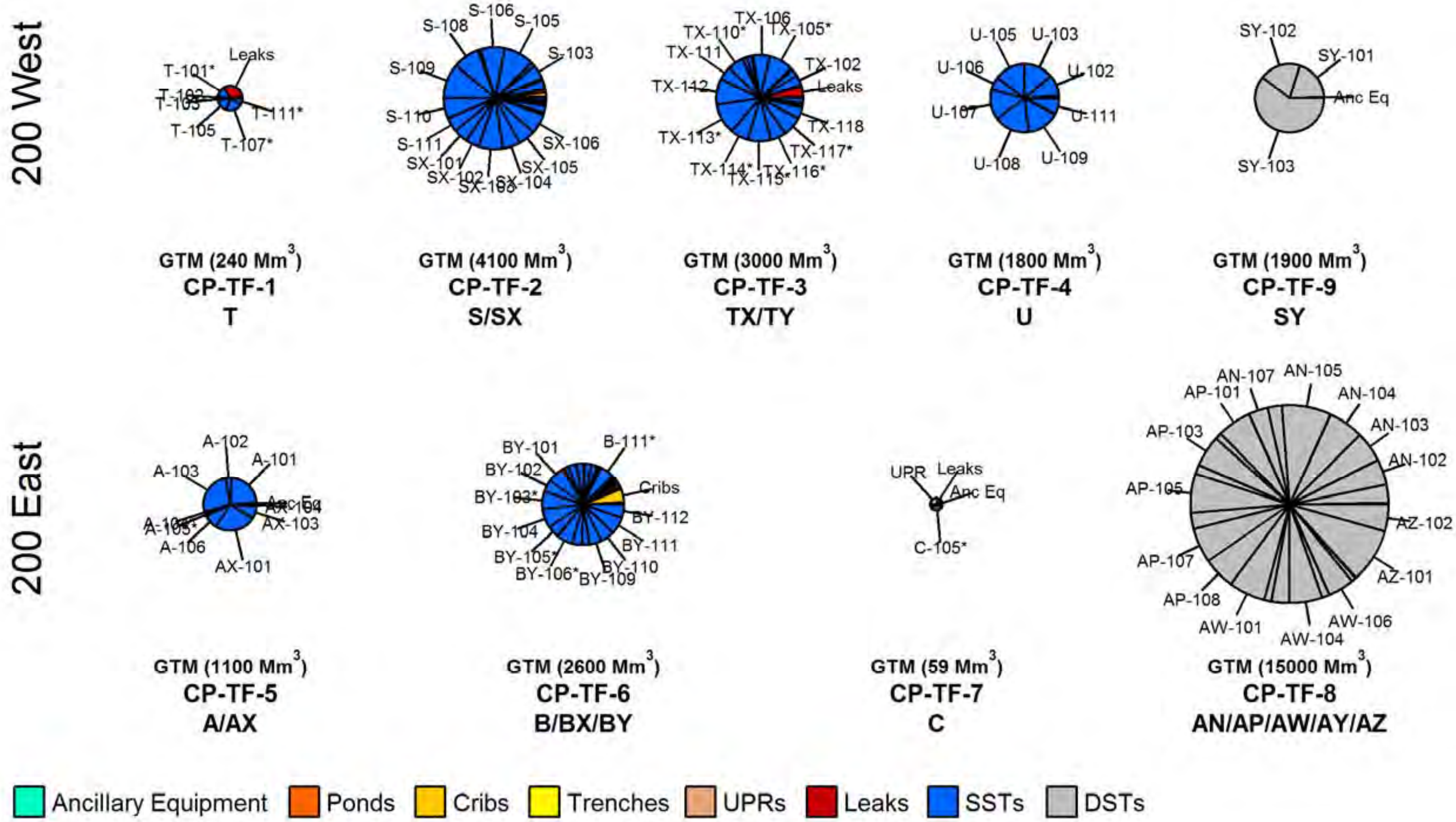

Figure ES-1-6. The risk to groundwater posed by individual waste tanks varies greatly. A groundwater threat metric (GTM) was developed to compare the risks posed by contaminants contained in tanks and contaminants already released to soils, the vadose zone and groundwater. The area for each pie represents the relative GTM for each Evaluation Unit, and each pie slice is proportionate to the fraction of the GTM represented by each tank or past release. Asterisk (*) indicates an assumed leaker tank.

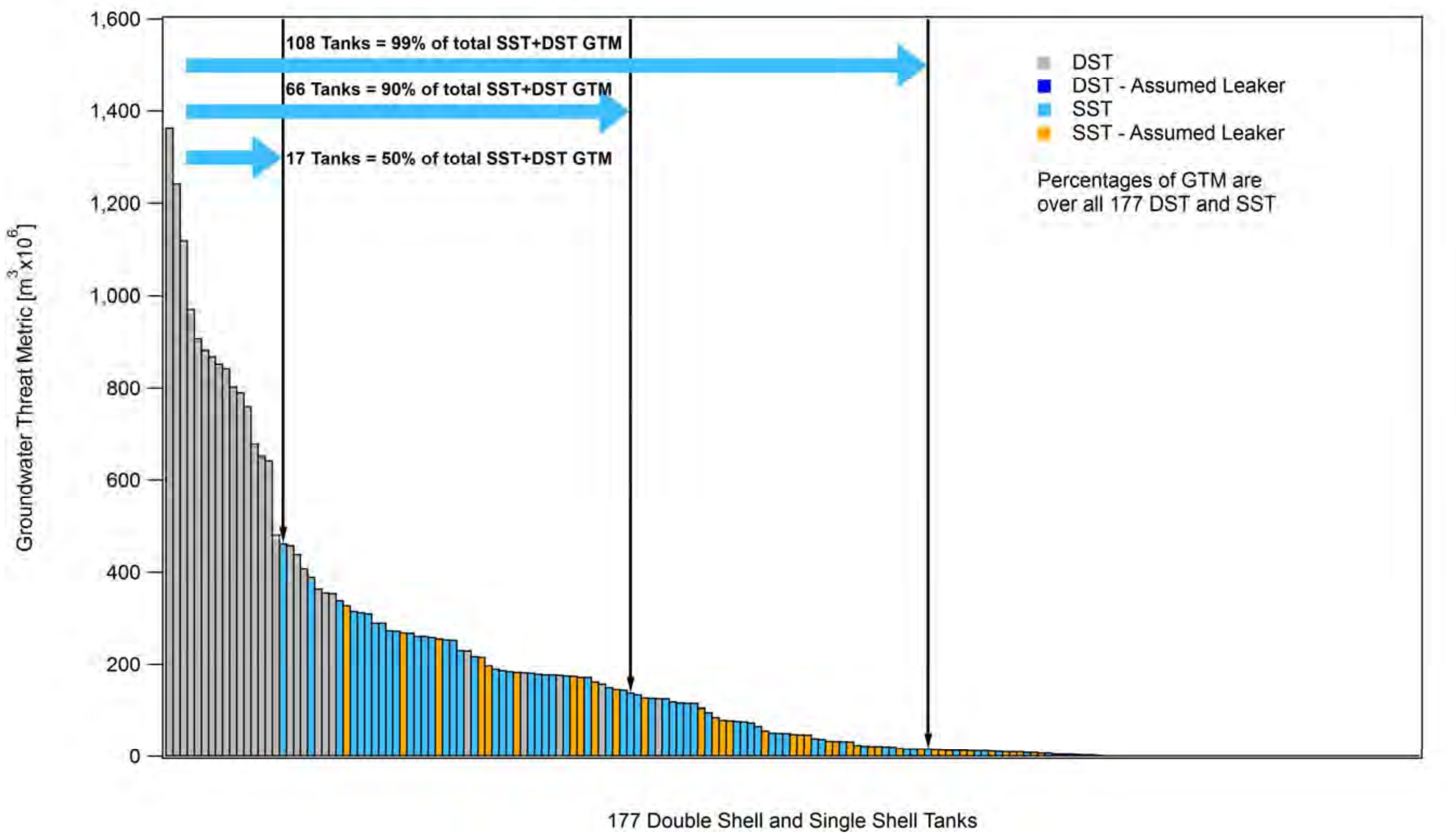

Figure ES-1-7. Groundwater threat: Which waste tanks are important? 66 waste tanks, including 10 assumed leaker single shell tanks (SSTs) represent 90 percent of the entire groundwater threat posed by the 177 waste tanks (17 tanks represent 50 percent of the total threat). Comparison of the groundwater threat metric (GTM) within double shell tanks (DSTs) and SSTs is presented by individual tank (individual bars, above).

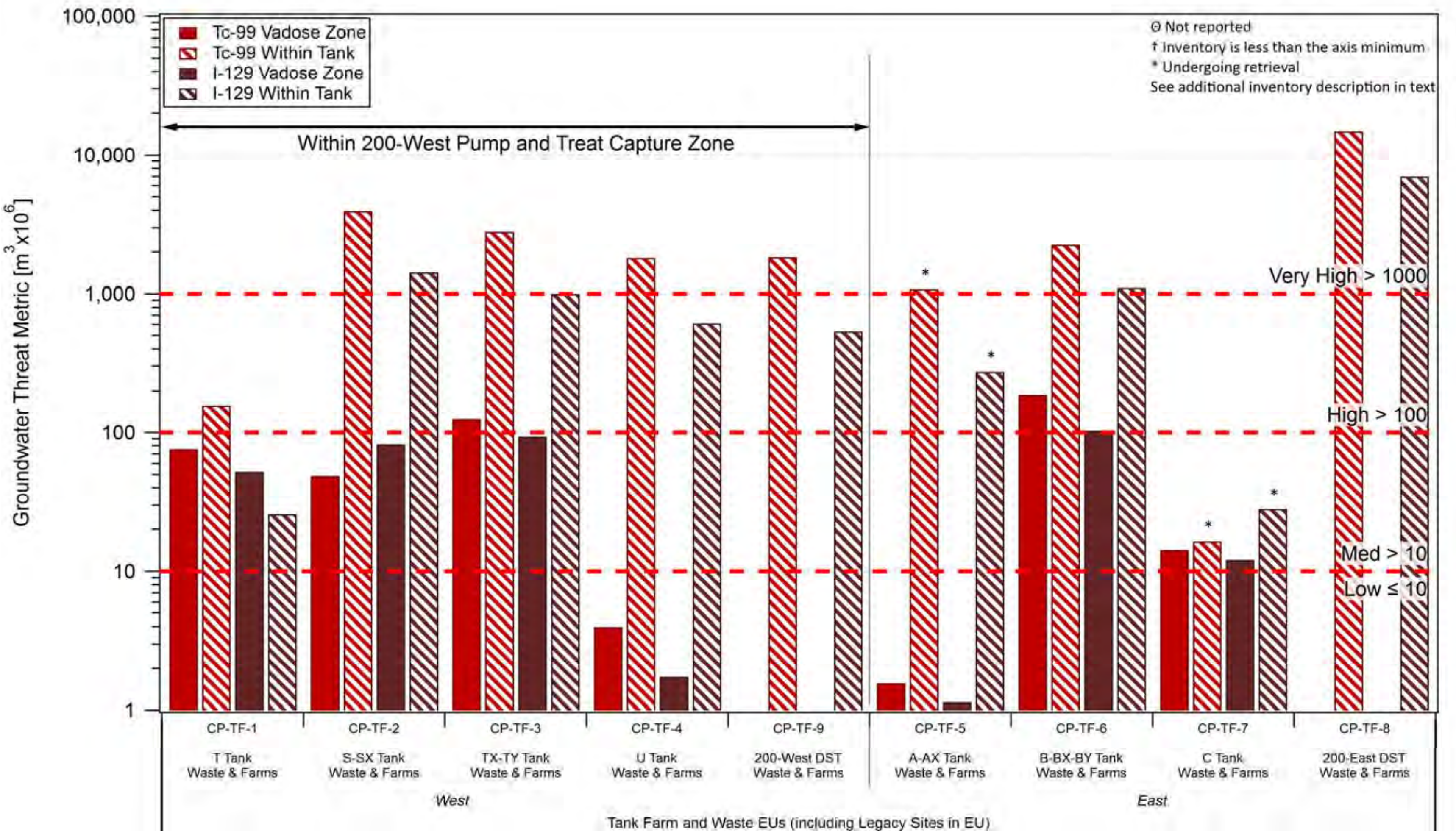

Figure ES-1-8. Evaluation unit-wide waste retrieval and closure plans should consider the relative threat to groundwater by contaminants within the waste tanks versus in the surrounding vadose zone and groundwater, as well as the multiple barriers and mechanisms to reduce current and prevent future environmental contamination. This approach would facilitate efficient risk reduction. Above, the GTM (Mm3) from existing contamination in the vadose zone is compared to the GTM associated with each Tank Waste and Farms Evaluation Unit.

Highest Risks During the Current Evaluation Period

Two summary tables (Table ES-1-1 and Table ES-1-2) are provided showing the receptors considered to be at high or very high risk for the current time period. If the rating was medium, low, or not discernible, those results are not provided in the summary tables. Included in both tables are a list of primary contaminants that are present, the reasons for the ratings (risk drivers), and mitigation measures.

The current highest rated risks *to human health (Facility Workers and Co-located Persons)* are from (1) loss of nuclear safety controls from major natural hazards (seismic events, volcanic ashfall, or wildfire) or major external events (prolonged loss of power or water) until the source of the risk has been removed or permanently contained; (2) operational accidents (including facility fires). For workers, ratings are provided in Table ES-1-1 showing the evaluation units in which workers were rated high during the current time period. Risks to workers are based on the unmitigated dose estimates captured in DOE documentation for certain events or conditions (e.g., explosions, fires, earthquakes, structural failures). In some cases, high risks extend to people located outside the facility boundary but on the Hanford Site (i.e., co-located persons). Table ES-1-1 also highlights the evaluation units where risks to co-located persons were rated as high.

The current risks rated high or very high to groundwater, the Columbia River, and ecological receptors (i.e., as protected resources[26]) are from existing groundwater contaminant plumes (that could spread in the future) and from migration of contaminants from some legacy surface disposal sites and the vadose zone (e.g., secondary sources including unplanned releases of contaminants from engineered facilities (e.g., waste tanks)). Current significant threats to the Columbia River from contaminants in the River Corridor are being treated, and significant threats from groundwater contaminants to the Columbia River from the Central Plateau are either being treated or would not be realized for a long time and only be realized if they are not treated during the active cleanup period. Table ES-1-2 shows which protected resources (groundwater, Columbia River, and ecological) had high or very high ratings during the current time period when the methodology developed for that receptor was applied.

Summary tables showing high or very high rating also have been developed for two other time periods: Active Cleanup (to 2064) (Table 6-3) and Near-term Post-cleanup (to 2164) (Table 6-4). The drivers for the ratings of high or very high are provided as table notes.

[26] These ratings reflect threats to groundwater and the Columbia River as protected resources and not human or ecological risks related to direct use of these resources.

Table ES-1-1. Human Resource Receptors (Facility Workers and Co-located Persons) with High, Unmitigated Rating for Current Evaluation Time Period. All Current, Mitigated Ratings are Not Discernible, Low, or Insufficient Information to Rate.

Evaluation Unit	Location	Receptor(s)	Contamination Source(s) or Risk	Reasons for Rating (Risk Drivers)	Mitigation
D4 (See Appendix F for completed templates of Evaluation Units)					
Building 324 (RC-DD-1)	River Corridor	Facility Worker[(a)]	Cesium-137, Plutonium-239, Plutonium-240, Strontium-90, and Americium-241	Seismic event (earthquake) releasing hot cell contaminants and potential for building collapse.	Removal of contamination and contaminated materials, surveillance and maintenance programs, and DOE emergency preparedness program.
Fast Flux Test Facility (FFTF) (RC-DD-4)	River Corridor	Facility Worker	Argon (inert atmosphere)	Release of argon into personnel space, thus causing an oxygen deficient work area.	Argon supply piping structure is identified as defense-in-depth equipment important to safety.
PUREX Plant (CP-DD-1)	Central Plateau	Facility Worker and Co-located Person[(b)]	Cesium-137, Plutonium-238, Plutonium-239, Plutonium-240, Plutonium-241, Plutonium-242, Strontium-90, and Americium-241	(1) Seismic (earthquake) or other event causing structural failure in 202-A canyon and/or storage tunnels, or (2) fire in Storage Tunnel #1.	(1) Safety management and emergency response programs; (2) Storage tunnel is isolated with no access.
B Plant (CP-DD-2)	Central Plateau	Facility Worker and Co-located Person	Cesium-137, Plutonium-238, Plutonium-239, Plutonium-240, Plutonium-241, Plutonium-242, and Strontium-90	Seismic event causing collapse of both 221-B and 224-B canyon buildings.	Safety management and emergency response programs
REDOX Plant (CP-DD-4)	Central Plateau	Facility Worker and Co-located Person	Cesium-137, Plutonium-239, Plutonium-240, and Strontium-90	Seismic event causing total failure of the 202-S Canyon Building structure with ground release of material.	Safety management and emergency response programs
Plutonium Finishing Plant (PFP) (CP-DD-5)	Central Plateau	Facility Worker and Co-located Person	Plutonium-238, Plutonium-239, Plutonium-240, Plutonium-241, Plutonium-242, Americium-241, and Cesium-137	(1) Seismic event or airplane crash, (2) first floor fire involving contaminated equipment in 234-5Z building, (3) contaminated internal equipment explosion in either 242-Z building or 234-5Z building, or (4) accident causing contaminated equipment drop in either 242-Z building or 234-5Z building.	(1) Safety management and emergency response programs; (2) Safety management, confinement and fire sprinkler flow alarm; (3) Safety management and confinement; (4) Safety management and confinement.

Evaluation Unit	Location	Receptor(s)	Contamination Source(s) or Risk	Reasons for Rating (Risk Drivers)	Mitigation
Tank Waste & Farms (See Appendix E for completed templates of Evaluation Units)					
T (CP-TF-1) S-SX (CP-TF-2) TX-TY (CP-TF-3) U (CP-TF-4) A-AX (CP-TF-5) B-BX-BY (CP-TF-6) C (CP-TF-7) AN-AP-AW-AY-AZ (CP-TF-8) SY (CP-TF-9)	Central Plateau	Facility Worker	Tank waste contaminants (e.g., Cesium-137 and Strontium-90) and vapors from tanks	(1) Flammable gas deflagrations in vessels/containers, including single-shell tanks, (2) waste transfer leaks, (3) releases from contaminated facilities from fires, load handling accidents, or compressed gas system failures, (4) industrial accidents (e.g., heat stress, slips, trips, & falls), and (5) radiation and vapors from tank leaks and contaminated soil.	(1) safety-significant structures, systems & components (ventilation and piping systems); Specific Administrative Controls; & Limiting Conditions for Operations, (2-3) safety-significant structures, systems & components (piping & transfer line systems; isolation valves); Specific Administrative Controls; & Limiting Conditions for Operations (4) monitoring & controlling for environmental hazards, (5) radiological control program and sealing materials & barriers used to control spread of contamination.
Operating Facilities (See Appendix H for completed templates of Evaluation Units)					
Central Waste Complex (CWC) (CP-OP-1)	Central Plateau	Facility Worker and Co-located Person	Radioactive material and toxic chemicals	(1) Fires and (2) seismic building collapse	*Active:* Fire Protection and fire suppression systems; *Passive*: Storage container, Secondary Containment, Epoxy resin floor coating, Building stabilization and grading; Administrative: Vehicle Controls, Container Management and Venting Program, Waste Acceptance Criteria, Source Strength Controls, and Emergency Response.
T Plant (CP-OP-2)	Central Plateau	Facility Worker and Co-located Person	Radioactive materials and hazardous chemicals, including corrosive, reactive, and toxic materials.	Small inside fires (impacting a single container), T Plant Perma-con fire (inside Building 221-T involving waste being packaged), and large fires (impacting 8 drums and confinement structure).	Fire suppression systems, Building-active ventilation systems, including associated exhaust HEPA filters, Building Structure, Container Vents

Evaluation Unit	Location	Receptor(s)	Contamination Source(s) or Risk	Reasons for Rating (Risk Drivers)	Mitigation
Waste Encapsulation and Storage Facility (WESF) (CP-OP-3)	Central Plateau	Facility Worker and Co-located Person	Cesium-137 and Strontium-90	(1) Loss of Pool Cell Water Event, (2) Hydrogen Explosion in Hot Cell G and K3 Duct, and (3) Earthquake with Releases from Hot Cells, Ventilation Ductwork, and HEPA filters.	(1) Defense-in-depth strategies (configuration management), Technical Safety Requirements (radiation monitoring); (2) Active Safety Controls (backup power for ventilation systems) and Specific Administrative Controls (e.g., maximum cesium capsule inventory); (3) passive structures, systems & components (e.g., building components including hot cells and canyon); operational controls including maximum capsule inventory.
Waste Receiving and Processing Facility (WRAP) (CP-OP-4)	Central Plateau	Facility Worker and Co-located Person	Radioactive materials (Plutonium-239)	(1) Large fires (involving 8 drums resulting in breach of confinement structure) and small inside fires (impacting a single container) and (2) criticality.	(1) Fire suppression systems, Building active ventilation systems, including associated exhaust HEPA filters, Building Structure, Container Vents; (2) limited curbing height, minimal slope floor, Building height and obstructions limit stacking height, criticality safety program.
Canister Storage Building (CSB) (CP-OP-5)	Central Plateau	Facility Worker and Co-located Person	Radioactive materials from spent fuel (including various isotopes of Plutonium and Uranium, Cesium-137, Strontium-90)	(1) Internal hydrogen deflagration of multi-canister overpack, (2) mechanical damage of multi-canister overpack, and (3) fires.	Active technical safety requirements (handling machine and confinement systems), administrative controls (Nuclear Criticality Safety, Combustible Loading Limits, etc.) and specific administrative controls (Operational Controls, Intermediate Impact Absorbers, etc.). There are also multiple passive safety class (e.g., subsurface structures, storage tubes and assemblies) and safety significant features (e.g., tube plugs, structural components) and a defense-in-depth strategy.

Evaluation Unit	Location	Receptor(s)	Contamination Source(s) or Risk	Reasons for Rating (Risk Drivers)	Mitigation
Mixed Waste Trenches (CP-OP-8)	Central Plateau	Facility Worker and Co-located Person	Radioactive material (e.g., Plutonium-238) and toxic chemicals	(1) Spills from Pu-238 drums breached during excavation, (2) criticality resulting in radiation exposure or release of materials (solid, liquid, radioactive, chemical), (3) natural phenomenon hazard (earthquake) resulting in the release of radioactive materials, and (4) standard industrial hazards (e.g., exposure of worker to hazardous material from operator error or failure)	(1) *Engineered*: container design; *Administrative*: Container Management, Hoisting & Rigging, Emergency Protection Plan, Source Strength Control, Vehicle Access, (2) *Administrative*: Criticality Safety, Container Management, Emergency Response Plan, Source Strength Control, Radiation protection; (3) *Engineered*: Container Bands / Straps; Container Design; Overburden; Standard Waste Box Design; Tie Downs; *Administrative*: Container Management, Emergency Response Plan, Source Strength Control; (4) *Administrative:* Work Planning process, Conduct of Operations, Fire Protection, etc.
242-A Evaporator (CP-OP-10)	Central Plateau	Facility Worker and Co-located Person	Radioactive and hazardous materials and prompt fatality or serious injury	(1) Flammable gas accidents and (2) waste leaks and misroutes	Work control, fire protection, training, occupational safety and industrial hygiene, emergency preparedness and response, and management and organization—which are fully integrated with nuclear safety and radiological protection.
222-S Laboratory (CP-OP-16)	Central Plateau	Facility Worker	Prompt fatality or serious injury	Building-wide fire causing part of the structure to collapse with falling debris	Fire protection and emergency preparedness and response.

a. Facility worker – any worker or individual within the facility (or within the activity geographic boundary as established for the DSA) and located less than 100 m from the potential contaminant release point. (See Terminology and Definitions section for additional details.)

b. Co-located Person – a hypothetical onsite individual (who may be a site worker not associated with the specific facility or activity, or may be a site visitor) located at a point equal to 100 m from the boundary of the facility (or activity or from the point of potential contaminant release), or beyond 100 m from the point at which maximum dose hypothetically occurs. or from the point of potential contaminant release). If the release is elevated (e.g., airborne), the person is assumed to be at the location of greatest dose, which is typically where the plume touches down. (See Terminology and Definitions section for additional details.)

Table ES-1-2. Protected Resource Receptors (Groundwater, Columbia River, and Ecological Resources) with High or Very High Rating for the Current Evaluation Time Period (Humans not considered at risk because groundwater is not available for use).

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
Legacy Sources (See Appendix G for completed templates of Evaluation Units)					
BC Cribs & Trenches (CP-LS-1)	Central Plateau (200 East)	Groundwater	**Radionuclides:** **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water) **Technetium-99 (Tc-99)** Half-life is very long (persistent); Very mobile (moves with water) **Hazardous Chemicals:** **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory that could impact groundwater; interim actions (soil removal) not sufficient to remove enough contamination to adequately reduce risk.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans; no plumes are being treated; and no final remedial decisions have been made involving treating vadose zone contamination.
Pu (Plutonium) Contaminated (CP-LS-2)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water)	Residual vadose zone inventory that could impact groundwater; current remedial action (pump & treat) effective for groundwater but does not address vadose zone contamination.	200 West Pump & Treat Facility is effectively treating contaminated groundwater; selected remedial actions will remove contaminated soil and reduce vadose zone source.
U Plant Cribs and Ditches (CP-LS-3)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** **Total Uranium (U)** Half-life is very long (persistent)[(a)]; Somewhat mobile (tied up in soil)	Residual vadose zone inventory; pump & treat used to treat uranium in groundwater but does not address existing vadose zone contamination.	Uranium in groundwater being treated using the U Plant area Pump & Treat system; soil cover is being maintained while alternatives are being considered to treat vadose zone.
REDOX Cribs and Ditches (CP-LS-4)	Central Plateau (200 West)	Groundwater	**Radionuclides:** **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water)	Residual vadose zone inventory; final action (pump & treat) for groundwater not effective for I-129; I-129 plume hydraulic control system active but not yet demonstrated effective; current treatment does not address vadose zone contamination.	I-129 plume hydraulic control system is active while alternatives for treating I-129 are being considered; soil cover is being maintained while alternatives are being considered to treat vadose zone, if necessary.

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
U and S Pond (CP-LS-5)[(b)]	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water) **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; final action (pump & treat) for groundwater effective but does not treat vadose zone contamination.	200 West Pump & Treat Facility is effectively treating contaminated groundwater; preferred actions have been defined to treat selected vadose zone areas.
T Plant Cribs and Trenches (CP-LS-6)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** **Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; final action (pump & treat) for groundwater effective but does not address vadose zone contamination.	200 West Pump & Treat Facility is effectively treating contaminated groundwater; soil cover is being maintained while alternatives are being considered to treat vadose zone, if necessary.
B Plant Cribs and Trenches (CP-LS-8)	Central Plateau (200 East)	Groundwater	**Radionuclides:** **Strontium-90 (Sr-90)** Half-life relatively short (not very persistent); Limited mobility (tied up in soil) **Hazardous Chemicals:** **Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim actions have been taken and no final remedial decisions have been made involving treating vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.
PUREX Cribs and Trenches (CP-LS-9)	Central Plateau (200 East)	Groundwater	**Radionuclides:** **Strontium-90 (Sr-90)** Half-life relatively short (not very persistent); Limited mobility (tied up in soil) **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim actions have been taken and no final remedial decisions have been made involving treating vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.
PUREX and Tank Farm Cribs and Trenches (Outside 200-East) (CP-LS-10)	Central Plateau (200 East)	Groundwater	**Hazardous Chemicals:** **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim actions have been taken and no final remedial decisions have been made involving treating vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
B Pond (CP-LS-11)[(b)]	Central Plateau (200 East)	Groundwater	**Radionuclides:** **Strontium-90 (Sr-90)** Half-life relatively short (not very persistent); Limited mobility (tied up in soil) **Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water)	Residual vadose zone inventory; preferred actions have been selected to treat some vadose zone areas in future.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans; preferred actions defined to treat selected vadose zone areas.
200-West Burial Ground (CP-LS-12)	Central Plateau (200 West)	Groundwater	**Radionuclides:** **Carbon-14 (C-14)** Half-life is long (persistent); Very mobile (moves with water) **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water) **Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water) **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; final action (pump & treat) effective for groundwater but does not address vadose zone contamination; no actions have been taken to address vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.
200-East Burial Grounds (CP-LS-14)	Central Plateau (200 East)	Groundwater	**Hazardous Chemicals:** **Total and *Hexavalent* Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim actions have been taken and no final remedial decisions have been made involving treating vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.
Tank Waste & Farms (See Appendix E for completed templates of Evaluation Units)					
T (CP-TF-1)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** **Total and *Hexavalent* Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory (not including tank waste); remedial actions (e.g., interim stabilization where pumpable liquids were transferred to double shell tanks) have not addressed vadose zone contamination.	Pumpable liquids in single shell tanks transferred to double shell tanks. A partial cover was emplaced over areas in and around the 241-T tank farms to limit water intrusion into areas contaminated with tank wastes (from leaks).

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
S-SX (CP-TF-2)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** **Total and *Hexavalent* Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory (not including tank waste); remedial actions (e.g., interim stabilization where pumpable liquids were transferred to double shell tanks) have not addressed vadose zone contamination.	Pumpable liquids in the 241-S-SX single shell tanks were transferred to double shell tanks. Groundwater extraction system is in operation to remove contaminants.
TX-TY (CP-TF-3)	Central Plateau (200 West)	Groundwater	**Radionuclide:** **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water) **Hazardous Chemicals:** **Carbon Tetrachloride (CCl_4)** Little biological breakdown (persistent); Very mobile (moves with water) **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory (not including tank waste); remedial actions (e.g., interim stabilization where pumpable liquids were transferred to double shell tanks) have not addressed vadose zone contamination.	Pumpable liquids in the 241-TX-TY single shell tanks were transferred to double shell tanks.
B-BX-BY (CP-TF-6)	Central Plateau (200 East)	Groundwater	**Radionuclide:** **Technetium-99 (Tc-99)** Half-life is very long (persistent); Very mobile (moves with water) **Hazardous Chemicals:** **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory (not including tank waste); remedial actions (e.g., interim stabilization where pumpable liquids were transferred to double shell tanks) have not addressed vadose zone contamination.	Pumpable liquids in the 241-B-BX-BY single shell tanks were transferred to double shell tanks.
Groundwater (See Appendix D for completed templates of Evaluation Units)					
300 Area GW Plumes (RC-GW-1)	River Corridor (300 Area)	Columbia River	**BENTHIC and RIPARIAN ZONES:**[c] **Hazardous Chemicals:** **Total Uranium (U)** Half-life is very long (persistent)[a]; Somewhat mobile (tied up in soil)	Ratio of maximum concentration and ratio of upper 95% confidence limit to the value used to identify areas contaminated by the Hanford Site[d]; length of Columbia River shoreline and riparian zone area “impacted by uranium (i.e., above drinking water standard).	Enhanced attenuation of uranium using sequestration by phosphate application at the top of aquifer; groundwater monitoring; institutional controls.
100-B/D/H//F/K Area GW Plumes (RC-GW-3)	River Corridor (100 Areas)	Ecological	Low to *Very High*	Degree of physical disruption (and potential additional exposure to contaminants).	None identified.

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
200 East Plumes (CP-GW-1)	Central Plateau (200 East)	Groundwater	**200-BP Interest Area Radionuclides:** **Strontium-90 (Sr-90)** Half-life relatively short (not very persistent); Limited mobility (tied up in soil) **200-PO Interest Area Radionuclides:** ***Iodine-129*** **(I-129)** Half-life is very long (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim or final actions have been taken to treat groundwater and no remedial decisions have been made involving treating vadose zone contamination that could contribute to additional groundwater contamination.	For 200-BP, an ongoing perched water treatability test is being conducted at WMA B-BX-BY to remove uranium and tank wastes are being retrieved from 241-C Tank Farm. Monitoring is taking place in 200-PO.
200 West Plumes (CP-GW-2)	Central Plateau (200 West)	Groundwater	**200-ZP Interest Area Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water)	Area of plume (that also corresponds to plume volume); final action (pump & treat) for groundwater effective but requires more time to adequately address contamination.	Final remediation decision (pump & treat) has been shown effective at treating groundwater contamination.

a. The risk to humans and biota from uranium is generally driven by its chemical toxicity not its radioactivity; the uranium isotopes considered in this Report are very long-lived.
b. Due to similarities between the Evaluation Units, the U and S Ponds (200 West) and B Pond (200 East) were evaluated together in Appendix G.6.
c. The drinking water standard is used to define both the shoreline and riparian zones impacted (i.e., impacts to biota). The total uranium plume does not present a High or Very High risk to groundwater as a protected resource. However, modeling suggests that the uranium concentration will fall below the drinking water standard before the beginning of the Active Cleanup period.
d. Note that there is a large uncertainty relative to the No Effects level for total uranium. As stated in the Columbia River Component Risk Assessment, “Effect levels span nearly three orders of magnitude (3 µg/L to 900 µg/L), reflecting considerable uncertainty in selection of a no-effect concentration. The value selected [12.9 µg/L] is a probable no effect concentration and is the 5th percentile of the toxicity data set” (DOE/RL-2010-117 Rev. 0, p. 6.2).

Highest Risks During the Active Cleanup Evaluation Period (until 2064)

The risks to workers rated high during cleanup are from (1) exposure to contaminants during removal actions or operational accidents (including facility fires) to human health receptors (Facility Workers and Co-located Persons); and (2) loss of nuclear safety controls from major natural hazards (seismic events, volcanic ashfall, or wildfire) or major external events (prolonged loss of power or water) until the source risk has been removed or permanently contained.

The risks to ecological resource receptors rated high or very high during cleanup are from (1) physical disruption or introduction of invasive species, either because of insufficient planning, selected cleanup methods, or lack of a prior knowledge about ecological resource receptors, including eco-cultural resources; (2) potential exposure of radionuclides and other contaminants because of physical disruption during cleanup; and (3) loss of nuclear safety controls from major natural hazards (seismic events, volcanic ashfall, or wildfire) or major external events (prolonged loss of power or water) until the source risk has been removed or permanently contained.

The risks to groundwater (i.e., as a protected resource) rated high or very high during cleanup are from existing vadose zone contamination (e.g., secondary sources) where interim or final remedial decisions have not been made that are thought to either sufficiently remove vadose zone contamination or sufficiently reduce infiltrating water. Current significant threats to groundwater and the Columbia River from contaminants already in groundwater are being treated, and significant threats from vadose zone contamination would not be realized for a long time and only be realized if they are not treated during the active cleanup period.

Highest Risks During the Near-term Post-Cleanup Evaluation Period (until 2164)

The risks rated high or very high remaining after cleanup are from potential failure of institutional or engineered controls to human health and groundwater, and ecological, including eco-cultural, resource receptors. In addition, ***safety of consumptive practices*** (such as those associated with some Tribal Nation cultural practices and some recreational activities) cannot be assured without both risk assessment and appropriate biomonitoring. For **threats to groundwater (as a protected resource)** ***remaining after cleanup***, ratings reflect where remedial actions have been made that would impact the vadose zone source or infiltrating water (i.e., from a surface barrier). Ratings (e.g., in 200 East) also reflect where remedial decisions are pending. For **threats to the Columbia River** ***remaining after cleanup***, ratings reflect that significant action has been taken in the River Corridor to address contamination and it is considered unlikely that contamination from the Central Plateau will impact the Columbia River.

Final Observations

The comprehensive risk evaluations completed on the Hanford Site areas (divided into 64 evaluation units) either undergoing or awaiting cleanup as of October 1, 2015 and compiled for this report (Appendices D-H) are offered to provide a better understanding of the current status of the evaluation units evaluated and of the risks and impacts to receptors during three evaluation periods: cleanup (until 2064), near-term post-cleanup (until 2164), and long-term post-cleanup (until 3064).

Risk evaluation is a necessary predecessor to risk management decisions that ultimately determine the order of priority for and sequencing of cleanup activities. However, risk evaluation is only one of many inputs to risk management decisions. Risk management decisions are outside the scope of this project and involve many factors, including regulatory requirements, resource availability (e.g., workforce, funding and disposition pathway availability), project continuity, and stakeholder input. While risk management has not been an objective or considered part of the Risk Review Project, certain general themes emerged during the execution of the Risk Review Project that may bear on risk management.

At the Hanford Site, current hazard and risk conditions reflect the inventory, site access controls that are in place, and cleanup actions in progress or already completed. These controls and completed actions have greatly reduced threats to human health and ecological resources and have addressed the groundwater contamination that poses risk to the Columbia River and significant part of the groundwater contamination in the 200 West area of the Central Plateau. When considering future cleanup, hazard and risk conditions are important:

- **a. To inform order and timing of cleanup activities –** *nuclear, chemical, and physical safety* (i.e., hazards, initiating events and accident scenarios) *and the threats to groundwater* and the Columbia River *are the primary risk considerations*.
- **b. To inform selection, planning, and execution of specific cleanup actions –** *potential risks and impacts to worker safety, ecological resources, and cultural resources are the primary risk considerations*.
- **c. To inform cleanup criteria** (i.e., cleanup levels to meet regulatory standards) **–** *future land use, protection of water resources, land ownership and control, durability of institutional and engineered controls, and legal/regulatory requirements are the primary considerations that influence future human health risk estimates*. Risks to human health should be considered in combination with risks to environmental and ecological resources for establishing cleanup criteria.

When considering future cleanup, understanding hazard and risk conditions is important to inform

a. order and timing of cleanup activities
b. selection, planning, and execution of specific cleanup actions
c. cleanup criteria

The Risk Review Project's primary focus is on items a and b above; CRESP is not making observations on specific cleanup criteria.

The following observations are offered in the form of overarching and specific observations that may help inform decisions on order and timing of cleanup and/or planning for activities associated with cleanup.

Overarching Observations

1. Currently, members of the public, whether located at the official Hanford Site boundary or at the controlled access boundary (river and highways), usually have Low to Non Discernible risks, even if postulated radioactive contaminant releases from bounding scenarios[27] were to occur.

2. Timing of cleanup of a specific evaluation unit **may reduce worker risk** (e.g., by radioactive decay) **or may increase worker risk** (e.g., by facility deterioration, insufficiently trained workforce availability, repetitive and chronic exposures due to continued operations and maintenance).
   a. Worker risk varies with respect to the nature of hazards, complexity, duration of project, technical approaches, and controls or mitigation measures in place to ensure worker health and safety.
   b. DOE documents promulgate a safety culture, and DOE and its contractors have accident rates that are lower than comparable non-DOE work. Ongoing vigilance will be necessary to sustain this culture and maintain this excellent record.

[27] A "bounding scenario" is a sequence of events that includes assumptions that lead to a greater than realistically expected risk estimate.

c. Discontinuities in project execution lead to losses of trained workforce and institutional memory that may increase worker risks.

3. A major seismic event at the Hanford Site, which would likely affect multiple facilities simultaneously, may release large quantities of radiological contaminants from multiple inactive canyon processing and other facilities (e.g., Waste Encapsulation and Storage Facility, K West Basin, Central Waste Complex (CWC)) that can pose greater risks to human health than contaminants in the legacy sites on the Central Plateau.

4. The ecological resources on the Hanford Site are very important to the Columbia River Basin ecoregion, where its shrub-steppe habitat (Figure ES-1-9) has decreased at a far greater rate region-wide than on the Hanford Site. The Site also contains some federal and state threatened and endangered species. DOE stewardship has helped protect and enhance these resources.

> Seasonal timing of cleanup can be used to reduce effects on ecological resources, including the Columbia River and eco-cultural resources.

   a. Since ecosystems are dynamic, including natural succession and spread of non-native species, up-to-date ecological evaluations (resource levels present) should be used to determine the best place for the laydown areas to minimize ecological risk.
   b. Since cleanup activities are dynamic and ongoing, the effect of such cleanup activities on evaluation unit and buffer area ecosystems needs to be reevaluated just prior to cleanup.

Figure ES-1-9. Vulnerable and Valuable Hanford Site shrub-steppe ecosystem.

5. The historical and cultural significance of the Hanford Site to Tribal Nations stretches over 10,000 years. The Hanford Site also is considered to have important historical significance to Western settlement, which began in the early 1800s and only ended at the site to make way for the Manhattan Project. Finally, the site played a major role during the Manhattan Project Era and after World War II during the Cold War Era. DOE's stewardship helps ensure continued recognition of the site's historical and cultural significance.

Specific Observations that Inform Cleanup Order and Timing

1. **Reduce threats posed by tank wastes** (Appendix E.1 through E.11). There is considerable range in the composition and risks posed by wastes stored in tanks – thus, tank farms and tanks should be considered individually for waste retrieval sequencing, waste treatment and the extent of retrieval necessary to reduce risk. Hydrogen gas generation[28] poses a threat to nuclear safety and human health in some tanks through hydrogen flammability events that may result in atmospheric or subsurface release of waste or contaminants from containment (worker risk from tank vapors are discussed below) from natural events or loss of engineering controls. Tc-99 and Iodine-129, both being persistent and highly mobile in the subsurface, threaten groundwater through potential leakage from tanks.[29] Risks posed by hydrogen gas generation can be somewhat reduced through removal of water-soluble Cesium-137. Groundwater threats can be substantially reduced by removing water-soluble constituents of potential concern from a selected set of tanks.[30] This observation is consistent with the priority given by DOE to addressing hydrogen hazards in applicable safety analyses and the agency's decision to treat low-activity waste (LAW) at the Hanford Tank Waste Treatment and Immobilization Plant (WTP) as early as possible. However, the risk to groundwater will not be reduced significantly if Tc-99 and Iodine-129 are returned to the tanks during low-activity waste treatment. The risk from hydrogen may remain the same or be reduced if Cesium-137 is returned to the tanks during low-activity waste treatment, depending on the resulting distribution of Cesium-137 amongst the tank wastes. DOE is also actively working to understand and protect workers from chemical vapors in the Hanford tank farms.

   Selective waste retrieval targets should be considered for individual tanks within each tank farm, allowing for different amounts of retrieval while completing waste retrievals at an entire tank farm and achieving consistent risk-informed endpoints. If selective waste retrieval targets of 99% or the limits of multiple technologies are applied to the group of 26 double shell tanks (DSTs) and 42 single shell tanks (SSTs) that comprise 90% of the total Groundwater Threat Metric in all tanks (current approach), the result would be a residual Groundwater Threat Metric of 1% of the initial inventory. Waste retrieval targets of 90% of the Groundwater Threat Metric or the limits a single technology would result in a residual Groundwater Threat Metric of less than an additional 1% of the current Groundwater Threat Metric with a cumulative result that is indistinguishable from the current target of 99% across all tanks, considering inventory and retrieval uncertainties. Furthermore, the barriers to environmental release of contaminants from residual waste in tanks after retrieval, tank grouting and tank farm capping have not been robustly evaluated. Selective waste retrieval targets as discussed above may allow for significant acceleration of tank waste retrievals and much more rapid reduction in groundwater threats from tank wastes than currently planned. *Further evaluation of this concept is warranted. A tank farm waste retrieval and processing system plan evaluation of this approach is suggested (see Section 3.2 Waste Management Implications for Hanford Tank Farms)*.

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[28] Hydrogen generation rate is primarily related to Cs-137 and Sr-90 content of the waste.

[29] The threat to groundwater from tank leakage has been mitigated in the near-term through interim stabilization of single-shell tanks (SSTs) where pumpable liquids were removed.

[30] For hydrogen generation, 200 East double-shell tanks (DSTs), 200 West DST SY-103, and SSTs East B-202, B-203, B-204, and West T-201 have times to 25% of the lower flammability limit of less than 6 months under unventilated conditions. Cs-137 removal would most significantly increase time to 25% of the lower flammability limit for tanks AZ-101, AN-102, AN-107, AP-101, AP-103, and AP-105. For groundwater threat, greater than 70% of the GTM is from 200 East DSTs, SY-101 and SY-103 (200 West DSTs), and SSTs AX-101, S-105, S-106, S-108, S-109, SX-106, TX-105*, TX-113*, TX-115*, U-109, and U-105 (*indicates assumed SST leaker).

Reduce dependence on active controls to maintain safety ...with large inventories of radionuclides.

2. **Reduce dependence on active controls (e.g., reliance on power, cooling water, active ventilation) to maintain safety for additional facilities with large inventories of radionuclides.** These conditions are (1) air-handling ducts at the Waste Encapsulation and Storage Facility, (2) sludge at K-Basins (sludge treatment project; Appendix H.2), and (3)T Plant.

    a. **For Waste Encapsulation and Storage Facility (WESF)** – **Hot Cells and Ventilation** (Appendix H.5): During the design basis event earthquake, contaminants from Waste Encapsulation and Storage Facility's hot cell and ventilation system are the hazard sources that could produce substantial radiation doses to the Co-located Person.

    b. **For Waste Encapsulation and Storage Facility – Cesium & Strontium Capsules Storage** (Appendix H.5): The primary scenario that could cause release of radionuclides from the capsules stored in the Waste Encapsulation and Storage Facility pool cells (Figure ES-1-10)is an accident that results in the loss of water from all pool cells, which provides cooling and radiation shielding. The design basis seismic event could not cause the loss of all pool cell water by itself: release of significant quantities of radionuclides could only result from multiple root causes (some in sequence, some in parallel) that include human errors, natural events, and external events. The storage pool structures have been exposed to high radiation fields for an extended period. An initial assessment indicated that the storage pools currently are safe, although the long-term integrity of the structures is uncertain.[31] DOE proposes to over-pack and then transfer cesium and strontium capsules to onsite dry storage.[32]

Figure ES-1-10. DOE photo of cesium and strontium capsules in the WESF pools.

    c. **For KW Basin Sludge** (Appendix H.2): Current safe storage relies on maintaining the K-Basin sludge submerged under water to reduce radiation exposure to workers and prevent fires of reactive metal fragments. Safe processing of K-Basin sludge also requires keeping it wet during retrieval, transfer, interim storage, and processing to prevent pyrophoric constituents from igniting.

    d. **For T Plant** (Appendix H.4): As a part of the Solid Waste Operations Division, T Plant has a mission life that extends beyond the cleanup of the rest of the Site. However, delays in

[31] A separate DOE-initiated review of the condition of the Waste Encapsulation and Storage Facility concrete structure and the reliability of the initial DOE estimate is in progress.

[32] The capsules may experience significantly higher temperatures in dry storage than in pool storage. The elevated temperatures, combined with the variable and uncertain chemical composition of some capsules, could raise concerns about the integrity of the capsules over time as storage is likely for at least decades (see Appendix H.4). This concern would be addressed as part of the safety analysis associated with the dry storage design process.

the waste package surveillance program, or extended delays in the ultimate disposition of the waste, may result in the degradation of the waste packages, which would lead to increased potential for leaks and exposure of workers or Co-located Persons unless the degraded waste storage containers were replaced.

3. **Consider interim actions to reduce or eliminate cleanup actions that could cause substantial human health risks**. The following cleanup activities themselves could cause substantial risks to human health and therefore warrant consideration of interim actions, and different cleanup approaches and timing (recognizing that mitigation measures would be both necessary and implemented before and during remedial actions):
    a. **Retrieval, treatment, and disposal of contaminated soils underlying Building 324 and disposal of the building after grouting the contaminated soils in the building** (Appendix F.2): Currently, no migration of soil contamination to groundwater has been identified, suggesting that required cleanup is not urgent. In addition, the excavation and transfer of the soils through the B-Cell floor may not be technically feasible currently and/or may present challenging risk scenarios. As a result, approaches that allow for immobilization and in situ decay of the soil contaminants (Cesium-137, Strontium-90) warrant further consideration.

    b. **Retrieval, treatment, and disposal of materials from 618-11 site within caissons, vertical pipe units, and burial grounds** (Appendix G.2): This is needed because of the characteristics of wastes (high activity, pyrophoric, poorly characterized) to be retrieved. The possible event of a fire and/or release from 618-11 site jeopardizes continued operations and worker safety at the Columbia Northwest Generating Station because of the proximity of the two facilities. The current cover over the buried wastes, but not present over the caissons and vertical pipe units, limits water infiltration to the wastes where the cover is present. These conditions warrant consideration of instituting interim mitigation measures (e.g., improved cover to prevent infiltration to caissons and vertical pipe units) and delaying waste retrieval until closure of the generating station.

4. **Address portions of specific evaluation units first before the whole.** For several evaluation units, specific activities, hazards, or risk characteristics warrant being addressed before considering the evaluation unit as a whole; that is, parts of some evaluation units need to be managed before other parts of the same evaluation unit.
    a. **618-11 Burial Ground.** (Appendix G.2) Further sampling and characterization of the 618-11 site would improve DOE's knowledge and understanding of the site, which might enable it to develop a remediation plan that reduces the risk to workers and Energy Northwest Generating Station employees.
    b. **Building 324**. (Appendix F.2) The highly contaminated soils under Building 324 must be addressed before anything can be done to demolish the building
    c. **KE/KW Reactor**. (Appendix F.3) The removal of the K-West Fuel Basin (RC-OP-1) must be completed before the initial D4 phases of the K-West Reactor building can move forward. This may also delay plans to “cocoon” the K-East Reactor, as it would most likely be more cost-efficient to do the cocooning of the East and West Reactor buildings at the same time.
    d. **Plutonium Uranium Extraction Plant.** (Appendix F.6) The possible collapse of the tunnels at the Plutonium Uranium Extraction Plant facility should be addressed earlier than the long-term plans to D4 the entire facility.

    e. **Reduction-Oxidation Plant.** (Appendix F.9) Unoccupied since the mid-1960s, the structural deterioration and spread of contamination in the 202 S Building and Annex could result in an unacceptable release and risk to human health and the environment in the absence of any near-term hazard mitigation actions.

5. **Reduce or eliminate risks associated with external events and natural phenomena (fires, severe seismic events, loss of power for long duration).** These risks typically arise from very low probability but very high consequence events. Facilities affected are the Waste Encapsulation and Storage Facility (cesium and strontium capsules), Central Waste Complex, Plutonium Finishing Plant, Plutonium Uranium Extraction Plant waste storage tunnels, and the B Plant and Reduction-Oxidation Plant Canyon buildings. (see also **Reduce dependence on active controls**, item 2 above**)**
    a. **For the Central Waste Complex** (Appendix H.3): Estimated unmitigated doses from accident scenarios to the Co-located Person exposed to the worst design basis event at the Central Waste Complex is from a large fire, involving more than eight drums or 82.5 Ci (dose equivalent) of material, resulting in an estimated exposure of 770 rem. This risk may increase near-term because the Central Waste Complex continues to receive wastes, but currently is unable to ship wastes to off-site disposal, due to shipment availability to the Waste Isolation Processing Plant (WIPP) and because budgets have been insufficient to support repackaging wastes into standard containers. Localized accumulation of material at risk without a disposition pathway can also increase overall risk. Consideration also should include reductions in the amount of material at risk for similar facilities, if disposal options are available.
    b. **For the T Plant** (Appendix H.4): T Plant, as a part of the Solid Waste Operations Division, has a mission life that extends beyond the cleanup of the rest of the Hanford Site. However, delays in the waste package surveillance program, or extended delays in the ultimate disposition of the waste, may result in the degradation of the waste packages, which would increase potential for leaks and exposure of Facility Workers or Co-located Persons. There are several events that have a high anticipated impact on the Co-located Person that relate to building fires. The highest of the unmitigated dose impacts to the Co-located Person is a building fire igniting a waste package (resulting estimated dose: 770 rem).
    c. **For the Plutonium Finishing Plant** (Appendix F.10): A design basis earthquake or aircraft crash into the PFP facility prior to completion of the current D4 activities could cause an estimated unmitigated acute dose of 890 rem to the Co-located Person, and fires or explosions involving contaminated equipment could cause estimated unmitigated doses from 240 rem to 710 rem.
    d. **For the Plutonium Uranium Extraction Plant.** (Appendix F.6):
        i. A design basis seismic event could lead to a total structural failure of the 202-A building and both tunnels, causing an estimated unmitigated combined 250 rem dose to the Co-located Person.
        ii. The wood ceiling and wall structure of Tunnel #1 are vulnerable to collapse due to ongoing degradation from continued exposure to the gamma radiation from

equipment being stored. A collapse accompanied by fire could release a large fraction of the 21,200 Ci radiological inventory to the environment.[33]

e. **For the B Plant and Reduction-Oxidation Plant Canyon Buildings** (Appendices F.7 and F.9): A seismic event of greater magnitude than the design basis at the Hanford Site could cause failure of the 221-B, 224-B, and 202-S Canyon buildings, resulting in loss of the confinement function and shock/vibration impacts to radioactive material in the canyon from seismic motions and displacement of equipment. The results are estimated unmitigated acute doses to Co-located Persons from 35.4 rem to 108 rem. These risks could be significantly reduced if all equipment on the canyon decks were moved into the below-ground processing cells and fully grouted in place and the interior canyon walls were sprayed with a fixative, such as has already been done at the U Plant.

6. **Continue reducing groundwater threats** (Appendix D.1 through D.6): Many of the threats and current impacts to groundwater are being interdicted and/or treated although some plumes have increased in area even in 200 West where groundwater contamination is being actively treated. This phenomenon is not atypical of pump-and-treat systems where treated water is reintroduced into the saturated zone. Current groundwater remedial action should be evaluated to determine if they are efficiently achieving risk reduction. The greatest threats and impacts to groundwater are from the following:

> **Continue reducing groundwater threats:**
>
> - The River Corridor and Central Plateau 200 West Area have active groundwater remediation systems that address their highest groundwater contamination risks.
> - The Central Plateau 200 East Area has contaminant plumes that are not currently being treated and are estimated to be a high risk to further contamination of groundwater.
> - Reduction of infiltration in areas of high levels of vadose zone contamination should be considered to reduce risks to groundwater.

a. **Groundwater plumes not currently being actively addressed.** (Appendix D) Tc-99 and I-129 are already in groundwater in 200 East Area (200-BP-5; EU CP-GW-1). The 200-BP-5 I-129 plume extends to the southeast (200-PO-1; EU CP-GW-1) but may be too dispersed for effective remediation other than natural attenuation. However, remedial actions are currently being investigated for this contamination.

b. **Vadose zone threats to groundwater not currently being addressed.** (Appendix D) Technetium-99, Iodine-129, and Chromium(VI) are in the vadose zone associated with BC Cribs and Trenches (EU CP-LS-1; Appendix D.4) and the legacy sites associated with B-BX-BY tank farms (EU CP-TF-6; Appendix E.7), both located in the 200 East Area. Strontium-90 results in a Very High rating in B-BX-BY because of the large inventory; however, Strontium-90 is relatively immobile and will naturally decay. Infiltration

[33] The document safety analysis for this facility provides a detailed analysis of potential upset events (see Appendix F.4).

control (e.g., capping) and other approaches may reduce the flux of these contaminants from the vadose zone into groundwater. Uranium currently is being extracted from the perched water zone in B-Complex.

c. **Building 324, where relatively modest interim actions could reduce threat.** (Appendix F.2) The largest risk for migration of cesium-137 and strontium-90 from the soils until cleanup can be completed (through a combination of D4, soil treatment and/or removal, and natural attenuation) is from breakage of a main water pipe and infiltration of precipitation and runoff near the building. Building 324 is currently being maintained in a safe surveillance and maintenance mode pending completion and evaluation of a pilot project and assurances that resources are available to complete a multi-year soil remediation and D4 activities. Current risks from potential water infiltration and resultant contaminant migration may be mitigated through water supply modifications, infiltration controls, and additional groundwater monitoring.[34]

d. **618-11 waste site, where relatively modest interim actions could reduce threat**. (Appendix G.2) At 618-11, the potential for release of additional contaminants to groundwater can be mitigated by installing a cover that prevents infiltration but maintains gas venting over the caissons and vertical pipe units (currently gravel-covered area).

7. **Unplanned changes in inventory in operating facilities have a time-dependent risk, which creates additional challenges that need to be addressed.** Unplanned changes in inventory can occur over time due to delays in planned processing and removal and storage of waste, which would result in increased risk. The hazard and risk profiles change as funding is available to implement identified plans as well as resulting from deterioration of infrastructure. For example, with ongoing waste processing delays, coupled with aging infrastructure (due to insufficient maintenance), waste storage conditions will deteriorate and additional waste will accumulate. In addition, operating facilities rely on interfaces with existing facilities (e.g., Waste Isolation Pilot Plant, T Plant, off-site processing and disposition facilities) and planned facilities (e.g., dry capsule storage for cesium and strontium capsules, Phase 2 K-Basin sludge processing). Outages or delays in availability of interfacing facilities will likely disrupt waste processing. For the 222-S Laboratory, the radiological inventory is limited by administrative controls and procedures such that it is considered a “less-than-Category-3” nuclear facility; as long as these safety-related administrative controls are in place, the facility should remain a low-hazard facility.

[34] While groundwater monitoring does not prevent infiltration or contaminant migration, it does mitigate risks by providing early warning of a change in the subsurface contaminant spatial distribution.

SPECIFIC OBSERVATIONS THAT INFORM PLANNING FOR, AND ACTIVITIES ASSOCIATED WITH, CLEANUP (NOT IN ANY SPECIFIC ORDER)

> **PLANNING FOR CLEANUP**
> 1. **Consider Selective Retrieval Targets for Tank Waste**
> 2. **Recognize that uptake and discharges of contaminants from groundwater threaten ecological resources**
> 3. **Expand consideration given to restoration of ecological resources**
> 4. **Reduce potential dispersal and/or transport of contaminants with re-vegetation at reactor sites**
> 5. **Expand consideration given to cultural resources**
> 6. **Decrease the footprint of cleanup activities**

1. **Consider Selective Retrieval Targets for Tank Waste** (Appendix E.1 through E.11)**.** Selective waste retrieval targets as indicated may allow for significant acceleration of tank waste retrievals and much more rapid reduction in groundwater threats from tank wastes than currently planned. Recognizing that waste retrievals are most efficiently carried out on a tank farm by tank farm basis, selective extents of retrieval focusing on tanks with large inventories of contaminants that threaten groundwater can be accomplished for individual tanks within each tank farm, allowing for different extents of retrieval while completing retrievals at an entire tank farm. Retrieval targets also should consider the extent of retrieval for specific contaminants that threaten groundwater rather than solely on volumetric-based or technology-based retrieval targets. Further evaluation of this concept is warranted. A tank farm waste retrieval and processing system plan evaluation of this approach is suggested.
2. **Recognize uptake and discharges of contaminants from groundwater can threaten ecological resources** (Chapter 4.4)**.** For almost all cases, the potential for adverse impacts to ecological resources from contaminants has already been mitigated, either by removal actions or by the presence of engineered barriers (e.g., cover materials, buildings, or engineered structures). Uptake of contaminants from groundwater in the riparian zone and groundwater discharge to the benthic zone of the Columbia River remain the most important pathways for contaminants to impact ecological resources. An additional potential future pathway includes irrigation and plant uptake associated with use of contaminated groundwater.
3. **Expand consideration given to restoration of ecological resources when planning cleanup activities** (Chapter 4.4)**.** Ecological restoration[35] is an important step in remediation, and should be carried out with native species. Monitoring to assess efficacy value, and rarity of the resource are critical to determining how to do restoration for future cleanup activities. The value of ecological resources at any given evaluation unit depends on the resources there and in the surrounding buffer, the historical presence of resources of high sources in comparison to off-site habitats, their cultural value, the remediation and restoration history on the evaluation unit and buffer, and chance/weather/fires. These factors affect the ecological restoration potential during remediation.

[35] In this report, the term "restoration" does not refer to Natural Resource Damage Assessment considerations. Instead, as used here, ecological restoration refers to a process that includes such activities as environmental assessment, vegetation assessment, geographical and contour considerations, re-vegetation, and monitoring, among other processes.

4. **Reduce potential dispersal and/or transport of contaminants with re-vegetation at reactor sites** (Appendix G). Remediation of the K Reactor Area Waste Sites evaluation unit (RC-LS-2) currently is uniquely a “work in progress” because it is a legacy source site where cleanup is continuously disrupted to await completion of D4 activities at the two reactors. Soil cover and vegetation have been removed in some areas, and active dust suppression is required, so there is increased potential for dispersal and/or transport to groundwater of contaminants remaining in the waste sites. Remediation and re-vegetation of the site will reduce infiltration and transport of residual vadose zone contamination to groundwater. Re-vegetation needs to consider topography and native plants.
5. **Expand consideration given to cultural resources when planning cleanup activities** (Chapter 4.5)**.** The Manhattan Project/Cold War Era built environment is well understood as extensive inventories have been completed to document the historical importance of the era’s buildings and structures and which of those buildings and structures will remain after remediation has ended. In contrast, less is known about the other two landscapes: the Native American and Historic Pre-Hanford Era. This is because very few evaluation units have been entirely inventoried for cultural resources within either landscape. Even less is known about subsurface archaeological resources. Physical exposure and disruption during remediation are the primary mechanisms for adverse impacts on cultural resources from activities associated with cleanup of specific evaluation units. Planning for remediation, particularly at the earliest stages, should include (1) how remediation activities, such as road traffic and heavy equipment through the cleanup area, could impact potential cultural resources that are, or could be, present within and adjacent to the area undergoing cleanup, and (2) the mitigation measures that could avoid or limit the impact. Limiting the footprint of activities associated with remediation can decrease the chances of exposing or adversely impacting a cultural resource during cleanup. Additionally, limiting the footprint decreases the chance of an indirect impact, such as exposing an area of the site that Native Americans consider to be important to their culture. Close coordination with the state’s historic preservation officer and affected Tribal Nations is also a key component.
6. **Decrease the footprint of cleanup activities** (Chapter 4.4)**.** Physical disruption and invasive species are the primary causes of adverse impacts on ecological resources at the Hanford Site. Patch size and interdiction of patches are important aspects of ecological value, and should be considered during cleanup. Decreasing the footprint of cleanup activities on the evaluation unit and buffer is one of the most important mechanisms of reducing risk to ecological resources. Planning for remediation requires careful consideration of how the activities will disrupt eco-receptors and ecosystems on the evaluation unit and surrounding areas (including vehicular traffic, people, roads, traffic routes, lay-down areas, and excess water), reducing effects where possible, and specifically avoiding high-quality ecological resource areas on or off the evaluation unit. Allowing non-native species to invade an evaluation unit or the surrounding buffer can disrupt and damage high-quality native resources and is preventable. If high-quality resources on the evaluation unit and buffer are disturbed, it may not be possible to restore them. Thus, protection of ecological resources during remediation is the best option and is superior to trying to repair damaged resources.

KEY INFORMATION GAPS

Information gaps emerged throughout the execution of the Risk Review Project and partially led to a determination to not complete templates on four of the evaluation units.[36] The remaining 60 evaluation units[37] were evaluated for risk, even though missing or incomplete information may have been identified during the analysis. These data gaps potentially have resulted in additional uncertainty in the risk evaluation provided in this final report. Three examples of how incomplete data affected the risk evaluations follow. (1) The exact extent and temporal trajectory of groundwater plumes is unknown, which could severely impact the riparian zone of the Columbia River (e.g. 100, 200, and 300 area groundwater evaluation units). (2) Verification of endangered species (including species of special concern to Washington) occurrence is incomplete for many evaluation units, particularly on buildings slated for demolition where ecological evaluation should be done immediately before demolition (e.g. bats recently removed from reactors). (3) Identification of vapor constituents in tanks causing respiratory and irritation is still under development; traditional 8-hour TWA sampling is insufficient to characterize exposures related from symptoms. More detail on information gaps may be found in the evaluation template for a specific evaluation unit (Appendices D-H).

Below are listed observations surrounding the key information gaps identified during the gathering of data for analysis of evaluation units. These data gaps may influence how risk is determined both currently and in the future.

Affecting Current Risk Determinations

1. Contaminant inventories at many of the legacy sites, groundwater, and Reduction-Oxidation Plant facility evaluation units are highly uncertain. In addition, there is no reported inventory for the majority of the individual waste sites[38] within the legacy evaluation units. Contaminated or potentially contaminated areas need further characterization to the extent necessary to make informed cleanup decisions and to ensure that residual risks to human health, water resources, and ecological resources are below acceptable thresholds.
2. For worker health and safety during remediation within D4 facilities and at certain legacy source sites (e.g., 618-11), the conditions, containment, and stability of the contaminants need to be determined.
3. The condition of the Hanford Site infrastructure and the impacts of infrastructure challenges on the waste management and long-term cleanup efforts, and resulting risks, are not well known and are subjects of current evaluation and planning by DOE. Continuity of key infrastructure (e.g., water supply, electrical power, communications) is essential to risk mitigation.
4. Safety assessments do not evaluate risks between the facility boundary and the site boundary except for unmitigated risks to the maximally exposed co-located person. As site access and

[36] Evaluation Templates for four of the 64 EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.

[37] 60 EUs were evaluated. Two of the EUs (CP-OP-11 and CP-OP-16) were combined and evaluated as CP-OP-11 (LERF + EFT).

[38] The Hanford Site has been divided into more than 2500 individual contaminated areas (i.e., operable units) and RCRA permitted facilities for regulatory purposes.

uses change, there will likely be a need to ensure that the changing boundaries and activities are reflected in existing and new risk assessments.

5. Exposure scenarios have not been established that link federal land use designations to risk assessment and cleanup requirements.
6. For many existing groundwater plumes and for many areas of contamination in the vadose zone, the vertical distribution of primary contaminants is highly uncertain because of limited characterization data.
7. For most evaluation units and areas on the Hanford Site, there has not been a recent evaluation or inventory of the ecological resource level (e.g., habitats). Planning and order and timing to reduce risk to eco-receptors depends on avoiding and protecting high-quality resources (especially large patches, or smaller patches close to large patches).
8. For most evaluation units and areas on the Hanford Site, there has not been any survey of the nature and extent of invasive species, especially on large patches of high-quality resources (Levels 3-5 resources, including habitat for important species and threatened or endangered species). There should also be monitoring in the years following cleanup to determine the extent of non-native species invasions and to determine the efficacy of measures to prevent invasion.
9. The majority of the Hanford Site has not been surveyed for cultural resources related to the Native American and Pre-Hanford Eras. There likely are cultural resources present from those eras, particularly those that are not directly visible. Cultural resources reviews are carried out on a case-by-case basis when cleanup actions or other activities may disrupt specific land areas or land transfers are being considered.
10. Existing cultural resources records often are not compiled or organized in ways that would be helpful during planning for cleanup at a particular location. Cultural resources reviews would benefit from a more streamlined process that provides information in a more timely fashion and with sufficient detail for planning and order and timing of remediation actions, while still protecting the cultural resources.

Affecting Future Risk Determinations

1. As the use of the Hanford Site evolves, there will be a need for regular updating of assumptions within the DSA regarding where the maximum exposed individual (public) is located. This is particularly true for those locations that are included as part of the Manhattan Project National Historical Park and locations to which Tribal Nations seek to access.
2. Additional risk analyses will be needed to evaluate risks to human health as part of planning for new controlled access activities. Current analyses do not provide sufficient resolution to understand potential safety risks to a broader range of people present between 100 m from facility or activity boundaries to the Hanford Site security boundaries.
3. Additional risk analyses of ecological resources (including the Columbia River riparian zone) will be needed as part of planning for new controlled access activities. Mitigation measures, such as biomonitoring, may be necessary for controlled access that includes gathering or consumptive activities such as Tribal cultural activities**.**

WHY THE RISK REVIEW PROJECT IS UNIQUE

The Risk Review Project should be considered unique because it consistently provides for all remaining cleanup areas:

1. An in-depth examination of diverse evaluation unit categories (legacy source sites, facilities for D4, tank waste and farms, operating facilities, and groundwater plumes) with comparisons within evaluation unit categories (e.g., tank waste and farms) provided, where practical. The review has been organized by commonality of the type of contamination source and geographic co-location of sources, rather than by regulatory compliance. Summary tables have been developed that allow quick comparison of contamination sources and receptor risk ratings.
2. The first integrated compilation of potential contamination sources and risks to a broad range of receptors in their current conditions, during cleanup (to 2064), and in the 100 years following cleanup (to 2164), including comparison of the risks (current, during active cleanup, near-term post-cleanup) for each evaluation unit to receptors. Also considered has been the risk to humans in different categories (Facility Workers, Co-located Persons, Controlled Access Persons, and members of the public outside the controlled access boundary).
3. Evaluation of risks to ecological resources, including a field evaluation and compilation of the percent of each ecological resource level within the evaluation unit and the surrounding buffer for all evaluation units. A list of functional effects of remediation on biota, ecosystems and embedded eco-cultural resources has been developed.
4. Comparisons of different risks posed to and by groundwater contamination, including consideration of groundwater movement and the potential risk from groundwater plumes to the riparian zone and benthic organisms in the Columbia River (benthic organisms are more sensitive than other biota or humans to chemicals and radionuclides).
5. A review by a professional archaeologist of information in existing records about the cultural resources within an evaluation unit as well as the buffer area of up to 500 m from the evaluation unit boundary that has been compiled in a publicly available report for that evaluation unit.

PROJECT REPORTS AND EXTERNAL REVIEW

This final report includes risk evaluations and results of 64 units evaluated for the Risk Review Project as well as final observations. All three major reports of this Risk Review Project (the methodology, interim progress report discussing 25 of the 64 evaluation units, and final report) are public documents.[39]

At various points during the Risk Review Project, a broad spectrum of stakeholders including members of the public, Tribal Nations, and government agencies were briefed and invited to provide comment. All written comments received were acknowledged and considered as input for this final report. CRESP's website (www.cresp.org/Hanford/) and Chapter 2.1 provide additional detail on Risk Review Project outreach efforts.

The draft final report has undergone an external peer review and technical review by DOE.

[39] These documents are available at www.cresp.org/Hanford/.

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Abbreviations and Acronyms

AHP	analytic hierarchy process
AWQC	ambient water quality criteria
Bq	Becquerel
BCG	Biota Concentration Guide
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHPRC	CH2M Hill Plateau Remediation Company
Ci	Curies
CLUP	Comprehensive Land Use Plan
CSNA	confirmatory sampling, no action
COPC	contaminant of potential concern
CRESP	Consortium for Risk Evaluation with Stakeholder Participation
CP	Central Plateau
CSB	Canister Storage Building
CSM	conceptual site model
CWC	Central Waste Complex
D&D	deactivation (decontamination) and decommissioning
D4	deactivation, decontamination, decommissioning, and demolition
DE-CI	dose equivalent curies
DOE	U.S. Department of Energy
DSA	documented safety analysis
DST	double-shell tank
EBR-II	Experimental Breeder Reactor II
ECRTS	Engineered Container Removal and Transfer System
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ETF	Effluent Treatment Facility`
EU	evaluation unit
FFC	found fuel container
FFS	focused feasibility study
FFTF	Fast Flux Test Facility
FHA	Fire Hazard Analysis
GIS	Geographic Information System
GTF	Grout Treatment Facility
GTM	groundwater threat metric
GW	groundwater
GWIA	ground water interest area
Gy	Gray
HA	hazard analysis
HAMMER	Volpentest Hazardous Materials Management and Emergency Response Federal Training Center
HEPA	high-efficiency particulate air
HGR	hydrogen generation rate
HLW	high-level waste
ICRP	International Commission on Radiological Protection

IDF	Integrated Disposal Facility
IEM	Interim Examination and Maintenance
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IS	insufficient information
ISA	Interim Storage Area (adjacent to the Canister Storage Building, CSB)
ISS	interim safe storage
LAW	low-activity waste
LERF	Liquid Effluent Retention Facility
LFL	lower flammability limit
LIGO	Laser Interferometer Gravitational Wave Observatory
LLBG	Low-Level Burial Grounds
LLW	low-level waste
KE	K-East
KW	K-West
MAUA	multi-attribute utility analysis
MCDM	multi-criteria decision making
MCO	multi-canister overpack
MLLW	mixed low-level waste
MNA	Monitored Natural Attenuation
MUST	miscellaneous underground storage tank
MOI	maximally exposed offsite individual
NA	not applicable
NCRP	National Council on Radiation Protection and Measurements
ND	not discernible
NEPA	National Environmental Policy Act
NOAEL	no observed adverse effect level
NR	not reported
NRC	U.S. Nuclear Regulatory Commission
NRDWL	Nonradioactive Dangerous Waste Landfill
OSHA	U.S. Occupational Safety and Health Administration
OU	operable unit
P&T	pump and treat
PC	primary contaminant
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
PRG	preliminary remediation goal
PSW	phosphate-sulfate waste (liquid)
PUREX	Plutonium Uranium Extraction Plant
RAL	removal action level
RC	River Corridor
RCB	Reactor Containment Building
RCRA	Resource Conservation and Recovery Act
REDOX	Reduction-Oxidation Plant
RH-SC	remote-handled special components
RIMSII	Regional Input-Output Modeling System
RL	Richland Operations Office

ROD	record of decision
RTD	remove, treat, dispose
SALDS	State-Approved Land Disposal Sites
SARAH	Safety Analysis and Risk Assessment Handbook
SHPO	State Historic Preservation Officer
SSFC	shipping port spent fuel canister
STSC	sludge transportation and storage casks
S&M	surveillance and maintenance
SRE	Sodium Reactor Experiment
SSE	safe storage enclosure
SST	single-shell tank
Sv	Sievert
SWL	Solid Waste Landfill
SWOC	Solid Waste Operations Complex
TBD	to be determined
TC&WM	Tank Farm Closure and Waste Management
TCE	trichloroethylene
TCP	traditional cultural place
TED	total effective dose
TEDE	total effective does equivalent
TEDF	Treated Effluent Disposal Facility
TMBC	transuranic multiple barrier containers
TPA	Tri-Party Agreement
TRIGA	Training Reactor Isotopes General Atomics (registered trademark name)
TRU	transuranic
TSR	technical safety requirement
UCL	upper confidence limit
UPR	unplanned release
UST	underground storage tank
VPU	vertical pipe unit
WAC	waste acceptance criteria
WCH	Washington Closure Hanford
WESF	Waste Encapsulation and Storage Facility
WMA	waste management area
WIPP	Waste Isolation Pilot Plant
WQS	water quality standard
WRAP	Waste Receiving and Processing Facility
WRP	Waste Retrieval Project
WRPS	Washington River Protection Solutions
WTP	Tank Waste Treatment and Immobilization Plant

List of Radionuclides and Other Contaminants

Am-241	americium-241
C-14	carbon-14
Cl-36	chlorine-36
CN	cyanide
Cr(VI)	chromium, hexavalent
Cr (total)	chromium, total
Cs-137	cesium-137 (radionuclide)
CT or CCl_4	carbon tetrachloride
Eu	eurpopium (selected isotopes)
H-3 or ^3H_2O	tritium or tritiated water
Hg	mercury
I-129	iodine-129 (radionuclide)
Ni	nickel (selected isotopes)
NO_3	nitrate
Pb	lead
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
Pu	plutonium (either specific isotopes or total, as indicated)
Sr-90	strontium-90 (radionuclide)
Tc-99	technetium-99 (radionuclide)
TBP	tributyl phosphate
TCE	trichloroethylene
TPH-diesel	diesel as total petroleum hydrocarbons
U	uranium
U (total)	uranium, total

Probability and Consequence Ratings

A	Anticipated
BEU	Beyond Extremely Unlikely
EU	Extremely Unlikely
H	High
L	Low
M	Moderate
ND	Not Discernible
U	Unlikely
VH	Very High
	Not Anticipated

Risk Review Project Risk Ratings

	Low
	Medium
	High
	Very High
ND	Not Discernible
IS	Insufficient Information

Symbology Used For Risk Review Project Summary Rating Tables

Symbols used in the rating tables indicate the highest rating when a rating range is present. Symbols within each entry in rating tables are a combination of a risk rating symbol and additional symbols used to indicate (1) the presence of engineered barriers to prevent release to the environment or further dispersion of radionuclides and chemicals, (2) when treatment, waste retrieval, or remediation is in progress, and (3) if interim stabilization has occurred (only applicable to single-shell tanks; through removal of pumpable liquid).

Symbol	Meaning
Risk Rating Symbols	
○	Not Discernible (ND) Rating
◔	Low Rating
◑	Medium Rating
◕	High Rating
●	Very High Rating
Barrier Symbols	
○	One engineered barrier, Intact (barriers include tanks, covers, liners, buildings, etc.)
◌	One engineered barrier, barrier compromised (e.g., leaking tank)
◎	Two engineered barriers, both barriers intact
◎	Two engineered barriers, inner barrier compromised and outer barrier intact
◎	Two engineered barriers, inner barrier intact and outer barrier compromised
◎	Two engineered barriers, both barriers compromised
Treatment, Remediation, and Waste Treatment Symbols	
[ ]	Treatment, remediation or waste retrieval in progress
ǂ	Interim stabilized (single shell tank, stabilization through removal of pumpable liquid)
Examples of Combined Rating, Barrier, and Treatment Symbols	
◔	Low rating, no engineered barriers or treatment present
◑	Medium rating, no engineered barriers or treatment present
◕	High rating, no engineered barriers or treatment present
◕	High rating, one engineered barrier that is compromised (i.e., leaking)
◕	High rating, two engineered barriers, inner barrier compromised, outer barrier intact
◕ ǂ	High rating, one engineered barrier present (i.e., single shell tank) with interim stabilization
[●]	Very High rating, currently undergoing treatment

Terminology and Definitions

The primary objective of the Risk Review Project is to characterize risks and impacts to human health (Facility Worker, Co-located Persons, and Public), ecological resources, cultural resources, and groundwater, and the Columbia River. These terms are collectively referred to as "receptors." For the purposes of this document, the following definitions apply: [40]

Absorbed dose – energy absorbed per unit mass from any kind of ionizing radiation in any kind of matter. Units: rad, which is equal to the absorption of 100 ergs per gram of material irradiated or gray, the International System of Units (SI) equivalent (1 gray = 100 rad).

Becquerel (Bq) – unit of activity or amount of a radioactive substance (also radioactivity) equal to one nuclear transformation per second (1 Bq = 1 disintegration per second). Another unit of radioactivity, the curie, is related to the becquerel: 1 Ci = 3.7×10^{10} Bq

Bioindicator – species (species group) or characteristic of a species (or species group) that is used to assess the condition of a species, population, community, or ecosystem.

Biomonitoring – regular, periodic assessment of human or ecological health and well-being.

Buffer – area around the evaluation unit (EU), equal to the widest diameter of the EU. It is an area potentially impacted by remediation activities on the EU.

Co-Located Person – a hypothetical onsite individual (who may be a site worker not associated with the specific facility or activity, or may be a site visitor) located at a point equal to 100 m from the boundary of the facility (or activity or from the point of potential contaminant release), or beyond 100 m from the point at which maximum dose hypothetically occurs. or from the point of potential contaminant release). If the release is elevated (e.g., airborne), the person is assumed to be at the location of greatest dose, which is typically where the plume touches down. (This is functionally equivalent to the "Co-located Worker" as defined and used in the DOE-STD-3009-2014 and expanded by Hanford Safety Analysis and Risk Assessment Handbook (SARAH) to address elevated releases.) However, the definition is expanded to represent any person at the postulated location, independent of that person's activity or employer.

Completed Pathway – the transport (transfer or movement) of radionuclides or chemical contaminants from existing environmental contamination sources, hazards (i.e., contained contaminant inventories, physical-chemical forms), or facilities (including those used for materials and waste processing, storage, and disposal) through air, water, or soil to any receptor through a specific set of mechanisms or transport paths. If the transfer is currently occurring, the pathway is referred to as "complete." If the transfer may occur in the future, the pathway may become complete. Other potential pathways may never become "complete" if there is cleanup or interdiction (barriers) or if receptors are kept out of harm's way, for example, by future land use restrictions or institutional controls.

Conceptual Site Model – a comprehensive depiction of sources, potential initiating events, and completed or potential pathways that may result in exposure, risks, and/or impacts to receptors and resources, as well as natural and engineered barriers that interdict the exposure or mitigate the impacts.

Contaminant Sources (or Sources) – chemical and/or radiological contaminants or waste present in a specific form and geographic location. Example sources include contaminated soils, vadose

[40] Some definitions are taken from DOE/RL-2016-33, Revision 0

zone, groundwater, buildings, tanks and drums, as well as historical, current, and future waste disposal areas, waste storage, and processing facilities.

Controlled Access Boundary – a portion of the Hanford Site bounded on the east and north by the south bank of the Columbia River and on the south and west by the public highways 240 and 24 and the cities of Richland and West Richland. Members of the public may be present along these boundaries, which are much closer to the contaminated EUs than the Hanford Site Boundary. Persons inside of this polygon are considered Controlled Access Persons.

Controlled Access Person – a hypothetical onsite individual granted limited access to the Hanford Site, within the Hanford Site's current controlled access boundary. This category has been developed for the Risk Review Project. The controlled access boundary is generally demarcated as the area bounded by the near bank of the Columbia River, Highway 240, and Horn Rapids Road on the southern boundary of the Site. (This is functionally equivalent to the "Onsite Public" as defined and used in the Hanford Safety Analysis and Risk Assessment Handbook (SARAH).)

Cribs – underground structure designed to receive liquid waste that percolates into the soil directly or after having traveled through a connected tile field; these structures are no longer used at the Hanford Site.

Criticality – an inadvertent self-sustaining nuclear chain reaction, with the potential release of high levels of radiation.

Curie (Ci) – unit of radioactivity equal to 37 billion (3.7×10^{10}) nuclear transformations per second (becquerels).

Cultural Resources – a collective term applicable to 1) pre-historic and historic archaeological sites and artifacts designating past Native American use of the Hanford Site; 2) historic archaeological sites and artifacts indicating post Euro-American activities relating to the pre-Hanford period; 3) Hanford Site Manhattan Project and Cold War Era buildings, structures, and artifacts; 4) landscapes, sites, and plants and animals of cultural value to the Native American community; and 5) landscapes, sites, and materials of traditional cultural value to non-Native Americans.

D&D or D4 – deactivation and decommissioning of facilities that are no longer used. D4 is a more comprehensive term including deactivation, decommissioning, decontamination, and demolition of excess facilities.

Dangerous Waste – waste is considered dangerous waste according to the Washington State Department of Ecology Dangerous Waste Regulations if listed within the Waste Acceptance Criteria (WAC) WAC 173-303-081(1) or 173-303-082(1) because it exhibits one or more characteristics of ignitability as defined under WAC173-303-090(5), corrosivity as defined under WAC 173-303-090(6), or reactivity as defined under WAC 173-303-090(7) or any criteria identified in WAC 173-303-100.

Direct effect or direct impact – to cultural resources includes but is not limited to physical destruction (all or part) or alteration such as diminished integrity.

Documented Safety Analysis (DSA) – means "a documented analysis of the extent to which a nuclear facility can be operated safely with respect to workers, the public, and the environment, including a description of the conditions, safe boundaries, and hazard controls that provide the basis for ensuring safety" as defined in 10 CFR 830.3 (a) [Title 10 Energy; Chapter III Department of Energy; Part 830 Nuclear Safety Management.

Dose equivalent -- product of the *absorbed dose*, a quality factor, and any other modifying factors. The dose equivalent is a quantity for comparing the biological effectiveness of different kinds of radiation on a common scale. The unit of dose equivalent is the *rem*.

Ecocultural – ecological resources that are an essential part of a cultural resource; for the ecocultural resource to be of high quality, the associated ecological resources must also be of high quality.

Ecoregion – regions of the United States that are defined on the basis of geology, soils, physiognomy, climate, vegetation, wildlife, and land use.

Ecological Resources – any living resource, including species, populations, communities, and ecosystems.

Ecosystem – the physical and living resources in a defined area, including topography, physical structures, water resources, plants, and animals (species to communities).

Evaluation Period – the timeframe considered over which risks or impacts may occur. This Risk Review Project considers three time intervals in addition to the current condition: 1) active cleanup, 2) near-term post-cleanup, and 3) long-term post-cleanup.

Evaluation Units (EUs) – groupings of sources, aggregated for evaluation as part of this Risk Review Project. Sources may be aggregated into an EU based on potential impacts to a common set of receptors or receptor geographic area, common past waste management practices, or integration in the waste management process. The grouping of sources to form specific EUs is discussed in Chapter 3.

Evaluation Unit Summary Template (or Evaluation Template) – a standardized format used to summarize information and risk ratings for each evaluation unit.

Facility Worker – any worker or individual within the facility (or within the activity geographic boundary as established for the DSA) and located less than 100 m from the potential contaminant release point. (This definition is consistent with the DOE definition of a Facility Worker under the DSA (DOE-STD-3009-2014) and the S*afety Analysis Preparation of Nonreactor Nuclear Facility and Risk Assessment Handbook* (SARAH) (HNF-8739 2012).)

Gray (Gy) – unit of absorbed dose in the International System of Units (SI) equal to the absorption of 1 joule per kilogram. The common unit of absorbed dose, the rad, is equal to 0.01 Gy.

Groundwater – the water located beneath the earth's surface at or below the water table in aquifers within geologic formations.

Groundwater Sites – groundwater areas at the Hanford Site that have been adversely impacted by contamination.

Half-life – length of time in which a radioactive substance will lose one half of its radioactivity by decay. Half-lives range from a fraction of a second to billions of years, and each radionuclide has a unique halflife.

Hazard – any source of potential damage, harm, or adverse health effects. Hazard must be distinguished from risk, since risk should reflect any actions that may have been implemented to reduce the hazard and exposure to receptors.

Impacts – the damage or consequences (death, illness, reduced reproduction, resource impairment, or access limitation) from current or post-remediation residual contamination, or from cleanup, including degradation of resources (including ecosystems, cultural resources, economic assets, groundwater, and surface water above defined thresholds).

Indicator – a physical or biological endpoint used to assess the health and well-being of humans, other species, or ecosystems.

Indirect effect or indirect impact – to cultural resources include but are not limited the introduction of visual, atmospheric, or audible elements that diminish the cultural resource's significant historic features. For example, a traditional cultural place that is visible from an EU would create a view shed that could be impacted under certain remediation options such as capping.

Industrial-Exclusive area – area is "suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes" (DOE/EIS-0222-F).

Initiating Events – natural or anthropogenic (man-made) events or processes that may result in the release or accelerated movement of contaminants from a source. Examples include water infiltration, earthquakes, fires, cleanup activities, volcanic eruptions, and sudden structural collapses or failures. Initiating events relevant to this Risk Review Project are discussed in Chapter 4.

Insufficient Information (IS) – adequate data or other forms of information are not available to complete the indicated part of the Evaluation Template.

Interest Area – informal groundwater interest areas defined by DOE, which include the groundwater operable units and the intervening regions, to provide scheduling, data review, and data interpretation for the entire Site.

Key Sources – the set of contaminated areas, wastes, and facilities within an EU that pose the primary risks from the EU. Key sources would not include minor contributors to the overall risks.

Legacy Source Sites – sites containing contaminant releases to the ground, surface, or subsurface resulting from prior actions, including waste disposal actions that are no longer being carried out at a particular location and that are potentially subject to cleanup.

Maximally Exposed Offsite Individual (MOI) – hypothetical individual, who has been defined to allow dose or dosage comparison with numerical criteria developed for the public. This individual is an adult typically located at the point of maximum exposure on the DOE site boundary nearest to the facility in question (ground-level release), or may be located at some farther distance where an elevated or airborne buoyant radioactive plume is expected to cause the highest or greatest exposure (airborne release). (MOI used here is not the same as the Maximally Exposed Individual or the Representative Person used in DOE Order 458.1 for demonstrating compliance with DOE public dose limits and constraints.)

Mitigated Hazards, Exposures, or Risks – there are many hazardous facilities and materials that could reach and harm receptors (see Unmitigated Hazards, Exposures, or Risks). Before and during remediation, a variety of engineered and administrative controls are used to reduce sources and interdict exposure pathways, thereby mitigating exposures and reducing risks.

Monitoring – the regular, periodic assessment of the condition of humans or ecosystems (and their component parts). Usually involves surveillance for humans and bioindicators for ecosystems.

Not Applicable (NA) – the indicated part of the Evaluation Template that is not applicable to the specific EU or evaluation period being considered.

Not Discernible (ND) – the indicated risk or potential impact is not distinguishable from surrounding conditions or background.

Not Reported (NR) – no data are available

Novel Remediation Approach – a remedial approach that is unprecedented or contains components that are unprecedented.

Operable Units (OU) – group of land disposal sites placed together for the purposes of a remedial investigation/feasibility study and subsequent cleanup actions under CERCLA. The primary criteria for placing a site into an operable unit includes geographic proximity, similarity of waste characteristics and site type, and the possibility for economies of scale. NOTE: OU can also be applied to areas of groundwater contamination.

Operating Sites – operating facilities at the Hanford Site that are currently being used as part of the cleanup process.

Potholing – use of non-mechanical techniques, such as hand digging or use of a vacuum extractor (guzzler or similar) at a sufficient number of locations to verify both horizontally and vertically the position of an obstruction[41].

Primary Contaminants (PCs) – contaminants that are considered either risk drivers from specific contaminant sources or site-wide contaminants (uranium, plutonium, technetium, etc.) for the Hanford Site. The terminology "primary contaminants" is used to differentiate the usage in this Risk Review Project from the regulatory usage of the terminology of "contaminants of potential concern."

Primary Sources – the origin of a potential or known release of contaminants to the environment (e.g., tanks, buildings, burial grounds, lagoons, cribs, plants that carry contaminants).

Public – represented by the MOI, a hypothetical human receptor located at or beyond the Hanford Site boundary at the distance and in the direction from the point of contaminant release at which the maximum dose occurs. (*This is functionally equivalent to the "Offsite Public" as defined and used in the DOE-STD-3009-2014 and SARAH.)*

Pyrophoric – the property of some compounds (such as fine metal shavings of uranium) to spontaneously ignite in air.

Rad – unit of absorbed dose. 1 rad = 0.01 gray (Gy).

Receptors – human populations, biota and ecological systems, environmental resources (ground and surface water), the Columbia River, and cultural resources that may be exposed to contaminants via one or more contaminant transport and uptake pathways or otherwise adversely impacted by the contamination or cleanup actions.

Rem – unit of dose equivalent and total effective dose (equivalent).

Resources – a source, either material or non-material, that is considered an asset or from which a benefit is produced or derived. Resources have three main characteristics: utility, limited availability, and potential for depletion or consumption.

[41] http://www.hanford.gov/files.cfm/DOE-0344_Rev_4-1_Public_Cleared.pdf

Risk – the potential (likelihood and magnitude) for adverse consequences to receptors. For human health, risks originate from exposure to contaminants or trauma associated with the presence of contaminants and/or cleanup of contaminant sources. For other receptors, such as groundwater and ecological and cultural resources, risks reflect the potential for damages or losses of the resource. Risk does not exist in the absence of exposure, although exposure and risks can be identified as "potential" (see also Mitigated and Unmitigated). Mitigated risk reflects those actions that have been implemented to reduce hazards, probability, and consequences of adverse events (e.g., source reduction or engineered barriers that prevent or reduce the transport of contaminants of concern from a source to a receptor).

Risk Assessment – used to characterize the nature and magnitude of health risks to humans (e.g., residents, workers, recreational visitors) and ecological receptors (e.g., birds, fish, wildlife) from radiological and chemical contaminants and other stressors that may be present in the environment.

Risk Characterization – a review of available information, including identification of key information gaps, to provide a comparative qualitative and semi-quantitative (order of magnitude) evaluation of relative risks to a set of receptors posed by a wide range of existing contamination of environmental media and sources of potential future additional environmental contamination. Risk characterization is in contrast to a regulatory risk assessment, which provides quantitative estimates of human health risks.

Risk Evaluation – an evaluation of the available information to evaluate potential harm to receptors and their ecosystems. It falls short of a formal risk assessment and relies on available information.

Risk Management– concept is based on the principles that risk management must be analytical, forward-looking, structured, informative, and continuous. Risk assessments should be performed as early as possible in the project life cycle and should identify critical technical, performance, schedule, and cost risks. Once risks are identified, sound risk mitigation strategies and actions should be developed and documented (DOE 0 413.3A).

Rough Order of Magnitude Relative Rating – binning to distinguish major differences in a risk to a specific receptor (i.e., human health, ecology, etc.) between multiple EUs by assigning values of Very High, High, Medium, Low, or Non Dicernible (ND) (i.e., relative risks posed when comparing amongst EUs). "Rough order of magnitude relative grouping" refers to drawing distinctions between groupings that are approximately a factor of 10 different (e.g., 10, 100, 1000 times) when based on quantitative information (or substantially different for qualitative assessments), recognizing the inherent uncertainties and data gaps.

Secondary Sources – locations in the environment that have received material from a primary source such that they can also act as sources (e.g., soil, groundwater, sediments).

Sievert (Sv) – unit of dose equivalent and its variants in the International System of Units (SI). The common unit for dose equivalent and its variants, the rem, is equal to 0.01 Sv.

Succession – the orderly transformation of an ecosystem after any perturbation (natural or man-made) to the ecosystem that would exist given the biological and physical conditions of the region.

Tank Waste and Farms Sites – areas at the Hanford Site (often referred to as tank farms) that contain single- and double-shell underground tanks that house radioactive and chemical wastes that are the byproduct of "reprocessing" spent nuclear fuel.

Total Effective Dose (TED) and Total Effective Dose Equivalent (TEDE) – radiation doses expressed in rems or sieverts, adding the radiation dose received externally and the committed effective dose received from internal exposures, which continue to emit radiation over time. The sum of committed effective dose equivalent from the intake of radioactive material and dose equivalent from exposure to external radiation.

Traditional cultural place – is a place or location that is associated with cultural practices or beliefs of a living community that 1) are rooted in that community's history, and 2) are important to maintaining the continuing cultural identity of that community (See National Historic Preservation Act, 16 U.S.C. 470 et seq.; DOE/RL 98-10, Rev. 1 1998, Rev, O (Issued to Public 2003), Hanford Cultural and Historic Resources Management Plan, U.S. Department of Energy, Richland Operations Office, Richland, WA)

Unmitigated Hazards, Exposures, or Risks – there are many hazardous facilities and materials that could reach and harm receptors if not mitigated. The Risk Review Project considers these in terms of probability and consequence, assuming no effective mitigation measures (engineered and administrative controls) are in place (see Mitigated Hazards, Exposures, or Risks).

Urgency – higher urgency refers to projects where the risks or impacts to receptors are likely to increase due to degradation at the source, further dispersion of contamination in groundwater, loss of structural integrity, or loss of institutional memory. Lower urgency refers mainly to passively stable hazard configurations and when radiologic decay significantly reduces risk depending on the half-life of each radionuclide.

Vadose Zone – zone of soil or rock between the land surface and the subsurface water table. Pore spaces in the vadose zone are partly filled with water and partly filled with air. The vadose zone is bounded by the land surface above and by the water table below.

CHAPTER 1. BACKGROUND, PROJECT GOAL, OBJECTIVES, AND SCOPE

1.1. BACKGROUND, PROJECT GOAL, AND OBJECTIVES

In January 2014, the Deputy Under Secretary for Management and Performance of the U.S. Department of Energy (DOE) asked the Consortium for Risk Evaluation with Stakeholder Participation (CRESP) to conduct a Hanford Site-wide evaluation of human health, nuclear safety, environmental, and cultural resource risks associated with existing hazards, environmental contamination, and cleanup activities (See Appendix A); hereinafter referred to as the "Risk Review Project." This report provides the results of the evaluations completed for the Project, as well as final observations.

From the beginning, the Risk Review Project's goal has been to develop and use a screening approach to help inform future cleanup sequencing at Hanford. Accomplishing this goal has included identifying and characterizing potential risks to both humans and resources (i.e., groundwater, the Columbia River, and ecological and cultural resources), collectively referred to as "receptors."

Project results are expected to provide DOE and regulators with a common understanding of the risks posed by hazards (i.e., contained radionuclide and chemical contaminant inventories, physical-chemical forms, structural integrity, vulnerability to initiating events), existing environmental contamination, and cleanup actions (including mitigation measures that offset or reduce risk associated with cleanup). Specific objectives of the Risk Review Project are to:

- Review hazards and existing environmental contamination site-wide, determine the potential for contaminants and cleanup actions to cause risks to receptors, and identify key uncertainties and data gaps.
- Provide relative ratings of risks to receptors from hazards and existing environmental contamination, and identify the most urgent risks to be addressed, to better enable the Tri-Parties (DOE, the U.S. Environmental Protection Agency [EPA], State of Washington) to make decisions on the sequencing of Hanford cleanup activities.

Meeting both of these objectives is daunting. Within the Risk Review Project, risk characterization relies on **existing** information about the Hanford Site that has been assembled and evaluated to describe risks. These identified risks are grouped for each type of receptor as Very High, High, Medium, Low, or Not Discernible (ND). This screening approach is intended to provide relative risk ratings *within* receptor categories (i.e., relative binning of risks to human health, groundwater, ecology, etc.). However, the Risk Review Project ratings have not been normalized across receptor categories (i.e., a rating of Very High for groundwater should not be equated to a rating of Very High for ecology).

The Risk Review Project has been carried out in multiple stages, which are:

- Development of the risk characterization approach, referred to as the methodology, and testing the developed methodology on pilot case sites that represent the primary sources of contamination at Hanford (e.g., operating facilities and tank waste and farms). The methodology has been adapted from prior risk characterization approaches used at Hanford and elsewhere and suitably tailored to fit the Hanford Site's unique cleanup and waste management activities and diversity of information, as well as the goal and objectives of the Risk Review Project. The methodology document may be found on CRESP's website at www.cresp.org/hanford (CRESP 2015b).

- Completion of an interim progress report to provide risk characterization of 25 of the EUs at the Hanford Site. The interim progress report may be found on CRESP's website at www.cresp.org/hanford (CRESP 2015a).
- Completion of a final report to include risk characterization of the full set of identified EUs at the Hanford Site included in the Risk Review Project.

Beginning in 1943, the area now known as the Hanford Site, which is located along the Columbia River in southeastern Washington State and covers 586 square miles (half the size of Rhode Island), was transformed from primarily an agricultural area into an industrial complex designed to produce plutonium for weapons to use as a military deterrent during World War II. This mission continued until the Cold War ended, and in 1989 the mission evolved to waste management and cleanup of the contamination remaining on the Hanford Site[42] from work conducted during the Manhattan Project and Cold War eras.

Cleanup at the Hanford Site has several stated goals, but three of the most important are protecting human health, protecting the Columbia River, and restoring groundwater to its beneficial use. Cleanup at Hanford consists of three major components: the River Corridor, the Central Plateau, and tank waste. Cleanup activities for all three are considered complex, involve multiple projects, and will cost billions of dollars. In fact, cleanup at Hanford has proven to be much lengthier, more complex, more technically challenging, and more expensive than was envisaged in 1989, when Hanford's mission was refocused to waste management and cleanup. Additionally, in some areas at the Site, cleanup will continue for many years and active systems may need to remain operational for long periods of time. Despite the difficulties, considerable progress has been made in cleaning up the Site (e.g., treating contaminated groundwater near the Columbia River) (DOE/RL-2014-11 2014).

Since the early 1990s, cleanup urgency in the *River Corridor* has been driven by the threats to the Columbia River posed by hundreds of waste sites and contaminated facilities, including nine retired plutonium production reactors. The corridor consists of 220 square miles, but considerable portions were never directly involved in or affected by weapons production activities.

The *Central Plateau* is composed of 75 square miles and is located, as the name suggests, in the central portion of the Hanford Site. The Central Plateau contains waste sites, active treatment and disposal areas, historical waste disposal (burial) grounds, and surplus facilities. Additionally, there are areas with deep soil contamination and an estimated 60 square miles of contaminated groundwater. About 10 square miles comprise the inner area within the Central Plateau and the remaining acreage is referred to as the outer area. The inner area serves as the location for long-term waste management and containment of residual contamination.

The third component of Hanford cleanup is *tank waste*, which is found in so-called "tank farms" in the inner area of the Central Plateau. The tank farms contain approximately 55 million gallons of radioactive waste stored in 177 tanks that are scattered throughout the inner area of the Central Plateau and intermingled with other waste sites. Retrieval of waste from 16 of the 177 tanks has been completed from a technical but not necessarily regulatory perspective. Intentional discharges, unintentional discharges, and leaks have occurred, and some contaminants from these releases have reached groundwater; furthermore, some tanks are assumed to be leaking at a very slow rate. In addition to containment and retrieval, the tank waste strategy includes treatment and disposal (DOE/RL-2009-10, Rev. 1, 2013).

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[42] Huge swaths of the Hanford Site have not been considered part of the cleanup effort because these areas were never occupied or used during or involved in the Manhattan Project and/or Cold War.

Cleanup at the Hanford Site is governed by environmental laws, primarily the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), P.L. 96-510, 42 U.S.C. 9601 (1980, et seq.) and the Resource Conservation and Recovery Act (RCRA) and their regulations and guidance documents. The purpose of both statutes is to reduce the risk from contamination at sites to levels that protect human health and the environment. Under CERCLA, cleanup is DOE's responsibility and implementation is overseen by EPA and state regulatory agencies through federal facility agreements and regulatory permits. The legal framework relied on at Hanford is the 1989 Tri-Party Agreement (TPA) executed by the DOE and its regulators, EPA, and the Washington State Department of Ecology (Ecology). That federal facility agreement document establishes milestones for completing agreed-upon cleanup activities and is regularly updated (most recently in 2016) (Ecology, DOE, and EPA 2016). Another important legal document is the 2010 Consent Decree and its amendments, which establishes milestones for cleanup of tank waste and farms.

Since cleanup began, DOE has maintained a dialogue with a broad spectrum of interested community members, neighboring state Oregon, four Native American Tribes having historical and cultural ties to the Hanford Site (Nez Perce, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes and Bands of the Yakama Nation, and Wanapum), local governments, and other stakeholder groups. Federal law, including CERCLA, also gives individuals, Tribes, governmental entities, and other stakeholder groups the opportunity to comment on documents that guide cleanup.

The Risk Review Project has been carried out in regular dialogue with senior management from DOE, EPA, and the Washington State Departments of Ecology and Health through a Core Team that provided advice on the development and execution of the Risk Review Project through completion of the interim progress report in 2015. Throughout the project, Pacific Northwest National Laboratory (PNNL) has provided analytical and research assistance, which includes gathering existing information on each unit being evaluated.

The Risk Review Project has been led by CRESP, and CRESP is responsible for its execution, results, conclusions, and recommendations. CRESP is a consortium of universities supported by DOE through a cooperative agreement.[43] The CRESP mission is to advance environmental cleanup by improving the scientific and technical basis for management decisions, while fostering opportunities for public participation. CRESP has completed risk-informed characterization projects involving complex issues at both large and small DOE Office of Environmental Management sites.

1.2. SCOPE OF FINAL REPORT

The scope of this final report for the Risk Review Project is to present the results of all 64 units identified for evaluation.[44] Results include completed templates for each evaluation unit (EU) (Appendices D-H) together with the qualitative and order-of-magnitude relative rating and binning of risks to receptors

[43] CRESP is supported by DOE under Cooperative Agreement Number DE-FC01-06EW07053, titled T*he Consortium for Risk Evaluation with Stakeholder Participation III*, and awarded to Vanderbilt University.

[44] Evaluation Templates for four of the 64 EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3. Two of the EUs (CP-OP-11 and CP-OP-16) were combined and evaluated as CP-OP-11 (LERF + EFT).

that include human health, groundwater and the Columbia River, and ecological resources. An overall risk rating is not provided for cultural resources; however, information about cultural resources has been gathered, described, and analyzed as a planning guide or tool for future activities. Chapter 2 summarizes the methodology and approach applied to human health and resource receptors to determine a relative rating and binning of risk.

Cleanup sites remaining at Hanford have been divided into 64 EUs organized into five categories: (1) legacy source sites, (2) tank waste and farms, (3) groundwater plumes, (4) inactive facilities undergoing deactivation, decommissioning, decontamination and demolition (D4), and (5) operating facilities. Chapter 3 of this report provides results from each category and makes comparisons where appropriate (e.g., tank waste and farms). Chapter 3 also compares inventories and physical/chemical states and provides a table of the impacts of the most important initiating events.

In addition to the results of the EUs identified for evaluation under the Risk Review Project, this final report includes the status of contaminants likely to be present during the long-term, post-cleanup evaluation period.

Chapter 4 describes details on the outcomes of the ratings or binning of risks to receptors. Integration in risk ratings among receptor categories is a part of risk management, not risk evaluation, and informs the development of program objectives that also must consider other factors such as programmatic goals; legal requirements; near- and long-term cost-benefit tradeoffs, values, and uses; and stakeholder input (including from the public, Tribes, and government officials at local, state, and federal levels). Integration of results among receptor categories has not occurred because it is beyond the purview of the Risk Review Project.

The Hanford Site needs to be viewed in the context of the regional economy, important onsite or adjacent economic assets, and the multiple relevant sources of human health risks and impacts to nearby resources. Examples include the Energy Northwest Columbia Generating Station (nuclear) and PNNL facilities in the Hanford 300 Area, the U.S. Ecology waste disposal site in the Central Plateau, and discharges from non-Hanford sources to the Columbia River of contaminants found on the Hanford Site (e.g., discharges from agricultural and industrial activities). Chapter 5 of this report provides context for the relationships between the Hanford Site cleanup and the regional economy.

Finally, Chapter 6 includes final observations and a summary of the results of the evaluations.Table 6-3, and Table 6-4 identify all EUs rated the highest (i.e., EUs where risks were rated High or Very High). Summarizing the information in this way is offered only to help inform sequencing decisions and planning and execution of specific cleanup actions.

1.3. WHAT THE RISK REVIEW PROJECT IS AND IS NOT

To better understand the context for this final report, it is important to describe the parameters for the Risk Review Project, including what the project is not:

- The Risk Review Project has focused only on portions of the Hanford Site where cleanup or waste management activities are ongoing and will continue past October 1, 2015, or where cleanup or waste management activities will occur beginning October 1, 2015, or later. Cleanup actions considered completed by the Tri-Parties are not part of the Risk Review Project and therefore have not been evaluated. Specific areas of the Hanford Site that are included, as well as those that are excluded from the Risk Review Project, are described in Chapter 3 of this document.

- The Risk Review Project has focused on risk characterization, which is a necessary predecessor to risk management, but does not focus on risk management decisions. Nonetheless, cleanup actions can cause risks to receptors, which are a part of risk management decisions. This report, however, does not recommend which cleanup option should be selected or the order in which they should be performed. Instead, the results identify and discuss a plausible range of cleanup actions for different types of hazards and existing environmental contamination to better understand the extent of potential risks that may be caused by future cleanup actions.
- The Risk Review Project is neither intended to substitute for nor preempt any requirement imposed under applicable federal or state environmental laws. As important, the Risk Review Project is not intended to make or replace any decision made under the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) and/or 2010 Consent Order, or amendments.
- The Risk Review Project is not intended to interpret treaty rights that exist between the United States and Native American Tribes.
- The Risk Review Project has not carried out a CERCLA risk assessment or a Natural Resources Damage Assessment evaluation. Evaluations of hazards, existing environmental contamination, and rough order-of-magnitude estimates of risks to receptors using existing information are the basis for developing groupings, or bins, of risk and identifying the most urgent risks to be addressed.
- The establishment of end-state cleanup criteria is not the focus of the Risk Review Project.

CHAPTER 2. METHODOLOGY OVERVIEW

2.1. OVERARCHING METHODOLOGY AND APPROACH

To accomplish the Risk Review Project's goal of developing and using a screening approach that would help to inform future cleanup sequencing at Hanford, the most recent, available information about hazards (i.e., contaminant inventories, physical chemical forms), existing environmental contamination, and events that may adversely impact receptors at the Hanford Site was gathered, described, and analyzed. The Risk Review Project has used information and reasonable planning assumptions that are available. Evaluations completed for the final report are based on data received as of October 2016. Evaluations completed for the interim progress report were based on data received as of January 2015 and have not been updated for this report except with regard to (1) groundwater evaluations (which have been updated for this report to reflect the most recent monitoring data available), and (2) as otherwise noted (e.g., Building 324 [RC-DD-1] or tank farm retrieval status) because more recent information materially affects the evaluation(s) made in the interim progress report. Updated references also are provided to key documents (e.g., Tri-Party Agreement) as appropriate.

The general risk characterization paradigm that has been used to evaluate risks to human health and other receptors includes the following steps (Table 2-1):

- **Identification of EUs.** The remaining cleanup sites[45] at Hanford as of October 1, 2015, have been divided into 64 EUs, which have been organized into five categories composed of geographically co-located sites to the extent possible, considering commonality among source types and the overlapping of impacts and risks to receptors.[46] The five categories are (1) legacy source sites, such as past practice liquid waste disposal and buried solid waste sites; (2) tank waste and farms and co-located legacy contamination sources; (3) groundwater plumes; (4) inactive facilities undergoing decommissioning, deactivation, decontamination, and demolition (D4); and (5) operating facilities used as part of the cleanup process. Table 2-1 lists all the EUs and Figure 2-3 provides a map showing the locations of EUs evaluated in this report. Further descriptions of the grouping methodology and sources included in each EU are provided in Chapter 3 of the methodology document (CRESP 2015b).
- **Summary Evaluation Templates.** Each EU is described in detail using existing information, including regulatory documents, maps, and studies (including environmental impact statements [EISs], CERCLA remedial investigations, preliminary documented safety analyses [PDSAs], etc.). Information gathered on each EU includes the unit description and history, an inventory of waste and contamination history, and selected or the potential range of cleanup approaches. Templates have not been completed on the following EUs: Pre-Hanford Orchard Lands (RC-LS-3) (lack of relevant information), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility construction not completed), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of relevant information). The ratings of risks to receptors, then, are based on a rough

[45] The Hanford Site has been divided into more than 2500 individual contaminated areas (e.g., operable units) and RCRA permitted facilities for regulatory purposes.
[46] The EU concept was developed by the Risk Review Project to provide a tractable basis for reviewing the myriad of cleanup challenges at the Hanford Site.

order of magnitude relative grouping[47] or binning of risks to each different type of receptor. The primary groupings are Very High, High, Medium, Low, and ND. A standardized summary report structure, referred to as Evaluation Template, is used to present the resulting information about each EU. The EU template may be found in Appendix B of the methodology document (CRESP 2015b).

- **Risk Ratings.** Potential receptors that may be at risk are characterized and rated using a defined rating scale derived from the specific evaluation methodology developed for each receptor type. The rating scale for each type of receptor is determined for that receptor using recognized thresholds, if they exist, as screening levels, as well as other factors. The receptors being rated using a defined rating scale are Facility Workers, Co-located Persons, Controlled Access Persons, Public, groundwater, the Columbia River, and ecological resources. Non-human receptors are also referred to as resources (e.g., ecological). This approach is intended to provide relative risk ratings *within* receptor categories (i.e., relative binning of risks to the Columbia River, groundwater, ecology, etc.), which may be used to identify the urgency of addressing specific hazards and existing environmental contamination. Risk ratings are not provided for cultural resources; however, information about cultural resources within or near (within 500 m of) each EU has been gathered, described, and analyzed as a planning guide or tool for future activities. For many cultural resources, a healthy and functioning ecosystem is an integral part of the cultural value (often called ecocultural resources). For Tribal Nations, cultural resources include healthy ecosystems and eco-receptors. Evaluations of ecological receptors thus provide additional information not otherwise provided in the cultural resources provisions of Section 2.3 of this chapter. Economic assets are described briefly at the end of this chapter and in Chapter 5, but identified economic assets are not evaluated individually in detail in this document. EU evaluations indicate when the current status, delay, or cleanup activities may affect DOE or non-DOE economic assets directly. The receptor methodologies or approaches are summarized in Section 2.3 of this chapter. More detailed descriptions of the methodologies for each receptor are in Chapters 5 through 8 of the methodology document (CRESP 2015b).
- **Initiating Events.** The likelihood of low-probability, high consequence initiating events, both localized and regional, which may occur during any or all of the evaluation periods, including operational events such as human error and external episodic events such as fire, volcanic eruptions, and loss of power, is described. This is to establish a consistent basis for identifying and categorizing phenomena that may remove or degrade barriers, placing receptors at risk from contaminants. Nuclear safety is considered in the context of potential initiating events and risks to receptors and described in more detail in Chapter 4 of the methodology document (CRESP 2015b). Furthermore, contaminants in environmental media (e.g., soils, vadose zone, groundwater) will flow, move, diffuse, and disperse under long-term prevailing conditions without the presence of specific episodic initiating events.
- **Temporal Evaluation Periods.** Risks are evaluated based on distinct time frames or evaluation periods. The evaluation periods are (1) active cleanup period (or until 2064), including the current status of the EU prior to cleanup, where applicable, and during active cleanup (or until 2064); (2) near-term post-cleanup (until 2164, or assuming a 100-year duration for institutional controls associated with areas transferred from federal control); and (3) long-term post-cleanup (or until 3064). Each EU and selected EU components are evaluated as if cleanup were not to

[47] "Rough order of magnitude relative grouping" refers to drawing distinctions between groupings that are approximately a factor of 10 different (e.g., 10, 100, 1000 times) when based on quantitative information (or substantially different for qualitative assessments), recognizing the inherent uncertainties and data gaps.

occur for 50 years to provide insights into the potential risks of delay to help inform sequencing of cleanup actions. However, this is not to imply that delay of cleanup for 50 years is recommended. Section 2.4 of the separate methodology document provides additional assumptions relative to each evaluation period (CRESP 2015b). Using the specific methodology to rate risks for each receptor (described in Chapters 5 through 8 of the methodology document (CRESP 2015b)), each EU has received a rating for each applicable receptor during the active cleanup period (including current status and as a result of cleanup actions where applicable) and the near-term post-cleanup period. The long-term post-cleanup period is considered for the remaining contaminant inventory and physical/chemical form, engineered and natural containment barriers to contaminant release, and potential risk pathways. However, a rating for specific receptors is not assigned to the long-term post-cleanup period.

- **Economic Assets.** The Hanford Site and its vicinity include a range of economic assets that may be impacted by cleanup activities at Hanford. DOE economic assets include the Hanford Site infrastructure. Commercial activities on the Hanford Site include the U.S. Ecology low-level waste (LLW) disposal facility, Energy Northwest Columbia Generating Station (nuclear power generation), and multiple PNNL research laboratories. Furthermore, the regional economy may be impacted by community perceptions of cleanup activities at the Hanford Site. EU evaluations indicate when the current status, delay, or cleanup activities may directly affect DOE and non-DOE economic assets.

The overall methodology is illustrated in Figure 2-1 and the methodologies followed for each of the receptors evaluated are discussed later in this chapter.

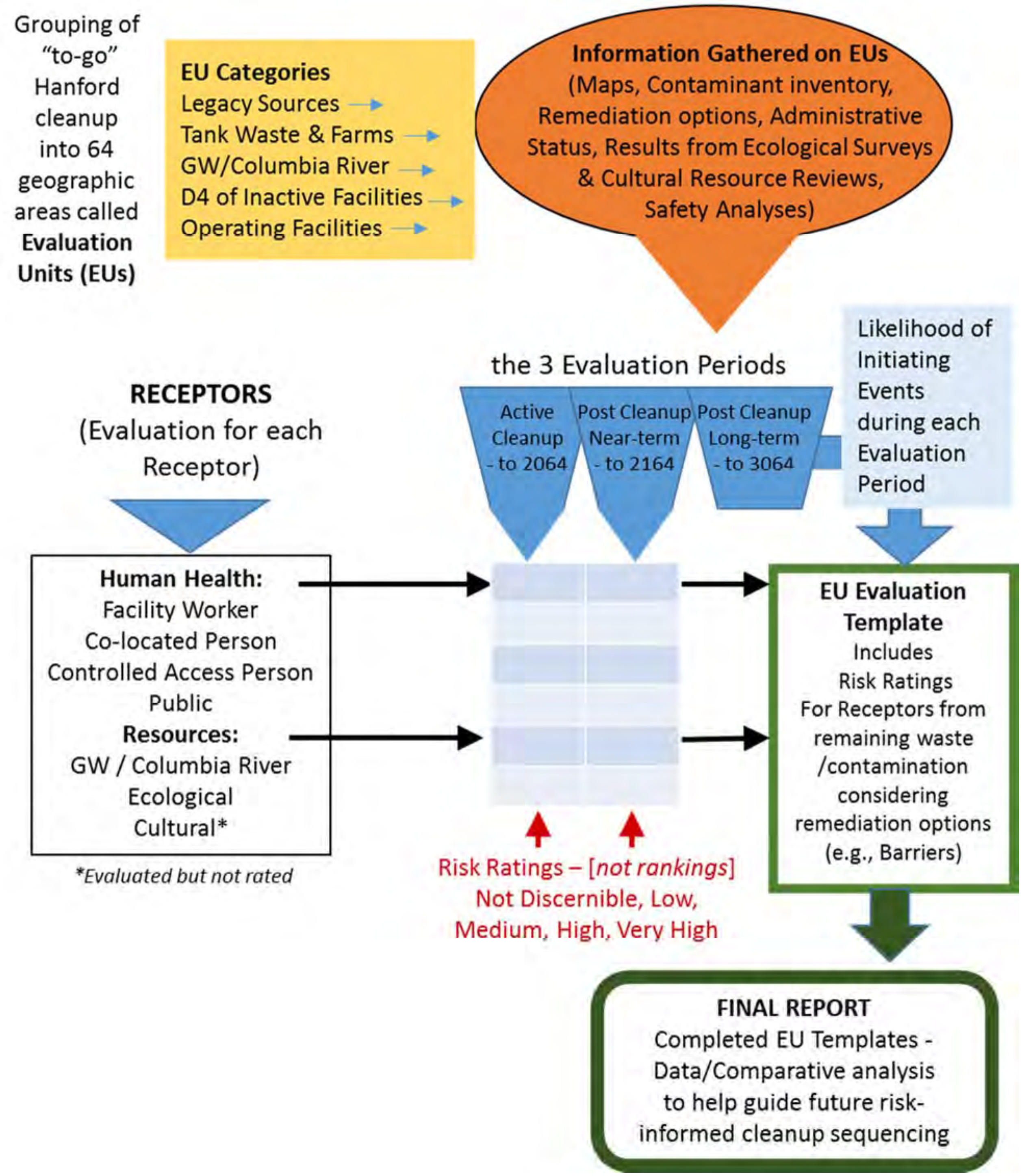

Figure 2-1. Methodology overview for the Hanford Site-wide Risk Review Project.

LIST OF EVALUATION UNITS / MAPS OF EVALUATION UNIT LOCATIONS

Figure 2-2 shows the general locations of all EUs included in this final report except the groundwater EUs. Figure 2-3 shows the general locations of EUs in the Central Plateau except groundwater plumes. More detailed maps of all EU locations can be found in Chapter 3.

Table 2-1. Listing of evaluation units.

(EUs highlighted in blue are included in the interim report. CP-OP-16, highlighted in gray, is incorporated into and evaluated under CP-OP-11.)

EU ID	Group	EU Name	Description & Comments	Operable Unit Crosswalk	Related EUs
Legacy Sources					
RC-LS-1	Legacy Source	618-11 Burial Ground	618-11 Burial Ground	300-FF-2	CP-GW-1
RC-LS-2	Legacy Source	K Area Waste Sites	Legacy waste sites within the fence at 100-K, where remediation is post 2015	100-KR-1, 100-KR-2	RC-DD-2
RC-LS-3*	Legacy Source	Orchard Lands	Pre-Hanford orchard lands	100-OL-1	
RC-LS-4	Legacy Source	618-10 Burial Ground	618-10 Burial Ground	300-FF-2	
CP-LS-1	Legacy Source	BC Cribs and Trenches	Cribs, trenches, and tank located to the south of the 200 E Area	200-BC-1	CP-LS-17, CP-GW-1
CP-LS-2	Legacy Source	Plutonium Contamin-ated Waste Sites	Plutonium (Pu) contaminated cribs and trenches associated with the Plutonium Finishing Plant (PFP) in central part of 200 W Area	200-PW-1,3,6 200-CW-5	CP-DD-5, CP-GW-2
CP-LS-3	Legacy Source	U Plant Cribs and Ditches	Liquid waste discharges in the central part of 200 W Area associated with U Plant operations	200-DV-1, 200-WA-1	CP-LS-7, CP-DD-3, CP-GW-2
CP-LS-4	Legacy Source	REDOX Cribs and Ditches	Liquid waste discharges in the southern part of 200 W Area associated with Reduction-Oxidation Plant (REDOX) (S Plant) operations	200-WA-1, 200-DV-1	CP-DD-4, CP-GW-2
CP-LS-5	Legacy Source	U and S Pond	Liquid waste discharges in the southern part of 200 W and outside the fence of 200 W associated with U and S ponds and closely related trenches, ditches, and cribs	200-CW-1, 200-OA-1	CP-GW-2
CP-LS-6	Legacy Source	T Plant Cribs and Ditches	Liquid waste sites on the northern end of 200 W Area (associated with T Plant operations)	200-WA-1, 200-DV-1	CP-GW-2
CP-LS-7	Legacy Source	200 Area HLW Transfer Pipeline	High-level waste (HLW) pipelines outside of tank waste and farms EUs. Includes 200 East-West transfer lines, IMUSTS, catch tanks, diversion boxes, etc.	200-IS-1	CP-TF-1 through -9
CP-LS-8	Legacy Source	B plant Cribs and Trenches	Liquid waste sites on the west side of 200 E (associated with B Plant operations)	200-EA-1, 200-DV-1, 200-OA-1	CP-DD-2, CP-GW-1
CP-LS-9	Legacy Source	PUREX Cribs and Trenches (inside 200 E)	Liquid waste sites on the east side of 200 E (associated with PUREX (Plutonium Uranium Extraction Plant) operations and immediately surrounding PUREX)	200-EA-1, 200-PW-3	CP-DD-1, CP-GW-1

EU ID	Group	EU Name	Description & Comments	Operable Unit Crosswalk	Related EUs
CP-LS-10	Legacy Source	PUREX and Tank Farm Cribs and Trenches (outside 200 E)	Liquid waste sites on the east side of 200 E (associated with PUREX and tank farm operations, but outside the 200 E Area fence)	200-EA-1	CP-GW-1
CP-LS-11	Legacy Source	B Pond	B Pond and associated ditches, where liquid wastes were discharged in the northern and western part of 200 E and outside the fence of 200 E	200-EA-1, 200-CW-1, 200-OA-1, 200-IS-1	CP-LS-7, CP-GW-1
CP-LS-12	Legacy Source	200 West Burial Grounds	Past practice radioactive waste burial grounds, including retrievable stored transuranic (TRU) trenches	200-SW-2	
CP-LS-13	Legacy Source	200 West Miscel-laneous Waste Sites	Waste sites, buildings, and structures associated with maintenance operations, laundry, and coal power plant in the west/central portion of 200 W	200-QA-1, 200-WA-1, 200-IS-1	CP-LS-7
CP-LS-14	Legacy Source	200 East Burial Grounds	Past practice radioactive waste burial grounds	200-SW-2	
CP-LS-15	Legacy Source	200 East Miscel-laneous Waste Sites	Waste sites, buildings, and structures associated with maintenance operations and coal power plant in the southern portion of 200 E	200-OA-1, 200-EA-1	
CP-LS-16	Legacy Source	Grout Vaults	Grout vaults located west of the Hanford Waste Treatment and Immobilization Plant (WTP)	NA	
CP-LS-17	Legacy Source	BC Control Zone	Surface contamination area to the south of 200 E (excluding the BC Cribs and Trenches)	200-OA-1	CP-LS-1
CP-LS-18	Legacy Source	Outer Area Sites	Outer area solid waste disposal sites (e.g., NRDWL, SWL, etc.) and other outer area waste sites, miscellaneous buildings, and structures	200-CW-1, 200-CW-3, 200-OA-1, 200-SW-1	
Tank Waste and Farms					
CP-TF-1	TF	T Tank Farm	T tank farm, ancillary structures, associated liquid waste sites, and soils contamination	200-DV-1, WMA T, 200-WA-1	CP-LS-7, CP-GW-2
CP-TF-2	TF	S-SX Tank Farms	S-SX tank farms, ancillary structures, associated liquid waste sites, and soils contamination. Includes 242-S Evaporator	WMA S/SX, 200-DV-1, 200-WA-1	CP-LS-7, CP-TF-9, CP-GW-2
CP-TF-3	TF	TX-TY Tank Farms	TX-TY tank farms, ancillary structures, associated liquid waste sites, and soils contamination. Includes 242-T Evaporator	WMA TX/TY, 200-DV-1, 200-WA-1	CP-LS-7, CP-GW-2
CP-TF-4	TF	U Tank Farm	U tank farm, ancillary structures, associated liquid waste sites, and soils contamination	WMA U, 200-WA-1	CP-LS-7, CP-GW-2

EU ID	Group	EU Name	Description & Comments	Operable Unit Crosswalk	Related EUs
CP-TF-5	TF	A-AX Tank Farms	A-AX tank farms, ancillary structures, associated liquid waste sites, and soils contamination	WMA A/AX, 200-EA-1, 200-PW-3	CP-LS-7, CP-TF-8, CP-GW-1
CP-TF-6	TF	B-BX-BY Tank Farms	B-BX-BY tank farms, ancillary structures, associated liquid waste sites, and soils contamination	WMA B/BX/BY, 200-DV-1, 200-EA-1	CP-LS-7, CP-GW-1
CP-TF-7	TF	C Tank Farms	C tank farm, ancillary structures, associated liquid waste sites, and soils contamination	WMA C	CP-LS-7, CP-GW-1
CP-TF-8	TF	200 East Double-Shell Tanks (DSTs)	AN, AP, AW, AY, AZ tank farms, ancillary structures, associated liquid waste sites, and soils contamination	NA	CP-LS-7, CP-TF-5
CP-TF-9	TF	200 West DSTs	SY tank farm, ancillary structures, associated liquid waste sites, and soils contamination	WMA S/SX	CP-LS-7, CP-TF-2
Groundwater					
RC-GW-1	GW	300 Area Ground-water (GW) Plumes	300 Area uranium and associated contaminant plumes	300-FF-5	RC-DD-1
RC-GW-2	GW	100-N GW Plume	100-N strontium and associated contaminant plumes	100-NR-2	
RC-GW-3	GW	100-B/D/H/F/K Area GW Plumes	100-B/D/H/F/K Area chromium and associated contaminant plumes, includes pump and treat systems	100-BC-5, 100-KR-4, 100-HR-3, 100-FR-3	
CP-GW-1	GW	200 East Ground-water	Existing groundwater plumes emanating from 200 E Area	200-BP-5, 200-PO-1	CP-LS-1, -8, -9, -10, -11, CP-TF-5, -6, -7
CP-GW-2	GW	200 West Ground-water	Existing groundwater plumes emanating from 200 W Area, includes pump and treatment systems	200-ZP-1, 200-UP-1	CP-LS-2 through -6, CP-TF-1 through -4
Decommissioning, Deactivation, Decontamination, and Demolition (D4)					
RC-DD-1	D&D	Building 324	Building 324 and associated soil contamination under the building	300-FF-2	RC-GW-1
RC-DD-2	D&D	KE/KW Reactors	KE/KW Reactors, basin, ancillary buildings, sludge, associated soil contamination	TBD, 100-KR-1, 100-KR-2	RC-LS-2, RC-GW-3
RC-DD-3	D&D	Final Reactor Disposition	C, D, DR, F, H, KE, KW, and N Reactors	TBD	
RC-DD-4	D&D	FFTF	Fast Flux Test Facility and ancillary buildings and structures	NA	

EU ID	Group	EU Name	Description & Comments	Operable Unit Crosswalk	Related EUs
CP-DD-1	D&D	PUREX	PUREX Canyon, tunnels, ancillary buildings, structures, and associated near-surface contaminated soils	200-CP-1	CP-LS-9
CP-DD-2	D&D	B Plant	B Plant Canyon, ancillary buildings (e.g., 224-B), structures, and associated near-surface contaminated soils, includes the D&D of the Waste Encapsulation Storage Facility (WESF) after the capsules are moved into dry storage	200-CB-1	CP-LS-8
CP-DD-3	D&D	U Plant	U Plant Canyon, ancillary buildings, structures, and associated near-surface contaminated soils	200-CU-1	CP-LS-3
CP-DD-4	D&D	REDOX	REDOX Canyon (S Plant), ancillary buildings, except 222-S laboratory, structures, and associated near-surface contaminated soils	200-CR-1	CP-LS-4
CP-DD-5	D&D	PFP	PFP ancillary buildings, structures, and associated near-surface contaminated soils	200-WA-1	CP-LS-2
Operating Facilities					
RC-OP-1	Ops	KW Basin Sludge	KW sludge, basin, and ancillary buildings	100-KR-1, 100-KR-2	RC-DD-2, RC-LS-2
RC-OP-2*	Ops	Retained Facilities	Retained Office of Science facilities including the 318, 320, 325, 331, and 350 buildings	300-FF-2	RC-GW-1
CP-OP-1	Ops	CWC	Central Waste Complex (CWC) operations, closure, and D&D	NA	
CP-OP-2	Ops	T Plant	T Plant Canyon, ancillary buildings, structures. Evaluate through operations, then will be preserved as a historical site or undergo D&D	NA	
CP-OP-3	Ops	WESF (only Cs/Sr capsules)	WESF – Evaluate for the storage and removal of Cs/Sr Capsules. D&D included with B Plant EU	NA	CP-DD-2
CP-OP-4	Ops	WRAP	Waste Repackaging and Processing (WRAP) facility operations, closure, and D&D	NA	
CP-OP-5	Ops	CSB	Canister Storage Building (CSB) operations and closure (including adjacent spent fuel dry storage pad)	NA	
CP-OP-6	Ops	ERDF	Environmental Restoration Disposal Facility (ERDF) operations and closure	NA	
CP-OP-7	Ops	IDF	Integrated Disposal Facility (IDF) operations and closure	NA	
CP-OP-8	Ops	Mixed Waste Trenches	Mixed waste trenches (Trenches 31 and 34, next to WRAP) operations and closure	200-SW-2	CP-LS-14

EU ID	Group	EU Name	Description & Comments	Operable Unit Crosswalk	Related EUs
CP-OP-9	Ops	Naval Reactors Trench	Naval reactors disposal trench operations and closure	200-SW-2	CP-LS-14
CP-OP-10	Ops	242-A Evaporator	Operations and D&D of the 242-A Evaporator	NA	CP-TF-5
CP-OP-11	Ops	LERF + ETF	Operations and closure of the Liquid Effluent Retention Facility (LERF) and Effluent Treatment Facility (ETF) (Evaluated under CP-OP-11 rather than CP-OP-16)	NA	CP-OP-11 CP-OP-12 CP-OP-13
CP-OP-12	Ops	TEDF	Operations and closure of the Treated Effluent Disposal Facility (TEDF)	NA	
CP-OP-13	Ops	SALDS	Operations and closure of the State Approved Land Disposal Sites (SALDS)	NA	
CP-OP-14*	Ops	WTP	WTP operations and D&D. Includes new tanks (if needed), preconditioning, four major facilities, and interim storage elements	NA	
CP-OP-15	Ops	222-S Laboratory	Operations and D&D of the 222-S Laboratory	NA	
CP-OP-16	Ops	ETF	Effluent Treatment Facility (incorporated into and evaluated under EU CP-OP-11)	NA	CP-OP-11 CP-OP-12 CP-OP-13
CP-OP-17*	Ops	WSCF	Waste Sampling and Characterization Facility and ancillary buildings and structures	200-ZP-1	CP-GW-2

Notes for River Corridor: Includes Energy Northwest Columbia Generating Station, PNNL, HAMMER, and LIGO as a comparator, but not as an EU. Includes infrastructure discussion as context, but not as an EU. Source remediation (remove, treat, dispose [RTD]) and D4 being completed in FY15 and FY16 are not included.

Notes for Central Plateau: Includes U.S. Ecology as a comparator, but not as an EU. Includes infrastructure discussion as context, but not as an EU. T Plant is an operating facility and an historic site that is eligible for inclusion in the Manhattan Project National Historical Park Act, which establishes the park at Hanford Site (National Defense Authorization Act of 2015, H.R. 3979, section 3039 [2014]). The National Park Service and DOE have agreed to consider including the T Plant in the park at the earliest feasible time after current mission use is complete.

*A description only is provided in Chapter 3 for starred EUs. An evaluation template has not been completed.

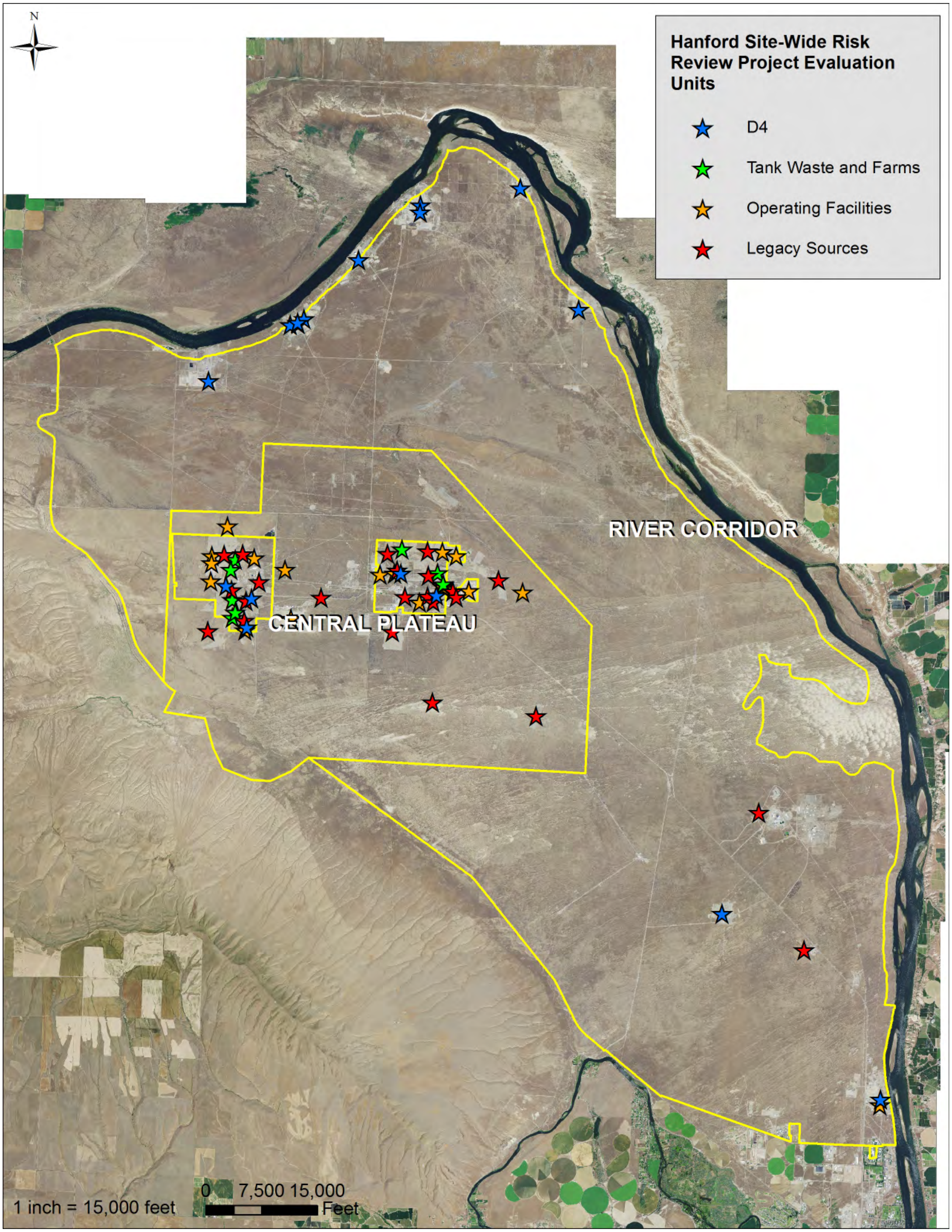

Figure 2-2. General locations of all evaluation units included in this final report except groundwater plumes.

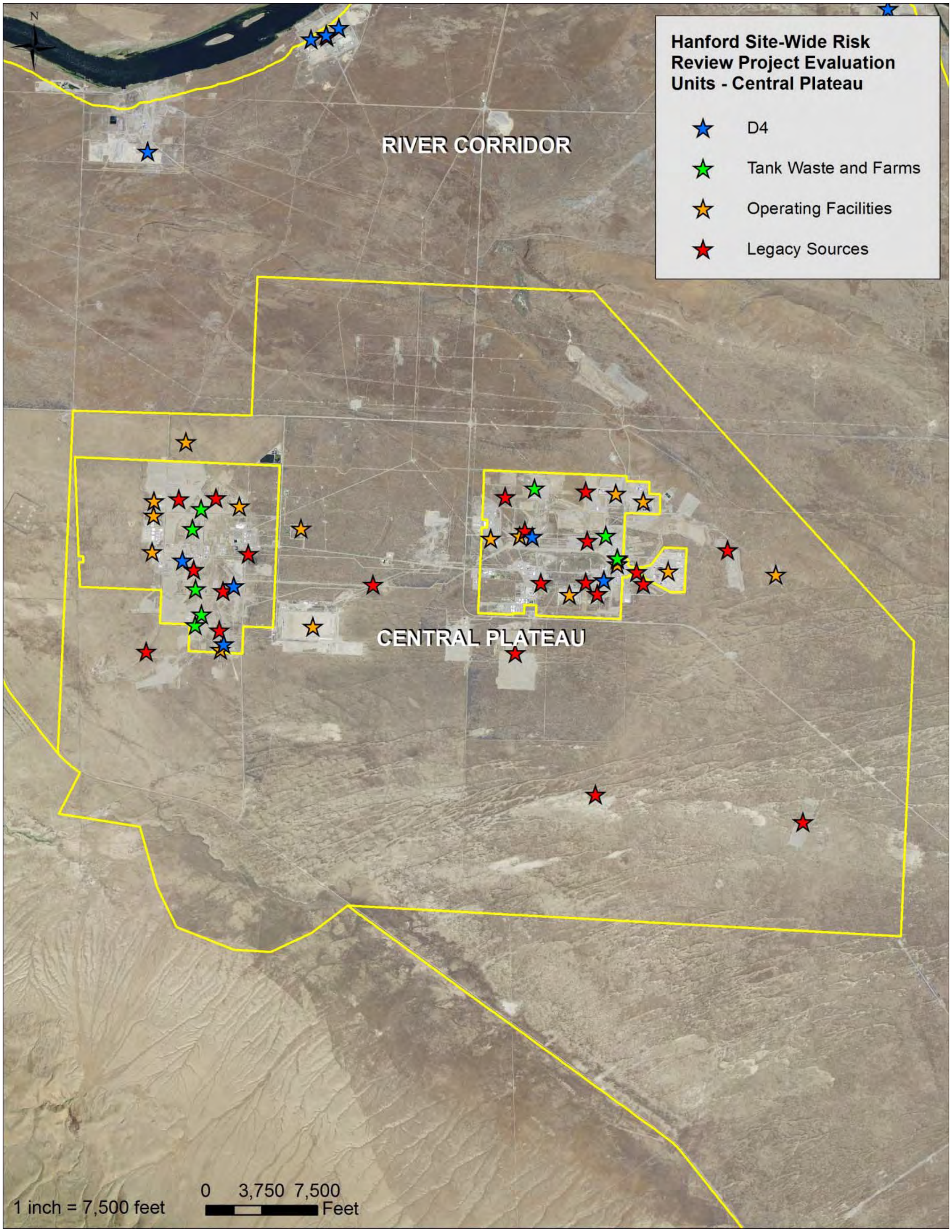

Figure 2-3. General location of evaluation units located at Hanford Site Central Plateau except groundwater plumes.

RADIONUCLIDES AND OTHER CONTAMINANTS CONSIDERED

The Risk Review Project has focused on radionuclides and contaminants that have been of large, Site-wide significance and stakeholder, Tribal, and community concern or are the major contributors to receptor risks at specific EUs (i.e., risk drivers). The set of radionuclides and contaminants considered may differ for specific EUs (because of either the presence or absence of specific radionuclides and contaminants and different risk and impact drivers), but are collectively referred to as “primary contaminants.”[48] In most cases, the list of primary contaminants for each EU is more limited than the regulatory list of contaminants of potential concern. The radionuclides and other contaminants that are considered to have site-wide significance and are of large stakeholder, Tribal, and community concern are:

- Radionuclides – cesium-137 (Cs-137); iodine-129 (I-129); isotopes of plutonium (Pu) including Pu-238, Pu-239, Pu-240, Pu-241, Pu-242; strontium-90 (Sr-90); technetium-99 (Tc-99); tritium (H-3 or ^3H_2O); and americium-241 (Am-241)
- Other contaminants – carbon tetrachloride (CT or CCl_4), trichloroethylene (TCE), hexavalent chromium [Cr(VI)], total chromium [Cr(total)], total uranium [U(total)][49], and nitrate (NO_3)

Examples of additional primary contaminants at specific or limited EUs are cyanide (CN), which is present in the B-Complex groundwater plume within the Central Plateau, diesel as total petroleum hydrocarbons (TPH-diesel), lead (Pb), and tributyl phosphate (TBP). Examples of radionuclides include carbon-14 (C-14), which is present in the 100-K Area groundwater plume, chlorine-36 (Cl-36), and selected isotopes of nickel and europium. Additional details are provided in the methodology document (CRESP 2015b).

Mercury is considered in inventory estimates and potential impacts through groundwater. Vapor exposure at the tank waste and farms EUs and impact pathways also are considered.

DURABILITY OF INSTITUTIONAL CONTROLS

Institutional controls are assumed to be effective for the duration that designated land areas, including EUs located within the areas, are under federal control. Furthermore, institutional controls are assumed to be effective only for 100 years after the transfer of land areas from federal to non-federal control. Certain areas of the Hanford Site are currently planned to be under federal control for very long periods (e.g., greater than 300 years for permitted disposal areas in the Central Plateau). Periods of planned federal control may change over time in response to changes in policy or other decisions. Changes in assumptions of institutional controls may necessitate changes in the end-states of an EU (i.e., changes in final barriers or physical-chemical forms or amounts of remaining contaminants) and cannot be predicted.

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[48] The terminology of “primary contaminants” is specific to the Hanford Risk Review Project, with the specific radionuclides and contaminants included based on Hanford history and prior evaluations and with input from the Core Team.

[49] In the Risk Review Project, the chemical toxicity of uranium tends to drive the risk from this element. The various major uranium isotopes are also tracked for completeness. These include U-232, U-233, U-234, U-235, U-236, and U-238. However, the relationships between total uranium (mass) and isotopic quantities has not been verified; only the total uranium is used for rating purposes.

EVALUATION PERIODS

Three evaluation periods are considered for each EU in this Risk Review Project:

- Active cleanup (50 years or until 2064), including the current status and during cleanup actions
- Near-term post-cleanup (2064 to 2164)
- Long-term post-cleanup (2164 to 3064)

The following provides the rationale for and a description of each of these evaluation periods.

Active Cleanup

The active cleanup period for Hanford Site is defined as 50 years (i.e., until the year 2064). During this timeframe, all currently planned cleanup is assumed to be completed, except groundwater cleanup, natural attenuation processes when selected as a remedy (for vadose zone and groundwater), and final disposition of entombed reactors and facilities along the Columbia River Corridor. The current designated actions for the entombed reactors are to evaluate the final timeline and the removal of these facilities to the Central Plateau in the future with ca. 75 years for reactor entombment to allow for radioactive decay and therefore increased safety associated with future actions.[50] Final onsite disposal units may require very long-term monitoring.

As indicated, the focus of the Risk Review Project is to help inform decisions by DOE and regulators concerning future sequencing of cleanup activities, including which areas should be focused on earlier for additional characterization and analysis. Thus, a fixed sub-interval in time for cleanup of any specific EU or EU component is not assumed. Rather, each EU and selected components are evaluated as if cleanup were not to occur for 50 years to provide insights into the risks that may be incurred through delay, as a way to help inform sequencing of cleanup actions. However, this is not to imply that delay of cleanup for 50 years is recommended.

Cleanup activities at the Hanford Site are ongoing and are not static. Since the Risk Review Project is being completed in a relatively short timeframe, this means that (1) risks to receptors may change as a result of changing contamination distributions or knowledge of these distributions, (2) risk to receptors may change as a result of nearby cleanup activities, and (3) currently undetermined cleanup methods or timing may affect risk in EUs or adjacent EUs.

Although characterization of each EU includes the risks posed by both current and projected contamination, the risk profile for each EU's sources may change significantly during, or as a result of, cleanup activities. Possible changes in the risk profile include increases in risks to workers, accidental or consequential dispersion of contaminants, disruption of biota and ecosystems, disruptions to or exposure of cultural resources, and impacts to nearby operating facilities. The final approach and timing selected for cleanup of a source area where there is no regulatory decision is typically, and by definition, not known at this time. Therefore, for EUs where regulatory determinations have not been made, a range of cleanup approaches is examined for each generic type of source when risks and impacts from cleanup are considered.

The primary distinctions among different cleanup approaches are the amount of contaminant inventory remaining, barriers that prevent dispersion of residual contamination, and the types of activities required to achieve cleanup (potentially impacting worker safety and surrounding ecology and cultural resources). The range of possible cleanup approaches for any EU will emerge from information on the sources and risks/impacts at specific EUs. Hence, any list of probable cleanup approaches reflects how

[50] The Reactor Decommissioning EIS (DOE/EIS-0119D 1989) and its Addendum (DOE/EIS-0222-F 1992) is for the disposition of eight surplus Hanford reactors.

the sources might be addressed. The list below provides several examples of the types of different remedial options for the sources grouped in this report:

Legacy Source Sites

- Removal (excavation), transport, and onsite disposal
- *In situ* immobilization (e.g., grouting or injections to form low-solubility minerals)
- *In situ* treatment resulting in contaminant removal (e.g., *in situ* biodegradation or natural attenuation)
- *In situ* phytoremediation (e.g., use of plants to remove contaminants)
- Capping and restoration

Tank Waste and Farms

- Retrieval of waste
- Grouting of tanks and ancillary equipment

Groundwater and Deep Vadose Contamination

- Natural attenuation (e.g., by radioactive decay or biodegradation processes)
- *In situ* immobilization (e.g., grouting, desiccation, or injections to form low-solubility minerals)
- Capping (i.e., to limit infiltration and recharge)
- Groundwater recovery with or without active flushing ("pump and treat")

D4 of Inactive Facilities

- Decommissioning and demolition, including *in situ* D&D
- Full or partial permanent entombment
- Interim entombment followed by further D&D (i.e., allowance for radioactive decay to reduce worker risks and potential impacts)

Operating Facilities

- Removal, transport, and disposal (either onsite or offsite)
- Decommissioning and demolition, including *in situ* D&D
- Capping and restoration
- Natural attenuation (e.g., by radioactive decay or biodegradation processes)
- RCRA clean closure

In addition, disposition of materials and wastes to an offsite federal or commercial disposal site or a national geologic repository is the disposition pathway for several sources of contamination (e.g., TRU, HLW).

For those sources where the cleanup plan has been determined by a final remedial action record of decision (ROD) (EPA 2013), such as for the 300 Area (EPA 2013), or evaluated in an EIS (e.g., DOE/EIS-0391 2012), such as for the tank farms, the selected remedy will be considered the baseline cleanup scenario in the risk ratings completed for this report. For sources where there has not been a final remedial decision, the DOE planning basis assumed for each EU is considered as a baseline reference for the range of potential cleanup approaches for each EU and is summarized in Appendix B.

The current status, potential initiating events, and pathways that cause or exacerbate risks are diverse because the EUs contain multiple sources and types of hazards, contaminant inventories, and existing environmental contamination. Initiating events can cause contaminants to move or migrate. Conceptual site models (CSMs) are provided for each EU category to help explain the potential initiating events and pathways to relevant receptors (Chapter 3). The nuclear safety analysis, which is embodied in the DSA process, including hazards analysis (HA), preliminary DSA, and final DSA, provides a detailed evaluation of external and operational initiating events and scenarios that can result in risks to human health from existing hazards. In addition to episodic events evaluated as part of a nuclear safety analysis, prevailing conditions, including infiltration and subsurface contaminant transport with groundwater flow, are considered as mechanisms for dispersion of existing environmental contamination and for potential impacts to receptors.

Near-Term Post-Cleanup

The near-term post-cleanup period is for 100 years after cleanup is completed (until the year 2164). This period was selected because it is the interval over which institutional controls are assumed to be in effect for land areas no longer maintained under federal control (CRESP 2015b). During this period, maintenance activities also are assumed to occur as necessary to maintain the integrity of the remaining engineered systems (landfill caps, liners, entombment, etc.) along with active monitoring to detect any new releases and confirm the efficacy of remaining remedial activities (natural attenuation, groundwater containment, etc.). Federal law also requires that periodic regulatory reviews be continued as long as institutional controls are in place (e.g., CERCLA 5-year reviews).

Post-cleanup does not mean that all contamination has been removed from an EU or the Hanford Site. Thus, there will be a diversity of end-states that constitute "completion" at EUs. The following are examples that illustrate the range of end-states for "sources" to be achieved at the completion of active cleanup:

- **Legacy Source Sites:** Cleanup to unrestricted use, cleanup to industrial use standards, or cleanup consistent with other land use designations
- **Tank Waste and Farms:** Removal of up to 99% of the waste contained in tanks (by volume), followed by grouting of tanks and ancillary equipment and capping of the tank farm[51]
- **Groundwater and Deep Vadose Zone Contamination:** Natural attenuation (e.g., by radioactive decay or biodegradation processes), removal or immobilization of a certain percent of the initial inventory, capping (i.e., to limit infiltration and recharge)
- **D4 of Inactive Facilities:** Decommissioning and demolition completed, final permanent entombment achieved
- **Operating Facilities:** Cleanup to industrial use standards, or cleanup consistent with other land use designations; natural attenuation (e.g., by radioactive decay or biodegradation processes); removal (transfer) of a certain percent of the initial inventory; decommissioning and demolition completed.

The presence of residual contaminants in remediated areas and engineered disposal facilities typically is evaluated through performance assessments under DOE Order 435.1.

Long-Term Post-Cleanup

The long-term post-cleanup period is assumed to extend for 900 years after the near-term post-cleanup period (until the year 3064) for a total post-closure assessment period of 1000 years. This interval was selected to be consistent with current DOE Order 435.1 for performance assessments, evolving U.S.

[51] According to the Tri-Party Agreement (Ecology, EPA, and DOE 1998), retrieval limits for residual wastes are 360 ft^3 and 30 ft^3 for 100-Series and 200-Series tanks, respectively, corresponding to the 99% waste retrieval goal as defined in TPA Milestone M-45-00.

Nuclear Regulatory Commission (NRC) recommendations for evaluation of closure of near-surface low-activity waste (LAW) disposal (ACRS Letter 2014), and the basis of prior contaminant transport modeling information. The same end-states associated with the end of the active cleanup period are assumed to apply until the year 3064, where reasonable. Associated uncertainties, uncertainty ranges, and impacts that may occur beyond this time frame are clearly identified, where possible.

For many remaining sources after cleanup completion (e.g., permitted landfills, entombed former canyon processing facilities), the only reasonable characterizations for EUs are (1) the remaining contaminant inventory along with the physical state and location; (2) the degradation, prevailing natural processes (contaminant transport and dispersion associated with recharge and groundwater flow, etc.), or failure modes that can result in dispersal or migration of contaminants from the remaining engineered systems or subsurface contamination; (3) the probability of significant initiating events; and 4) the amount and degree of monitoring necessary (and its effect on human ecological and cultural resources). The assumed set of infiltration and recharge rates for the long-term post-cleanup period will be the same as for the near-term, post-cleanup period because they bracket very low to very high infiltration rates that may be possible under a range of land cover and climate conditions.

LAND USE AND GROUNDWATER USE

For the purposes of the Risk Review Project, it is assumed that all reasonably available land uses at the Hanford Site will have been realized when the near-term post-cleanup period begins or by 2064. This means that land use is a factor to be considered as part of the evaluation for each EU for two periods: near-term post-cleanup (until 2164) and long-term post-cleanup (until 3064). However, while future land use is an important consideration for determining the extent of cleanup, it is not a direct factor in the urgency or sequencing of cleanup activities from a risk perspective (although it may be for other factors, including community preferences). Additionally, in this Risk Review Project, the human health risks associated with land use have been separated between (1) surface (i.e., facilities, soils, and waste disposal sites) and near-surface exposures associated with the land use scenario, and (2) use of groundwater. This separate consideration is important because (1) cleanup of facilities and surface and near-surface contamination is most frequently a separate effort from groundwater remediation, (2) treatment or alternate forms of water supply can be provided to facilitate desired land use when the groundwater within the unit being evaluated is not suitable, and (3) groundwater remediation timeframes may be much longer than required to achieve near-surface remediation, allowing alternative land uses.

Direction for the Risk Review Project states, "The review should place Hanford environmental and nuclear safety hazards and risks in context with currently designated future uses of the Hanford Site and nearby land uses and activities that have a potential to impact risks, natural resources and cultural resources" (Appendix A). The DOE National Environmental Policy Act (NEPA) determination for future land use at the Hanford Site is defined in the preferred land use alternative under the Comprehensive Land Use Plan EIS and ROD (DOE/EIS-0222-F 1999, DOE/EIS-0222 1999, DOE/EIS-0222-SA-02 2015). See Figure 2-4 and Table 2-2 for more specific information on each designation. However, specific exposure scenarios that correspond with the EIS and ROD land use categories have not been developed through past Tri-Party[52] efforts and therefore were not available for evaluating risks under those future land use designations.

[52] Tri-Party refers to The State of Washington, DOE, and EPA.

The State of Washington currently recognizes only “unrestricted use”[53] and “industrial use” as standard land use designations with established exposure scenarios (WAC 173-340-200, 2007). However, for many analyses, the cleanup levels are equivalent and are based on protecting groundwater. The EPA has recognized the following land uses as available following completion of remedial actions: any combination of unrestricted uses, restricted uses, and use for long-term waste management (OSWER Directive No. 9355.7-04, p. 2).

The Core Team has requested that the Risk Review Project consider “unrestricted use,” which also has been referred to as “residential land use” to serve as a second basis for assessment along with the primary designation from the land use EIS whenever the primary future land use designation would conflict with the “unrestricted use” designation or is not designated for industrial use. The alternative land use designation or “unrestricted use” does not apply to EUs located within the Central Plateau.[54]

The Risk Review Project is using “unrestricted use” and “industrial use” scenarios and cleanup levels to understand the risks when land is cleaned up to a less restrictive standard but then failure of institutional controls leads to land usage that would have required a more restrictive exposure scenario (e.g., areas cleaned up to industrial land use and then used in a manner consistent with the residential use scenario).

[53] “...has determined that residential land use is generally the site use requiring the most protective cleanup levels and that exposure to hazardous substances under residential land use conditions represents the reasonable maximum exposure scenario” (WAC 173-340-740(1)(a)). Therefore, residential landuse cleanup levels are considered equivalent to unrestricted use criteria.

[54] However, it should be noted that the T Plant (221-T Process Building) has been specifically identified as eligible for protection under the legislation that established a Manhattan Project National Historical Park (see Chapter 8 of the methodology report [CRESP 2015b]). This designation may require additional considerations with respect to cleanup requirements.

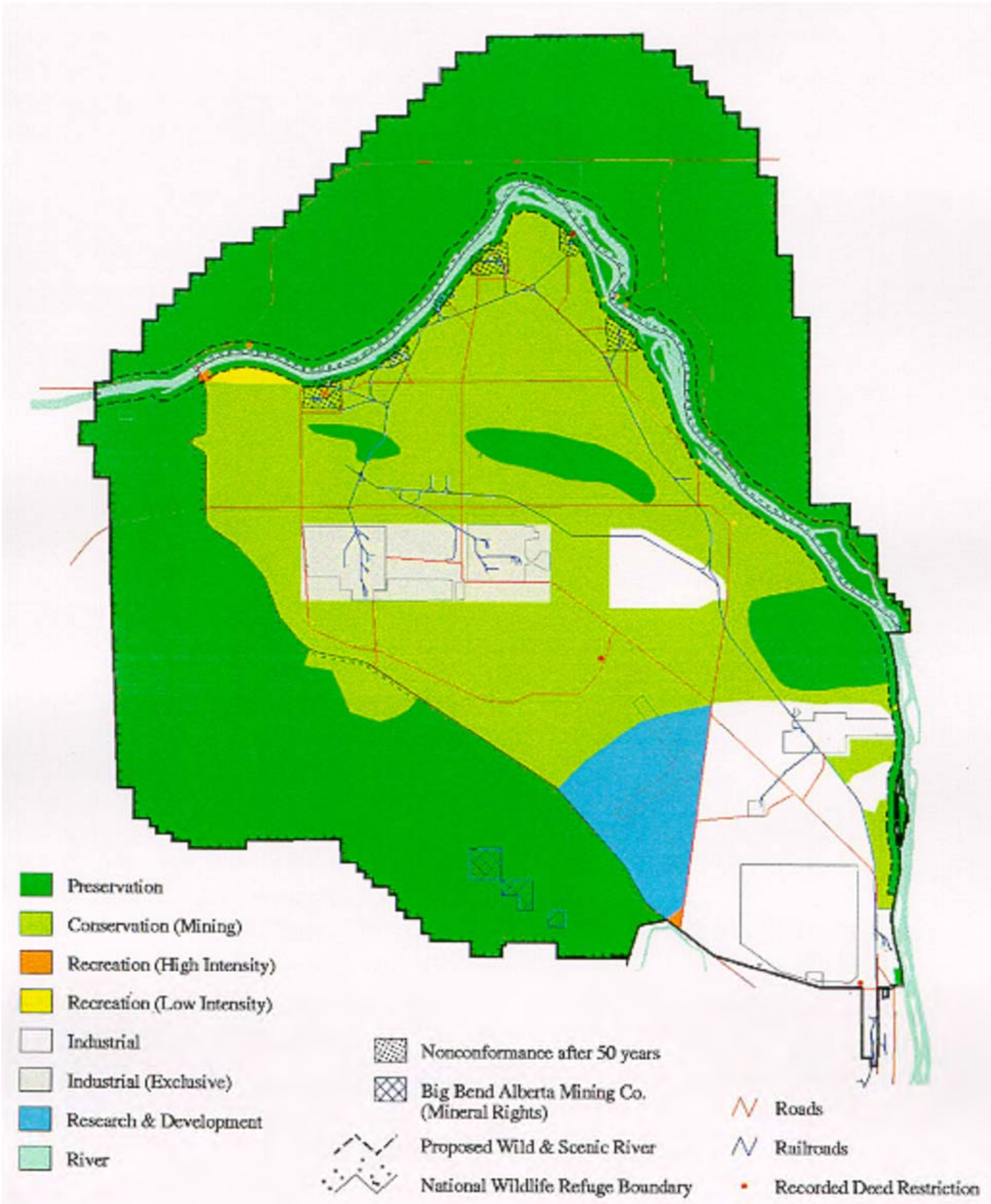


Figure 2-4. Future land use designations from the Hanford Comprehensive Land-use Plan (DOE/EIS-0222-F, Figure 3-3).

Table 2-2. Definitions of land use designations in the land use EIS and ROD (DOE/EIS-0222-F 1999, DOE/EIS-0222 1999).

Industrial-Exclusive	An area suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes. Includes related activities consistent with Industrial-Exclusive uses.
Industrial	An area suitable and desirable for activities, such as reactor operations, rail, barge transport facilities, mining, manufacturing, food processing, assembly, warehouse, and distribution operations. Includes related activities consistent with Industrial uses.
Research and Development	An area designated for conducting basic or applied research that requires the use of a large-scale or isolated facility, or smaller scale time-limited research conducted in the field or within facilities that consume limited resources. Includes scientific, engineering, technology development, technology transfer, and technology deployment activities to meet regional and national needs. Includes related activities consistent with Research and Development.
High-Intensity Recreation	An area allocated for high-intensity, visitor-serving activities and facilities (commercial and governmental), such as golf courses, recreational vehicle parks, boat launching facilities, Tribal fishing facilities, destination resorts, cultural centers, and museums. Includes related activities consistent with High-Intensity Recreation.
Low-Intensity Recreation	An area allocated for low-intensity, visitor-serving activities and facilities, such as improved recreational trails, primitive boat launching facilities, and permitted campgrounds. Includes related activities consistent with Low-Intensity Recreation.
Conservation (Mining)	An area reserved for the management and protection of archeological, cultural, ecological, and natural resources. Limited and managed mining (e.g., quarrying for sand, gravel, basalt, and topsoil for governmental purposes) could occur as a special use (i.e., a permit would be required) within appropriate areas. Limited public access would be consistent with resource conservation. Includes activities related to Conservation (Mining), consistent with the protection of archeological, cultural, ecological, and natural resources.
Preservation	An area managed for the preservation of archeological, cultural, ecological, and natural resources. No new consumptive uses (i.e., mining or extraction of non-renewable resources) would be allowed within this area. Limited public access would be consistent with resource preservation. Includes activities related to Preservation uses.

EVALUATION TEMPLATE

Each Evaluation Template provides a consistent, cohesive, and useful portrayal of the multiple source types within each EU considered. For the units evaluated for this report, Evaluation Templates may found in Appendices D through H. (See Appendix B of the methodology [CRESP 2015b] for a copy of the Evaluation Template.) The Evaluation Template contains the following sections:

- **Part I – Executive Summary** provides an overview of the EU and its risk evaluations.
- **Part II – Administrative Information** allows cross-walking of EUs used in this Risk Review Project with regulatory operable units (OUs) in use at Hanford Site.

- **Part III – Summary Description** includes location and layout maps, primary EU components, and land use information.
- **Part IV – Unit Description and History** includes former and current uses, current extent of environmental contamination, ecological resources setting, and cultural resources setting.
- **Part V – Waste and Contamination Inventory** summarizes the inventory and physical-chemical form of contaminants present.
- **Part VI – Potential Risk Pathways and Events** summarizes the current conceptual model, cleanup approaches, initiating events, and pathways that can result in risks to receptors over the three evaluation periods.
- **Part VII – Supplemental Information and Considerations** may include co-location of facilities, sequencing considerations, linkages to other required facilities or unique skills, loss of facility integrity, and other considerations.

EXTERNAL REVIEW

It is important that a broad spectrum of stakeholders including members of the public, Tribal Nations, and government agencies have an opportunity to comment on documents prepared for the Risk Review Project.

In early September 2014, a draft methodology was posted on a CRESP web page (www.cresp.org/hanford), which is dedicated to the Risk Review Project and was made available for written comment. In addition, CRESP team members met with the Hanford Advisory Board (public invited), Tribal Nation representatives, affected government agencies, and local elected officials to explain the methodology and encourage feedback. Finally, Core Team members and their staff reviewed the draft methodology, as did a peer-review group of experts. All written input received on the draft document was acknowledged and considered, and provided important input for improving the Risk Review Project methodology. A list of the comments received and an overview of revisions reflected in the methodology document (CRESP 2015b) are available as a separate summary document (CRESP 2015c).

Written comment also was solicited from stakeholders after the release of the interim progress report (concurrent with the release of the methodology [CRESP 2015b]). CRESP team members conducted meetings with stakeholders in Richland, Washington, as well as through webinar, to explain the report, answer questions, and address concerns. Core Team members and their staff reviewed the draft report. A meeting open to the public was held in Richland during the comment period. All written comments received on the interim report were acknowledged and are considered to be input for this final report.

The draft final report has undergone a peer review and a technical review by DOE.

2.2. A PRESUMPTIVE SET OF POTENTIAL PATHWAYS FROM CONTAMINANT RELEASE TO RECEPTORS

Despite the diversity of sources and receptors, there is a limited set of potential contaminant release mechanisms and pathways from source areas to receptors that constitute the focus of the Risk Review Project. The list below identifies the relevant contaminant release and impact pathways of primary importance for each source type. Hence, the following may be considered a “checklist” for evaluating sources within each EU.

Pathways

- **Risks from Contaminated Near-Surface Soils** – occur from (1) direct human exposure through land use; (2) transport to the subsurface and groundwater through infiltration; (3) contaminant transport through erosion, biotic processes, or atmospheric dispersion; (4) biota exposure and biotic transport; and (5) exposure to cultural resources.
- **Risks from Vadose Zone Contamination** – occur from infiltration-induced transport through the subsurface to groundwater and the Columbia River.
- **Risks from Engineered Waste Management Facilities** (either currently operational or inactive) – occur from initiating events (external or operational) that cause loss of waste/contaminant containment followed by either (1) direct human exposure, (2) atmospheric dispersion, (3) near-surface soil contamination, (4) impaired or precluded use of other resources and facilities, (5) damage to biota or ecosystems, or (6) damage to or destruction of cultural resources.
- **Risks from D4 Facility Activities** – occur primarily from unanticipated facility conditions and accidents during cleanup and maintenance activities. Accidents or other initiating events prior to completion of decommissioning may cause loss of waste/contaminant containment followed by combinations of (1) direct human exposure; (2) atmospheric dispersion; (3) near-surface soil contamination; (4) impaired or precluded use of other resources and facilities; or (5) damage to biota, ecosystems, or cultural resources.
- **Risks from Groundwater Contamination** – only may occur when there is active or projected use and/or consumption of contaminated groundwater, or as a consequence of contaminant discharge to the Columbia River. However, groundwater is a protected resource under Washington State and federal regulations, so risks or impacts to groundwater itself are also considered.
- **Risks from the Remediation Process** – may occur from accidental or inadvertent dispersion of contamination, disruption of cultural resources and habitat destruction or introduction of non-native biota.

Receptors

- **Human Health Risks (to Facility Workers and Co-located Persons)** – occur primarily from unanticipated circumstances and accidents during cleanup and maintenance activities. Occupational health exposures and traumas may occur as a consequence of existing conditions, maintenance, monitoring, or cleanup activities.
- **Human Health Risks (to Public and Controlled Access Persons)** – occur from exposures to contaminants in air, water, or near-surface soils or consumption of food grown in or harvested from contaminated soils. Potential exposure due to routine excavation or other activities is considered to a depth of 5 m. Groundwater contamination is evaluated separately from other pathways because groundwater use can be (and often is) managed separately from land use. Controlled access persons are unlikely to encounter a release, however, dose and risks encountered by controlled access persons may be greater than that of the public. Few modeled releases reach Hanford boundaries to directly impact the public. Future land uses that exceed the cleanup criteria (i.e., residential use of industrial-cleanup site) increases exposure.
- **Risks to Groundwater** – occur either from waste currently in engineered facilities, near-surface contaminated soils, vadose zone contamination plumes, or through the movement, diffusion,

and dispersion of contaminants already present in groundwater[55]. Sources currently in engineered facilities require an initiating event (e.g., cover or liner failure, corrosion or other induced leakage, infrastructure failure causing large water release, large precipitation event, earthquake, accident) to release contaminants to the soil surface or subsurface. Contaminants in near-surface soils and the vadose zone are transported to the groundwater as a function of prior moisture conditions and infiltration rate (location and surface condition dependent), individual contaminant sorption/transport characteristics (subsurface stratigraphy and contaminant dependent), and the distance to groundwater (location dependent). Further spreading of contaminants in the groundwater depends on contaminant concentration, groundwater flow rate and dispersion, and the individual contaminant sorption/transport characteristics.

- **Risks to the Columbia River** – occur either from current or projected contaminated groundwater discharge through the riverbed or seepage, direct waste discharges, or overland flow and erosion that discharges to surface water. Risks of contaminant exposure in the riparian zone (through seeps) and benthic zone (through groundwater upwellings) originating from the Hanford Site are considered. Human health risks associated with potential surface water contamination originating from the Hanford Site are considered in the context of Columbia River use.
- **Risks to Biota and Ecosystems (Ecological Resources)** – occur from physical disruption of an ecosystem, contaminant dispersion and uptake, fragmentation of habitats, or introduction of invasive species resulting from contaminant releases or cleanup activities (either near sensitive ecosystems or as a result of transit pathways to/from remediation activities). Physical disruptions, such as soil compaction, introduction of barriers (e.g., roads), and soil removal have major impacts on species distribution and ecosystems. Physical disruptions can be caused by natural events or initiating events.
- **Risks to Cultural Resources** – occur from physical disruption, destruction, exposure, impaired access, or precluded access resulting from contaminant releases or cleanup activities. Indirect impacts from impairment of view sheds are also considered. Risks to cultural resources will be described but not rated.

There are also potential risks to economic assets as a consequence of cleanup activities, but they are limited to EUs where either the presence of contamination or cleanup activities may directly impact other DOE or non-DOE facilities. Thus, the consideration of economic assets is constrained to (1) the intersection of specific EUs with specific facilities (e.g., 618-11 with the Energy Northwest Columbia Generating Station, Building 324 impacting river activities), and (2) a description of the general economic context of the Hanford Site (See Chapter 5).

Many EUs may have multiple sources that are aggregated to provide a clearer picture of the risks associated within a geographic area (e.g., individual tank farms). Evaluations of risks to certain receptors then lend themselves to consideration in the context of individual EUs. These include risks to human health, impacts to groundwater, and risks to the Columbia River. In addition, some receptors require consideration from broader perspectives: (1) a site-wide perspective and (2) the potential risk or impact based on the geographic location of the EU and surrounding areas. These broadly geographically defined receptors include sensitive biota and ecosystems, cultural resources (notably indirect impacts), and economic assets.

[55] In some areas, reverse or injection wells were used to directly transfer waste to groundwater.

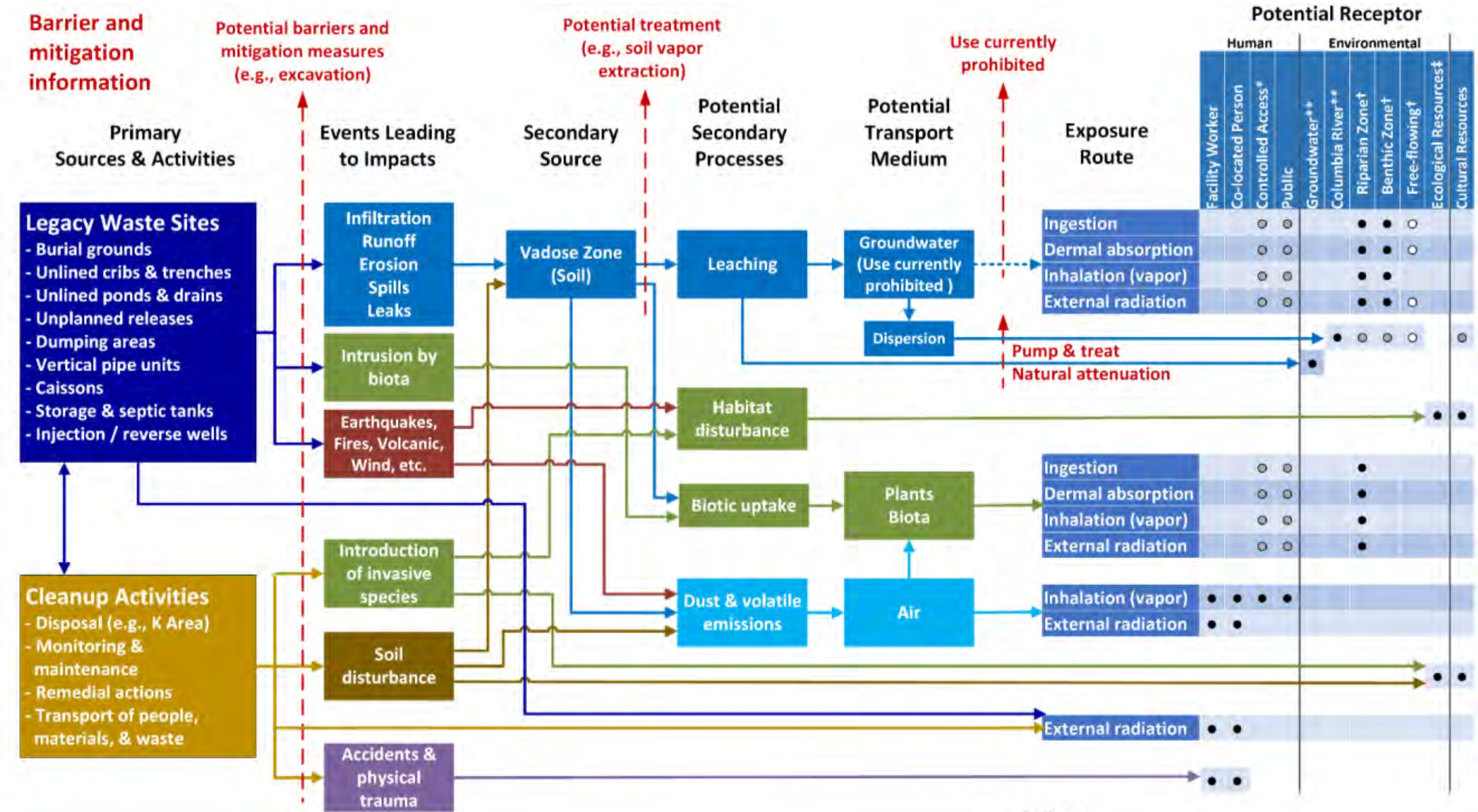
Furthermore, cumulative risk assessments are often performed to evaluate the combined fate and effects of multiple contaminants from multiple sources through multiple exposure pathways (MacDonell et al. 2013). However, the risk evaluations completed for this Risk Review Project are very different from that of a baseline risk assessment or performance assessment. First, this Risk Review Project, consistent with the position taken at the Hanford Site, already assumes that there are unacceptable risks associated with contamination on the Hanford Site that must be addressed. Second, isolating single contaminants for EUs through a single exposure pathway (e.g., groundwater), which is the approach used in this Risk Review Project, allows the most urgent risks to be identified and helps inform sequencing of remedial actions across the Hanford Site.

A convenient representation of how sources are linked to potential receptors is a conceptual site model (CSM) (ASTM 1995; Brown 2008). For an environmental system, a CSM represents (often in block form) the biological, physical, and chemical processes that determine contaminant transport from sources through environmental media to potential receptors. Examples of CSMs for each of the five EU source types (e.g., legacy source) were developed (Figure 2-5 through Figure 2-9) to help elucidate the sources, pathways, and receptors considered in the Risk Review Project. For example, legacy sources (and associated cleanup activities) are common to three of the five EU types, including the tank waste and farms and inactive facilities (D4) EUs. Furthermore, as shown in Figure 2-5, legacy sources typically include sources such as burial grounds, unlined cribs and trenches, unplanned releases, events such as infiltration leading to further contamination of the vadose zone, and other pathways leading to exposure via ingestion and other routes of both human and ecological receptors. Impacts from cleanup activities are also included.

The groundwater EU CSM (Figure 2-8) only considers contaminants already in the saturated zone (and potential impacts to groundwater, the Columbia River, and related receptors).

The operating facilities EU CSM (Figure 2-7) only considers facilities that do not include legacy sources although many of the pathways and receptors are common to all EU types.

For all five EU source types, the detailed approaches, including assumptions regarding sources, pathways, and receptors that are used in the Risk Review Project evaluations are provided in the methodology document (CRESP 2015b).



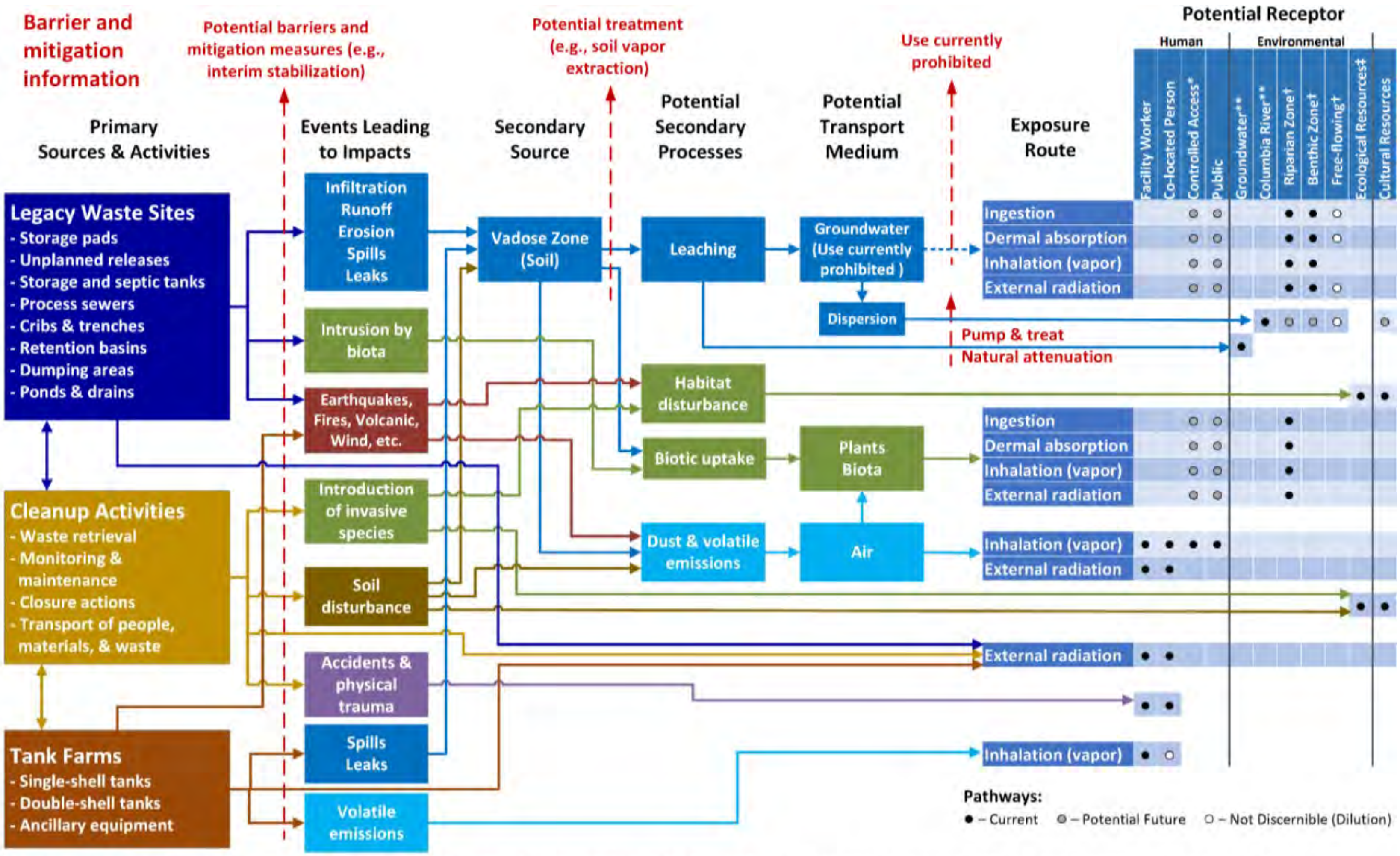
* Activities by members of Tribal Nations are considered a Controlled Access group within human health, recognizing the potential for different exposures as a result of specific cultural practices.

** These are evaluated as protected resources, independent of use.

† Threats to the Columbia River specifically include potential contaminant impacts to the ecology of the Riparian Zone, Benthic Zone, and Free-Flowing River component.

‡ Threats indicated within Ecological Resources focus on habitant disruption and potential impacts to endangered and sensitive species.

Figure 2-5. Legacy source evaluation unit conceptual site model.



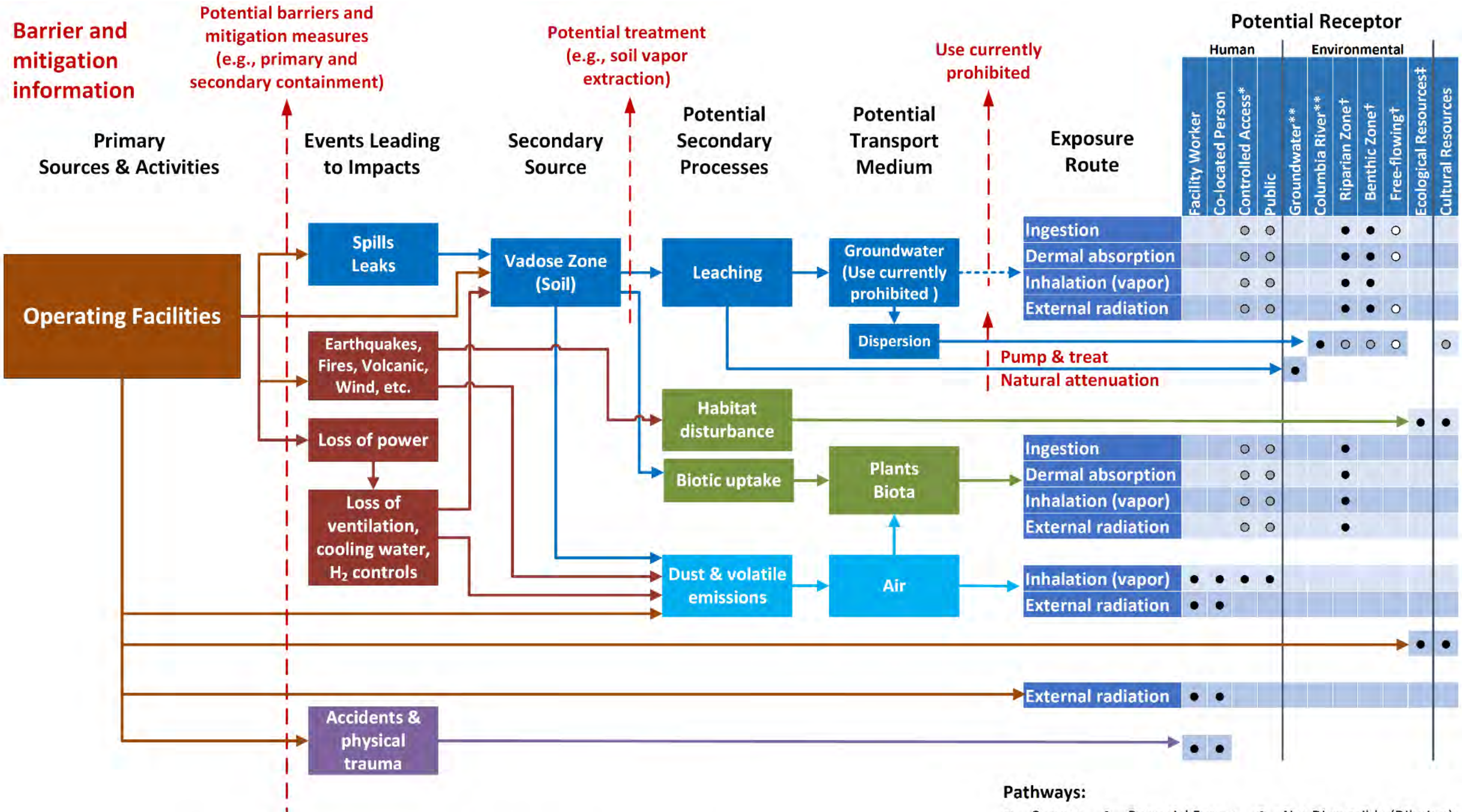
* Activities by members of Tribal Nations are considered a Controlled Access group within human health, recognizing the potential for different exposures as a result of specific cultural practices.

** These are evaluated as protected resources, independent of use.

† Threats to the Columbia River specifically include potential contaminant impacts to the ecology of the Riparian Zone, Benthic Zone, and Free-Flowing River component.

‡ Threats indicated within Ecological Resources focus on habitant disruption and potential impacts to endangered and sensitive species.

Figure 2-6. Tank waste and farms evaluation unit conceptual site model. These evaluation units include legacy waste sites from past leaks as well as unplanned and planned releases to the environment.



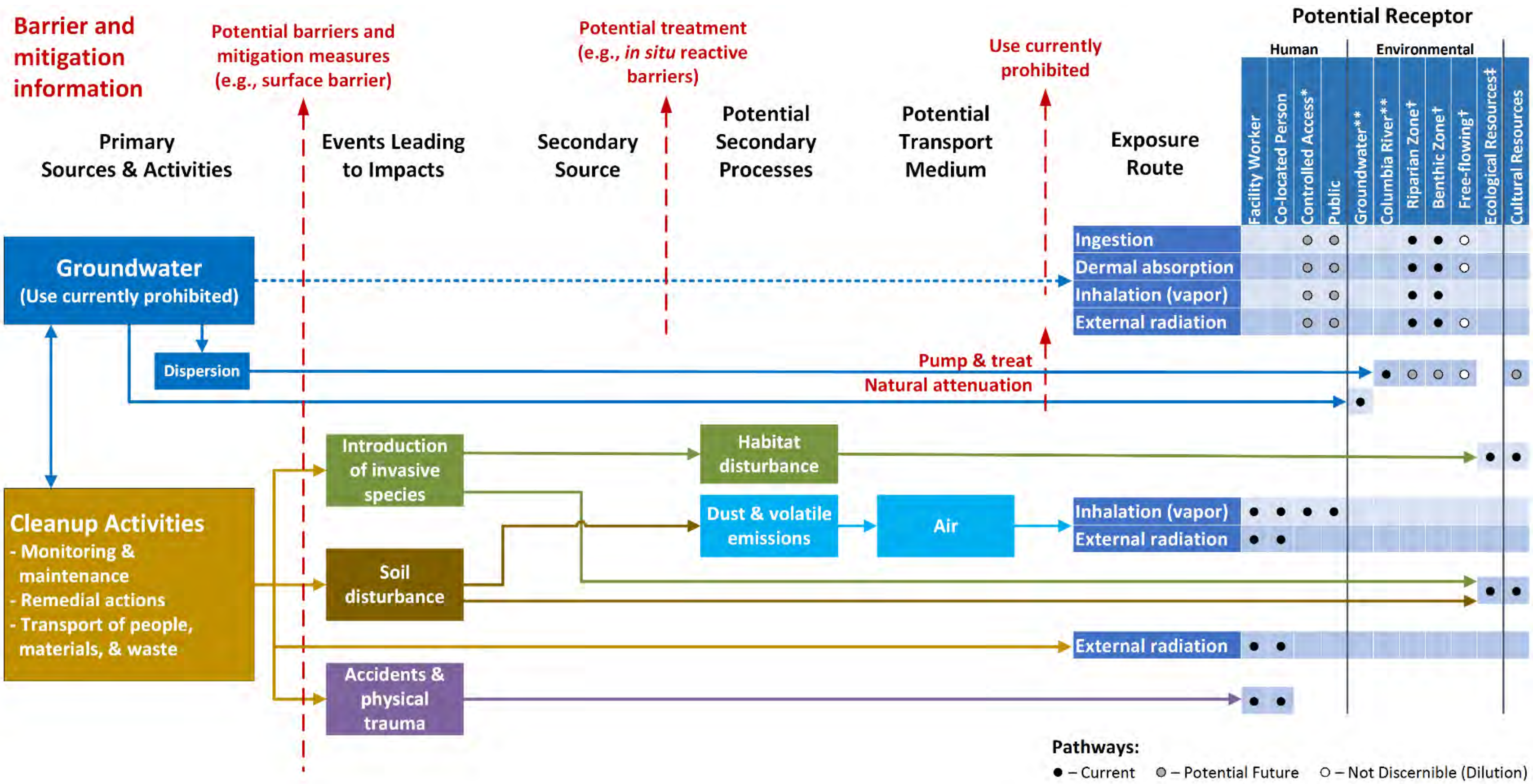
* Activities by members of Tribal Nations are considered a Controlled Access group within human health, recognizing the potential for different exposures as a result of specific cultural practices.

** These are evaluated as protected resources, independent of use.

† Threats to the Columbia River specifically include potential contaminant impacts to the ecology of the Riparian Zone, Benthic Zone, and Free-Flowing River component.

‡ Threats indicated within Ecological Resources focus on habitant disruption and potential impacts to endangered and sensitive species.

Figure 2-7. Operating facilities evaluation unit conceptual site model.



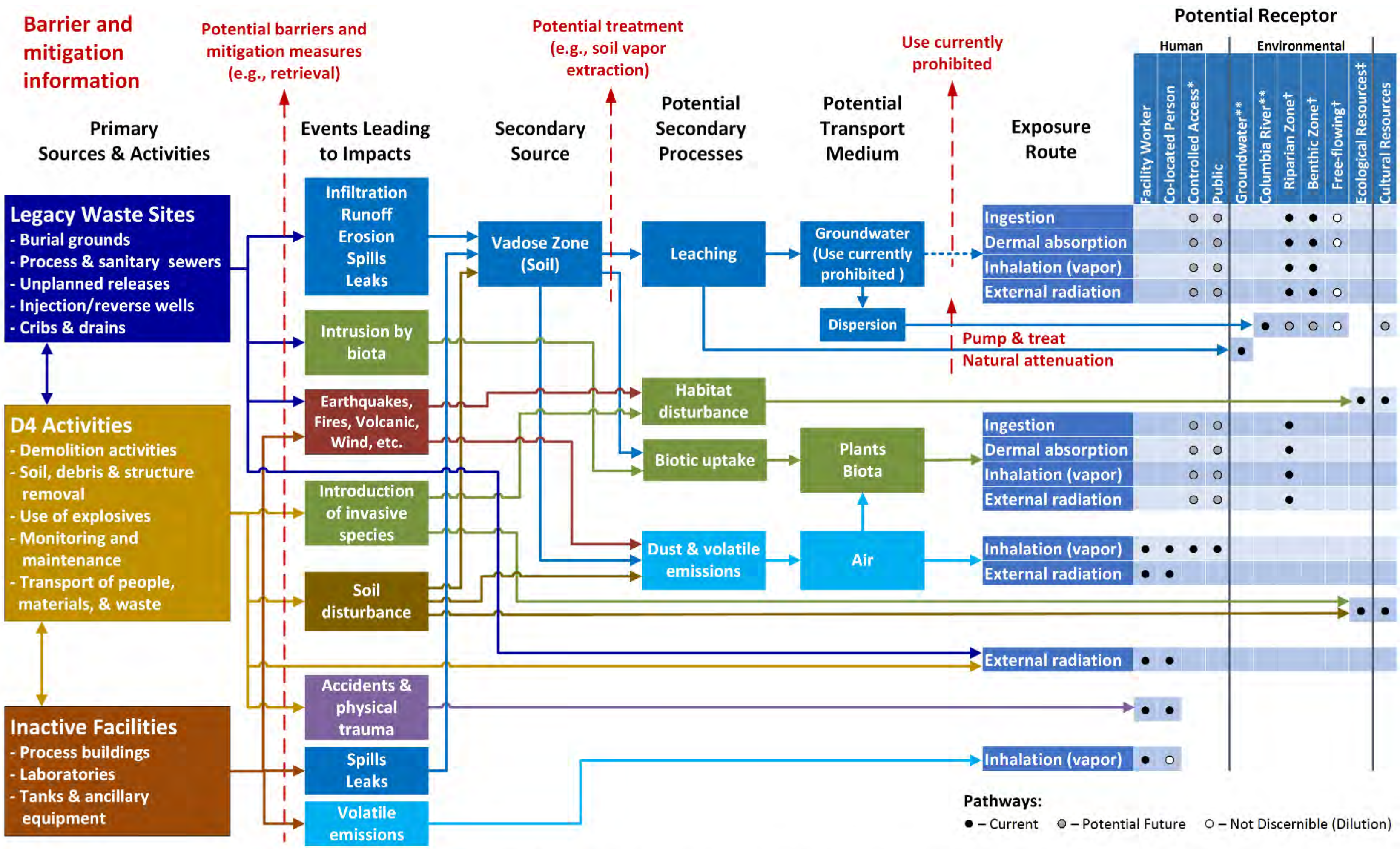
* Activities by members of Tribal Nations are considered a Controlled Access group within human health, recognizing the potential for different exposures as a result of specific cultural practices.

** These are evaluated as protected resources, independent of use.

† Threats to the Columbia River specifically include potential contaminant impacts to the ecology of the Riparian Zone, Benthic Zone, and Free-Flowing River component.

‡ Threats indicated within Ecological Resources focus on habitant disruption and potential impacts to endangered and sensitive species.

Figure 2-8. Groundwater evaluation unit conceptual site model.



* Activities by members of Tribal Nations are considered a Controlled Access group within human health, recognizing the potential for different exposures as a result of specific cultural practices.

** These are evaluated as protected resources, independent of use.

† Threats to the Columbia River specifically include potential contaminant impacts to the ecology of the Riparian Zone, Benthic Zone, and Free-Flowing River component.

‡ Threats indicated within Ecological Resources focus on habitant disruption and potential impacts to endangered and sensitive species.

Figure 2-9. Inactive facilities (D4) evaluation unit conceptual site model. These evaluation units include legacy waste sites from past releases to the environment.

2.3. EVALUATION APPROACHES FOR SPECIFIC RECEPTORS

USE OF METRICS AND ASSIGNMENT OF RISK RATINGS

A system for categorizing the magnitude and likelihood of risks to each receptor forms the basis for assigning risk ratings to receptors for each EU, within each evaluation period. The risk rating assumes that nuclear safety hazards are assessed based on unmitigated dose estimates because the unmitigated dose integrates across the radionuclide inventory as a *relative* risk metric, and acknowledges that some mitigation measures may fail. The Risk Review Project recognizes that typical DOE/contractor mitigation actions substantially reduce most risks, typically to ND or Low.

Specific metrics for each receptor type that provide the basis for the risk ratings are identified in Chapters 5 through 8 of the methodology (CRESP 2015b). Risks and potential impacts are categorized into five ratings: ND, Low, Medium, High, or Very High, where Very High is used only for exceptional cases. Further, for many receptors, the risk rating for an equivalent impact during the active cleanup period is higher than in the near-term post-cleanup period. This rating reduction is considered appropriate for most cases because of the additional response time available before preventative action would be required, and therefore addressing the risk or potential impact is less urgent. In addition, within similar types of EUs, the risk ratings are expected to differ. Risks that are rated higher, therefore, should suggest that remediation should proceed more quickly.

As discussed earlier in this report, a final list of the risk ratings for each receptor group, except cultural resources, is provided in Chapter 4. For example, a final set of tables of the risk ratings by receptor category for all EUs is provided. There is no scientifically rigorous or accepted method of normalizing ratings between and among receptors. For example, a High risk rating may mean different things for human health, ecological resources, or groundwater. The final risk ratings explain the meaning of the risk rating designation with respect to each receptor.

Also, as noted, risks to receptors have not been integrated across different receptor types. The balancing and relative importance of risks to different receptors are driven by individual and collective values, which vary considerably and therefore make integration across different receptor types the domain of DOE and its regulators with input from their constituencies.

The methodologies for evaluating risk to receptors are summarized in this section and are detailed in Chapters 5 through 8 of the methodology document (CRESP 2015b). Descriptions or characterization of the receptors vary somewhat depending on the receptor. For example, ecological receptors are examined in terms of both species and ecosystems of value, cultural receptors include several key periods (Native American [10,000 years ago to present], pre-Hanford Era [1805-1943], and the Manhattan Project/Cold War Era [1943-1990]), and the Columbia River and groundwater are described together because it is the groundwater that has the potential to discharge radionuclides and other contaminants from the Site to the river. The characterization of resources that are at risk forms an important basis for developing the methodology for each resource, as well as the basis for determining the risk rating.

The methodology for evaluating each receptor varies because the nature of the receptor varies (e.g., groundwater vs. Facility Workers). For example, workers and the public include only humans, while ecological receptors include thousands of species and many different kinds of ecosystems, and cultural receptors include many kinds of resources (e.g., artifacts, traditional cultural places, and historic buildings). Further, the Risk Review Project recognizes that risk to any individual is important, while for ecosystems the important consideration is the population of a given species (except in the case of federally or state-listed species).

INITIATING EVENTS

The initiating event methodology provides a basis for assigning the likelihood of loss or degradation of barriers and guidance for assigning impacts (consequences) due to the loss of barriers based on the event being considered. See Chapter 4 of the methodology (CRESP 2015b). For EUs for which there is a DSA, HA, and/or other document that provides initiating event likelihoods and consequence estimates, these documents have been used. Initiating events interact with each other and with risks to receptors.

Initiating events are typically episodic events that may occur over short time frames (less than a day) and are considered in addition to natural prevailing processes (e.g., groundwater flow) that may result either by themselves or in combination with initiating events, in risks to receptors from contaminants already in environmental media (e.g., soils, vadose zone, and groundwater).

The consideration of initiating events includes those directly attributed to human initiators or to natural phenomena. Human-initiated events include human errors of omission or commission leading to accidents, loss of institutional controls, failure of engineered systems, and external events from anthropogenic (man-made) sources (e.g., nearby transportation accidents, aircraft impacts, events at other EUs). Natural events include earthquakes, high winds, volcanic ashfall, and wildfires, as well as processes such as structural decay of barriers and facilities exposed to the environs, changes in water table, and drought/climate change that may occur over time. Severe natural phenomena hazards (e.g., seismic events, 1000-year flooding, and large geomagnetic disturbances) can result in site-wide or regional impacts leading to additional releases while also limiting the availability and capability to respond to the event.

Initiating events are qualitatively grouped within the following likelihood ranges, which are consistent with DOE and Hanford contractor guidance (e.g., DOE-STD-3009, HNF-8739, TFC-ENG-DESIGN-C-47) for the development of safety analyses:

- **Anticipated (A)** – events expected to occur >10^{-2}/yr (i.e., once per 100 years)
- **Unlikely (U)** – events expected to occur within the range of 10^{-2} - 10^{-4}/yr (i.e., between once per 100 to once per 10,000 years)
- **Extremely Unlikely (EU)** – events expected to occur within the range of 10^{-4} - 10^{-6}/yr (i.e., between once per 10,000 to once per 1,000,000 years)
- **Beyond Extremely Unlikely (BEU)** – events expected to occur <10^{-6}/yr (i.e., greater than once per 1,000,000 years)

The initiating event methodology also provides guidance related to damage to the barrier that the event is expected to cause. The consequence determinations within HAs and DSAs and the hazardous material exposures are usually limited to short durations (e.g., less than 8 hours) and do not include food or water pathways. For the Risk Review Project, longer-term consequences and additional receptor pathways are also considered. Event consequences are categorized as having the following impacts:

- **(Low) Localized Impacts** – events associated with damage to individual barriers, which may result in release of material and immediately impact the nearby Facility Worker but which are not expected to have impacts outside the facility/area boundary. Environmental impacts, due to relatively limited inventories of radioactive materials involved, are expected to be limited and amenable to mitigation and remediation.[56] Within a DSA or HA, these events may be identified as having High or Significant consequences to the Facility Worker and are typically **Low** or Negligible consequences to a Co-located Person (e.g., <25 rem, < Protective Action Criteria [PAC]-2) and **Low** or Negligible consequences to a Controlled Access Person or the Public (e.g., <5 rem, <PAC-1).

- **(Moderate) Facility Impacts** – events associated with damage to more than one barrier or a single, entire facility/system, which may result in release of material and have an immediate impact on receptors outside the EU site or facility/area boundary but not the overall Hanford Site boundary. Environmental impacts would be expected to be limited to the Hanford Site boundary but could include potential impacts to groundwater. Within a DSA or HA, these events are typically identified as having High or Significant consequences to the Facility Worker, **Moderate** (e.g., >25 rem, >PAC-2) to High consequences (e.g., >100 rem, >PAC-3) to a co-located person and **Low** or Negligible (<5 rem, <PAC-1) consequences to the Public or to a Controlled Access Person (a distinction not included in DSAs).
- **(High) Offsite Impacts** – Events associated with damage to multiple facilities/systems, which may result in release of material and have an immediate impact on receptors outside the Hanford Site boundary. Environmental impacts would be expected to be seen on- and offsite and could include potential impacts to groundwater and surface water. Within the DSA or hazards analysis, these events are typically identified as having High or Significant consequences to the Facility Worker and High or Significant (e.g.,> 100 rem, >PAC-3) consequences to Co-Located Person and Moderate (e.g.,> 5 rem, >PAC-1) to High (e.g.,> -25 rem, >PAC-2) consequences to the Public or Controlled Access Person.

HUMAN HEALTH

The following categories of potentially exposed individuals or populations (considered human receptors) are defined for evaluation purposes: (1) Facility Worker, (2) Co-located Person, (3) Controlled Access Person, and (4) Public. More details on the assumptions and methodology developed for rating the relative risk for each of the four categories of potentially exposed individuals are provided in Chapter 5 of the methodology (CRESP 2015b). As previously noted, the overall Risk Review Project encompasses three evaluation periods: (1) the active cleanup period (or until 2064), which includes the current status of the EU prior to cleanup; (2) the near-term post-cleanup period (until 2164, or assuming a 100-year duration for functioning institutional controls associated with areas transferred from federal control by 2064); and 3) the long-term post-cleanup period (until 3064). The four categories of human receptors have been rated only for the active cleanup period (including a rating for the category's current status), due to the absence of sufficient information on post-cleanup contamination levels and uncertainty on potential exposure scenarios.

The Hanford Site consists of large areas of uncontaminated or minimally contaminated landscapes and a mosaic of former industrial lands and disposal areas that are subject to cleanup. In addition, some areas have near-surface contamination from non-DOE uses (e.g., former orchard lands contaminated from agricultural use of lead arsenic pesticide). Currently, public occupancy is prohibited at the Hanford Site, non-worker exposure is minimal, and access is highly controlled inside the highways that are located

[56] These impact descriptions are comparable to the definitions used for categorizing nuclear facilities as either Hazard Category (HAZCAT) 1, 2, or 3 in 10 CFR 830, *Nuclear Safety Management*. That is: HAZ CAT 1, significant off-site consequences; HAZ CAT 2, significant on-site consequences beyond localized consequences; and HAZ CAT 3, only local significant consequences.

within Hanford Site's controlled access boundary. Substantial funding resources are needed annually to maintain current conditions that are protective of human health. It is anticipated that the occupancy, exposure, and access described above will continue at least through the active cleanup evaluation period or until 2064.[57]

For the purposes of the Risk Review Project, near-surface contamination has been defined as being within the uppermost 5 m of soil or the depth of the constructed facility if it is deeper than 5 m. Groundwater has been evaluated separately from land use because (1) groundwater use can be, and often is, managed separately from land use; (2) groundwater is considered a protected resource by the State of Washington, with a goal of restoration to the highest potential use; and (3) there is short-term potential for provision of alternate or treated water supply commensurate with the anticipated uses (including residential), until groundwater quality can meet relevant water quality standards (WQSs).

The Risk Review Project has not performed independent risk assessment, but rather an order-of-magnitude rating or binning of potential risks to human health based on hazards, accident or exposure scenarios, and consequences to different categories of human receptors who may be present on or adjacent to the Hanford Site. The definitions for these categories are found below and apply for the current status of the EU and during the active cleanup evaluation period (until 2064). Individuals or groups who may use or access the Hanford Site in the future after cleanup is complete have not been evaluated for risk and therefore are not considered to be included in the definitions.

[57] The mosaic of planned future land uses depends in part on existing contamination, cleanup objectives, and potential future exposure pathways. The Hanford Site Comprehensive Land Use Plan (CLUP) (DOE/EIS-0222-F 1999) identifies a limited range of future land uses, including no activities, industrial-commercial, recreational, and preservation. In both post-cleanup evaluation periods, some land (e.g., the Central Plateau) is likely to continue to be owned and controlled by DOE or transferred to another federal agency, and may have very limited controlled access. Additionally, many of the EUs evaluated for this report likely will be remediated in place or have some residual contamination inventory remaining after cleanup is considered complete, and will be considered part of the "Industrial-Exclusive" area as currently defined in the CLUP. This includes the core zone of the Central Plateau, which is anticipated to remain under federal control and remediated to industrial levels. Access to these areas will be strictly controlled. Other parts of the Hanford Site after cleanup may be transferred from federal control and released for other uses (e.g., commercial/industrial, recreational, or preservation). It is anticipated that many of these areas will be remediated using unrestricted cleanup levels. Future risk assessments may be needed to address uncertainties identified in current modeling (Scott et al. 2005) or additional cleanup actions may be needed if land use changes.

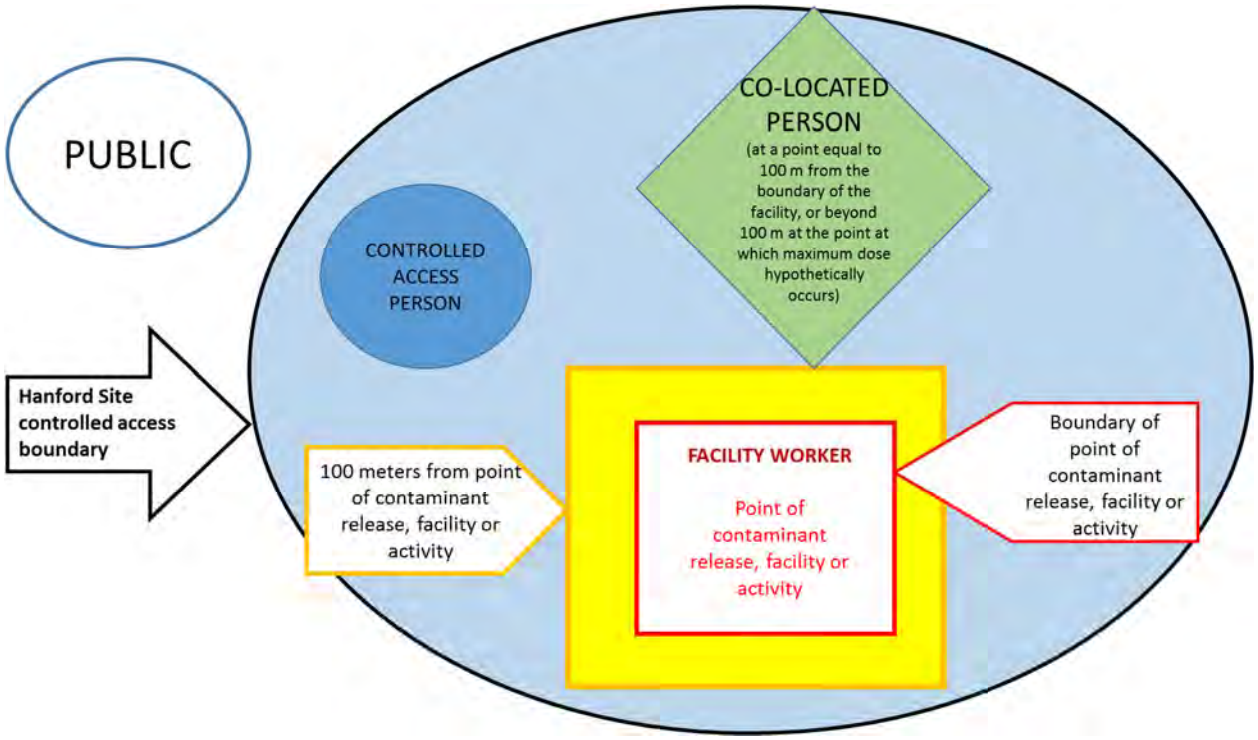


Figure 2-10. Human health categories.

Categories of Human Receptors Used for Evaluation

The following are definitions for different categories of individuals or populations used in the Risk Review Project. The human receptor definitions are also illustrated in Figure 2-10. Additionally, the definitions indicate where they are similar or are different from terms for human receptors used in DOE documents.

- **Facility Worker** – any worker or individual within the facility (or within the activity geographic boundary as established for the DSA) and located less than 100 m from the potential contaminant release point. (This definition is consistent with the DOE definition of a Facility Worker under the Documented Safety Analysis [DOE-STD-3009-2014] and the Safety Analysis Preparation of Nonreactor Nuclear Facility and Risk Assessment Handbook [SARAH] [HNF-8739, 2012]).
- **Co-located Person** – a hypothetical onsite individual (who may be a site worker not associated with the specific facility or activity, or may be a site visitor) located at a point equal to 100 m from the boundary of the facility (or activity or from the point of potential contaminant release), or beyond 100 m from the point at which maximum dose hypothetically occurs. If the release is elevated (e.g., airborne), the person is assumed to be at the location of greatest dose, which is typically where the plume touches down. *(This is functionally equivalent to the "Co-located Worker" as defined and used in the DOE-STD-3009-2014 and expanded by Hanford Safety Analysis and Risk Assessment Handbook [SARAH] to address elevated releases.)* However, the definition is expanded to represent any person at the postulated location, independent of that person's activity or employer.
- **Controlled Access Person** – a hypothetical onsite individual granted limited access to the Hanford Site, within the Hanford Site's current controlled access boundary. This category has

been developed for the Risk Review Project. The controlled access boundary is indicated in Figure 2-11 and is generally demarcated as the area bounded by the near bank of the Columbia River, Highway 240, and Horn Rapids Road on the southern boundary of the Site. *(This is functionally equivalent to the "Onsite Public" as defined and used in the Hanford Safety Analysis and Risk Assessment Handbook [SARAH].)* It is important to note that under SARAH, consequences to the "onsite public" receptor are used for informational reporting purposes only.

The following also applies to Controlled Access Persons:

1. Individuals typically require badging and/or escorts.
2. Many Controlled Access Persons will be present only once or rarely, while others may have regular tasks on site (e.g., delivery workers, repair workers). Controlled Access Persons are considered to have lower risks than Co-located Persons or Facility Workers.
3. There are risk mitigation measures that have been developed and implemented to provide adequate protection of human health, such that resultant health risks to Controlled Access Persons are considered to be ND to Low. If these individuals could be working near (close to 100 m) a potential or hypothetical contaminant release, they are considered to be Co-located Persons for purposes of assignment of risk under this Risk Review Project.
4. Controlled Access Persons include those individuals who are part of a group that has been granted access for (1) work-related visits, (2) educational activities (e.g., site tours or visiting the B Reactor), (3) recreational activities, and (4) cultural or religious reasons (e.g., Native Americans).
5. The actual risks to Controlled Access Persons under non-work-related activities are not well established at this time because the specific exposure scenarios and mitigation measures are not part of the currently analyzed cases under DOE HAs and DSAs or environmental risk assessments. The absence of detailed analysis of the risk for these groups means that further risk analysis most likely will be required, along with evaluations of specific risk mitigation strategies, at the time consideration is given to granting access to various areas of the Hanford Site for non-work-related activities.

- **Public** – an individual present for any purpose outside the Hanford Site controlled access boundary (see Figure 2-11). This individual is an adult typically located at the point of maximum exposure on the DOE site boundary nearest to the facility in question (ground level release), or may be located at some farther distance where an elevated or buoyant radioactive plume is expected to cause the highest exposure (airborne release). *(This is functionally equivalent to the "Public" as defined and used in the DOE-STD-3009-2014 and Site contractor documents, i.e., Hanford Safety Analysis and Risk Assessment Handbook [SARAH].)*

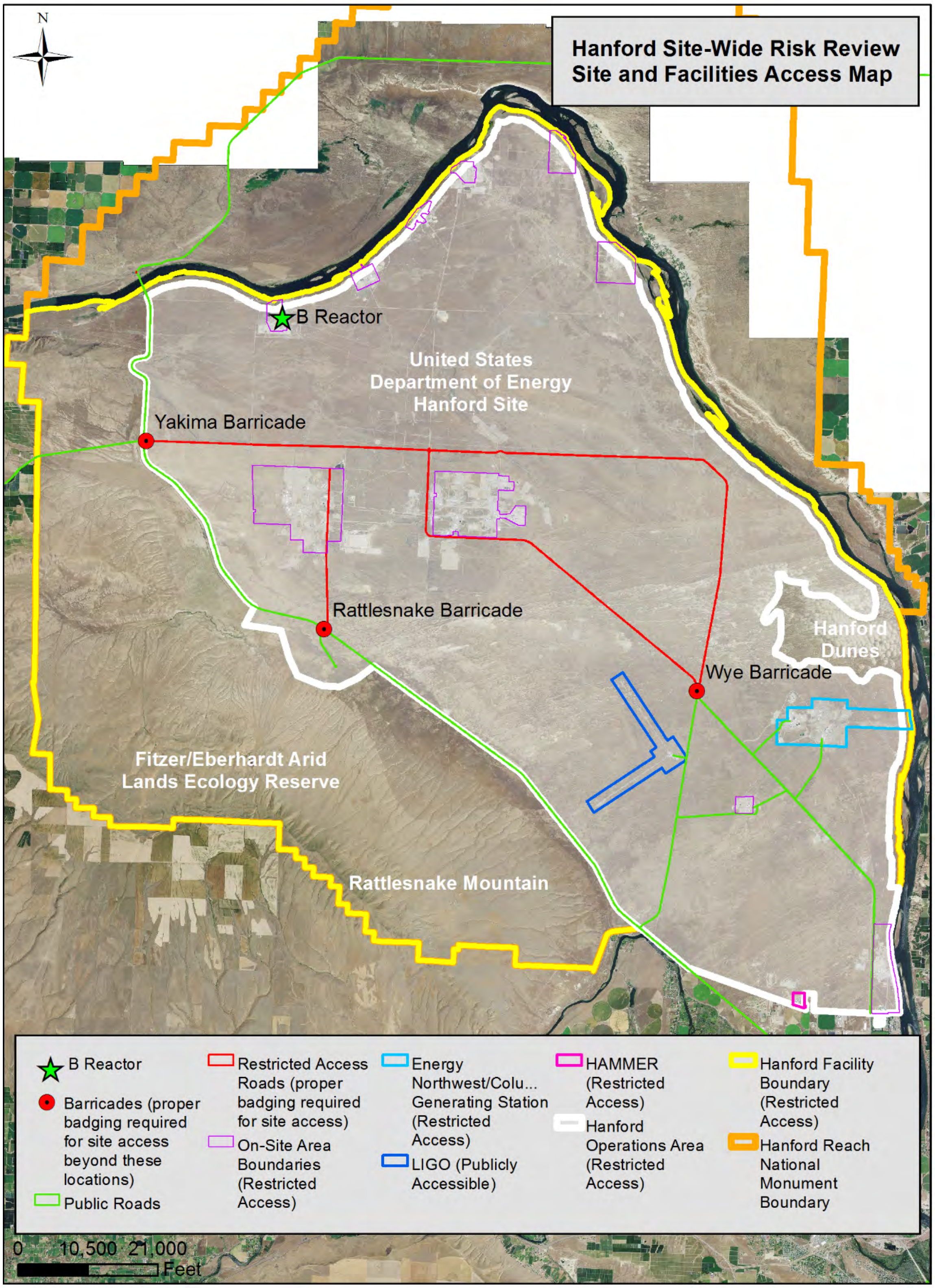


Figure 2-11. Hanford Site boundaries, public roads, and access control points. The shaded area between the river and the highways indicates the controlled access portion of the site. People outside of the lighter gray shaded area would be considered "public."

Human Health Risk Ratings

With regard to risk, the Hanford Site has implemented Integrated Safety Management requirements under federal regulations (10 CFR 851) as part of its Integrated Safety Management Policy (DOE P 450.4). The policy states in part "that work be conducted safely and efficiently and in a manner that ensures protection of workers the public, and the environment" and that systems be in place that "integrate safety into management and work practices at all levels in the planning and execution of work." Achieving the policy means "effective safety requirements and goals are established; applicable national and international consensus standards are adopted; and where necessary to address unique conditions, additional standards are developed and effectively implemented." Implementation has occurred through various DOE directives under the DOE worker safety and health program that include potential hazards and upset conditions that must be identified at the time scopes of work are developed. Also required are day-to-day assessments of hazards and controls during the conduct of work. All DOE contracts reference DOE orders and standards necessary to help ensure worker safety while at the same time the public and the environment are protected.

Two basic assumptions of worker protection are that risk for workers only exists when work is actually occurring and that any work-related illness or injury is preventable. This is integral to the DOE safety culture. However, some facilities are intrinsically hazardous due to their inventory and physical condition. Some tasks are intrinsically hazardous due both to the inventory and to the activities that must be conducted. Some inventories are vulnerable to distant dissemination of contamination under certain initiating event scenarios.

The Risk Review Project considers three types of Facility Worker risk:

- **Type 1** – acute events or upset conditions (i.e., from explosions, fires, earthquakes, structural failures) resulting in blast injuries, fires, collapses, and sudden radiation and chemical releases. These are low-probability, high-consequence events that may result in death, injury, or exposure of individual or large numbers of Facility Workers, Co-located Persons, Controlled Access Persons, or potentially the public. These events or scenarios are captured in HAs or DSAs, which are available (at least in draft) for many of the EUs. The initiating events may be natural disasters or anthropogenic.
- **Type 2** – potential threats associated with occupational hazards from subacute or chronic exposure (hours to days) to site-specific radioactive or chemical hazards (intermediate probability and consequence). Worker safety programs strive to prevent these exposures under "normal" operating conditions. Specific types of hazards in addition to radiation and chemical hazards are known to exist in many Hanford facilities (e.g., asbestos, beryllium, polychlorinated biphenyls [PCBs]) and are considered as part of analyses.
- **Type 3** – industrial accidents and injuries, including, for example, transportation accidents, falls, struck by objects, crush injuries, machinery injuries, and heat stress. These are relatively frequent events, particularly in construction activities, that may result in death or injury, but usually to one or a few individuals, and can be considered higher probability and lower consequence events compared to Type 1 (above).

The three types of Facility Worker risk are considered individually to develop the risk rating for an EU, since the risks are not additive. Type 2 and Type 3 risks are the domains of industrial hygiene and industrial safety and are part of the safety culture emphasized in DOE's Integrated Safety Management. DOE's safety culture propagates through all tiers of subcontractors, each assuming responsibility for their own and lower tier worker safety. As a result, fatalities have been rare in DOE's environmental management program, and lost-time injuries (per job hour) occur at a much lower rate than that of comparable outside work. **Thus, mitigated Type 2 and Type 3 risks are considered Low or ND for most EUs.**

An overview of unmitigated hazards to workers that are related to the five source types (e.g., tank waste and farms) of EUs evaluated for this report is provided in Chapter 5 of the methodology (CRESP 2015b). Generally, it should be noted that the following is true: The more complex the task and the greater the number of subcontractors, the higher the probability of a safety breakdown and the need for increased safety oversight.

The HAs and DSAs develop worst-case assessments of unmitigated risks, varying in probability and consequence. These documents also address measures used to prevent (reduce the probability of an event) or mitigate the consequences. Nuclear safety assessment and engineering plays a primary role in anticipating, evaluating, preventing, and mitigating Type 1 hazards**. As a result, the mitigated risks for Type 1 hazards are usually Low or even ND.**

For each EU, the scenarios that result in the highest unmitigated dose (including the dose estimate) and the primary mitigation measures are summarized in the EU template, whenever those scenarios are available for an EU.

For remediation projects and/or operating facilities that have HAs or DSAs, the rating for Type 1 risks relies on the unmitigated dose estimates to the Co-located Person as the primary differentiating characteristic, whenever these estimates are available. This is because dose estimates usually are not directly calculated for Facility Workers, and the unmitigated dose to the Co-located Person considers all significant radiological and chemical hazards present in a facility[58]. *The scenarios that result in a significant unmitigated dose are the result of initiating events that may occur with a high uncertainty and therefore the consequence rating is assumed to be the risk rating.* For each EU, the scenarios with the greatest unmitigated dose to the Co-located Person (including the dose estimates) and the mitigation measures are summarized in the EU template (See appendices).

Radiation Dose Considerations and Risk Review Project Ratings

Table 2-3 summarizes various dose limits, standards, guidelines, benchmarks, and recommendations regarding human exposure to radiation. The discussion that follows only refers to whole body doses. The exposures being considered in the Risk Review Project are from Type 1 events, with ***theoretical scenarios constructed for safety analysis causing postulated exposures*** lasting hours (typically 2 to 8 hours). The dose limits and standards provided in the following table refer most frequently to the dose delivered over a year—referred to as the annual dose. The doses are expressed as "total effective dose." The standard developed for DOE sites (DOE-STD-3009, Section 3.2.4.2 [2014]) states in part:

> *Radiological consequences are presented as a Total Effective Dose (TED) based on integrated committed dose to all target organs, accounting for direct exposures as well as a 50-year commitment. The dose pathways to be considered are inhalation, direct shine, and ground shine. Direct shine and ground shine from gamma emitters only need to be evaluated if they cause an upward change in the consequence level as defined… Slowly-developing dose pathways, such as ingestion of contaminated food, water supply contamination, or particle re-suspension, are not included. However, quick-release accidents involving other pathways, such as a major tank rupture that could release*

[58] If the DSA indicated that (based on a qualitative assessment) that the action could result in "Prompt death, serious injury, or significant radiological and chemical exposure" a "High" rating was assigned.

large amounts of radioactive liquids to water pathways, should be considered. In this case, potential uptake locations should be the evaluation points for radiological dose consequences.

In most cases, the airborne pathway is of primary interest for nonreactor nuclear facilities. This position is supported by NUREG-1140, A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees, which states that 'for all materials of greatest interest for fuel cycle and other radioactive material licenses, the dose from the inhalation pathway will dominate the (overall) dose.' For some types of facilities such as liquid processing with the potential for significant spills to the environment outside the facility, the surface and groundwater pathways may be more important, and accident releases usually would be expected to develop more slowly than airborne releases. More time would also be available for implementing preventive and mitigative measures.

Doses from natural background, therapeutic and diagnostic medical radiation, and participation as a subject in medical research programs are not included in the dose estimates or in the assessment of compliance with the occupational dose limits, consistent with common practice. The average U.S. background radiation (excluding medical uses) was estimated at 310 mrem/yr (3.1 mSv/yr; NRC 2014).

The values in Table 2-3 include the regulatory levels such as dose limits set by DOE (DOE 10 CFR 835) and the NRC (NRC 10 CFR 20) and standards set by the U.S. Occupational Safety and Health Administration (OSHA). Two advisory bodies, the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP) also make recommendations regarding allowable or excessive exposure for consideration by regulatory authorities.

The primary applicable DOE document for controlling radiation exposure of workers at DOE installations is *Occupational Radiation Protection* (10 CFR 835), which defines the radiation protection standard applicable to DOE, its contractors, and persons conducting DOE activities and includes equivalent dose limits. In addition to radiation protection limits, DOE establishes "administrative control levels." These control levels are below the dose limits and are intended to ensure that the DOE limits and control levels are not exceeded. Implementation of these control levels also helps reduce the collective dose to individuals and the worker population by incorporating engineered features and administrative controls. The DOE dose limits account for information provided by the ICRP, NCRP, and EPA. The whole body dose limit is 5 rem/yr (5 rem = 5000 mrem = 0.05 Sv = 50 mSv). The DOE administrative level is 2 rem/yr. DOE also has a dose limit applicable to the public of 0.1 rem (100 mrem = 1 mSv) per year.

The NRC has similar standards that limit maximum radiation exposure to individual members of the public to 100 mrem (1 mSv) per year above background and that limit occupational radiation exposure to adults working with radioactive material to 5 rem (50 mSv) per year (NRC 10 CFR 20). The OSHA worker standard is also 5 rem/yr. These values are often stated in terms of the TED.

Table 2-3. Criteria, standards, guidelines, benchmarks, and recommendations from various U.S. and international agencies for human exposure to radiation (1 mSV = 100 millirem).

Estimated Total Effective Dose (TED) [(a)]	DOSE Limits, Standards, Guidelines, Benchmarks, and Recommendations
0.012 rem (12 mrem or 0.12 mSv)	EPA recommends a 12 mrem/yr dose (effective dose equivalent), corresponding to an estimated 3 x 10^{-4} excess lifetime cancer risk (incidence) for 30 yr residential land use at CERCLA sites.[(b)] This is equivalent to three excess cancers among 10,000 people.
0.015 rem (15 mrem or 0.15 mSv)	Washington State Department of Health cleanup criteria (WDOH/320-015 2015).
0.025 rem (25 mrem or 0.25 mSv)	NRC's License Termination Rule specifies 25 mrem/yr dose (TEDE) for unrestricted use from all exposure pathways combined to an average member of the critical group (http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/full-text.html#part020-1402).
0.1 rem (100 mrem or 1mSv)	Expressed as an annual dose limit for public (DOE O 458.1). It is set at 0.1 rem (100 mrem or 1 mSv) per year above background. Other federal agencies (OSHA, NRC 10 CFR 20) use the same limit for public exposures.
0.3 rem (300 mrem or 3 mSv)	Average annual U.S. background radiation from natural sources is about 0.3 rem per year (NRC 2014) NOT including medical uses.[(b)] An individual's dose depends on many factors including location, altitude, geology, and lifestyle.
2 rem (or 2,000 mrem or 20 mSv)	Occupational dose as recommended by the ICRP[c] is 2 rem (or 0.02 Sv or 20 mSv) per year. DOE establishes an Administrative Control at an occupational dose of 2 rem/yr (10 CFR 835).
5 rem (or 5,000 mrem or 50 mSv)	Annual occupational dose limit as set by the DOE (10 CFR 835, *Occupational Radiation Protection)* rule for radiation workers specifies a dose limit of 5 rem (or 5,000 mrem or 50 mSv) per year. This is equivalent to both the NRC and the OSHA occupational radiation exposure standard of 5 rem/yr for non-DOE workplaces.
25 rem (or 25,000 mrem or 250 mSv)	If from *a single short-term event*, the 25 rem DOE dose limit applies to a worker who is protecting large populations or critical infrastructure or performing life-saving efforts in emergency circumstances (DOE 2007). This one-time qualified worker dose requires DOE prior authorization to proceed. (DOE-HDBK-1130-2007, *Radiological Worker Training*).
100 rem (or 100,000 mrem or 1000 mSv)	A 100 rem dose, occurring from a single short-term event, may cause acute symptoms (nausea and vomiting within 4 h) in 5% to 30% of the exposed population. The risk of fatal cancer is increased by up to 8% over the lifetime risk of fatal cancer, which is approximately 24% (NCRP 2005). A 100 rem dose accumulated over a working lifetime yields the ICRP[(c)] recommended maximum lifetime dose for a radiation worker: 1 Sv (or 100 rem). This dose, accumulated over a long period, will not cause acute symptoms in the exposed population. Because the dose is spread out over time, the estimated risk of cancer is cut in half to approximately 4%. (In contrast, the NCRP recommends a maximum permissible dose of 0.65 Sv, or 65 rem, which is 10 mSv × age.)

a. Use of TED is consistent with DOE-STD-30009-2014.
b. "Although radiation may cause cancers at high doses and high dose rates, currently there are no data to establish unequivocally the occurrence of cancer following exposure to low doses and dose rates – below about 10,000 mrem (100 mSv)." From the USNRC, http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html.
c. The ICRP is a consensus body with no regulatory authority.

Table 2-4 presents the Risk Review Project ratings for Facility Workers and Co-located Persons that are based on *unmitigated* dose estimates from DSA or hazard assessments using the estimated unmitigated dose to the co-located person as the metric for Risk Review Project rating. The highest rating for risk to human health is High.

In the event of a radiologic release, worker exposure to radiation is mainly due to inhalation. At other times during remediation and for future industrial workers, the direct, external radiation route predominates. However, radioisotopes may be inhaled or ingested. These isotopes deposit in tissues and continue to emit radiation over time. This cumulative radiation is referred to as a committed dose. The total effective dose equivalent is the sum of the external radiation exposure and the committed dose. These doses are expressed as estimated total effective dose (TED), which is replacing the earlier term (total effective dose equivalent) TEDE, reflecting current international, industry and federal standards and reflects DOE-STD-3009-2014. Some of the documents cited in this report specify doses using TEDE. For most circumstances, the differences are not substantial.

Similarly, Table 2-5 presents the Risk Review Project ratings for the public. The highest rating for risk to human health is High. Rating categories for the public are more stringent than for Facility Workers and Co-located Persons because the latter have a higher level of training and are assumed to give informed consent associated with their role as workers. Note that rating definitions used by the Risk Review Project are different from DOE-STD-3009-2014 risk rating assignments. These differences were to facilitate more effective risk communication with a general audience in context with information provided in Table 2-3. For example, since the DOE's annual occupational dose limit and the OSHA Permissible Exposure Limit are 5 rem/yr, doses exceeding this level are characterized as Medium rather than Low risk (Table 2-4), since the maximum exposed Co-located Person is not necessarily a radiation worker and exposing a member of the public to a one-time a 5 rem dose is different from chronic worker exposure. Further, the same dose for the public is better characterized as High rather than Medium risk since the dose limit for the public is 0.1 rem above background (i.e., 50 times lower).

Table 2-4. DOE-STD-3009-2014 and Risk Review Project "Facility Worker" and "Co-located Person" risk rating basis for unmitigated Type 1 design basis events (single event unmitigated dose estimates).

Unmitigated Estimated Total Effective Dose TED[a]	DOE-STD-3009-2014 Rating (corresponding to DSA or HA ratings)	Risk Review Project Rating
≤0.1 rem		ND[b]
>0.1 rem to ≤5 rem	Low	Low
>5 rem to ≤25 rem	Low	Medium
>25 rem to ≤100 rem	Moderate	High
>100 rem	High	High

a. The term TED, which is replacing the earlier TEDE, reflects current international, industry, and federal standards and reflects DOE STD 3009-2014. Some of the documents cited in this report specify doses using TEDE. For most circumstances, the differences in are not substantial.
b. ND or Not Discernible does not exist in the DOE nuclear safety risk or consequence levels (DOE-STD-3009-2014). This rating is added for binning purposes.

Table 2-5. DOE-STD-3009-2014 and Risk Review Project "public" risk rating basis for unmitigated Type 1 design basis events (single event unmitigated dose estimates).

Unmitigated Estimated Total Effective Dose TED[a]	**DOE-STD-3009-2014 Rating** (corresponding to DSA or HA ratings)	Risk Review Project Rating
≤0.1 rem		ND[b]
>0.1 rem to ≤1 rem	Low	Low
1 to ≤5 rem	Low	Medium
>5 rem	Moderate	High
>25 rem	High	

a. The term TED, which is replacing the earlier TEDE, reflects current international, industry and federal standards and reflects DOE STD 3009-2014. Some of the documents cited in this report specify doses using TEDE. For most circumstances, the differences in are not substantial.
b. ND or Not Discernible does not exist in the DOE nuclear safety risk or consequence levels (DOE-STD-3009-2014). This rating is added for binning purposes.

Primary Contaminants and Human Health Risks

The Risk Review Project has focused on radionuclides and contaminants that have been of large, Site-wide significance and stakeholder, Tribal, and community concern or are the major contributors to receptor risks at specific EUs (i.e., risk drivers). Collectively, the set of radionuclides and contaminants considered may differ for specific EUs (because of either the presence or absence of specific radionuclides and contaminants and different risk and impact drivers), but are collectively referred to as primary contaminants. The primary radiological contaminants used in the Risk Review Project with regard to human health impacts are listed in Table 2-6 with their half-life and effective dose equivalents. Half-life is the time it takes for one-half of the atoms of the radioactive material to disintegrate and for various radioisotopes it can range from a few microseconds to billions of years. Only those radionuclides with half-lives longer than about 1 year are of concern for DOE environmental management sites, as shorter-lived radionuclides will have already decayed to innocuous levels because production activities involving radioactive materials at major sites such as Hanford ceased more than 10 years ago (ANL 2007).

DOE estimates the radiological consequences (total effective dose) to the Co-located Person and Public for an initiating event or accident by (1) determining the source term, which is the maximum amount of respirable radioactive or other hazardous material that may be released as a result of the postulated accident scenario; and (2) calculating the radiological dose, which is a function of the location and exposure time of the receptor, dispersion of the material to the receptor location, *radiotoxicity of the material as characterized by dose coefficients*, or toxicity of other hazardous materials whose consequences are calculated in terms of exposure concentrations. In most cases, the airborne pathway is of primary interest for nonreactor nuclear facilities. This position is supported by NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*, which states that "for all materials of greatest interest for fuel cycle and other radioactive material licenses, the dose from the inhalation pathway will dominate the (overall) dose" (DOE-STD-3009-2014) The effective dose equivalents shown in Table 2-6 are for particles of 1 µm and 5 µm inhaled by a worker (ICRP 2011).

These radiological isotopes can be categorized according to their effective dose equivalent:

Effective dose equivalent <1.0×10^{-6}: Am-241, Pu-239, and Pu-240

Effective dose equivalent 1.0×10^{-7} to 1.0×10^{-8}: U-238, U-235, U-233, U-234, Sr-90, and I-129

Effective dose equivalent 1.0×10^{-9} to 1.0×10^{-11}: Cs-137, Tc-99, C-14, and Tritium (H-3)

Cesium-137 presents an external as well as internal health hazard that is not fully captured by this categorization. The strong external gamma radiation associated with its short-lived decay product barium-137m makes external exposure a concern (ANL 2007).

The primary contaminant groups used in this Risk Review are described in Table 2-7, which categorizes contaminants according to their mobility and persistence in the Hanford environment. The categorization was done on a relative basis among the primary contaminants that pertain to the 25 interim report EUs (CRESP 2015a). Mercury was added to the groupings based on review of the full set of EUs. Mobility relates to the primary contaminant's relative ability to be transported in the subsurface environment (as represented by the contaminant transport retardation factor, R) and is mainly a function of the contaminant's chemistry and sorption with the Hanford subsurface geology. For radioactive contaminants, the persistence category is based on the radionuclide's half-life; whereas, the persistence category for the organic and inorganic contaminants is based on their chemical degradation and biodegradation potential. For the purposes of this site-wide review, primary contaminants were divided into four groups based on their persistence and mobility. The groups are ranked relative to one another with respect to potential for threats to water resources, with Group A being the highest (highly mobile and highly persistent) and Group D being the lowest (low mobility and highly persistent) for the purpose of this study.

Table 2-6. Radiological Contaminants: Effective Dose Equivalents

Isotope	Half-Life (years)	Effective Dose Equivalent (Sv/Bq)	
		1 µm	5 µm
Americium-241	432	$3.9X10^{-5}$	$2.7X10^{-5}$
Carbon-14[a]	5,730	$5.8X10^{-10}$	NA
Cesium-137	30	$4.8X10^{-9}$	$6.7X10^{-9}$
Iodine-129	16 million	$3.7X10^{-8}$	$5.1X10^{-8}$
Plutonium-239	24,000	$4.7X10^{-5}$	$3.2X10^{-5}$
Plutonium-240	6,500	$4.7X10^{-5}$	$3.2X10^{-5}$
Strontium-90	29.1	$2.4X10^{-8}$	$3.0X10^{-8}$
Technetium-99	213,000	$2.9X10^{-10}$	$4.0X10^{-10}$
Tritium (H-3)[a]	12.4	$1.8X10^{-11}$	NA
Uranium-233	159,000	$5.7X10^{-7}$	$6.6X10^{-7}$
Uranium-234	240,000	$5.5X10^{-7}$	$6.4X10^{-7}$
Uranium-235	704 million	$5.1X10^{-7}$	$6.0X10^{-7}$
Uranium-238	4.5 billion	$4.9X10^{-7}$	$5.8X10^{-7}$

a. Dose coefficient for inhalation of soluble or reactive gases and vapors.

Table 2-7. Primary contaminant groups used in this Risk Review Project.

		Mobility*		
		Low (R>500)	Medium (5<R<500)	High (R<5)
Persistence	Low		TPH-diesel	^3H_2O, NO_3
	Medium	Cs-137, Am-241	Sr-90	CN, TCE
	High	Pu, Eu, Ni, Hg (all isotopes)	U-Total, Cr-Total	Tc-99, I-129, C-14, Cl-36, Cr-VI, CCl_4

Group A Primary Contaminants (red)
Group B Primary Contaminants (orange)
Group C Primary Contaminants (green)
Group D Primary Contaminants (blue)

* Assume most mobile form of contaminant
R = retardation factor

EVALUATING IMPACTS TO GROUNDWATER AND THE COLUMBIA RIVER AS PROTECTED RESOURCES

The major steps of the evaluation process are (1) identifying EUs that either are impacting or may impact groundwater; (2) compiling relevant information concerning the source, vadose zone, and saturated zone for each EU; (3) calculating the evaluation metrics for each EU; and (4) comparing the evaluation metrics. Information gaps, uncertainties, and data gaps will be described for each EU. The methodology considers the three evaluation time frames defined for the Risk Review Project: active cleanup (50 years, to 2064), near-term post-cleanup (100 years post cleanup, to 2164), and long-term post-cleanup (1000 years post-cleanup, to 3064 or beyond where indicated) (CRESP 2015b). Three possible recharge rates (i.e., surface barrier [0.5 mm/yr], undisturbed plant communities [5 mm/yr], and disturbed soil [50 mm/yr]) are considered to reflect uncertainties and a range of potential local surface conditions over the indicated time frames as a result of ground cover, closure covers, climate variation, and localized surface hydrologic effects.[59]

The evaluation metrics for risks to groundwater from current groundwater plumes and near-surface or vadose zone sources are as follows:

1. The estimated time interval until groundwater would be *impacted* by a primary contaminant where a current plume does not exist over the three evaluation periods. Groundwater is considered *impacted* when a primary contaminant concentration exceeds a threshold value, e.g., a drinking water standard or maximum contaminant level.
2. The estimated amount of groundwater (e.g., areal extent) currently *impacted* by the primary contaminants with existing plumes.
3. The *groundwater threat metric (GTM)*, defined as the volume of groundwater potentially contaminated at the reference threshold concentration (e.g., drinking water standard) based on the estimated contaminant inventory over the three evaluation periods.

Figure 2-12 provides the decision logic for assigning Risk Review Project ratings for existing groundwater contamination and contaminants in the vadose zone and engineering systems.

The selected evaluation metrics for risks to the Columbia River from near surface, vadose zone, and groundwater contamination sources are as follows:

1. The estimated time interval until the Columbia River is *impacted* over the three evaluation periods. The Columbia River is considered *impacted* when a primary contaminant concentration exceeds a benthic or free-flowing threshold value.
2. The ratio (R1) of the maximum primary contaminant concentration within the plume to the reference threshold screening value (e.g., Biota Concentration Guide (BCG) for radionuclides or ambient water quality criterion (AWQC) for chemicals).
3. The ratio (R2) of the upper 95th percentile upper confidence limit (UCL) on the log-mean plume concentration to the reference threshold screening value.
4. For benthic impacts, the length of river shoreline estimated to be impacted by the plume above a reference threshold (CRESP 2015b).[60]

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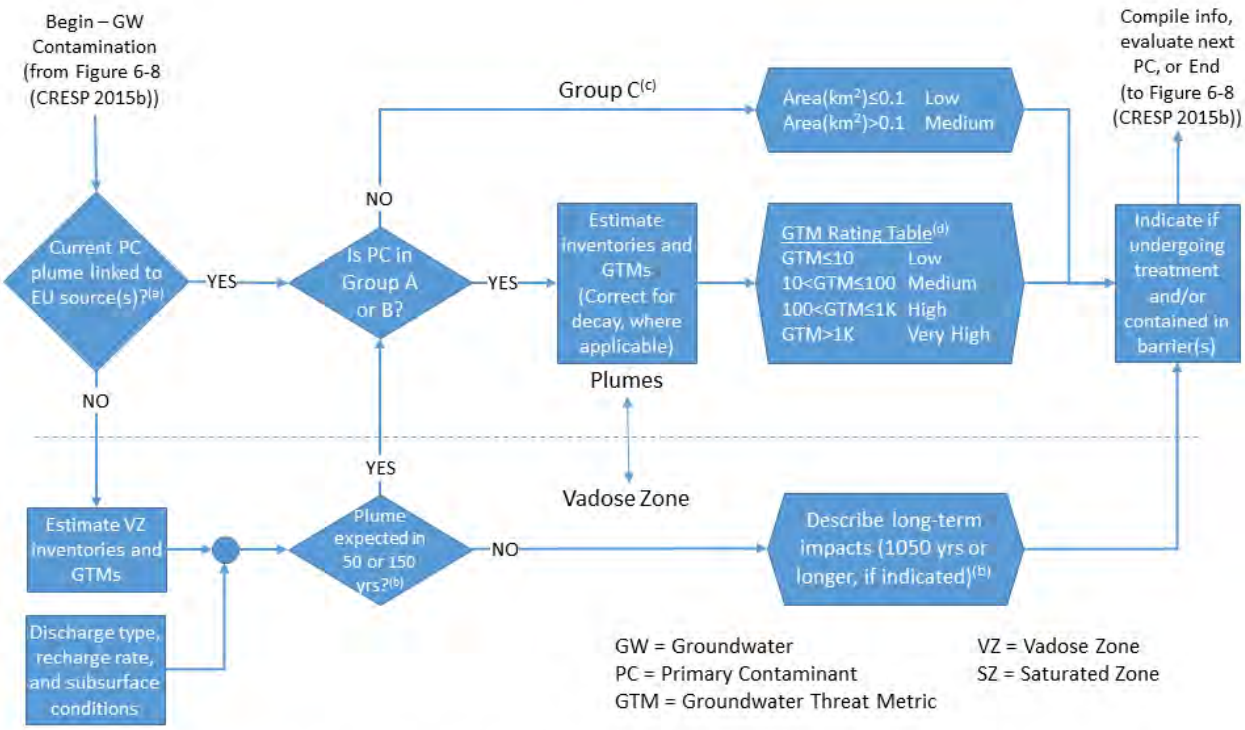
[59] A value of 100 mm/yr is used when needed to reflect specific conditions (e.g., gravel cover).

[60] The impact area of the Columbia River for the benthic ecology is inherently more uncertain than the length of river reach because the specific area of the groundwater discharge into the river is unknown for most cases. Rather, the length of the river reach can be estimated based on the plume intersection with the river edge.

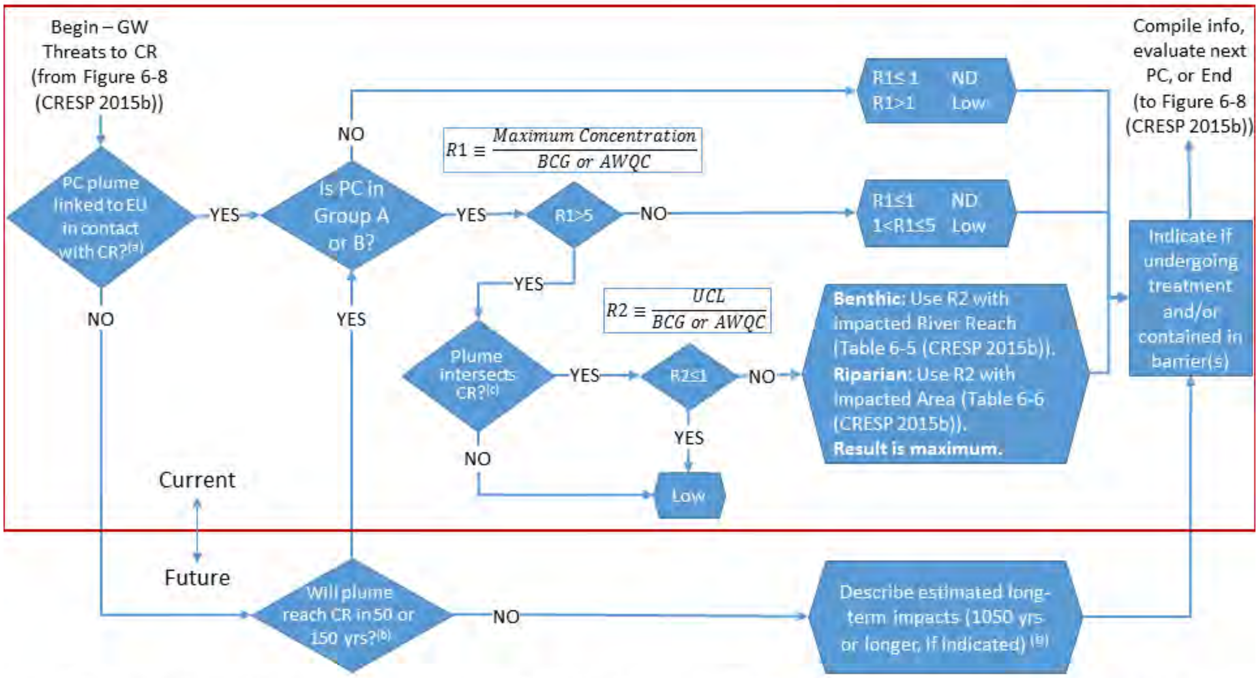
5. For riparian zone impacts, the area of the riparian zone estimated to be impacted by the plume above a reference threshold.

Figure 2-13 provides the decision logic for assigning Risk Review Project ratings for threats to the Columbia River. Figure 2-8 and Table 2-9 provide the ratings for Group A and Group B primary contaminants for riparian zone and benthic zone threats, respectively. Furthermore, the impacted river length and impacted area are highly correlated based on limited available data (CRESP 2015b).



a. Based on plume area above a threshold (e.g., Water Quality Standard (WQS) from 2015 Annual GW Monitoring Report (DOE/RL-2016-09 Rev. 0)). Note plume areas and corresponding estimated plume volumes are (highly) positively correlated.
b. Use available information (e.g., environmental impact statements, risk assessments) to evaluate.
c. Note, no Group D contaminants have been identified as groundwater threats (CRESP 2015b).
d. GTM Rating Table for Group A and B PCs (Table 6-3 (CRESP 2015b)).

Figure 2-12. Decision logic for characterizing threats to groundwater as a protected resource with respect to existing groundwater contamination and vadose zone contamination. Note: No Group D contaminants have been identified as groundwater threats.



PC = Primary Contaminant
GTM = Groundwater Threat Metric
UCL = Upper 95% confidence limit (log-mean)
VZ = Vadose Zone
CR = Columbia River
AWQC = Ambient Water Quality Criterion (chemicals)
BCG = Biota Concentration Guide (radionuclides)
ND = Not discernible

a. Based on plume area above a threshold (e.g., Water Quality Standard (WQS) from 2015 Annual GW Monitoring Report (DOE/RL-2016-09 Rev. 0)). Note plume areas and corresponding estimated plume volumes are (highly) positively correlated.
b. Use available information (e.g., environmental impact statements, risk assessments) to evaluate.
c. Based on aquifer tube data or contours exceeding the threshold from the Hanford Environmental Information System (HEIS).

Figure 2-13. Decision logic for rating threats to the Columbia River from groundwater contaminants (where steps in red box are for current impacts and those below are for potential future impacts to the river).

Table 2-8. Riparian zone ratings for contaminants based on the area of the potentially impacted riparian zone and the ratio R2 (i.e., (log-mean concentration, 95th UCL)/BCG or AWQC)).

	(Log-Mean Concentration, 95th UCL)/(BCG or AWQC)			
Area (hectares)	< 1	1 to < 5	5 to < 10	> 10
<0.5	ND	Low	Medium	Medium
0.5 to < 5	ND	Medium	Medium	High
5 to < 15	ND	Medium	High	High
> 15	ND	Medium	High	Very High

UCL = upper confidence level
ND = Not Discernible
BCG = biota concentration guide for radionuclides
AWQC = ambient water quality criterion for chemicals

Table 2-9. Benthic zone ratings for contaminants based on the estimated length of potentially impacted river reach and the ratio R2 (i.e., (log-mean concentration, 95th UCL)/BCG or AWQC)).

	(Log-Mean Concentration, 95th UCL)/(BCG or AWQC)			
River Reach (m)	< 1	1 to < 5	5 to < 10	> 10
<50	ND	Low	Medium	Medium
50 to < 500	ND	Medium	Medium	High
500 to < 1500	ND	Medium	High	High
> 1500	ND	Medium	High	Very High

UCL = upper confidence level
ND = Not discernible
BCG = biota concentration guide for radionuclides
AWQC = ambient water quality criterion for chemicals

Ecological Resources

The Risk Review Project methodology for evaluating ecological resources on the Hanford Site is an independent evaluation that encompasses evaluations of site resources in comparison to the Columbia Basin ecoregion; evaluations by DOE, the State of Washington, the State of Oregon, the Nature Conservancy, and Tribes (where available); and onsite field evaluations in 2014 and 2015 (CRESP 2015b). It uses the level of resource values designed by DOE (DOE/RL-96-32 2013) in conjunction with information from the State of Washington, Tribes, others, and the field evaluations. The resource values are modified by field work evaluations of current resource levels and landscape features (patch size, patch shape, connectivity), and exotic/alien species, and considerations of physical disruptions and contamination (potential exposure during active cleanup or in the 100 years thereafter). A major contribution of the ecological risk evaluation is the acquisition of new field data on resource-level values for the EUs and the surrounding buffer areas.

The risk that the ecological resources experience is a function of contaminants that are present, as well as ecological accessibility, remediation types, functional remediation parameters (e.g., number of people, cars, trucks, heavy equipment, capping, excavation), and scales (temporal, spatial). Ecological resources are at risk not only from contaminants and onsite activities, but also from the activities on adjacent habitats. That is, people, cars, and trucks moving through a non-target site to reach the target remediation site can affect adjacent, non-target sites (defined as buffer areas). These effects can be direct (e.g., traffic and habitat disruption, exposure to contaminants) or indirect (e.g., disturbance to animals, dispersal of seeds, movement barriers). Laydown areas can have an important effect and must be selected carefully to minimize disruption to both EUs and the buffer zone. Post-cleanup risks to ecological receptors include contamination left in place as well as physical disruptions from monitoring and associated activities.

This methodology is designed to use available, Geographic Information System (GIS)-based information on ecological resources on the Hanford Site, in addition to field data gathered in 2014 and 2015 (CRESP 2015b). The information relates to individual species that are at risk (including listed species), species groups (e.g., native grasses and shrubs, migratory species), and key unique habitats or ecosystems that could be at risk. The methodology was developed so that it could be applied to different EUs and could be applied by personnel with basic ecological knowledge. While landscape features can be determined from maps, they must be checked in the field. Other field work is necessary including determining the percent of alien/exotic species present on the site, as well as the occurrence of endangered/threated/ species of special concern.

The rating scale of ND to Very High used for ecological resources is described briefly below and is based on the resource levels defined by DOE (DOE/RL-96-32 2013):

- ND = Not discernible from the surrounding conditions; no additional risk.
- Low = Little probability to disrupt or impact Level 3-5 ecological resources.[61]
- Medium = Potential to disrupt or impair Level 3-5 ecological resources.
- High = Likely to disrupt and impair Level 3-5 ecological resources of high value or resources that have restoration potential, and may cause permanent disruption.
- Very High = High probability of impairing (or destroying) ecological resources of high value (Levels 3-5) that have typical (and healthy) shrub-steppe species, low percent of exotic species, and may have federally listed species. Likely to cause permanent degradation or disruption.

CULTURAL RESOURCES

The methodology for evaluating cultural resources at risk at Hanford Site during the active cleanup and near-term post-cleanup periods is an independent analysis that encompasses a thorough review of existing documentation for each unit being evaluated (and buffer area) (Chapter 8 of methodology

[61] Level 3 and above resources are those with important and unique habitats (Level 3), essential habitat for important species (state threatened and endangered species, Level 4), and irreplaceable habitat or federal threatened and endangered species Level 5).

[CRESP 2015b]). The definition of the term "cultural resources" is identical to the definition used in the Hanford Cultural and Historic Resources Management Plan, which states:

> *Cultural resources is a collective term applicable to: 1) prehistoric-and historic-archaeological sites and artifacts designating past Native American utilization of the Hanford Site; 2) historic-archaeological sites and artifacts indicating post Euro-American activities relating to the pre-Hanford period; 3) Hanford Site Manhattan Project and Cold War era buildings, structures, and artifacts; 4) landscapes, sites, and plants and animals of cultural value to the Native American community; and 5) landscapes, sites, and materials of traditional cultural value to non-Native Americans* (DOE/EIS/RL-98-10, Rev 0, Appendix A, 2003)*.*

An overall risk or impact rating or binning for cultural resources is not provided for any of the evaluation periods. This is because cultural resources risks cannot be estimated in the same way that risks to groundwater, for example, can be characterized. Additionally, federal law requires that a cultural resources review be completed before any project activity may begin, including those associated with remediation, regardless of any rating that may be provided (National Historic Preservation Act and Section 106 reviews, 16 U.S.C. 470 et. seq.; 36 CFR Part 800 [2004]). A similar mandate is not imposed for other receptors being evaluated.

At the Hanford Site, this required cultural resources review is carried out for each project activity consistent with federal statutory and regulatory requirements. Requirements include identification, evaluation, and assessment of the potential effects of remediation on cultural resources. If adverse impacts to cultural resources are anticipated from the activity, the regulatory process calls for an agreement to be negotiated that outlines mitigation measures intended to minimize and/or avoid any adverse impacts, including those resources located subsurface. The process also mandates procedures for consultation with Washington Department of Archaeology and Historic Preservation, State Historic Preservation Officer (SHPO), Tribes, and interested parties or stakeholders.

While the analysis does not include an overall impact rating of ND, Low, Medium, High, or Very High, the cultural resources impacts (both direct and indirect) during current operations, active cleanup (until 2064), and near-term post-cleanup are made and expressed as known, unknown, or none to cultural resources within the unit being evaluated (and the buffer area). These assignations are based on existing cultural resources documentation from DOE and Washington State records for the unit being evaluated (and immediate surrounding area) or other information made available by Tribes and/or historical societies to establish whether cultural resources are or have been present within that EU. Such a determination is made for each of the three overlapping landscapes that comprise the cultural resource setting at Hanford Site (i.e., Native American [10,000 years ago to present], Pre-Hanford Era [1805-1943], and Manhattan Project and Cold War Era [1943-1990]). Additionally, as noted, direct and indirect impacts are provided. Direct impacts include but are not limited to physical destruction (all or part) or alteration such as diminished integrity. Indirect impacts include but are not limited to the introduction of visual, atmospheric, or audible elements that diminish the cultural resource's significant historic features. Table 2-10 also describes the analysis used.

Table 2-10. Analysis for rating impacts to cultural resources under current conditions and during active cleanup. Analysis is identical for all three landscapes. (Indirect Impact Analysis in Bold)

	Current Conditions/Operations	During Active Cleanup
Known	• Literature review includes documentation establishing the presence of cultural resources, or • Documentation regarding eligibility of cultural resources for the National Register of Historic Places within EU has been completed • **EU is within landscape/setting of traditional cultural place (TCP)**	• Literature review includes documentation establishing the presence of cultural resources, or • Documentation regarding eligibility of cultural resources for the National Register of Historic Places within EU has been completed • **EU is within landscape/setting of TCP**
Unknown	• Literature review indicates uncertainty in the presence of cultural resources (e.g., reviews are incomplete or indicators are present but actual presence of resources not documented) • Documentation regarding eligibility of cultural resources for the National Register of Historic Places within EU has not been completed • **Unknown if there are TCPs within EU or view shed**	• Literature review indicates uncertainty in the presence of cultural resources (e.g., reviews are incomplete or indicators are present but actual presence of resources not documented) • Documentation regarding eligibility of cultural resources for the National Register of Historic Places within EU has not been completed • **Unknown if there are TCPs within EU or view shed**
None	• Literature review does not indicate the presence of cultural resources	• Literature review does not indicate the presence of cultural resources

The purpose of the cultural resources documentation review is to provide guidance to DOE and regulatory agencies as remediation options for the EU are considered. If the remediation option has already been determined, the purpose is to provide additional insights to DOE, regulatory agencies, SHPO, Tribes, and other interested parties or stakeholders on the extent to which remediation activities may adversely affect cultural resources. Finally, the analysis of cultural-resource-related documentation is intended to provide insights into the residual effects that may remain after completion of cleanup.

The third period, long-term post-cleanup (until 3064), is not being evaluated for risks to cultural resources. This is because it is difficult to predict the presence of cultural resources for a period so remote as no tools exist to determine which of the resources considered significant today and in the near future will have the same significance hundreds of years from now.

2.4. CONSIDERATION OF UNCERTAINTY IN THE HANFORD RISK REVIEW PROJECT

The Hanford Risk Review Project is not a regulatory risk assessment; however, the project has many elements in common with regulatory risk assessment, especially in terms of the uncertainties in the information used, including that from prior assessments. For example, each step in the risk assessment process incurs several types of uncertainties, and these uncertainties encumber discussions of risk and communication of risk. Uncertainty is inherent in the process even when using the most accurate data and the most sophisticated models (EPA 2005). Sources of uncertainty include (1) intrinsic variability in the processes, variables being studied or analyzed, and variation in biological systems (including humans and eco-receptors); (2) model variability (including parameter estimates); (3) decision-rule variability (choices of processes or variables for inclusion and standards for comparison); and (4) residual variability due to random errors, systematic errors, and inadequate sampling or data. In some cases uncertainties can be estimated or bounded, while in other cases they are unknown. Some information is unknown, and some is unknowable, although more data can often reduce these uncertainties (EPA 2005).

For the Risk Review Project, a central uncertainty results from the unevenness in terms of the extent of information available for individual EUs, which is frequently very limited or incomplete (and in some cases inconsistent). Identifying key data gaps is also an important part of characterizing risk. The variability in available data is a direct result of the long time period and step-wise process being taken for cleanup of the Hanford Site and the fact that different EUs are at different stages of investigation and cleanup. There are also uncertainties in the natural chemical, hydrologic, and biological systems themselves, as well as the waste characterization and distribution of current environmental contamination. The Risk Review Project has used consistent sources of information wherever possible and has selected a rough order-of-magnitude basis for comparing risks (i.e., ratings for different receptors[62]) as a way of managing the large uncertainties and differing states of information as described below. As stated, the major contaminated sites were grouped into 64 EUs to make the Risk Review Project and its results tractable. There is an inherent trade-off between grouping contaminated areas into EUs (with the concomitant loss of information, specificity, and variability due to aggregation of source information) and the ability to complete the Project and provide sufficient information to support decision making in a timely and efficient manner. Contaminated areas were grouped in a way to minimize the loss of information and to not mask major risk factors (considering the rough order-of-magnitude basis used for comparison). Where found necessary, evaluations are focused on a much finer gradation, including consideration of individual operable units for potential groundwater impacts and individual tank farms (and individual waste tanks and constituents) for evaluating impacts from Hanford tanks and farms.

Additional information on key uncertainties and the approaches used in the Risk Review Project evaluations is provided in the methodology, Section 2.14 (CRESP 2015b).

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[62] For example, ratings of ND to Very High for impacts to groundwater as a protect resource *or* ecological impacts are intended to represent the same comparative ratings; however, ratings are not intended to represent the same results across impacts (e.g., a Low rating for potential impacts to groundwater as a protected resources does not have the same meaning as a Low rating for ecological impacts).

CHAPTER 3. RESULTS FROM REVIEW FOR EACH CATEGORY OF EVALUATION UNITS

3.1. LEGACY EVALUATION UNITS

The Hanford Legacy Source evaluation units (EUs) represent sites containing contaminant releases to the ground surface or subsurface resulting from prior actions, including waste disposal actions that are no longer being carried out at a particular location and are potentially subject to cleanup. They include past practice liquid waste disposal sites (e.g., cribs, ponds, and ditches), buried solid waste sites (including retrievably stored TRU waste sites), unplanned releases, and associated underground piping and infrastructure. These EUs also contain miscellaneous active and inactive buildings and structures associated with maintenance operations, laundry services, former coal power plants, low activity waste grouting, and nonradioactive hazardous and solid waste landfills. Legacy Source EUs may affect human health and environmental resources primarily either through near-surface soil-borne contamination or through potential impacts to groundwater.

An evaluation has been completed on the current condition and cleanup alternatives for the 21 Legacy Source EUs and a comparison of findings is provided in the summaries below. Figure 3-1 is a map of the Hanford Site showing the location of each of these EUs, with green stars identifying the four EUs that were included in the Interim Report and red stars identifying the EUs evaluated as part of this Final Report. More information on the EUs may be found in the Evaluation Templates (see generally Appendix G). Several Legacy Source EUs and their associated templates have been consolidated based on their similarities in contaminants, sources, and disposal method. No risk review template was prepared for RC-LS-3 Pre-Hanford Orchard Lands. Thus, the templates for the 21 Legacy Source EUs are found in 12 appendices, numbered G.2 through G.13.

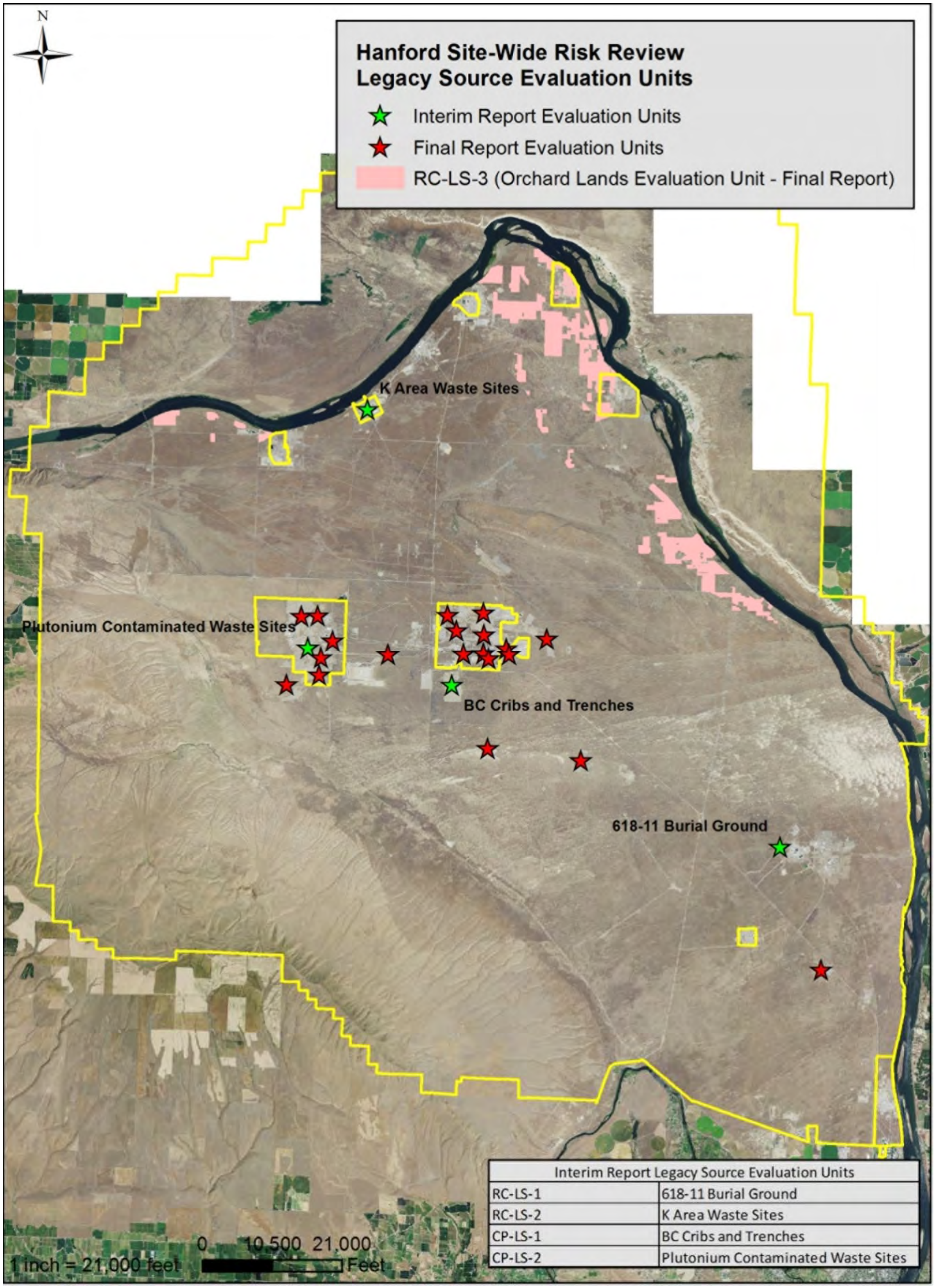

Figure 3-1. Legacy source evaluation unit locations.

Description of Legacy Source Evaluation Units

The following sections include short overview summaries of the Hanford Legacy Source Group of Evaluation Units:

- 618-11 Burial Ground (RC-LS-1)
- K Reactor Area Waste Sites (RC-LS-2)
- Pre-Hanford Orchard Lands (RC-LS-3)
- 618-10 Burial Ground and 316-4 Waste Site (RC-LS-4)
- BC Cribs and Trenches (CP-LS-1)
- Plutonium Contaminated Waste Sites (CP-LS-2)
- U Plant Cribs and Ditches (CP-LS-3)
- REDOX Cribs and Ditches (CP-LS-4)
- U and S Ponds (CP-LS-5) and B Pond (CP-LS-11)
- T Plant Cribs and Ditches (CP-LS-6)
- 200 Area HLW Transfer Pipeline (CP-LS-7)
- B Plant Cribs and Trenches (CP-LS-8)
- PUREX Cribs and Trenches (inside 200 E) (CP-LS-9)
- PUREX and Tank Farm Cribs and Trenches (outside 200 E) (CP-LS-10)
- 200-W Burial Grounds (CP-LS-12)
- 200-W Waste Sites (CP-LS-13)
- 200-E Burial Grounds (CP-LS-14)
- 200-E Waste Sites (CP-LS-15)
- Grout Vaults (CP-LS-16)
- BC Controlled Zone (CP-LS-17)
- Outer Area Sites (CP-LS-18)

618-11 Burial Ground (RC-LS-1)

The 618-11 Burial Ground (Figure 3-2) received TRU and mixed fission waste from March 1962 until December 1967 from all of the 300 Area radioactive material handling facilities. The burial ground consists of three trenches, approximately 900 ft long, 25 ft deep, and 50 ft wide, laid out in an east-west direction. The trenches comprise 75% of the site area. There are 50 vertical pipe units (VPUs) that consist of five 55-gallon steel drums welded together and placed vertically in the soil. These are buried in three rows in the northeast corner of the site. There are also approximately five 8-foot-diameter caissons situated at the west end of the center row of the vertical pipe units (Figure 3-3).

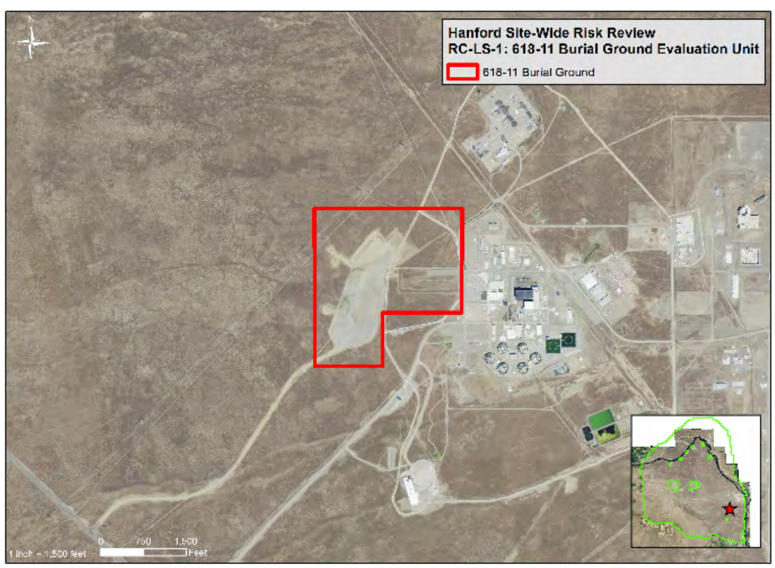

Figure 3-2. Aerial view of 618-11.

Current Status: The 618-11 Burial Ground is closed, covered with soil, and vegetated. It is currently embedded with unconsolidated sands and gravels of the Hanford formation and covered with eolian silts characteristic of this region that have been vegetated with crested wheatgrass. The vegetated silt acts as a hydraulic barrier that limits percolation of meteoric water into the waste to minute amounts (1 to 3 mm/yr). However, there is gravel cover over the vertical pipe units and caissons that facilitates elevated levels of infiltration and may drive future contaminant release to the groundwater.

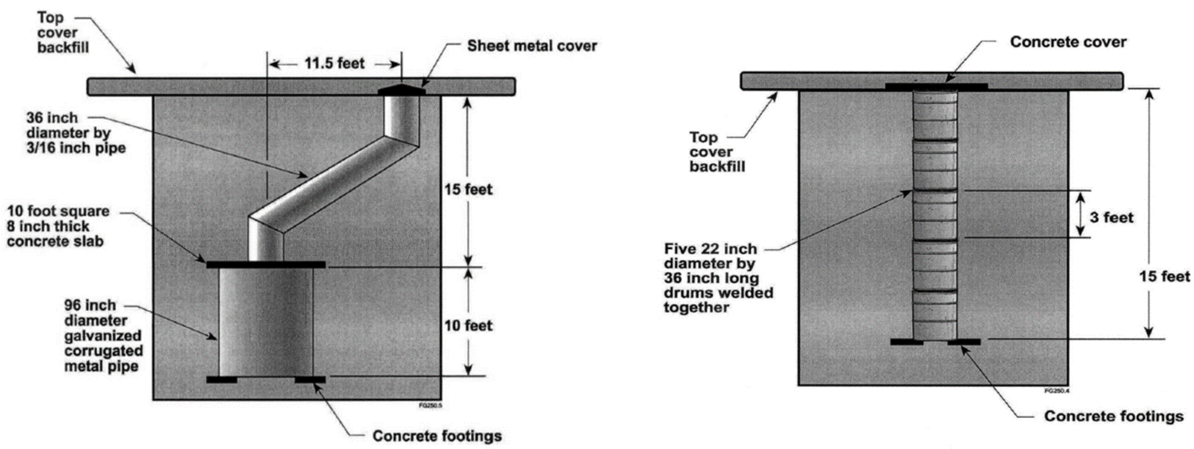

Figure 3-3. Illustrations of caissons and vertical pipe units at the 618-11 site (DOE CP-14592).

A plume containing tritium and nitrate is beneath the site. Concentrations are diminishing due to natural dilution, dispersion, and decay such that the tritium concentration is not expected to exceed drinking water standards when the plume reaches the Columbia River. That is, natural attenuation processes are managing the plume effectively. Additional releases of tritium may occur in the future as a result of leakage from disposed containers.

Primary Contaminants: The waste material was generated during laboratory examinations and studies, including analyses of reactor fuel samples, characterization of the chemical and physical properties of immobilized forms of plutonium, and analysis of ruptured reactor fuel (Dunham 2012). Specific waste items may include wipes, towels, protective clothing, cardboard, metal cans, high-efficiency particulate air (HEPA) filters, stainless steel tubing, plastic pipe, lead (bricks and sheeting), polyethylene bottles, failed machinery, used labware (beakers, pipettes, vials, and tubing), gloves, lab equipment (balances, drying ovens, heating mantles, pumps, and reaction vessels), thermometers, concrete, soil, plumbing fixtures, and tools (screw drivers, wrenches, and shears). Some drums disposed of in trenches contain oil. Also included are sample residues from nuclear fuel pellets, ruptured fuel elements, ceramics, and grouted plutonium in cans.

Surficial contamination was noted in 1980 after the site was initially closed and covered with soil. The entire site was subsequently regraded, backfilled with an additional 2 ft of soil, and seeded with crested wheat grass. The seed was irrigated for 6 weeks to establish the vegetation. The current barriers to release include an intact soil cover over the waste site. The depth varies based on what is covered (trench, caisson, vertical pipe units), but the cover is at least 2 m of clean soil. In addition, specific waste disposal units such as the vertical pipe units and caissons contain the higher activity wastes. Boxes containing low-level wastes (LLWs) that were disposed in the trenches probably have degraded.

Table 3-1 and Table 3-2 list the primary radionuclide and chemical contaminants present and estimated quantities in the 618-11 Burial Ground (RC-LS-1) EU**.**

Table 3-1. 618-11 Burial Ground (RC-LS-1) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	230
Carbon-14	A	NR[(b)]
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	5,300
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[(c)]	D	770
Strontium-90	B	4,200
Technetium-99	A	NR
Uranium-Total Rad[(d)]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-2. 618-11 Burial Ground (RC-LS-1) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	330
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: The primary risks associated with 618-11 arise from sampling, characterization, and removal operations because of the poorly characterized, high-activity and pyrophoric wastes that were disposed. A primary concern is that an upset event during cleanup activities may disrupt operations at the Columbia Northwest generating station, which borders 618-11.

Cleanup and Disposition: A new TPA milestone (DOE, EPA, and Ecology 2016), M-016-86, was recently approved that moves the completion date for remedial actions for 618-11 Burial Ground in accordance with the *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils* (DOE/RL-2014-13-ADD1) to September 30, 2021. Buried wastes and associated hard infrastructure (caissons, vertical pipe units) will be removed and disposed in ERDF. During remediation, the primary pathways are likely to be air releases from energetic events and/or accidental fires (where the site has a mixture of potentially explosive and or pyrophoric constituents).

When remediation is completed, contaminant levels will be below industrial cleanup standards. Over time, tritium in ground water will diminish below drinking water standards due to natural attenuation.

K Reactor Area Waste Sites (RC-LS-2)

The K Area Waste Sites (Figure 3-4) consist of a variety of sites within the fence at the 100-K Area associated with the original plant facilities constructed to support K Reactor operation. Included within the EU are 4 burial grounds (includes pits, dumping areas, burial grounds), 33 cribs (subsurface liquid disposal, including French drains, cribs, sumps), 2 infrastructure buildings, 10 pipelines and associated valves, 1 pond/ditch, 6 process buildings, 10 septic systems, 19 storage pads, 11 underground storage tanks, and 9 unplanned release sites. Many of the sites have no contamination but need to be removed as part of larger K Reactor area remediation efforts.

Figure 3-4. Aerial view of K Area Waste Site.

Current Status: Most of the waste sites around the K-East Reactor Building have been remediated; those around the K-West Reactor Building must wait for removal of the sludge in the K-West fuel basin and demolition of the basin and remaining ancillary buildings.

Primary Contaminants: Table 3-3 and Table 3-4 list the primary radionuclide and chemical contaminants present and estimated quantities in the K Area Waste Sites (RC-LS-2) EU**.** Most of the contamination resides in the soil and is sorbed onto sediments and soils.

Primary Risks: Many of the sites, such as underground pipelines, were never used with radioactive materials and so remediation is unlikely to expose radioactive contamination. Other sites are considered to have minimal contamination. An HA identified 18 potential scenarios. The postulated unmitigated hazardous conditions result in Low consequences to the onsite and offsite receptors and no significant impact to the Facility Worker. Several scenarios were identified as presenting a standard industrial hazard to the Facility Worker, which is consistent with the nature of the activities.

Table 3-3. K Area Waste Sites (RC-LS-2) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	110
Chlorine-36	A	NR
Cobalt-60	C	11
Cesium-137	D	0.67
Europium-152	D	0.0026
Europium-154	D	0.17
Tritium	C	82
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	0.019
Strontium-90	B	2.1
Technetium-99	A	NR
Uranium-Total Rad[d]	B	0.0022

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-4. K Area Waste Sites (RC-LS-2) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition: This waste site remediation needs to be coordinated with the K-West Sludge removal project and cocooning of the K-East and K-West Reactor Buildings. Many of the waste sites identified with this EU will be remediated through the process of "confirmatory sampling, no action," also known as CSNA. Others will be remediated through the process of remove-treat-dispose (RTD). For these sites, excavation, coupled with removal of underground structures such as piping, will take place, samples will confirm that cleanup criteria are met, and the site will be backfilled with clean and compacted soil. The contaminated soil will be disposed of at ERDF or elsewhere if it contains hazardous materials that exceed ERDF acceptance criteria. Where contamination must be left in place to maintain structural integrity, soils will be remediated to 15 ft below ground surface. To the extent practical, the current plan is for the soils to be cleaned such that unlimited future use is allowed. Where this is not practical, institutional controls and long-term monitoring will be required.

The known/likely presence of Native American cultural resources complicates remediation efforts.

PRE-HANFORD ORCHARD LANDS (RC-LS-3)

The Pre-Hanford Orchard Lands (Figure 3-5) consist of approximately 5,000 discontinuous acres along the River Corridor. The Orchard Lands EU is the area designated as the 100-OL-1 Operable Unit (OU) by the Tri Parties in 2012. Some regions of the Orchard Lands were disturbed during the Manhattan Project and Cold War; these areas are co-located within the 100-B/C, 100-KR-1, 100-HR-1, 100-HR-2, 100-FR-2, 100-IU-2, and 100-IU-6 vadose OUs.

Prior to the establishment of the Hanford Site in 1943, areas along the Columbia River primarily were devoted to agricultural operations, including fruit orchards. Historically, these orchards consisted of tree-fruits (i.e., apple, cherries, apricots, peaches, pears, plums, and prunes). Orchard operations accelerated beginning around 1905 as pumping plants capable of providing irrigated water via canals were more widely available. Inland areas became dependent on irrigated water supplied through these canal systems. However, in the 1930s, many of these inland operations failed due to drought conditions, low water supply, and the economic depression. When that occurred, trees were abandoned, and some were cut down for firewood while others are logs and branches where the trees died after irrigation ceased.

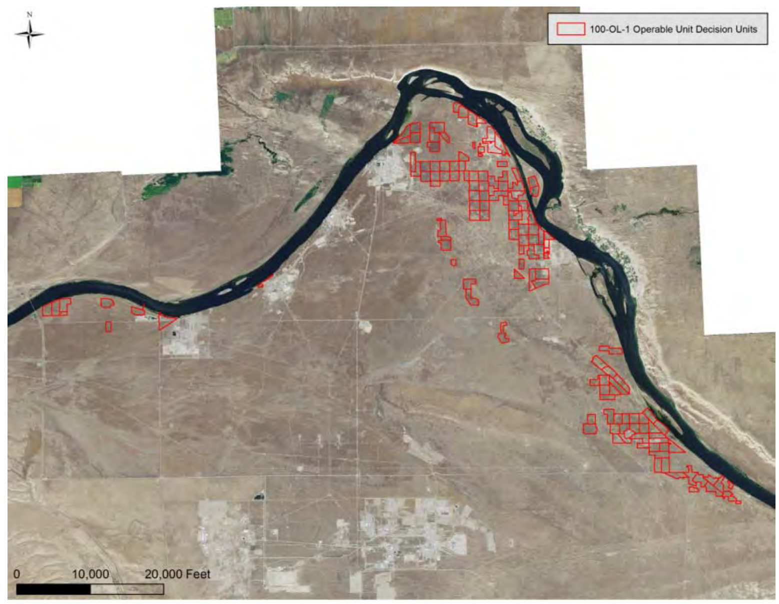

Figure 3-5. Aerial view of Pre-Hanford Orchard Lands.

To thrive, orchards and other crops required protection from frost and pests, including codling moths, scale, and mites. To control pests, a variety of insecticides was used. The most common and effective pesticide to destroy codling moths was lead arsenate. It could be sprayed as a powder or mixed in a solution, such as with soaps or oils, or applied as a mist. Other insecticides included cryolite (sodium aluminum fluoride) to control codling moths, “lime sulphur” to control scale, and “lime sulfate” to control mites. The persistence of the lead arsenate residues in the soil has been a concern on the Hanford Site as well as in other areas across the country.

The Manhattan Project and subsequent activities at the Site ultimately led to the cessation of all agricultural operations, including orchards.

Current Status: Evidence of the orchards remains today with old trees (mostly stumps and branches) still being visible. A pilot study of four regions within the OU was conducted in 2014 (DOE/RL-2012-64, Rev. 0 2016). Surface soils were characterized *in situ* using a field portable x-ray fluorescence analyzer to evaluate the nature and extent of lead and arsenic remaining from past pesticide applications in the orchards. The results demonstrated that the analyzer met quality control standards. Additionally, samples contained concentrations of lead and arsenic exceeding the screening criteria for unrestricted use by Washington State administrative code.

A Remedial Investigation Work Plan (DOE/RL-2012-64, Rev. 0 2016) has been approved that identifies future tasks to complete the remedial investigation for the 100-OL-1 OU. On approval of the remedial investigation by DOE, EPA, and Ecology, the feasibility study will be undertaken.

Primary Contamination: Surface soil samples taken at four locations during the pilot study found lead (Pb) and arsenic (As).

Primary Risks: Until such time as the feasibility study is completed, insufficient information exists about the extent of contamination at the EU to complete both an evaluation of risk to humans and impacts to resources and a rating of the EU.

Cleanup and Disposition: No cleanup or disposition decisions have been made.

618-10 Burial Ground (RC-LS-4)

Figure 3-6. Aerial view of the 618-10 Burial Ground.

The 618-10 Burial Ground (Figure 3-6) was operated from March 1954 until September 1963. This site consists of 12 slope-sided trenches and 94 vertical pipe units (VPUs). The base of the burial ground is about 36 ft above ground water with the average depth of the burial ground about 25 ft below the ground surface. The 618-10 Burial Ground received low- to high-activity radioactive waste, including fission products, small amounts of irradiated fuel element sample residue, and some plutonium-contaminated waste from the 300 Area laboratories and fuels development facilities. The low-activity containing wastes were primarily disposed of in trenches while the moderate- and high-activity wastes were primarily disposed of in the VPUs. A portion of the moderate- to high-activity wastes was also disposed in trenches in concrete/lead-shielded drums (DOE 2014).

Wastes included radiologically-contaminated laboratory instruments, bottles, boxes, filters, aluminum cuttings, irradiated fuel element sample residues, metallurgical samples, electrical equipment, lighting fixtures, barrels, laboratory equipment and hoods, and low- and high-activity waste sealed in containers. The actual contents of the containers transported to the burial ground are uncertain; however, radiological survey records provide the number of waste shipments and the types of containers used. Trenches generally received low-activity containing wastes in cardboard boxes. Materials with higher levels of radioactivity were packaged in concrete and lead-shielded drums for disposal in the trenches.

The 316-4 Crib is an inactive, liquid, radioactive, mixed waste site located about 35 m southeast of the 618-10 site. It consists of two inverted, bottomless, 0.25-in. stainless steel tanks. The tanks have concrete footings and sit on a bed of gravel. They are 10 ft below grade and have discharge and ventilation pipes leading to the surface (DOE/RL-2009-30 2010).

Current Status: The 618-10 Burial Ground and 316-4 Crib are a closed waste site undergoing active remediation[63]. TPA Milestone M-016-00B requires that all 300 Area remedial actions, except for the 618-11 Burial Ground, be completed by September 30, 2018.

Primary Contaminants: The 618-10 Burial Ground received low- to high-activity radioactive waste, including fission products, transuranics, small amounts of irradiated fuel element sample residue, and some plutonium-contaminated waste from the 300 Area laboratories and fuels development facilities. Radiological and chemical hazards include, but are not limited to, cesium, strontium, plutonium, americium, neptunium, beryllium, uranium, lead, zirconium, and deactivated sodium-potassium metals (DOE 2014).

Based on a thorough review of historical records and detailed modeling of waste disposals, the radiological inventory of the 618-10 Burial Ground is estimated to be 4,690 curies (130.1 plutonium-239 dose-equivalent curies [DE-Ci] of which 359 curies [10.3 DE-Ci] are located in the trenches and 4,330 curies [119.8 DE-Ci] are located in the VPUs).

Residual quantities of chemical wastes associated with laboratory and fuel-manufacturing processes were also disposed of in the 618-10 Burial Ground. Small quantities of solid waste contaminated with beryllium as a result of N Reactor fuel development and fabrication activities were disposed of in the trenches.

The 316-4 Crib received an estimated 200,000 L of hexane-bearing uranium wastes, approximately 2,205 lb of nitrate, 4,409 lb of uranium, and 6,614 lb of hexane (DOE/RL-2009-30 2010). Radiological and volatile organic contamination has been found in several boreholes near the 618-10 and 316-4 sites (Bradford 2006). Remediation of the site began in 2004 and the planned excavation was completed in April 2005. The extent of contamination in the soil resulting from the use of the 316-4 Crib will be further evaluated following completion of the 618-10 site remediation work.

The 618-10 Burial Ground and adjacent 316-4 Crib are the sources of uranium detected in groundwater at the 618-10 Burial Ground site, but there are no plumes (i.e., measured concentrations above the drinking water standard) associated with the RC-LS-4 waste sites in the area (DOE/RL-2016-09, Rev. 0). Uranium concentrations in nearby downgradient wells increased in 2004 and again in 2012 following application of dust-control water during implementation of the interim remedial action. The 316-4 Crib, which received liquid waste containing uranium, also is the source of tributyl phosphate contamination in groundwater.

Table 3-5 and Table 3-6 list the primary radionuclide and chemical contaminants present and estimated quantities in the 618-10 Burial Ground and adjacent 316-4 Crib (RC-LS-4) EU**.**

Primary Risks: A 2014 DSA (WCH-459, Rev. 1, 2014) considered 11 events with the largest potential releases or consequences at the 618-10 Burial Ground during active remediation. It determined that five

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[63] "Workers are in the final stages of completing two components of the cleanup of Hanford's 618-10 burial ground, recently completing the removal of the final buried piece of pipe filled with contaminated waste and the removal of contaminated soil from the 316-4 waste site…. Workers are now removing the remaining contaminated soil in a mass excavation effort that, once completed later this year [CY 2017], will be followed by verification sampling to validate cleanup levels have been achieved and then complete backfilling the excavated site." (http://www.hanford.gov/news.cfm/RL/618-10_Press_Release.pdf)

would cause an unmitigated radiological dose to the Co-located Person that is equivalent to an ND human health risk rating. The other six would cause a radiological dose of greater than 0.1 rem but less than 2.0 rem to the Co-located Person, which is equivalent to a Low human health risk rating. Of these, four would cause a dose of 0.32 to 0.53 rem. The two with the highest consequential dose to the Co-located Person are related fires during potholing trench excavation work during remediation.

Table 3-5. 618-10 Burial Ground (RC-LS-4) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[(b)]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[(c)]	D	130[(e)]
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[(d)]	B	0.00013

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238
e. Units are Pu-239 dose equivalent curies (DE-Ci)

Table 3-6. 618-10 Burial Ground (RC-LS-4) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	0.77
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	350
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	0.19

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition: The 618-10 site is currently undergoing active remediation. The remediation of the trenches, which began in March of 2011, was considered high risk because the trenches are known to contain a large radiological inventory and have the potential to release airborne contaminants. To minimize these risks, the remediation program used a combination of engineering controls and monitoring equipment. Development of the controls was based on experience gained from previous experience with Hanford nuclear site burial ground remediation, including evaluations of operational parameters and past practices from a number of Hanford remediation projects using open excavation designs (Haass and Walton 2012).

The process chosen for remediation of the 618-10 VPUs was to install a steel over-casing around the VPU, then auger the contents to size-reduce and stabilize the VPU and its contents, and finally mix with the soil within the over-casing to form a waste/soil matrix. The over-casing is a 4 ft diameter, 0.5-in. thick carbon-steel pipe that is approximately 28.3 ft long. A crane with a vibratory hammer was used to drive the casing into the ground until it extended several feet below the bottom of the VPU. Approximately 3.5 ft of over-casing remains above the ground to provide a safety barrier during the subsequent remediation phases (Washington Closure Hanford 2015). If the augured VPU is determined to meet the ERDF waste acceptance criteria (WAC) for radiological constituents, grout will be introduced and mixed with the contents. If it is not determined that the augured VPU meets the ERDF WAC (e.g., suspect TRU or greater than Class C waste), the augured VPU will be retrieved and transferred into drums. The drums filled with the augured VPU will be radiologically characterized. Drums that contain waste that is determined to meet the ERDF WAC will be grouted and shipped to the ERDF. Drums that contain waste that is not determined to meet the ERDF WAC will be shipped to the CWC for eventual shipment to the Waste Isolation Process Plant (WIPP) (Haass and Walton 2012).

This auguring process became operational in September 2015. By April 2016 the waste in 38 VPUs had been augured and mixed with grout, and non-TRU waste was beginning to be removed to ERDF (Cary 2016)[64].

[64] Excavation of the 316-4 waste site to about 67 feet deep to groundwater, and removal of the last vertical pipe unit (VPU) and retrieval of the 2,201 contaminated drums and other debris waste at the 618-10 Burial Ground site

BC Cribs and Trenches (CP-LS-1)

CP-LS-1 includes the BC Cribs and Trenches, which are part of the 200-BC-1 OU and Zone A in the northern portion of the adjoining unplanned release site UPR-200-E-83, which is part of the BC Control Zone and 200-UR-1 OU (Figure 3-7). This EU is located south of the 200 East Area near the center of the Hanford Site and lies between Route 4S and the Army Loop Road. The 200-BC-1 OU consists of 28 waste sites, including 26 cribs and trenches, one siphon tank, and one pipeline. These waste sites were used in the 1950s to dispose of more than 38 million gal (140 million L) of tank waste supernatant from the B, BX, BY, and C Tank Farms. Four trenches received smaller quantities of liquid waste that were generated in the 300 Area and transferred by tanker truck to the 200 Area. The largest volume of waste at these sites was disposed of in six cribs and 16 trenches and was conveyed by an underground pipeline from the B, BX, BY, and C Tank Farms.

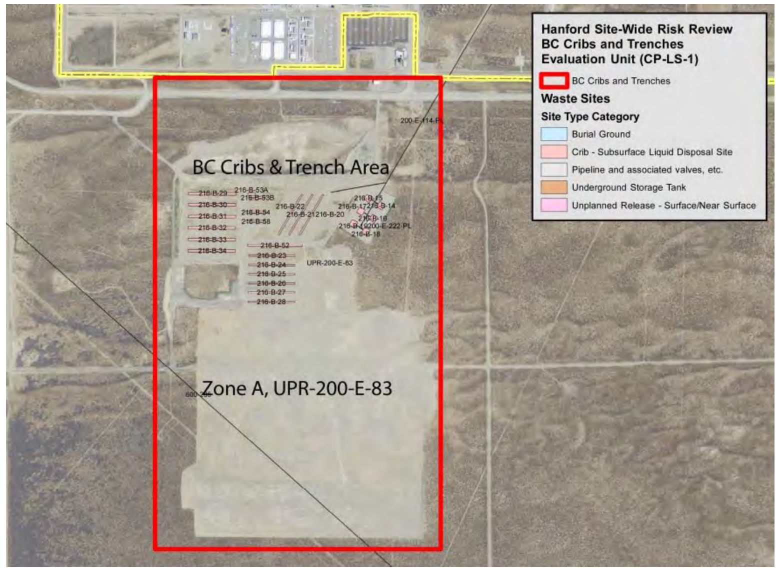

Figure 3-7. Aerial view of BC Cribs & Trenches and Zone A.

The northern section of UPR-200-E-83 adjoins the BC Cribs and Trenches to its south and became contaminated as a result of animal intrusion and wind dispersion from the BC Cribs and Trenches. In 1969, about 46,000 m^3 (60,000 yd^3) of sand and gravel were used to cover and stabilize the BC Trenches in an effort to stop the spread of contamination from these sources by animals. However, sampling and studies showed that contamination continued to spread, and in 2008 radioactive hazardous substances in the northern part of the site were found to present a potential threat to human health and the environment to the extent that a removal action was warranted before a final remedial decision was documented. A 140-acre area designated as Zone A was identified as having the highest continuous radiological contamination that was greater than the 200-UR-1 OU radionuclide soil cleanup preliminary remediation goals (PRGs) and presenting the greatest risk to human health and the environment. Zone A is located directly south of the BC Cribs and Trenches area. The 3,660-acre balance of the northern section of UPR-200-E-83 was designated as Zone B and is included in the CP-LS-17 (BC Controlled Area) EU.

Current Status: The BC Cribs and Trenches waste sites are separated into the following four distinct groups based on waste site configuration, primary waste source, and relative volume of waste received: (1) high-volume scavenged waste cribs and trenches, (2) specific retention scavenged waste trenches, (3) specific retention 300 Area waste trenches, and (4) one underground storage tank (200-E-14). An additional contaminant source is derived from the contaminated vadose zone underneath the cribs and trenches. The area is currently covered with clean soil backfill.

were completed in March-May 2017. Excavation of the remaining contaminated soil at the site will be completed later in 2017, followed by verification sampling to validate cleanup levels have been achieved and then complete backfilling the excavated site.

Removal of the contaminated soils in Zone A of UPR-200-E-83 began in 2008 and was completed in 2011. Approximately 483,000 tons of contaminated soil was removed and the area was revegetated with seed and about 280,000 pounds of mulch.

Primary Contaminants: The primary contaminants present at the BC Cribs and Trenches include nitrate (NO_3^-), chromium, Tc-99, Sr-90, Cs-137, U-238, and Pu (Table 3-7 and Table 3-8). According to Ward, et al. (2004), the BC Cribs and Trenches are believed to have received approximately 30 Mgal (million gallons) of scavenged tank waste containing an estimated 400 Ci of Tc-99 as well as large quantities of NO_3 and U-238.

The physical states of the primary contaminants are adsorbed in the contaminated soil and present in crib and trench debris, and the depth of contamination varies by waste site and contaminant. Serne, et al. (2009, pp. 9.2 and 9.3) indicate that there is an approximately 15-ft-thick layer of sandy silt and fine silty sand at a depth of approximately 120 to 130 ft below ground surface that contains "elevated technetium-99 and EC (electrical conductivity)," and that "the most elevated nitrate concentrations are found from 28 to 245 ft bgs." According to Ward, et al. (2004, p. 1.1),

> "Tc-99 at concentrations over 75,000 pCi/L were recently reported for a monitoring well near SX-115, although the exact source is unknown. In contrast, some 3.686 x 10^6 L (9.737 × 10^6 gal) of supernatant fluid containing 128 Ci of Tc-99 were discharged to seven trenches over a period of about 1.5 years in the BC Cribs and Trenches area, yet there is no evidence of groundwater contamination from the cribs or trenches. The current distribution of Tc-99 in the vadose zone beneath 216-B-26 is therefore not easy to explain using current conceptual models. Recent sampling at the 216-B-26 Trench shows a zone of Tc-99 contamination between 18 and 53 m. The peak soil concentration exceeds 100 pCi/g, while the pore water concentration is approximately 1.4 x 10^6 pCi/L, both at a depth of about 30 m."

Table 3-7. BC Cribs and Trenches (CP-LS-1) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	190
Carbon-14	A	28
Chlorine-36	A	NR[(b)]
Cobalt-60	C	27
Cesium-137	D	5,000
Europium-152	D	1.7
Europium-154	D	130
Tritium	C	740
Iodine-129	A	0.65
Nickel-59	D	1.1
Nickel-63	D	95
Plutonium-Total Rad[(c)]	D	170
Strontium-90	B	4,400
Technetium-99	A	410
Uranium-Total Rad[(d)]	B	2.9

a. Inventory details and references are found in the corresponding EU appendix.

b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-8. BC Cribs and Trenches (CP-LS-1) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	23,000
Chromium-VI	A	NR
Mercury	D	35
Nitrate	C	2.2E+07
Lead	D	61
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	3,700

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: The primary risk to human health would be through direct contact with the waste in the cribs and trenches area, particularly cesium-137 and strontium-90, because high concentrations of cesium-137 and strontium-90 are at relatively shallow depths in the cribs and trenches. However, casual contact with the waste is prevented by site access controls and the layer of clean soil over the buried wastes. The primary vadose zone risks to groundwater (rated as High) are Tc-99, I-129, Cr(total), and Cr(VI). A significant quantity of Sr-90 is present but is not anticipated to contaminate groundwater within the 150-year evaluation period.

Radiological surveys with mobile survey systems demonstrated that excavation and soil removal of soils in Zone A of the northern section of UPR-200-E-83 eliminated the direct contact exposure pathway for cesium-137, thereby preventing future releases of radiological contamination from this site.

Cleanup and Disposition: The designated future land use is Industrial-Exclusive. For the BC Cribs and Trenches Area waste sites, five remedial alternatives were identified for detailed and comparative analyses: (1) no action; (2) maintain existing soil cover, institutional controls, and monitored natural attenuation; (3) removal, treatment, and disposal; (4) capping; and (5) partial removal, treatment, and disposal with capping.

PLUTONIUM-CONTAMINATED WASTE SITES (CP-LS-2)

This EU consists of a variety of plutonium-contaminated cribs, trenches, piping, burn pits, and ancillary structures associated with PFP in the central part of the 200 West Area (Figure 3-8). CP-LS-2 is one of seven EUs situated in the 200 West Area of the Hanford Site. The 200 West Area is located in the middle of the Central Plateau, which encompasses the region where chemical processing and waste management activities occurred. Pipes conveyed the liquid waste from nuclear processing facilities to the waste sites. At the cribs, tile field, and French drain, liquid waste was discharged into a layer of gravel that drained into the underlying soil and may have drained laterally as well as downward. As a consequence, the soils in, or underlying, these sites contain substantial amounts of radionuclides, including plutonium and cesium, as well as large quantities of chemical constituents such as carbon tetrachloride, chromium, and nitrate.

Figure 3-8. Aerial view of Pu-Contaminated Waste Site.

Current Status: Most of the area is currently stabilized and covered with clean soil backfill, and many areas area are marked and posted as an underground radioactive material area. Soil vapor extraction was implemented as an interim action in 1992 to remove carbon tetrachloride from the vadose zone in 200-PW-1 overlying the 200-ZP-1 groundwater OU (DOE/RL-2016-09, Rev. 0). The system removed 80,107 kg of carbon tetrachloride from the vadose zone between 1992 and 2012, where 2012 was the last year of operation because EPA concurred that this remedy satisfied Remedial Action Objectives (RAOs) in the Record of Decision (DOE/RL-2016-09, Rev. 0). The 200 West pump and treat system was started in 2012 as a final remedy and has removed 9,264 kg of carbon tetrachloride; 249.91 kg of chromium; 242 pCi of I-129; 844,113 kg of nitrate, 4.82 Ci of Tc-99; and 36.73 kg of TCE; and 8.25 kg of U[65] by 2013 (DOE/RL-2016-09, Rev. 0).

Primary Contaminants: The primary radionuclide and chemical contaminants and inventory estimates for this collection of sites are provided in Table 3-9 and Table 3-10. Compared to other EUs evaluated in this report, this EU contains a substantial amount of mercury and TBP.

Primary Risks: Many of the principal contaminants of concern (plutonium, cesium, strontium, and uranium) are relatively immobile in soils in the absence of significant amounts of water to mobilize them. However, other contaminants such as carbon tetrachloride may pose a long-term threat to groundwater unless they are further reduced in concentration.[66] No hazard assessment or DSA has been

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[65] Uranium is not a contaminant of concern for the 200-ZP-1 OU; it is included to track 200-UP-1 groundwater treated.

[66] Approximately 910,000 kg of carbon tetrachloride was discharged to waste sites associated with the CP-LS-2 EU (Appendix G.5.2). Through 2015, treatment activities, including two pump and treat systems and soil vapor extraction in the Central Plateau removed 103,282 kg, or approximately 11% of the amount originally discharged

found for these specific sites, but it is estimated that the principal hazard would be collapse of trenches with potential for small localized release of radioactive materials. The primary threat to groundwater is from carbon tetrachloride (rated Very High), although it has been treated by vapor extraction and is currently being treated by the 200 West pump-and-treat system. Chromium also is considered a threat to groundwater (rated Medium). A significant amount of Sr-90 is present in the vadose zone but is not anticipated to impact groundwater because of retention in the vadose zone and radioactive decay.

Cleanup and Disposition: Because this EU contains multiple sites, a series of remedial actions have been identified based on their specific characteristics and inventories. Groundwater remediation is in progress using the 200 West pump-and-treat system. Clean soil covers will be added back over sites to provide at least 15 ft of cover over cesium-contaminated soils. Institutional controls and long-term monitoring will be required for sites where contamination is left in place and to ensure that land use is consistent with the ROD. The large volume of waste associated with these sites and structures makes complete retrieval and disposal infeasible. Where possible, TRU waste will be recovered and disposed of at the Waste Isolation Pilot Plant (WIPP). Other contaminated soils will be disposed at the ERDF. However, there will be residual waste left in place that is not feasible to retrieve.

Table 3-9. Plutonium Contaminated Waste Sites (CP-LS-2) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	27,000
Carbon-14	A	0.000015
Chlorine-36	A	NR[b]
Cobalt-60	C	0.026
Cesium-137	D	160
Europium-152	D	0.000069
Europium-154	D	0.0070
Tritium	C	0.0015
Iodine-129	A	0.0037
Nickel-59	D	0.00014
Nickel-63	D	0.013
Plutonium-Total Rad[c]	D	47,000
Strontium-90	B	160
Technetium-99	A	0.0036
Uranium-Total Rad[d]	B	1.7

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

to the vadose zone (DOE/RL-2016-09, Rev. 0). A sink other than treatment was the loss of carbon tetrachloride to the atmosphere. This amount is highly uncertain; a range of 21 to 38% was estimated (DOE/RL-2007-22 2007, p. 4-3).

Table 3-10. Plutonium Contaminated Waste Sites (CP-LS-2) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	910,000
Cyanide	B	NR
Chromium	B	3,500
Chromium-VI	A	NR
Mercury	D	760,000
Nitrate	C	7.9E+06
Lead	D	480
TBP	---	110,000
Trichloroethene	B	NR
Uranium	B	220

a. Inventory details and references are found in the corresponding EU appendix.

U PLANT CRIBS AND DITCHES (CP-LS-3)

The 200-WA-1 Operable Unit (OU (Figure 3-9), formerly part of the 200-UW-1 OU, is part of the Hanford 200 Area and consists of waste sites in the 200 West Inner Area not already assigned to other OUs. The waste sites primarily consist of liquid waste disposal sites associated with 221-U Facility operations and a few solid waste sites such as debris piles and a burial trench. The CP-LS-3 liquid waste disposal sites include cribs, trenches, French drains, septic systems, unplanned release sites, one underground settling tank (241-U-361), and one underground pipeline (200-W-42 Vitrified Clay Pipe) with significant near-surface vadose zone contamination (UPR-200-W-163).

Figure 3-9. U Plant Cribs and Ditches location.

Current Status: The waste sites were covered with clean soil, and the soil cover is maintained as needed to prevent release to the air or intrusion by biological receptors or humans. The primary accident scenarios are direct human and ecological contact as well as continued groundwater impact.

Primary Contaminants: The primary contaminants listed in the Soil Inventory Model (Corbin et al. 2005) for the CP-LS-3 EU include:

- *Radionuclides*: tritium or H-3, Co-60, Sr-90/Y-90, Tc-99, Cs-137/Ba-137m, U-All isotopes, Pu-All isotopes
- *Chemicals*: Cr/Cr-VI, Hg, nitrate (NO_3), Pb, U-Total, and tributyl phosphate (TBP

In aggregate, the largest radiological inventories that are known to be present (as measured in curies) are tritium or H-3 (12,000 Ci), Cs-137 (1,600 Ci), and Sr-90 (810 Ci). There are also 7.2 million kg of nitrate (NO_3) and 110,000 kg of total uranium introduced into the vadose zone.

Table 3-11 and Table 3-12 list the primary radionuclide and chemical contaminants present and estimated quantities in the U Plant Cribs and Ditches (CP-LS-3) EU**.**

The CP-LS-3 EU straddles an area including parts of both the 200-UP and 200-ZP groundwater interest areas (GWIAs) that are described in the CP-GW-2 EU (Appendix D.6). The saturated zone beneath the vicinity of the CP-LS-3 (U Plant Cribs and Ditches) area has elevated levels of chromium, nitrate, Tc-99, uranium (total), carbon tetrachloride (CCl_4), trichloroethene (TCE), and I-129 based on the 2014 groundwater monitoring results (http://phoenix.pnnl.gov/apps/gw/phoenix.html); sites within the CP-LS-3 EU are suspected of being able to contribute mobile contaminants to the saturated zone (DOE/RL-92-16, Rev. 0). Current threats to groundwater corresponding to only the CP-LS-3 EU contaminants *remaining* in the vadose zone (Appendix G.5.3) have an overall rating of High (based on total uranium).

Table 3-11. U Plant Cribs and Ditches (CP-LS-3) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	0.047
Carbon-14	A	0.011
Chlorine-36	A	NR[b]
Cobalt-60	C	0.20
Cesium-137	D	1,600
Europium-152	D	0.00063
Europium-154	D	0.034
Tritium	C	12,000
Iodine-129	A	0.013
Nickel-59	D	0.00075
Nickel-63	D	0.066
Plutonium-Total Rad[c]	D	0.81
Strontium-90	B	810
Technetium-99	A	11
Uranium-Total Rad[d]	B	25

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-12. U Plant Cribs and Ditches (CP-LS-3) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	420
Chromium-VI	A	NR
Mercury	D	2.7
Nitrate	C	7.2E+06
Lead	D	21
TBP	---	12,000
Trichloroethene	B	NR
Uranium	B	110,000

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: Facility workers are at risk when working in or around areas with contaminated soils, including working on active remedial activities involving these legacy sources; these remedial activities are currently not being conducted. Exposure to such contaminants is limited because waste sites and contaminated soils are located below grade. However, during certain operations (e.g., drilling, sampling, removal, treatment, and disposal) near the CP-LS-3 waste sites, there may be the potential for limited exposure to hazardous and radioactive contaminants; however, risks would be minimal and short-term, resulting from monitoring and maintenance activities conducted by experienced workers and appropriate safety precautions (DOE/RL-2003-23, Rev. 0, p. 5-14).

Cleanup alternatives range from no action (monitoring and natural attenuation) to significant actions, including installation of an engineered barrier and removal, treatment, and disposal (RTD) (DOE/RL-2003-23, Rev. 0). Thus impacts to Facility Workers (i.e., those performing the cleanup actions) from potential cleanup approaches would vary significantly.

Contaminants from the CP-LS-3 EU waste sites are currently impacting the vadose zone and groundwater; treatment processes are not predicted to decrease all concentrations to below thresholds before the Active Cleanup phase commences although there should be significant decreases in contaminant levels. Secondary sources in the vadose also threaten to continue to impact groundwater in the future, including the Active Cleanup period.

Cleanup and Disposition: There is no DSA, HA, or feasibility study that includes the CP-LS-3 waste sites. The *Focused Feasibility Study for the 200-UW-1 Operable Unit* (FFS) (DOE/RL-2003-23, Rev. 0) was used because the hazards (associated with buried liquid waste legacy sites) are assumed similar enough for the rough order of magnitude analysis provided in this review. Thus, the four alternatives (and the quantitative analysis) provided in the 200-UW-1 FFS are used instead of those provided in the Evaluation Unit Disposition Table (Appendix B) for this EU. The remedial action alternatives include:[67]

- No Action (Alternative 1)
- Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation (Alternative 2)
- Removal, Treatment, and Disposal (Alternative 3)
- Engineered Barrier (Alternative 4)

These were considered as standalone alternatives; however, impacts from remedial activities at adjacent sites should also be considered during implementation. These alternatives provide a range of remedial responses deemed appropriate to address site-specific conditions.

Monitoring and treatment of groundwater is being conducted within the 200-UP GWIA (via the WMA S-SX groundwater extraction system with treatment in the 200 West Pump and Treat facility, the U Plant area P&T system for the uranium plume, and the I-129 plume hydraulic control system), which is described as part of the CP-GW-2 EU (Appendix D.6). Treatment efforts indicate a general downward trend in contaminant concentrations; however, some plume areas have increased (e.g., carbon tetrachloride, chromium, and TCE in 200-ZP and all plumes except for nitrates and uranium in 200-UP) and concentrations continue to exceed cleanup levels.

The remedial actions that have either been identified (i.e., those non-time-critical actions for the CP-LS-3 waste sites also in the 200-MG-2 OU (DOE/RL-2009-37, Rev. 0)) or are being evaluated (e.g., those in the 200-UW-1 FFS (DOE/RL-2003-23, Rev. 0)) would leave existing contamination in CP-LS-3 waste sites as well as that contamination that has been released from CP-LS-3 waste sites into some shallow and deep vadose zones.

[67] Non-time-critical actions have also been defined for selected 200-MG-2 OU waste sites that are also within the CP-LS-3 EU (DOE/RL-2009-37, Rev. 0).

REDOX Cribs and Ditches (CP-LS-4)

The 200-WA-1 OU (Figure 3-10), formerly part of the 200-UW-1 OU, is part of the Hanford 200 Area and consists of waste sites in the 200 West Inner Area not already assigned to other OUs. The CP-LS-4 EU waste sites primarily consist of liquid waste disposal sites associated with 202-S (REDOX) Facility operations and a few other waste sites such as infrastructure buildings and pipelines and associated equipment. Liquid waste disposal sites include cribs, trenches, retention basins, and unplanned release sites. The 202-S process generated significant amounts of liquid waste that were discharged to various legacy waste sites (i.e., waste ponds, cribs, ditches, French drains, and trenches) (EPA 2012, p. 27). Ponds and ditches received the highest volumes of contact cooling water and steam condensates that were typically non-radioactive. Condensed process vapors and cell drainage (which were typically higher in radionuclide and chemical contaminants) were sent to cribs. French drains received the relatively very-low-volume radioactive waste streams. Nonradioactive and lower volume chemical sewer wastes were typically discharged to ponds and ditches, and septic systems used tile fields for nonradioactive wastes.

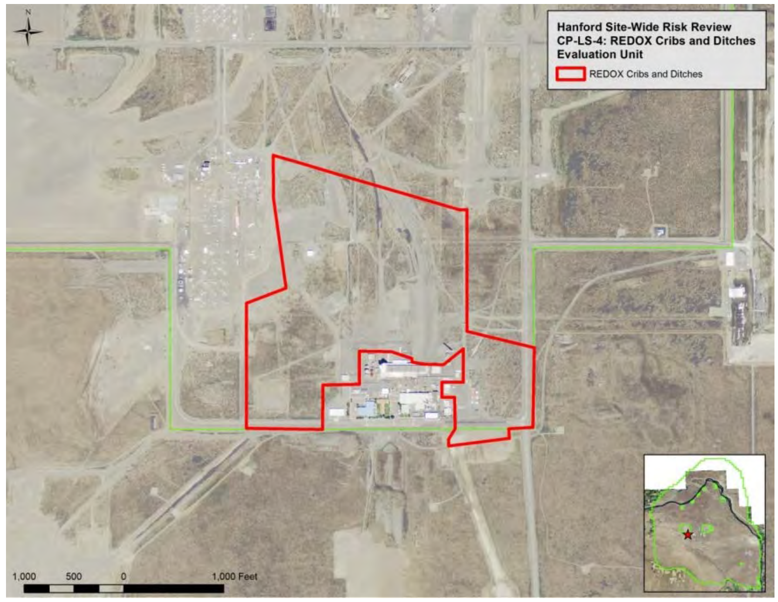

Figure 3-10. REDOX Cribs and Ditches location.

The CP-LS-4 EU waste sites include ten pipelines and associated equipment waste sites that are part of the Single Shell Tank (SST) System (DOE/RL-2010-114, Draft A, p. A-25 – A-28) that were assumed treated in the Tank Waste and Farms EU (Appendix E.1 through Appendix E.11). Other CP-LS-4 pipelines and associated equipment may have been addressed in the TC&WM EIS and thus Tank Waste and Farms EU (Appendix E.1 through Appendix E.11); however, the remaining pipeline and related wastes sites will not be evaluated further due to a lack of inventory information.

Current Status: The waste sites were covered with clean soil, and the soil cover is maintained as needed to prevent release to the air or intrusion by biological receptors or humans. The primary accident scenarios are direct human and ecological contact as well as continued groundwater impact.

Monitoring and treatment of groundwater (using the WMA S-SX groundwater extraction system, the U Plant area P&T system, and the I-129 plume hydraulic control system) is being conducted within the 200-UP GWIA, which is described as part of the CP-GW-2 EU (Appendix D.6).

Primary Contaminants: The primary contaminants listed in the Soil Inventory Model (Corbin et al. 2005) for the CP-LS-4 EU include:

- *Radionuclides*: Am-241, C-14, Co-60, Cs-137/Ba-137m, Eu-154, tritium or H-3, I-129, Sr-90/Y-90, Tc-99, U-All isotopes, Pu-All isotopes
- *Chemicals*: Cr/Cr-VI, Hg, nitrate (NO_3), Pb, and U-Total

In aggregate, the largest radiological inventories that are known to be present (as measured in curies) are tritium or H-3 (9,600 Ci), Cs-137 (1,300 Ci), and Sr-90 (1,700 Ci). There are also 660,000 kg of nitrate (NO_3); 5,900 kg of chromium; and 4,300 kg of total uranium introduced into the vadose zone.

Table 3-13 and Table 3-14 list the primary radionuclide and chemical contaminants present and estimated quantities in the REDOX Cribs and Ditches (CP-LS-4) EU**.**

The saturated zone beneath the CP-LS-4 area (REDOX Cribs and Ditches) is approximately 255 ft below ground surface and currently has elevated levels of nitrates, Tc-99, uranium, and carbon tetrachloride (DOE/RL-2003-24, Rev. 0). Sites within the CP-LS-4 EU are suspected of contributing mobile contaminants to the saturated zone (DOE/RL-92-16, Rev. 0). Monitoring and treatment (via pump and treat) of groundwater is being conducted within the 200-UP-1 OU, which is described as part of the CP-GW-2 EU.

Table 3-13. REDOX Cribs and Ditches (CP-LS-4) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	74
Carbon-14	A	2.7
Chlorine-36	A	NR[b]
Cobalt-60	C	1.3
Cesium-137	D	1,300
Europium-152	D	0.025
Europium-154	D	3.1
Tritium	C	9,600
Iodine-129	A	0.39
Nickel-59	D	0.00022
Nickel-63	D	0.021
Plutonium-Total Rad[c]	D	220
Strontium-90	B	1,700
Technetium-99	A	3.1
Uranium-Total Rad[d]	B	3.4

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-14. REDOX Cribs and Ditches (CP-LS-4) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	5,900
Chromium-VI	A	NR
Mercury	D	2.6
Nitrate	C	660,000
Lead	D	63
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	4,300

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: Facility workers are at risk when working in or around areas with contaminated soils, including working on active remedial activities involving these legacy sources; these remedial activities are currently not being conducted. Exposure to such contaminants is limited because waste sites and contaminated soils are located below grade. However, during certain operations (e.g., drilling, sampling, removal, treatment, and disposal) near the CP-LS-4 waste sites, there may be the potential for limited exposure to hazardous and radioactive contaminants, but risks would be minimal and short-term, resulting from monitoring and maintenance activities conducted by experienced workers and appropriate safety precautions (DOE/RL-2003-23, Rev. 0, p. 5-14).

Contaminants from the CP-LS-4 EU waste sites are currently impacting the vadose zone and groundwater; the aforementioned treatment processes are not predicted to decrease all concentrations to below thresholds before the Active Cleanup phase commences although there should be significant decreases in many contaminant levels (with the possible exception of I-129). Secondary sources in the vadose also threaten to continue to impact groundwater in the future, including the Active Cleanup period[68]. The High rating associated with the CP-LS-4 EU waste sites (Appendix G.5.4, Table G.5.4-5) is associated with a current I-129 plume in the 200-UP GWIA (which is part of CP-GW-2, Appendix G.6).

Cleanup and Disposition: There is no documented safety analysis, hazards analysis, or feasibility study that includes the CP-LS-4 waste sites. The200-UW-1 FFS (DOE/RL-2003-23, Rev. 0) was used because the hazards (associated with buried liquid waste legacy sites) are assumed similar enough for the rough order of magnitude analysis provided in this Risk Review Project. Thus, the four alternatives (and the quantitative analysis) provided in the 200-UW-1 FFS are used instead of those provided in the Evaluation Unit Disposition Table (Appendix B) for this EU. The remedial action alternatives include:[69]

- No Action (Alternative 1)

[68] Note that Sr-90 and total uranium, which have large remaining vadose zone sources, are not considered significant threats to groundwater due to their limited motilities in the Hanford subsurface and decay. See **Part V** of Appendix G.5.4 for details.
[69] Non-time-critical actions have also been defined for selected 200-MG-2 OU waste sites that are also within the CP-LS-3 EU (DOE/RL-2009-37, Rev. 0).

- Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation (Alternative 2)
- Removal, Treatment, and Disposal (Alternative 3)
- Engineered Barrier (Alternative 4)

These were considered as standalone alternatives; however, impacts from remedial activities at adjacent sites should also be considered during implementation. These alternatives provide a range of remedial responses deemed appropriate to address site-specific conditions.

There appears to be insufficient impact to the overall rating from radioactive decay (since I-129 is the risk driver), recharge rate (due to large amounts of contaminants already in the groundwater), or the containment of I-129 and treatment of other contaminants in the 200-UP GWIA (using the WMA S-SX groundwater extraction system, the U Plant area P&T system, and the I-129 plume hydraulic control system) to change ratings; thus the I-129 rating would remain High by the end of the Active Cleanup period, especially since I-129 may only be controlled during this period while treatment options are currently being evaluated.

The remedial actions that have either been identified (i.e., those non-time-critical actions for the CP-LS-4 waste sites also in the 200-MG-2 OU (DOE/RL-2009-37, Rev. 0)) or are being evaluated using the 200-UW-1 FFS (DOE/RL-2003-23, Rev. 0)) would leave existing contamination in CP-LS-4 waste sites as well as that contamination that has been released from CP-LS-4 waste sites into shallow and deep vadose zones.

LIQUID DISPOSAL PONDS: U AND S PONDS (CP-LS-5) AND B POND (CP-LS-11)

The two Liquid Waste Disposal Pond EUs, CP-LS-5 (Figure 3-11) and CP-LS-11 (Figure 3-12) are located in the western and eastern areas, respectively, of the Central Plateau 200 Inner Area. They have been combined into a single Evaluation Template because (1) the contaminants are primarily the result of chemical sewer discharges from the separation and concentration processes at the U Plant, REDOX (S Plant), B Plant, and Plutonium Finishing Plant (Z Plant), and other facilities in the 200 Area; and (2) the four primary TSD liquid waste sites within the two EUs – 216-S-10 Pond and Ditch, 216-S11 Pond, 200-A-29 Ditch, and 200-B-63 Ditch systems—are the primary components of the 200-CS-1 Chemical Sewer Group OU.

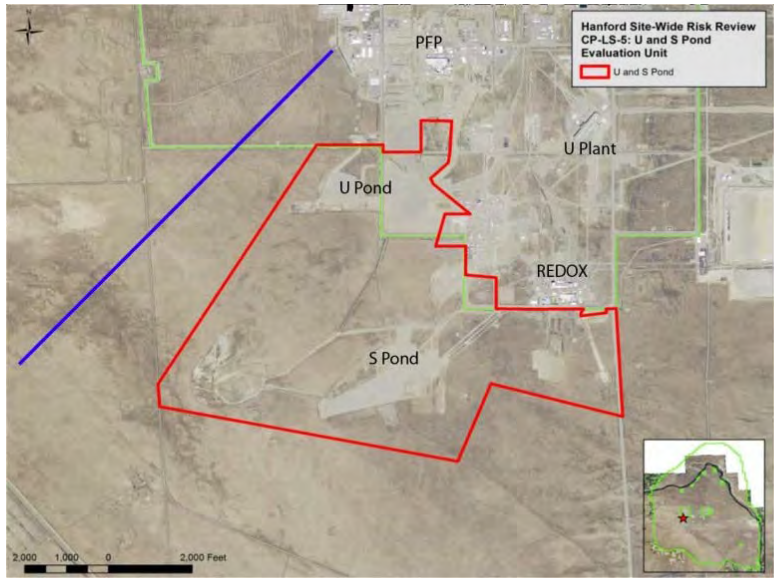

Figure 3-11. Aerial view of U and S Pond locations.

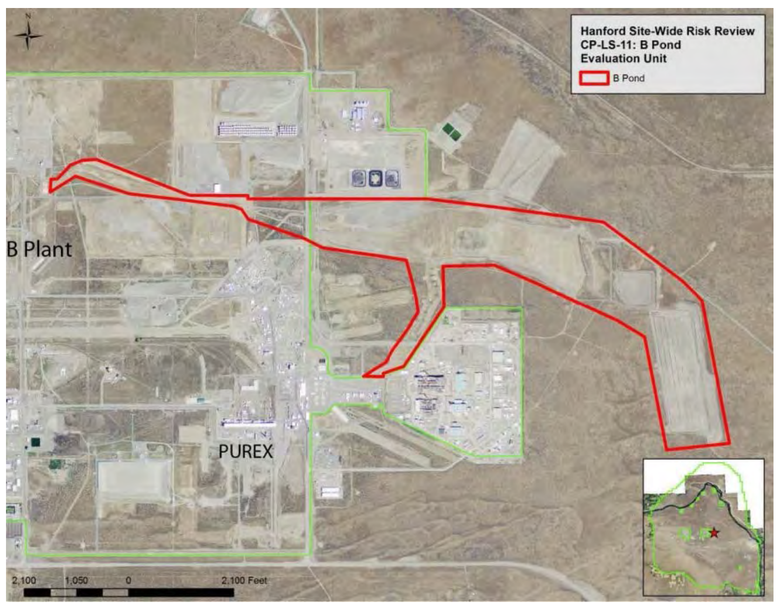

Figure 3-12. Aerial view of B Pond location.

Chemical sewer wastes were generated from many of the separation/concentration processes conducted at the large canyon buildings. The chemical sewers were designed to capture nonradioactive waste from operations in these process facilities, including operating galleries, service areas, aqueous makeup galleries, maintenance areas, overflow tanks, and various floor drains. Early chemical sewer wastes were combined with the larger cooling water and steam condensate streams during the bismuth phosphate ($BiPO_4$) and uranium recovery processes, and they were discharged to ponds and ditches. With the introduction of continuous solvent extraction processes at the Hanford Site, new plants such as the REDOX Facility, PUREX Plant, and the 1970s cesium/strontium recovery operations at B Plant were designed with separated chemical sewers and separate waste disposal sites.

Current Status: The various sites comprising these two evaluation units are currently inactive and awaiting decisions and future actions toward cleanup as determined appropriate.

Primary Contaminants: Primary contaminants in the two EUs are similar in that they were primarily the result of chemical sewer discharges from the separation and concentration processes at the U Plant, REDOX (S Plant), B Plant, Plutonium Finishing Plant (Z Plant), and other facilities in the 200 Area, but differ based on the processes being used in these canyons facilities. Wastes in the B Pond sites are fission products (Cs-137, Sr-90), plutonium, uranium, inorganics (such as nitrates), heavy metals (e.g., cadmium, chromium), and various organic waste (e.g., PCBs). Predominant contaminants within most of the U and S Pond sites are uranium, nitrates, chromium, and to a lesser extent tritium and various fission products. For the Z Ditches, the contaminants of concern are americium, plutonium, radium, PCBs, boron, mercury, cesium, and strontium. The contaminated media by and large is soil (sometimes in association with groundwater), with some small fraction of the media consisting of piping and limited concrete for spillways and flow control structures.

Table 3-15 and Table 3-16 list the primary radionuclide and chemical contaminants present and estimated quantities in the U and S Ponds (CP-LS-5) EU**.** Table 3-17 and Table 3-18 list the primary radionuclide and chemical contaminants present and estimated quantities in the B Pond (CP-LS-11) EU**.**

Though there is a widespread groundwater plume east of the U and S Ponds (CP-LS-5) site that includes hexavalent chromium, nitrates, and tritium, it is not known to what degree these sites have contributed to those plumes, if at all. However, current threats to groundwater corresponding to only the CP-LS-5 EU contaminants *remaining* in the vadose zone (Appendix G.6, Table G.6-5) has an overall rating of Very High (related to carbon tetrachloride). The saturated zone beneath the CP-LS-11 area has elevated levels of cyanide (CN), I-129, nitrate, Sr-90, Tc-99, tritium (H-3), and uranium (total) based on the 2014 groundwater monitoring results (http://phoenix.pnnl.gov/apps/gw/phoenix.html); sites within the CP-LS-11 EU are suspected of being able to contribute mobile contaminants to the saturated zone (DOE/RL-92-19, Rev. 0). Current threats to groundwater corresponding to only the CP-LS-11 EU contaminants *remaining* in the vadose zone (Appendix G.6, Table G.6-6) have an overall rating of Very High (based on carbon tetrachloride).

Primary Risks: The DOE has conducted a remedial investigation for the 200-CS-1 OU, as specified in the remedial investigation/feasibility study work plan and associated sampling and analysis plan approved by EPA (DOE/RL-2005-63, 2008). During the remedial investigation phase, four of the five waste sites (216-A-29 Ditch, 216-B-63 Trench, 216-S-10 Ditch, and 216-S-10 Pond) were chosen for field investigation. One of these four sites, the 216-S-10 Pond, is very similar to the remaining site, 216-S-11 Pond. The 216-A-29 Ditch was found to contain cesium-137 at a depth of about 4 to 5 ft below the ground surface, which should not represent a human health risk to a Facility Worker in its current location; however, the 216-S-10 Ditch was found to have benzo(a)pyrene (listed as a Group 1 carcinogen by the International Agency for Research on Cancer) at greater than human health cleanup requirement levels at the surface to 1.5 ft below.

There are no risk drivers present at the 216-B-63 Trench and the 216-S-10 and 216-S-11 Ponds.

Table 3-15. U and S pond (CP-LS-5) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	210
Carbon-14	A	2.8
Chlorine-36	A	NR[b]
Cobalt-60	C	6.3
Cesium-137	D	340
Europium-152	D	0.0012
Europium-154	D	0.13
Tritium	C	260
Iodine-129	A	0.22
Nickel-59	D	0.0024
Nickel-63	D	0.23
Plutonium-Total Rad[c]	D	1,900
Strontium-90	B	49
Technetium-99	A	0.13
Uranium-Total Rad[d]	B	3.7

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-16. U and S pond (CP-LS-5) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	39,000
Cyanide	B	NR
Chromium	B	12,000
Chromium-VI	A	NR
Mercury	D	210
Nitrate	C	6.4E+06
Lead	D	12,000
TBP	---	140,000
Trichloroethene	B	NR
Uranium	B	5,300

a. Inventory details and references are found in the corresponding EU appendix.

Table 3-17. B Pond (CP-LS-11) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	15
Carbon-14	A	130
Chlorine-36	A	NR[(b)]
Cobalt-60	C	0.30
Cesium-137	D	7,700
Europium-152	D	0.013
Europium-154	D	1.0
Tritium	C	21,000
Iodine-129	A	0.017
Nickel-59	D	0.017
Nickel-63	D	1.6
Plutonium-Total Rad[(c)]	D	360
Strontium-90	B	320
Technetium-99	A	2.0
Uranium-Total Rad[(d)]	B	12

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-18. B Pond (CP-LS-11) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	6,900
Cyanide	B	NR
Chromium	B	1,400
Chromium-VI	A	NR
Mercury	D	280
Nitrate	C	460,000
Lead	D	6,000
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	15,000

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition: Because the 216-A-29 Ditch and 216-B-63 Trench waste sites are located within an area that is anticipated to remain Industrial-Exclusive with existing institutional controls for the foreseeable future, the remediation goals and preferred remedial alternative were developed based on industrial land-use exposures and worker risks. For the 216-S-10 Ditch, 216-S-10 Pond, and 216-S-11 Pond, which lie outside the Industrial-Exclusive boundary, residential land-use exposures and worker risk scenarios were conducted to evaluate the units for clean closure.

Of the remediation alternatives evaluated in the 200-CS-1 OU Feasibility Study Report, the preferred alternative as selected by DOE, EPA and Ecology is to mitigate the source of the contamination as follows:

- 216-A-29 Ditch- Removal, Treatment, and Disposal
- 216-B-63 Trench- No Action
- 216-S-10 Ditch- Removal, Treatment, and Disposal
- 216-S-10 Pond- No Action
- 216-S-11 Pond- No Action.

A CERCLA risk evaluation of an industrial worker estimated an unmitigated risk of 5.9×10^{-4} excess lifetime cancer risk which is greater than the CERCLA action level. The levels of contamination at the 216-A-29 and 216-S-10 Ditches are not expected to pose a substantial health risk to remediation workers when typical mitigation practices are followed in accordance with a site specific health and safety plan. Typical practices should include enclosed excavation equipment and water-based dust suppression. These practices limit the worker risk, with minimal impact on schedule and cost because excavation with dust suppression and health and safety controls have been proven effective in excavating soil sites.

T Plant Cribs and Ditches (CP-LS-6)

The 200-WA-1 OU (Figure 3-13), formerly part of the 200-UW-1 OU, is part of the Hanford 200 Area and consists of waste sites in the 200 West Inner Area not already assigned to other OUs. The CP-LS-6 EU waste sites primarily consist of liquid waste disposal sites associated with T Plant operations and a few other waste sites such as infrastructure buildings and pipelines and associated equipment. Liquid waste disposal sites include cribs, ditches, trenches, ponds, wells, and unplanned release sites. The T Plant (221-T) process generated significant amounts of liquid waste that were discharged to various legacy waste sites (i.e., cribs, ditches, wells, and trenches). Cribs and drains were designed to percolate low-level liquid wastes into the soil without exposing it to air (DOE/RL-91-61, Rev. 0). Most cribs, drains, and trenches were designed to receive liquid until the unit's specific retention or radionuclide capacity was met.

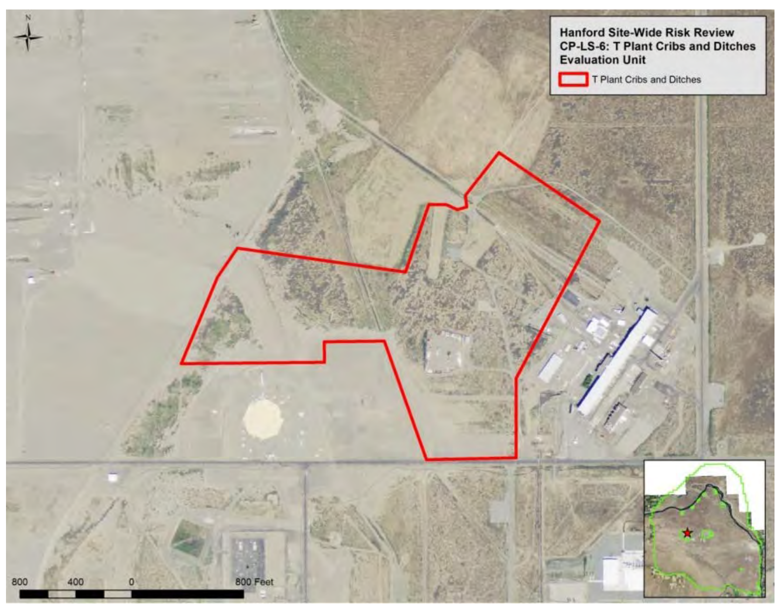

Figure 3-13. Aerial view T Plant Cribs and Ditches.

Current Status: The waste sites were covered with clean soil, and the soil cover is maintained as needed to prevent release to the air or intrusion by biological receptors or humans. The primary accident scenarios are direct human and ecological contact as well as continued groundwater impact.

Monitoring and treatment of groundwater is being conducted within the 200-ZP GWIA using the 200 West Pump and Treat Facility.

Primary Contaminants: The primary contaminants listed in the Soil Inventory Model (Corbin et al. 2005) for the CP-LS-6 EU include:

- *Radionuclides*: Am-241, C-14, Co-60, Cs-137/Ba-137m, Eu-154, Ni-63, Sr-90/Y-90, U-All isotopes, Pu-All isotopes
- *Chemicals*: Cr/Cr-VI, Hg, nitrate (NO_3), Pb, and U-Total

In aggregate, the largest radiological inventories that are known to be present (as measured in curies) are total Pu (14,000 Ci), Cs-137 (4,900 Ci), Am-241 (1,600 Ci), and Sr-90 (890 Ci). There are also 1 million kg of nitrate (NO_3) and 10,000 kg of chromium introduced into the vadose zone.

Table 3-19 and Table 3-20 list the primary radionuclide and chemical contaminants present and estimated quantities in the T Plant Cribs and Ditches (CP-LS-6) EU**.**

The saturated zone beneath the CP-LS-6 area (T Plant Cribs and Ditches) currently has elevated levels of Cr-VI, I-129, nitrates, and TCE based on the 2014 groundwater monitoring results (http://phoenix.pnnl.gov/apps/gw/phoenix.html). Associated plumes are described as part of the 200-UP Interest Area described in CP-GW-2 EU. Sites within the CP-LS-6 EU, including 216-T-3, 216-T-6, 216-T-34, and 216-T-35, are suspected of being able to contribute mobile contaminants to the saturated zone (i.e., representing migration of contaminants from the waste site to the uppermost aquifer) (DOE/RL-92-16, Rev. 0, Table 2-2).

Primary Risks: Facility workers are at risk when working in or around areas with contaminated soils, including working on active remedial activities involving these legacy sources; these remedial activities are currently not being conducted. Exposure to such contaminants is limited because waste sites and contaminated soils are located below grade. However, during certain operations (e.g., drilling, sampling, removal, treatment, and disposal) near the CP-LS-6 waste sites, there may be the potential for limited exposure to hazardous and radioactive contaminants, but risks would be minimal and short-term resulting from monitoring and maintenance activities conducted by experienced workers and appropriate safety precautions (DOE/RL-2003-23, Rev. 0, p. 5-14).

Table 3-19. T Plant Cribs and Ditches (CP-LS-6) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	1,600
Carbon-14	A	0.26
Chlorine-36	A	NR[b]
Cobalt-60	C	0.11
Cesium-137	D	4,900
Europium-152	D	0.0030
Europium-154	D	0.29
Tritium	C	0.043
Iodine-129	A	0.0082
Nickel-59	D	0.0050
Nickel-63	D	0.43
Plutonium-Total Rad[c]	D	14,000
Strontium-90	B	890
Technetium-99	A	0.0099
Uranium-Total Rad[d]	B	0.42

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-20. T Plant Cribs and Ditches (CP-LS-6) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	10,000
Chromium-VI	A	NR
Mercury	D	1.0
Nitrate	C	1,000,000
Lead	D	7.1
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	120

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition: There is no DSA, HA, or feasibility study that includes the CP-LS-6 waste sites. The 200-UW-1 FFS (DOE/RL-2003-23, Rev. 0) was used because the hazards (associated with buried liquid waste legacy sites) are assumed similar enough for the rough order of magnitude analysis provided in this review. Thus, the four alternatives (and the quantitative analysis) provided in the 200-UW-1 FFS are used instead of those provided in the Evaluation Unit Disposition Table (Appendix B) for this EU. The remedial action alternatives include[70]:

- No Action (Alternative 1)
- Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation (Alternative 2)
- Removal, Treatment, and Disposal (Alternative 3)
- Engineered Barrier (Alternative 4)

These were considered as standalone alternatives; however, impacts from remedial activities at adjacent sites should also be considered during implementation. These alternatives provide a range of remedial responses deemed appropriate to address site-specific conditions.

The remedial actions that have either been identified (i.e., non-time-critical actions for the CP-LS-6 waste sites also in the 200-MG-2 OU (DOE/RL-2009-37, Rev. 0)) or are being evaluated using the 200-UW-1 FFS (DOE/RL-2003-23, Rev. 0)) would leave existing contamination in CP-LS-6 waste sites as well as that contamination that has been released from CP-LS-6 waste sites into the shallow and deep vadose zones. Waste sites within the CP-LS-6 EU have likely contributed to groundwater contamination in the 200-ZP GWIA / 200-ZP-1 GW OU (DOE/RL-92-16, Rev. 0), which are currently being treated using the 200 West Pump and Treat Facility. However, remedial actions will be taken until resulting residual contamination levels satisfy remedial objectives and monitoring of both vadose and saturated zone contamination will continue to assess remedial action performance. These residual concentrations cannot be determined at this time.

Regardless of the alternative selected, long-term site use restriction, vadose zone and groundwater monitoring, and maintenance must remain due to the presence of persistent contaminants in the deep vadose zone that are not amendable to excavation and the likely continued release from CP-LS-6 waste sites and migration of these contaminants through the vadose zone to the groundwater.

200 Area HLW Transfer Pipeline (CP-LS-7)

The 200-WA-1 OU consists of waste sites in the 200 West Inner Area not already assigned to other OUs. The CP-LS-7 EU waste sites (Figure 3-14) primarily consist of cross-site transfer pipelines and associated equipment (and waste sites) outside of the tank waste and farms evaluation units. Waste sites include transfer lines, MUSTs, tanks, sewers, a dumping area, diversion boxes, buildings, and unplanned release sites. The CP-LS-7 EU

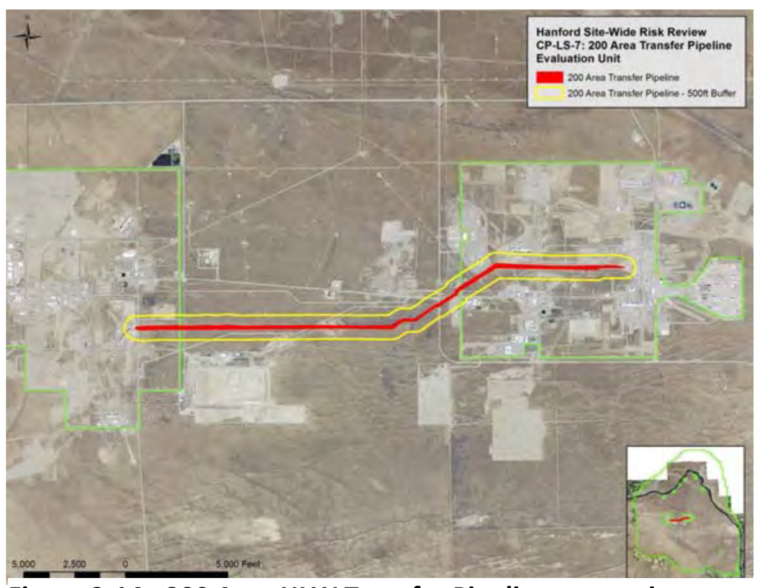

Figure 3-14. 200 Area HLW Transfer Pipeline waste site.

[70] Non-time-critical actions have also been defined for selected 200-MG-2 OU waste sites that are also within the CP-LS-3 EU (DOE/RL-2009-37, Rev. 0).

“connects” the 200 East and 200 West areas (Appendix G.13, Table G.13-3) and includes an area overlaying parts of the 200-UP (200 West) and 200-BP and 200-PO (200 East) groundwater interest areas (GWIAs) that are described in the CP-GW-2 EU (Appendix D.6) for the 200 West GWIAs and in CP-GW-1 EU (Appendix D.5) for the 200 East GWIAs.

Current Status: Many CP-LS-7 EU waste sites were covered in soil, which is maintained as needed to prevent release to the air or intrusion by biological receptors or humans. Other sites have been partially remedied.

Monitoring and treatment of groundwater is being conducted (using the WMA S-SX groundwater extraction system, U Plant area P&T system, and I-129 plume hydraulic control system in 200-UP) and a treatability study is being conducted to remove uranium from the perched water zone beneath B Complex in 200-BP.

Primary Contaminants: The primary contaminants listed in the Soil Inventory Model (Corbin, et al. 2005) for the CP-LS-9 EU include:

- *Radionuclides*: tritium (H-3), Sr-90/Y-90, and Pu-All isotopes
- *Chemicals*: nitrate (NO_3) and U-Total

Only two radionuclides have an aggregate inventory greater than one curie: Sr-90 (60 Ci) and Pu Total (3 Ci). There are also 230 kg of nitrate (NO3) and 13 kg of total uranium.

Table 3-21 and Table 3-22 list the primary radionuclide and chemical contaminants present and estimated quantities in the 200 Area HLW Transfer Pipeline (CP-LS-7) EU**.**

The saturated zone beneath the vicinity of the CP-LS-7 (200 Area Transfer Pipeline) area has elevated levels of total and hexavalent chromium (200 West only), nitrate, Tc-99, uranium (total), carbon tetrachloride (CCl_4) (200 West only), trichloroethene (TCE) (200 West only), tritium (H-3), I-129, and uranium based on the 2014 groundwater monitoring results (http://phoenix.pnnl.gov/apps/gw/phoenix.html); no sites within the CP-LS-7 EU are suspected of being able to contribute mobile contaminants to the saturated zone (DOE/RL-92-16, Rev. 0; DOE/RL-92-19, Rev. 0), and no plumes have been linked to CP-LS-7 waste sites.

Primary Risks: Facility workers are at risk when working in or around areas with contaminated soils, where exposure is limited because waste sites and contaminated soils are located below grade. However, during maintenance and monitoring operations near the CP-LS-7 waste sites (e.g., drilling and sampling), there may be the potential for limited exposure to hazardous and radioactive contaminants; however, risks would be minimal and short-term. The primary accident scenarios are direct human and ecological contact to any aboveground contamination, which is considered limited with signs posted.

Table 3-21. 200 Area HLW Transfer Pipeline (CP-LS-7) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	0.00017
Carbon-14	A	3.9E-08
Chlorine-36	A	NR[b]
Cobalt-60	C	0.00000020
Cesium-137	D	0.000046
Europium-152	D	1.8E-08
Europium-154	D	0.0000013
Tritium	C	0.30
Iodine-129	A	0.0000038
Nickel-59	D	9.9E-09
Nickel-63	D	0.00000092
Plutonium-Total Rad[c]	D	3.0
Strontium-90	B	60
Technetium-99	A	0.00044
Uranium-Total Rad[d]	B	0.0088

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-22. 200 Area HLW Transfer Pipeline (CP-LS-7) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	0.0016
Chromium-VI	A	NR
Mercury	D	0.000055
Nitrate	C	230
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	13

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition: There is no Documented Safety Analysis, hazards analysis, or feasibility study that includes the CP-LS-7 EU waste sites. Some interim actions have been planned and taken for the 241-WR Vault (WHC-SD-DD-TI-074, Rev. 0; WHC-SD-DD-TI-080, Rev. 0) and 241-CX Tank System

(WA7890008967 Part V, Closure Unit Group 15; 241-CX Tank System). A draft RFI/CMS/RI/FS Work Plan was written for the 200-IS-1 OU waste sites, which include the CP-LS-7 pipeline and associated equipment (DOE/RL-2010-114, Draft A). The draft work plan listed a set of six preliminary remedial alternatives: i) No Action; ii) Monitored Natural Attenuation (MNA); iii) Removal, Treatment, and Disposal (RTD); iv) *In Situ* Treatment; v) Containment under a Planned Barrier, and vi) Removal of Pipeline System Waste Sites Versus Pre-ROD Characterization. The remedial actions that are being evaluated would leave existing contamination in CP-LS-7 waste sites as well as any contamination that has been released from the waste sites.

Contaminants from the CP-LS-7 EU waste sites are in the vadose zone and may eventually reach groundwater although not in concentrations (from solely the CP-LS-7 waste sites) likely to impact groundwater (DOE/RL-92-16, Rev. 0; DOE/RL-92-19, Rev. 0). Thus, concentrations in the groundwater from the CP-LS-7 EU waste sites are likely far below thresholds before the Active Cleanup phase commences. Secondary CP-LS-7 sources in the vadose are unlikely to significantly threaten groundwater in the future, including during and after the Active Cleanup period.

The remedial actions that are being evaluated (i.e., those in the draft RFI/CMS/RI/FS Work Plan for the 200-IS-1 OU waste sites (DOE/RL-2010-114, Draft A)) would leave existing contamination in CP-LS-7 waste sites as well as any contamination that has been released from the waste sites. Waste sites within the CP-LS-7 EU are not suspected of contributing to groundwater contamination in the area (DOE/RL-92-16, Rev. 0; DOE/RL-92-16, Rev. 0). However, monitoring of both vadose and saturated zone contamination will continue to assess contamination in the vadose and saturated zones. Residual concentrations cannot be determined at this time.

B PLANT CRIBS AND TRENCHES (CP-LS-8)

Figure 3-15. Aerial View B Plant Cribs & Trenches

The CP-LS-8 waste sites (Figure 3-15) primarily consist primarily of liquid waste disposal sites associated with 221-B Facility (B Plant) operations (see the CP-DD-2 EU described in Appendix F.7). The CP-LS-8 liquid waste disposal sites include cribs, French drains, reverse/injection wells, a trench, and unplanned releases (UPRs). B Plant was a plutonium recovery facility located in the 200 East Area that operated from 1945 to 1952 using the bismuth-phosphate chemical separation process; the Plant was then used between 1968 and 1983 to separate more than 100 million curies of high-heat isotopes (Cs-137 and Sr-90) from single-shell tank wastes that was then stored at the Waste Encapsulation and Storage Facility (WESF) adjacent to B Plant; and B Plant then continued to support WESF operations from 1990 to 1995 when US DOE issued a shutdown order for B Plant (WA7890008967 Part V, Closure Unit Group 24; B Plant Complex). Of the wastes generated from B Plant operations, steam and process condensate streams were sent to cribs and chemical sewer waste was sent to a trench (DOE/EIS-0089-D 1983, p. 5-12; WHC-SD-WM-ER-575, Rev. 0).

Current Status: These are currently inactive waste sites with contaminated soils and groundwater located below grade. The waste sites were covered in soil, which is maintained as needed to prevent release to the air or intrusion by biological receptors or humans.

The cover soil is still in place although waste sites within the CP-LS-8 EU continue to contaminate the surrounding vadose zone media and may be leading to additional saturated zone contamination. Monitoring and a treatability study of the perched water zone beneath the B Complex (to remove uranium) is being conducted within the 200-BP GWIA, which is described as part of the CP-GW-1 EU (Appendix D.5).

Primary Contaminants: There are 34 waste sites (not including a sand filter) in the CP-LS-8 EU that have reported inventory information in the SIM, Rev. 1 (Corbin, et al., 2005) and are considered representative of the major inventory sources and risks from this EU. Those sites with reported inventories consist of one MUST, eight French drains, seven cribs, one trench, ten reverse/injection wells, and seven UPRs. The largest aggregate inventories in curies are: Cs-137 (10,000 Ci); Sr-90 (3,300 Ci); H-3 (2,300 Ci); and Pu(total) (210 Ci). There is also 4 million kg of NO3; 15,000 kg of U(total); and 7,600 kg of Cr.

Table 3-23 and Table 3-24 list the primary radionuclide and chemical contaminants present and estimated quantities in the B Plant Cribs and Trenches (CP-LS-8) EU**.**

The saturated zone beneath the CP-LS-8 area (B Plant Cribs and Trenches) has elevated levels of I-129, NO_3, Sr-90, and Tc-99, and uranium based on the groundwater data from 2014 (http://phoenix.pnnl.gov/apps/gw/phoenix.html). The 200-East Area plumes are described in detail as part of the CP-GW-1 EU (Appendix D.5). Sites, including the 216-B-4, 216-B-5, and 216-B-6 reverse/injection wells; 216-B-10A and 216-B-12, 216-B-55, and 216-B-62 cribs; and 216-B-59/59B trench/retention basin, within the CP-LS-8 EU are suspected of being able to contribute mobile contaminants to the saturated zone although the potential impact to groundwater from unplanned releases in the area is considered low because these sites were remediated by either removing soil or covering the area with uncontaminated fill material (DOE/RL-92-19, Rev. 0). However, current threats to groundwater corresponding to only the CP-LS-8 EU contaminants *remaining* in the vadose zone (Appendix G.5.6, Table G.5.6-5) has an overall rating of High (based on Sr-90 and hexavalent chromium (Cr-VI)).

Table 3-23. B Plant Cribs and Trenches (CP-LS-8) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	0.60
Carbon-14	A	0.11
Chlorine-36	A	NR[b]
Cobalt-60	C	0.71
Cesium-137	D	10,000
Europium-152	D	0.044
Europium-154	D	3.5
Tritium	C	2,300
Iodine-129	A	0.0017
Nickel-59	D	0.028
Nickel-63	D	2.7
Plutonium-Total Rad[c]	D	210
Strontium-90	B	3,300
Technetium-99	A	4.4
Uranium-Total Rad[d]	B	10

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-24. B Plant Cribs and Trenches (CP-LS-8) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	7,600
Chromium-VI	A	NR
Mercury	D	2.2
Nitrate	C	4.0E+06
Lead	D	14
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	15,000

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: Facility workers are at risk when working near or within those areas with contaminated soil. Exposure to such contaminants is limited because contaminated soils and groundwater are located below grade. However, during certain characterization activities (e.g., drilling and sampling), there may be the potential for exposure to hazardous and radioactive contaminants; however, the potential exposure would be small and limited in duration.

The primary barriers to release and transport from the waste sites include sorption to vadose zone and saturated zone media and soil cover (EPA 2011). The cover soil is still in place although waste sites within the CP-LS-8 EU continue to contaminate the surrounding vadose zone media and may be leading to additional saturated zone contamination.

Cleanup and Disposition: There is no Documented Safety Analysis, hazards analysis, or feasibility study that includes the CP-LS-8 EU waste sites. The evaluation provided in the *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites* (FFS) (DOE/RL-2004-66, Draft A) was used to evaluate remedial alternatives for the LP-LS-8 EU because the hazards associated with buried liquid waste legacy sites are considered similar enough for the rough order of magnitude analysis provided in this Risk Review. As described in the BC Cribs and Trenches FFS, remedial action alternatives include: No Action (Alternative 1); Maintain Existing Soil Cover, Institutional Controls (ICs), and Monitored Natural Attenuation (MNA) (Alternative 2); Removal, Treatment, and Disposal (RTD) (Alternative 3); Capping (Alternative 4); and Partial Removal, Treatment, and Disposal with Capping (Alternative 5). The alternatives were considered as standalone alternatives; however, impacts from remedial activities at adjacent sites should also be considered during implementation. These alternatives provide a range of remedial responses deemed appropriate to address site-specific conditions.

Contaminants from the CP-LS-8 EU waste sites are currently impacting the vadose zone and groundwater. Without treatment, concentrations are unlikely to fall below thresholds before the Active Cleanup phase commences. Secondary sources in the vadose also threaten to continue to impact groundwater in the future, including the Active Cleanup period. The High rating associated with the CP-LS-8 EU waste sites (Appendix G.5, Table G.5.6-5) is associated with Sr-90 and hexavalent chromium (Cr-VI) that could potentially impact the 200-BP GWIA (which is part of CP-GW-1, Appendix D.5). As described in the TC&WM EIS, radioactive decay would support that the rating would be reduced to Medium for Sr-90 during the Active Cleanup period and Low for the Near-term, Post Cleanup period.

The remedial actions that were proposed for CP-LS-8 or were evaluated above would leave existing contamination in CP-LS-8 waste sites as well as that contamination that has been released from CP-LS-8 waste sites into some shallow and deep vadose zones.

PUREX CRIBS AND TRENCHES (INSIDE 200 E) (CP-LS-9)

Figure 3-16. Aerial View of PUREX Cribs and Trenches.

The 200-EA-1 OU (Figure 3-16) is part of the Hanford 200 Area and consists of waste sites in the 200 East Inner Area not already assigned to other OUs. The CP-LS-9 EU waste sites primarily consist of liquid waste disposal sites associated with PUREX facility operations and a few other waste sites such as infrastructure buildings and pipelines and associated equipment. Liquid waste disposal sites include cribs, French drains, wells, trenches, and unplanned release sites.

For a 4-month period in 1956, process condensate liquid waste from PUREX operations was discharged to the ground at the 216-A-10 crib south of the PUREX facility in the 200 East area (PNNL-11800, p. 4.51). The crib received PUREX effluent continuously from 1961 to 1973 and then sporadically until 1981. In 1982, discharges resumed until the crib was taken out of service and replaced by the 216-A-45 crib in 1987.

Current Status: The waste sites were covered in soil, which is maintained as needed to prevent release to the air or intrusion by biological receptors or humans. The primary accident scenarios are direct human and ecological contact as well as continued groundwater impact.

The soil is still in place although waste sites within the CP-LS-9 EU are contaminating the surrounding vadose zone media and may be leading to additional saturated zone contamination. Groundwater monitoring is being conducted within the 200-PO GWIA, which is described as part of the CP-GW-1 EU (Appendix D.5).

Primary Contaminants: The primary contaminants listed in the Soil Inventory Model (Corbin et al. 2005) for the CP-LS-9 EU include:

- *Radionuclides*: Am-241, Co-60, Cs-137/Ba-137m, Eu-154, tritium (H-3), I-129, Ni-63, Sr-90/Y-90, Tc-99, U-All isotopes, Pu-All isotopes
- *Chemicals*: Cr/Cr-VI, nitrate (NO_3), tributyl phosphate (TBP), and U-Total

In aggregate, the largest radiological inventories that are known to be present (in curies) are tritium or H-3 (78,000 Ci), Cs-137 (1,600 Ci), and Sr-90 (1,200 Ci). There are also 5.5 million kg of nitrate (NO_3); 170,000 kg of TBP; and 6,800 kg of total uranium introduced into the vadose zone.

Table 3-25 and Table 3-26 list the primary radionuclide and chemical contaminants present and estimated quantities in the PUREX Cribs and Trenches (inside 200 E) (CP-LS-9) EU**.**

The CP-LS-9 EU is in the 200-PO groundwater interest area (GWIA) that is described in the CP-GW-1 EU (Appendix D.5). The saturated zone beneath the vicinity of the CP-LS-9 (PUREX Cribs and Trenches (inside 200-E)) area has elevated levels of I-129, nitrate, Sr-90, tritium (H-3), and uranium (total) based on the 2014 groundwater monitoring results (http://phoenix.pnnl.gov/apps/gw/phoenix.html); sites within the CP-LS-9 EU are suspected of being able to contribute mobile contaminants to the saturated zone (DOE/RL-92-19, Rev. 0). Current threats to groundwater and the Columbia River from contaminants already in the groundwater are evaluated as part of the CP-GW-1 EU (Appendix D.5). However, current threats to groundwater corresponding to only the CP-LS-9 EU contaminants *remaining* in the vadose zone (Table G.5.7-6) has an overall rating of High (based on Sr-90 and I-129).

Primary Risks: Facility workers are at risk when working in or around areas with contaminated soils, including working on active remedial activities involving these legacy sources; these remedial activities are currently not being conducted. Exposure to such contaminants is limited because waste sites and contaminated soils are located below grade. However, during certain operations (e.g., drilling, sampling, removal, treatment, and disposal) near the CP-LS-9 waste sites, there may be the potential for limited exposure to hazardous and radioactive contaminants, but risks would be minimal and short-term resulting from monitoring and maintenance activities conducted by experienced workers and appropriate safety precautions (DOE/RL-2003-23, Rev. 0, p. 5-14).

In general, large-scale treatment efforts directed at groundwater have not been started in 200 East and some plume areas (e.g., CN, Cr, Sr-90, and Tc-99) are increasing. However, these plumes are unlikely to impact the Columbia River (as a protected resource) during the time period evaluated in this Risk Review.

Table 3-25. PUREX Cribs and Trenches (inside 200-East) (CP-LS-9) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	130
Carbon-14	A	0.025
Chlorine-36	A	NR[b]
Cobalt-60	C	1.5
Cesium-137	D	1,600
Europium-152	D	0.024
Europium-154	D	2.1
Tritium	C	78,000
Iodine-129	A	2.7
Nickel-59	D	0.0067
Nickel-63	D	0.63
Plutonium-Total Rad[c]	D	400
Strontium-90	B	1,200
Technetium-99	A	2.0
Uranium-Total Rad[d]	B	5.2

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-26. PUREX Cribs and Trenches (inside 200-East) (CP-LS-9) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	19
Chromium-VI	A	NR
Mercury	D	0.17
Nitrate	C	5.5E+06
Lead	D	0.020
TBP	---	170,000
Trichloroethene	B	NR
Uranium	B	6,800

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition:

Final cleanup decisions for the CP-LS-9 EU waste sites have not been made (DOE/RL-2014-11, Rev. 0) and will be included in future remedial decision documents (e.g., Records of Decision). The BC Cribs and Trenches area includes 28 waste disposal sites, including 26 cribs and trenches. A draft FFS was developed for this area (DOE/RL-2004-66, DRAFT A). A similar study has not been prepared for the PUREX Cribs and Trenches (inside 200-E) waste sites. Because of similarities in waste sites (cribs and trenches) and location (200-E), the analysis provided in the REDOX Cribs and Trenches FFS was used because the hazards (associated with buried liquid waste legacy sites) are assumed similar enough for the rough order of magnitude analysis provided in this review. Thus, these alternatives (and the quantitative analysis provided in the BC Cribs and Trenches FFS) are used instead of those provided in the Evaluation Unit Disposition Table (Appendix B) for this EU.

Four remedial actions alternatives will be considered[71]:

- No Action
- Maintain Existing Soil Cover, Institutional Controls, and Monitored Natural Attenuation
- Removal, Treatment, and Disposal
- Capping
- Partial RTD with Capping

Contaminants from the CP-LS-9 EU waste sites are currently impacting the vadose zone and groundwater. Without treatment, concentrations are unlikely to fall below thresholds before the Active Cleanup phase commences. Secondary sources in the vadose also threaten to continue to impact groundwater in the future, including during the Active Cleanup period. The High rating associated with the CP-LS-9 EU waste sites (Appendix G.5.7, Table G.5.7-6) is associated with Sr-90 and I-129 remaining in the vadose zone that potentially could continue to impact 200-PO GWIA (which is part of CP-GW-1, Appendix D.5); these contaminants already have 200-PO plumes that have been linked to CP-LS-9 sources. As described in the TC&WM EIS, radioactive decay would support that the rating would be

[71] DOE/RL-2004-69, Draft A; DOE/RL-2004-66, Draft A

maintained (at High) for Sr-90 during the Active Cleanup period and changed to Medium for the Near-term, Post Cleanup period.

The remedial actions that have either been identified for 200-PW-3 (including the 216-A-31 Crib) (EPA 2011) or are being evaluated BC Cribs and Trenches FFS (DOE/RL-2004-69, Draft A) would leave existing contamination in CP-LS-9 waste sites as well as that contamination that has been released from CP-LS-9 waste sites into shallow and deep vadose zones.

PUREX AND TANK FARM CRIBS AND TRENCHES (OUTSIDE 200 E) (CP-LS-10)

The CP-LS-10 waste sites (Figure 3-17) primarily consist of liquid waste disposal sites associated with 202-A Facility (PUREX Plant) operations, including pipelines and associated equipment. Between 1955 and 1972 and between 1983 and 1992, the 202-A Facility used an advanced solvent extraction process to recover uranium and plutonium from nitric acid solutions of irradiated uranium. The CP-LS-10 liquid waste disposal sites include cribs, a basin, sewers, and unplanned release sites.

Figure 3-17. Aerial View of CP-LS-10 EU.

Current Status: The PUREX and Tank Farms Cribs and Trenches (outside 200-E) EU encompass several inactive and active waste sites and roadways. Over half of the EU is bare or graveled ground. The individual waste sites are comprised of contaminated soils and groundwater located below grade.

Primary Contaminants: Cribs 216-A-37-1/2 and 216-A-30 received PUREX Plant steam condensate and 202-A Evaporator condensate until 1992. These cribs received approximately 8.58 x 10^9 L (2.27 x 10^9 gal) of effluent during their operating life (WHC-SD-EN-EV-032, Rev. 0). There are four waste sites in the CP-LS-10 EU that have reported inventory information in the SIM, Rev. 1 (Corbin, et al., 2005) and are considered representative of the major inventory sources and risks from this EU. The primary contaminants include:

- *Radionuclides*: Am-241, C-14, Cs-137, tritium (H-3), Sr-90, U-All isotopes, Pu-All isotopes
- *Chemicals*: carbon tetrachloride (CCl_4), Cr/Cr-VI, nitrate (NO_3), lead (Pb), and U-Total

The largest aggregate reported radiological inventories in curies are H-3 (1,800 Ci) and Pu(Total) (260 Ci). Other radioisotopes present have aggregate inventories of less than 4 Ci each. In addition, the four waste sites with reported inventories contain a total of 410,000 kg NO3; 11,000 kg Cr; and 870 kg U(Total).

Table 3-27 and Table 3-28 list the primary radionuclide and chemical contaminants present and estimated quantities in the PUREX and Tank Farm Cribs and Trenches (outside 200 E) (CP-LS-10) EU**.**

The saturated zone beneath the CP-LS-10 area has elevated levels of I-129, nitrate, tritium (H-3), and uranium based on the groundwater monitoring data from 2014 (http://phoenix.pnnl.gov/apps/gw/phoenix.html). The 200-East Area plumes are described in detail as part of the CP-GW-1 EU (Appendix D.5). Waste sites (cribs) within the CP-LS-10 EU are suspected of being able to contribute mobile contaminants to the saturated zone although the potential impact to groundwater from unplanned releases in the area is considered low because these sites were remediated by either removing soil or covering the area with uncontaminated fill material (DOE/RL-92-19, Rev. 0). No current plumes have been linked to the CP-LS-10 EU waste sites. Current threats to groundwater corresponding to only the CP-LS-10 EU contaminants *remaining* in the vadose zone has an overall rating of High (based on total and hexavalent chromium). Contaminated groundwater is being monitored but not treated in the 200-PO GWIA (DOE/RL-2016-09, Rev. 0).

Table 3-27. PUREX and Tank Farm Cribs and Trenches (outside 200-East) (CP-LS-10) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	3.1
Carbon-14	A	2.0
Chlorine-36	A	NR[b]
Cobalt-60	C	0.0037
Cesium-137	D	3.9
Europium-152	D	0.00033
Europium-154	D	0.025
Tritium	C	1,800
Iodine-129	A	0.082
Nickel-59	D	0.00040
Nickel-63	D	0.038
Plutonium-Total Rad[c]	D	260
Strontium-90	B	3.4
Technetium-99	A	0.022
Uranium-Total Rad[d]	B	2.8

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-28. PUREX and Tank Farm Cribs and Trenches (outside 200-East) (CP-LS-10) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	67
Cyanide	B	NR
Chromium	B	11,000
Chromium-VI	A	NR
Mercury	D	0.060
Nitrate	C	410,000
Lead	D	2.9
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	870

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: Facility workers are at risk when working near or within those areas with contaminated soil. Exposure to such contaminants is limited because contaminated soils and groundwater are located below grade. However, during certain characterization activities (e.g., drilling and sampling), there may be the potential for exposure to hazardous and radioactive contaminants; however, the potential exposure would be small and limited in duration.

There is potential for additional contaminant release and migration through the vadose that may eventually impact groundwater as cleanup decisions and remedial activities are delayed.

Cleanup and Disposition: There is no Documented Safety Analysis, hazards analysis, or feasibility study that includes the CP-LS-10 EU waste sites. The evaluation provided in the *Focused Feasibility Study for the BC Cribs and Trenches Area Waste Sites* (FFS) (DOE/RL-2004-66, Draft A) was used to evaluate remedial alternatives for the LP-LS-10 EU because the hazards associated with buried liquid waste legacy sites are considered similar enough for the rough order of magnitude analysis provided in this Risk Review. As described in the BC Cribs and Trenches FFS, remedial action alternatives include: No Action (Alternative 1); Maintain Existing Soil Cover, Institutional Controls (ICs), and Monitored Natural Attenuation (MNA) (Alternative 2); Removal, Treatment, and Disposal (RTD) (Alternative 3); Capping (Alternative 4); and Partial Removal, Treatment, and Disposal with Capping (Alternative 5). The alternatives were considered as standalone alternatives; however, impacts from remedial activities at adjacent sites should also be considered during implementation. These alternatives provide a range of remedial responses deemed appropriate to address site-specific conditions.

The remedial actions that have been proposed for CP-LS-10 or were evaluated above would leave existing contamination in CP-LS-10 waste sites as well as that contamination that has been released from CP-LS-10 waste sites into some shallow and deep vadose zones.

200-W Burial Grounds (CP-LS-12)

The 200-W Burial Grounds are located in the Central Plateau's Inner Area and consist of 30 past practice radioactive waste sites; TSD unit, industrial and dry landfills; surface and near-surface unplanned release areas; and trench, pond and ditch sites, as well as three active buildings and structures (Figure 3-18). Many of the sites are part of the 200-SW-2 OU.

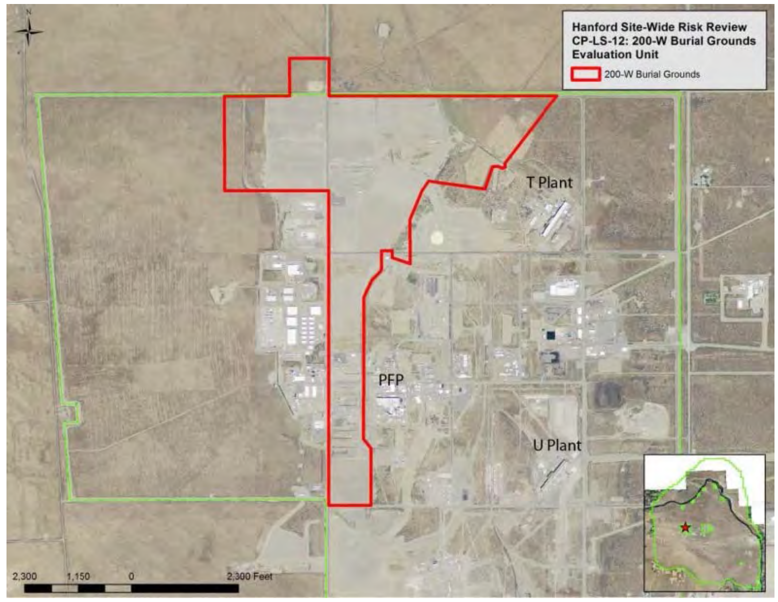

Figure 3-18. Aerial view of 200-W Burial Grounds location.

The 200-SW-2 OU is composed of 24 landfills and includes about 20 caissons that are located below grade in the 218-W-4A and 218-W-4B Landfills, which are part of CP-LS-12. The individual 200-W Landfills operated over periods of from 4 to 30 years between 1945 and 2003.

The 200-SW-2 OU is made up of six types of landfills, four of which are relevant to CP-LS-12 (CHPRC 2015a):

- **Dry Waste Alpha Landfills**. These past-practice landfills contain waste that is highly contaminated with alpha-emitting radionuclides, mainly plutonium and uranium. A variety of miscellaneous wastes, including contaminated soils and potentially contaminated rags, paper, wood, and small pieces of equipment such as tools, has been placed in these sites. A small proportion of the waste is packaged in metal drums. Some larger equipment (e.g., motor vehicles, large canyon processing equipment) is known to have been disposed to these sites. This landfill type includes the 218-W-1, 218-W-2, 218-W-3, and 218-W-4A Landfills.
- **Industrial Landfills.** These past-practice landfills received radioactive waste that usually was packaged in large wooden or concrete boxes containing large pieces of failed or obsolete equipment. Some equipment was shrouded in plastic or placed directly in the ground after partial decontamination in the facility from which it came, mainly one of the 200 Area chemical processing facilities, although some items came from the 100 Area. Landfills of this type include the 218-W-2A, 218-W-1A, and 218-W-11 Landfills.
- **Caissons or Vertical Pipe Units.** These units are engineered structures built directly into a trench within a landfill (Figure 3-3). They were used for disposal of hot cell waste or high-dose-rate waste, and are located within the 218-W-4A and 218-W-4B Landfills. The caissons in the 218-W-4A Landfill, also called vertical pipe units or VPUs, were made of 55-gal drums welded end to end, or pipes about 1 m in diameter. The caissons in the 218-W-4B Landfill were larger and made of corrugated metal and concrete, and some contain TRU waste.
- **TSD Unit Landfills.** These are RCRA TSD units that contain waste forms similar to those in past-practice landfills such as dry waste packaged in small fiberboard cartons, directly disposed dirt and

weeds, large concrete and wooden boxes containing used equipment, and construction debris. This landfill type includes the 218-W-3A, 218-W-3AE, 218-W-4B, 218-W-4C, and 218-W-5 Landfills.

CP-LS-12 also contains several ponds and ditches that were used for disposal of liquid wastes (primarily process and condenser cooling water and steam condensate from T Plant). There were also seven unplanned release sites within this EU.

Current Status: The various sites comprising this EU are currently inactive and awaiting decisions and future actions toward cleanup as determined appropriate.

Primary Contaminants: Landfills in the 200-SW-2 OU received solid wastes (e.g., bulk quantities of trash, construction debris, soiled clothing, failed equipment, and laboratory and process waste). The wastes were placed into the landfills directly or packaged (e.g., in cardboard, wooden, or fiber reinforced polyester boxes, steel drums, concrete burial vaults, or other containers). Some wastes were contaminated with radionuclides, organics, and/or inorganic chemicals from various facilities (mainly from the Hanford Site 200 Area). Relatively small amounts of wastes from the 100 and 300 Areas and from offsite sources were placed in the landfills (mostly in the RCRA TSD units) (CHPRC 2015a).

Several landfills in the 200-W Burial Grounds EU have significant primary contaminant inventories that when aggregated total:

Cs-137	480,000 Ci
Tritium	350,000 Ci
Sr-90	210,000 Ci
Total Pu	41,000 Ci
Total U	840,000 kg
Pb	380,000 kg
NO3	370,000 kg

Table 3-29 and Table 3-30 list the primary radionuclide and chemical contaminants present and estimated quantities in the 200-W Burial Grounds (CP-LS-12) EU.

The saturated zone beneath the CP-LS-12 area overlaying the 200-ZP GWIA has elevated levels of carbon tetrachloride (CCl_4) and nitrate based on 2014 groundwater monitoring results (http://phoenix.pnnl.gov/apps/gw/phoenix.html); the 216-T-4A site is the only CP-LS-12 EU waste site suspected of being able to contribute mobile contaminants to the saturated zone (DOE/RL-92-16, Rev. 0). The current threats to groundwater corresponding to only the CP-LS-12 EU contaminants *remaining* in the vadose zone (Appendix G.7.1, Table G.7.1-8) has an overall rating of High (related to multiple primary contaminants).

Primary Risks: Low-ND human health risk rating has been given for the Facility Worker and Co-located Person, and ND to the Public because there is no information to indicate that any of these sites currently represent a risk to human health, there is little or no worker activity at the sites, and the area is restricted from public access.

Table 3-29. 200-West Burial Grounds (CP-LS-12) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	16,000
Carbon-14	A	320
Chlorine-36	A	NR[b]
Cobalt-60	C	0.00016
Cesium-137	D	480,000
Europium-152	D	0.0000087
Europium-154	D	0.00066
Tritium	C	350,000
Iodine-129	A	0.55
Nickel-59	D	0.000033
Nickel-63	D	0.0031
Plutonium-Total Rad[c]	D	41,000
Strontium-90	B	210,000
Technetium-99	A	52
Uranium-Total Rad[d]	B	1,100

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-30. 200-West Burial Grounds (CP-LS-12) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	1,200
Cyanide	B	NR
Chromium	B	12,000
Chromium-VI	A	NR
Mercury	D	240
Nitrate	C	370,000
Lead	D	380,000
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	840,000

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition: The 200-SW-2 OU includes 24 landfills that include those in CP-LS-14 (200-E Burial Area) as well as this EU and 14 co-located waste sites. Seven of the landfills are RCRA TSD units and 17 are past-practice waste sites. The co-located sites include 11 unplanned release (UPR) sites, the Z Plant burn pit, the T Ponds, and the 216-C-9 Pond.

No cleanup decisions have been made to remediate the 200-SW-2 OU.

Range of Plausible Alternatives (DOE/RL-2014-11, Table B-3, CP-14)

- Excavation, treatment (as necessary), and disposal of all waste from within individual landfills.
- Excavation, treatment (as necessary), and disposal of waste from selected sections of individual landfills followed by capping of remaining waste; includes continued cap maintenance and monitoring.
- Capping of individual landfills; includes continued cap maintenance and monitoring.
- *In situ* treatment/stabilization (e.g., vitrification or grouting) of portions of individual landfills followed by capping; includes continued cap maintenance and monitoring.

If residual contamination remains after cleanup actions are completed, cleanup work will transition to long-term stewardship, including institutional controls and 5-year reviews of remedy effectiveness.

200-W Waste Sites (CP-LS-13)

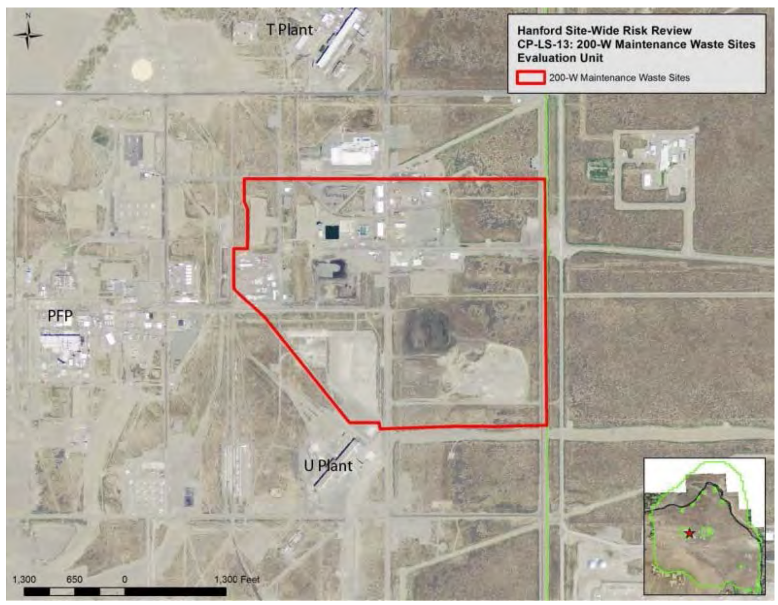

Figure 3-19. Aerial view of 200-W Miscellaneous Waste Site.

The 200-W Miscellaneous Waste Sites EU (Figure 3-19) is composed of 63 miscellaneous waste sites, active and inactive buildings and structures associated with maintenance operations, laundry, and a coal power plant in the west/central portion of the 200 West Area. The area is north-northeast of the U Plant. Contaminant inventory information is available for only 3 of the 63 miscellaneous sites (216-U-5, 216-U-6, and 216-W-LWC).

Site 216-W-LWC was a laundry waste crib that received effluent from the 2724-W, 2724-WA, 2724-WB laundry facilities, MO-412 mask cleaning facility, and the 2723-W old laundry. Soiled protective work clothing (coveralls, gloves, hoods, canvas boots, and rubber shoe covers) were sent to the laundry facilities from all the Hanford work areas. Two thirds of the laundry received was radioactively contaminated. One third consisted of "blue" (non-contaminated) coveralls and towels. The non-contaminated laundry was washed separately from the contaminated laundry. By 1981, approximately 3 million pounds of laundry was processed per year in 600-lb capacity washing machines and 400-lb capacity dryers. An average of 26,250,000 L (691,000 gal) of wastewater was discharged to the 216-W-LWC Crib each month. This site is located east of Beloit Ave., south of 20th Street (DOE/RL-88-30 2015).

The 216-U-5 and 216-U-6 sites consist of backfilled trenches that are posted "Underground Radioactive Material," and located northwest of the 221-U building. Both were used as disposal sites for liquid unirradiated uranium waste from the cold startup run at 221-U.

Forty-two of the remaining sixty miscellaneous sites are described as buildings or structures, many of which are in active use and are not included within an OU. A random search for these facilities in the *Hanford Site Waste Management Units Report* (DOE/RL-88-30 2015) yielded no results.

Ten of the remaining eighteen miscellaneous sites are described as burial grounds. Most appear to be locations of where buildings were demolished, and they currently have gravel or concrete surfaces with signs and other indications that asbestos or other hazardous materials may be buried there (DOE/RL-88-30, Revision 24, 2015).

Current Status: The various sites comprising this EU are currently inactive and awaiting decisions and future actions toward cleanup as determined appropriate.

Primary Contaminants: Contaminant inventory information is available for only 3 of the 63 miscellaneous sites (216-U-5, 216-U-6, and 216-W-LWC). The only contaminants that cumulatively across these 3 sites have more than 1 curie of radioactivity are (DOE 2011):

- Cobalt-60 (1.23 Ci)
- Plutonium-241 (1.96 Ci)

Both radionuclides are located in site 216-W-LWC, which was a laundry waste crib that received effluent from the 2724-W, 2724-WA, 2724-WB laundry facilities, MO-412 mask cleaning facility, and the 2723-W old laundry. The waste in 216-U-5 and U-6 sites contained 0.427 Ci of total Pu, and hundreds of kilograms of each of Ca, Cl, Cr, Fe, K, Na, NH_3, Ni, NO_2, Si, SO_4, and CO_3 (DOE/RL-88-30, Revision 24, 2015).

The lack of any information about contaminant inventories for the other 60 sites could be construed to indicate that there are no contaminants at these sites, as it is reasonable to believe that some investigation would have been conducted if there was a concern that radioactive or hazardous materials were present and thus represent a risk to public health. However, it may be prudent to do sampling of the ten sites that are described as burial grounds and that may contain asbestos or other potential hazards to human health.

Table 3-31 and Table 3-32 list the primary radionuclide and chemical contaminants present and estimated quantities in the 200-W Miscellaneous Waste Sites (CP-LS-13) EU**.**

The saturated zone beneath the CP-LS-13 area has elevated levels of carbon tetrachloride (CCl_4), trichloroethene (TCE), and nitrate based on 2014 groundwater monitoring results (http://phoenix.pnnl.gov/apps/gw/phoenix.html); the 216-W-LWC Crib and 216-U-5 and 216-U-6 Trenches are suspected of being able to contribute mobile contaminants to the saturated zone (DOE/RL-92-16, Rev. 0). The current threats to groundwater corresponding to only the CP-LS-13 EU contaminants *remaining* in the vadose zone (Appendix G.8, Table G.8-6) has an overall rating of Medium (related to multiple primary contaminants).

Primary Risks: A Low-ND human health risk rating has been given to the Facility Worker and Co-located Person, and ND to the Public because there is no information to indicate that any of these sites currently represent a risk to human health, there is little or no worker activity at the sites, and the area is restricted from public access.

Table 3-31. 200-West Miscellaneous Waste Sites (CP-LS-13) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	0.013
Carbon-14	A	NR[b]
Chlorine-36	A	NR
Cobalt-60	C	1.2
Cesium-137	D	0.26
Europium-152	D	NR
Europium-154	D	0.011
Tritium	C	0.000044
Iodine-129	A	0.051
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	2.3
Strontium-90	B	0.19
Technetium-99	A	NR
Uranium-Total Rad[d]	B	0.86

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-32. 200-West Miscellaneous Waste Sites (CP-LS-13) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	1,900
Chromium-VI	A	NR
Mercury	D	2.5
Nitrate	C	50,000
Lead	D	210
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	1,300

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition: Several future cleanup approaches based on existing action memorandums for similar sites at Hanford will likely be considered. The first is relevant to the disposition of the substantial number of buildings and structures in this EU, if and when they become inactive and surplus, as well as a number of burial grounds containing debris from previous building demolitions. Action memoranda are in place (DOE/RL-2010-22 2010; DOE/RL-2008-80-ADD1 2010) to D4 buildings and facilities to slab-on-grade and evaluate below-grade portions for contamination, and cleanup of debris. The types of wastes and debris likely to require disposal include, but are not limited to, solid waste, low-level radioactive waste, asbestos waste, and PCB-contaminated waste.

The second approach will be relevant to cleaning up those sites that are believed to contain contaminated soil, structures, and debris. Action memoranda (DOE/RL-2009-86 2010; DOE/RL-2009-37 2009) are in place to pursue a Closed Site/No Further Action alternative or an RTD option. Under CS/NFA**,** sampling and analysis will be conducted on waste sites to confirm that soil contaminant concentrations are at or below removal action levels (RALs) and that no further action is required. Radiological surveys will be included in the initial site investigation as appropriate for site conditions to support the selection of sampling locations. If confirmatory sampling results indicate that the RALs are not met (i.e., soil concentrations of contaminants of potential concern [COPCs] exceed RALs), then the RTD alternative will be implemented or the waste site will be evaluated as part of a final remedial action.

200-East (E) Burial Grounds (CP-LS-14)

The CP-LS-14 site (Figure 3-20) is composed of a series of landfills, pipelines, cribs, tanks, unplanned releases, and buildings. It contains the eastern portion of the 200-SW-2 OU, which spans both the West and East Inner Areas of the Central Plateau. 200-SW-2 OU is a collection of waste trenches that received mostly solid waste from the 200 and 300 Areas. 200-SW-2 OU also received liquid waste into one trench and offsite waste to one trench. The non-landfill sites associated with this EU are the cribs, pipelines, tanks, unplanned releases, and buildings found in the eastern inner area of the Central Plateau and associated with CP-LS-14 Landfill sites.

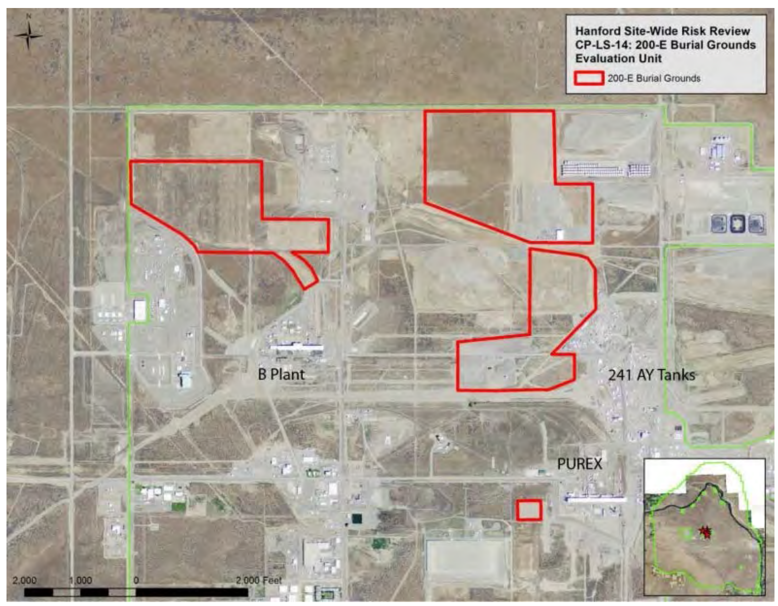

Figure 3-20. Aerial view of 200-E Burial Grounds.

The landfills received dry and industrial waste between 1945 and 2004 from onsite Hanford and some waste that came from offsite. The 200-SW-2 OU is made up of six types of landfills, four of which are relevant to CP-LS-14 (see Figure 3-18 for locations within CP-LS-12):

- **Dry Waste Landfills**. These are past-practice landfills that received radioactive waste packaged primarily in fiberboard or small wooden boxes, wrapped in heavy brown paper or burlap, or placed in the trench without packaging. Small miscellaneous wastes, ranging from contaminated soils and potentially contaminated rags, paper, and wood, have been placed in these landfills. This landfill type includes the 218-E-1 and 218-E-12A Landfills.

- **Industrial Landfills.** These past-practice landfills received radioactive waste that usually was packaged in large wooden or concrete boxes containing large pieces of failed or obsolete equipment. Some equipment was shrouded in plastic or placed directly in the ground after partial decontamination in the facility from which it came; mainly 200 Area chemical processing facilities, although some items came from the 100 Area. Landfills of this type include the 218-E-5A, 218-E-2, 218-E-2A, 218-E-5, 218-E-9 Landfills.

- **Construction Landfills.** These are past-practice landfills mainly limited to disposal of low-activity wastes resulting from construction/demolition work on existing facilities. Landfills of this type include the 218-C-9, 218-E-8, and 218-E-4 Landfills.
- **TSD Unit Landfills.** These are RCRA TSD units that contain waste forms similar to those in past-practice landfills such as dry waste packaged in small fiberboard cartons, directly disposed dirt and weeds, large concrete and wooden boxes containing used equipment, and construction debris. This landfill type includes the 218-E-10 and 218-E-12B Landfills.

The 200-E Burial Grounds are located above groundwater plumes associated with the 200-BP-5 Groundwater OU, but none of these plumes are attributed to releases originating from the landfills.

Current Status: The various sites comprising this EU are currently inactive and awaiting decisions and future actions toward cleanup as determined appropriate.

Primary Contaminants: Many of the landfills contain uranium, including depleted uranium, and plutonium radioactive waste that originated from processes in the 200 Area, as well as waste from offsite generators (CHPRC 2015a).

Table 3-33 and Table 3-34 list the primary radionuclide and chemical contaminants present and estimated quantities in the 200-E Burial Grounds (CP-LS-14) EU**.**

The saturated zone beneath the CP-LS-14 area overlaying the 200-PO and 200-BP GWIAs have elevated levels of cyanide (CN), I-129, nitrate, Sr-90, Tc-99, and total uranium based on 2014 groundwater results (http://phoenix.pnnl.gov/apps/gw/phoenix.html); CP-LS-14 waste sites are suspected of being able to contribute mobile contaminants to the saturated zone (DOE/RL-92-19, Rev. 0). The current threats to groundwater corresponding to only the CP-LS-14 EU contaminants *remaining* in the vadose zone (Appendix G.7.2, Table G.7.2-8) has an overall rating of Very High (related to hexavalent chromium).

Primary Risks: A Low-ND human health risk rating has been given to the Facility Worker and Co-located Person, and ND to the Public because there is no information to indicate that any of these sites currently represent a risk to human health, there is little or no worker activity at the sites, and the area is restricted from public access.

Cleanup and Disposition: The 200-SW-2 OU includes 24 landfills that include those in CP-LS-14 (200-E Burial Area) as well as this EU and 14 co-located waste sites. Seven of the landfills are RCRA TSD units and 17 are past-practice waste sites. The co-located sites include 11 UPR sites, the Z Plant burn pit, the T Ponds, and the 216-C-9 Pond.

No cleanup decisions have been made to remediate the 200-SW-2 OU.

<u>Range of Plausible Alternatives</u> (DOE/RL-2014-11, Table B-3, CP-14)

- Excavation, treatment (as necessary), and disposal of all waste from within individual landfills.
- Excavation, treatment (as necessary), and disposal of waste from selected sections of individual landfills followed by capping of remaining waste; includes continued cap maintenance and monitoring.
- Capping of individual landfills; includes continued cap maintenance and monitoring.

- *In situ* treatment/stabilization (e.g., vitrification or grouting) of portions of individual landfills followed by capping; includes continued cap maintenance and monitoring.

If residual contamination remains after cleanup actions are completed, cleanup work will transition to long-term stewardship, including institutional controls and 5-year reviews of remedy effectiveness.

Table 3-33. 200-East Burial Grounds (CP-LS-14) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	54
Carbon-14	A	0.027
Chlorine-36	A	NR[b]
Cobalt-60	C	3.9
Cesium-137	D	1.1E+06
Europium-152	D	0.75
Europium-154	D	59
Tritium	C	92
Iodine-129	A	0.000070
Nickel-59	D	0.55
Nickel-63	D	52
Plutonium-Total Rad[c]	D	1,000
Strontium-90	B	910,000
Technetium-99	A	1.0
Uranium-Total Rad[d]	B	1.4

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-34. 200-East Burial Grounds (CP-LS-14) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	58,000
Chromium-VI	A	NR
Mercury	D	8.3
Nitrate	C	2.8E+06
Lead	D	1.1E+10
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	3,700

a. Inventory details and references are found in the corresponding EU appendix.

200-E Waste Sites (CP-LS-15)

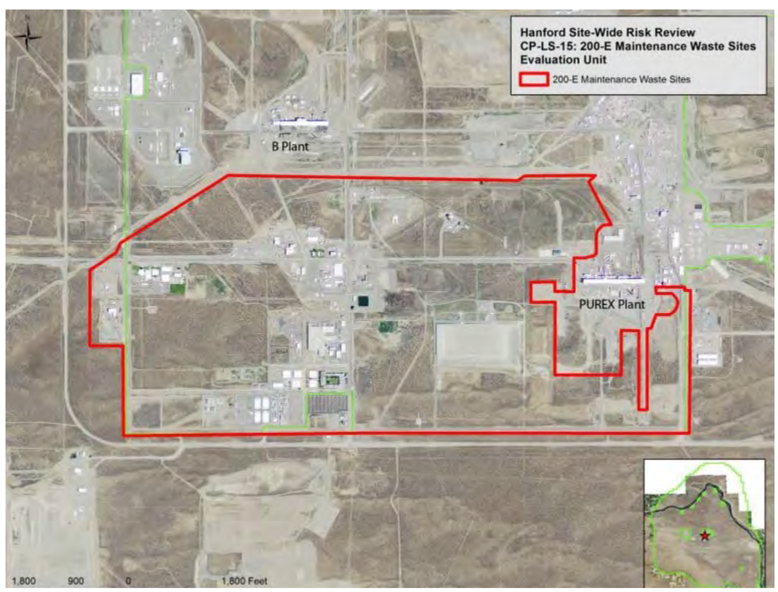

Figure 3-21. Aerial view of 200-E Miscellaneous Waste Site.

The 200-E Miscellaneous Waste Sites EU (Figure 3-21) is composed of 26 waste sites (ditch, drain, dumping area, pipeline, sewer, and unplanned release areas), of which 2 are indicated as still active; 3 tanks, of which 2 are active; and 76 buildings and structures, of which 64 are still active. The waste sites, buildings, and structure sites are associated with maintenance operations and a coal power plant in the southern portion of the 200 East Area. Information is available on only 10 of these sites, such as an open ditch posted with underground radioactivity signs; dumping areas containing construction debris such as wood, asphalt, dirt, steel pipe, and concrete; an old laydown area with scattered debris (wire rope, steel railroad rail, metal bar, wood, fiberglass insulation, aluminum cans, coal, pipe, aluminum wire, copper wire, concrete, and glass) over a large area; a fenced area northwest of PUREX that was used to stage railroad tank cars that transported liquid radioactive waste; several unplanned release areas related to radioactive particulates and drippings from contaminated railcars using the tracks; a site where the 284-E Powerhouse was demolished and covered with a gravel cap; a chemical drain field designed to receive non-hazardous liquid waste from the 272-E and 2703-E Buildings; and a parking lot for the Telephone and Utilities Department (DOE/RL-88-30 2015).

Current Status: The waste sites, buildings, and structure sites are associated with maintenance operations and a coal power plant in the southern portion of the 200 East Area. Most are inactive. There is no contaminant inventory information is available for any of these 105 sites (DOE 2011).

Primary Contaminants: There is no contaminant inventory data available on any of the 105 sites in this EU (Table 3-35 and Table 3-36). However, the Powerhouse Ditch and Pond potentially contributed contaminants to the unconfined aquifer. In addition, both the pond and the ditch may have significantly impacted the groundwater flow based on the large volume of liquid waste they received.

The majority of the unplanned releases reported in the PUREX Plant Aggregate Area were confined to shallow surface spills. Many of these spills were remediated by either removing the affected soil or covering the spill area with uncontaminated fill material. Based on the low natural recharge rates in the 200 East Area, the potential for these unplanned releases in the PUREX Plant Aggregate Area to contribute contaminants to the unconfined aquifer is low.

Primary Risks: A Low-ND human health risk rating has been given to the Facility Worker and Co-located Person, and ND to the Public because there is no information to indicate that any of these sites currently represent a risk to human health, there is little or no worker activity at the sites, and the area is restricted from public access.

There are no reported vadose zone inventories and thus no known significant threats to the vadose zone, groundwater, or the Columbia River for the purposes of this review.

Cleanup and Disposition: Several future cleanup approaches based on existing action memorandums for similar sites at Hanford will likely be considered. The first is relevant to the disposition of the substantial number of buildings and structures in this EU, if and when they become inactive and surplus, as well as a number of burial grounds containing debris from previous building demolitions. Action memoranda are in place (DOE/RL-2010-22 2010; DOE/RL-2008-80-ADD1 2010) to D4 buildings and facilities to slab-on-grade and evaluate below-grade portions for contamination, and cleanup of debris. The types of wastes and debris likely to require disposal include, but are not limited to, solid waste, low-level radioactive waste, asbestos waste, and PCB-contaminated waste.

The second approach will be relevant to cleaning up those sites that are believed to contain contaminated soil, structures and debris. Action memoranda (DOE/RL-2009-86 2010; DOE/RL-2009-37 2009) are in place to pursue a CSNA alternative or an RTD option. Under CSNA**,** sampling and analysis will be conducted on waste sites to confirm that soil contaminant concentrations are at or below RALs and that no further action is required. Radiological surveys will be included in the initial site investigation as appropriate for site conditions to support the selection of sampling locations. If confirmatory sampling results indicate that the RALs are not met (i.e., soil concentrations of COPCs exceed RALs), then the RTD alternative will be implemented or the waste site will be evaluated as part of a final remedial action.

Table 3-35. 200-East Miscellaneous Waste Sites (CP-LS-15) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	NR
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-36. 200-East Miscellaneous Waste Sites (CP-LS-15) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

GROUT VAULTS (CP-LS-16)

In an April 1988 ROD, DOE stated that its "Preferred Alternative" for the final disposition of the low-activity fraction of wastes in the double shell tanks was mixing it with a cement-based grout and disposal of the mixture in near surface preconstructed, lined concrete vaults. This decision was based on DOE's *Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes* (DOE/EIS-0113).

Figure 3-22. Aerial view of Grout Vaults Site.

To demonstrate the grouting concept and the mixture that would be stored in these vaults, the DOE grouted and disposed of approximately 1 million gallons of liquid phosphate-sulfate waste (PSW) in 1988 and 1989. The PSW grout was disposed of as a monolithic solid waste located in Vault V-101 of the Grout Treatment Facility (GTF) (Figure 3-22). The PSW was N Reactor's decontamination waste and was chosen because it was a low-level radioactive waste that contained source term radioactivity of 0.11 mCi/L. Also, the chemical component of the waste stream was not considered a dangerous waste according to the requirements of WAC 173-303-070 (Ecology 2009a).

In the early 1990s, Washington state regulators and other stakeholders raised concerns about the ability of the grout to prevent long-lived radionuclides, such as Tc-99, from migrating into groundwater over a long period, as well as the large land area (over 200 acres) that would be needed for the underground vaults. DOE suspended the grouting effort, and in 1994 DOE officially decided against the use of grout and chose to pursue vitrifying the low-activity tank wastes while leaving for future decisions to decide whether or not some portion of the waste may be treated by other means.

Current Status: Four other underground vaults were constructed between 1984 and 1988. None of them accepted or managed dangerous or mixed waste and they remain empty today. The GTF and other related buildings and equipment were abandoned in place.

Primary Contaminants: Approximately 1 million gallons of liquid PSW from N Reactor were mixed with grout and disposed of as a monolithic solid waste located in Vault V-101 of the GTF. The PSW was a low-level radioactive waste that contained source term radioactivity of 0.11 mCi/L dominated by Co-60 (0.11 mCi/L) and leachable Tc-99 (55 nCi/L) and Sr-90 (33 nCi/L). In terms of total alpha and total beta, it contained 7.79 nCi total alpha and 9,260 mCi total beta during the grouting campaign (Ecology 2009a).

Negligible amounts of radiological contaminants are known to be present at other above and below ground areas of the EU.[72]

Table 3-37 and Table 3-38 list the primary radionuclide and chemical contaminants present and estimated quantities in the Grout Vaults (CP-LS-16) EU.

[72] Waste Information Data System (WIDS), U.S. Department of Energy, Richland, WA.

There are no reported vadose zone inventories (i.e., reported inventories are in the grout vaults that is considered isolated from the environment during the evaluation period) and thus no significant threats to the vadose zone, groundwater, or the Columbia River for the purposes of this Review.

Table 3-37. Grout Vaults (CP-LS-16) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	420
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	NR
Strontium-90	B	0.12
Technetium-99	A	0.21
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-38. Grout Vaults (CP-LS-16) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: An evaluation by Ecology in 2009 found that the PSW grout disposed of in the GTF vault "does not pose any immediate threat to human health and the environment" (Ecology 2009b).

Cleanup and Disposition: According to DOE/RL-2010-22, the proposed remedial action program for facilities of this type includes D4 of the excess buildings/structures, cleanup of debris, and packaging and shipping the associated waste to ERDF or other approved onsite or offsite disposal facility for treatment, as needed, and disposal. Demolition of building and structures will include removal of above-grade structures. If below-grade structures (including pipes and utility systems) are not contaminated or may be decontaminated, they will optionally be left in place, backfilled, and brought to grade. This description would appear to include all five underground grout vaults. Backfill will consist of clean fill materials and/or inert demolition waste from the above-grade structures.

BC Control Zone (CP-LS-17)

The BC Controlled Area (CP-LS-17) is located south of the 200 East Area (in what is commonly called the 600 Area) near the center of the Hanford Site and lies between Route 4S and the Army Loop Road (Figure 3-23). The contamination in the BC Controlled Area (UPR-200-E-83) was the result of animal and plant (e.g., tumbleweed) intrusion and wind dispersion from the BC Cribs and Trenches. The BC Cribs and Trenches are separate waste sites and are discussed in the CP-LS-1 Evaluation Unit (Appendix G.5.1). The BC Cribs and Trenches were constructed in 1955 and received radioactive discharges of waste from two general sources: the uranium recovery project and 300 Area wastes, with the majority of the waste coming from the uranium recovery project.

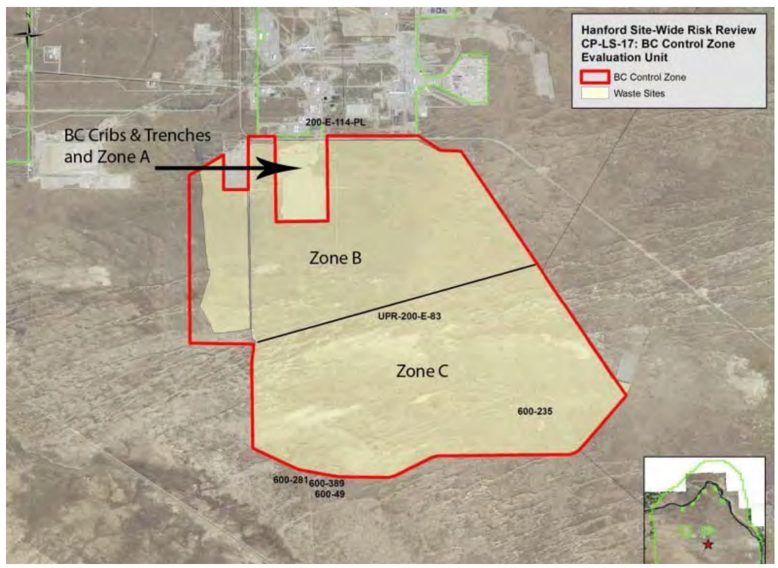

Figure 3-23. Aerial view of BC Controlled Area.

Characterization activities from 1973-1988 showed varying amounts of Cs-137, with the highest level of contamination in the area south of the BC Trenches; an arm of the contaminated area extending toward the southeast; an arm of the contamination extending toward the southwest; a contaminated area to the west; and contamination to the south and extending into the dunes (sparse contamination) that run generally east to west.

In 2008, CERCLA radioactive hazardous substances in the northern part of the BC Controlled Area were found to present a potential threat to human health and the environment to the extent that a removal action (DOE/RL-2008-22 2008) was warranted before a final remedial decision was documented. A 140-acre area designated as Zone A was identified as having the highest continuous radiological contamination over the PRGs and presenting the greatest risk to human health and the environment. Zone A is located directly south of the BC Cribs and Trenches area and is included in the CP-LS-1 (BC Cribs and Trenches) EU. The 3,660-acre balance of the northern section of UPR-200-E-83 was designated as Zone B and is included in this EU risk analysis along with the equally large area in the southern section of UPR-200-E-83 that is designated as Zone C.

Current Status: A total of approximately 20,000 tons of contaminated soil was removed from Zone B during the spring of 2010. This resulted in the removal of approximately 15 acres of contaminated spots. Because the original funding was limited to accomplishing the removal of 15 acres of contaminated soil, soil removal in Zone B was suspended after the completion of this scope. Recent radiological surveys concluded that contamination levels in the southern part of the BC Controlled Area (Zone C), the region south of and including the sand dunes, were not sufficient to warrant classification as a Soil Contamination Area.

Primary Contaminants: The primary radionuclides found in the BC Controlled Area soils were cesium (Cs-137) and strontium (Sr-90). However, no reported estimates of inventory were found (Table 3-39 and Table 3-40).

There are no reported vadose zone inventories and thus no significant threats to the vadose zone, groundwater, or the Columbia River for the purposes of this Review.

Primary Risks: No DSA or HA of these posted areas has been conducted, but radiological surveys with the mobile survey systems demonstrate that excavation and soil removal eliminated the direct contact exposure pathway for Cs-137, thereby preventing future releases of radiological contamination from this site. Small are hot spots are present in Zone B and have been appropriately marked.

Cleanup and Disposition: A final remedial decision for the 200-UR-1 OU has not been made; however, an interim ROD, Explanation of Significant Difference, and action memoranda are in place to remove contaminated soil, structures, and debris in the Central Plateau with disposal at ERDF. The range of cleanup alternatives mirrors what has been done to date across the UPR-200-E-83 waste site, which include RTD contaminated soil sites to achieve remedial action objectives comparable to the 100 Areas; backfill, contour, and revegetate excavated areas; allow monitored natural attenuation to proceed for all sites with appropriate institutional controls; and if residual contamination remains after cleanup actions are completed, cleanup work would transition to long-term stewardship, including institutional controls and 5-year reviews of remedy effectiveness.

Table 3-39. BC Control Zone (CP-LS-17) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	NR
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-40. BC Control Zone (CP-LS-17) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

OUTER AREA SITES (CP-LS-18)

Figure 3-24. Aerial view of Outer Area Sites.

The Outer Area Sites EU consists of the Nonradioactive Dangerous Waste Landfill (NRDWL) and the Solid Waste Landfill (SWL) and other waste sites, miscellaneous buildings, and structures in the 600 Area of the Hanford Site. The NRDWL and SWL sites are located in the central part of the Hanford Site about 3.4 mi. southeast of the 200 East Area (Figure 3-24). The NRDWL provided a site for disposal of nonradioactive dangerous waste generated from process operations, research and development laboratory maintenance activities, and transportation functions throughout Hanford. It operated from 1975 through 1985 and occupies an area of approximately 10 acres. The landfill consists of 19 parallel trenches, each about 400 ft long, 18 ft wide at the base, and 15 ft deep. The trenches typically were backfilled and covered with 6 to 10 ft of soil at the end of each operating day.

The majority of the waste disposed at SWL consisted of sanitary solid waste composed mostly of office and lunchroom waste and construction and demolition debris. The waste generally was not containerized prior to disposal. The sanitary solid waste mass has no known specific source areas but originated from throughout Hanford Site operations. The estimated total volume of sanitary solid waste is approximately 400,000 m^3.

Neither landfill currently has an engineered permanent cover; the operational covers are a non-vegetated, very coarse-textured, loamy sand/sand cover with a very low water-holding capacity. Groundwater historically has been impacted from leachate migrating out of the waste material through the vadose zone and into groundwater. However, current NRDWL/SWL trends in groundwater quality indicate contaminants of concern are at or below detection levels (DOE/RL-2010-28).

Current Status: Both are inactive waste sites. Groundwater monitoring at the SWL has been performed for over 20 years in accordance with a site-specific monitoring plan and is coordinated with the overall Hanford Site groundwater-monitoring project (200-PO-1 OU). The monitoring network consists of two upgradient wells on the west side of the SWL (Well 699-26-35A is shared with the NRDWL) and seven downgradient wells along the east and south of the SWL.

Primary Contaminants: Four main waste types (sanitary solid waste, asbestos, liquid waste, and drummed dangerous waste) were disposed at the NRDWL and the SWL. In addition to dangerous waste, the NRDWL also received a small amount of sanitary solid waste and a substantial amount of both friable and non-friable asbestos-containing waste material (over 50% by volume) through 1988, when it ceased operations. Beginning in 1975, drummed chemical waste was disposed of in six trenches, asbestos in nine trenches, and nonhazardous solid waste in one trench; three trenches were unused. Dangerous waste was disposed of in six dedicated trenches. All dangerous waste was containerized in drums prior to being placed in a trench. Asbestos waste generally was not containerized prior to disposal; however, it was disposed of and covered in accordance with regulatory requirements in place at the time.

SWL received non-dangerous and nonradioactive solid waste, as well as limited liquid wastes, approximately 1,200,000 gal of sewage and 1100 Area catch tank liquid, and approximately 100,000 gal of garage wash water. The liquid waste (likely the garage wash water) contained residual amounts of carbon tetrachloride, 1,1,1-TCA, TCE, and PCE.

Table 3-41 and Table 3-42 list the primary radionuclide and chemical contaminants present and estimated quantities in the Outer Area Sites (CP-LS-18) EU.

The saturated zone beneath the CP-LS-18 area has elevated levels of I-129 and tritium (H-3) based on 2014 groundwater results (http://phoenix.pnnl.gov/apps/gw/phoenix.html); however, CP-LS-18 waste sites are not suspected of being able to contribute mobile contaminants to the saturated zone (DOE/RL-92-19, Rev. 0).

Primary Risks: No radioactive contaminants are present in the two landfills, and the various chemical contaminants buried at the site do not present a risk to human health as they relate to air or surface soil pathways. Current NRDWL/SWL trends in groundwater quality indicate contaminants of concern are at or below detection levels (DOE/RL-2010-28).

Table 3-41. Outer Area Sites (CP-LS-18) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	NR
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-42. Outer Area Sites (CP-LS-18) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	94
Cyanide	B	NR
Chromium	B	26
Chromium-VI	A	NR
Mercury	D	140
Nitrate	C	11,000
Lead	D	10
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	0.0

a. Inventory details and references are found in the corresponding EU appendix.

Cleanup and Disposition: Currently, the proposed closure activities are addressed under a single plan for both facilities in DOE/RL-90-17, Rev. 2, *Nonradioactive Dangerous Waste Landfill/Solid Waste Landfill Closure/Postclosure Plan*. The proposed closure activities would focus on final barrier installation including oversight of the unit during barrier installation and appropriate certifications. A uniform design for a single evapotranspiration (ET) barrier over both NRDWL and SWL would be used.

Existing waste within NRDWL/SWL, including containerized dangerous waste, asbestos materials, and sanitary waste, will be left in place beneath the ET cover. As part of construction, geophysical surveys will be performed to assess the subsurface distribution of waste containers and voids within the NRDWL/SWL. This survey will support the final detailed cover design and determine if any void reduction or compaction will be required as part of construction to minimize the potential for future settling or subsidence.

Post-closure activities would include long-term groundwater monitoring activities (including installation of six additional wells—two new upgradient, four new downgradient, and one replacement), periodic inspections, and maintenance activities to ensure the long-term integrity of the closed landfill. Groundwater monitoring would continue during the post-closure period consistent with a compliant, State-approved groundwater monitoring program. Additional activities would be identified in the approved RCRA closure plan.

The most plausible remedial actions for the CP-LS-18 EU waste sites would primarily involve installation of an ET cover over existing contamination and log-term monitoring. Contaminants from the CP-LS-18 EU waste sites are suspected of impacting the vadose zone (as they consist of unlined trenches) but not yet the groundwater; treatment options are still being considered for the 200 East groundwater. Secondary sources in the vadose thus threaten to impact groundwater in the future, including the Active Cleanup period. The Medium (carbon tetrachloride) and Low (total and hexavalent chromium) ratings for the CP-LS-18 EU waste sites (Appendix G.12, Table G.12-5) are associated with primary contaminants that may impact groundwater in the 200 East Area (CP-GW-1, Appendix D.5). However, the groundwater transport results and more recent groundwater data would suggest that contamination from CP-LS-18 would not be expected to significantly impact groundwater or the Columbia River over the evaluation period. Furthermore, expected remedial options would tend to limit infiltrating water, which is the primary motive force to release and transport contaminants to groundwater.

COMPARATIVE SUMMARY

The Hanford Legacy Source EUs represent sites containing contaminant releases to the ground surface or subsurface resulting from prior actions, including waste disposal actions that are no longer being carried out at a particular location and are potentially subject to cleanup. They include past practice liquid waste disposal sites (e.g., cribs, ponds, and ditches), buried solid waste sites (including retrievably stored TRU waste sites), unplanned releases, and associated underground piping and infrastructure. These EUs also contain miscellaneous active and inactive buildings and structures associated with maintenance operations, laundry services, former coal power plants, LAW grouting, and nonradioactive hazardous and solid waste landfills. Legacy Source EUs may affect human health and environmental resources, primarily either through near-surface, soil-borne contamination or through potential impacts to groundwater.

Although individual risk review templates have been prepared on virtually all Hanford Site EUs and are included as individual appendices to this final report, several Legacy Source EUs and their associated templates have been consolidated based on their similarities in contaminants, sources, and disposal method. No risk review template was prepared for RC-LS-3 Pre-Hanford Orchard Lands. Thus, the risk review templates for the 21 Legacy Source EUs discussed above will be found in 12 appendices, numbered G.2 through G.13.

Comparing differences between the legacy waste sites in terms of their risks to human and ecological health necessitates consideration of the following:

- Activities of radionuclides (in Ci) and chemical inventories (in kg) of the contaminants
- Location of the contaminant relative to the soil surface and status of containment
- Mobility of the contaminant (sorbed, presence in vadose zone or groundwater)
- Whether cleanup work could cause unintended contact with the contaminant or airborne release of the contaminant
- For Public or Maximally Exposed Offsite Individual (MOI), the distance between the initiating event and the Hanford Site boundary

Table 3-43 briefly describes and compares the sources of contamination, current condition, risks, and remediation strategies of each of the Legacy Source EUs summarized at the applicable appendix level. They can be grouped further into liquid waste, solid waste, and other waste sites and evaluated with regard to current and long-term risk drivers.

Liquid Waste Sites:

- Appendix G.5.1 through Appendix G.5.8 (CP-LS-1 to CP-LS-4, CP-LS-6, and CP-LS-8 to CP-LS-10)
- Appendix G.6 (CP-LS-5 and CP-LS-11)

Most of the individual sites represent significant near-surface vadose zone risks to groundwater. The 200 West pump-and-treat system is remediating groundwater that may have been impacted by EUs CP-LS-2, 3, 4, and 6, but no treatment system is available for contamination from liquid waste sites in the 200 East Area. There is no current human health risk to workers or the public at any of these 200 East sites and no decisions have been made regarding future remediation strategies.

Solid Waste Sites:

- Appendix G.2 (RC-LS-1)

- Appendix G.4 (RC-LS-4)
- Appendix G.7.1 and Appendix G.7.2 (CP-LS-12 and CP-LS-14)
- Appendix G.12 (CP-LS-18)

The 618-10 and 618-11 Burial Grounds represent the highest risk during remediation among the 21 Legacy Source waste sites. The burial grounds contain Cs-137, Sr-90, Pu, Am-241, and other radiological contaminants, including pyrophoric wastes. The high-activity wastes were disposed of in VPUs, caissons, and concrete/lead-shielded drums, with the low-activity wastes buried in trenches, but specific quantities and locations were poorly characterized. Special handling procedures to minimize unexpected explosions or fires are being used with each drum unearthed, and a unique auguring method is being used to remove each VPU and its waste contents at the 618-10 site. TRU wastes are being separated out and temporarily stored until they can be transferred to WIPP. Characterization activities at the 618-11 Burial Grounds and eventual remediation of the site are being made more difficult because the site borders the privately operated Columbia Northwest generating station.

Although the 200 East and West Burial Grounds contain the largest quantities of Cs-137, Sr-90, tritium, or H-3 among the Legacy Source EUs, there is no information to indicate that these sites currently represent a risk to human health in their current state, as there is little or no worker activity at the sites and the area is restricted from public access. No decisions have been made regarding the future cleanup of these two burial grounds, and DOE is not required to submit a RCRA Facility Investigation/Corrective Measures Study & Remedial Investigation/Feasibility Study Report and Proposed Corrective Action Decision/Proposed Plan for the 200-SW-2 OU to Ecology until January 31, 2023.

Other Sites:

- Appendix G.3 (RC-LS-2) – K-West Area
- Appendix G.8 (CP-LS-13) – miscellaneous waste
- Appendix G.9 (CP-LS-15) – miscellaneous waste
- Appendix G.10 (CP-LS-16) – grout vaults
- Appendix G.11 (CP-LS-17) – soil contamination
- Appendix G.13 (CP-LS-7) – 200 Area Transfer Pipeline

Based on the information available, these six evaluation units represent the lowest risk in their current state among the 21 legacy EUs. Soils in the K-West Area contain small amounts of radiological contaminants that represent low worker risk. The two (200 East and 200 West Area) miscellaneous waste sites lack sufficient information with which to determine the long-term human health and ecological risks of doing nothing. Contaminant inventories are available for only 3 individual sites out of the 168 contained in these two EUs. Of the five grout vaults that were constructed, four were never used and are empty, and the fifth contains low-level (and low activity) waste contained in a cement grout. Contaminations of surface soils in the BC control area are in small hot spots that are widely dispersed across about 3,500 acres and sufficiently marked if DOE decides to remediate them.

Table 3-43. Comparison of legacy source evaluation units.

Evaluation Unit	Short Name	Ap-pendix	Type of Waste	Primary Contaminants	Disposal Method	Containment/ Mobility	Primary Risks	Cleanup Plan & Status
RC-LS-1	618-11 Burial	G.2	Fuel reactor samples; wipes, towels, clothing, cardboard, metal cans, HEPA filters failed machinery, used labware, tools	Cs-137, Sr-90, Pu, Am-241, Be	3 large trenches, 50 VPUs, and 3 caissons	Min. 2 ft soil cover on trenches; VPUs and caissons contain higher activity wastes, with gravel cover. H-3 and NO3 have Medium current ratings (groundwater)	Poorly characterized, high activity and pyrophoric wastes that were disposed.	Buried wastes and associated hard infrastructure (caissons, VPUs) will be removed and disposed in ERDF; TPA 9-30-21
RC-LS-2	K Area Waste	G.3	Contaminated wastes released from reactor support facilities, cooling water processing facilities, underground piping, liquid waste disposal sites, solid waste disposal sites, and surface spills were primary sources of contamination in 100-K during operations	Inventories only available for 2 crib sites. Small amounts of C-14 (110 Ci), tritium or H-3 (82 Ci), and Co-60 (11 Ci)	4 burial grounds, 33 cribs, 10 pipelines, 1 pond/ditch, 10 septic systems, 19 storage pads, 11 underground storage tanks, and 9 unplanned release sites	Low amounts of radionuclide contaminants in the soils. C-14 vadose zone inventory has High current rating (groundwater)	Unmitigated hazardous conditions result in Low consequences to the onsite and offsite receptors and no significant impact to the Facility Worker. Several scenarios present a standard industrial hazard to the Facility Worker	Sites will be remediated either by the process of CSNA or RTD. Samples will confirm that cleanup criteria are met, and the site will be backfilled with clean and compacted soil
RC-LS-3	Orchards	NA	Insecticides	Pb and As	Sprayed on trees to prevent pests	On soil surfaces and stumps	Insufficient information	No plan or decision

Evaluation Unit	Short Name	Ap-pendix	Type of Waste	Primary Contaminants	Disposal Method	Containment/ Mobility	Primary Risks	Cleanup Plan & Status
RC-LS-4	618-10 Burial	G.4	Radiological contaminated lab instruments, bottles, boxes, filters, irradiated fuel element sample residues, metallurgical samples, lab equipment, and low- and high-activity waste sealed in containers	Cs-137, Sr-90, Pu, Am-241, Np, U, Be, Pb, Zr, deactivated sodium-potassium metals; total 4,690 curies (130.1 Pu-239 dose-equivalent curies [DE-Ci])	12 trenches and 94 VPUs	Moderate- and high-activity wastes primarily disposed of in VPUs, with portion also disposed of in concrete/lead-shielded drums; Base of burial ground is 36 ft above ground water at average depth about 25 ft below the ground surface. Primary contaminants in vadose zone have Low ratings (groundwater).	DSA found highest consequential dose to the Co-located Person is related fires during potholing trench excavation work during remediation	Undergoing active remediation to be completed by September 2018
CP-LS-1	BC Cribs	G.5.1	Tank waste supernatant and other liquid waste in cribs and trenches, with animal intrusion and wind dispersion causing contamination into Zone A	Nitrate (NO_3), Cr, Tc-99, Sr-90, Cs-137, U-238, and Pu in cribs and trenches; high vadose zone risks to ground-water are Tc-99, I-129, Cr(total), and Cr(VI)	Underground pipes and trucked liquids to 28 waste sites, including 26 cribs and trenches, 1 siphon tank, and 1 pipeline	Contaminants are adsorbed in soil; no evidence of groundwater contamination from the cribs or trenches. Vadose zone I-129, Tc-99, and Cr have High current ratings (groundwater).	High levels of Cs-137 and Sr-90 at relatively shallow depths in the cribs and trenches; casual contact is prevented by site access controls and layer of clean soil on buried wastes	No decision on remedial action of cribs and trenches; removal of the contaminated soils in Zone A of UPR-200-E-83 began in 2008 and was completed in 2011

Evaluation Unit	Short Name	Ap-pendix	Type of Waste	Primary Contaminants	Disposal Method	Containment/ Mobility	Primary Risks	Cleanup Plan & Status
CP-LS-2	Pu Waste Site	G.5.2	Ponds and ditches received the highest volumes of contact cooling water and steam condensates that were typically non-radioactive Condensed process vapors and cell drainage (which were typically higher in radionuclide and chemical contaminants) were sent to cribs. French drains received the relatively very low-volume radioactive waste streams. Designed to percolate low-level liquid wastes into the soil without exposing it to air.	Varies by site, but generally substantial amounts of Am-241, Pu, Cs-137, Sr-90, H-3, nitrate, carbon tetrachloride, mercury and TBP; significant near-surface vadose zone contamination	Liquids disposed in cribs, trenches, French drains, detention basins, septic systems, underground settling tanks, and underground pipelines; also unplanned release sites	Sites suspected of being able to contribute mobile contaminants to the saturated zone; considerable nitrate, Sr-90 and uranium introduced to vadose zone; Chromium also considered a threat to groundwater. To summarize, current overall ratings for vadose zone contaminants (groundwater) are at least High for each of these EUs with the highest rating of Very High (CCl_4) in CP-LS-2.	Exposure to contaminants is limited because waste sites and contaminated soils are located below grade. Limited exposure from operations such as drilling, sampling, removal, treatment, and disposal.	Areas currently stabilized and covered with clean soil backfill with many posted as underground radioactive material areas 200-West pump and treat system remediating groundwater. Final cleanup alternatives range from no action (monitoring and natural attenuation) to significant actions, including installation of an engineered barrier and removal, treatment, and disposal
CP-LS-3	U Plant Cribs	G.5.3						
CP-LS-4	REDOX Cribs	G.5.4						
CP-LS-6	T Plant Cribs	G.5.5						
CP-LS-8	B Plant Cribs	G.5.6						
CP-LS-9	PUREX Cribs	G.5.7						
CP-LS-10	PUREX-TF Cribs	G.5.8						
CP-LS-5	U & S Ponds	G.6	Chemical sewer discharges from separation and concentration processes at canyon facilities	Vary by location, but include H-3, Pu, Cs-137, Sr-90, U, nitrates, TBP, CCl4, Cr, Pb, and Hg	Liquid waste piped to ponds, ditches, piping, and cribs for percolation	Contaminants accumulated in the sediment, and vegetation and algae collected and concentrated radionuclides. Both EUs have	Contamination at the 216-A-29 and 216-S-10 Ditches are not expected to pose a health risk to remediation workers when typical practices	Preferred alternatives are RTD of 216-A29 and 216-S-10 ditches and no action on other primary areas
CP-LS-11	B Pond	G.6						

Evaluation Unit	Short Name	Ap-pendix	Type of Waste	Primary Contaminants	Disposal Method	Containment/ Mobility	Primary Risks	Cleanup Plan & Status
						Very High groundwater threat ratings (CCl_4).	are followed from a health and safety plan	
CP-LS-12	200 West Burial	G.7.1	Landfills received bulk quantities of trash, construction debris, soiled clothing, failed equipment, and laboratory and process waste	Significant inventories (>200,000 Ci) of Cs-137, H-3, and Sr-90 each, and (>300,000 kg) of total U, Pb, and NO_3 each in West Burial Area; equipment burial area 218-E-10 has 1 million Ci of Cs-137 and 850,000 Ci of Sr-90	The 200-SW-2 OU is composed of 24 landfills and includes about 20 caissons that are located below grade; wastes placed in landfills directly or in cardboard, wooden, or reinforced polyester boxes, steel drums, concrete burial vaults, or other containers	Seven of the landfills are RCRA TSD units and 17 are past-practice waste sites; all are inactive and covered over with soil. Current vadose zone threats to groundwater have ratings of High (C-14, I-129, CCl_4, and Cr) for CP-LS-12 and Very High for CP-LS-14 (Cr-VI).	There is no information to indicate that any of these sites currently represent a risk to human health, there is little or no worker activity at the sites, and the area is restricted from public access	No cleanup decisions have been made to remediate the 200-SW-2 OU; range of alternatives include RTD, capping, and *in situ* treatment of individual landfills
CP-LS-14	200 East Burial	G.7.2						
CP-LS-13	200 West Misc	G.8	63 miscellaneous waste sites, active and inactive buildings and structures associated with maintenance operations, laundry, and coal power plant	Inventory information only available for 3 sites (216-U-5, 216-U-6, and 216-W-LWC); Co-60 and Pu-241 only contaminants more than 1 curie of radioactivity; both located in	42 sites are buildings or structures, many of which are in active use; 10 sites are burial grounds, with many appearing to be locations of demolished buildings	3 sites are backfilled trenches (2 posted URM); 52 sites are buildings, structures, or location of demolished buildings. Current vadose zone threats to	There is no information to indicate that any of these sites currently represent a risk to human health, there is little or no worker activity at the sites, and the area is restricted from public access	Little is known about most sites and the range of cleanup alternatives includes No Action to RTD

Evaluation Unit	Short Name	Ap-pendix	Type of Waste	Primary Contaminants	Disposal Method	Containment/ Mobility	Primary Risks	Cleanup Plan & Status
				laundry waste crib		groundwater has rating of Medium (I-129 and Cr).		
CP-LS-15	200 East Misc	G.9	105 miscellaneous waste sites, tanks, active and inactive buildings and structures associated with maintenance operations, and coal power plant	There is no contaminant inventory data available on any of the 105 sites in this EU	76 sites are buildings or structures, many of which are in active use; 26 are waste sites (ditch, drain, dumping area, pipeline, sewer, and unplanned release areas)	76 sites are buildings or structures, many of which are in active use; little is known about current condition of remaining sites. Current vadose zone threats to groundwater has ND rating.	There is no information to indicate that any of these sites currently represent a risk to human health, there is little or no worker activity at the sites, and the area is restricted from public access	Little is known about most sites and the range of cleanup alternatives includes No Action to RTD
CP-LS-16	Grout Vaults	G.10	Five near-surface concrete vaults constructed; one was used to test disposition of the low-activity fraction of wastes in double shell tanks mixed with a cement-based grout; other 4 are empty and closed	1 million gallons of liquid PSW was mixed with grout and disposed of as a monolithic solid waste located in vault V-101; equal to about 420 Ci of Co-60	Mixed with grout and disposed as a monolithic solid waste located in vault V-101	Mixed with grout and disposed as a monolithic solid waste located in vault V-101. Current vadose zone threats to groundwater has ND rating.	An evaluation by Ecology in 2009 found that the PSW grout disposed of in the GTF vault "does not pose any immediate threat to human health and the environment"	An evaluation by Ecology in 2009 found that the PSW grout disposed of in the GTF vault "does not pose any immediate threat to human health and the environment"
CP-LS-17	BC Control Area	G.11	Contamination in the BC Control Area was the result of windblown plant and soil	Primary radionuclides are Cs-137 and Sr-90; hot spots in Zone B remain but levels in Zone C	Contamination caused by wind dispersion from BC Cribs	Radionuclides are in the top 1 in. of the surface layer of soil, with the exception of Sr-90, which is	Contaminated hot spots in Zone B were investigated and accurately posted; soil contamination in	A total of approximately 20,000 tons of contaminated soil was removed from Zone B

Evaluation Unit	Short Name	Ap-pendix	Type of Waste	Primary Contaminants	Disposal Method	Containment/ Mobility	Primary Risks	Cleanup Plan & Status
			contamination from the BC Cribs and Trenches	are not sufficient to warrant classification as a Soil Contamination Area		distributed about 6 in. deep. Current vadose zone threats to groundwater has ND rating.	Zone C not human health risk	during the spring of 2010; no decision has been made regarding further remediation of the area
CP-LS-18	Outer Area	G.12	NRDWL received nonradioactive dangerous solid wastes and friable and non-friable asbestos-containing waste material; SWL received non-dangerous and nonradioactive solid waste and limited liquid wastes	Groundwater historically impacted from NO_3 leachate migrating out of the waste material through the vadose zone and into groundwater; however, current NRDWL/SWL trends in groundwater quality indicate contaminants of concern at or below detection levels	NRDWL provided a site for disposal of nonradioactive dangerous waste generated from process operations, research and development laboratory maintenance activities, and transportation functions throughout Hanford; SWL provided site for disposal of office and lunchroom waste and construction and demolition debris	Neither NRDWL nor SWL has an engineered permanent cover; the operational covers are a non-vegetated, very coarse-textured, 2 to 4 ft loamy sand/sand cover with a very low water-holding capacity. Current vadose zone threats to groundwater has Medium rating (CCl_4).	No radioactive contaminants are present in the two landfills, and the various chemical contaminants buried at the site do not present a risk to human health as they relate to air or surface soil pathways; groundwater monitoring at SWL has been performed for over 20 years in accordance with a site-specific monitoring plan	Proposed closure activities would focus on final barrier installation; a uniform design for a single evapotranspiration barrier over both NRDWL and SWL would be used
CP-LS-7	Transfer Pipeline	G.13	Waste sites primarily consist of cross-site transfer pipelines outside of the Tank Waste	The saturated zone beneath the area has elevated levels of total and hexavalent chromium (200	Pipelines and associated equipment were used to move waste within the 200 West and	Contaminants from the waste sites are in the vadose zone and may eventually reach	Facility workers are at risk when working in or around areas with contaminated soils, where	Preliminary remedial alternatives range from No Action to RTD

Evaluation Unit	Short Name	Ap-pendix	Type of Waste	Primary Contaminants	Disposal Method	Containment/ Mobility	Primary Risks	Cleanup Plan & Status
			Farms evaluation units, and include transfer lines, MUSTs, tanks, sewers, a dumping area, diversion boxes, buildings, and unplanned release sites.	West only), nitrate, Tc-99, uranium (total), carbon tetrachloride (CCl_4) (200 West only), trichloroethene (TCE) (200 West only), tritium (H-3), I-129, and uranium.	200 East Areas as well as to move waste from 200 West to 200 East Areas.	groundwater although not in concentrations (from solely the CP-LS-7 waste sites) likely to impact groundwater. Current vadose zone threats to groundwater has Low rating (multiple contaminants).	exposure is limited because waste sites and contaminated soils are located below grade.	

3.2. TANK WASTE AND FARMS EVALUATION UNITS

DESCRIPTION OF TANK WASTE AND FARMS EVALUATION UNITS

Nine tank waste and farms EUs were identified for inclusion in the interim progress report as indicated in Table 3-44. These EUs represent all 149 Hanford Site single-shell tanks (SSTs) and 28 double-shell tanks (DSTs) as well as ancillary equipment and geographically co-located legacy disposal sites. They are located in the Central Plateau within the 200 West and 200 East Areas. All current land-use activities in the 200 West and 200 East Areas are *industrial* in nature (Hanford 200 Area ROD[73]) and the land-use designations contained in the land use EIS and ROD indicate that the 200 West and 200 East Areas are denoted *Industrial-Exclusive* (DOE/EIS-0222-F). An Industrial-Exclusive area is "suitable and desirable for treatment, storage, and disposal of hazardous, dangerous, radioactive, and nonradioactive wastes" (DOE/EIS-0222-F).

Table 3-44. Tank waste and farms EUs and tank information included in the interim report (corresponding co-located legacy sites not listed). All Hanford single- and double-shell tank farms are included in the tank farm evaluation units.

Evaluation Unit	Tank Farm(s)	Waste Management Area(s) (WMAs)	Tank Type	Tanks	Location
CP-TF-1	241-T (T)	WMA T	Single-shell	16	200 West
CP-TF-2	241-S/SX (S-SX)	WMA S-SX	Single-shell	27	200 West
CP-TF-3	241-TX/TY (TX-TY)	WMA TX-TY	Single-shell	24	200 West
CP-TF-4	241-U (U)	WMA U	Single-shell	16	200 West
CP-TF-5	241-A/AX (A-AX)	WMA A-AX	Single-shell	10	200 East
CP-TF-6	241-B/BX/BY (B-BX-BY)	WMA B-BX-BY	Single-shell	40	200 East
CP-TF-7	241-C (C)	WMA C	Single-shell	16	200 East
CP-TF-8	241-AN/AP/AW/AY/AZ (AN-AP-AW-AY-AZ)	Not applicable	Double-shell	25	200 East
CP-TF-9	241-SY (SY)	Not applicable	Double-shell	3	200 West

Figure 3-25 shows the locations of the tank waste and farms EUs within the Central Plateau. The 177 underground waste storage tanks at the Hanford Site were constructed in groups of similarly designed structures called "tank farms." Eighteen tank farms are distributed between the 200 East and 200 West Areas and are connected by a cross-site transfer line that allows for waste transfers between the two areas. Over 50 million gallons of waste are stored in the tank farms. The tanks contain a mixture of liquid, sludge, and saltcake (precipitated solid salts) waste with both radioactive and chemically hazardous constituents. Liquids in the tanks exist as supernatant (liquid above solids) and interstitial liquid (liquid filling the voids between solids). Sludge consists primarily of solids (hydrous metal oxides) that were precipitated by the neutralization of acid wastes. Saltcake, when present, generally exists from evaporation of water from the waste. These waste types do not necessarily exist as distinct layers but may be intermingled at the interfaces between layers (RPP-13033).

Detailed maps and characteristics of the waste tanks, ancillary equipment, and legacy source units in each tank waste and farm EU are provided in the relevant EU description (see Appendix E.1 through E.11).

[73] http://www.epa.gov/region10/pdf/sites/hanford/200/hanford_200_rod.pdf

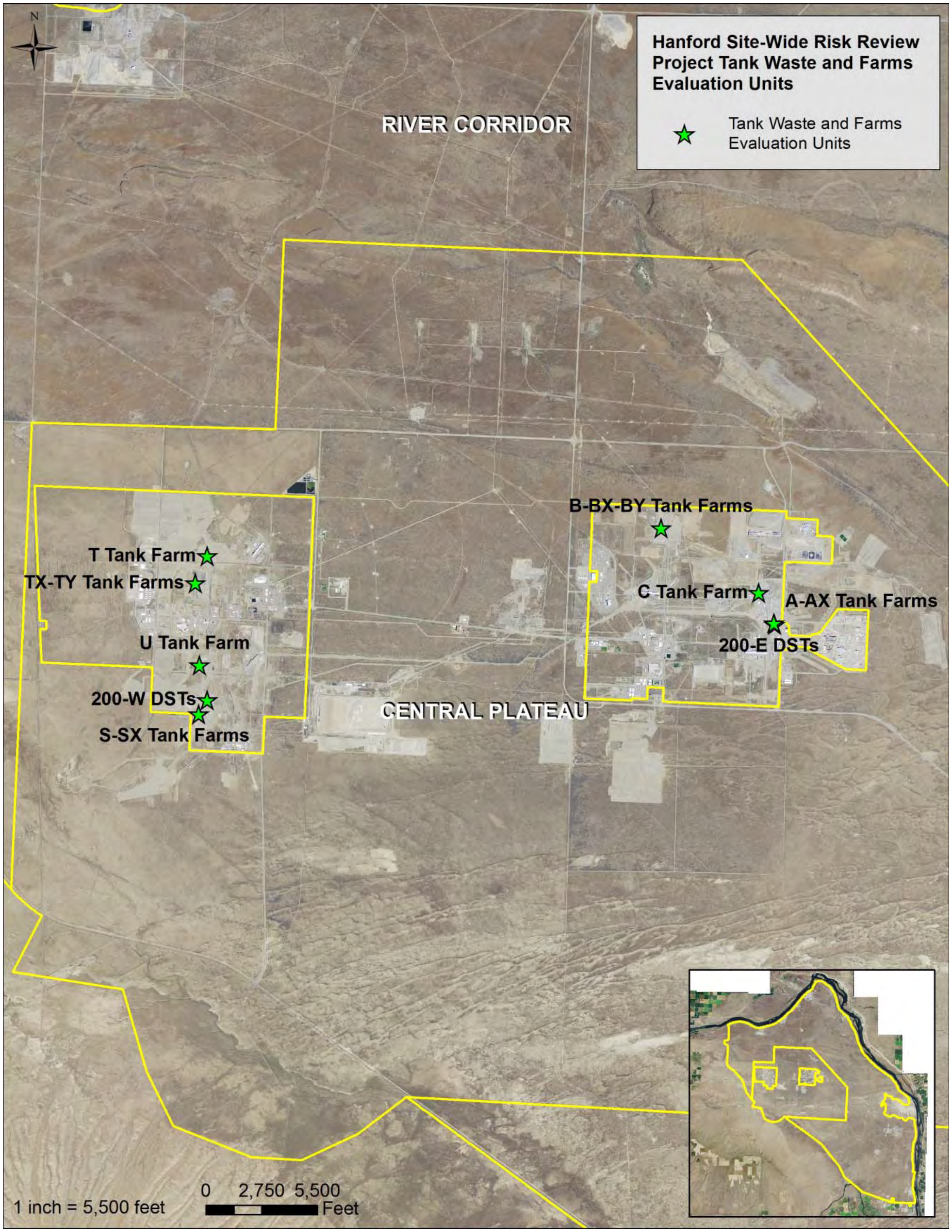

Figure 3-25. General location of the Hanford tank waste and farms evaluation units (Where A-AX Tanks Farms and 200-E DSTs are both represented by the star in the southeastern part of 200 East). The location of the 200 East and 200 West Areas in relation to the Hanford Site boundary is shown in the inset.

Hanford Single-Shell Tanks (SSTs)

Of the 18 tank farms, 12 are SST farms that contain 149 of the 177 tanks. The SST farms, constructed between 1943 and 1964, are in groups of 4 to 18 tanks and are divided between the 200 East and 200 West Areas. The original SST design was a reinforced concrete shell and dome with an internal liner (structurally independent from the reinforced concrete tank) of mild carbon steel covering the bottom and sidewalls. The first SSTs were designed with operating volumes of 530,000 gallons. The succeeding generations of SSTs were built with operating volumes of 758,000 gallons and 1 million gallons. Included among the 149 SSTs are 16 smaller tanks that have the same design as the larger tanks, but have operating volumes of only 55,000 gallons. A typical SST configuration is shown in Figure 3-26 (RPP-13033). A congressional mandate prohibited waste additions to Hanford SSTs after January 1, 1981.[74]

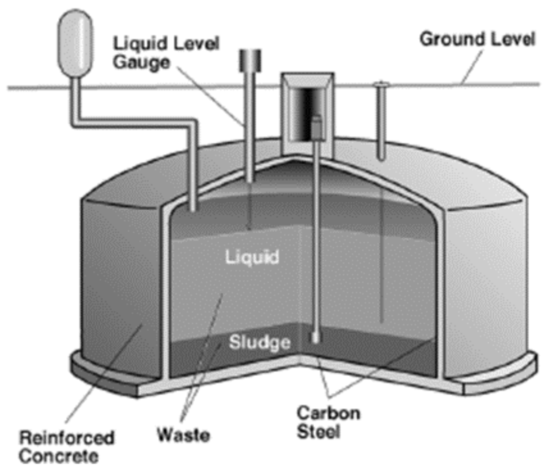

Figure 3-26. Typical Hanford single-shell tank design.

Hanford Double-Shell Tanks (DSTs)

To provide additional storage capacity, 28 DSTs were built in six tank farms between 1968 and 1986. Some SST waste has been transferred to the DSTs for subsequent treatment elsewhere on the Hanford Site starting after 2019. DSTs will also be used for future staging of SST wastes for treatment. Five of the DST farms are located in the 200 East Area, and one is located in the 200 West Area. All DSTs are similar in design and each has a storage capacity of approximately 1 million gallons. A typical DST configuration is shown in Figure 3-27 (RPP-13033).

[74] Berman presentation on July 29, 2009, titled "Hanford Single-Shell Tank Integrity Program." Available at www.em.doe.gov.

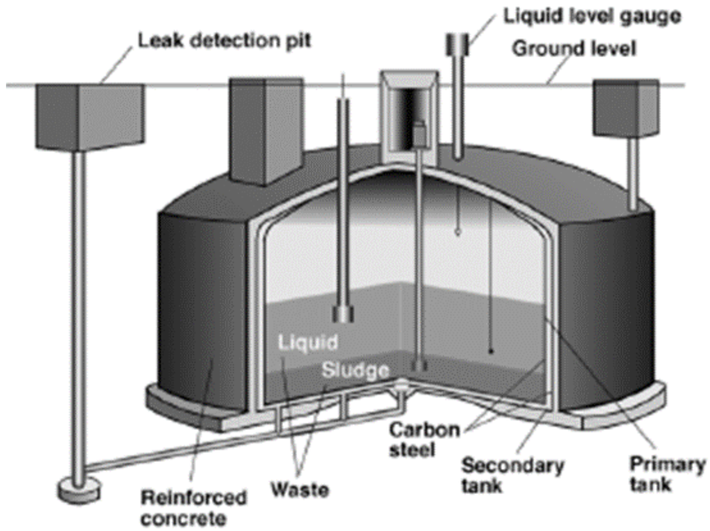

Figure 3-27. Typical Hanford double-shell tank design.

Each DST consists of a carbon-steel primary tank and a carbon-steel secondary tank within a protective reinforced concrete shell. The primary tank contains waste, is freestanding, and rests on an insulating concrete pad. The insulating pad rests on the secondary tank and was cast with air distribution and drain grids to provide for leak detection, maintain a uniform tank bottom temperature, facilitate heat removal, and eliminate pockets of water condensation. The secondary tank is 5 ft larger in diameter than the primary tank, providing an air space, or annulus, that separates the two steel tank walls. The secondary tank serves as a barrier to the environment in the event that the primary tank leaks (Templeton 2016). Tank 241-AY-102 has been observed to leak small waste quantities only through the primary tank (and not through the secondary tank). As of 2017, Tank 241-AY-102 is undergoing retrieval (Templeton 2016). No DSTs are known to have leaked to the environment.

Tank Waste Retrieval and Tank Farm Closure

Between 1978 and 1996, 147 of the 149 SSTs[75] were interim stabilized (Weyns 2015), where pumpable liquids (both drainable interstitial liquid and supernatant) were removed (versus liquids and solids as in waste retrieval) to reduce the hydraulic pressure on the tanks and thereby reduce the potential for leakage.

The SSTs in WMA C were previously interim stabilized (i.e., liquid transferred to DSTs to <50 kgal drainable interstitial liquid and <5 kgal of supernatant). Tank waste retrieval is in progress in the C Tank Farm (Templeton 2016, p. 9):

- Retrieval has been declared “Retrieval Completed” in ten of the C Tank Farm tanks (C-103, C-104, C-106, C-110 through C-112, and C-201 through C-204).
- Retrieval has been declared retrieved to various limits of technology in five tanks (C-101, C-102, C-107, C-108, and C-109).
- Retrieval is in progress in the remaining tank (C-105).

Final retrievals have not yet begun at other SST farms.

[75] Tank 241-C-106 went straight to retrieval and was not interim stabilized and Tank 241-S-102 was again considered interim stabilized in 2010 (Weyns 2015).

The preferred tank closure alternative includes 99% retrieval of waste from the SSTs for staging in DSTs and treatment elsewhere onsite; operations and necessary maintenance, waste transfers and associated operations, and upgrades to existing tanks or construction of waste receipt facilities (DOE/EIS-0391 2012, Chapter 2, p. 2-321). SST closure operations include filling the tanks and ancillary equipment with grout to immobilize residual waste contaminants. Disposal of contaminated equipment and soil would occur on site. Decisions on the extent of soil removal and/or treatment would be made on a tank farm or WMA[76] basis through the RCRA closure permitting process. Under this process, the tanks would be stabilized by filling with grout, and an engineered modified RCRA Subtitle C barrier put in place followed by post-closure care.

Thus, workers, the public and surrounding environment would be isolated from the residual contamination in the tanks by the tank structure, grout, and soil cover. Tank waste contamination already in the vadose and saturated zones would experience reduced infiltrating water (the primary driver for the release and transport of contaminants) because of the surface barrier.

Legacy Disposal Sites and Unplanned Contaminant Releases Associated with Tank Waste and Farms EUs

Each EU associated with SST waste and farms has geographically co-located legacy disposal sites as well as subsurface contamination from tank leaks and other unplanned releases. Furthermore, each of the SST farms is being regulated under RCRA as part of a corresponding WMA. In general the tank farm and tanks are within the WMA, which is within the EU (the EU also includes geographically co-located legacy sites and underlying vadose zone contamination, some of which may not be part of the WMA). A summary of past disposal practices and releases that have resulted in subsurface contamination within the boundary of the EU follows. There are no subsurface contamination inventories associated with the 200 West DST waste and farm EU (from two unplanned release sites without known inventories) and a small source associated with the 200 East DST waste and farm EU (from one crib and some unplanned release sites); therefore, those two EUs are not described below. The small 200 East DST waste and farm EU sources and 200 West unplanned release sites are described in Appendix E.10, and E.9, respectively.

<u>EU CP-TF-1: T Tank Farm, WMA T, and Associated Legacy Sites (200 West)</u>

Historical liquid waste disposal practices as well as leaks and unplanned release have resulted in contamination near the 241-T (T) tank farm (Horton 2006, p. 2.2-2.3) and within the boundary of the T tank waste and farms EU:

- 216-T-7 crib operated from 1948 to 1955 and received 110×10^6 L of second-cycle, T Plant cell drainage waste, and plutonium concentrator waste.
- 216-T-32 crib operated from 1946 to 1952 and received 29×10^6 L of waste from the 224-T building by way of the 241-T-201 SST.
- 216-T-14 through 216-T-17 specific retention trenches each received 785,000 to 1×10^6 L of first-cycle waste in 1954.
- 216-T-36 crib southwest of the T tank farm received about 522,000 L of decontamination waste and condensate in 1967 and 1968.

[76] A waste management area, or WMA, is a grouping of tanks and waste sites for regulatory purposes, which may not correspond with the EU groupings used in this report.

- 216-T-5 crib, located just west of the T tank farm, received about 2.6×10^6 L of second cycle waste[77] in 1955.
- Seven of the T tank farm SSTs are "assumed leakers" with leaks estimates ranging from <1,000 gallons (T-103, T-108, and T-109) to 115,000 gallons (T-106 in 1973) (Templeton 2016).
- Nine unplanned releases have been documented in or near WMA T that also fall within the T tank waste and farms EU boundary.

EU CP-TF-2: S-SX Tank Farms, WMA S-SX, and Associated Legacy Sites (200 West)

Various cribs in the area around the S-SX tank farms (and within the S-SX tank waste and farms EU boundary) received large volumes of slightly contaminated waste and other waste streams (Wood et al. 1999), where the largest include:

- 216-S-8 trench (east of WMA SX) received 2.6×10^6 gallons of REDOX waste (including unirradiated uranium) between 1951 and1952.
- 216-S-23 trench (northeast of S tank farm) received 76×10^6 gallons of evaporator condensate between 1973 and 1995.
- 216-S-1 crib (east of WMA SX) received 42×10^6 gallons of process condensate between 1952 and 1956.
- 216-S-3 crib (east of WMA SX) received 1.1×10^6 gallons of stream condensate between 1953 and 1956.
- 216-S-5 crib (southwest of WMA SX) received $1,100\times10^6$ gallons of stream condensate between 1954 and 1957.
- 216-S-6 crib (southwest of WMA SX) received $1,200\times10^6$ gallons condenser waste (REDOX) between 1954 and 1957.
- 216-S-7 crib (east of WMA SX) received 82×10^6 gallons of stream condensate between 1956 and 1965.
- 216-S-9 crib (east of S tank farm) received 13×10^6 gallons of redistilled process condensate between 1965 and 1975 (replacing 216-S-7 crib).
- 216-S-21 crib (west of S tank farm) received 23×10^6 gallons of stream condensate between 1954 and 1970.
- 216-S-25 crib (west of S tank farm) received 76×10^6 gallons of evaporator condensate between 1973 and 1995.
- Nine of the S-SX tank farm SSTs are declared "assumed leakers," with leaks estimates ranging from <5,000 gallons (SX-114 and SX-107) to 50,000 gallons (SX-115 in 1965) (Templeton 2016).
- Twenty-five unplanned releases have been documented in or near WMA S-SX that also fall within the S-SX tank waste and farms EU boundary.

It appears that tank wastes were not directly cascaded from the S-SX tank farm tanks to the cribs.

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[77] As part of the early plutonium recovery process in T Plant and B Plant, second cycle waste was the wastestream resulting from the second decontamination cycle. It contained less than 0.1 percent of the fission products. This is not the same second-cycle waste that results from PUREX process.

EU CP-TF-3: TX-TY Tank Farms, WMA TX-TY, and Associated Legacy Sites (200 West)

Past practices and unplanned disposals have resulted in legacy (vadose zone) contamination near the WMA TX-TY (Horton 2007, p. 2.3-2.6)[78] and that fall within the TX-TY tank waste and farms EU boundary:

- 216-T-21 through T-24, specific retention trenches were used in 1954 and received a total of 5×10^6 L of first cycle supernatant waste from TX tank farm tanks.
- 216-T-25 trench was active during September 1954 and received 3×10^6 L of evaporator waste from the 242-T Evaporator.
- 216-T-28 crib was active from 1960 to 1966 and received 42.3×10^6 L of waste including steam condensate decontamination waste, miscellaneous waste from 221-T Building, and decontamination waste from the 2706-T Building and 300 Area laboratory waste.
- 216-T-19 crib and tile field, located south of the TX tank farm, operated from 1951 to 1980 and received 455×10^6 L of effluent from the 242-T Evaporator and T Plant operations.
- Thirteen of the TX-TY tank farm's 24 SSTs are declared "assumed leakers" (Templeton 2016), with leaks estimates ranging from <1,000 gallons (TY-101 in 1973) to 35,000 gallons (TY-105 in 1960).
- Eleven unplanned releases have been documented in or near WMA TX-TY that also fall within the TX-TY EU boundary.

EU CP-TF-4: U Tank Farm, WMA U, and Associated Legacy Sites (200 West)

Waste was cascaded among the U tank farm waste tanks; however, it appears none was released to cribs or ditches related to the U tank waste and farms EU. The 216-U-3 French drain (located south of WMA U and within the U tank waste and farms EU) received 7.9×10^6 L of liquid from steam condensers on waste tanks in the U tank farm and likely contains nitrate and minor amounts of fission products and actinides.

Four of the tanks in the U tank farm (U-101, U-104, U-110, and U-112) are "assumed leakers" (Templeton 2016), ranging from 5000 to 8100 gallons (U-110 in 1975) to 55,000 gallons (U-104 in 1961). All four "assumed leakers" have been stabilized and contain little or no pumpable liquid.

Four unplanned releases have been documented associated with the U tank waste and farms EU with unknown waste volumes. Three unplanned releases that may have significant impacts are beta contamination in diversion boxes east of the U tank farm, a "violent chemical reaction" in a vault (244-UR) that spread first-cycle metal waste contaminants over an unspecified area, and a ruptured waste line at tank U-103 (Hodges and Chou 2000, p. 2.3).

EU CP-TF-5: A-AX Tank Farms, WMA A-AX, and Associated Legacy Sites (200 East)

Various non-tank sources that received large volumes of slightly contaminated waste and other waste streams have resulted in extensive vadose zone and groundwater contamination in the areas around the WMA A-AX (Narbutovskih and Horton 2001, p. 3.4-3.5) that fall within the A-AX tank waste and farms EU boundary:

- Surface spills associated with leaks from transfer lines, diversion boxes, catch tanks, and vaults.

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[78] The wastes disposed to some of the cribs and trenches adjacent to WMA TX-TY were similar to the wastes stored in the SSTs, making it difficult to distinguish waste sources for existing groundwater contamination.

- Liquid disposal facilities including cribs, trenches, and French drains were used to discharge from 1600 gallons to 304 Mgal of volume effluents, including condensate and condenser cooling water, depleted uranium waste, cell and stack drainage waste, and tributyl phosphate (TBP)-kerosene organic waste from PUREX.
- Two of the A-AX tank farm SSTs are declared "assumed leakers," with leak estimates ranging from 500 to 2500 gallons (from A-104 in 1975) to 10,000 to 270,000 gallons (from A-105 in 1963, which occurred when a steam explosion ruptured the tank bottom), not including leaks from transfer lines, other ancillary equipment, surface spills, or overflow amounts (Templeton 2016).

<u>EU CP-TF-6: B-BX-BY Tank Farms, WMA B-BX-BY, and Associated Legacy Sites (200 East)</u>

Various non-tank sources (e.g., cribs, trenches, tile fields, and reverse wells) that received large volumes (7.2 to 36.8 Mgal) of contaminated waste and other waste streams have resulted in extensive vadose zone and groundwater contamination in the areas around the WMA B-BX-BY (PNNL-13022) and fall within the B-BX-BY tank waste and farms EU:

- Liquid wastes that vary from high-level metals waste to large quantities of ferrocyanide scavenged uranium recovery waste taken directly from tanks in the 241-BY tank farm
- Large volumes of tritium-rich tank condensate generated during the in-tank solidification program that began in 1965

<u>EU CP-TF-7: C Tank Farm, WMA C, and Associated Legacy Sites (200 East)</u>

Various non-tank sources that received large volumes of contaminated waste and other waste streams have resulted in vadose zone and groundwater contamination in the areas around the C tank waste and farms EU, including 14 documented, unplanned releases (i.e., surface spills and leaks from transfer lines, diversion boxes, catch tanks, and vaults) (Horton and Narbutovskih 2001) that fall within the C tank waste and farms EU.

INVENTORIES OF KEY WASTE CONSTITUENTS AND PRIMARY CONTAMINANTS

Operations at the Hanford Site included multiple processes for recovery of specific nuclear materials from irradiated fuel elements, and thus many different waste streams were delivered to the tank farms over several decades. Furthermore, additional processing was carried out on some wastes contained in tanks to recover specific constituents (uranium, Cs-137, Sr-90, etc.) and additional waste transfers were made between tanks (within and between tank farms) as part of tank farms management. For this review, several models have been used to estimate characteristics of the Hanford tank wastes as they exist today. These models were developed from historical information (Remund et al. 1995). For example, the Hanford Defined Wastes/Tank Layering Model (HDW/TLM) (Agnew 1994) was used to estimate tank contents for all 149 SSTs (Brevick et al. 1994). Tank wastes are categorized based on the major waste types (primary and secondary) that were deposited in each tank and based on process histories. A chemical composition is specified for each waste type, and tanks are identified by volume percentages of all possible waste types (derived from historical information). The chemical compositions are then volume averaged to obtain a final waste composition estimate for each SST. The tank wastes in the tank waste and farms EUs can be summarized (Remund et al. 1995) as:

- CP-TF-1 (T tank farm) in 200 West – first cycle decontamination from bismuth phosphate process, lanthanum fluoride finishing waste, and PUREX and REDOX cladding wastes
- CP-TF-2 (S-SX tank farms) in 200 West – REDOX wastes and salt and slurry cake from evaporator campaigns

- CP-TF-3 (TX-TY tank farms) in 200 West – salt cake from evaporator campaigns T1 and T2
- CP-TF-4 (U tank farms) in 200 West – aluminum cladding REDOX wastes, salt and slurry cake from evaporator campaigns
- CP-TF-5 (A-AX tank farms) in 200 East – salt cake and slurry from evaporator campaigns A1 and A2 and washed PUREX sludge
- CP-TF-6 (B-BX-BY tank farms) in 200 East – salt cake from evaporator campaigns B and BY, metal waste from bismuth phosphate process, first/second cycle decontamination from the bismuth phosphate process, and lanthanum fluoride finishing waste
- CP-TF-7 (C tank farm) in 200 East – First cycle decontamination from bismuth phosphate process, aluminum cladding PUREX wastes, metal waste from bismuth phosphate process, and ferrocyanide sludge

More recent, detailed compositional estimates of what is currently in the Hanford waste tanks are available in the Best Basis Inventory,[79] which also was used to specify inventories of specific constituents for the EUs.

The primary constituents evaluated for the tank waste and farms EUs include (1) radionuclides - tritium (H-3); Sr-90; Tc-99; I-129; Cs-137; the sum of U-233, U-234, U-235, U-236, and U-238 (for completeness although risk is driven by uranium toxicity); and the sum of Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242; and (2) chemicals – Cr (total), Cr(VI), nitrate (NO_3), U (total), and TCE. Subsurface inventories of some contaminants (e.g., tritium, TCE, Cr) may have resulted from legacy disposal practices within the defined EU rather than from tank leaks or unplanned releases.

Figure 3-28 compares the relative amount of radionuclides (Ci) for tritium (H-3), Sr-90, Tc-99, I-129, Cs-137, the sum of U-233, 234, 235, 236, 238, and the sum of Pu-238-239-240-241-242 by tank farm. Sr-90 and Cs-137 dominate the overall radionuclide inventory (activity). However, since this comparison is based on individual radionuclide activity, this comparison does not directly correspond to dose consequence due to the very different dose conversion factors for the individual radionuclides listed.

Figure 3-29 through Figure 3-39 represent a set of pie diagrams summarizing several of the primary constituents and the total activity estimated to be within each tank waste and farms EU. "Slices" of each pie diagram represent the relative amounts of an identified primary constituent (e.g., tritium) estimated to be within the specified tank farm tanks in the EU, as well as from leaks and legacy disposal practices for each EU. The area for each EU pie is scaled relative to the total amount of the constituent present across all nine tank waste and farms EUs. The primary radioactive contaminants represent much of the total activity (Figure 3-35) in the waste tanks, with the notable exceptions of Y-90 (which is in secular equilibrium with Sr-90) and Ba-137m (which is in secular equilibrium with Cs-137). These two isotopes (Y-90 and Ba-137m) account for approximately 48% of the activity in the Hanford tanks (which is also approximately equal to that represented by Sr-90 and Cs-137). Other tanks have significant proportions of Sm-151 (a U-235 fission product), Pu-241 (formed by neutron capture), Am-241 (primarily from beta decay of Pu-241), and Ni-63 (an activation product). However, these other isotopes are not risk drivers in the evaluations used to support this review.

One message from these figures is that the identified constituents are unevenly distributed across the individual tanks within an EU as well as across the set of tank waste and farms EUs. For example, the

[79] Best Basis Inventory (BBI) Summary (March 24, 2014) provided in spreadsheet form by Mark Triplett (PNNL). The current version of the BBI is stored online and can be accessed using the Tank Waste Information Network System (TWINS) at: https://twinsweb.labworks.org/ (July 2015).

inventory of tritium is dominated by intentional discharges to cribs in EUs CP-TF-2 (S-SX), CP-TF-3 (TX-TY), and CP-TF-5 (A-AX), and relatively small quantities of tritium remain in the tanks compared to prior releases.

For the single shell tanks, the vast majority of the radionuclide and chemical inventory shown in the figures is contained in the tanks with the following exceptions:

- I-129 and Tc-99 in the T (CP-TF-1), TX-TY (CP-TF-3), and B-BX-BY (CP-TF-6) tank waste and farms EUs, where significant releases occurred either through leaks or discharges to cribs; however, the total inventory of Tc-99 and I-129 is relatively small compared to other EUs (Figure 3-32 and Figure 3-33);
- Cr(total) inventory in the T tank waste and farms EU (CP-TF-1) is dominated (approximately 75%) by intentional discharges to cribs and trenches, and significant amounts have been intentionally discharged also at tank waste and farms EUs S-SX, TX-TY, and B-BX-BY (Figure 3-36);
- Uranium in the A-AX tank waste and farms EU (CP-TF-5), where disposal through trenches and cribs contribute more than half of the inventory within the EU, and B-BX-BY and TX-TY, where significant releases occurred through leaks and cribs (Figure 3-37); and
- Nitrate in EUs T and B-BX-BY where greater than 50% of the inventory has been through intentional discharges, as well as a significant fraction in EUs S-SX and TX-TY (Figure 3-38).

Another illustration may provide additional insight to the large variations in the radionuclide concentrations in, risks posed by, and characteristics of the Hanford tank wastes. Figure 3-35 illustrates a recent snapshot of the total radionuclide inventories for all 177 waste tanks. Total radionuclide concentrations (using the best basis inventory) vary by more than five orders of magnitude from Tank 241-T-202 (with the lowest total activity of approximately 23 Ci) to Tank 241-AZ-101 (with the highest total activity of approximately 16 MCi). However, the radionuclides that comprise the inventories and their properties (e.g., half-lives and environmental mobilities) can also make a significant difference on the resulting risks posed. The Tank Waste Subcommittee of the DOE Environmental Management Advisory Board (EMAB) indicated that approximately 40 of the Hanford waste tanks contain wastes that would satisfy the NRC Class C classification without treatment (Ferrigno, et al. 2011). Also there may be as many as 11 Hanford tanks (T and B Tank Farms) that contain wastes that potentially could be reclassified as contact-handled TRU (CH-TRU) waste (Tingley, et al. 2004) for off-site disposal. These analyses would be improved if the characteristics of the wastes in the tanks were further evaluated to determine what types of wastes (e.g., low-heat waste from the bismuth phosphate process) correspond to the lowest risks.

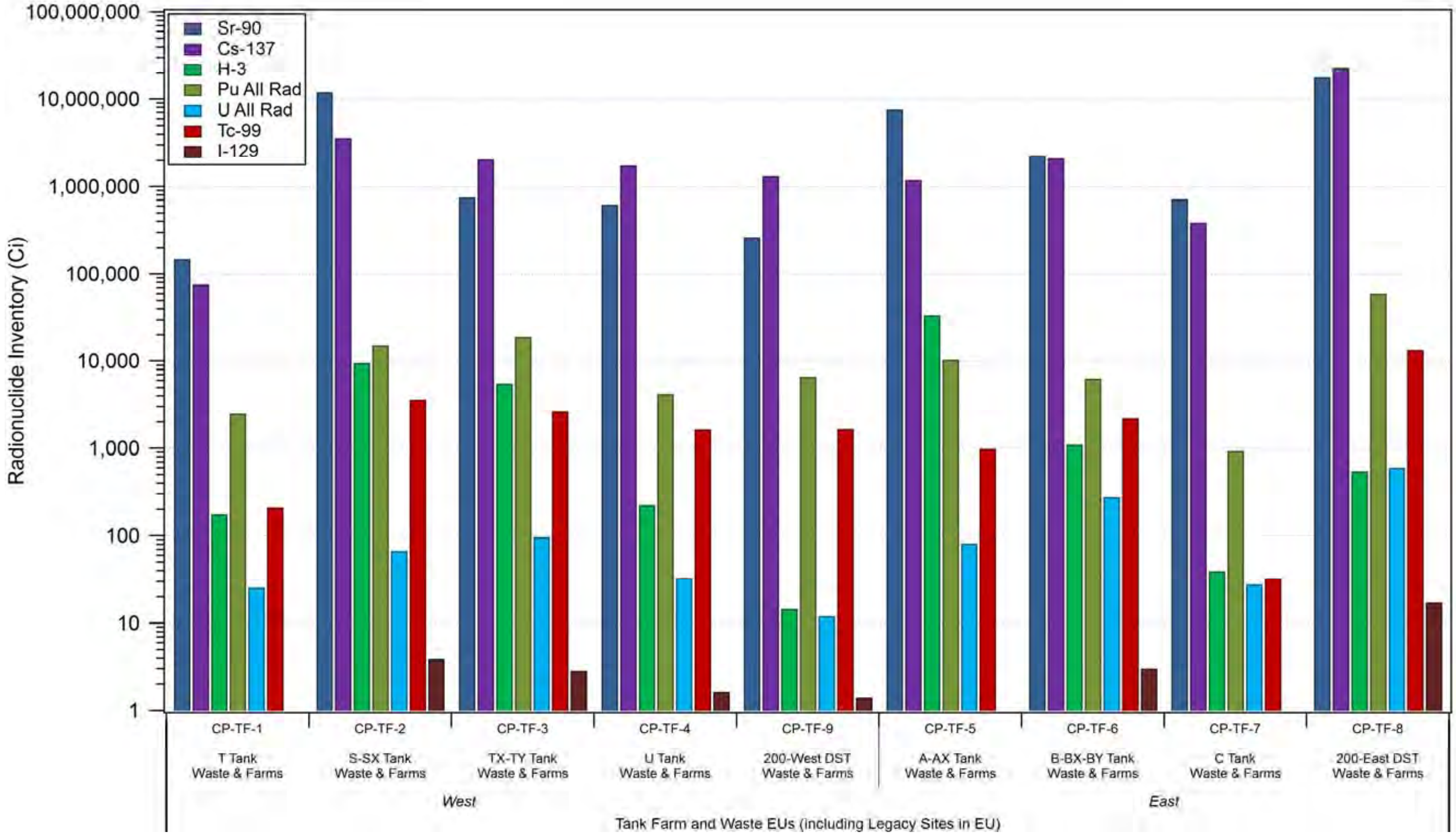

Figure 3-28. Radionuclide inventories by tank waste and farms EUs.

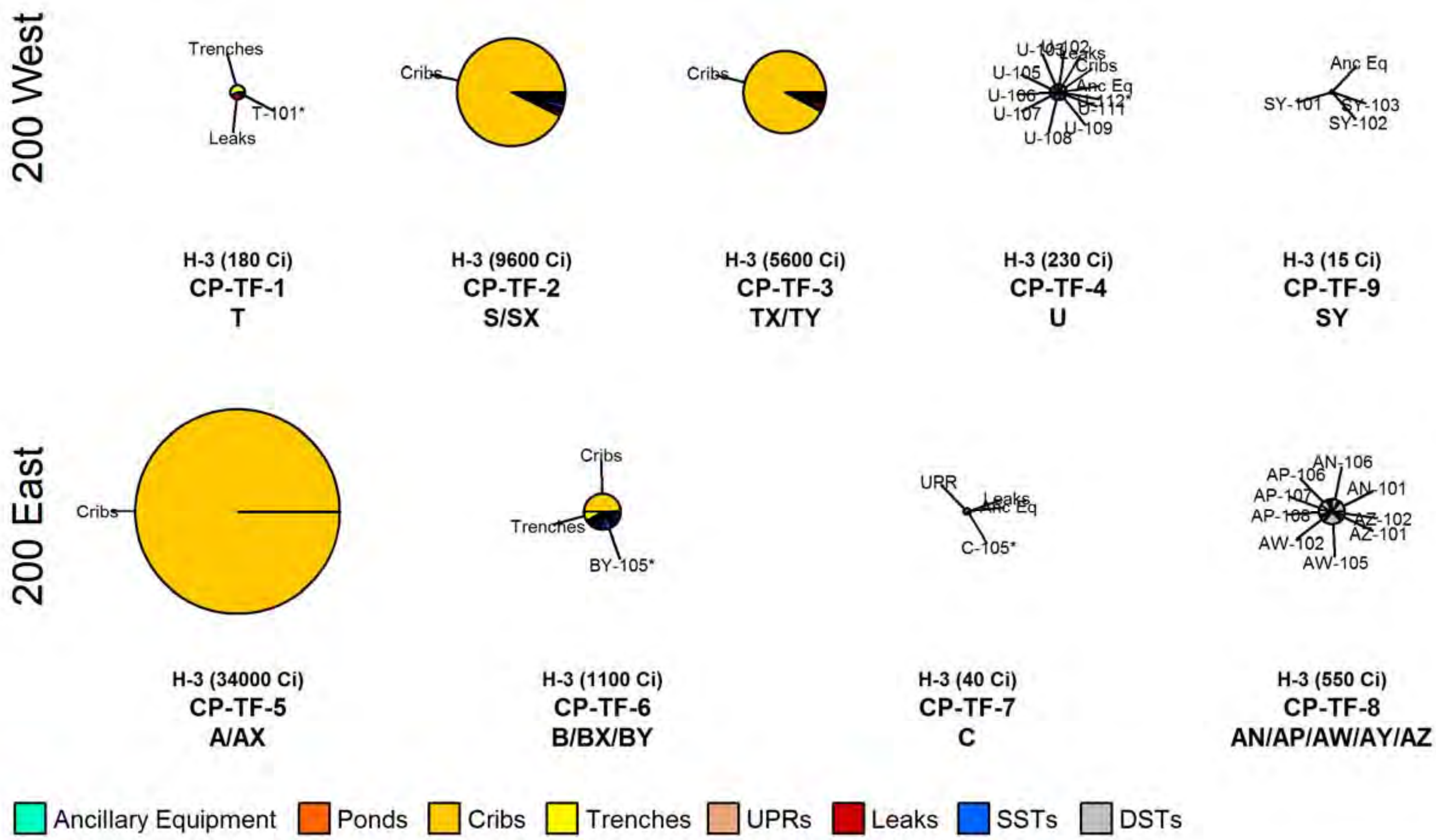

Figure 3-29. Tritium (H-3) as tritiated water (^3H_2O): Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches) and leaks. Each pie represents a single tank waste and farm EU. The relative inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

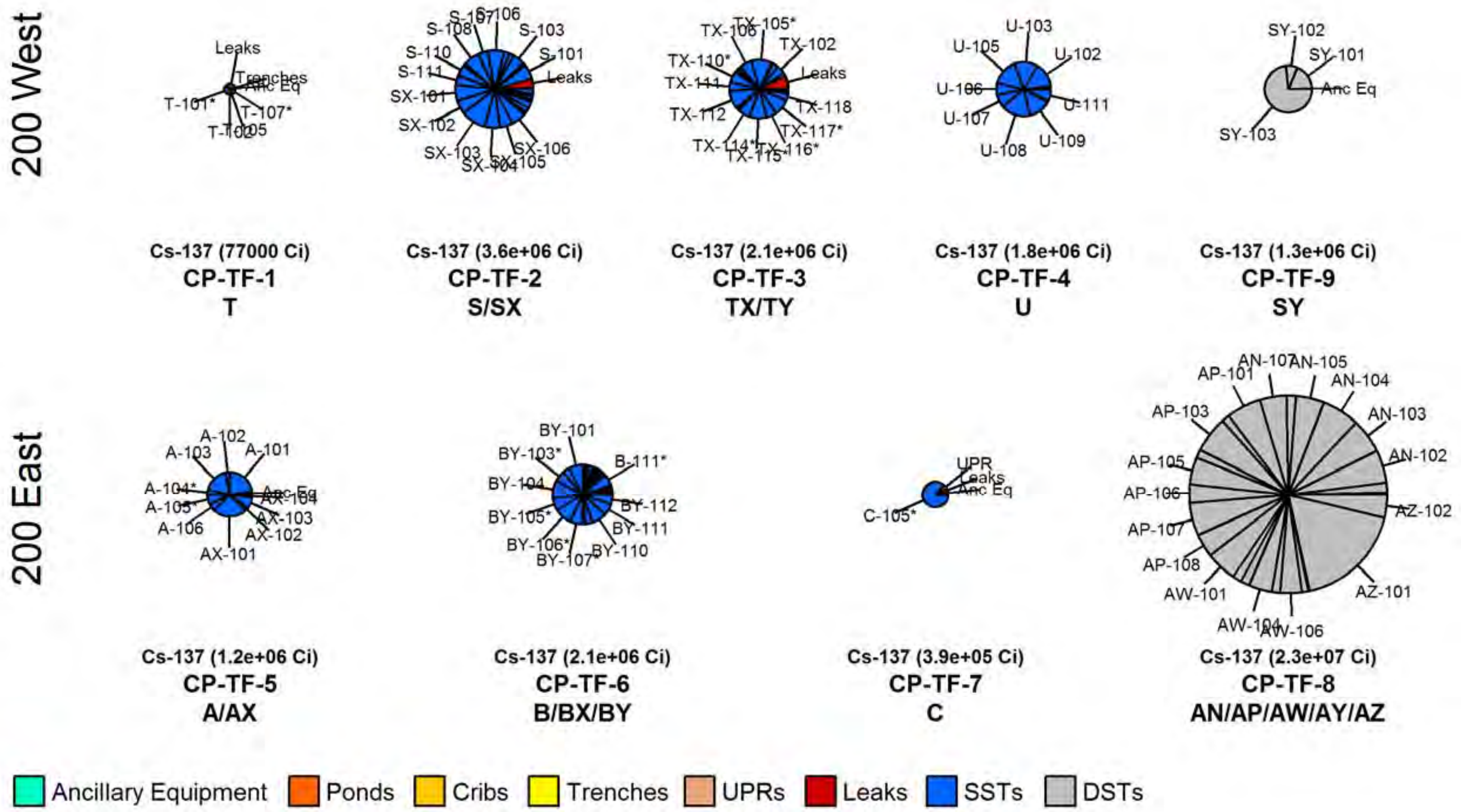

Figure 3-30. Cesium-137: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and unplanned releases (UPRs). The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

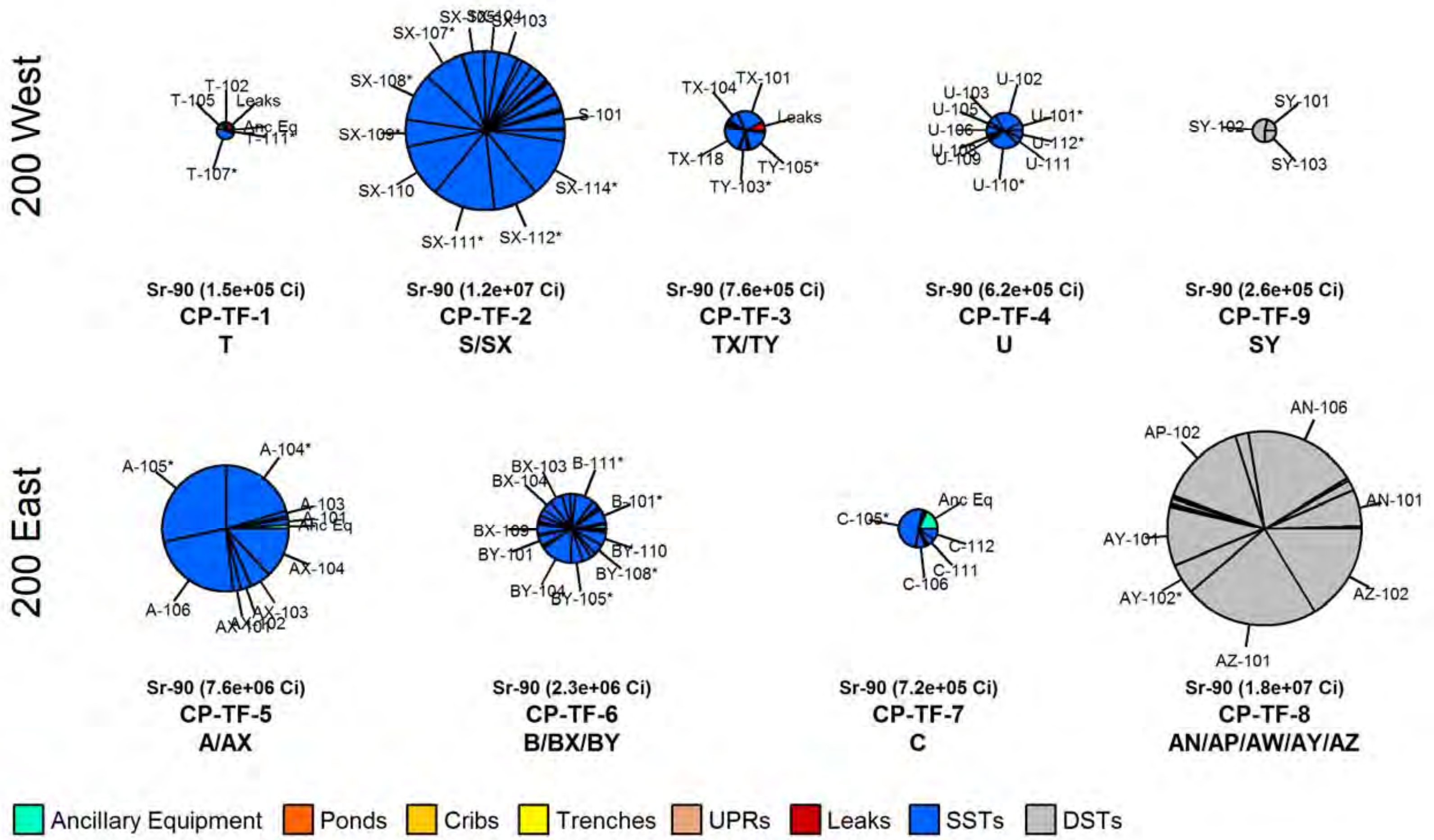

Figure 3-31. Strontium-90: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

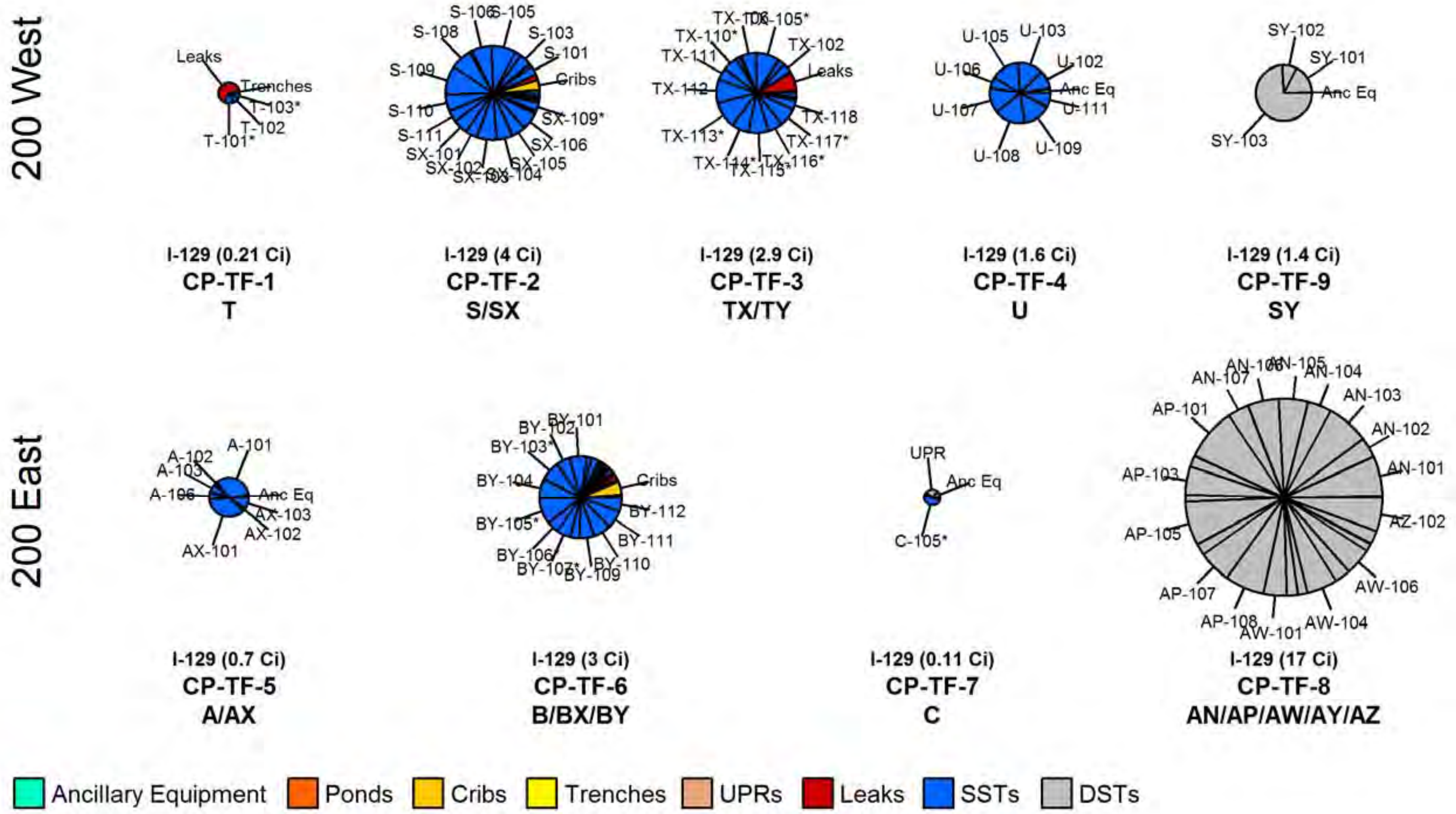

Figure 3-32. Iodine-129: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

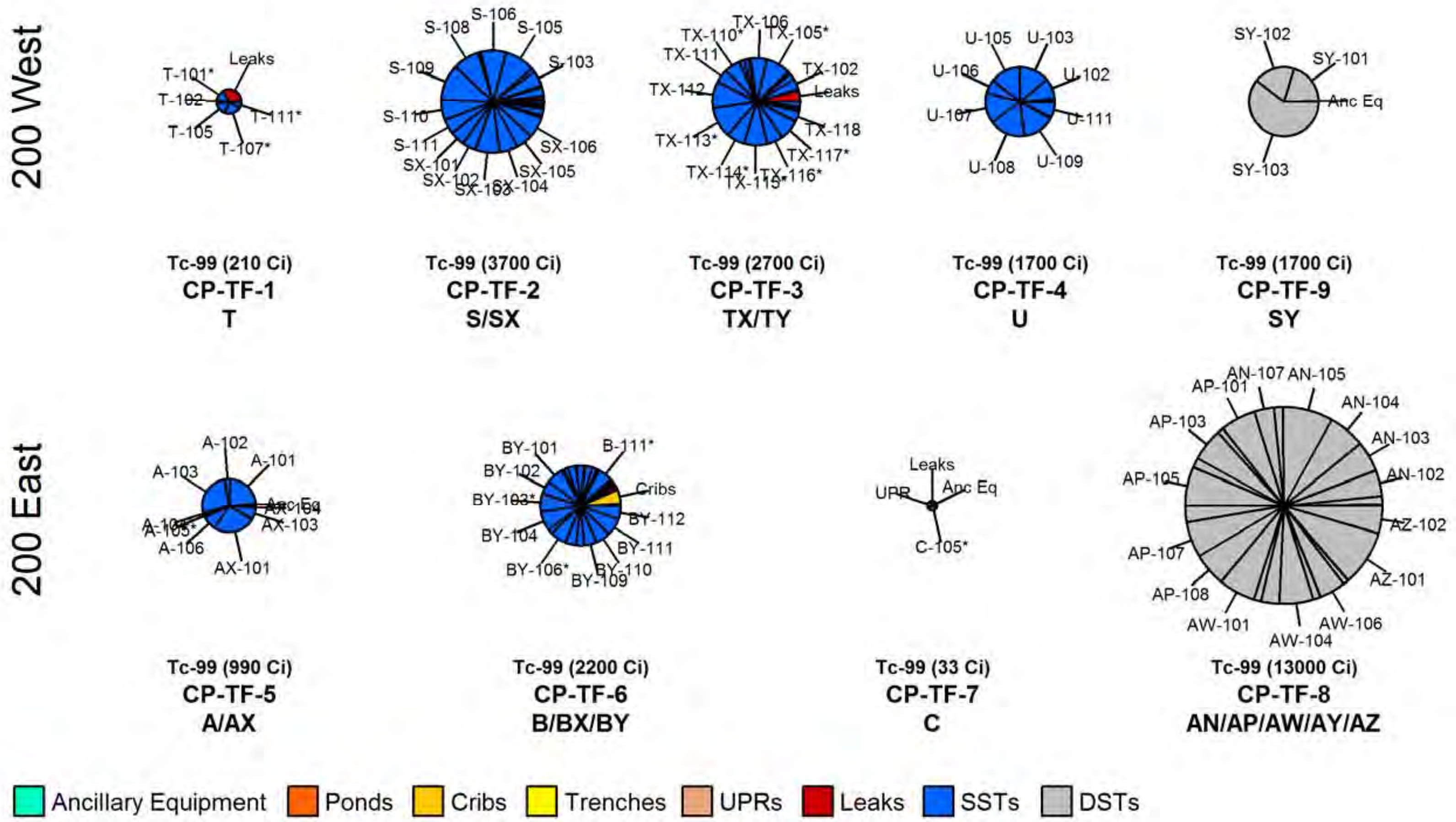

Figure 3-33. Technetium-99: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

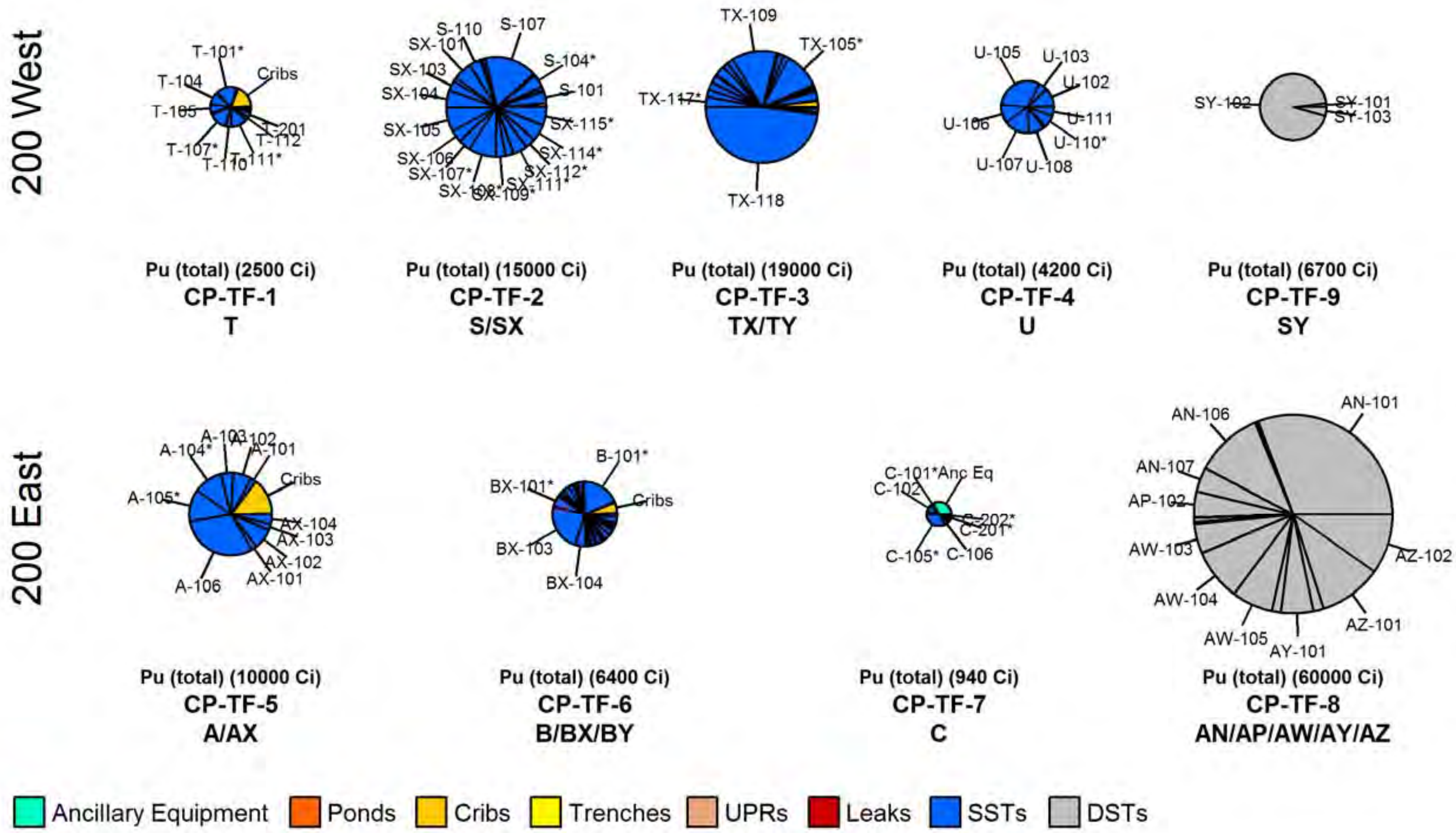

Figure 3-34. Plutonium-Rad (sum of isotopes 238, 239, 240, 241, and 242): Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

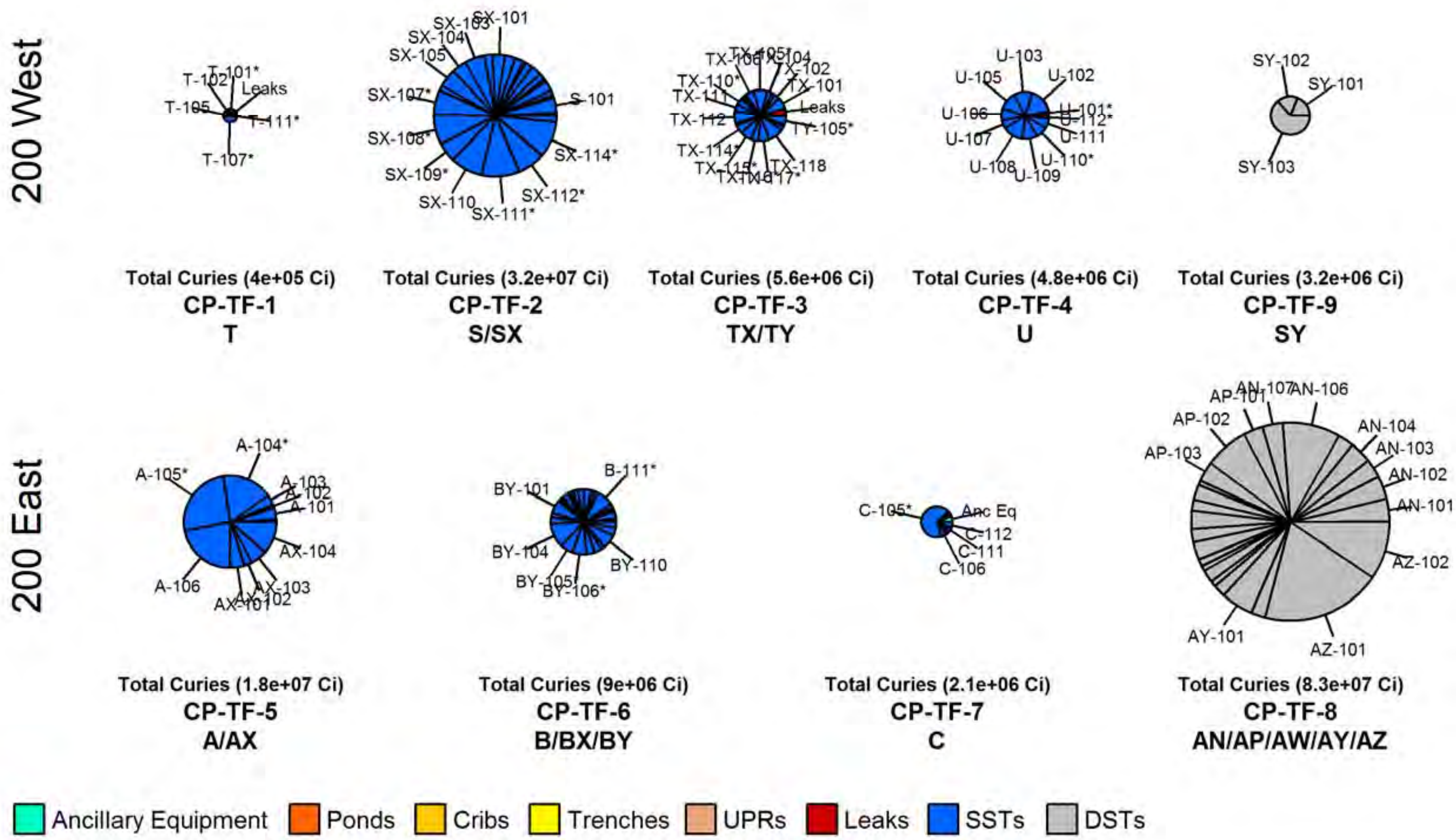

Figure 3-35. Summary of total radionuclide content (Ci) associated with each tank farm: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

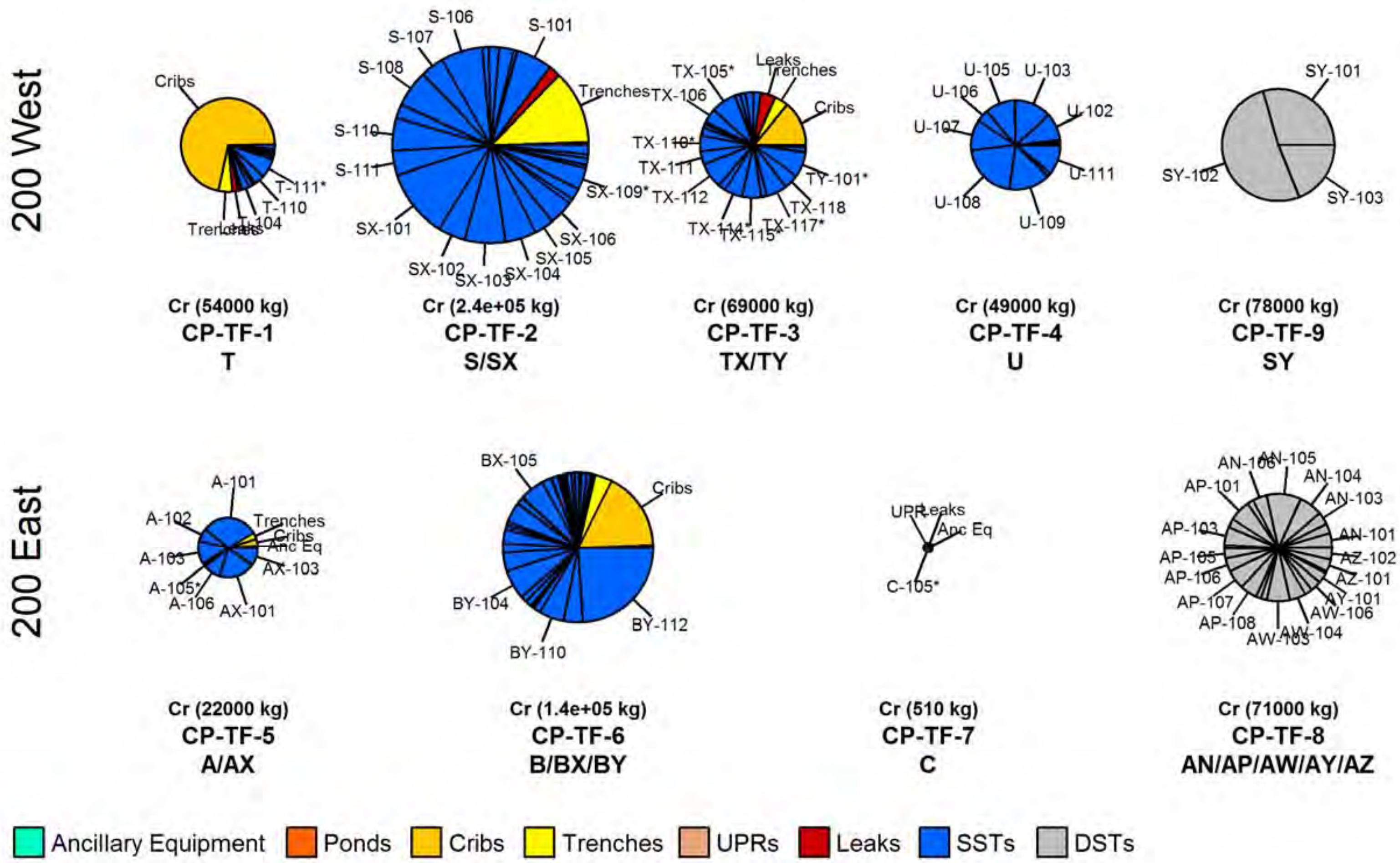

Figure 3-36. Total chromium: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

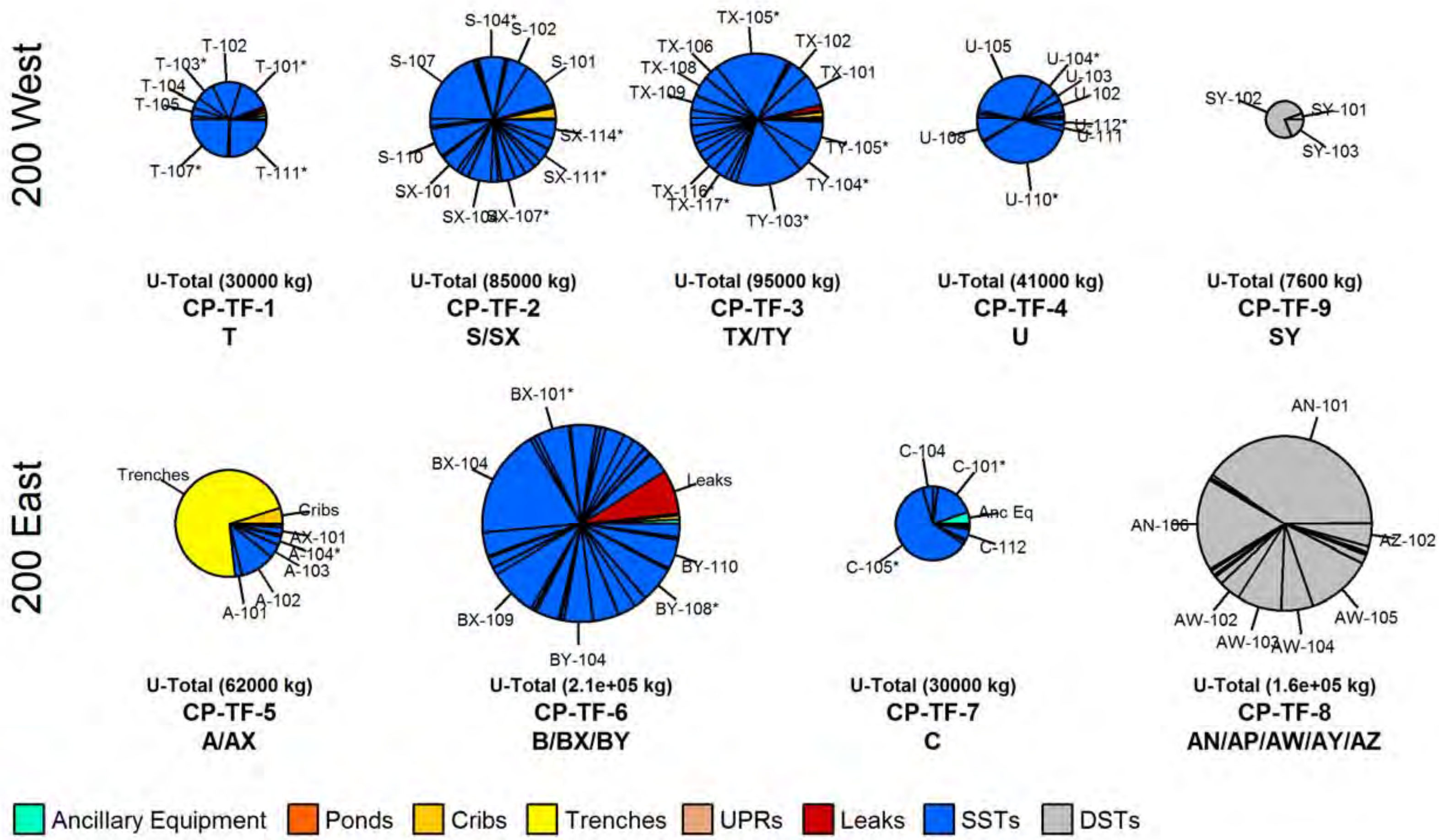

Figure 3-37. Total uranium: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

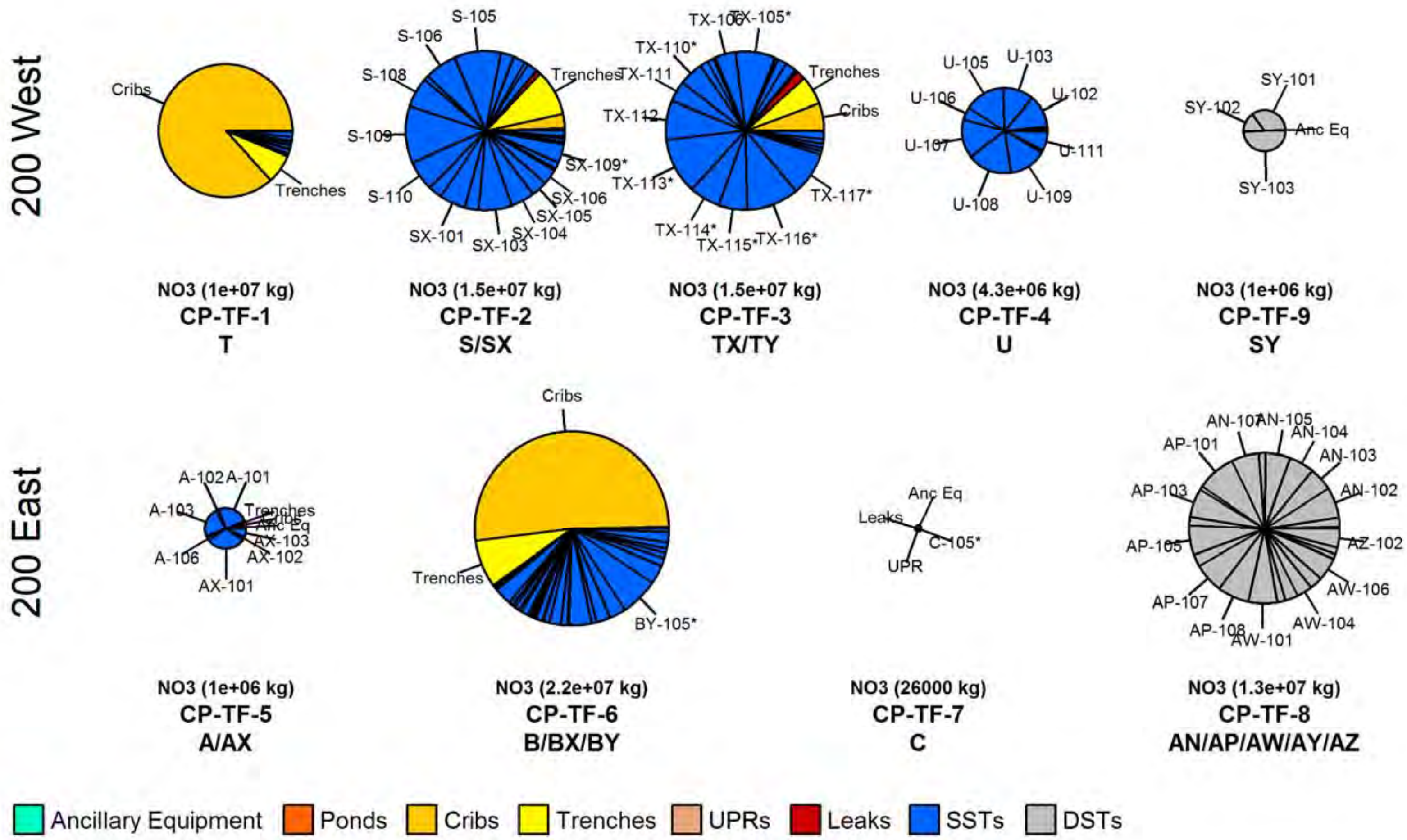

Figure 3-38. Nitrate: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

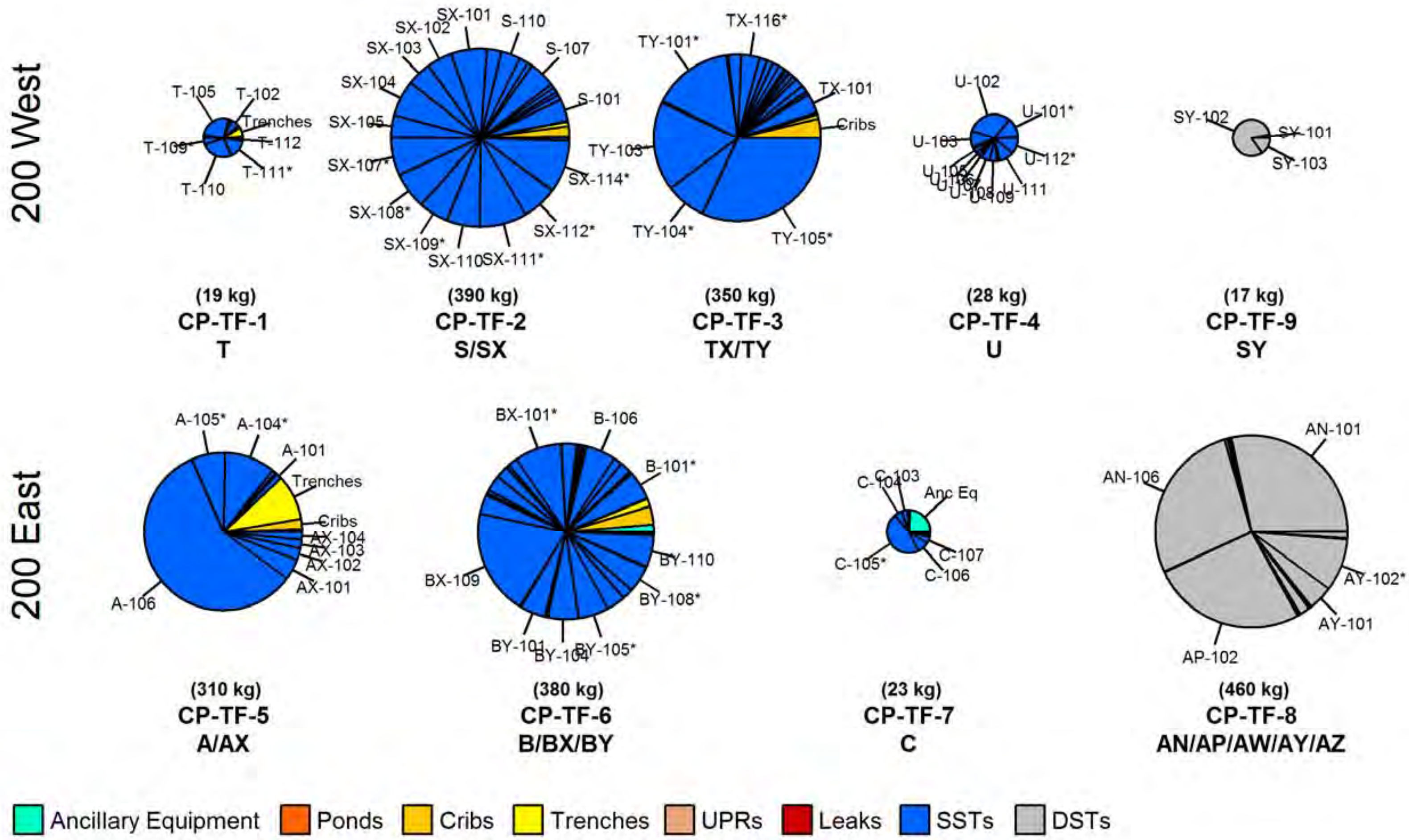

Figure 3-39. Mercury: Inventory distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative amount of inventory within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

Primary Nuclear Safety and Human Health Risks

Major Event Scenarios with the Potential for Significant Human Health and Environmental Impacts

The potential accidents evaluated in the tank farms DSA include flammable gas accident leading to fire/explosion; nuclear criticality resulting in a localized high-energy event; waste transfer leak or air blow accident leading to a spill, leak, or aerosolized spray; release from a contaminated facility; excessive load resulting in partial or total tank (dome) failure; mixing of incompatible materials resulting in unwanted chemical reactions; tank bump leading thermally induced release; and filter failure leading to unfiltered releases of contaminants (RPP-13033).

There are four accidents designated as *Anticipated*[80] for Hanford waste tanks ***if no controls are in place*** **(i.e., unmitigated)**:

- **Flammable gas accidents** – This accident involves flammable gas deflagrations in waste storage vessels/containers (including SSTs) where the bounding event is a flammable gas deflagration from the steady-state generation and accumulation or a gas release event in a DST/SST.
- **Waste transfer leaks** – This accident involves a wide spectrum of waste leaks where the bounding event is a fine spray leak using a high head waste transfer pump.
- **Releases from a contaminated facility** – This accident involves various release mechanisms (i.e., flammable gas deflagrations, fires, load handling accidents, or compressed gas system failures) in contaminated facilities.
- **Air blow accidents** – This accident involves a waste release from a contaminated hose-in-hose transfer line (HIHTL) primary hose assembly and connected waste transfer piping system pressurized by compressed air where the bounding event is a small crack leak below the waste surface.

A nuclear criticality accident is considered *Beyond Extremely Unlikely* (i.e., a frequency of less than once in a million years) (RPP-13033). The flammable gas accident (specifically a detonation in a DST/SST) and waste transfer leaks (specifically a fine spray when using a high head pump) was selected as the bounding accident for evaluation in the tank farms DSA.

Separate evaluations are carried out for radiological doses and toxicological effects (i.e., chemical effects) as part of DOE safety analyses. Of the four anticipated accidents listed above, only the waste transfer leak is considered to have the potential for an onsite radiological total effective dose (consequence) >100 rem. None of the design basis accidents[81] is considered to have the potential for an off-site dose greater than the 25 rem standard that would require safety class engineered systems (i.e., safety class structures, systems, or components) or other technical safety requirements. For onsite toxicological consequences, both the waste transfer leak and air blow accidents are considered less than

[80] An anticipated event has frequency greater than once in 100 operating years (RPP-13033). External and natural events are not treated separately since they lead to the same accident types.

[81] A design basis accident is an "accident explicitly considered as part of the facility design for a new facility (or major modifications) for the purpose of establishing functional and performance requirements for safety class and/or safety significant controls" (DOE-STD-3009-2014). There are design basis accidents considered other than the four listed (RPP-13033).

Protective Action Criteria[82] 3 (life-threatening health effects), and accidents are considered to have offsite toxicological consequences (in contrast to radiological consequences) of less than Protective Action Criteria 2 (irreversible or other serious health effects that could impair the ability to take protective action).

Qualitatively, only the air blow accident (of the four accidents listed above) was judged not to represent a significant impact to a Facility Worker (i.e., result in "prompt death, serious injury, or significant radiological or chemical exposure to the Facility Worker") (RPP-13033).

Other representative accidents are considered to have consequences that are less than onsite worker guidelines, and thus do not pose significant Facility Worker hazards. However, defense-in-depth features are in place at Hanford Site to mitigate the potential for the following additional accident scenarios (RPP-13033):

- SST failure may be caused by excessive concentrated loads or excessive uniform loads, excessive vacuum, load drops, or seismic events and failures of other tanks; dome loading requirements are selected as the defense-in-depth protection feature.
- SST failure could result from chemical reactions resulting from mixing incompatible materials; the verification of paperwork to ensure that the correct chemical is being delivered has been selected as a defense-in-depth feature.
- Contaminated soils may be released (from a crib, ditch, pond) from unplanned excavations or drilling into contaminated soils or ruptures of underground pressurized lines in contaminated soils; environmental air permitting requirements and the excavation permitting process are selected as defense-in-depth features.
- A thermally induced upset (e.g., steam bump in an SST liner gap) could cause a failure in an SST.

There are other representative accidents (e.g., aboveground tank or structure failure, transportation-related waste sample handling accidents, filtration failures, organic solvent fires) that are considered to have consequences less than the guidelines for an onsite worker, do not pose significant Facility Worker hazards, and have no defense-in-depth features.

The air blow accident and most other accidents evaluated in the tank farms DSA pertain to the active cleanup period (until 2064) evaluated in this Risk Review Project. After closure, the preferred alternative for the SST farms as stated in the Tri-Party Agreement (Ecology, EPA, and DOE 1998) is to have 99% of the waste retrieved[83] (although this may not be practically achievable). Each tank will be filled with grout and covered with an engineered cap that would mitigate potential initiating events, such as fire and natural events that degrade barriers and increase infiltration of water. The manner in which the DSTs will be closed after tank wastes are treated is still to be determined.

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[82] Protective Action Criteria may be used "to evaluate the severity of the event, to identify potential outcomes, and to decide what protective actions should be taken" and may be used "to estimate the severity of consequences of an uncontrolled release and to plan for an effective emergency response." There are benchmark values (i.e., PAC-1, -2, and -3) for a set of evaluated chemicals. Each successive benchmark represents an increasingly severe effect involving a higher exposure level: (1) mild, transient health effects, (2) irreversible or other serious health effects that could impair the ability to take protective action, and (3) life-threatening health effects. http://orise.orau.gov/emi/scapa/chem-pacs-teels/.

[83] According to the Hanford Tri-Party Agreement (TPA), the retrieval limits are 360 ft^3 and 30 ft^3 for 100-Series and 200-Series tanks, respectively, (Ecology, EPA, and DOE 1996, Appendix H, p. H-5).

Hanford Tank Farm Vapor Exposures

Among the unmitigated hazards related to the Hanford Tank Farms are reports of respiratory symptoms attributed to vapors from the tank wastes[84]. Short-term, intermittent vapor exposure has been associated with respiratory irritation symptoms. Dozens of workers have sought medical attention for non-specific symptoms, and such events have occurred for more than a decade (NIOSH 2004), although the specific offending agent(s) and sources have not been identified.

An independent review of WRPS Tank Farm Chemical Vapors Strategy (jointly requested by WRPS and Hanford Challenge) found (Hanford Concerns Council 2010) that the proposed periodic sampling strategy should be expanded to strengthen the exposure assessment process, the WRPS job hazard analysis should be expanded, and site Industrial Hygienists should expand their capabilities (especially when quantitative data are not available).

In 2014 The Hanford Tank Vapor Assessment Team (TVAT) of the Savannah River National Laboratory concluded that available information suggested a causal link between tank vapor releases and the adverse health effects reported by Hanford tank farm workers (SRNL 2014). Furthermore, an industrial hygiene program emphasizing full-shift (8-hour) exposure measurements and compliance with standard occupational exposure limits cannot adequately characterize the complex, episodic nature of short-term tank vapor exposures. Such "bolus" or intermittent excursions may be sufficient to trigger symptoms in sensitive workers, without causing any exceedances of Action Levels or OSHA Permissible Exposure Limits. The TVAT recommended the increased use of personal respiratory protection, improved personal sampling, and further tank vapor characterization.

In 2016, at the request of the DOE Office of River Protection (DOE-ORP) and WRPS, the National Institute for Occupational Safety and Health (NIOSH) visited the Hanford Site to conduct a review of tank farms worker safety and health programs. The NIOSH team reviewed documentation and reports from previous worker health and safety evaluations and obtained information regarding the health and safety programs of both WRPS and DOE. The NIOSH team concluded that WRPS and DOE have (NIOSH 2016)[85]

- "taken positive steps, invested considerable resources, created a comprehensive OSH program, developed detailed procedures, hired staff, and established technical worker-management groups to help resolve concerns regarding exposure to tank farm vapors and gases."
- "collected a significant amount of data they believe demonstrates worker exposures are very low (i.e., well below [Occupational Exposure Limits (OELs)]), not toxicologically significant, and provide evidence there is no, or minimal, health risk to workers in the tank farms."

However, workers continued to report odors and symptoms that they attributed to exposure to tank farm chemicals. In 2016 WRPS in conjunction with the Hanford Atomic Metal Trades Council has enhanced the safety culture, developed a more transparent web-based information system (hanfordvapors.com) and expanded use of both mandatory and voluntary respiratory protection, including powered air-purifying respirators (PAPRs). Vapor Control Zones, where vapor concentration may exceed an Action Level have entry requirements, including required respirators. In other zones, respirator use is voluntary (https://hanfordvapors.com/protect-workers/vapors-management-

[84] Washington River Protection Solutions (WRPS) is the DOE Tank Operations Contractor responsible for managing Hanford tank wastes and preparing it for delivery to the Waste Treatment and immobilization Plant. WRPS created a website (https://hanfordvapors.com/) to provide background information, data, and news concerning the Hanford Vapors issue.

[85] DOE has invested $50 million in the last two years to increase worker protection and is working on an additional $65 million in additional improvements.

strategy/administrative-controls/). The Action Level is typically 50% of the Permissible Exposure Limit, which is based on an 8-hour time-weighted average, so intermittent, "bolus" releases may still go undetected.

Mitigation of Flammable Gas Accidents

Flammable gas accidents are a concern because of two potential conditions that may result in the accumulation of hydrogen gas in the vapor space of a tank:

- Long-term loss of ventilation that could occur when a regional scale event reduces power to ventilation and other active control systems and passive ventilation is reduced or lost (e.g., from ash fall or other ventilation plugging events)
- Accumulation of gas through entrainment within the settled solids in the tank, followed by a sudden rapid gas coalescence and release event that exceeds the dilution rate to below the LFL by ventilation systems.[86]

Even in the event of flammable gas accumulation as described above, an ignition source still would be necessary for a flammable gas accident to occur.

The following engineered systems are in place to mitigate the potential for flammable gas accidents in the tank farms (RPP-13033, p. T3.3.2.4.1-4):

- *DST primary tank ventilation systems* to maintain the concentration of flammable gases below the LFL in the DST headspace for steady-state releases and induced gas release events due to water or chemical additions and waste transfers into DSTs.
- *Waste transfer primary piping systems* to confine the waste to protect the Facility Worker from flammable gas accidents in a DST annulus due to a misrouting of materials.

The following flammable gas operational controls for the Hanford tank farms are defined (RPP-13033, p. T3.3.2.4.1-5&6):[87]

- *DST primary tank ventilation systems* for all DSTs ensure the DST primary tank ventilation systems are operable and operating to prevent flammable gas hazards from steady-state releases and slow, continuing induced gas releases following water additions, chemical additions, and waste transfers into DSTs.
- *SST steady-state flammable gas control* for all SSTs, except those in the 241-AX and 241-SX tank farms, protect the Facility Worker from a flammable gas deflagration caused by steady-state flammable gas releases in an SST by monitoring the flammable gas concentration, verifying passive ventilation for 241-B-203 and 241-B-204, and reducing the flammable gas concentration or eliminating potential ignition sources before the flammable gas concentration exceeds the LFL.
- *DST-induced gas release event flammable gas controls* for all DSTs protect the Facility Worker from a flammable gas deflagration in a DST due to an operations-induced gas release event by requiring evaluations of waste transfers from DSTs and water additions, chemical additions, and

[86] The flammability range of a gas is the range (often provided in volumetric terms) in which the gas and air are in the right proportions to burn when ignited. Below the LFL, there is not enough fuel to burn (http://energy.gov/eere/fuelcells/glossary#l).

[87] There are additional controls related to double-contained receiver tanks (DCRTs); inactive/miscellaneous tanks/facilities and waste intruding equipment; and waste packaging that are external to the waste tanks.

waste transfers into DSTs to determine restrictions or required controls to prevent an induced gas release event flammable gas deflagration.[88]

- *DST-induced gas release event flammable gas control* for all DSTs (when required) ensure the DST primary tank ventilation systems are operable and operating to prevent flammable gas hazards from induced gas release events during water additions, chemical additions, and waste transfers into DSTs.
- *DST annulus flammable gas control* for all DSTs protects the Facility Worker from a flammable gas deflagration in a DST annulus caused by steady-state flammable gas releases from waste in the DST annulus by monitoring the DST annulus waste level and controlling the flammable gas concentration or eliminating potential ignition sources if a significant quantity of waste is detected in the DST annulus.

The key elements evaluated relative to flammable gas accidents in the Hanford tank farms are (RPP-13033, p. T3.3.2.4.1-7):

- *DST and SST time to LFL* to protect assumptions used to develop surveillance frequencies and action completion times in the limiting conditions of operation for DST primary tank ventilation systems and safety administrative controls for SST steady-state flammable gas control and DST annulus flammable gas control.
- *Ignition controls* to be consistent with the National Fire Protection Association requirements for eliminating potential flammable gas ignition sources; to evaluate activities, equipment, and materials to determine the applicability of and compliance with ignition source control requirements; and to be an important contributor to defense-in-depth by applying ignition controls for the spontaneous gas release event hazard in DSTs 241-AN-103, 241-AN-104, 241-AN-105, 241-AW-101, and 241-SY-103.
- *Waste characteristics controls* to protect assumptions used to develop controls for flammable gas deflagrations due to gas release events by preventing the formation of waste gel in DSTs and SSTs.
- *Emergency preparedness requirements* to reduce the risk from seismic-induced flammable gas accidents in DSTs.

The potential for flammable gas-related accidents in the Hanford tank farms is indicated by hydrogen generation rates (HGRs) and times to reach LFLs. Both are provided for each tank in each tank waste and farms EU summary section (Appendix E.1 through Appendix E.11). A summary showing tanks with times to reach 25% of the LFL[89] under the zero ventilation scenario (i.e., most restrictive) of less than 6 months[90] is provided in Figure 3-40. The time it would take for a tank to reach 25% of the LFL was selected as a safety indicator by the Risk Review Project because a range of site or regional initiating

[88] In 2012, the Defense Nuclear Facilities Safety Board submitted Recommendation 2012-2, *Hanford Tank Farms Flammable Gas Safety Strategy*, which identified the need to reduce risk posed by flammable gas events at the Hanford tank farms. DOE responded with an implementation plan including a revision to the DSA to include a new control that measures ventilation flow through each DST periodically, supplementing the existing flammable gas monitoring control. This DSA revision also placed requirements on operability of the in-service and standby primary ventilation trains. DOE is working toward installing safety-significant instrumentation for real-time monitoring of the ventilation exhaust flow from each DST.
[89] NFPA Standard 69 (2008) requires that fuel concentration only reach 25% of the LFL value, which has been the long-standing practice in the United States.
[90] Typical response times of 14 and 30 days also are shown in Figure 3-40 for reference only.

events potentially could result in temporary or extended loss of ventilation controls (e.g., prolonged loss of power, severe seismic event, high ash fall from volcanic eruption) and indicate the needed response time in an event. Most of the tanks shown are DSTs in the 200 East Area. Under the potential accident scenario of loss of ventilation, current tank waste inventories reveal that three tanks would reach 25% of the LFL in less than 14 days, 16 tanks would reach 25% of the LFL in less than 30 days, and 26 tanks would reach 25% of the LFL in less than 180 days.

The Risk Review Project considered variables that would increase the time to reach the 25% LFL in the tanks, thereby reducing the risk of a flammable gas accident. Removal of Cs-137 was considered because it is very water soluble and potentially could be removed from tanks by the LAW Pretreatment System (LAWPS) currently under design to enable startup of LAW vitrification prior to startup of the entire set of Waste Treatment Project facilities (e.g., prior to startup of the WTP HLW Vitrification Facility and Pretreatment Facility). The current design basis for LAWPS is to return separated Cs-137 to the tank farms. Modifications could allow for separation without return to the tank farms if a viable disposition pathway is identified. This analysis also can provide insights into which tanks to consider for Cs-137 return when necessary.

Table 3-41 depicts the contribution of Cs-137 to the hydrogen generation rate (HGR), which, in conjunction with the amount of waste in the tank and the volume of the tank vapor space, is a primary variable for the time to reach 25% LFL for an individual tank. The contribution of Cs-137 to the HGR varies by tank from less than 1% to 46% for the tanks with less than 180 days to reach 25% of the LFL under unventilated conditions. Table 3-42 depicts the resulting impact of Cs-137 removal from the tanks that have less than 180 days to reach 25% of the LFL. The total number of tanks with less than 180 days is 26, but the number of tanks with less than 14 days is reduced from 3 to 2, and the number of tanks with less than 30 days is reduced from 16 to 9. Removal of Cs-137 also eliminates a significant source of penetrating radiation (gamma radiation) associated with tank wastes.

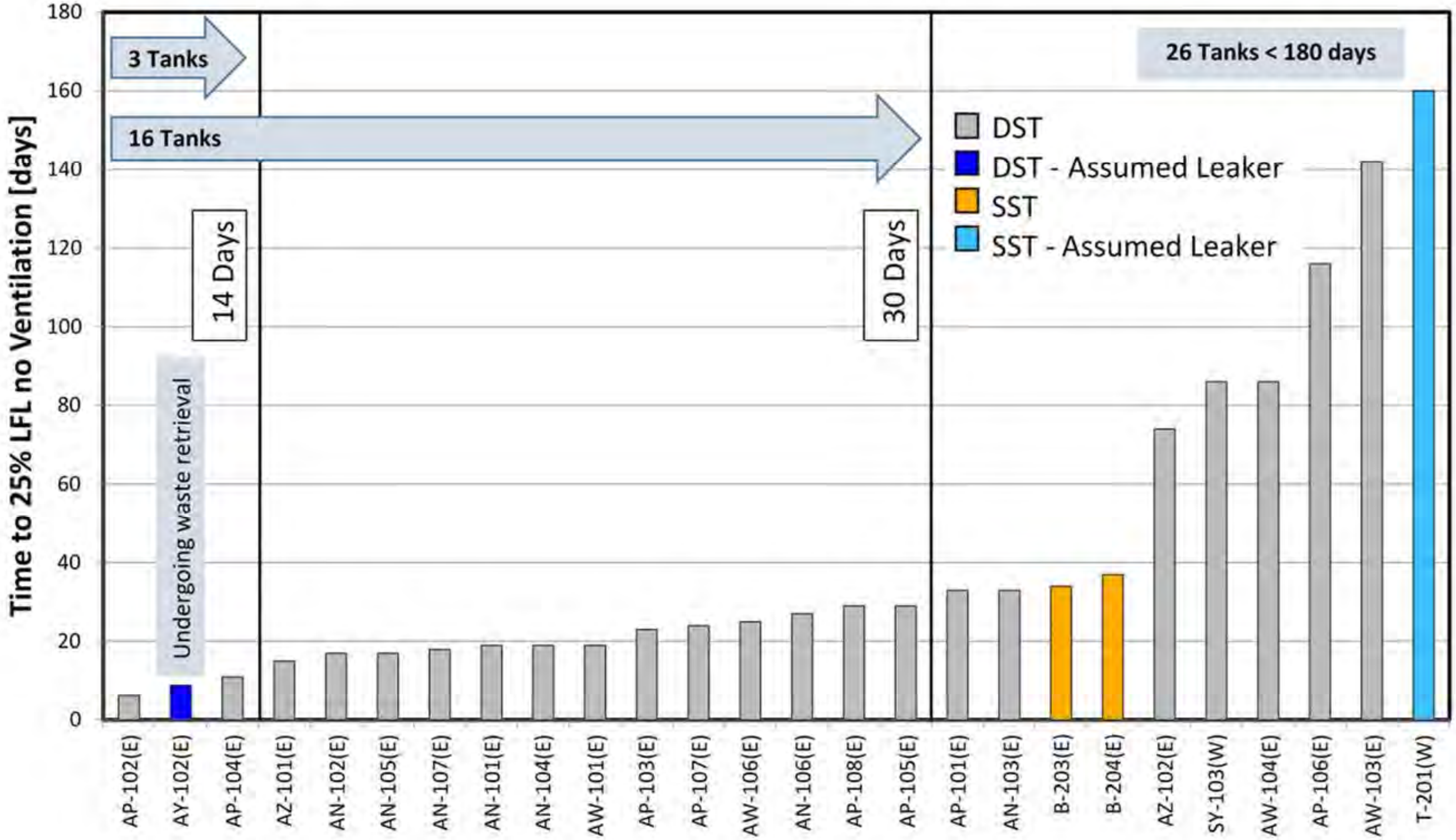

Figure 3-40. Current conditions: Time to 25% LFL for tanks with less than 6 months assuming loss of controls leads to no ventilation (after RPP-5926, Rev. 17). The location (E = 200 East and W = 200 West) is provided after each tank name.

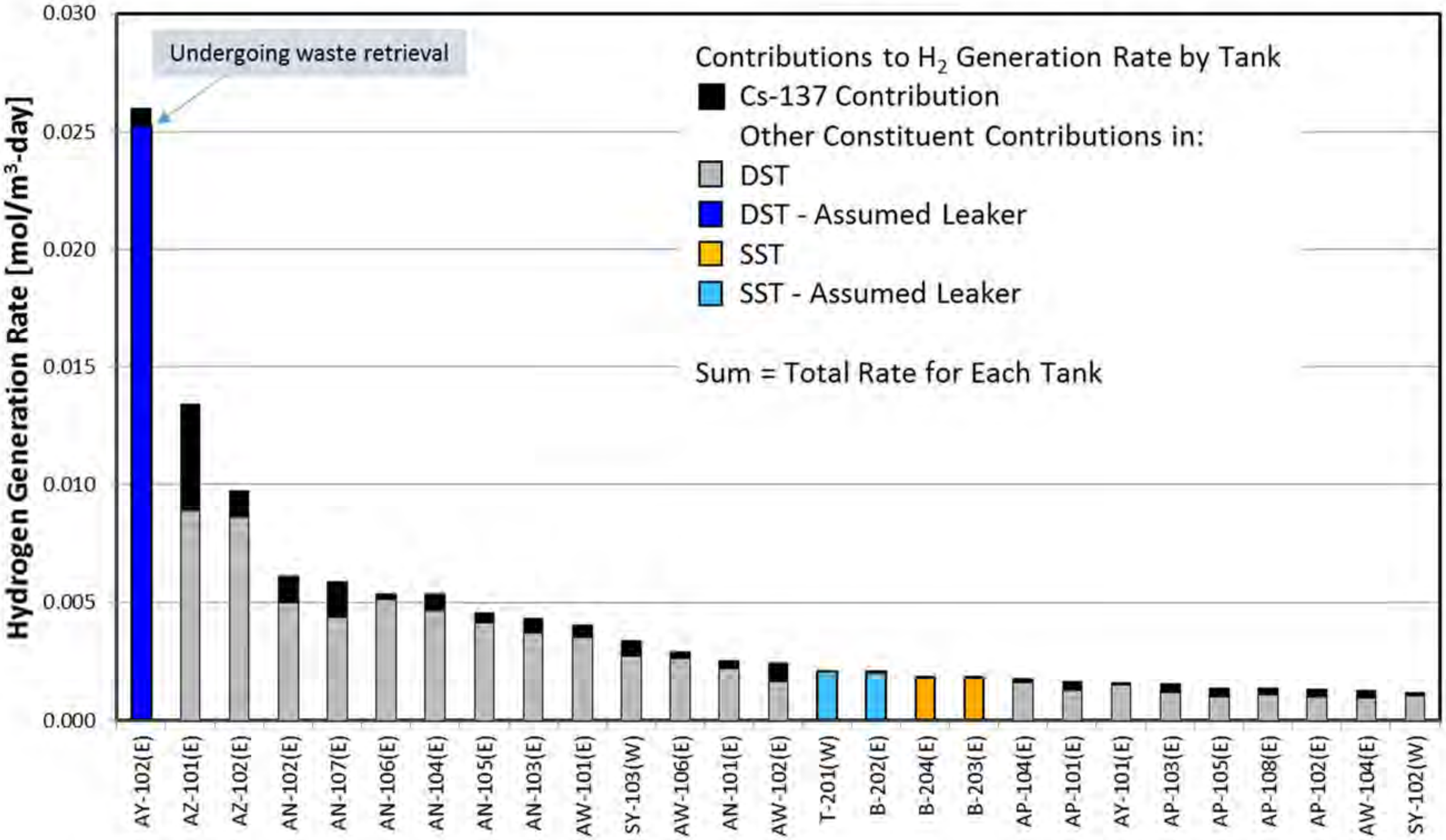

Figure 3-41. Cesium-137 contribution to the HGR for tanks having less than 6 months to 25% of the LFL rate under unventilated conditions (Kirch 2015).

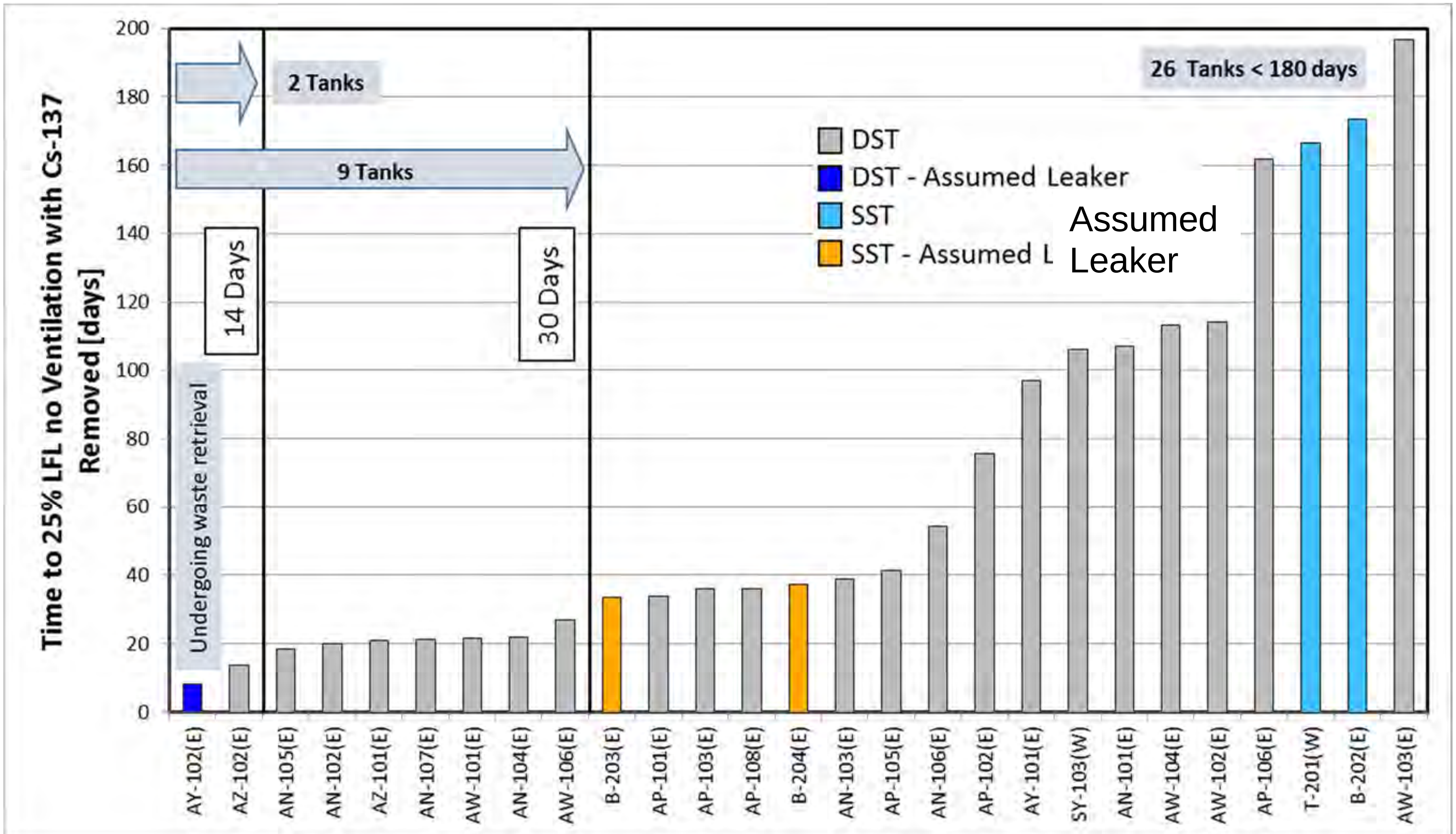

Figure 3-42. Impact of cesium-137 removal: Time to 25% LFL for tanks with less than 6 months assuming removal of Cs-137 and loss of controls leads to no ventilation (based on Kirch 2015 after RPP-5926, Rev. 15). The location (E = 200 East and W = 200 West) is provided after each tank name.

Mitigation of Waste Transfer Leak Accidents and Release from a Contaminated Facility

The following engineered systems are in place to mitigate waste transfer leak accidents and release from contaminated facilities (RPP-13033, p. T3.3.2.4.3-2):

- *Waste transfer primary piping systems* confine waste to decrease the frequency of a fine spray leak, which also protects the Facility Worker from wetting spray/jet/stream leaks into a normally occupied area and from flammable gas deflagrations in a waste transfer-associated structure due to a waste transfer leak.
- *Hose-in-hose transfer line systems (HIHTL)* confine waste, thus decreasing the frequency of a fine spray leak and protecting the Facility Worker from wetting spray/jet/stream leaks into a normally occupied area and from flammable gas deflagrations in a waste transfer-associated structure due to a waste transfer leak. This is also an important contributor to defense-in-depth by providing secondary confinement of leaks in the hose-in-hose transfer line primary hose assemblies.
- *Isolation valves for double valve isolation* limit the leakage of waste (through valve leakage), decreasing the consequences of a fine spray leak due to a misrouting and thus protecting the Facility Worker from wetting spray/jet/stream leaks into a normally occupied area and from flammable gas deflagrations in a waste transfer-associated structure (or other facility) due to a misrouting.

The following additional operational controls are in place to mitigate the potential for waste transfer leaks and releases from contaminated facilities for the Hanford tank farms (RPP-13033, p. T3.3.2.4.1-5-7):

- *Double valve isolation* is required to ensure that safety-significant isolation valves for double-valve isolation are in the closed or block flow position when used to physically disconnect waste transfer primary piping systems, HIHTL primary hose assemblies, and interfacing water systems. This limits waste leakage into the physically disconnected systems, thus decreasing the consequences of a fine spray leak due to a misroute and protecting the Facility Worker from a wetting spray/jet/stream leak and from a flammable gas deflagration in a waste transfer-associated structure (or other facility) due to a misrouting.
- *Waste transfer-associated structure cover installation and door closure* is an important contributor to defense-in-depth that provides secondary confinement of leaks into waste transfer-associated structures.

Mitigation of Air Blow Accidents

The following engineered systems are used to mitigate the potential for air blow accidents (RPP-13033, p. T3.3.2.4.5-2):

- *Compressed air system pressure relieving devices* limit compressed air system pressure.
- *Waste transfer primary piping systems* provide confinement of waste.

External and Natural Events

No specific engineered systems or operational controls related to external or natural events were identified in the tank farms DSA. The external events evaluated in the DSA include aircraft crash, vehicle accident, and range fire. The external event frequencies range from *Beyond Extremely Unlikely* for accidents like commercial or military aircraft impacting a tank or facility to *Anticipated* for range fires.

The natural events evaluated in the DSA include lightning, high winds, earthquakes, volcanic eruptions/ashfall, severe dust storms, heavy snow, hail storms, and floods. For natural events, frequencies range from *Not Credible* for floods to *Anticipated* for extreme temperatures, high winds, hail storms, and dust storms. Natural flooding was determined to be not a credible hazard because of the relative elevations of the tanks and the potential maximum sources of flooding; the physical location of the tanks precludes any potential for impact. The consequences, which relate to the operating accidents described above, would not be increased specifically because the initiating event was an external or natural event. Thus, additional engineered systems and controls were not considered necessary. The only unique aspect of natural events is the possibility that these events cause multiple failures both within a tank farm and also across the Hanford Site; however, it was considered unreasonable to expect all releases to be at their highest estimated releases for individual accidents (RPP-13033, p. 3.3.2.4.7-3) in the event of multiple failures. The consequences that relate to the operating accidents described above (e.g., waste transfer leaks, air blow events) would not be increased as a result of external or natural initiating events.

THREATS TO GROUNDWATER

Impact Pathways and Timeframes

The estimated inventories for the vadose zone, groundwater, and treatment amounts associated with the Tank Waste and Farm EUs are found in Appendix E.1 through E.11. These values are used to estimate the inventory remaining in the vadose zone using the process described in Chapter 6 of the methodology document (CRESP 2015b). These estimates necessarily have high uncertainties. Recharge travel times for water through the vadose zone have been estimated (Figure 3-43), and while rapid during active site operations with high discharge rates, they are relatively slow, with 50 to 75 years expected for recharge rates of 100 and 50 mm/yr, which correspond with gravel cover or disturbed soil conditions. Lower infiltration rates associated with vegetated cover or engineered covers (less than 3.5 mm/yr) are estimated to result in vadose zone travel times of several hundred years. The focus here is on the Group A and B contaminants in the vadose zone due to their mobility and persistence and thus their potential threats to groundwater. To summarize:

- *Tc-99, I-129* (Figure 3-32 and Figure 3-33) – The vadose zone inventory is dominated by past leaks in the EU CP-TF-1 (T tank farm and associated legacy waste sites, 200 West) and the EU CP-TF-3 (TX-TY tank farms and associated legacy waste sites, 200 West), along with legacy disposal activities in the EU CP-TF-6 (B-BX-BY tank farms and associated legacy waste sites, 200 East).
- *Sr-90* (Figure 3-31) – The vadose zone inventory is dominated by past leaks in the EU CP-TF-1 (T tank farm and associated legacy waste sites, 200 West) and the EU CP-TF-3 (TX-TY tank farms and associated legacy waste sites, 200 West). Thus, the majority of the Sr-90 originally discharged into the vadose zone would have to travel through much of the vadose zone to impact groundwater. The Tank Farm Closure and Waste Management (TC&WM) EIS groundwater transport analysis (DOE/EIS-0391 2012, Appendix O) indicates that Sr-90 is not expected to reach the boundary (T Barrier) closest to the T and TX-TY tank waste and farms EUs.[91]

[91] The barrier represents the edge of the infiltration barrier to be constructed over disposal areas that are within 100 m (110 yards) of facility fence lines (DOE/EIS-0391 2012). The T Barrier is the closest to the T and TX-TY Tank Waste and Farms EUs. Despite including sources other than those for the T and TX-TY Tank Waste and Farms EUs, the analysis in the TC&WM EIS was considered reasonable to assess rate of movement of contaminants to groundwater through the vadose zone.

- Furthermore, the average time for water to travel through the vadose zone to groundwater is 64 years, with a range estimated from 50 to greater than 100 years (Figure 3-43) for the 200 West Area (DOE/EIS-0391 2012, Table N-52); thus, the resulting average travel time for Sr-90 to move through the vadose zone to groundwater is more than 300 years (or 10+ half-lives), accounting for retardation by sediment adsorption.[92] It would likely require more time to reach groundwater in a sufficient amount to exceed the drinking water standard over an appreciable area. Thus, a Sr-90 plume is not expected to reach groundwater in significant quantities in the next 150 years due to retardation or after 150 years due to radioactive decay (+99.99% reduction in Sr-90 inventory).
- *Chromium* (Figure 3-36) – The vadose zone inventory is dominated by past discharges to cribs and trenches (for the CP-TF-1, CP-TF-3, and CP-TF-6 TF EUs).
- *Uranium* (Figure 3-37) – The vadose zone inventory is divided among discharges to trenches and cribs (predominantly EU CP-TF-5, but also EUs CP-TF-2, CP-TF-3) and leaks (predominantly EU CP-TF-6). Thus, at least part of the uranium originally discharged into the vadose may have been driven deeper into the vadose zone (with high volume discharges) and may have less of the vadose zone to travel until potentially impacting groundwater. There is an existing uranium plume in the groundwater underlying CP-TF-5 (A-AX tank farms); however, this plume is associated with PUREX and not tank farm operations.

[92] The minimum K_d for Sr-90 for WMAs T and TX-TY is 0.6 mL/g (Cantrell et al. 2008, p. 3.87), which translates to a retardation factor of ~6.

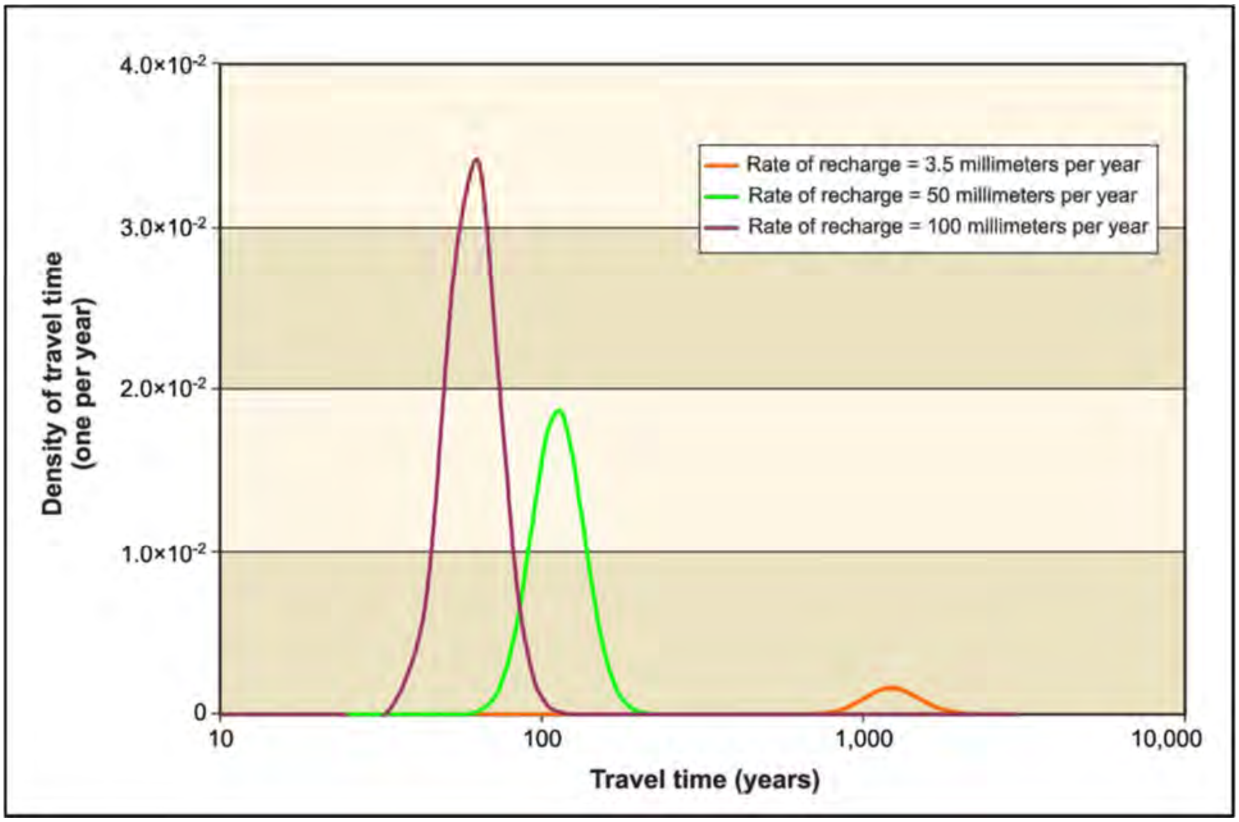

Figure 3-43. Distribution of travel time in the vadose zone for the 200 West Area (DOE/EIS-0391 2012, Fig. N-159, Appendix N).

Estimated Groundwater Threat Metric

The GTM, which represents the maximum volume of water that could be contaminated from a source at the reference threshold (e.g., water quality standard), is used in conjunction with consideration of the time estimated for specific contaminants to reach the groundwater as the primary basis to evaluate the potential for existing contamination in the vadose zone to contaminate groundwater. Similarly, the GTM is used to estimate the potential extent of groundwater contamination if releases from individual tanks occurred. The GTM is defined as the volume of groundwater that could potentially be contaminated by the inventory of a primary contaminant from a source (groundwater plume, vadose zone contamination, tank, etc.) if it was found in the saturated zone at the WQS (e.g., drinking water standard) and in equilibrium with the soil. The GTM accounts only for (1) source inventory, (2) partitioning with the surrounding subsurface, and (3) the WQS. The GTM reflects a snapshot in time (assuming no loss by decay/degradation or dispersion, etc.) and does not account for differences in contaminant mobility or bulk groundwater flow. Refer to the methodology document, Chapter 6, for a more complete discussion of the GTM (CRESP 2015b).

The GTM is summarized for each tank in Figure 3-44. For evaluating groundwater threats from tank wastes, the GTM is presented using the maximum GTM value obtained from I-129 and Tc-99 for each tank, existing environmental contamination (from legacy sources), and each EU. The focus is placed on I-129 and Tc-99 because the TC&WM EIS (DOE/EIS-0391 2012) identified these as the risk-driving primary contaminants in the tank wastes that potentially threaten groundwater and the Columbia River.[93] The chart in Figure 3-44 and those like it show the relative fractions of the GTM (or other metrics) for individual tanks and legacy sources across the tank waste and farms EUs; the sizes of the diagrams are also scaled to be relative to the total GTM in the tank waste and farms EU.

Figure 3-44 indicates that the threat to groundwater posed by the tank wastes is very unevenly distributed between tank farms and among tanks within each tank waste and farms EU. The greatest GTM, 15,000 Mm^3, is associated with the 200 East DSTs (CP-TF-8). The next greatest grouping of GTM is associated with EUs CP-TF-2 (S-SX, 200 West, 4100 Mm^3), CP-TF-3 (TX-TY, 200 West, 3000 Mm^3) and CP-TF-6 (B-BX-BY, 200 East, 2600 Mm^3), which are essentially indistinguishable given uncertainties in the tank waste inventory estimates associated with I-129 and Tc-99. The lowest grouping of GTM is associated with EUs CP-TF-1 (T, 200 West, 240 Mm^3) and CP-TF-7 (C, 200 East, 59 Mm^3), noting that the C tank farm has undergone waste retrieval in most tanks and waste retrieval currently is ongoing.

Figure 3-45 illustrates the uneven distribution of GTM among individual tanks within the single-shell tank waste and farm EUs. For the A-AX tank waste and farms EU, the GTM is dominated by tanks A-101, A-103, A-106 and AX-101 (i.e., 4 of 10 tanks). For the T tank waste and farms EU, the GTM is dominated by tanks T-101, T-105, T-107, and T-111 (4 of 14 tanks), three of which are assumed leakers. Also note that for the T tank waste and farms EU, the GTM associated with past leaks is greater than the GTM associated with any individual tank and dwarfs the GTM associated with all but the four tanks with the greatest GTMs. For the T tank waste and farms EU, reducing 99% of the tank inventory in all tanks would reduce the overall GTM for that tank waste and farms EU by only 65.9%, while a 99% reduction for tanks T-101, T-105, T-107, and T-111, along with a 90% reduction of the tank inventory for the remaining 12 tanks, would reduce the overall GTM by 65.2%.

Figure 3-46 compares the GTM for waste in all tanks within each EU to the GTM for the existing environmental contamination in the vadose zone from legacy discharges and leaks. These results indicate that reducing the GTM remaining in the tanks after waste retrieval to levels commensurate with the surrounding vadose zone GTM should be considered, especially in the context where residual inventories in the tanks after retrieval would be grouted in place and would therefore have significantly less leaching potential to impact groundwater than inventories in the vadose zone. Waste retrievals that result in reduction of the GTM contained in the tanks within each tank waste and farms EU by 90% would meet this criterion (i.e., tank end-state less than the GTM in the vadose zone) for each SST tank farm except for U and A-AX tank farms. Overall, the GTM in the vadose zone is approximately 6% and 4% of the GTM in the SSTs for 200 East and 200 West tank farms, respectively (Table 3-45).

Figure 3-47 presents the GTM for all DSTs and SSTs. The waste inventory in 17 tanks (16 DSTs and 1 SST) accounts for 50% of all of the GTM within tanks, while 66 of 177 tanks (26 DSTs and 40 SSTs, including 10 assumed SST leakers) account for 90% of the total GTM within tanks (Table 3-46). All DSTs and SSTs in the group that accounts for 90% of the total GTM have a GTM greater than 100 Mm^3.

If the focus is solely on SSTs, then 90% of the total GTM within SSTs is contained in 55 tanks (Figure 3-48). All of these SSTs have a GTM greater than 78 Mm^3, with 49 of the 55 SSTs having a GTM greater than 100 Mm^3.

[93] Cr(VI) also is identified as having significant potential to threaten groundwater and the Columbia River, but the potential threat from Cr(VI) is from existing environmental contamination (legacy discharges), not from chromium currently in the tanks. Chromium in the tank wastes is primarily precipitated in solids as Cr(III) and is not reported based on fractional speciation between Cr(III) and Cr(VI).

If the focus is on SSTs that are assumed leakers (Figure 3-49), 10 are in the group of tanks that comprises 90% of the total GTM (DSTs and SSTs), and each of these 10 tanks has a GTM greater than 100 Mm^3 (i.e., 7 in the TX tank farm, 2 in the BY tank farm, 1 in the B tank farm). Thirty-seven SSTs that are assumed leakers have a GTM greater than 10 Mm^3.

Table 3-45. Groundwater threat metric by tank waste and farm EU, existing contamination within the vadose zone and within tanks.

		GTM (Mm^3) [(a)]		
Tank Waste and Farms EUs	**200 West SSTs**	**Vadose Zone**	**Within Tanks**	**(GTM Vadose Zone)/ (GTM within Tanks)**
CP-TF-1	T	78	160	49%
CP-TF-2	S-SX	98	4,000	2%
CP-TF-3	TX-TY	130	2,800	5%
CP-TF-4	U	4.0	1,800	0.2%
	Sum:	310	8,800	
	200 East SSTs			
CP-TF-5	A-AX	2.1	1,100	0.2%
CP-TF-6	B-BX-BY	200	2,400	8%
CP-TF-7	C	24	29	84%
	Sum:	220	3,500	

a. The groundwater threat metric (GTM) represents the maximum volume of water that could be contaminated from a source at the reference threshold (e.g., water quality standard).

Table 3-46. 26 of 28 DSTs and 40 of 149 SSTs account for 90% of the total DST+SST GTM based on maximum of I-129 and Tc-99 GTM by tank. Asterisk (*) indicates an assumed leaker tank.

200 East (35 of 91 tanks)		**200 West (33 of 86 tanks)**	
CP-TF-5 **3 Tanks**	A-101, A-103, AX-101	CP-TF-1 0 Tanks	
CP-TF-6 **8 Tanks**	B-111*, BY-101, BY-103*, BY-104, BY-106*, BY-110, BY-111, BY-112	CP-TF-2 13 Tanks	S-103, S-105, S-106, S-108, S-109, S-110, S-111, SX-101, SX-102, SX-103, SX-104, SX-105, SX-106
CP-TF-7 **0 Tanks**		CP-TF-3 10 Tanks	TX-105*, TX-106, TX-110*, TX-111, TX-112, TX-113*, TX-114*, TX-115*, TX-116*, TX-117*
CP-TF-8 **23 Tanks (DSTs)**	AN-101, AN-102, AN-103, AN-104, AN-105, AN-106, AN-107, AP-101, AP-102, AP-103, AP-104, AP-105, AP-106, AP-107, AP-108, AW-101, AW-102, AW-103, AW-104, AW-105, AW-106, AZ-101, AZ-102	CP-TF-4 6 Tanks	U-102, U-103, U-105, U-107, U-108, U-109
		CP-TF-9 3 Tanks (DSTs)	SY-101, SY-102, SY-103

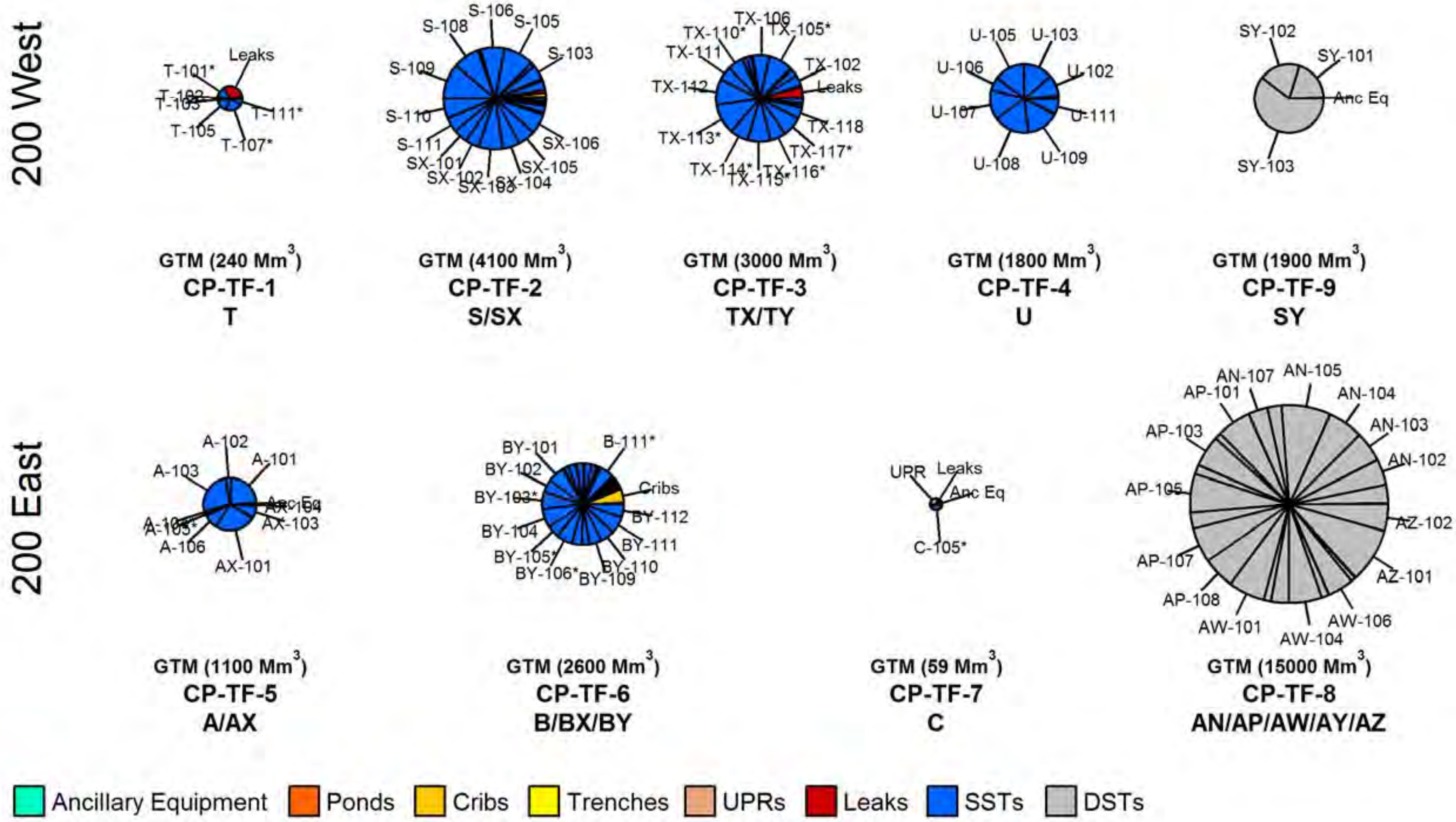

Figure 3-44. Groundwater threat metric based on the maximum GTM between I-129 and Tc-99. The GTM distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative GTM within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

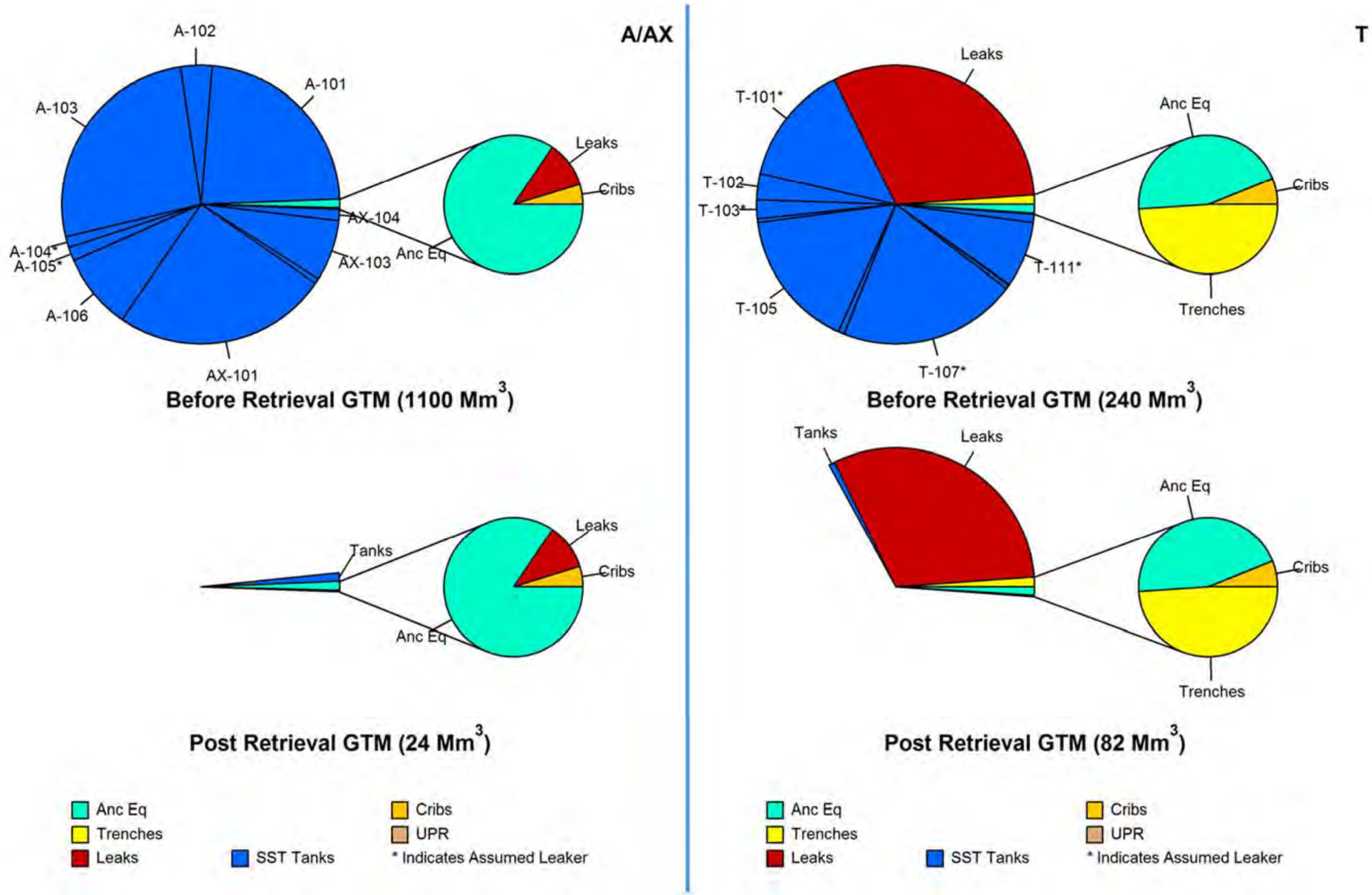

Figure 3-45. Distribution of the GTM based on the maximum GTM of I-129 and Tc-99 among individual tanks and existing environmental contamination for two tank waste and farm EUs (CP-TF-5, A/AX, 200 East; CP-TF-1, T, 200 West). Asterisk (*) indicates an assumed leaker tank.

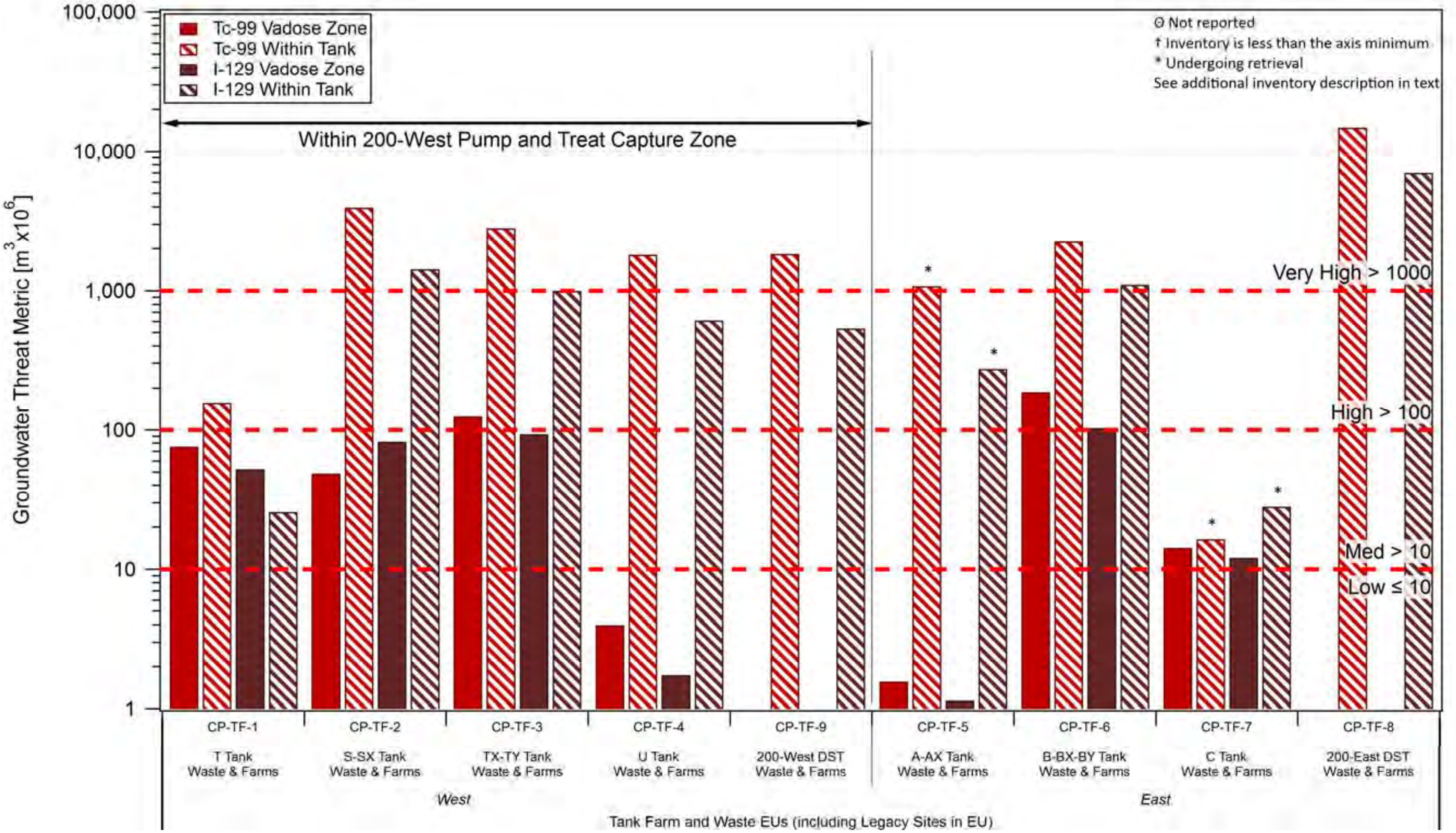

Figure 3-46. Comparison of the GTM (Mm^3) from existing contamination in the vadose zone to the GTM associated with the inventories in each tank waste and farms EU.

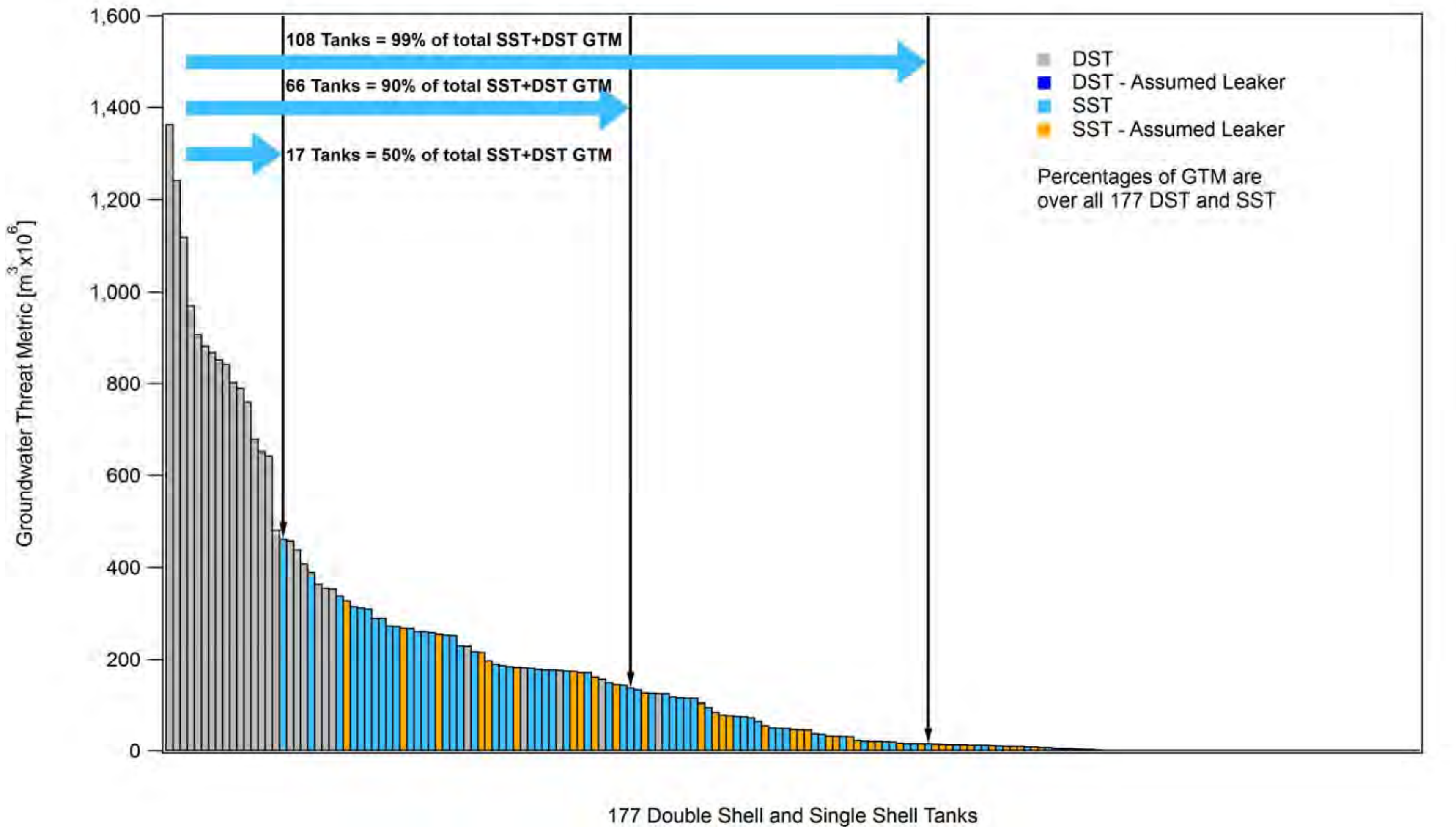

Figure 3-47. Groundwater threat: Which tanks are important? Comparison of GTM within DSTs and SSTs by tank.

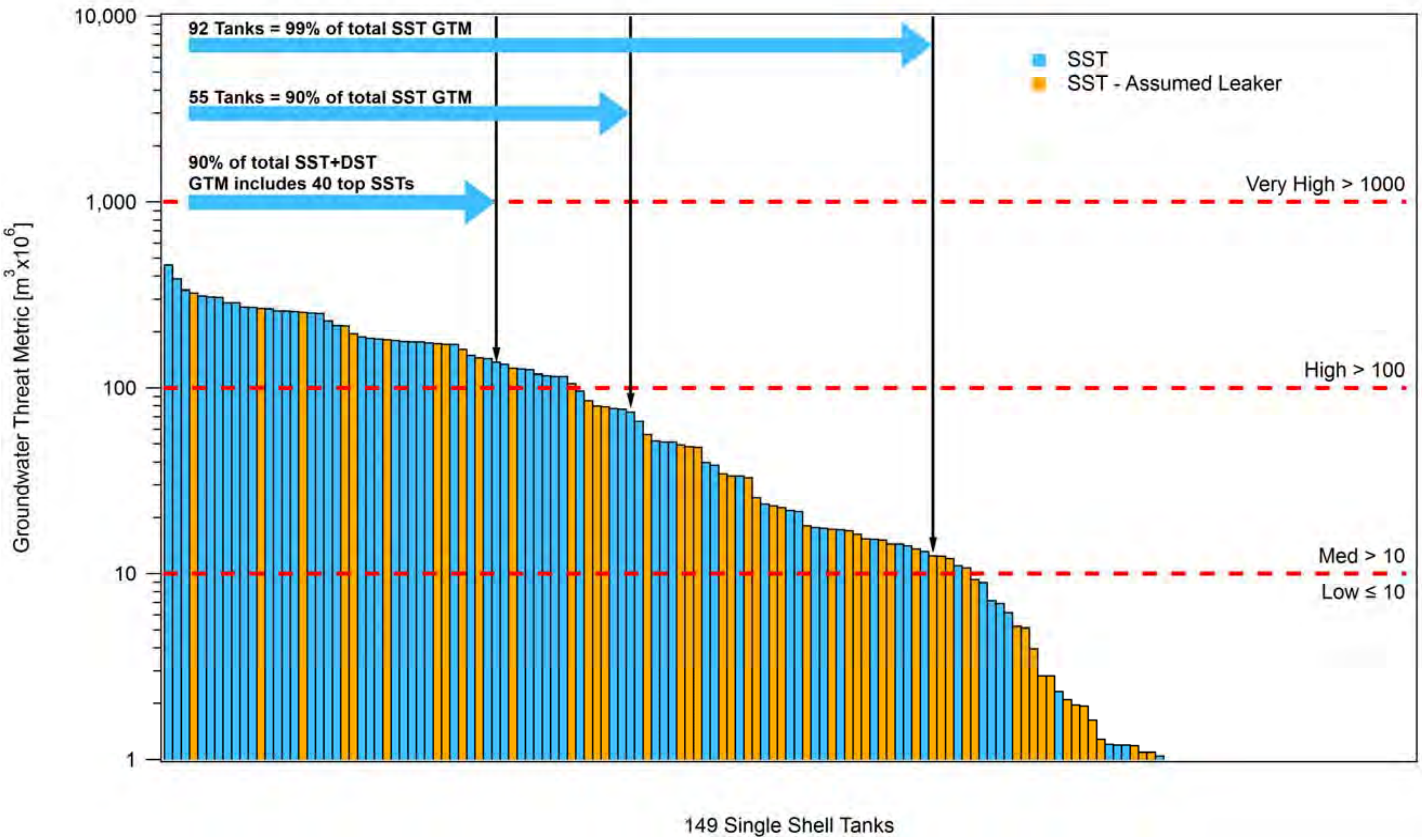

Figure 3-48. Groundwater threat: Which single-shell tanks are important? Comparison of GTM within SSTs by tank.

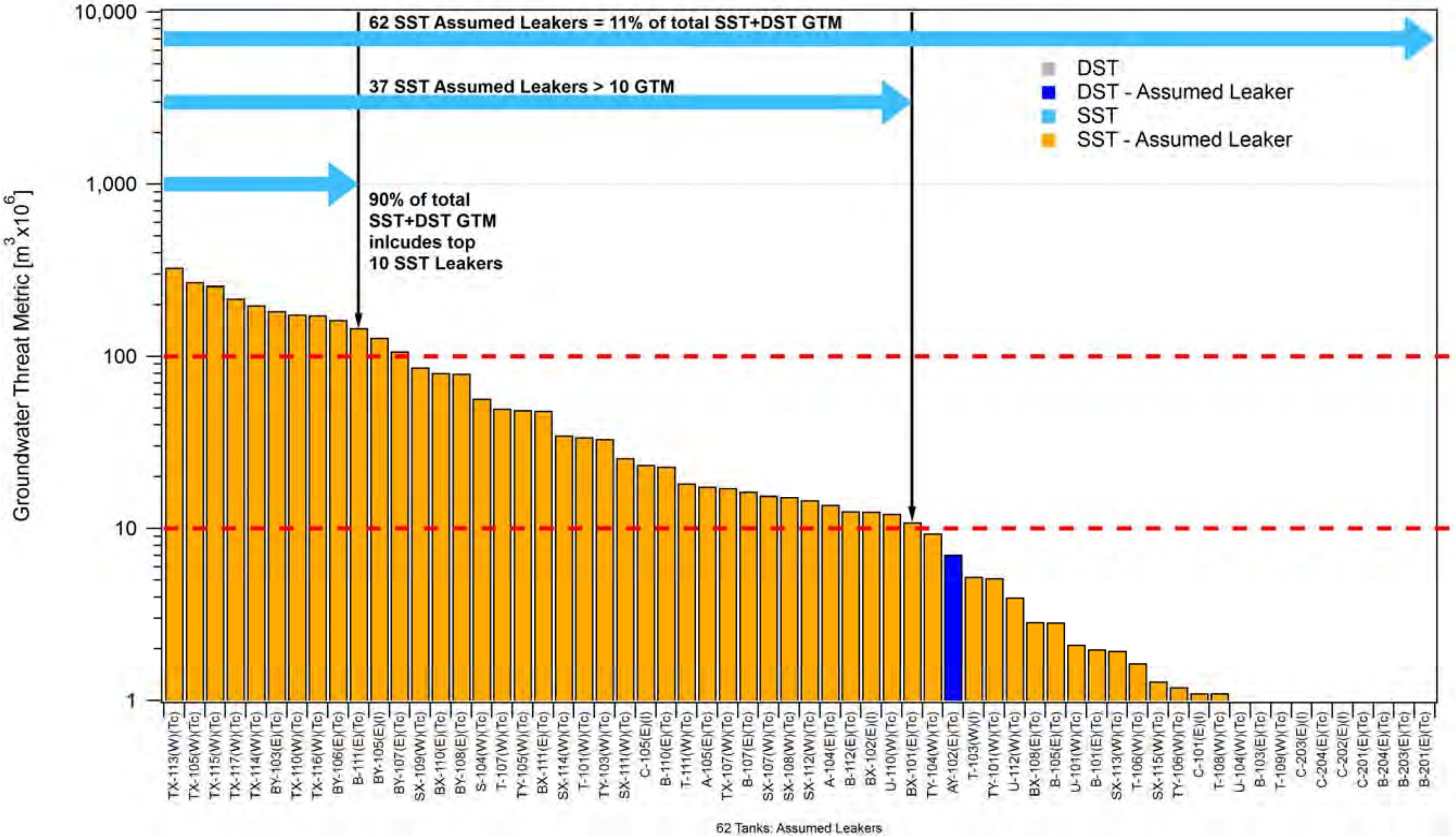

Figure 3-49. Groundwater threat: Which assumed leakers are important? Comparison of GTM for SST assumed leakers by tank.

THREATS TO THE COLUMBIA RIVER

200 West Tank Waste and Farms EUs

Current impacts from the tank waste and farms EUs to the benthic, riparian, and free-flowing ecology associated with the Columbia River are rated as ND for the 200 West tank waste and farms EUs. The groundwater plumes in the 200 West Area (CP-GW-2) resulting from releases related to the 200 West tank waste and farms EUs are managed using the 200-UP and 200-ZP groundwater interest areas (GWIAs) (DOE/RL-2016-09, Rev. 0). The ND rating is based on the information in the 2015 Hanford Annual Groundwater Report (DOE/RL-2016-09, Rev. 0) and PHOENIX (http://phoenix.pnnl.gov/), which indicates that even though contaminants associated with the 200 West tank waste and farms EUs (including Tc-99, I-129, and chromium) are in the saturated zone (as reflected in the 200-ZP and 200-UP GWIAs), no plumes from the GWIAs (and thus the 200 West tank waste and farms EUs) are currently intersecting the Columbia River at concentrations exceeding the WQS.

It is unlikely that the tank waste and farms EU plumes originating from 200 West (CP-GW-2 EU) would reach the Columbia River in the next 150 years (see Figure 3-50) at concentrations exceeding thresholds since the *water* travel time is greater than 50 years (and likely significantly more) from 200 West to 200 East and approximately 10 to 30 years from 200 East to the Columbia River (Gephart 2003; PNNL-6415 Rev. 18). It is likely that significantly more time would be required to reach the river in sufficient quantity to exceed the WQS or appropriate aquatic screening values.[94]

An ecological screening analysis was performed in the TC&WM EIS (DOE/EIS-0391 2012, Appendix P) to evaluate potential long-term impacts of radioactive and chemical contaminants (*from sources in addition to those in the 200-West Tank Waste and Farms EUs under a No Action Alternative*[95]) discharged with groundwater on aquatic and riparian receptors at the Columbia River. The screening results indicate that exposure to radioactive contaminants from peak groundwater discharge was below benchmarks (0.1 rad per day for wildlife receptors and 1 rad per day for benthic invertebrates and aquatic biota, including salmonids, consistent with DOE-STD-1153-2002) (DOE/EIS-0391 2012, Appendix P, p. P-52), indicating adverse effects from radionuclides should not be expected, which would lead to an ND rating for radionuclides for benthic, riparian, and free-flowing receptors (for Current, Active Cleanup, and Near-term, Post Cleanup periods). Compared with the DOE technical standard, recent European Union work has estimated a no observed adverse effects level (NOAEL) at 0.024 rad/d (10 µGy/h) (Anderson et al. 2009) and a LOAEL at 0.24 rad/d (100 µGy/h) (Real et al. 2004) for nonhuman biota.[96]

The screening ecological evaluation in the TC&WM EIS (Appendix P, DOE/EIS-0391 2012) for potential impacts of chemical contaminants discharged with groundwater to the near-river ecology (benthic and riparian) indicates that chromium and nitrate would have predicted hazard quotients exceeding one for aquatic and riparian receptors over the EIS evaluation period (10,000 years). Furthermore, the results of

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[94] Based on current and expected subsurface conditions, the only path currently considered from 200 West to the Columbia River is that from 200 West to 200 East and then to the Columbia River (Chapter 6 in the methodology (CRESP 2015b)).

[95] Results were not provided for specific tanks or tank farms so the aggregated screening analysis in the TC&WM EIS (DOE/EIS-0391 2012) was used as an indicator of contaminant travel from the Central Plateau to the Columbia River for the purposes of this Review.

[96] For aquatic biota, the maximum Hazard Index (HI), which is the sum of the external and internal radiation doses from exposure to all radioactive COPCs divided by the toxicity reference value (TRV) or 1 rad-per-day, is 2.81×10^{-4} (DOE/EIS-0391 2012, Appendix P, p. P-49) or a total dose of 2.81×10^{-4} rad/d, which is significantly less than the European Union NOAEL of 0.024 rad/d.

the screening evaluation at the near-shore region under the No Action Alternative (DOE/EIS-0391 2012, Appendix O) that were used to support the screening ecological evaluation indicate that the nitrate peak concentration (and discharge) occurred in the past and that future concentrations are anticipated not to exceed either the drinking water standard or AWQC in the future. Furthermore, the potential impact of increased nitrate levels may depend on other factors (e.g., phosphorus) and are highly uncertain.

The EIS results of the screening evaluation at the near-shore region under the No Action Alternative (DOE/EIS-0391 2012, Appendix O) indicate that the chromium concentration was predicted to exceed the drinking water standard for total chromium (100 µg/L) and the EIS benchmark threshold (as well as the AWQC of 10 µg/L) for hexavalent chromium within the next decade.[97] However, the predicted concentrations are likely overestimated since all discharge is assumed to occur in a 40-m near-shore region. Furthermore, well measurements indicate that chromium movement towards the Columbia River is significantly slower than that predicted in the TC&WM EIS, and that the plume would be unlikely to reach the river in either the Active Cleanup or Near-term, Post Cleanup periods. Because of the long travel times expected from 200 West, the ratings for all evaluation periods is ND.

As described in Chapter 6 of the methodology (CRESP 2015b), the large dilution effect of the Columbia River on the contamination from the seeps and groundwater upwellings results in long-term ratings of ND for the free-flowing ecology.

Finally, the No Action Alternative evaluation in the TC&WM EIS (DOE/EIS-0391 2012) suggests that remedial actions (e.g., surface barrier emplacement that would decrease recharge near the tank farms) do not significantly affect the long-term peak concentrations in the near-shore area (benthic and riparian receptors) of the Columbia River. This result is not due to an ineffective barrier but instead likely due to large amounts of contaminants already in the subsurface and possible impacts from sources outside the 200 West Tank Waste and Farms EUs. Thus, the ratings are not changed based on the remedial actions (landfill closure or surface barrier emplacement) assumed in the TC&WM EIS.

[97] The benchmark value used for chromium (hexavalent) in the TC&WM EIS was the sensitive-species-test-effect concentration, defined as the concentration that affects 20% of a test population (EC_{20}), despite the fact that the less toxic trivalent form of chromium is more like to be present in oxygenated, aquatic environs (DOE/EIS-0391 2012, Appendix P, pp. P-52 to P-53).

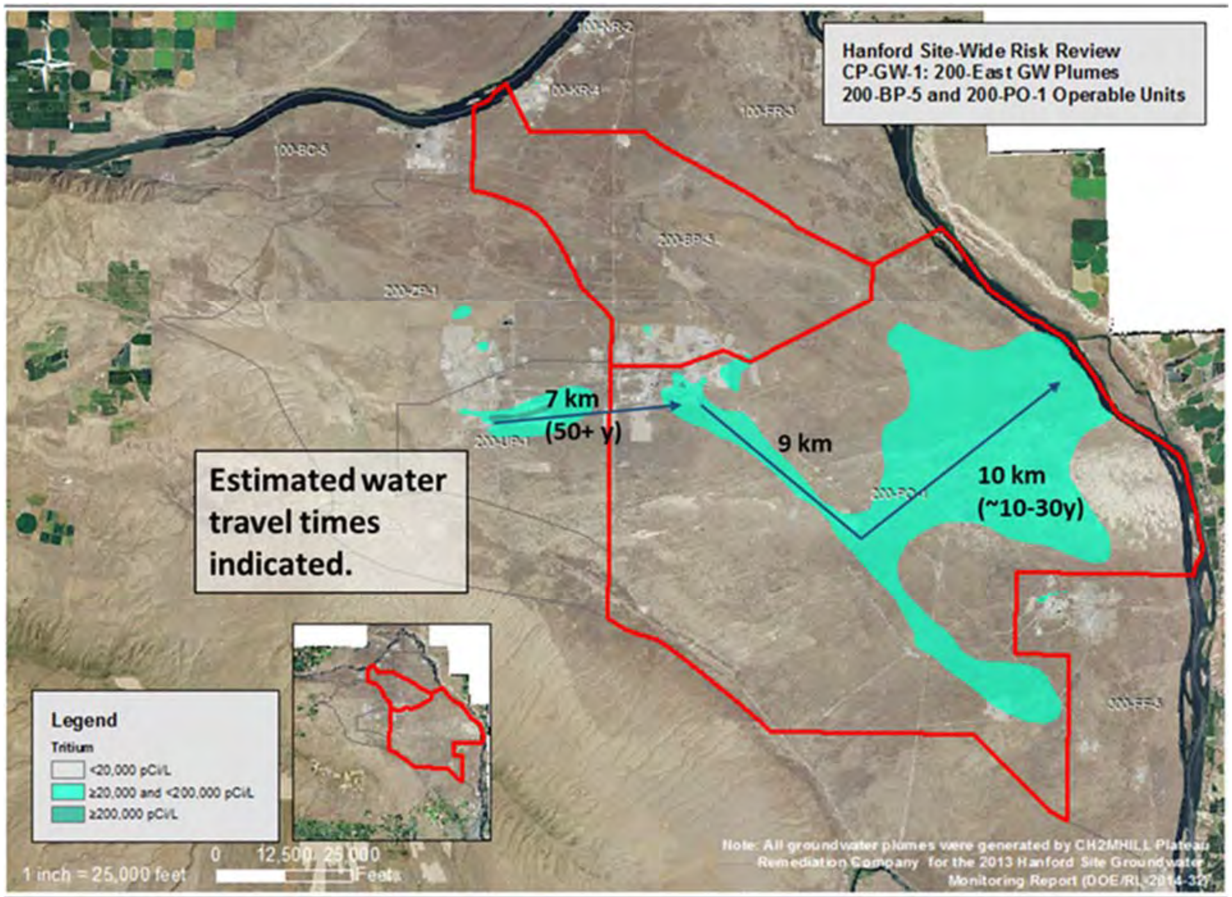

Figure 3-50. Estimating pathways and travel times of groundwater from the 200 Areas to the Columbia River based on past tritium plume movement.

200 East Area Tank Waste and Farms EUs

The groundwater plumes in the 200 East Area (CP-GW-1) resulting from releases related to the 200 East tank waste and farms EUs are managed using the 200-BP and 200-PO groundwater interest areas (GWIAs) (DOE/RL-2016-09, Rev. 0). Only the tritium (H-3) plume from the 200-PO GWIA currently intersects the Columbia River at concentrations exceeding the appropriate WQS; however, this plume is from past PUREX-related operations and is not related to 200 East Tank Waste and Farms EUs. The Risk Review Project rating for tritium for all evaluation periods is ND.

Because current 200-PO GWIA plumes originate from 200 East, it is possible that a current plume might reach the Columbia River in the next 150 years since the *water* travel time is relatively fast (approximately 10 to 30 yr) from 200 East to the Columbia River (Gephart 2003; PNNL-6415 Rev. 18) when compared to travel times for 200 West. In addition, a plume has reached the Columbia River from 200 East. Following the framework process (Figure 2-13), the ratio, R1, of the predicted peak concentration (Table O-8, Appendix O, DOE/EIS-0391 2012, p. O-59) to the BCG for each radioactive contaminant associated with the 200 East Tank Waste and Farms EUs with a current plume (including I-129 and Tc-99) is far less than 1, again indicating low risk. These results agree with those from the TC&WM EIS ecological screening evaluation (Appendix P, DOE/EIS-0391 2012). For 200 East Tank Waste and Farms EU chemical contaminants with existing plumes (nitrate and TCE), the predicted peak concentration (Table O-8, Appendix O, DOE/EIS-0391 2012, p. O-59) is less than the standard indicating no adverse risk and an ND rating.

The alternatives (No Action versus Landfill Closure) evaluation in the TC&WM EIS (DOE/EIS-0391 2012, Appendix O) suggests that planned remedial actions (namely surface barrier emplacement that would decrease recharge in the areas near the tank farms) would have little moderating impact on nearshore contaminant concentrations. This result is likely due to the large amounts of contaminants already in the subsurface from the 200 East and other sources considered and not due to an ineffective barrier. Thus, the ratings would not be modified based on projected changes in recharge.

Results of the Threat Evaluation to the Benthic Zone and Riparian Zone Ecology

An ecological screening analysis was performed in the TC&WM EIS (DOE/EIS-0391 2012, Appendix P) to evaluate potential long-term impacts of radioactive and chemical contaminants (*from all sources under a No Action Alternative*) discharged with groundwater on aquatic and riparian receptors located in the near-shore region of the Columbia River. The screening results indicate that exposure to radioactive contaminants from peak groundwater discharge was below benchmarks (0.1 rad per day for wildlife receptors and 1 rad per day for benthic invertebrates and aquatic biota, including salmonids consistent with DOE-STD-1153-2002 (DOE/EIS-0391 2012, Appendix P, p. P-52), indicating there should be no expected adverse effects from radionuclides. The Risk Review Project ratings for radionuclides during the active cleanup and near-term post-cleanup evaluation periods are thus ND. This rating is consistent with the indication of no adverse impacts from radionuclides for both benthic and riparian receptors made under the TC&WM EIS evaluation period, which was a 10,000-year period (DOE/EIS-0391 2012).

The screening evaluation in the TC&WM EIS (DOE/EIS-0391 2012) of potential impacts of chemical contaminants discharged with groundwater to the near-river ecology (benthic and riparian) indicates that nitrate would have expected hazard quotients exceeding 1 (implying moderate risk) for aquatic and riparian receptors over the 10,000-year evaluation period in the TC&WM EIS. However, the nitrate peak concentration (and discharge) occurred in the past and that future concentrations would not exceed either the drinking water standard or AWQC in the future. Furthermore, the potential impact of increased nitrate levels may depend on other factors (e.g., phosphorus) and be highly uncertain. Thus an ND rating is ascribed to nitrate for the Current, Active Cleanup, and Near-term, Post-Cleanup periods.

The EIS results of the screening evaluation at the near-shore region under the No Action Alternative (DOE/EIS-0391 2012, Appendix O) indicate that, although not a current plume from the 200 East Area, the chromium concentration is predicted to exceed thresholds for chromium (48 or 100 µg/L) and the EIS benchmark threshold[98] (as well as the AWQC of 10 µg/L) for hexavalent chromium. The predicted concentrations are likely overestimated since all discharge is assumed to occur within a 40 m, near-shore region. Using the framework outlined in Chapter 6 of the methodology document (CRESP 2015b), the peak predicted concentrations would correspond to ratings of Medium and High for the benthic and riparian ecology, respectively, for the active cleanup and near-term post-cleanup evaluation periods. However, well data suggest that the chromium is moving much slower than predicted in the TC&WM EIS, and it is unlikely that a chromium plume would reach the Columbia River from the 200 East Tank Waste and Farms EU sources in the next 50 or 150 years. Thus a rating of ND is ascribed for the benthic and riparian zones for the Current and Active Cleanup periods, and a corresponding rating of Low is ascribed for the Near-term, Post-Cleanup period.

The TC&WM EIS Alternative 2B (*Tank Closure Alternative 2B: Expanded WTP Vitrification; Landfill Closure*) (DOE/EIS-0391 2012) gives an idea of the impact on chromium in the near-shore region if surface barriers are emplaced (i.e., landfill closure). The maximum predicted chromium concentration (over the 10,000-year EIS evaluation period) for the landfill closure alternatives is 228 µg /L (DOE/EIS-0391 2012, Appendix O, p. O-67 for cribs and trenches) versus a value of 232 µg/L for the No Action Alternative. Thus, the rating would not change based on surface barrier installation and changes in recharge rates. This is likely because there is already significant contamination in the groundwater as well as possible impacts from sources outside the 200 East Tank Waste and Farms EUs that were considered in the screening analysis.

Threats to the Columbia River Free-flowing Ecology

The threat determination approach for evaluating the free-flowing river ecology is similar to that described above for benthic receptors (Chapter 6 in the methodology [CRESP 2015b]). However, because the Columbia River has a large dilution effect on contamination from the seeps and groundwater upwellings,[99] the differences from EU to EU are not distinguishable and groundwater contaminant discharges from Hanford Site have a very remote potential to achieve surface water concentrations above relevant water quality standard thresholds.[100]

RISK RATINGS

Table 3-47 summarizes the Risk Review Project ratings for the tank waste and farms EUs. Additional supporting information is provided in Appendix E.1 through Appendix E.11.

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[98] The benchmark value used for chromium (hexavalent) in the TC&WM EIS was the sensitive-species-test-effect concentration that affects 20% of a test population (EC_{20}), even though the less-toxic trivalent form of chromium is more likely to be present in oxygenated, aquatic environs (DOE/EIS-0391 2012, Appendix P, pp. P-52 to P-53).

[99] Groundwater is a potential pathway for contaminants to enter the Columbia River. Groundwater flows into the river from springs above the water line and through areas of upwelling in the riverbed. Hydrologists estimate that groundwater currently flows from the Hanford unconfined aquifer to the Columbia River at a rate of ~ 0.000012 cubic meters per second (Section 4.1 of Peterson and Connelly 2001). For comparison, the average flow of the Columbia River is ~3400 cubic meters per second (DOE/RL-2014-32, Rev. 0). This represents a dilution effect of more than eight orders of magnitude (a dilution factor of greater than 100 million).

[100] Bioaccumulation and biomagnification of some contaminants in aquatic biota may be possible; however, these effects typically are considered in the development of surface water quality standards and insufficient information exists at the Hanford Site to consider these effects in the screening process for the Risk Review Project.

Risks and Potential Impacts during the Active Cleanup Period

Groundwater: The ratings for potential impacts or threats to groundwater as a protected resource are described in the appropriate section for each tank waste and farms EU and summarized in Table 3-48. The Overall High ratings for most 200 West and 200 East Single-Shell tank waste and farms EUs are typically driven by chromium (total and hexavalent) with the exceptions of the C tank waste and farms EU (200 East) where I-129 and Tc-99 have Medium ratings and the U tank waste and farms EU (200 West) that has an overall Low rating. The TX-TY tank waste and farms EU (200 West) also includes carbon tetrachloride and Tc-99 and the B-BX-BY tank waste and farms EU (200 East) includes Tc-99.

Columbia River: The ratings for potential impacts or threats to the Columbia River are described in the appropriate section for each tank waste and farms EU and summarized in Table 3-49. The ratings for radionuclides are all ND. The Overall Low ratings (benthic and riparian zone) for the 200 East Tank Waste and Farms EUs in the Near-Term, Post-Cleanup evaluation period are related to total and hexavalent chromium from Central Plateau sources, including sources other than those for the specific tank waste and farms EUs.

Near-Term Post-Cleanup Risks and Potential Impacts

The EIS preferred HLW tank closure alternative includes 99% retrieval of waste from the SSTs[101] for staging in DSTs and treatment elsewhere onsite, operations and necessary maintenance, waste transfers and associated operations, and upgrades to existing tanks or construction of waste receipt facilities (DOE/EIS-0391 2012, Chapter 2, p. 2-321). SST closure operations include filling the tanks and ancillary equipment with grout to immobilize residual waste contaminants. Disposal of contaminated equipment and soil would occur on site. Decisions on the extent of soil removal and/or treatment are planned to be made on a tank farm or WMA basis through the RCRA closure permitting process. The tanks would be stabilized with grout, and an engineered modified RCRA Subtitle C barrier put in place followed by post-closure care.

Thus, workers and the public would be isolated from the residual contamination in the tanks by the tank structure, grout and soil cover. Tank waste contamination already in the vadose and saturated zones would experience reduced infiltrating water (the primary driver for the release and transport of contaminants) because of the surface barrier.

Continued monitoring could disturb the ecological resources in the T tank waste and farms EU and buffer lands. Remediation may improve habitat through revegetation (and increased monitoring may increase exotic species and change species composition).

Indirect effects to a historic trail may be permanent (cultural resources). Capping could cause permanent indirect effects to the viewshed of a traditional cultural place due to presence of contamination.

[101] According to the Hanford Tri-Party Agreement (TPA), the retrieval limits are 360 ft^3 and 30 ft^3 for 100-Series and 200-Series tanks, respectively, (Ecology, EPA, and DOE 1996, Appendix H, p. H-5).

Risk Review Rating Symbols: Risk review ratings for each receptor are tabulated in summary tables using a combination of text summaries and symbolism. Specific symbology was developed for the Risk Review Project and is defined in front matter section *Symbology Used For Risk Review Project Summary Rating Tables*, and repeated here for convenience. Symbols used in the rating tables indicate the highest rating when a rating range is present, although the accompanying text indicates the risk rating range, where applicable, to reflect uncertainty. Symbols within each entry in rating tables are a combination of a risk rating symbol and additional symbols used to indicate 1) the presence of engineered barriers to prevent release to the environment or further dispersion of radionuclides and chemicals, 2) when treatment, waste retrieval or remediation is in progress, and 3) if interim stabilization has occurred (only for single-shell tanks). Examples of resulting combined symbols are on page xxix.

Symbol	Meaning
○	ND Rating
◔	Low Rating
◑	Medium Rating
◕	High Rating
●	Very High Rating
	Barrier Symbols
○	One engineered barrier, Intact (barriers include tanks, covers, liners, buildings, etc.)
◌	One engineered barrier, barrier compromised (e.g., leaking tank)
◎	Two engineered barriers, both barriers intact
◎	Two engineered barriers, inner barrier compromised and outer barrier intact
◎	Two engineered barriers, inner barrier intact and outer barrier compromised
◌	Two engineered barriers, both barriers compromised.
	Treatment, Remediation and Waste Treatment Symbols
[ ]	Treatment, remediation or waste retrieval in progress
ǂ	Interim stabilized (single shell tank, stabilization through removal of pumpable liquid)

Table 3-47. Tank Waste and Farms impact rating summary for human health (unmitigated basis with mitigated basis provided in parentheses (e.g., "High (Low)").

	Population or Resource	Evaluation Period – Active Cleanup (to 2064) – **Current Condition:** Maintenance & Monitoring (M&M)		Evaluation Period – Active Cleanup (to 2064) – **From Cleanup Actions:** Retrieval & Closure	
Human Health	Facility Worker	***M&M***:	Low-High[(a)] (Low-High)[(a)]	***Preferred method***:	High (Low)
		Soil:	ND-High (ND-Low)	***Alternative***:	High (Low)
	Co-located Person	***M&M***:	Low-Medium (Low)	***Preferred method***:	Low-Medium (Low)
		Soil:	Not Discernible (ND) (ND)	***Alternative***:	Low-Medium (Low)
	Public	***M&M***:	Low (Low)	***Preferred method***:	Low (Low)
		Soil:	ND (ND)	***Alternative***:	Low (Low)
Environmental	Groundwater	SST Farm EUs[(c)] 200 W Overall: Low to High 200 E Overall: Medium to High DST Farm EUs[(c)] 200 W Overall: ND 200 E Overall: ND to Low		SST Farm EUs[(c)] 200 W Overall: Low to High 200 E Overall: Medium to High DST Farm EUs[(c)] 200 W Overall: ND 200 E Overall: ND to Low	
	Columbia River	DST & 200 W SST Tank Farm EUs[(d)] **Overall**: Not Discernible 200 East SST Farm EUs[(d)] **Overall**: Not Discernible		DST & 200 W SST Tank Farm EUs[(d)] **Overall**: Not Discernible 200 East SST Farm EUs[(d)] **Overall**: Not Discernible	
	Ecological Resources[(b)]	Refer to specific tank farm EU		Refer to specific tank farm EU	
Social	Cultural Resources[(b)]	Refer to specific tank farm EU		Refer to specific tank farm EU	

a. ***Industrial safety*** consequences range from Low to High (based on the evaluation scale used) for both mitigated (with controls) and unmitigated (without controls). ***Radiological and toxicological*** consequences to Facility Workers are High (unmitigated) and Low (mitigated).
b. For both ecological and cultural resources see Appendices J and K, respectively, for a complete description of ecological field assessments and literature review for cultural resources.
c. Refer to Table 3-48 for details. The Overall High ratings for the 200 West SST and waste farms EUs are driven by chromium (total and hexavalent) for most EUs with the TX-TY tank waste and farms EU also including carbon tetrachloride and Tc-99. The U tank waste and farms EU has a Low rating. The Overall Medium and High ratings for the 200 East SST farms result from I-129 and Tc-99 (C), total and hexavalent chromium (A-AX), and Tc-99 and total and hexavalent chromium (B-BX-BY). The large amounts of Sr-90 would translate to High or Very High in many of these EUs; however, the relative immobility of Sr-90 in the Hanford subsurface results in ND ratings during the Active Cleanup period. This is also the case for uranium in the A-AX tank waste and farms EU.
d. Refer to Table 3-49 for details. The ratings with respect to radionuclides and chemicals are all ND consisted with the results of the TC&WM EIS screening analysis.

Table 3-48. Summary of groundwater overall threat ratings for current vadose zone contaminant inventories in the Hanford tank farm evaluation units.[(a)]

EU Name	EU	Risk Driver	Current	Risk Driver	Active Cleanup	Risk Driver	Near-Term Post-Cleanup
T Tank Farm	CP-TF-1	Cr[(a,c)]	High ǂ	Cr[(a,c)]	High ǂ	Cr[(a,c)]	High
S-SX Tank Farms	CP-TF-2	Cr[(a,c)]	High ǂ	Cr[(a,c)]	High [ ]ǂ	Cr[(a,c)]	High
TX-TY Tank Farms	CP-TF-3	Tc-99, CCl4, Cr[(a,c)]	High ǂ	Tc-99, CCl4, Cr[(a,c)]	High [ ]ǂ	Tc-99, CCl4, Cr[(a,c)]	High
U Tank Farm	CP-TF-4	Various [(b,c)]	Low ǂ	Various [(b,c)]	Low [ ]ǂ	Various [(d,c)]	Low
A-AX Tank Farms	CP-TF-5	Cr[(a,c)]	Medium ǂ	Cr[(a,c)]	Medium [ ]ǂ	Cr-VI[(c)]	Medium
B-BX-BY Tank Farms	CP-TF-6	Tc-99, Cr[(a,c)]	High ǂ	Tc-99, Cr[(a,c)]	High [ ]ǂ	I-129, Tc-99, Cr[(a,c)]	High
C Tank Farms	CP-TF-7	I-129, Tc-99[(c)]	Medium [ ]ǂ	I-129, Tc-99[(c)]	Medium [ ]ǂ	I-129[(c)]	Medium
200 East (DSTs)	CP-TF-8	Various [(b)]	Low [ ]	Various [(b)]	Low [ ]	Various [(d)]	Low
200 West (DSTs)	CP-TF-9		ND		ND [ ]		ND

a. Cr represents both total and hexavalent chromium
b. The various non-zero inventory PCs are C-14, I-129, Tc-99, Cr[(a)]
c. The Sr-90 and U-Total inventories may be large; however, these contaminants are largely immobile in the Hanford subsurface and thus these contaminants are generally given ND ratings during the Current and Active Cleanup periods and Low afterwards to reflect uncertainties.
d. The various non-zero inventory PCs are C-14, I-129, Sr-90, Tc-99, Cr[(a)], U-Total

Table 3-49. Summary of Columbia River threat ratings for contaminants currently in the vadose zone at the Hanford tank waste and farms evaluation units.

	EU Name	EU	Current	Active Cleanup	Near-Term Post-Cleanup
200 W	T, S-SX, TX-TY, and U Tank Farms	CP-TF-1 CP-TF-2 CP-TF-3 CP-TF-4	Benthic – ND (all)	Benthic – ND (all)	Benthic – ND (all)
			Riparian – ND (all)	Riparian – ND (all)	Riparian – ND (all)
			Overall: ND	Overall: ND	Overall: ND
200 E	A-AX and B-BX-BY Tank Farms	CP-TF-5 CP-TF-6	Benthic –	Benthic –	Benthic –
			ND (radionuclides)	ND (radionuclides)	ND (radionuclides)
			ND (chemicals)	ND (chemicals)	Low (chemicals[a])
			Riparian –	Riparian –	Riparian –
			ND (radionuclides)	ND (radionuclides)	ND (radionuclides)
			ND (chemicals)	ND (chemicals)	Low (chemicals[a])
			Overall: ND	Overall: ND	Overall: Low
	C Tank Farm	CP-TF-7	Benthic –	Benthic –	Benthic –
			ND (radionuclides)	ND (radionuclides)	ND (radionuclides)
			ND (chemicals)	ND (chemicals)	Low (chemicals[a])
			Riparian –	Riparian –	Riparian –
			ND (radionuclides)	ND (radionuclides)	ND (radionuclides)
			ND (chemicals)	ND (chemicals)	Low (chemicals[a])
			Overall: ND	Overall: ND	Overall: Low
200 East (DSTs)		CP-TF-8	Benthic – ND (all)	Benthic – ND (all)	Benthic – ND (all)
			Riparian – ND (all)	Riparian – ND (all)	Riparian – ND (all)
			Overall: ND	Overall: ND	Overall: ND
200 West (DSTs)		CP-TF-9	Benthic – ND (all)	Benthic – ND (all)	Benthic – ND (all)
			Riparian – ND (all)	Riparian – ND (all)	Riparian – ND (all)
			Overall: ND	Overall: ND	Overall: ND

a. The threat to the Columbia River related to chemicals is driven by hexavalent chromium in the vadose zone. Also chromium is from Central Plateau sources in addition to those for the specific tank waste and farms EU.

IMPLICATIONS FOR SEQUENCING TANK WASTE PROCESSING

Taken together, the information above suggests the following:

- Hydrogen gas generation[102] poses a threat to nuclear safety and human health through loss of safety systems from a major external event.
- Tc-99 and I-129, both being persistent and highly mobile in the subsurface, pose threats to groundwater through leakage from tanks (these threats have been substantially reduced.)
- As a first-order analysis, groundwater threats can be substantially reduced by removing water-soluble constituents (Tc-99 and I-129) from a selected set of tanks.[103] Similarly, nuclear safety threats also can be reduced for several tanks by removing water-soluble Cs-137. This is consistent with the priority given by the Tri-Party agencies to treat LAW at WTP as early as possible if Cs-137, Tc-99, and I-129 separated from the waste are not returned to the tanks. However, the risk to groundwater profile will neither be reduced significantly nor increased if Tc-99 and I-129 are returned to the tanks during LAWPS treatment. The nuclear safety risk profile will be reduced if separated Cs-137 is not returned to the tanks or to tanks with low HGR, and may remain the same or be increased or reduced depending on the time to hydrogen flammability thresholds for the tank(s) accepting returned Cs-137.
- The sequencing of SST retrievals should focus on assumed leakers with significant GTM, and if it is assumed that retrievals are to be staged by tank farm, the initial focus should be on the BY tank farm in 200 East and the TX tank farm in 200 West.
- Processing LAW from the 200 East DSTs would substantially reduce the overall GTM related to the tank waste and farms EUs.
- If a target of 95 % reduction in GTM across all SSTs is selected and in-tank grouting of the residual waste inventory is completed, the threat of groundwater contamination from SSTs would be reduced to substantially less than the GTM from existing environmental contamination in the vadose zone in both the 200 West and 200 East Areas from past leaks and legacy disposal activities near the SST farms. Waste retrievals that result in reduction by 90% of the GTM contained in the tanks collectively across all tanks within each tank waste and farms EU would meet the criteria of tank end-states being less than the GTM in the vadose zone for all SST tank farms except for U and A-AX tank waste and farms EUs.
- If selective waste retrieval targets of 99% or the limits of multiple technologies are applied to the group of 26 DSTs and 40 SSTs that comprise 90% of the total GTM in all tanks, the result would be a residual GTM of approximately 1% of the initial inventory. Waste retrieval targets of 90% of the GTM or the limits a single technology (if greater than 90% retrieval) would result in a residual GTM of less than an additional 1% of the current GTM with a cumulative result that is indistinguishable from a target of 99% across all tanks, considering inventory and retrieval uncertainties. Similarly, selective retrieval targets can be used if the target reduction was 90% of the GTM across individual tank farms. Selective waste retrieval targets may allow for significant acceleration of tank waste retrievals and much more rapid reduction in groundwater threats

[102] Hydrogen generation rate is primarily related to Cs-137 and Sr-90 content of the waste.

[103] For hydrogen generation, 200 East DSTs and SSTs B-202, B-203, B-204, and T-201 have times to 25% of the LFL of less than 6 months under unventilated conditions; for groundwater threat, greater than 70% of the GTM is from 200 East DSTs, SY-101 and SY-103 (200 West DSTs), and SSTs AX-101, S-105, S-106, S-108, S-109, SX-106, TX-105,* TX-113,* TX-115,* U-109, U-105 (* indicates assumed SST leaker).

from tank wastes than currently planned. Selective retrieval targets can be accomplished for individual tanks within each tank farm, allowing for different amounts of retrieval while completing waste retrievals at an entire tank farm. *Further evaluation of this concept is warranted. A tank farm waste retrieval and processing system plan evaluation of this approach is suggested.*

WASTE MANAGEMENT IMPLICATIONS FOR HANFORD TANK FARMS[104]

Four decades of plutonium production at the Hanford Site resulted in approximately 56 million gallons of radioactive and chemical wastes that are currently stored in 177 underground tanks, including 149 aging single-shell tanks (SST), located in the Hanford Central Plateau. DOE-ORP is addressing the risks posed by the tank waste through interim actions, retrieval, and treatment, with ultimately the final closure of the tanks and decommissioning of facilities used to treat the tank waste. For example, in the Interim Stabilization Project, DOE transferred the pumpable liquids (i.e., the supernatant and drainable liquids that are most likely to leak) from the aging SSTs to the newer DSTs (Weyns 2015). Furthermore, the Waste Treatment and Immobilization Plant (WTP) is being constructed to treat and immobilize the Hanford tank wastes. Although there are no immediate risks to the Hanford workforce, the public, or the accessible environment from leaking tanks, there are ongoing health concerns related to tank vapor releases[105] as well as continuing impacts to the vadose zone and groundwater from past releases and leaks of tank wastes (Appendices E.1 through E.11). Therefore, treating tank wastes is a primary focus of DOE's waste management portfolio.

Upon retrieval, tank waste that will be processed either through the LAW or HLW treatment facilities (i.e., from reprocessing of spent nuclear fuel[106]) will be separated and treated (by vitrification) in the WTP, which is a complex processing facility with many first-of-a-kind technology applications developed to treat the complex and heterogeneous Hanford tank waste. The complex nature of the tank waste and the WTP has led to unresolved technical issues for portions of the facility (primarily the Pretreatment [PT] Facility). The current WTP design anticipates that all waste would be processed through the PT Facility, however, an alternative approach (i.e., Direct Feed Low Activity Waste or DFLAW) is being implemented to begin treating the largest fraction of tank waste (by volume) as soon as practicable (using a new LAW Pretreatment System, a new LAW Effluent Management Facility, and the WTP LAW Vitrification), while simultaneously resolving the remaining technical challenges[107]. Other options for processing and disposing the tank waste are also being considered as discussed below.

Retrieval

The preferred Hanford waste tank closure alternative includes retrieving 99 percent of waste from the single-shell tanks (SSTs) for staging in double-shell tanks and treatment in WTP or the achievable extent of retrieval achieved by sequentially implementing three retrieval technologies. According to the Hanford Tri-Party Agreement (TPA), the retrieval limits corresponding to 99 percent retrieval are 360 ft^3

[104] In general, information for this section was taken from: "Hanford Tank Waste Retrieval, Treatment, and Disposition Framework," U.S. Department of Energy, Washington, D.C, 2013, download from http://energy.gov/downloads/hanfordtank-waste-retrieval-treatment-and-disposition-framework.

[105] Washington River Protection Solutions (WRPS) is the DOE Tank Operations Contractor responsible for managing Hanford tank wastes and preparing it for delivery to WTP. WRPS created a website (https://hanfordvapors.com/) to provide background information, data, and news concerning the Hanford Vapors issue.

[106] This definition may not apply to as many as 11 Hanford waste tanks that are currently ongoing an evaluation to classify the wastes as CH-TRU waste (Appendix E.1) which may allow those wastes to be disposed at WIPP.

[107] Currently the technical issues associated with the Pretreatment Facility are anticipated to be resolved during FY18.

and 30 ft^3 of waste remaining for 100-Series and 200-Series tanks, respectively (Ecology, EPA, and DOE 1996, Appendix H, p. H-5). Planned retrievals are thus based solely on waste volume remaining in each tank or the limits of retrieval technology and are not related to any other waste characteristics (e.g., activity, toxicity, radiotoxicity, radioactive or hazardous constituents) or amounts of waste or the associated risks either on a tank farm basis or over all Hanford waste tanks.

There are large variations in radionuclide concentrations in, the risks posed by, and the characteristics of the Hanford tank wastes that are not accounted for in the current volume and technology focused retrieval standard. The total radionuclide content (using the best basis inventory as illustrated in Figure 3-35) varies by more than five orders of magnitude from Tank 241-T-202 (with the lowest total activity of approximately 23 Ci) to Tank 241-AZ-101 (with the highest total activity of approximately 16 Million Ci). Furthermore, the specific radionuclides that comprise the inventories and their characteristics (e.g., half-lives and environmental mobilities) vary widely from tank to tank (and even within the waste layers in each tank) and can make a significant difference concerning the corresponding risks posed by residual wastes. For example, the Groundwater Threat Metric (GTM), as computed in this Risk Review (CRESP 2015b), represents the potential impact to groundwater from the long-lived and highly mobile constituents (e.g., Tc-99 and I-129) in a given waste; this metric also varies over several orders of magnitude from tank to tank (Figure 3-44 and Figure 3-47) and is dominated by the 200-East DSTs where pumpable liquids (including highly soluble and radioactive Cs-137 that contributes to hydrogen generation) were transferred during the Interim Stabilization Project (Weyns 2015). Thus, the selective removal of Cs-137 (in the supernatant or soluble fraction of Hanford tank waste) could reduce the hydrogen generation rate in some tanks (Figure 3-41) and would remove a large source of penetrating radiation (gamma) from the vessels. Furthermore, focused removal and treatment of the soluble fraction of Hanford tank waste could increase the projected benefit by treating those constituents (as represented by the GTM) that most likely could impact groundwater in the future. For example, 90% of the total GTM within the Hanford SSTs is contained in 55 tanks, including ten “suspected” leakers (Figure 3-48).

In 2011 the Tank Waste Subcommittee of the DOE Environmental Management Advisory Board (EMAB) indicated that approximately 40 of the Hanford waste tanks, representing a significant fraction of the Hanford tank wastes, contain wastes that would satisfy the NRC Class C classification for disposal *without treatment* (Ferrigno, et al. 2011). There may also be as many as 11 Hanford tanks (from the 241-T and 241-B Tank Farms) that contain wastes that potentially could be reclassified as contact-handled transuranic (CH-TRU) waste (Tingley, et al. 2004). It has been estimated that processing these 11 tanks for disposal at WIPP could shorten WTP operation by up to 1 year and save as many as 100 canisters of HLW glass. These tanks are undergoing a classification analysis to determine whether the waste may be properly and legally classified as CH-TRU per DOE 435.1. These sort of screening analyses would be improved if the characteristics of the wastes in the tanks were further evaluated (including considering uncertainty) to determine what types of wastes (e.g., low-heat waste from the bismuth phosphate process) correspond to the lowest risks to human health and the environment (including protected resources like groundwater). Retrieval and subsequent treatment options could thus be tailored accordingly.

Treatment -- Waste Treatment and Immobilization Plant (WTP)

Upon retrieval, tank waste is planned to be separated and treated in the WTP, which is a complex processing facility designed to treat the complex and heterogeneous tank waste. The current WTP design consists of five facilities: Analytical Laboratory (LAB), Balance of Facilities (BOF), LAW (Vitrification) Facility, HLW (Vitrification) Facility, and Pretreatment (PT) Facility. The WTP is being designed to process Hanford tank farm waste over an approximately 40-year period. The current WTP design basis plans for tank waste retrieved to be processed through the PT Facility, where it would be separated into a low-activity waste (LAW) stream to be treated in the LAW Facility (via vitrification) and a high-level waste (HLW) stream to be vitrified in the HLW Facility. The LAB and BOF support the vitrification activities.

BOF and the LAW and LAB Facilities are nearest completion and do not have any substantial remaining technical issues. The outstanding technical issues are instead associated primarily with mixing and sampling of waste in PT Facility vessels (and to a lesser extent issues in the HLW Facility and the tank farms); these issues have caused construction of the PT Facility to be suspended (pending design changes), construction of the HLW Facility to be slowed, and thus impact DOE-ORP's overall ability to begin treating the Hanford tank waste (as currently designed). As discussed earlier, direct feed LAW is being implemented to allow wastes to be treated as soon as is practicable while allowing outstanding technical issues at the PT and HLW Facilities to be resolved.

Direct feed LAW preparations would include completing the tank farm infrastructure and an interim pretreatment capability (i.e., LAW Pretreatment System or LAWPS for removal of cesium and miscellaneous solids) needed to directly feed supernatant to the LAW Facility; completing, commissioning, and starting up the LAW Facility; and obtaining the final permit for on-site disposal of treated LAW in the Integrated Disposal Facility (IDF)[108]. Furthermore, 241-C Tank Farm retrievals will be completed, as well as the classification analysis to determine whether selected tank wastes can be properly and legally classified as CH-TRU (although corresponding CH-TRU waste shipments from Hanford would depend on WIPP availability). Design, construction, and startup of the LAW and LAB Facilities and BOF will also be completed in the initial phase. Then, as technical issues are resolved, construction will move to the HLW Facility and then the PT Facility. The scope and pace of work within each phase would be dependent on a number of factors, including technical issue resolution and Congressional funding appropriations. Future phases would consider Direct Feed HLW, including completion and commissioning of the HLW Facility, completion and commissioning of the PT Facility, and finally integration of the various WTP Facilities to treat Hanford tank wastes. The phased approach, provides opportunities to complete the Hanford tank waste cleanup mission with the potential to reduce the overall duration of the tank waste mission.

Additional Retrieval, Treatment, and Disposal Options

DOE has developed the currently planned phased approach to complete the Hanford waste treatment mission; however, there are additional alternatives that could provide additional treatment and disposal flexibility and potentially reduce the cleanup duration. Starting with the tank farm, risk-based retrieval or tank waste retrieval focused on the highest risk tanks (e.g., tanks with the highest GTM values and largest potential threat to groundwater), may allow for significant acceleration of tank waste retrievals and more rapid reduction in groundwater threats from tank wastes than currently planned. This approach could be coupled with cost-benefit analysis of the multiple retrieval methods currently employed at the Hanford tank farms. The need to process wastes through the PT Facility (and DFLAW) could be relaxed (also providing greater flexibility to the overall process) if challenging waste fractions, including high-risk constituents (e.g., Tc-99) and high-impact constituents (e.g., Cs-137) could be selectively removed from tank wastes and treated for either on-site or potentially off-site disposal[109]. Additionally, reclassifying those tanks wastes (excluding those designated as CH-TRU) that currently

[108] In the current DFLAW design, Cs-137 would be removed using an elutable (from which cesium can be recovered) ion exchange resin and returned to the Hanford waste tanks for future immobilization in HLW glass.
[109] For example, the Cs-137 could instead be removed using a non-elutable resin (which permanently retains cesium) in a commercially available cartridge system for either onsite or potentially offsite disposal.

meet NRC Class C requirements provides potential treatment and disposal alternatives that may be considered based on projected benefits and challenges, including risk reduction. These alternatives can include the use of non-vitrified waste forms for both the removed constituents (Cs-137 or Tc-99) as well as the LAW fraction of tank waste. For example, SRS LAW has been grouted since 1990; this waste form is currently being studied for Hanford LAW as a potential option for the Supplemental LAW Facility at Hanford, which may be needed to treat a significant fraction of Hanford tank waste. Past results show that this waste form may be a viable disposal option for some of the LAW.

3.3. GROUNDWATER EVALUATION UNITS AND THE COLUMBIA RIVER

The process developed as a general framework for binning EUs using the evaluation metrics has been applied to the Risk Review Project groundwater EUs considering three distinct potential impacts: (1) groundwater as a protected resource, (2) groundwater as a pathway to impact the Columbia River (also as a protected resource), and (3) impact to groundwater from potential future sources (e.g., tank leaks) and current vadose zone contamination to groundwater and the Columbia River.

The focus on the evaluation metrics allows for differentiation of the potential groundwater-related risks from the EUs. This process is not concerned directly with highly uncertain point estimates of risks and impacts often used for other analyses (e.g., performance assessments or baseline risk assessments). The uncertainties associated with the analyses related to EUs become more tractable when evaluation metrics are considered in relative, rather than absolute terms. A detailed description of the methodology used for rating risks to groundwater and the Columbia River is provided in the methodology document (CRESP 2015b). Detailed results for each groundwater EU are provided in Appendices D.1 through D.6.

The evaluation metrics for risks to groundwater *as a protected resource* from current groundwater plumes and near surface or vadose zone sources are:

1. The estimated time interval until groundwater would be *impacted* over the three evaluation periods by a primary contaminant if the specific contaminant source is not currently causing a groundwater plume. Groundwater is considered *impacted* when a primary contaminant concentration exceeds a threshold value (e.g., a drinking water standard or maximum contaminant level).
2. The estimated amount of groundwater (e.g., areal extent) currently *impacted* by the primary contaminants with existing plumes.
3. The *GTM*, defined as the volume of groundwater that could potentially be contaminated by the inventory of a primary contaminant from a source (be it groundwater plume, vadose zone contamination, tank, etc.) if it was found in the saturated zone at the WQS (e.g., drinking water standard) and in equilibrium with the soil. The GTM accounts only for (1) source inventory, (2) partitioning with the surrounding subsurface and (3) the WQS. The GTM reflects a snapshot in time (assuming no loss by decay/degradation or dispersion, etc.) and does not account for differences in mobility or bulk groundwater flow.

The selected evaluation metrics for risks to the Columbia River from near-surface, vadose zone, and groundwater contamination sources are:

1. The estimated time interval until the Columbia River is *impacted* over the three evaluation periods. The Columbia River is considered *impacted* when a primary contaminant concentration exceeds a benthic or free-flowing threshold value.

2. The ratio (R1) of the maximum primary contaminant concentration within the plume to the reference threshold screening value (e.g., BCG for radionuclides or AWQC for chemicals).
3. The ratio (R2) of the upper 95th percentile UCL on the log-mean plume concentration to the reference threshold screening value.
4. For benthic impacts, the length of river shoreline estimated to be impacted by the plume above a reference threshold.
5. For riparian zone impacts, the area of the riparian zone estimated to be impacted by the plume above a reference threshold.

The screening thresholds used in the Risk Review Project are provided in Table 3-50. The primary contaminant groups used in this Risk Review Project are described in Section 2.3 and Table 2-7, which categorizes them according to mobility and persistence in the Hanford Site environment. When considering groundwater as a protected resource, the drinking water standard is used as the screening threshold, except for Cr(VI), where a drinking water standard is not available, and a screening threshold of 48 µg/L is used. When considering impacts to the Columbia River, a combination of the AWQC and the BCG are used, whichever value is more stringent and therefore more conservative. However, for total uranium, the natural background groundwater concentration of uranium at 12.9 µg/L is used, which is greater than the Tier II screening concentration value (SCV) reported.

Table 3-50. Thresholds considered in the Risk Review Project for the Group A and B primary contaminants. The primary thresholds used in the analysis are indicated in the red boxes.

PC	Grp	WQS[a]	DWS	DOE DCS[b]	BCG[c]	AWQC[d]/SCV[e]
Tc-99	A	900 pCi/L	900 pCi/L	44000 pCi/L	667000 pCi/L	---
I-129	A	1 pCi/L	1 pCi/L	330 pCi/L	38400 pCi/L	---
C-14	A	2000 pCi/L	2000 pCi/L	62000 pCi/L	609 pCi/L	---
Cl-36	A	---	700 pCi/L	32000 pCi/L	15100 pCi/L	---
Cr-VI	A	10-48 µg/L[f]	---	Human Health	Benthic/ Riparian	10 µg/L[f]
CCl_4	A	3.4 µg/L[g]	5 µg/L			9.8 µg/L
Sr-90	B	8 pCi/L	8 pCi/L	1100 pCi/L	279 pCi/L	7 µg/L (Sr)
U(tot)	B	30 µg/L	30 µg/L	750 pCi/L (U-238)	224 pCi/L (U-238)	5-12.9 µg/L[h]
Cr(tot)	B	48 µg/L[f]	100 µg/L[f]	---	---	55 µg/L
CN	B	200 µg/L	200 µg/L	---	---	5.2 µg/L
TCE	B	4[g]- 5 µg/L	5 µg/L	---	---	47 µg/L

a. Water Quality Standard (WQS) from 2015 Annual GW Report (DOE/RL-2016-09, Rev. 0). Some values vary by Interest Area (IA).
b. DOE Derived Concentration Standard (Ingested Water DCS from Table 5 in DOE-STD-1196-2011).
c. Biota Concentration Guide (BCG) from RESRAD-BIOTA v1.8 (consistent with DOE Technical Standard DOE-STD-1153-2002).
d. Ambient Water Quality Criterion (AWQC) (Table 6-1 in DOE/RL-2010-117, Rev. 0).
e. Tier II Screening Concentration Value (SVC) (http://rais.ornl.gov/documents/tm96r2.pdf) when AQWC not provided.
f. Different values tabulated for different GW IAs. 10 µg/L is the surface water standard for Cr-VI. 20 µg/L is the groundwater cleanup target for Cr-VI for interim remedial action. 48 µg/L is the MTCA groundwater cleanup standard. 100 µg/L is the DWS for total chromium.
g. Risk-based cleanup value from the ROD as reported in the 2015 Annual GW Report.
h. Uranium (total) screening values were 0.5 µg/L (RCBRA) and 5 µg/L (CRCRA). PNNL-17034 indicated background of ~5-12.9 µg/L (300-FF). CRCRA indicated effect levels span 3-900 µg/L reflecting considerable uncertainty in no-effect concentration.

Groundwater Contaminant Plumes Associated with Each Evaluation Unit

Figure 3-51 provides an overview of all primary groundwater contaminant plumes present within the Hanford Site, which are further grouped into three groundwater EUs along the River Corridor and two groundwater EUs in the Central Plateau.[110] Figure 3-52 focuses on the Central Plateau groundwater plumes and Figure 3-53 provides a simplified version of the Central Plateau groundwater plumes (excluding nitrate and tritium) in the 200 East Area (EU CP-GW-1) and 200 West Area (EU CP-GW-2) that includes only the Group A primary contaminants (high mobility and high persistence; Tc-99, I-129, C-14, Cr(VI) and carbon tetrachloride) and Group B primary contaminants (high mobility with medium persistence, i.e., cyanide, TCE, and PCE, and medium mobility with high or medium persistence, i.e., U(total), Cr(total), and Sr-90).

An overview of the River Corridor groundwater contaminant plumes is provided in Figure 3-54 through Figure 3-56. Figure 3-54 is enlarged to show the intersection of the existing groundwater plume with the riparian zone (magenta cross hatch area) and also provides the primary contaminant groupings, plume areas, and AWQS.

[110] 2015 groundwater monitoring data (DOE/RL-2016-09, Rev. 0. 2016) is used for evaluation as the most recent published data set available at the time of preparation of this report.

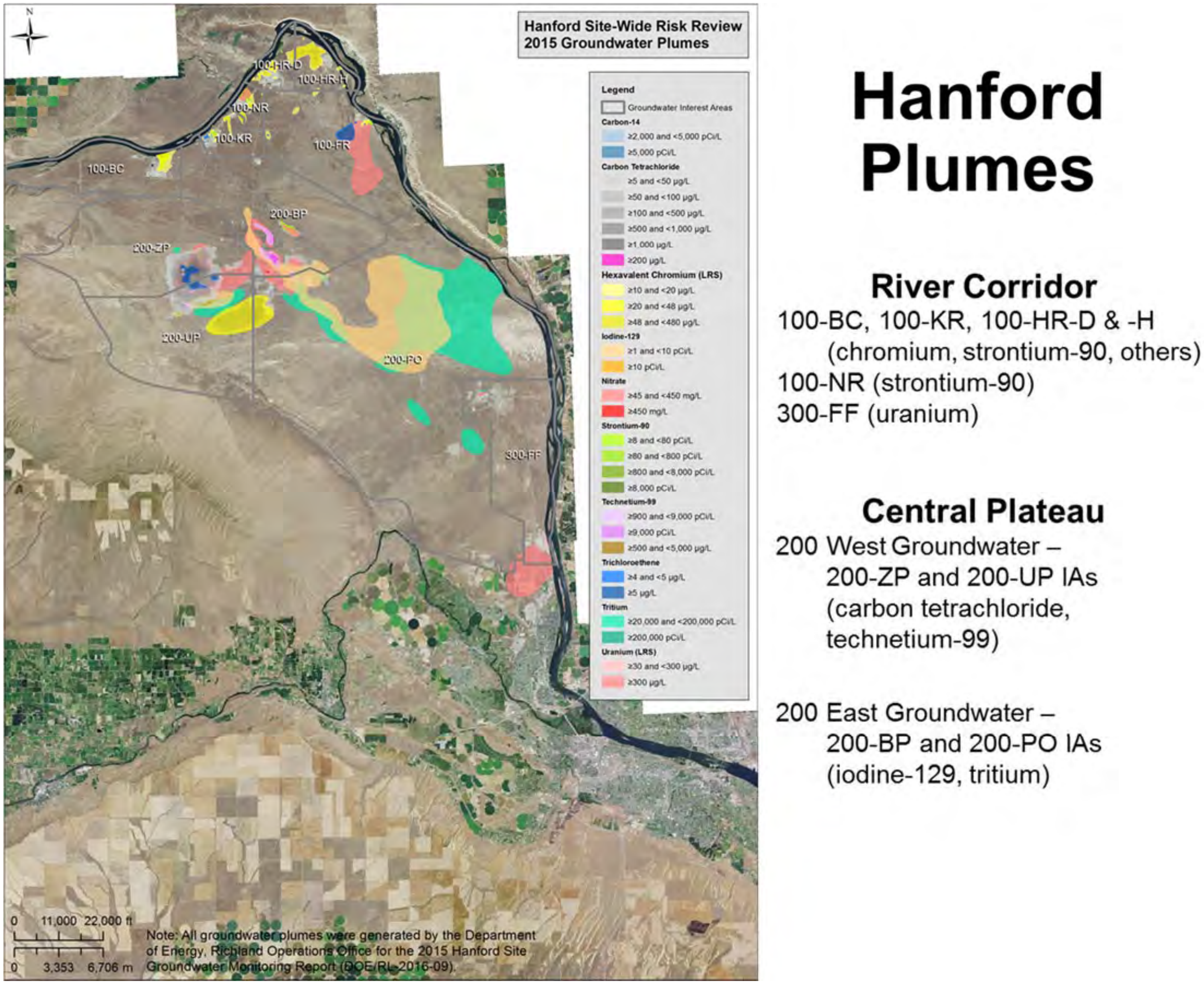
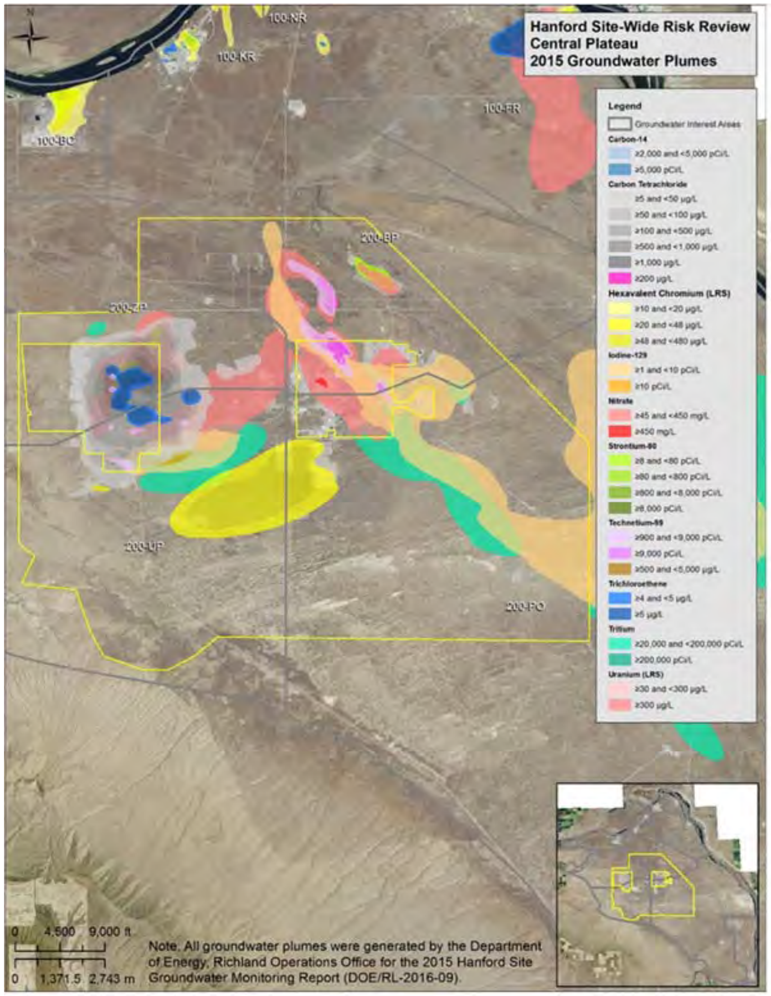


Figure 3-51. Groundwater plumes at the Hanford Site based on 2015 groundwater monitoring data (DOE/RL-2016-09, Rev. 0. 2016) and listing of EU and corresponding corresponding interest area (IA) designations.



CP-GW-1 (200 East GW EUs)

PC	Grp	WQS	200-BP Area (km²)	200-PO Area (km²)
H-3	C	2E4 pCi/L	0.1	69.5
I-129	A	1 pCi/L	5.5	54.8
NO_3	C	45 mg/L	8.2	2.1
Tc-99	A	900 pCi/L	2.1	0.06
Sr-90	B	8 pCi/L	0.6	<0.01
U (tot)	B	30 µg/L	0.6	0.04
CN	B	200 µg/L	0.7	---

CP-GW-2 (200 West GW EUs)

PC	Grp	WQS	200-ZP Area (km²)	200-UP Area (km²)
CCl_4	A	5 µg/L	18	
NO_3	C	45 mg/L	7.2	5.7
H-3	C	2E4 pCi/L	0.20	5.4
Cr-VI	A	48 µg/L	0.6	5.7
I-129	A	1 pCi/L	0.09	3.5
TCE	B	5 µg/L	1.13	---
U (tot)	B	30 µg/L	---	0.3
Tc-99	A	900 pCi/L	0.06	0.3

Figure 3-52. Central Plateau groundwater plumes (200 E, 200 W, and Central Plateau indicated by yellow outlines), plume areas, primary contaminant (PC) groups, and applicable WQS based on 2015 monitoring data (DOE/RL-2016-09, Rev. 0. 2016).

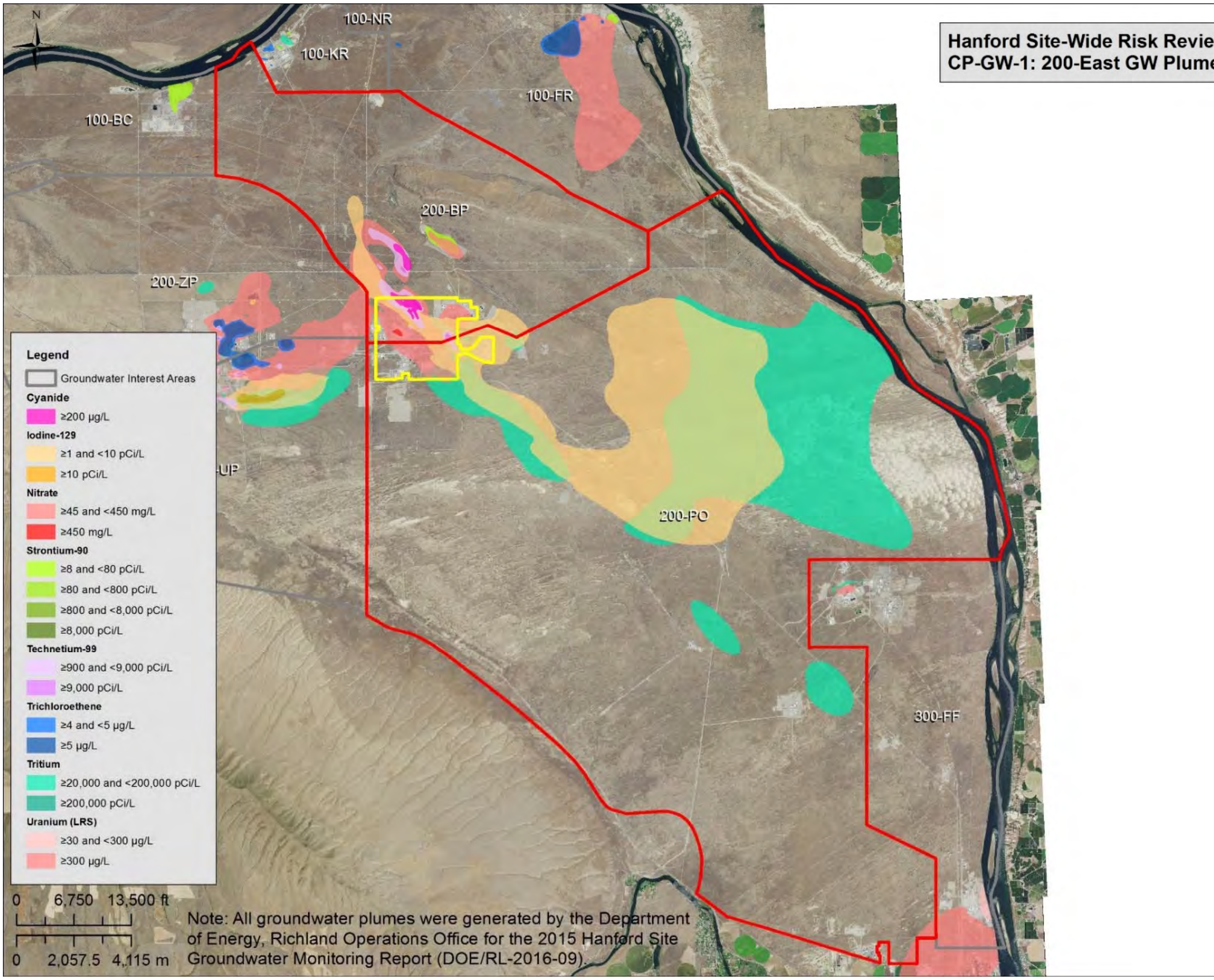
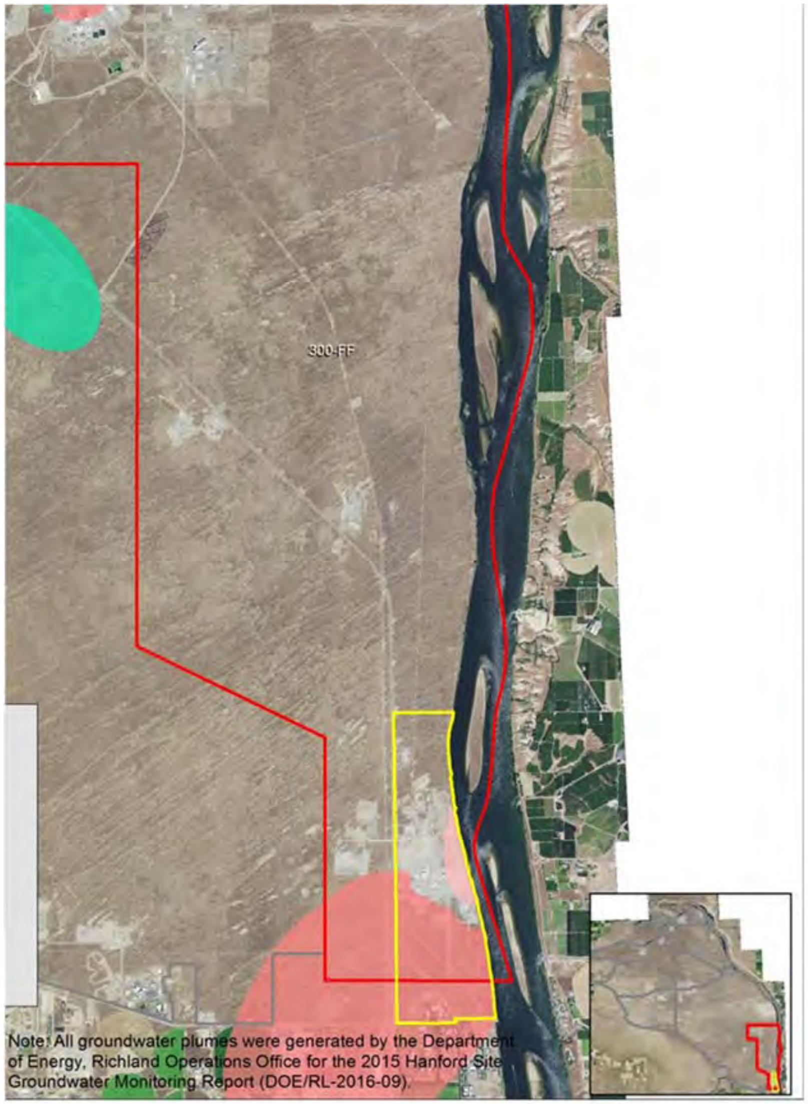


Figure 3-53. 200 East Area groundwater plumes (EU: CP-GW-1) and 200 West Area groundwater plumes (EU: CP-GW-2) based on 2015 groundwater monitoring data, excluding carbon tetrachloride, and chromium. 200 East Area is indicated by the yellow outline.



PC	Grp	WQS	RC-GW-1 300-FF Area (km^2)	RC-GW-2 100-NR Area (km^2)
Cr-VI	A	10 µg/L	---	0.49
Sr-90	B	8 pCi/L	---	0.64
U (tot)	B	30 µg/L	0.34	---
H-3	C	2E4 pCi/L	0.12	---
NO_3	C	45 mg/L	0.18	0.55

PC	Grp	WQS	RC-GW-3 100-BC Area (km^2)	RC-GW-3 100-HR Area (km^2)
Cr-VI	A	48 µg/L	1.6	4.8
Sr-90	B	8 pCi/L	0.55	0.02
NO_3	C	45 mg/L	---	0.0

PC	Grp	WQS	RC-GW-3 100-FR Area (km^2)	RC-GW-3 100-KR Area (km^2)
NO_3	C	45 mg/L	9.7	<0.01
Cr-VI	A	48 µg/L	0.21	1.5
TCE	B	5 µg/L	1.4	0.0
Sr-90	B	8 pCi/L	0.13	0.0
C-14	A	2000 pCi/L	---	0.0
H-3	C	2E4 pCi/L	---	0.0

Figure 3-54. 300 Area groundwater plume map (EU: RC-GW-1) indicating intersection with the riparian zone along with Columbia River plume areas, PC groups, and applicable WQS (DOE/RL-2016-09, Rev. 0. 2016)

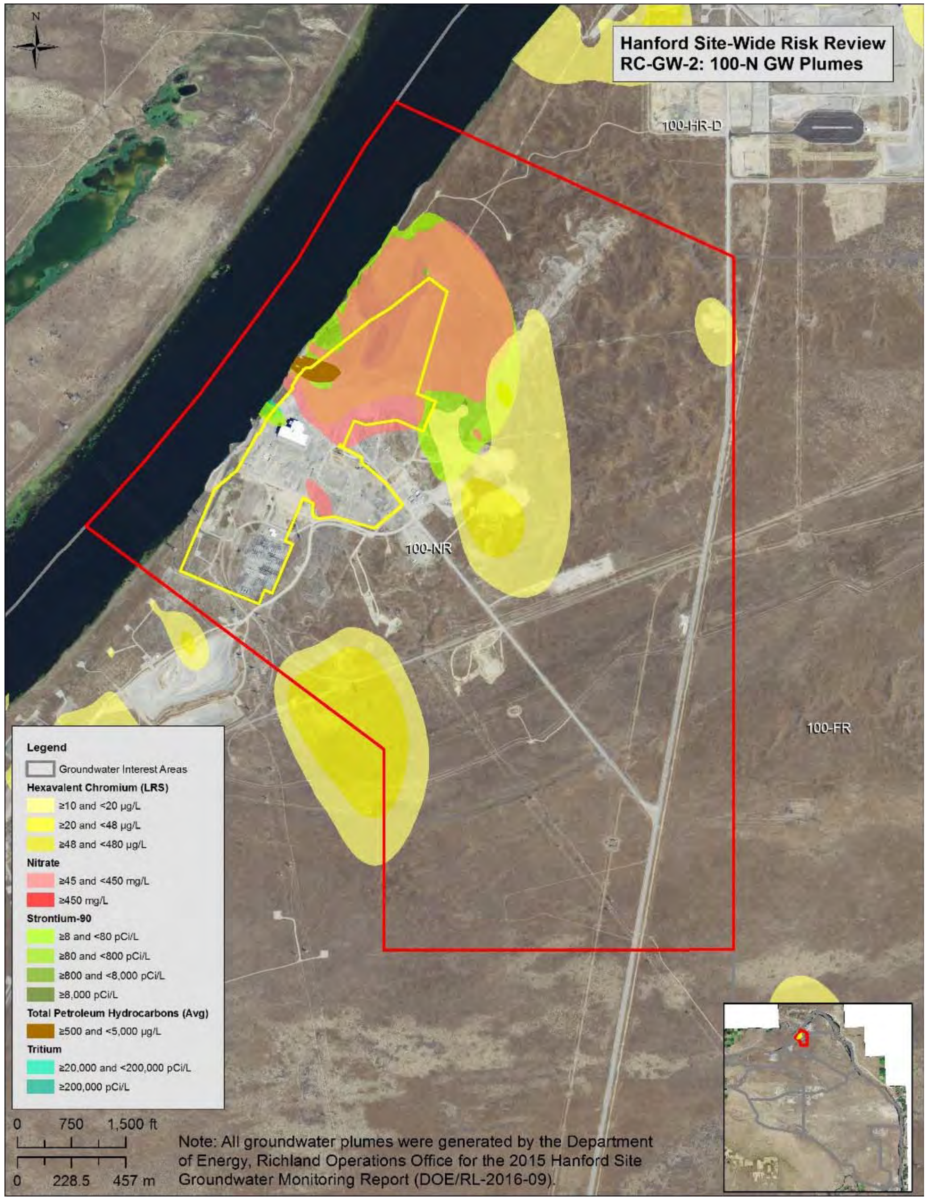


Figure 3-55. 100-N Area River Corridor groundwater plumes (EU: RC-GW-2, based on 2015 monitoring data; riparian zone not indicated).

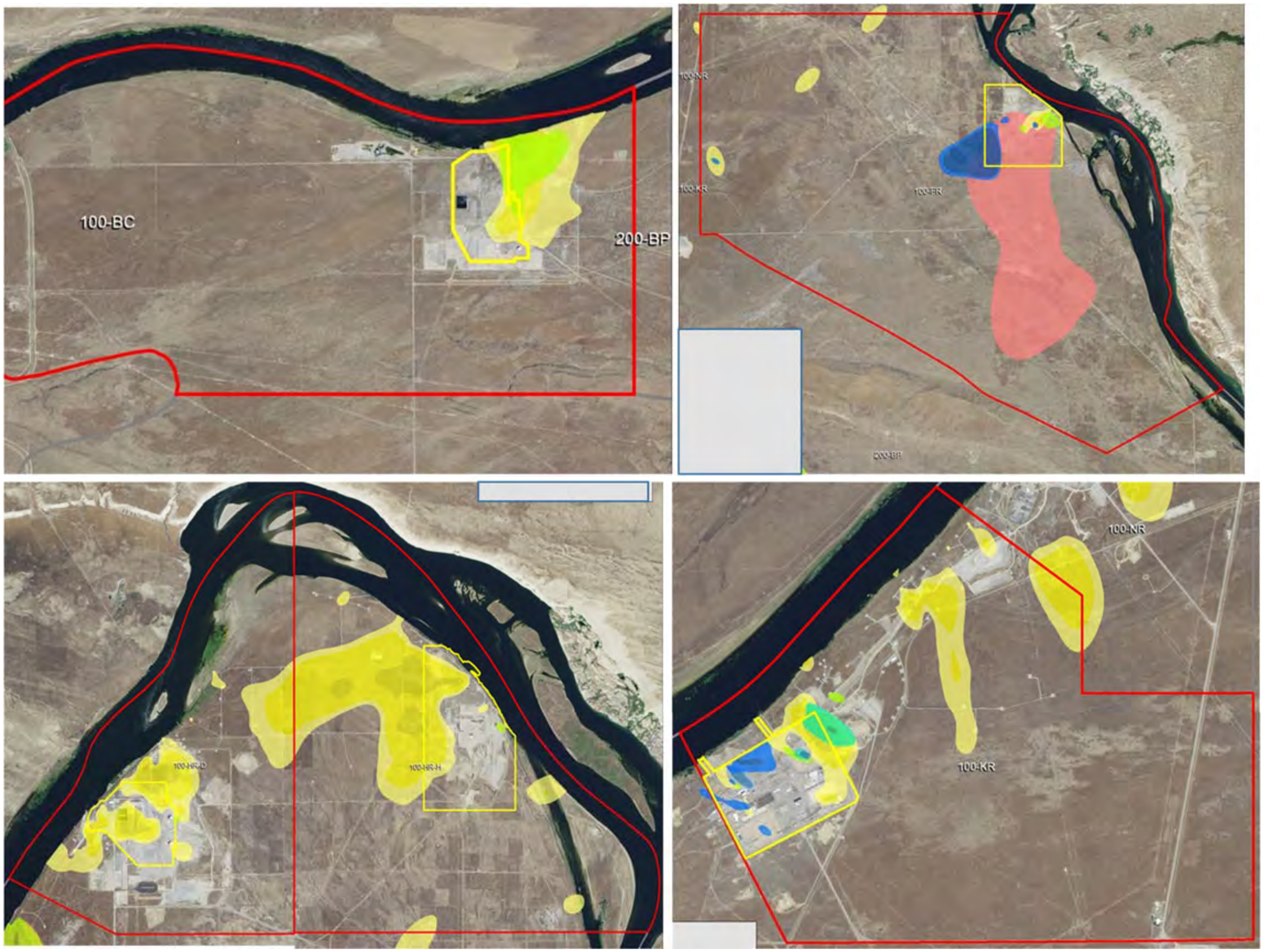


Figure 3-56. 100-B/D/H/F/K Area groundwater plumes (DOE/RL-2016-09, Rev. 0. 2016) (EU: RC-GW-3, based on 2015 monitoring data; riparian zone not indicated).

THREATS TO GROUNDWATER AS A PROTECTED RESOURCE

The scale used to rate threats to groundwater as a protected resource is focused on the amount of groundwater that is currently or could become contaminated above the screening threshold (see Table 3-50). Table 3-51 provides the rating scale used for Group A and Group B primary contaminants, which is based on the GTM. For Group C contaminants, the area of the groundwater plume above the screening threshold is used to rate each plume,[111] where Group C contaminant plume areas of less than 0.1 km^2 are rated as Low and plume areas of greater than 0.1 km^2 are rated as Medium.[112]

Table 3-51. Groundwater threat metric rating table for Group A and B primary contaminants.

GTM (millions of m^3)	Rating
GTM = 0[a]	Not Discernible (ND)[a]
GTM ≤ 10	Low
10 < GTM ≤ 100	Medium
100 < GTM ≤ 1,000	High
GTM > 1,000	Very High

a. This relationship has been added to reflect current use.

Currently Contaminated Groundwater

Figure 3-57 compares the results of calculating the GTM for each Group A and Group B contaminant (with the exception of cyanide that has no reported vadose zone inventory estimates) in the River Corridor and Central Plateau groundwater plumes. Contaminant plumes currently undergoing treatment are indicated with an asterisk. For example, remediation of the 100-C-7 waste site in the 100-B/C area for hexavalent chromium contamination was completed in 2013; whereby 2.3 million tons of soil, concrete debris, and scrap metal was removed. Thus the 100-BC hexavalent chromium plume does not indicate that it is currently undergoing treatment.

When considering contaminant impacts to groundwater as a protected resource, all contaminant plumes along the River Corridor are rated as Low, except the Sr-90 plume in EU RC-GW-2 (OU 100-NR-2), which is rated as Medium and is undergoing treatment using an *in situ* reactive barrier. For groundwater contaminant plumes in the Central Plateau, the highest GTM value (rated Very High) is associated with carbon tetrachloride plume in EU CP-GW-2 (200 West, GWIA 200-ZP), which is being treated with along with other contaminants through the 200 West Area pump-and-treat system. The next highest GTM value (also rated Very High) is for the I-129 plume, which is very large (>53 km^2) and may be too dispersed for effective treatment (Figure 3-53). However, the I-129 plume is currently being hydraulically controlled while remedial options are being investigated. The next highest rated plume (rated High) is the Sr-90 plume in EU CP-GW-1 (200 East, OU 200-BP-5) and is not currently undergoing treatment.

Threats to Groundwater from Contaminants in the Vadose Zone

Figure 3-58 through Figure 3-65 compares the results of the GTM applied to contaminants currently present in the vadose zone with the GTM for contaminants in the saturated zone (i.e., groundwater

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[111] Group C includes tritium, which has a relatively short radioactive decay half-life (12.3 years), and nitrate, which is readily biodegraded. Additional information is provided in the methodology (CRESP 2015b).
[112] Group D contaminants have very low mobility in the vadose zone and groundwater. Additional information is provided in the methodology (CRESP 2015b).

contaminant plumes). Results are not reported for the vadose zone in the River Corridor because prior extensive excavation and remediation prevents meaningful estimates to be made of remaining vadose zone contaminant inventories. The highest vadose zone GTM value (rated Very High) is associated with carbon tetrachloride in EU CP-LS-2 (Figure 3-61), which is currently being treated using the 200 West pump-and-treat system.[113] Strontium-90 is the cause of five GTM values greater than 1000 and four additional GTM values greater than 100. However, the relatively low mobility of strontium-90 in the vadose zone, coupled with its relatively short half-life for natural radioactive decay, suggests a low potential for substantial groundwater contamination resulting from these vadose zone sources under current recharge rates. Several of the vadose zone contaminant sources with GTM values greater than 100 (rated High) are located in the 200 East Area, either associated with the BC Cribs and Trenches (EU CP-LS-1) or the legacy sites at the A-AX and B-BX-BY tank waste and farms EUs (EUs CP-TF-5 and CP-TF-6) and currently are not undergoing treatment (although there is currently a treatability study for the perched water contaminated with uranium in EU CP-TF-6). Many of the GTM values greater than 100 in the 200 West Area are associated with legacy sites within tank waste and farms EUs (CP-TF-1 (T), CP-TF-2 (S, SX), CP-TF-3 (TX-TY)) and are within the current or planned capture zones of the 200 West pump-and-treat system. These results suggest that if groundwater cleanup and quality is a priority, then focus on the 200 East Area is warranted.

[113] Carbon tetrachloride was treated using soil vapor extraction (SVE) in the 200-PW-1 OU overlying the 200-ZP-1 groundwater OU (and 200-ZP GWIA). Between 1992 and 2012, 80,107 kg of carbon tetrachloride were removed from the vadose zone. In November 2015, EPA concurred that the remedy met RAOs in the ROD and that SVE activities could be ended (DOE/RL-2016-09, Rev. 0).

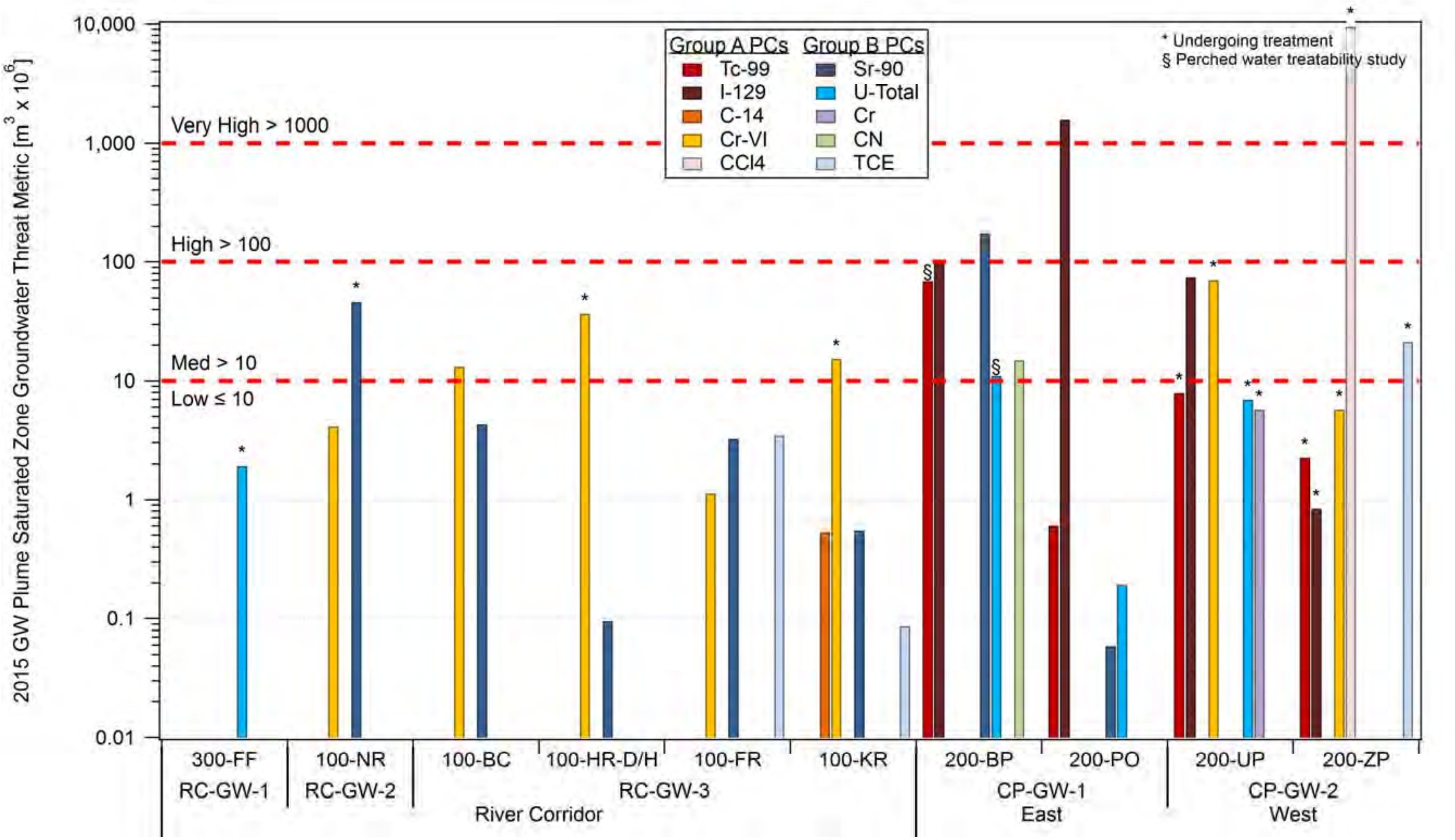


Figure 3-57. Rating groundwater contaminant plumes as threats to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

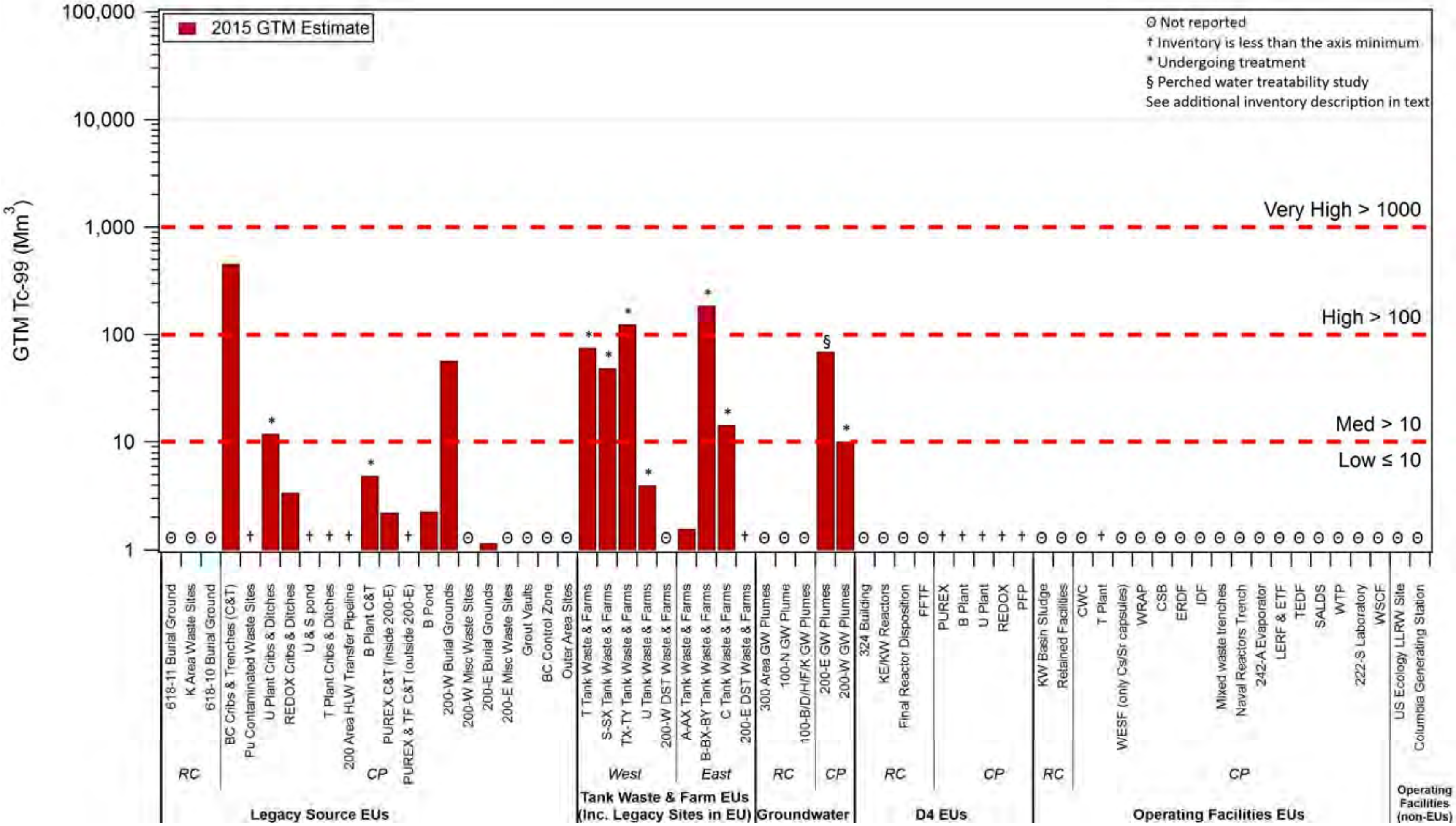


Figure 3-58. Rating vadose zone Tc-99 (Group A) inventories as a threat to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

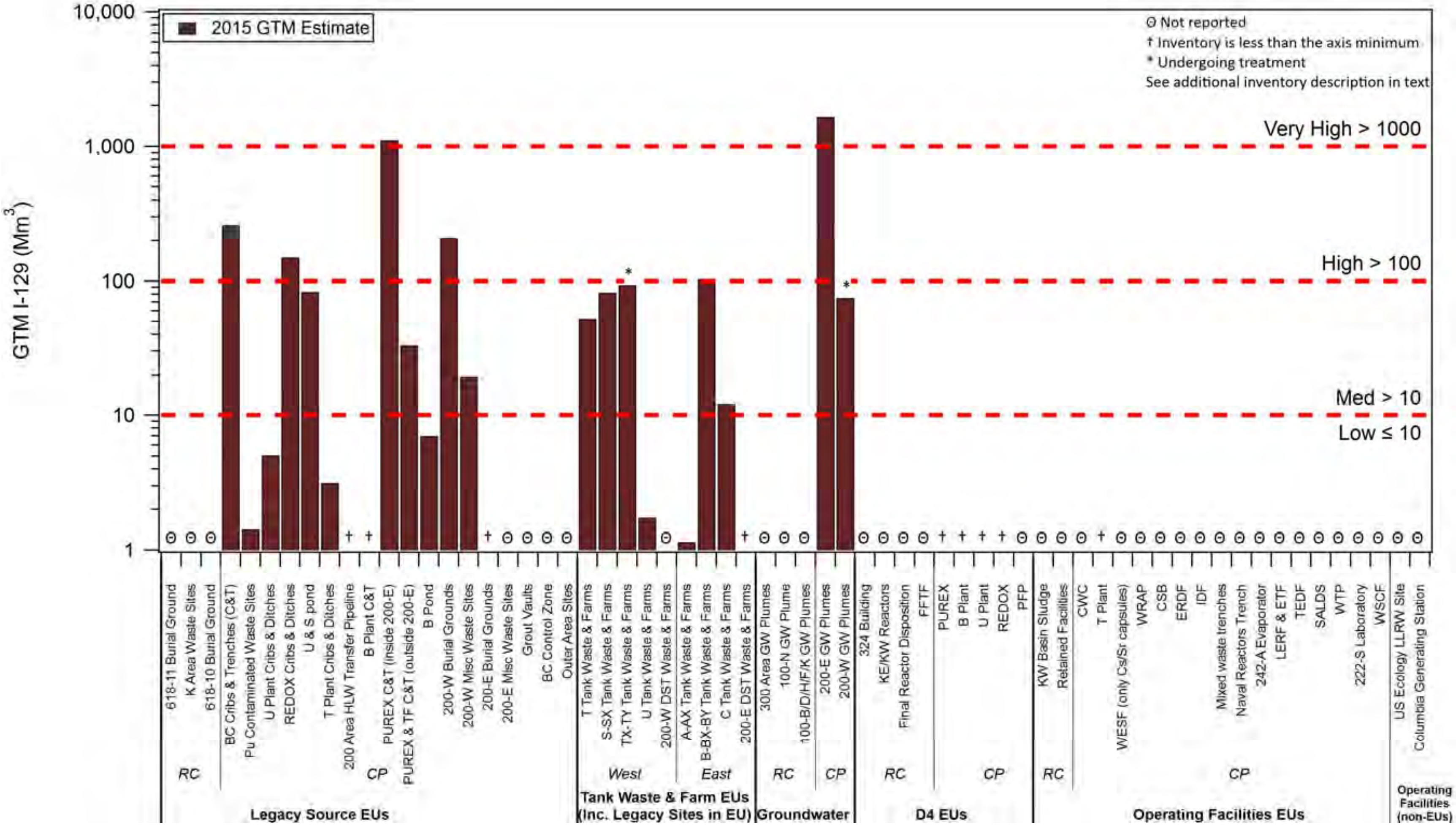


Figure 3-59. Rating vadose zone I-129 (Group A) inventories as threats to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

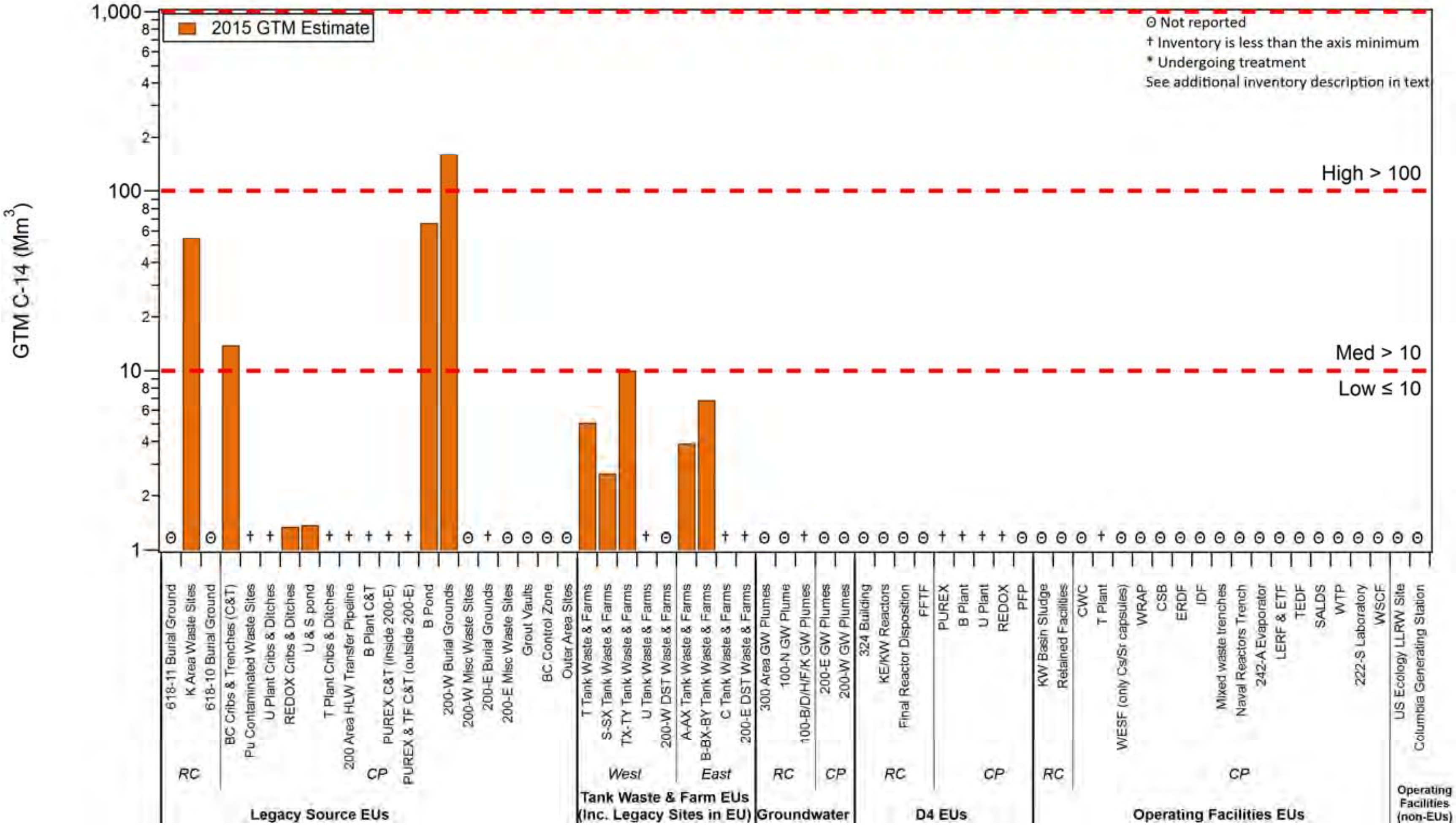


Figure 3-60. Rating vadose zone C-14 (Group A) inventories groundwater contaminant plumes as a threat to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

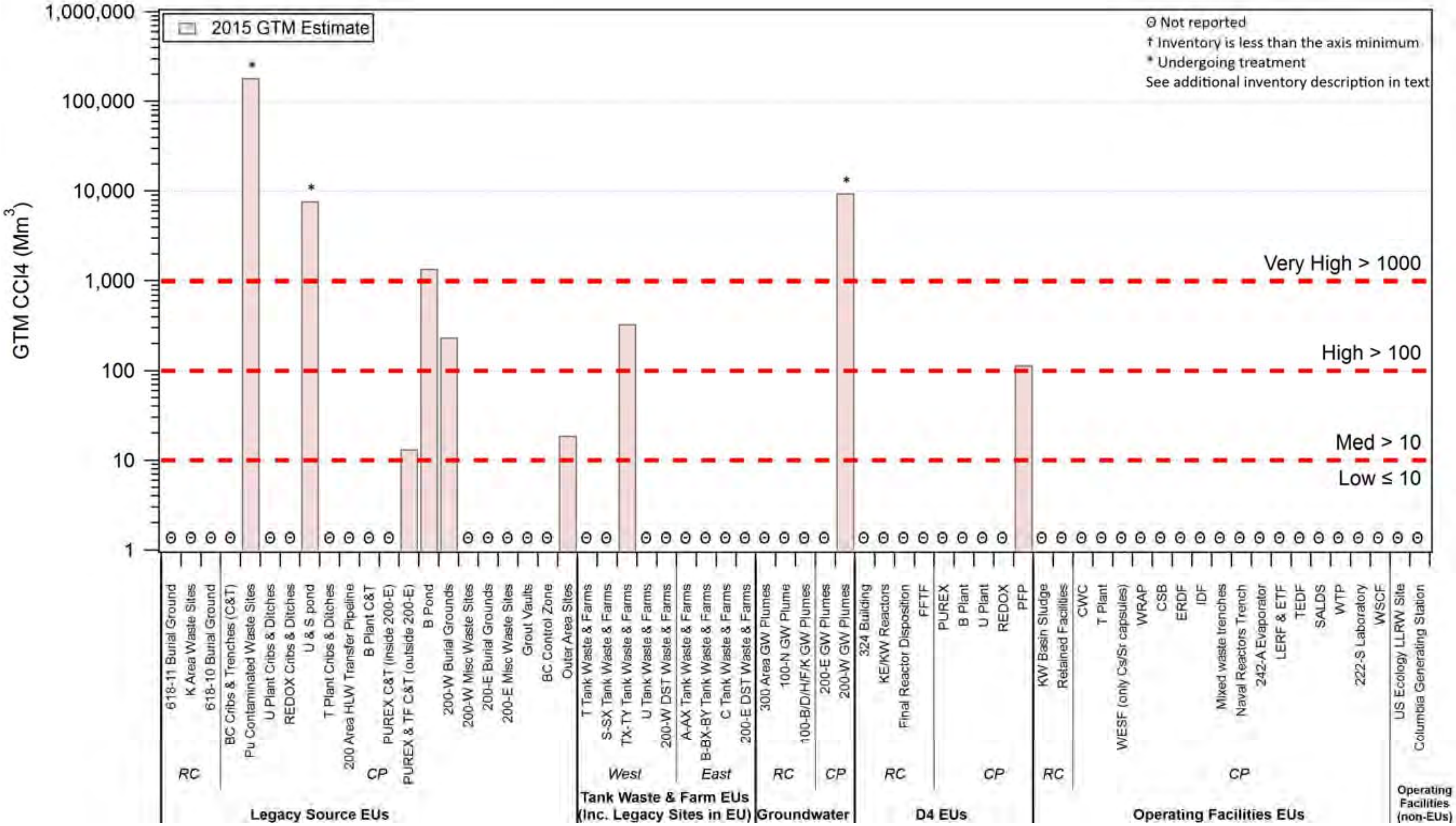


Figure 3-61. Rating vadose zone carbon tetrachloride (CCl_4) (Group A) inventories as a threat to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

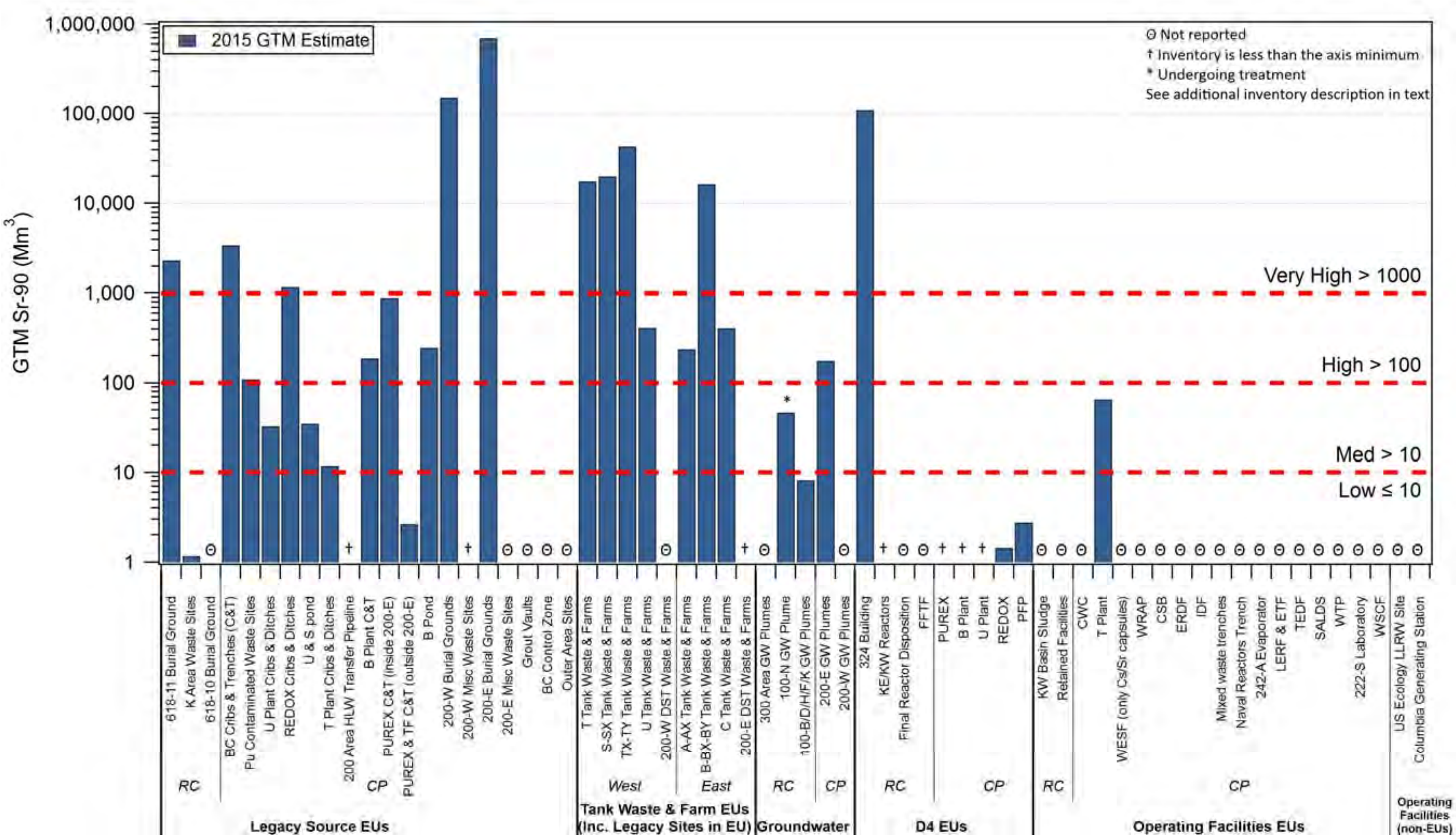


Figure 3-62. Rating vadose zone Sr-90 (Group B) inventories as a threat to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

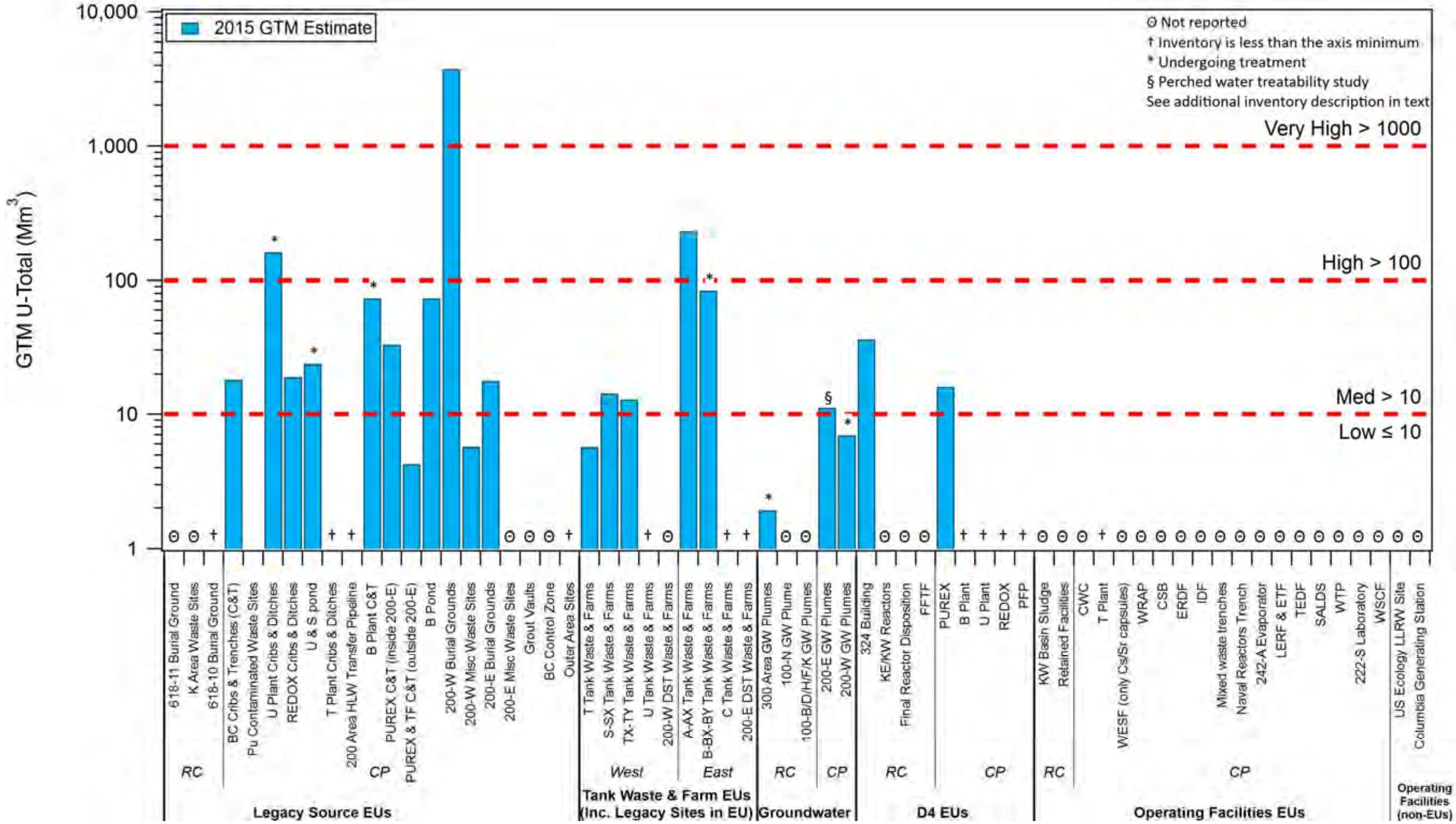


Figure 3-63. Rating vadose zone U-Total (Group B) inventories as a threat to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

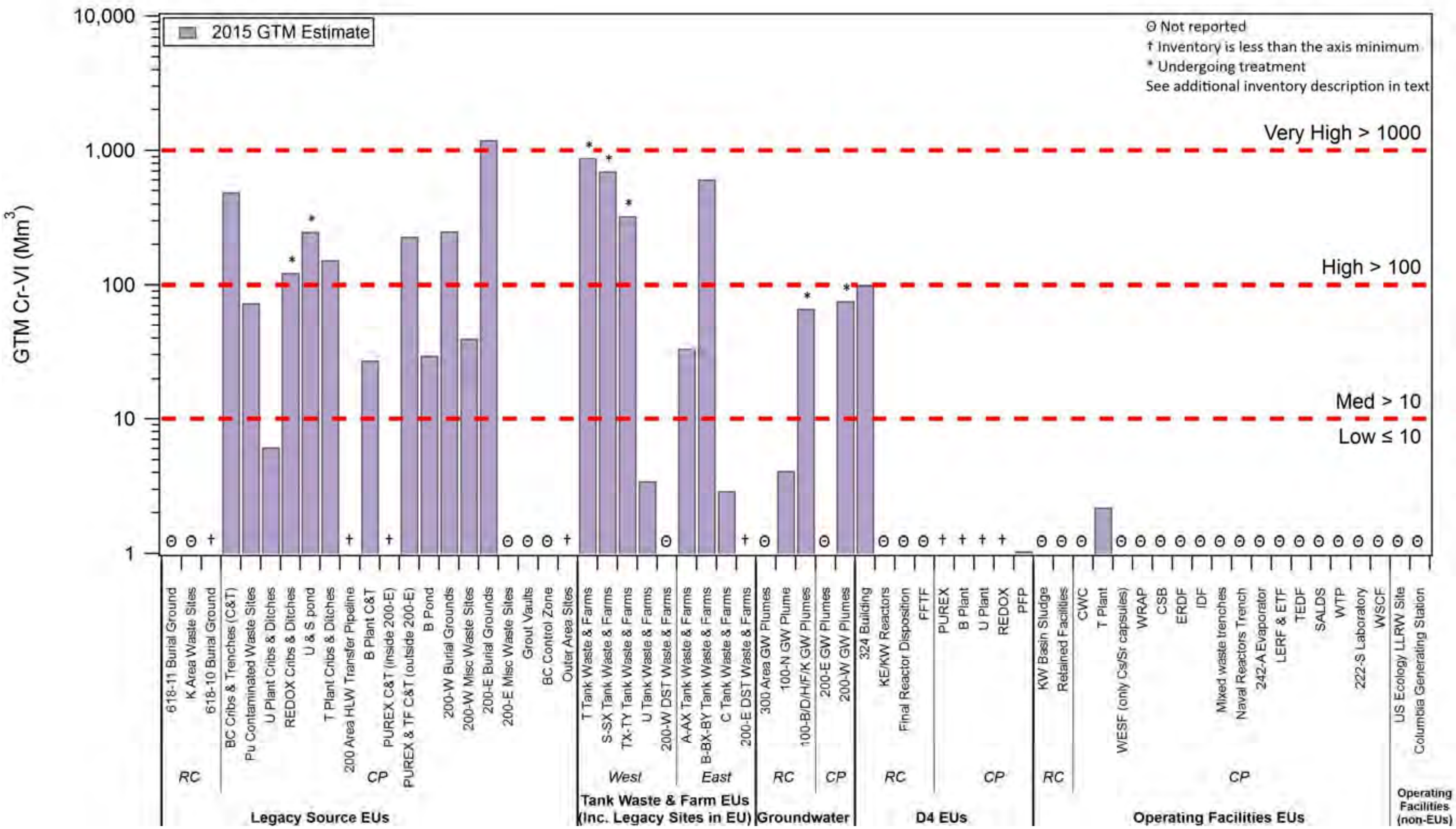


Figure 3-64. Rating vadose zone hexavalent chromium (Group A) inventories as a threat to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

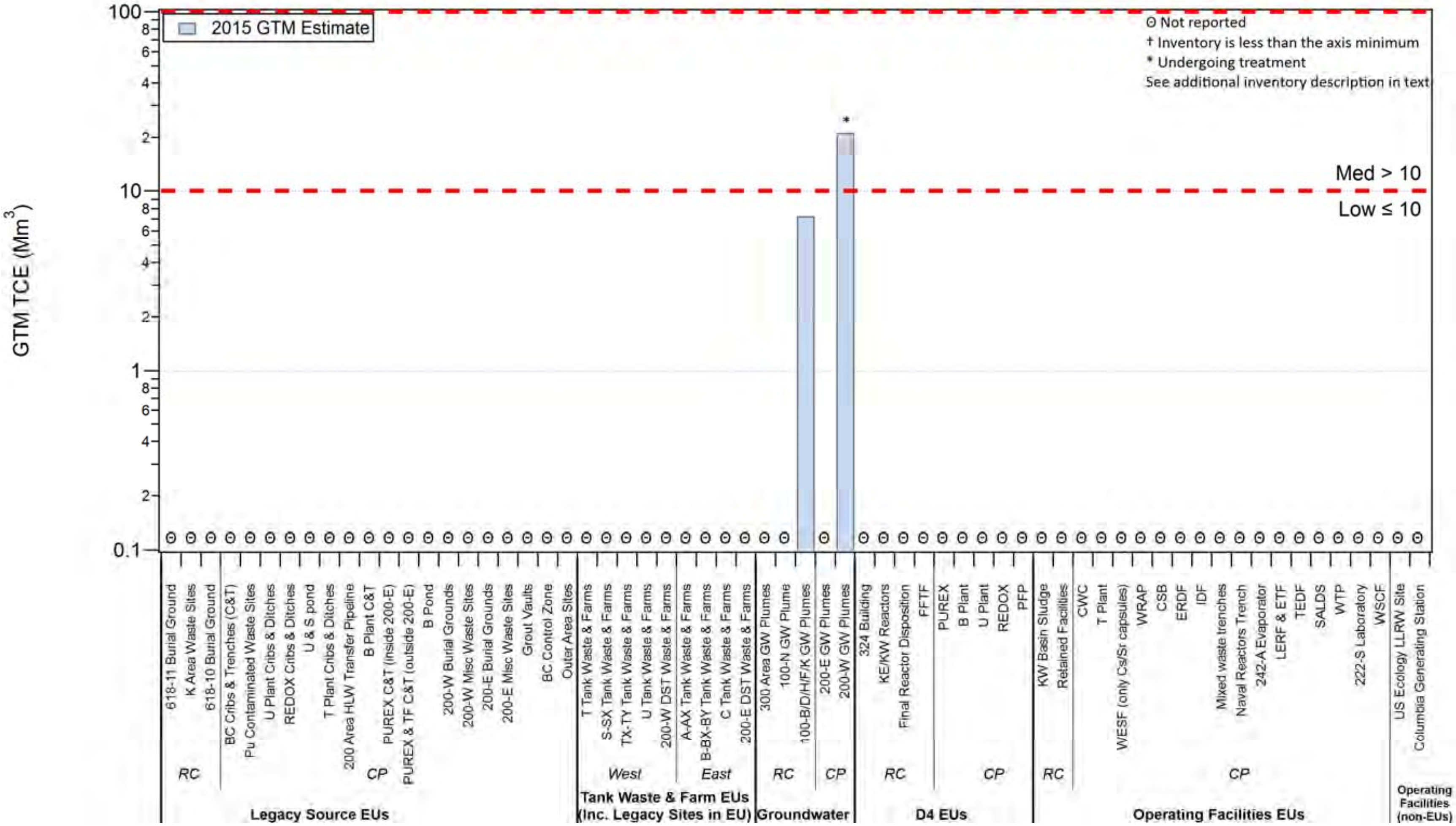


Figure 3-65. Rating vadose zone trichloroethene (TCE) (Group B) inventories as a threat to *groundwater as a protected resource* based on the groundwater threat metric (GTM). Groundwater threat metric in millions of cubic meters.

Groundwater Contamination Mitigation Efforts in the Central Plateau

A number of groundwater (GW) interim remedial actions have been conducted in the 200 West Area as part of the 200-UP-1 and 200-ZP-1 OUs. Figure 3-57 through Figure 3-65 indicate where remediation efforts have been undertaken by an asterisk (*) associated with vertical bar representing each contaminant source. In the 200-UP-1 OU, these actions include (EPA 2012):

- *216-U-1 Crib and 216-U-2 Crib Groundwater Interim Remedial Action (1985)*: An interim remedial action was designed to pump-and-treat (P&T) groundwater below these cribs. Pumping started in June 1985 and continued until November 1985. The system removed 687 kg of uranium via ion exchange treatment.
- *200-UP-1 Groundwater OU Interim Remedial Action (1997, amended in 2009 & 2010)*: A pilot-scale treatability test consisting of a P&T system was constructed adjacent to the 216-U-17 Crib. Phase I operations commenced September 1995 and continued until February 1997. The test demonstrated that the ion exchange resin and granular activated carbon were effective at removing Tc-99, uranium, and carbon tetrachloride from groundwater. Based on the success of the pilot system, and interim groundwater extraction and treatment system was implemented. Cleanup started in 1997 and met its remedial action objective of reducing highest concentrations to below 10 times the cleanup level of 48 µg/L for uranium and 10 times the maximum contaminant level of 900 pCi/L for Tc-99. This system removed 220.5 kg of uranium, 127 g (2.17 curies) of Tc-99, 41 kg of carbon tetrachloride, and 49,000 kg of nitrate (see also DOE/RL-2014-32, Rev. 0, p. UP-2). The system was shut down in 2012.
- *WMA S-SX Groundwater Extraction System*: A groundwater extraction system for Tc-99 was constructed in 2011 and started operation in August 2012. The design consists of a three-well extraction system, aboveground pipelines, and a transfer building to pump extracted groundwater to the 200 West Groundwater Treatment Facility for treatment and reinjection. As of 2015, the system has extracted 510 million L (135 million gal) of groundwater and removed 2.18 Ci of Tc-99; 22,600 kg of nitrate; 36.1 kg of chromium; and 39.5 kg of carbon tetrachloride (CCl_4) from the aquifer (DOE/RL-2016-09, Rev. 0, p. 11-39).
- *U Plant Pump and Treat (P&T) System*: This system was designed primarily to remediate the uranium plume from the 216-U-1/2 Cribs near U Plant, but the system also removes Tc-99, nitrate, and carbon tetrachloride (CCl_4). Construction of the remedy was completed in 2015 and the system was brought online in September 2015. A total of 65.4 million L (17.3 million gal) of groundwater was pumped, and 1.8 kg of uranium, 0.19 Ci of Tc-99, 22,300 kg of nitrate, and 5.3 kg of carbon tetrachloride (CCl4) were removed from the aquifer (DOE/RL-2016-09, Rev. 0, p. 11-37).
- *I-129 Plume Hydraulic Control*: The 2012 interim action ROD (EPA 2012) requires containment of the I-129 plume while treatment technologies are evaluated. Hydraulic control will be achieved by locating injection wells for the 200 West P&T on the downgradient side of the plume. The injection wells began operating in October 2015; however, it is too early to assess the effect of their operation on hydraulic gradients in the area and migration of the I-129 plume (DOE/RL-2016-09, Rev. 0, p. 11-46). No contamination has been removed using this action.

The last two remedial actions were started during 2015, while the WMA S-SX P&T system has been operating since 2012. The final ROD for the 200-UP-1 OU will be pursued when future groundwater impacts are adequately understood and potential technologies to treat I-129 are completed (EPA 2012).

In addition to the actions above, the following actions have been or are being taken to address groundwater contamination in the 200-ZP-1 OU:

- *200-ZP-1 OU Interim Remedial Action (1995)*: In 1996, a pump-and-treat system was started to reduce the mass of carbon tetrachloride (as well as secondary contaminants TCE and chloroform) in the groundwater primarily from waste sites south and east of the Plutonium Finishing Facility (DOE/RL-2012-03, Rev. 0). This action was completed and the interim P&T system was deactivated in May 2012 (with startup of the 200 West Area P&T facility). From 1994 through 2015, the P&T system removed 23,175 kg of carbon tetrachloride (CCl_4); 265 kg of chromium; 242 pCi of I-129; 928,806 kg of nitrate; 6.21 Ci of Tc-99; 37.73 kg of trichloroethene (TCE); no tritium (H-3); and 11.1 kg of uranium (DOE/RL-2016-09, Rev. 0, p. 12-25). By 2015, remedial activities (also see below) had removed a total of 103,282 kg of the estimated 570,000 to 920,000 kg of carbon tetrachloride (CCl_4) discharged to the ground (DOE/RL-2016-09, Rev. 0, p. 12-20).
- *200-ZP-1 Record of Decision (2008)*: The 200-ZP-1 ROD was issued in 2008 and selected P&T, MNA, and Institutional Controls to remediate contaminated groundwater including impacting the direction of groundwater flow and further reducing the levels of carbon tetrachloride present and migrating towards the 200-UP-1 OU. The P&T system was started in 2012 and removed 3,580 kg of carbon tetrachloride, 91.24 kg of chromium, 0.000242 µCi of I-129, 243,905 kg of nitrate, 98.03 g (1.5 Ci) of Tc-99, and 15.49 kg of TCE, and 1.08 kg of U[114] by 2013 (DOE/RL-2014-32, Rev. 0, p. ZP-25).
- *200-PW-1 Interim Record of Decision (1992)*: Soil vapor extraction was implemented as an interim action in 1992 to remove carbon tetrachloride from the vadose zone in 200-PW-1 overlying the 200-ZP-1 groundwater (DOE/RL-2014-32, Rev. 0). The system has removed 80,107 kg of carbon tetrachloride to date; however, the mass removed each year has been decreasing (DOE/RL-2014-32, Rev. 0, p. ZP-28). The system did not operate in 2013.

The 200-BP and 200-PO OUs have neither interim nor final RODs with groundwater being monitored under requirements of the Atomic Energy Act of 1954 (AEA), Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and Resource Conservation and Recovery Act of 1976 (RCRA). The 200-PO-1 OU is being monitored to determine the impact to groundwater prior to determining the path forward for remedial action.[115] For 200-BP-5, the following actions are being conducted:

- *Perched Water Treatability Study*: A perched water treatability test (200-DV-1) was conducted at WMA B-BX-BY to remove uranium. By 2013, approximately 691,000 L of perched water containing approximately 373 kg of nitrate, 0.022 Ci of Tc-99, and 31.9 kg of uranium was extracted (DOE/RL-2013-22, Rev. 0; DOE/RL-2014-32, Rev. 0, page BP-8). In 2015 DOE continued the treatability test to investigate the feasibility of contaminant removal until August 2015 when the extraction was temporarily discontinued to enhance perched water removal by adding two new perched water wells (completed in December 2015). Control of the extraction system was transferred to 200 West P&T operations where the perched water treatability test also transitioned to a CERCLA removal action planned to start operating in 2016. In 2015 a total of

[114] Uranium is not a contaminant of concern for the 200-ZP-1 OU; it is included to track 200-UP-1 groundwater treated.
[115] Tank 241-AY-102 is undergoing waste retrieval operations (Templeton 2016); however, this tank has not been a source of environmental contamination although waste has leaked into the tank annulus.

194,660 L (51,429 gal) of water was removed, containing 84.1 kg of nitrate, 0.005 Ci of Tc-99, and 17 kg of uranium (DOE/RL-2016-09, Rev. 0, p. 9-10).

- *Waste Management Area (WMA) C Tank Waste Retrieval*: Tank wastes are currently being retrieved from WMA C. Waste retrieval has been completed in ten of the 16 tanks, has been completed to various limits of technology in five other tanks, and retrieval is in progress in the remaining tank (Templeton 2016).

DOE is scheduled to submit a 200-BP-5 and 200-PO-1 OU Feasibility Study Report and Proposed Plan(s) to Ecology in 2018 (Ecology, EPA, and DOE 1996, Milestone M-015-21A).

GROUNDWATER-RELATED THREATS TO THE COLUMBIA RIVER

The assessment of threats from primary contaminants to the Columbia River is based on consideration of the benthic and riparian zones. Impacts to benthic and riparian zones were considered more sensitive evaluation bases than free-stream concentrations because of the very high dilution of groundwater discharges within the Columbia River. The basic concept employed is that the threat or risk is a function of three factors: i) contaminant characteristics, ii) how much greater the contaminant concentration is with respect to the relevant screening threshold (i.e., informed by ecotoxicity), and iii) how large of an area (either river reach or riparian zone) is impacted.

Threats to the Columbia River Benthic Ecology from Contaminants

The first step in the threat determination process for impacts to the Columbia River (Figure 2-13) was to determine if the plume is in contact with the Columbia River at concentrations exceeding the WQS based on the 2015 Hanford Annual Groundwater Report (DOE/RL-2016-09, Rev. 0) and the groundwater well and aquifer tube data from HEIS (http://ehs.hanford.gov/eda/). If the plume is not in contact with the Columbia River, then available information (EISs, baseline risk assessments, records of decision, etc.) is used to determine if a plume can be expected to intersect the Columbia River in the next 150 years. If not, then available modeling results are used to describe potential long-term impacts (1050 years or longer, if appropriate).

If the plume either is in contact with the Columbia River or expected to intersect the River in 150 years, then the threat to the Columbia River is evaluated using the multi-step process illustrated in Figure 2-13.

First the ratio (R1) of the maximum concentration to the appropriate benthic screening value is computed using the screening values provided in Table 3-50:

- For radionuclides, the BCG consistent with DOE-STD-1153-2002 is used.
- For chemicals, the AWQC is used (the Tier II screening risk values are used when the AWQC is unavailable). The only exception is (total) uranium where the AWQC (5 µg/L) from the Columbia River Component Risk Assessment (DOE/RL-2010-117, Rev. 0, 2010) is less than most measured background concentrations (e.g., ranging from 0.5 - 12.8 µg/L in the 300 Area) (PNNL-17034, p. 6.9). A value (12.9 µg/L) was selected for total uranium to identify those areas contaminated by the Hanford Site.[116]

[116] The selected value of 12.9 µg/L represents between the 90th and 95th percentile for site-wide background uranium concentration (DOE/RL-96-61, 1997). Note that there is a large uncertainty relative to the No Effects level for total uranium. As stated in the Columbia River Component Risk Assessment, “Effect levels span nearly three orders of magnitude (3 µg/L to 900 µg/L), reflecting considerable uncertainty in selection of a no-effect concentration. The value selected is a probable no effect concentration and is the 5th percentile of the toxicity data set” (DOE/RL-2010-117, Rev. 0, p. 6.2).

The rating process for ***benthic threats*** under current conditions (Figure 2-13) proceeds as follows:

- If the ratio R1 ≤ 1 (i.e., the maximum concentration is less than the screening threshold), then the rating for benthic threats is ND. Results for calculation of the ratio R1 are provided in Figure 3-66. Note that total uranium, and TCE in EU RC-GW-1 (OU 300-FF-5), chromium in EU RC-GW-2 (OU 100-NR-2) and EU RC-GW-3 (OUs 100-BC-5, 100-HR-3, 100-FR-3 and 100-KR-4) as well as carbon-14 and strontium-90 in EU RC-GW-3 (OU 100-KR-4) have R1 values that exceed 1, and therefore proceed to the next steps.
- If the primary contaminant is in Group C (Table 2-7), then the rating for benthic impacts is Low.
- If the primary contaminant is in Group A or B (Table 2-7), then the rating is Low if the ratio R1 ≤ 5.
- If the ratio R1 > 5, the rating is Low if the plume is not currently intersecting the Columbia River (using aquifer tube data or contours exceeding the threshold). If the plume is currently intersecting the River, then the ratio R2 of the log-mean 95% upper confidence limit (UCL) estimate to the screening value (BCG or AWQC) is computed. Results of the calculated ratio R2 are presented for the River Corridor groundwater EUs in Figure 3-67.
- If the ratio R2 ≤ 1 (i.e., the mean concentration is less than the screening threshold), then the rating is Low if the ratio R1 ≤ 5.
- If the ratio R2 > 1, then the matrix represented in Table 2-9 is used to determine the rating based on the ratio R2 and the Shoreline Impact provided in the 2015Hanford Annual Groundwater Report (DOE/RL-2016-09, Rev. 0). The relative lengths of shoreline impact for each plume is presented in Figure 3-68.

Results of the above assessment process for the River Corridor EUs is presented in Figure 3-69. The results for the uranium plume in the 300 F Area are reflected by a range from ND to High because of the large uncertainty associated with the uranium no observed effects level (NOEL).

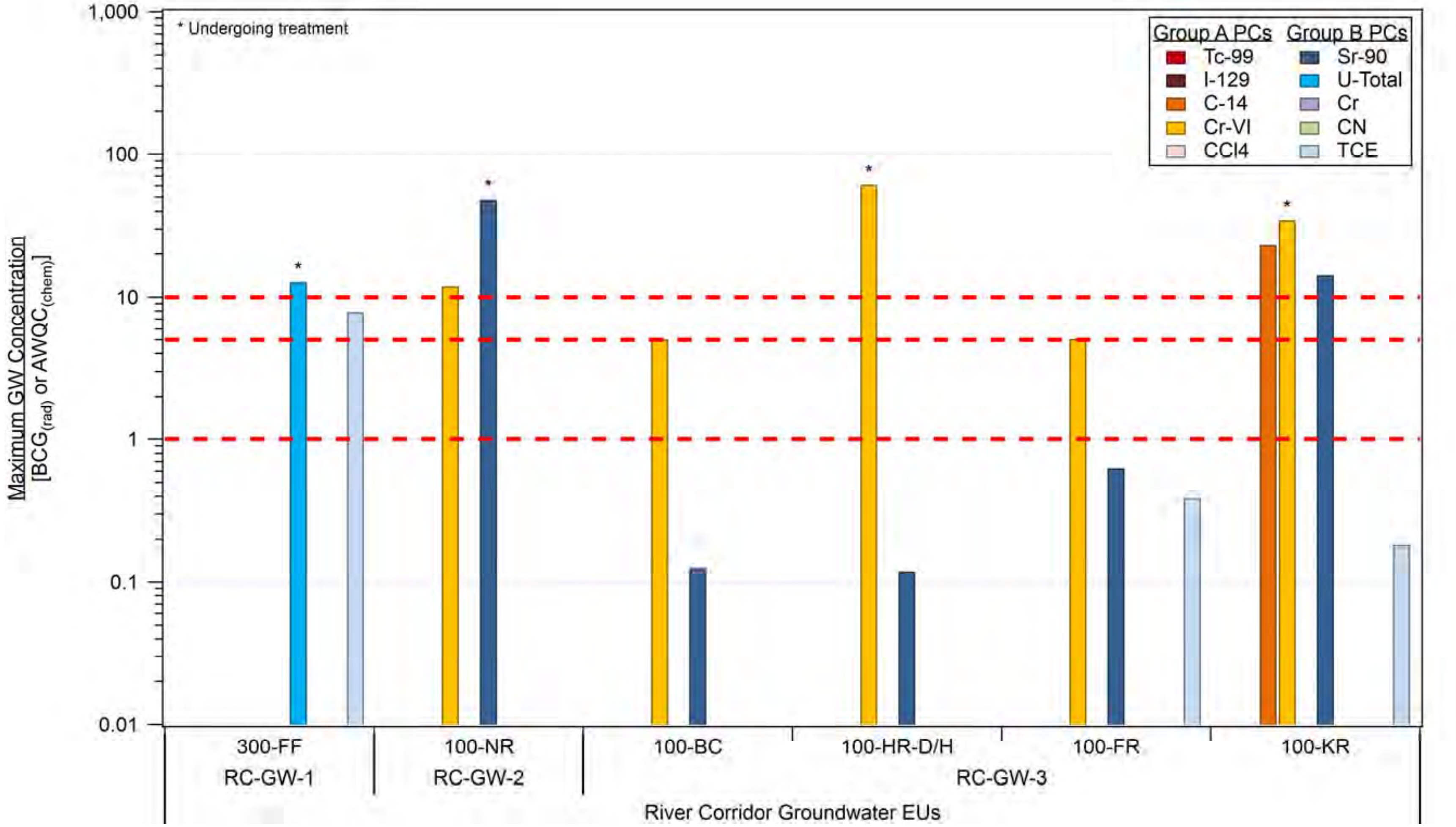


Figure 3-66. Calculated values of the ratio R1 for the River Corridor EUs using the 2015 groundwater monitoring data. Maximum concentration based on 2015 groundwater monitoring data ≥ Ambient Water Quality Criteria (AWQC, chem.) or Biota Concetration Guide (BCG, rad.). In 300-FF, the uranium data excludes values associated with a transient spike caused by the enhanced attenuation component of the 300‑FF‑5 remedy and the TCE data includes all measured values in addition to the calculated value given in the 2015 Hanford Annual Groundwater Report (DOE/RL-2016-09, Rev. 0 and further discussed in Appendix D.2).

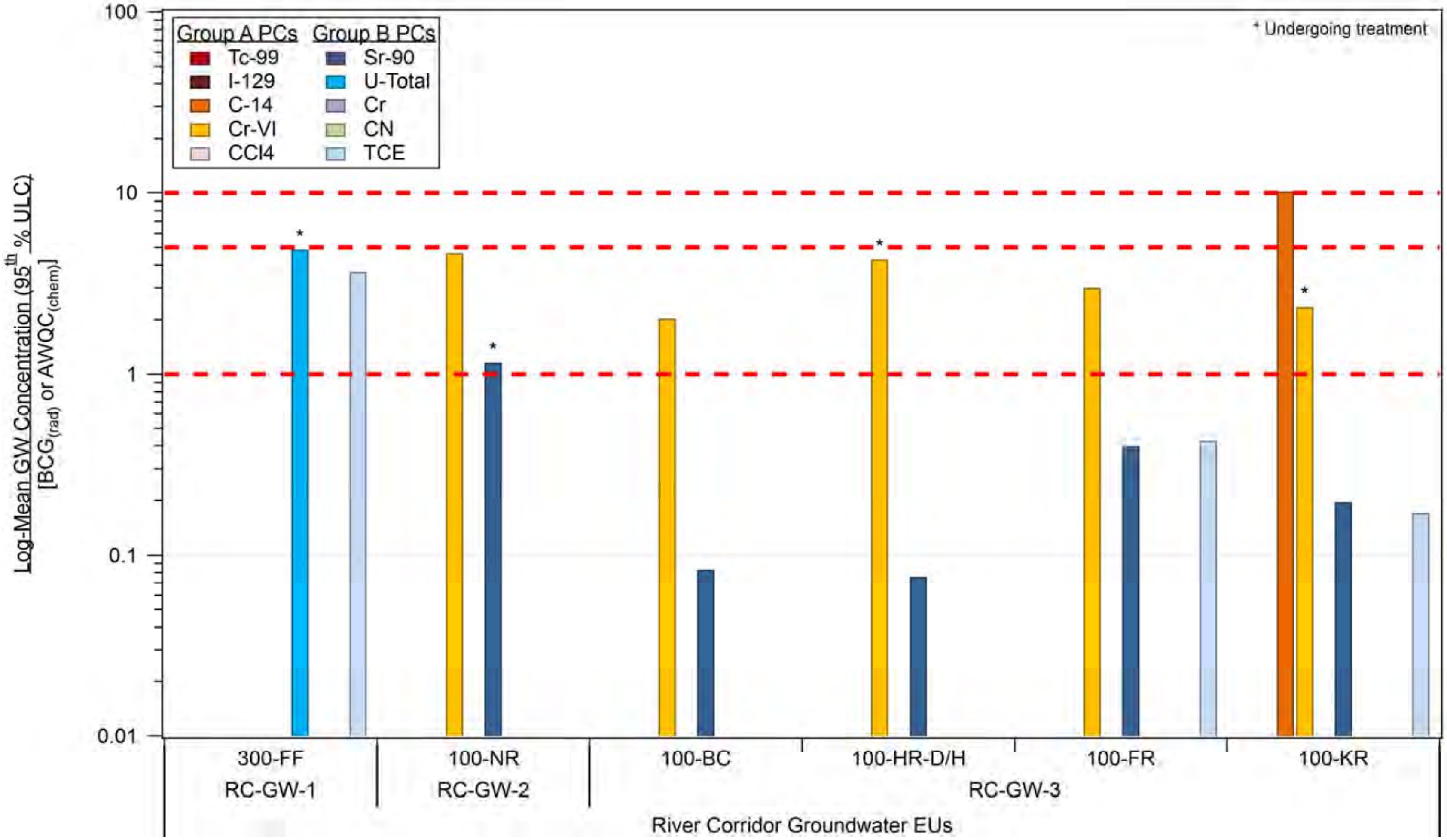


Figure 3-67. Calculated values of the ratio R2 for the River Corridor EUs using the 2015 groundwater monitoring data. Upper 95th percentile of the log-mean concentration (95th % UCL) based on 2015 groundwater monitoring data ≥ Ambient Water Quality Criteria (AWQC, chem.) or Biota Concetration Guide (BCG, rad.). In 300-FF, the uranium data excludes values associated with a transient spike caused by the enhanced attenuation component of the 300-FF-5 remedy and the TCE data includes all measured values in addition to the calculated value given in the 2015 Hanford Annual Groundwater Report (DOE/RL-2016-09, Rev. 0 and further discussed in Appendix D.2).

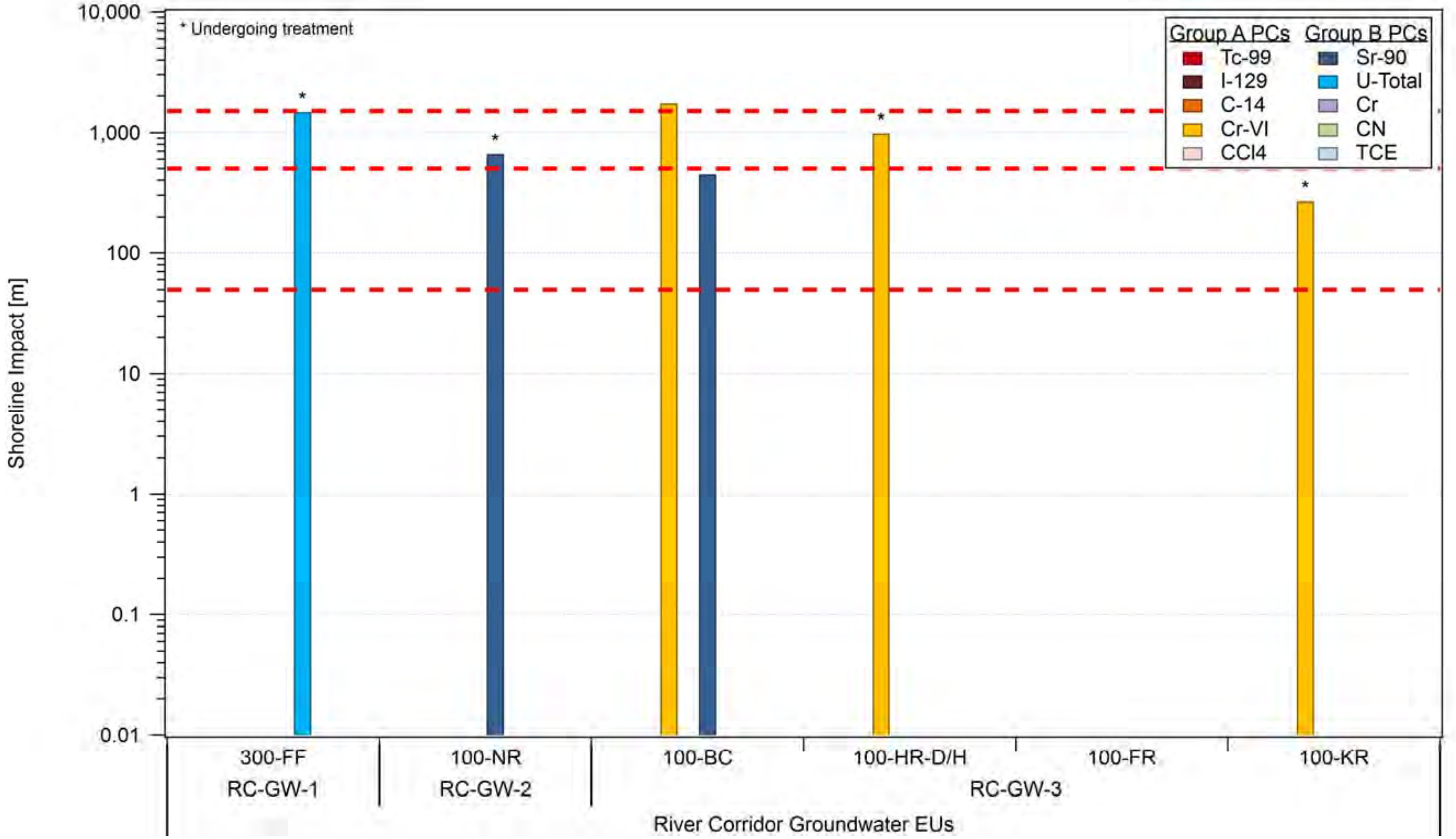
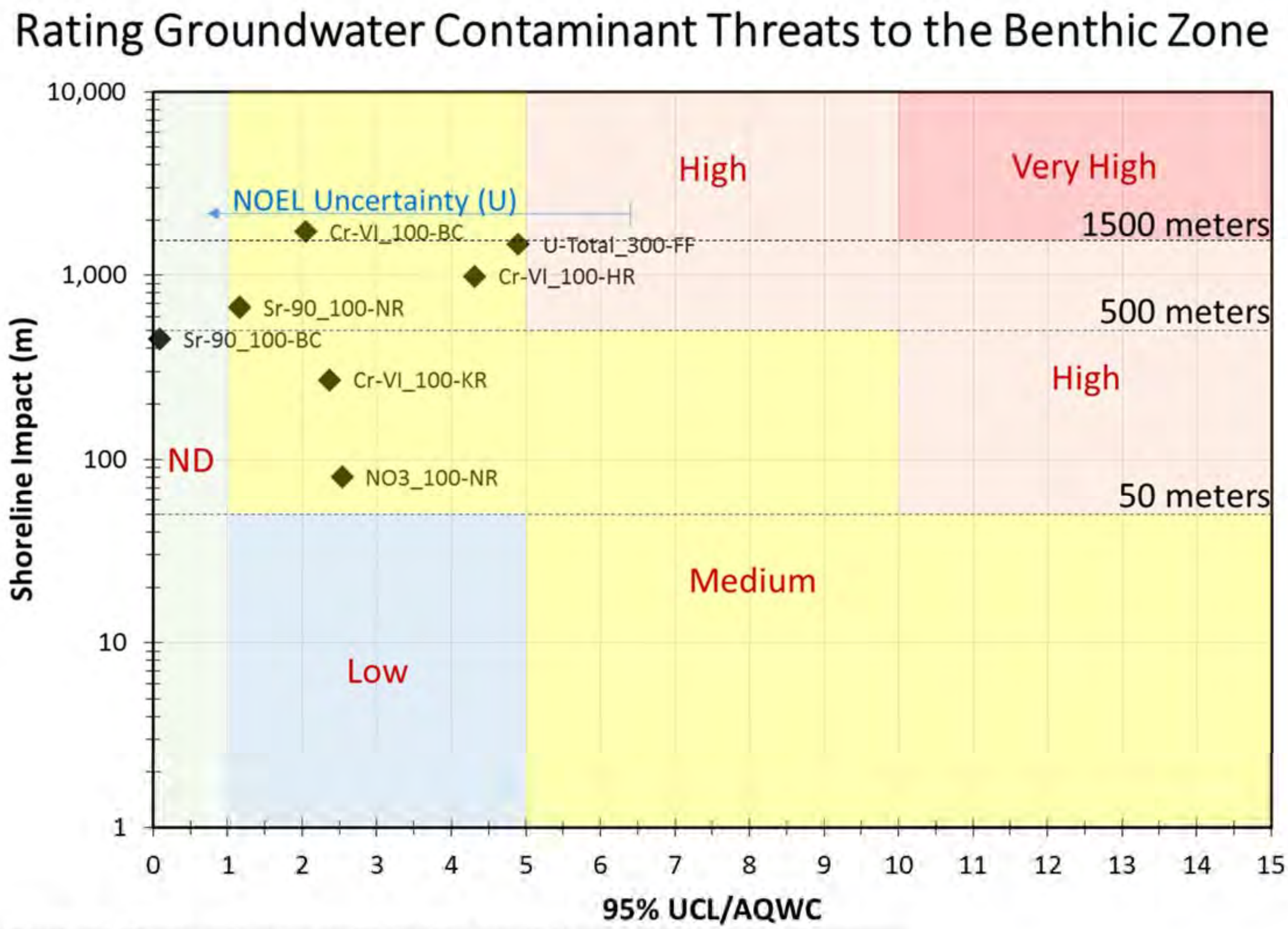


Figure 3-68. Estimated extent of shoreline impact (i.e., river reach) by the groundwater plumes in the River Corridor based on 2015 groundwater monitoring data.



95% UCL – 95th percentile upper confidence limit on the log-mean plume concentration;
AQWC - Aquatic Life Ambient Water Quality Criterion

Figure 3-69. Risk Review Project ratings for groundwater contaminant threats to the benthic zone for River Corridor EUs.

Threats to the Columbia River Riparian Zone Ecology from Contaminants

The rating process for the riparian zone (Figure 2-13) proceeds along the same lines as the rating process for benthic receptors with the exception that if the ratio R2 exceeds unity, then the final step in the threat assessment process is

- If the ratio R2 > 1, then the matrix represented in Table 2-8 is used to determine the rating based on the ratio R2 and the Riparian Zone impact area.[117] The riparian zone area impacted by each of the River Corridor groundwater plumes was estimated based on habitat definition along the river and the intersection with the groundwater plumes greater than the screening threshold (Figure 3-70).

Results of the rating process for each River Corridor groundwater plume are presented in Figure 3-71.

[117] The intersection area between the groundwater plume and the riparian zone was provided by PNNL based on the 2015 Hanford Site Groundwater Monitoring Report (DOE/RL-2016-09, Rev. 0).

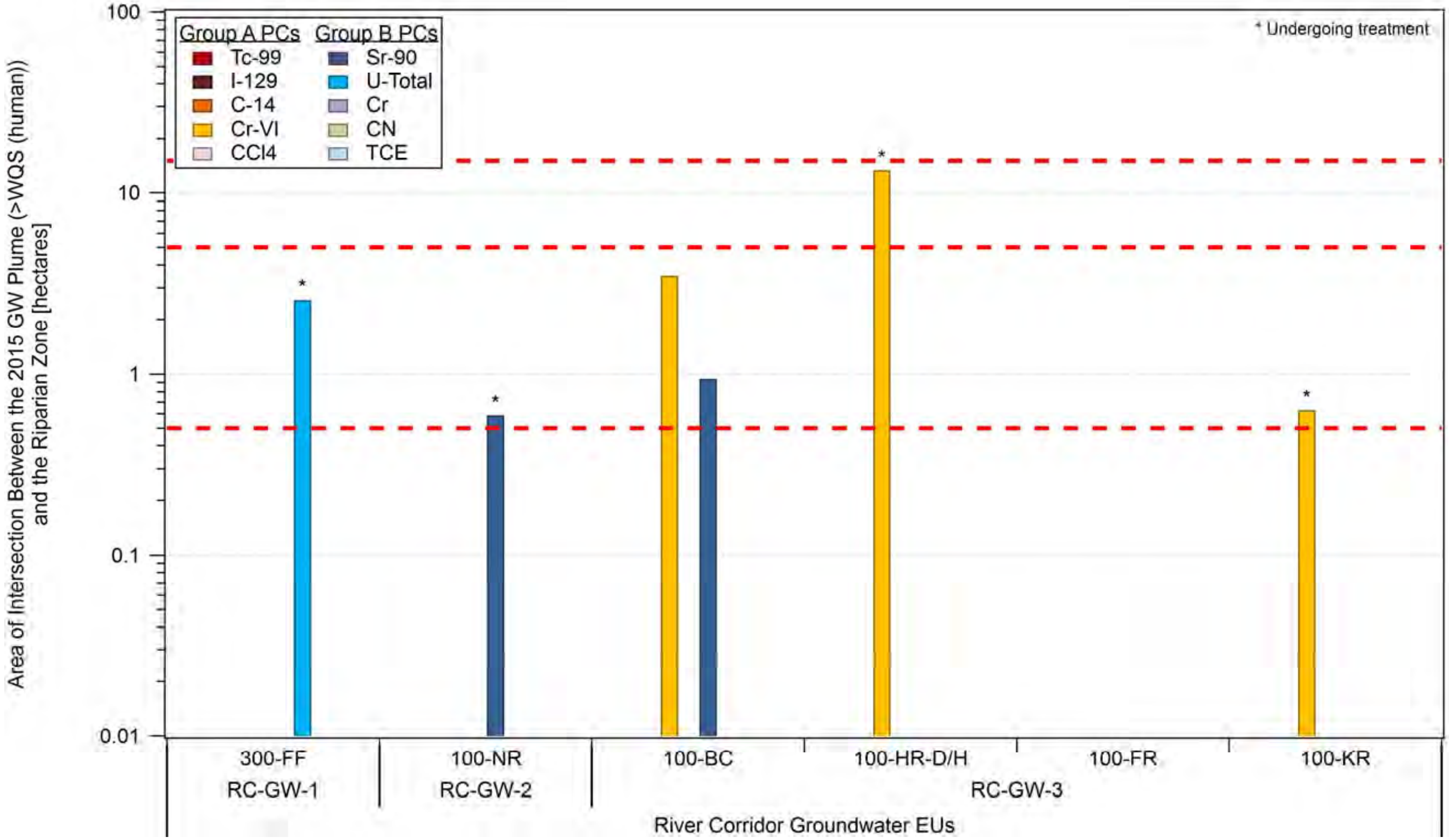


Figure 3-70. Area of intersection between the 2013 groundwater plumes along the River Corridor and the riparian zone.

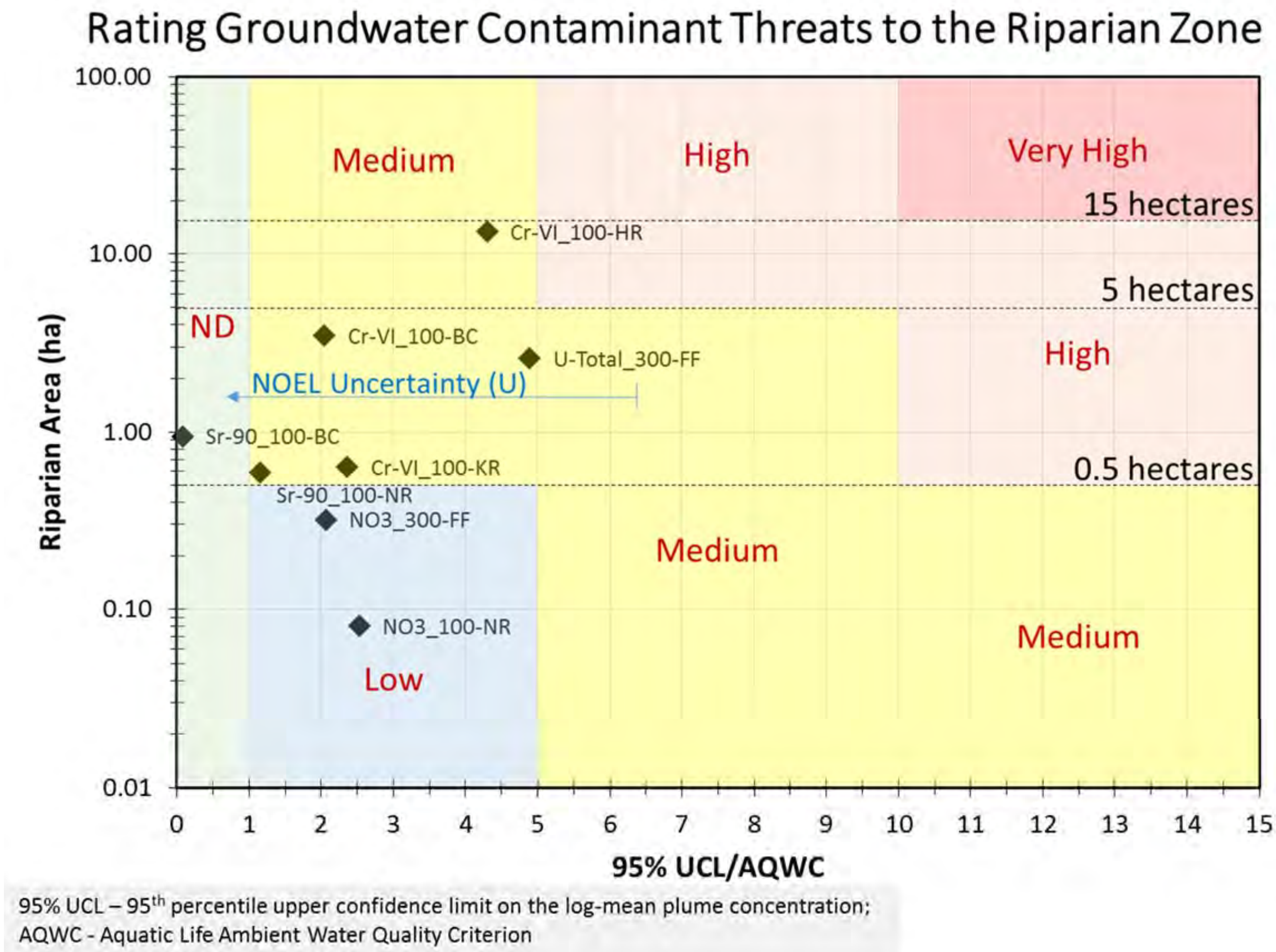


Figure 3-71. Risk Review Project ratings for groundwater contaminant threats to the riparian zone for River Corridor EUs.

Threats to the Columbia River Free-flowing Ecology

The threat determination process for the free-flowing river ecology was evaluated in a manner similar to that described above for benthic receptors (Figure 2-13). However, because of the Columbia River's large dilution effect on the contamination from the seeps and groundwater upwellings,[118] differences among EUs were not found distinguishing; the potential for groundwater contaminant discharges from Hanford to achieve concentrations above relevant thresholds is very remote. Additional information (e.g., concentration measurements or indications of bioaccumulation in certain areas of the Hanford Reach) was not available since the Interim Report was published that led to significant differentiation among EUs based on potential free-flowing river impacts.

SUMMARY OF RISK RATINGS

A summary of all groundwater EU risk ratings is provided in Section 4.3 (see Table 4-5).

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[118] "Groundwater is a potential pathway for contaminants to enter the Columbia River. Groundwater flows into the river from springs located above the water line and through areas of upwelling in the riverbed. Hydrologists estimate that groundwater currently flows from the Hanford unconfined aquifer to the Columbia River at a rate of ~ 0.000012 cubic meters per second (Section 4.1 of Peterson and Connelly 2001). For comparison, the average flow of the Columbia River is ~3,400 cubic meters per second (DOE/RL-2014-32, Rev. 0)." This represents a dilution effect of more than eight orders of magnitude (a dilution factor of greater than 100 million).

3.4. DEACTIVATION, DECOMMISIONING, DECONTAMINATION, AND DEMOLITION OF FACILITIES (D4) EVALUATION UNITS

The Hanford Site facilities that are currently or will be in the future undergoing one or more D4 phases consisting of one facility in the 300 Area (Building 324), eight reactors along the Columbia River and six former nuclear material processing facilities on the Central Plateau.

The B Reactor was the world's first full-scale plutonium production reactor and has been designated for preservation as a National Monument and is included in the Manhattan Project National Historical Park.

Six of the eight reactors that will undergo final demolition in the future have been cocooned for interim safe storage to protect their structures from the environment. The K Reactor ancillary buildings are currently undergoing D4 and the two K Reactor core buildings will be also cocooned until such time that they and the six other cocooned reactors along the Columbia River undergo final demolition and are buried at ERDF. See summary in Table 3-52.

Final disposition of all of these D4 facilities that will be burial of the demolition debris at ERDF or WIPP for plutonium/TRU contaminants, or the placement of an engineered barrier over the partially demolished structure and maintenance of institutional controls and post-closure monitoring and maintenance.

Table 3-52. Current Status of Hanford Nuclear Reactors.

Reactor	Began Operations	Shutdown	Current Status
B	1944	1968	National Historic Landmark in 2008
D	1944	1967	Cocooned in 2004
F	1945	1965	Cocooned in 2003
H	1949	1965	Cocooned in 2005
DR	1950	1967	Cocooned in 2002
C	1952	1969	Cocooned in 1998
K-West	1955	1970	Removal of sludge required, followed by partial D4 and cocooning
K-East	1955	1971	Waiting to be cocooned
N	1963	1987	Cocooned in 2012

An evaluation has been completed on the current condition and proposed future actions for nine D4 EUs and a short overview summary of findings is provided below. Figure 3-72 is a map of the Hanford Site showing the location of each of these EUs.

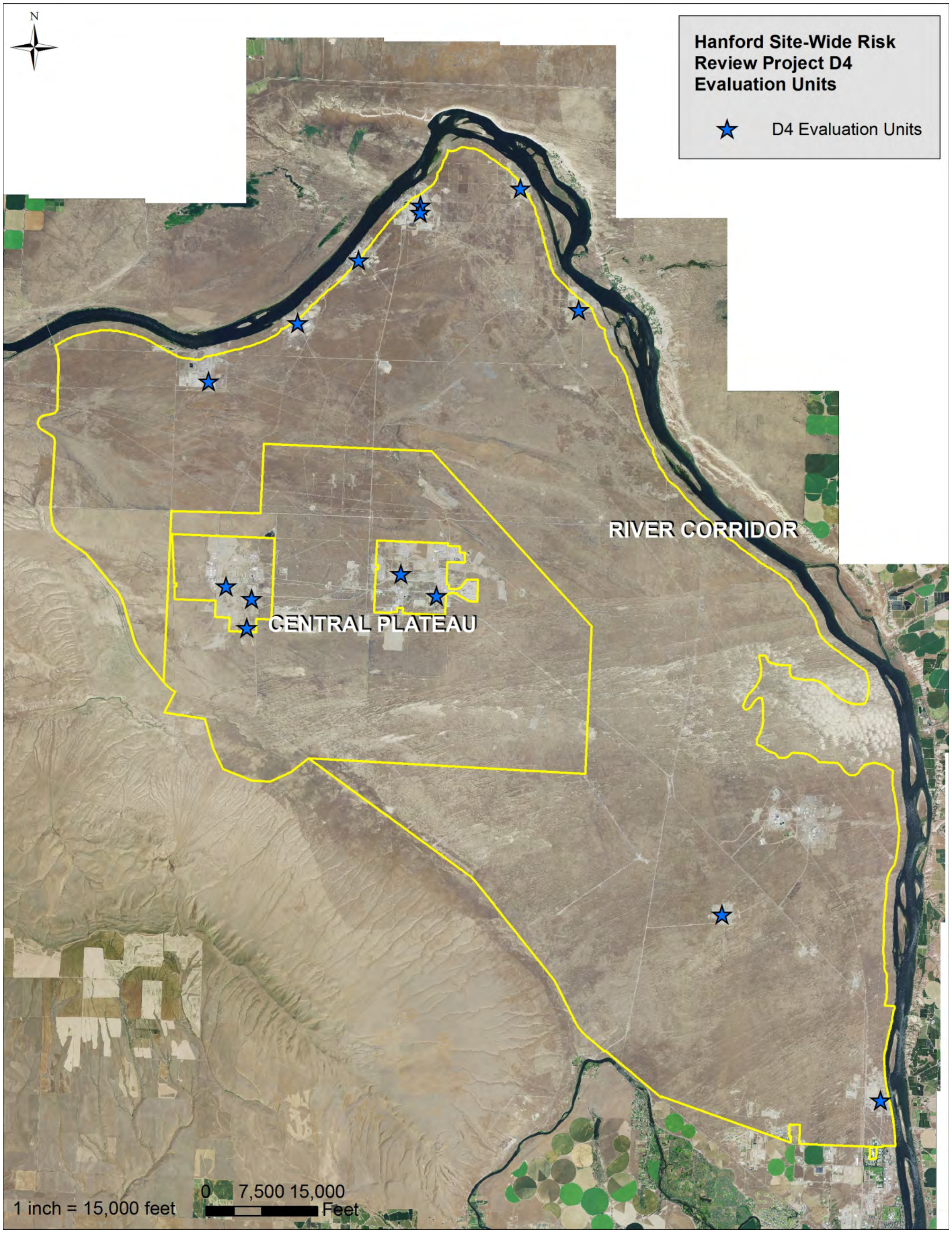

Figure 3-72. Map of D4 EU locations.

The following are short overview summaries of the Hanford D4 group of the following evaluation units:

- Building 324 (RC-DD-1)
- K Reactors (RC-DD-2)
- Final Reactor Disposition (RC-DD-3)
- Fast Flux Test Facility (RC-DD-4)
- PUREX (CP-DD-1)
- B Plant (CP-DD-2)
- U Plant (CP-DD-3)
- REDOX (CP-DD-4)
- Plutonium Finishing Plant (CP-DD-5)

BUILDING 324 (RC-DD-1)

Figure 3-73. Aerial view Building 324.

The 324 Chemical and Materials Engineering Laboratory (Figure 3-73) was constructed in 1965 as a dual purpose facility that contained both radiochemical and radio-metallurgical hot cells and laboratories. Located approximately 1,000 ft from the Columbia River, the facility was operated by Pacific Northwest National Laboratory until 1996, although it continued limited operations in the Building 324 until October 1998. The facility was transferred at that time to B&W Hanford Company, a sub-contractor of Fluor Hanford, for interim operation and eventual stabilization and deactivation in preparation for building decommissioning. In 2005 Fluor turned the project over to Washington Closure, which in turn transferred it to CH2M Hill in 2016.

In 2009, a breach in the B-Cell liner was discovered during grout removal in the trench and sump. Research determined that a spill of approximately 510 Liters of a highly radioactive waste stream containing about 883,000 curies of ^{137}Cs and 388,000 curies of ^{90}Sr occurred in the B-Cell of the 324 Building in October 1986. High radiation levels at failed liner locations led to concerns that contamination had spread to the soil beneath the cell. In 2010, closed casings (Geoprobes) installed beneath B-Cell indicated contamination up to 8,900 rad/hour in soils up to 4 m directly below B-Cell. This contaminated area was designated as waste site 300-296.

Current Status: The Building 324 is a Hazard Category 2 nonreactor nuclear facility currently undergoing stabilization, deactivation, decontamination, decommissioning of equipment and systems, and limited demolition of some adjoining structures and nonessential support buildings. CH2M Hill replaced Washington Closure Hanford as the contractor on the Building 324 and 300-296 waste site remediation projects in September 2016. DOE submitted a Class 2 Modification Request to the Hanford Dangerous Waste Permit based on a revised Building 324 Closure Plan (DOE/RL-96-73 2016) developed by CH2M Hill that modifies the proposed process of extracting the contaminated soils through the floor and estimates that it will require approximately 7 years to complete the cleanup of the building and the waste site 300-296 contaminated soils depending upon funding).

Primary Contaminants: A recent analysis indicates that an estimated 23,000 curies of Sr-90 and 42,000 curies of Cs-137 are primarily located in the building's A and B Cells and the High-Level Vault and Low-Level Vault tanks. Assuming the benefit of radioactive decay since the 1986 spill, it is estimated that there are about 200,000 curies of Sr-90 and 460,000 curies of Cs-137 in the soils decayed to 2014 extending up to about 4 m below the B-Cell foundation. There has been no indication of Cs-137 or Sr-90 migration from the soils underlying the building to the groundwater or the Columbia River. An important consideration with respect to prevention of Cs-137 and Sr-90 migration is prevention of infiltration of water to the contaminated soils. The greatest risk of water infiltration is from a leak or pipe rupture of the water supply main that runs close to the building.

Table 3-53 and Table 3-54 list the primary radionuclide and chemical contaminants present and estimated quantities in the Building 324 (RC-DD-1) EU**.**

Table 3-53. Building 324 (RC-DD-1) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	57
Carbon-14	A	NR[(b)]
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	510,000
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[(c)]	D	7.8
Strontium-90	B	220,000
Technetium-99	A	NR
Uranium-Total Rad[(d)]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-54. Building 324 (RC-DD-1) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	1,000
Chromium-VI	A	NR
Mercury	D	10
Nitrate	C	NR
Lead	D	600
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	10,000

a. Inventory details and references are found in the corresponding EU appendix.

Final Cleanup and Disposition: One of the biggest challenges facing DOE is how to safely remove or contain the highly radioactive soils beneath the Building's B-Cell. The original plan was to extract the soil up through the B-Cell floor, followed by grouting and transfers to the C and D hot cells. The outer shell of Building 324 would be demolished, and the hot cells would be cut into monoliths and transported to ERDF for disposal. The revised Building 324 Closure Plan developed by CH2M Hill modifies this soil removal plan, because it was determined that there is insufficient space in the hot cells adjacent to the B-Cell to accept all of the contaminated soils that it is believed would need to be removed up through the B-Cell floor. The objective will now be to remove a sufficient amount of contaminated soil to reduce dose rates to acceptable levels in order to complete remediation of remaining contaminated soils using conventional excavation after the building and foundation are removed. Following completion of the revised through-cell retrieval, the excavated area beneath B-Cell will be backfilled with stabilizing agents such as grout or controlled density fill (i.e., self-leveling grout). It is estimated that take 7 years to complete the cleanup of the building and 300-296 contaminated soils.

An alternative evaluated by WCH, that is believed to be consistent with the Final ROD, and deemed by its analysis (Washington Closure Hanford 2011) to be safer and more feasible, involves injecting a grout or polymer into and/or under the waste matrix. The majority of the building would be demolished and transported to ERDF for disposal; however, the B-Cell foundation would remain and used as part of an engineered cap over the area. The monolith contaminants would be removed in 100 years and transported to ERDF.

Primary Risks: Building 324's current and future primary risks to Facility Workers, Co-located Persons, and Public are associated with the significant radiological residual contaminates in the B hot cell and other hot cells. Any one of several worker related accidents could release high radiological doses to workers and the public because of the short distances from the building to off-site and Public areas. The soils beneath the B Cell represent the highest risk to Facility Workers and possibly Co-located Persons, but only if they are excavated and brought into the B, C, and A Cells under the proposed remediation plan. The Public, in the form of users of water from the Columbia River, are at risk only if the soil contaminants reach ground water through a large infusion of water at the surface, such as the rupture of the aging high-pressure fire suppression water line system located above the contaminated area.

K-East, K-West Reactors (RC-DD-2)

The K Reactors were two (K-West, K-East) (Figure 3-74) third-generation-design plutonium production reactors. Construction of K-West began in 1952, with the initial startup of the reactor on January 4, 1955. The final shutdown of the reactor occurred on February 1, 1970. Construction of K-East began in 1953, with the initial startup of the reactor occurring on April 17, 1955. The final shutdown of the reactor occurred on January 28, 1971. During final shutdown of the reactor buildings, extensive procedures were performed to safely shut down the entire facility and contain contamination within the reactor block.

Figure 3-74. Aerial view of K-East, K-West Reactors.

Current Status and Interim Cleanup: The K-East fuel basin was closed in 2007. Fuel racks and other debris were removed and transferred to ERDF. The remaining sludge was transferred to underground tanks in the K-West fuel basins. The K-East Reactor building achieved Cold & Dark status (electrical and mechanical systems air-gapped to eliminate potential external energy sources) in February 2010, and the current plan is to put the building into interim safe storage (ISS) until approximately 2068, followed by deferred demolition of the building. ISS consists of demolishing part of the reactor building, constructing a safe storage enclosure (SSE) around the reactor block ("cocooning" the reactor building), and providing long-term monitoring. The SSE will be a structurally independent building supported on a new concrete foundation.

The K-West Reactor building is currently managed as less than a Hazard Category 3 facility for authorized surveillance and maintenance activities. D&D of buildings and structures ancillary to the reactor core building will begin when the contaminated sludge is removed from the K-West fuel basin, which is expected to occur in the next two years. The K-West fuel storage basin and sludge treatment project is addressed as a separate EU, as is the cleanup of the waste sites at the K-West area.

Although DOE is currently following a remediation path of temporarily cocooning the two reactor buildings as selected in the 1993 NEPA ROD (58 FR 48509) and applied to the other Hanford surplus reactors, DOE has introduced a second option in its decommissioning approach that would use an immediate one-piece removal alternative that was deemed equally favorable based solely on the evaluation of environmental impacts. An EIS Supplemental Analysis prepared in July 2010 (DOE/EIS-0119F-SA-01) addresses a proposed action to pursue accelerated dismantlement, removal, and disposal of all eight surplus reactor facilities on the Hanford Site, with an initial focus on the K-East Reactor as a demonstration of capabilities to accelerate the dismantlement, removal, and disposal of the remaining seven surplus production reactors. It has not been determined which action will be implemented.

The current TPA milestone for completing construction of SSEs for both K Reactors and putting them into ISS is September 2024.

Primary Contaminants: The reactor blocks each contain approximately 18,000 Ci of radionuclides. The primary contaminants within the reactor building, based on curies, are Hydrogen-3, Carbon-14, Nickel-

63, Cobalt-60, Chlorine-36, and Cesium-137. The block is located near the center of the building, and consists of a graphite moderator stack (41 ft wide by 41 ft high by 33.5 ft deep) encased in a cast iron thermal shield (10 in. thick) and a biological shield consisting of high-density aggregate concrete (45 to 83 in. thick). The entire block rests on a massive concrete foundation. The reactor block, including the foundation, weighs approximately 12,100 tons. A cast iron thermal shield surrounding the graphite stack isolates the biological (radiation) shield from the core (Figure 3-75).

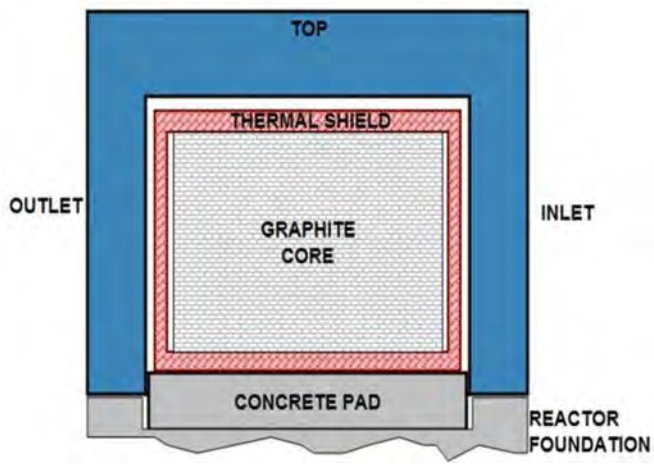

Figure 3-75. Schematic reactor cross-section.

In addition, about 187 tons of lead is believed to exist in surface coatings (i.e., lead-based paint), plumbing, and as radiological shielding (e.g., lead shot, brick, sheet and cast-lead forms) inside some of the 100-K Area facilities. About 926 yd^3 of asbestos-containing material is located in and around the facilities and may exist as vessel or piping insulation, floor tiles, transite wall coverings or panels, sheetrock, electrical wire insulation, and ducting. PCBs are identified as potential contaminants in the 100-K Area facilities and PCB-contaminated waste will likely be generated.

In addition, there is a fixed radionuclide contamination area on the lower part of the north exterior wall of the K-E Reactor building of approximately 864 ft^2 that was caused by openings between the chute feeding the fuel basin and the reactor building. It has been covered with polymeric barrier system (PBS) fixative.

Table 3-55 and Table 3-56 list the primary radionuclide and chemical contaminants present and estimated quantities in the K-East, K-West Reactors (RC-DD-2) EU**.**

Hexavalent chromium is the primary groundwater contaminant underlying the 100-K Area (100-KR-3 and 100-KR-4 OUs) and the potential exists for high concentrations of chromium to be present in the soils underlying the reactor building and related facilities.

Final Cleanup and Disposition: If pursued, interim safe storage of the two reactor buildings is expected to last until approximately 2068. The reactor block, including the thermal and biological shields, is of robust construction and has shown little degradation after 50 years. However, as noted above, long delays in constructing the SSEs over each of the K-East and K-West Reactor buildings could cause a loss of building envelope integrity such that precipitation and animals can infiltrate. Once constructed, the safe storage enclosure will protect the reactor block from the elements, and it is reasonable to expect that the reactor will remain structurally sound for the duration of ISS. It is therefore highly unlikely that the Co-located Person or Public would be at more than a Low risk of radiological exposure throughout this period.

In or about 2068, DOE has proposed to demolish the two safe storage enclosures and the remaining reactor shell around the reactor block, and to dismantle the reactor block using remote handling of radioactive components that would be packaged and transported to ERDF for permanent disposal. Contaminated structural surfaces would also be removed, packaged, and transported to the ERDF for disposal. The site would be backfilled, graded, revegetated, and released for other DOE use. Dismantlement of each reactor is expected to take about 3 years.

Table 3-55. KE/KW Reactors (RC-DD-2) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	0.84
Carbon-14	A	14,000
Chlorine-36	A	110
Cobalt-60	C	1,500
Cesium-137	D	35
Europium-152	D	24
Europium-154	D	5.9
Tritium	C	15,000
Iodine-129	A	NR[b]
Nickel-59	D	44
Nickel-63	D	4,900
Plutonium-Total Rad[c]	D	7.4
Strontium-90	B	12
Technetium-99	A	0.066
Uranium-Total Rad[d]	B	2.0

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-56. KE/KW Reactors (RC-DD-2) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: The K Reactors represent an ND to Low risk to a Facility Worker, Co-located Person or Public because the primary contaminants are decaying inside a reactor core that can withstand a design based seismic event.

Final Reactor Disposition (RD-DD-3)

This EU contains six of the nine water-cooled, graphite-moderated reactors constructed along the Columbia River by the U.S. Government within the Hanford Site's 100 Areas (Figure 3-76) to support the plutonium production effort initiated in 1942. They are designated C, D and DR, F, H, and N. Two of these reactors were built during World War II (1944–1945) and four were built during the Cold War (1949–1963). The reactor buildings contain the nuclear reactor and equipment directly associated with reactor operations. Cooling water for the reactors was withdrawn from the Columbia River, filtered and treated, pumped through the reactor block, and then returned to the river in a single-pass process.

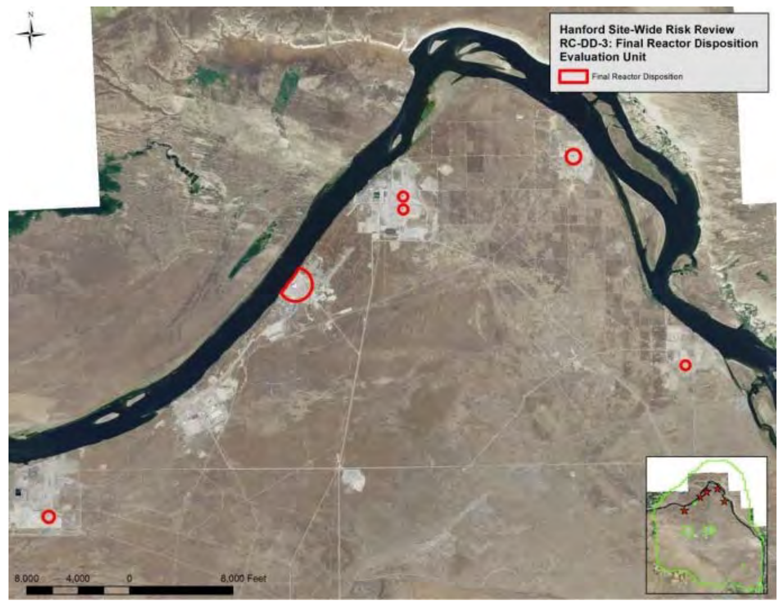

Figure 3-76. Map of reactor locations.

Not included in this EU is the 105-B Reactor Building, which was the first full-scale production nuclear reactor ever constructed. It was placed on the National Register of Historical Places on April 3, 1992, by the National Park Service of the U.S. Department of the Interior and made a National Historic Landmark in 2008. The 105-K East and 105-K West Reactor Buildings are reviewed separately in the RC-DD-2 EU. Both were third-generation design plutonium production reactors, and larger than the six older reactors with about twice the production capacity.

The six cocooned reactors are currently designated less than Hazard Category 3.

Current Status: Each of these reactors has been placed in final shutdown, declared surplus by the DOE, and placed in ISS. This consists of demolishing part of the reactor building and non-essential buildings on the site and construction of a SSE over the reactor block ("cocooning" the reactor building). During this safe storage period, surveillance, site and facility inspections, radiological and environmental surveys, and site and facility maintenance will be carried out periodically.

Primary Contaminants: The principal radiological contaminants of interest greater than 10 curies in aggregate within each of the 105-C, 105-D, 105-DR, 105-F, and 105-H Reactors (as of 1998 [DOE/RL-98-44 2002; DOE/RL-2005-67 2005) are:

- Carbon-14
- Tritium (H-3)
- Cobalt-60
- Nickel-63
- Cesium-137
- Europium-152
- Calcium-41
- Chlorine-36

The 105-N Reactor also has the following additional contaminants of interest (as of 2005) (DOE/RL-2011-106 2011):

Europium-154
Niobium-93m
Nickel-59
Strontium-90
Yittrium-90
Zirconium-89

Table 3-57 and Table 3-58 list the primary radionuclide and chemical contaminants present and estimated quantities in the Final Reactor Disposition (RD-DD-3) EU**.**

Final Cleanup and Disposition: Seven reactor buildings (including the two K Reactors) will remain in this cocooned condition for at least 75 years from the issuance of the ROD (58 FR 48509) that followed the EIS, *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland Washington* (DOE 1992). The 75-year safe-storage period was determined to be adequate for decay of cobalt-60 and partial decay of cesium-137, radionuclides that contribute significantly to occupational dose. This period will permit the reactors to be decommissioned with less occupational radiation dose than in the case of immediate one-piece removal. The safe-storage period for all but the first reactor will actually be for longer than 75 years because the reactors would be decommissioned in sequence at estimated 1- to 2-year intervals. During the safe storage period, surveillance, site and facility inspections, radiological and environmental surveys, and site and facility maintenance would be carried out (DOE/EIS-0119F 1992).

The eighth reactor in the 100 Area, N Reactor, has been cocooned like the others, but it is not within the scope of the Final EIS or ROD, and its final disposition will be determined by a subsequent NEPA or CERCLA decision process (DOE/RL-2015-10 2015).

The B Reactor will not be removed from its building, as it is being preserved as a National Historic Landmark pursuant to the recent congressional enactment of the Manhattan Project National Historical Park Act (H.R. 3979, section 3039, 2014).

DOE prepared a supplemental analysis to the EIS in July 2010 (*Supplement Analysis, Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington* [DOE/EIS-0119F-SA-01]) to broaden the possible decommissioning approach, retaining the one piece removal option and including the option for immediate dismantlement. A final decision on which approach will be taken has not been made.

Table C in the *2016 Hanford Lifecycle Scope, Schedule and Cost Report* indicates that the final reactor disposition program will begin about 2054 and be completed about 2068.

Primary Risks: During the ISS period, the primary risk is a seismic event. A 2004 Auditable Safety Analysis (DOE-RL 2004) postulated that a seismic event would result in a structural failure of the 105-KE and 105-C Reactor Buildings. The 105-KE Reactor was selected for analysis because its graphite stack inventory is larger than the 105-B, 105-C, 105-DR, or 105-F graphite stack inventories also being reviewed. The 105-C Reactor Building was selected because of its high cobalt-60 inventory. The impact of the building collapse onto the reactor block was assumed to breach the biological and thermal shields and crush 1% of the graphite into a fine (i.e., respirable) powder. The radiological consequences were calculated assuming a ground-level, point source release and adverse atmospheric dispersion conditions. The estimated dose to the Facility Worker (in this instance anyone within 30 m of the point of release) is 1.7 rem (Low), the Co-located Person is 0.22 rem (Low), and to the Public is $4.6x10^{-3}$ rem (ND).

Table 3-57. Final Reactor Disposition (RC-DD-3) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	1.9
Carbon-14	A	29,000
Chlorine-36	A	200
Cobalt-60	C	NR[b]
Cesium-137	D	150
Europium-152	D	200
Europium-154	D	92
Tritium	C	51,000
Iodine-129	A	NR
Nickel-59	D	12,000
Nickel-63	D	5,600
Plutonium-Total Rad[c]	D	7.6
Strontium-90	B	57
Technetium-99	A	0.014
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-58. Final Reactor Disposition (RC-DD-3) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	440,000
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

FAST FLUX TEST FACILITY (RC-DD-4)

Construction of FFTF (Figure 3-77) was completed in 1978, and initial criticality was achieved on February 9, 1980, with full power initiated on December 21, 1980. It operated as a 400-MW sodium-cooled, low-pressure, high-temperature, fast-neutron flux, nuclear fission reactor plant from 1982 to 1992. It was originally designed and constructed to develop and test advanced fuels and materials for the Liquid Fast-Breeder Reactor Program, though several additional irradiation-related missions were later added. In 1993, DOE concluded that FFTF was no longer needed and ordered that it be shut down. Following 8 years of additional study of potential new missions, the final decision to shut down the facility was made in 2001. During this 8-year period, the plant was maintained in a condition to allow safe and efficient shutdown or restart.

The FFTF is a three-loop reactor with the reactor vessel and primary heat transport system loops within the containment building (Figure 3-77). Heat was transferred to three secondary heat transport loops in the intermediate heat exchangers. These secondary system loops extended outside the containment building where the heat was removed by air-cooled tubes in the dump heat exchangers.

Figure 3-77. Aerial photo of FFTF.

Current Status: Deactivation was completed in 2009, including removal of all nuclear fuel, bulk drain of all sodium and sodium-potassium alloy systems, and removal of all PCB cooled transformers. An inert gas (argon) blanket will be maintained over the primary and secondary Main Heat Transport System and most auxiliary sodium and cover gas systems. From a safety standpoint, nitrogen gas would also be acceptable for a blanket gas over the systems and components with residual sodium, but argon was chosen to provide for potential reuse of systems for reactor operation. Without the inert gas blanket, the residual sodium in the piping and components would slowly react as air enters the systems.

Approximately 243,000 gallons of sodium were transferred from FFTF to the Sodium Storage Facility, Building 402, during the bulk sodium drains. The frozen sodium is stored in four storage tanks with an inert argon cover gas. After a period of holding the sodium in this condition, the facility will be reactivated to either transfer the sodium to another location or transfer it for chemical reaction to another product.

The facility is categorized as a Hazard Category 3 Nuclear Facility. There are currently no operational processes or deactivation activities ongoing at the FFTF facility, and the plant will be maintained in a surveillance and maintenance mode (S&M) configuration until DOE makes the decision to begin decontamination and demolition.

Primary Contaminants: To the extent practical, inventories of readily dispersible hazardous substances, radiological material, and hazardous chemicals and toxic materials were removed from FFTF as part of deactivation. The remaining materials primarily consist of:

- Residual sodium remaining following the "bulk draining" of sodium systems. Residual sodium also includes the sodium in some components that are filled with sodium and were not drained. It is estimated that about 4,000 gallons of residual sodium remains in the drained systems and that it contains approximately 0.00143 curies of Cs-137, 2.29 curies of tritium, and 7.44 curies of sodium-22 (EIS-0391-FEIS 2012).
- Radionuclide inventory from activation: Contamination within FFTF is primarily confined to the reactor containment vessel, internal surfaces of system components that handled primary sodium and radioactive argon, cells within the reactor containment building (RCB), decontamination areas, liquid radioactive waste holding and exporting systems, sodium removal and sampling systems, fuel handling systems, Interim Examination and Maintenance (IEM) Cell, and Contaminated Equipment Repair Shop. The reactor vessel and in-vessel components have a total of 900,000 curies of activation products (decayed to 2003). Table 3-59 summarizes the location and primary radionuclides present.

Table 3-59. Reactor component radionuclide inventories from activation (curies).

Location	Ni-59	Ni-63	Tc-99	Total
Reactor hardware	177	17,200	6.52×10^{-8}	237,000
Core components	1,410	183,000	26.9	662,000
Nonfueled hardware	6.93	1,110	0.163	4,020
IEM Cells	6.79	1,080	0.160	3,930
Total	1,600	202,000	27.2	907,000

The bioshield surrounding the FFTF reactor vessel is constructed of magnetite concrete with carbon steel rebar and liner. It contains a total of approximately 45 curies in the form of multiple radionuclides, most of which are in/on the concrete.

This EU also contains four waste sites consisting of two underground fuel tanks, an active storage pad, and a burial site associated with a demolished 4722-A Building Slab. No inventory data is available for any of these sites (DOE/RL-88-30 2015).

Table 3-60 and Table 3-61 list the primary radionuclide and chemical contaminants present and estimated quantities in the Fast Flux Test Facility (RC-DD-4) EU**.**

Table 3-60. FFTF (RC-DD-4) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	700,000
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	200,000
Plutonium-Total Rad[c]	D	NR
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-61. FFTF (RC-DD-4) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Final Cleanup and Disposition: DOE's preference for the decommissioning of FFTF on its support facilities is for entombment (Alternative 2 in the Final TC&WM EIS [EIS-0391-FEIS 2012]), which would decontaminate and remove all above-grade structures. The RCB structures below-grade level, as well as the FFTF reactor vessel and radioactive and contaminated equipment, components, piping, and other materials that have become radioactive or otherwise contaminated, would remain in place. Sodium residuals would be either removed from the RCB and treated in existing 400 Area facilities or treated in place. In addition, the RCB below-grade level would be filled with grout or other suitable fill material to immobilize remaining hazardous chemicals and radioactive materials to the maximum extent practicable and to prevent subsidence. The RCB fill material may include other demolition debris containing hazardous or radioactive materials, as allowed by regulations. A modified RCRA Subtitle C barrier would be constructed over the filled area to provide long-term containment and hydrologic protection for a performance period of 500 years, assuming no maintenance is performed after a 100-year institutional control period. The barrier also would extend over part or all of the immediately adjacent facility footprints. The barrier would be circular with a radius of about 39.2 m (128.5 ft), not including the side slope used for drainage.

The main FFTF RCB and two adjacent support facilities (Buildings 491E and 491W) would have all above-grade structures dismantled and the demolition waste would be disposed of in the Integrated Disposal Facility (IDF) or consolidated in the below-grade spaces. All other ancillary buildings, including their internal equipment and components, would be demolished and the contaminated demolition debris would be disposed of in the IDF or consolidated within available below-grade spaces within the RCB or Buildings 491E and 491W.

However, a number of components would require special handling and disposition because of high radiation levels and/or the inability to drain the component effectively. These remote-handled special components (RH-SCs) include the primary cold trap (N-5), the cesium trap (N-3), two sodium condenser vapor traps (U-527 and U-532), and the associated filter vapor traps (VT-61, VT-62, VT-63, and VT-64). Each of these components has a high-radiation-dose level due to the presence of high-energy, gamma-emitting fission products (primarily cesium-137). Each of these components would require remote operations to disconnect and isolate the traps from process system piping, to cap or blind off inlets and outlets, and to remove them from the facility. Isolation and removal of these components is a major activity that must be completed before other D&D activities can occur.

The current plan is to leave the sodium residuals frozen in the traps until after removal and to transport the traps to an interim storage facility. Two alternatives were analyzed for treatment of these RH-SCs. The first is treatment at the Idaho Nuclear Technology and Engineering Center (INTEC) at Idaho National Laboratory (INL). Following treatment at INTEC, the FFTF components and residuals would be disposed of with other INL waste at the Nevada National Security Site or returned to Hanford for disposal at ERDF. The second alternative is to treat these components at a new facility constructed at Hanford, possibly at the T Plant. This new facility would be designed and constructed to be the same as the INL facility, and disposal of the treated components and residuals would be at ERDF.

There is currently no NRC-licensed transportation cask with the capacity to handle these traps for shipment to INL, so the EIS assumed that a transportation cask or other shielded container would exist at the time of removal to transport the RH-SCs to an interim storage facility either at Hanford or at INL.

There are approximately 1.1 million liters (300,000 gallons) of sodium that will need to be disposed of at the Hanford Site. This inventory consists of the FFTF sodium contained in the Sodium Storage Facility and the following:

- *Hallam sodium*: The Hallam Reactor, located in Hallam, Nebraska, shut down in 1964, and its approximately 128,700 liters (34,000 gallons) of sodium were received at Hanford in 1967. This sodium is stored in solid form under an inert cover gas in five storage tanks at the 2727-W Hallam Sodium Storage Building in the 200 West Area at Hanford.

- *Sodium Reactor Experiment (SRE) sodium:* The SRE sodium, approximately 26,500 liters (7,000 gallons), was received at Hanford in 1975 from the SRE, located at the Santa Susanna Field Laboratory, California. This sodium is stored in solid form in 158 208-liter (55-gallon) drums sealed within 322-liter (85-gallon) overpacks. The SRE sodium is stored in eight South Alkali Metal Storage Modules in the 200 West Area CWC at Hanford.

Two options for disposal of Hanford's sodium inventory are being considered: the Hanford Reuse Option and the Idaho Reuse Option. Both would produce a 50 wt% caustic sodium hydroxide solution that would be used by DOE for the Hanford WTP. The capability to process the bulk sodium does not currently exist at Hanford, thus a new treatment facility would need to be constructed near the Sodium Storage Facility. The capability to process bulk metallic sodium currently exists at the INL Materials and Fuels Complex in the existing Sodium Processing Facility, with modifications, which previously has been used to process metallic sodium from the Experimental Breeder Reactor II (EBR-II) and other facilities. Following processing, the caustic sodium hydroxide solution would be returned to Hanford for use in the WTP or for supporting Hanford tank corrosion controls.

Primary Risks: An inert gas (argon) blanket is being maintained over the primary and secondary Main Heat Transport System and most auxiliary sodium and gas cover systems at FFTF, to prevent an exothermic reaction between the residual sodium in the piping and components and water vapor in the air. This risk is deemed low, as the reaction would be very slow because there is no ignition source within these components and because some hydrogen would leave by the path the air entered. However, the argon gas could cause an oxygen-deficient atmosphere at FFTF, which is considered an industrial hazard with potentially significant consequences of worker fatality. It is appropriate to maintain a strong industrial safety control based on the potential consequences because:

- A small argon leak would probably not be detected based on argon supply surveillances.
- The deactivation of permanent monitoring equipment in S&M mode requires use of personal oxygen monitors.
- Normally there is no forced heating and ventilation to mix and exhaust the argon, but it is standard practice to activate the electrical and ventilation systems prior to planned S&M activities.

Argon is denser than the normal atmosphere and would tend to pocket in the bottom of cells, where it is highly unlikely that Facility Workers would be present.

The only initiating event identified that represents a potential risk to the Facility Worker and Co-located Person would be a seismic event that causes the polar crane in the RCB to fall on the reactor vessel and results in a ground-level release of material. The inventory of the reactor vessel and the Test Assembly Conditioning Station are affected. This inventory consists of the activated stainless-steel components of the vessel that are integrally part of the metallic structure. The resulting Facility Worker and Co-located Person dose is estimated to be 2.30 rem (Low) and the dose to the Public is 0.0036 rem (ND).

PUREX (CP-DD-1)

The Plutonium Uranium Extraction Plant (PUREX Plant) complex (Figure 3-78) is a nuclear fuel processing facility that was constructed between 1953 and 1955 and was operated until 1990 to chemically separate plutonium, uranium, and neptunium from Hanford Site nuclear reactor fuel elements. Plutonium was recovered as an acidic solution of plutonium nitrate or was converted to plutonium oxide in N-cell. Nearly 70% of Hanford's uranium was reprocessed through PUREX. The original Plant was a concrete rectangle 1,005 ft long, 104 ft high (with approximately 40 ft below grade), and 61.5 ft wide.

The PUREX Plant incorporated a unique feature for disposing of large pieces of radioactive solid waste, such as failed or outworn equipment. A 500-ft rail extension running southward was built onto the single-track rail tunnel that was used to bring irradiated slugs to the east end of the PUREX building. The tunnel rectangular walls and ceiling are primarily constructed of 12 in. x 14 in. creosoted timbers arranged side by side with the 12-in. face exposed. Between June 1960 and January 1965, eight railcars with radioactive equipment were pushed into the tunnel by a remote controlled electric engine. In 1964 a 1,700-ft tunnel was constructed to provide storage space for 40 railcars after the first tunnel had become full and was sealed. Its semicircular walls are supported by internal steel I-beams attached to externally constructed 3-ft-thick reinforced concrete arches, with a bituminous coated steel liner on the interior. It currently contains 28 railcars of radioactively contaminated equipment.

Figure 3-78. Aerial photo of PUREX Facility.

During 1995-1997, the PUREX Plant was brought to a safe, low-cost, low-maintenance deactivation status. As part of the deactivation, the water-fillable doors of both tunnels and the outer PUREX railroad tunnel door were sealed. The scope of work includes S&M that maintains confinement of hazardous wastes and protects the worker. This work scope includes pre-approved activities for surveillance of the facility, preventative maintenance of selected equipment, and incidental storage of necessary supplies and equipment.

In May 2017, PUREX Tunnel 1 experienced a partial collapse without any detected release of radiological contaimination.

Primary Contaminants: The radioactive material inventory remaining at the end of deactivation in 1995-1997 was primarily in the form of contaminated equipment and surfaces, dust and debris, with some remaining plutonium and oxide dust stabilized in gloveboxes (total of about 29,000 Ci). Various pieces of dangerous debris and equipment containing or contaminated with dangerous/mixed waste stored on the PUREX Canyon Deck were removed and placed in PUREX Storage Tunnel 2. In total, this tunnel contains more than 400,000 Ci of Cs-137 and Sr-90, as well as about 7,200 Ci of total Pu. The PUREX Building and two tunnels are classified as nuclear Hazard Category 2 facilities (potential for significant on-site consequences). Other hazardous materials that remain are relatively minor risks, as there are no substantial volatiles, caustics, or reactive materials remaining.

Table 3-62 and Table 3-63 list the primary radionuclide and chemical contaminants present and estimated quantities in the PUREX (CP-DD-1) EU**.**

Final Cleanup and Disposition: Final D&D of the PUREX Building is expected to be similar to the "Close in Place-Partially Demolished Structure" alternative chosen for the 221-U Plant. There are several D&D options for the rail cars and equipment in the two tunnels, including injecting grout and close in-place or removal, treatment, and on-site or off-site disposal. The Tri Party Agreement requires DOE to submit to Ecology, as a secondary document by September 30, 2017, a data quality objectives report to assess the structural integrity of the PUREX storage Tunnels 1 and 2, and a Remedial Investigation/Feasibility Study Work Plan for 200-CP-1 (PUREX) by September 30, 2020.

Table 3-62. PUREX (CP-DD-1) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	2,000
Carbon-14	A	0.000015
Chlorine-36	A	NR[(b)]
Cobalt-60	C	0.00018
Cesium-137	D	350,000
Europium-152	D	0.000012
Europium-154	D	0.0013
Tritium	C	42
Iodine-129	A	0.0000026
Nickel-59	D	0.00000011
Nickel-63	D	0.000010
Plutonium-Total Rad[(c)]	D	18,000
Strontium-90	B	190,000
Technetium-99	A	0.28
Uranium-Total Rad[(d)]	B	2.2

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-63. PUREX (CP-DD-1) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	2.0
Chromium-VI	A	NR
Mercury	D	0.011
Nitrate	C	47,000
Lead	D	0.0000018
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	3,300

a. Inventory details and references are found in the corresponding EU appendix.

In July 2016, DOE proposed to demolish and remove tanks TK-P4 and TK-40, along with remaining tanks, piping, and ancillary structures in the PUREX 203A and 211A storage areas. This proposed removal action is needed to facilitate access to the PUREX Canyon Building in support of future remedial and site closure actions (DOE/RL-2015-72 2016).

Primary Risks: The primary risks at PUREX are largely linked to a seismic or other natural phenomenon event that would cause structural failure of the 202-A Building or tunnels and would release much of the dispersible radiological contaminates. An equally high risk is a fire in Tunnel 1 due to the extensive use of timbers as tunnel structural material that would result in a similar release. A 1991 study found that the structural timber materials in Tunnel 1 were degrading from continued exposure to the gamma radiation from equipment being stored there, and it was estimated that a standard factor of safety could be breached in 2040. Although no contaminants were released, the recent collapse of a 20-foot section of the Tunnel indicates that degradation and weakening of the timbers is occurring faster. A follow-on engineering evaluation of the second tunnel found that "overstressed conditions in structural support members and connections and uncertainty of additional unknown stresses induced during original construction, Tunnel 2 has a potential high risk of localized collapse."

B PLANT (CP-DD-2)

The B Plant (Figure 3-79), a Hazard Category 2 nuclear facility, was constructed in 1945 and designed to chemically process spent nuclear fuel using the bismuth-phosphate process. B Plant began separations processing using actual irradiated uranium feed from Hanford's B and D Reactors on April 13, 1945. Process solutions were transferred from the 221-B Canyon Building to the 224-B Building process cells for purification and plutonium concentration. The original separations process used at B Plant produced a plutonium nitrate product that was shipped to Los Alamos, New Mexico, for fabrication into atomic weapons. In 1952, due to the greater efficiency of a new radiochemical separations process at Hanford known as reduction-oxidation, B Plant closed as a plutonium separations facility.

In the early 1960s, the decision was made to retrofit B Plant for a large waste-partitioning mission to separate Sr-90 and Cs-137 from high-level wastes already stored in tank farms associated with the PUREX and REDOX Plants, as well as PUREX acid wastes and sludge. During the separations mission, individual strontium and cesium solutions were transferred to WESF for processing, encapsulation, and storage in pool cells. The primary contaminants are large inventories of Cs-137 and Sr-90 in the 221-B Canyon and A-D Filters. The canyon and process cells were extensively decontaminated of residual plutonium when B Plant was prepared for the cesium separations mission in the 1960s.

Located contiguous to B Plant in the 200 East Area of the Hanford Site, the WESF was designed to ship, inspect, decontaminate, and store strontium and cesium capsules that were produced in past campaigns at WESF. The capsules were produced in WESF from 1974 to 1985 to reduce the quantity of Sr-90 and Cs-137 in liquid waste in underground tanks. The Sr-90, in the form of strontium fluoride, and the Cs-137, in the form of cesium chloride, were doubly encapsulated in WESF hot cells and then stored underwater in WESF pool cells.

Current Status: There are currently no operating processes at B Plant since it is deactivated. During the current facility life-cycle stage, planned facility activities will consist primarily of S&M and storage of incidental goods and supplies required for S&M activities of B Plant.

Current WESF operations consist of safely storing the cesium and strontium capsules within a series of interconnected pools within the WESF building while DOE is evaluating alternatives for placing the capsules in dry storage. The current scope of the WESF mission is limited to facility maintenance activities: inspection, decontamination, and movement of capsules; and storage and surveillance of capsules.

Primary Contaminants: The primary contaminants are large inventories of Cs-137 and Sr-90 in the 221-B Canyon, sand filter and A-D Filters. The canyon and process cells were extensively decontaminated of residual plutonium when B Plant was prepared for the cesium separations mission in the 1960s. Some plutonium may remain in the air tunnel, the underground ducts, and other portions of the canyon and old ventilation system; however, the only known or estimated remaining plutonium is in the old ventilation system filters (CHPRC 2013a). In addition, small quantities of Pu-238 to 242 and Am-241 are present in the 224-B deactivated plutonium concentration building (CHPRC 2013b). Underground pipes are also believed to be contaminated, including the pipes between the 212-B and 224-B Buildings; however, the levels of contamination in these pipes are unknown.

The majority of radioactive material (cesium chloride and strontium fluoride) at WESF is confined in doubly encapsulated stainless steel capsules. WESF currently stores 1,335 cesium capsules, 23 of which are single-contained Type W overpack capsules, and 601 strontium capsules in pool cells located in the 225-B Building. The radioactivity level contained within the Cs capsules is approximately 68 MCi (34 MCi of Cs-137 and 34 MCi of Ba-137m). The radioactivity level contained within the Sr capsules is approximately 30 MCi (15 MCi of Sr-90 and 15 MCi of Y-90). Contamination within the hot cells and connecting ventilation is approximately 300 kCi. The hot cells A through F (G is clean) contain around 55 kCi of Cs and 43 kCi of Sr. The connecting ventilation and ductwork to the hot cells contain around 2,800 Ci of Cs and 107,500 Ci of Sr.[119]

This EU also includes 118 miscellaneous waste sites and 48 active and inactive structures. Contaminant inventories are available for only one of these sites, 216-B-13, which is a French drain associated with the 291-B Stack, and there are indications of contaminants of 1 mCi of Sr-90 and 5.7 mCi of C-137 (DOE 2011).

Table 3-64 and Table 3-65 list the primary radionuclide and chemical contaminants present and estimated quantities in the B Plant (CP-DD-2) EU**.**

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[119] CRESP Interim Report (2015a), Appendix H.4, Waste Encapsulation and Storage Facility (WESF) (CP-OP-3, Central Plateau), Evaluation Unit Summary Template.

Table 3-64. B Plant (CP-DD-2) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	11
Carbon-14	A	0.000010
Chlorine-36	A	NR[(b)]
Cobalt-60	C	0.0000049
Cesium-137	D	240,000
Europium-152	D	0.0000040
Europium-154	D	0.00038
Tritium	C	4.6E-09
Iodine-129	A	4.1E-10
Nickel-59	D	0.0000027
Nickel-63	D	0.00023
Plutonium-Total Rad[(c)]	D	95
Strontium-90	B	120,000
Technetium-99	A	0.00000093
Uranium-Total Rad[(d)]	B	0.00000056

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-65. B Plant (CP-DD-2) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	28
Chromium-VI	A	NR
Mercury	D	0.0050
Nitrate	C	2,300
Lead	D	97,000
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	0.00076

a. Inventory details and references are found in the corresponding EU appendix.

Final Cleanup and Disposition: The 1996 Agreement in Principle (DOE-RL 1996) among the Tri-Parties of DOE, EPA, and Ecology established that the CERCLA Remedial Investigation/Feasibility Study process would be followed, on a case-by-case basis, to evaluate potential cleanup remedies and identify preferred alternatives for the final end state for the five major canyon buildings in the 200 Area of the Hanford Site. The 221-U Facility was selected as a pilot project for this effort. The selected remedy was "Close in Place-Partially Demolish Structure," under which equipment on the canyon deck will be consolidated into the process cells and hot pipe trench; equipment, process cells, and other open areas will be filled with grout; the structure will be partially demolished; and the remaining structure will be buried under an engineered barrier. This alternative was determined to be more protective of remedial action workers and provide somewhat greater long-term effectiveness and permanence when compared to full removal and disposal of the facilities. It was also determined to provide somewhat greater long-term effectiveness and permanence at a lower cost than the two Entombment alternatives considered (CHPRC 2008). The B Plant and U Plant are very different with respect to their prior uses and levels of residual radiological contamination, but their canyon structures and the primary locations of radiological contaminants are similar.

New TPA milestones were approved in May 2016 that require DOE to submit to Ecology a Remedial Investigation/Feasibility Study Work Plan for 200-CB-1 (B Plant) by September 30, 2019, and a Removal Action Work Plan to implement the approved Action Memorandum for 224-B (DOE/RL 2004-36) by September 30, 2020 (DOE, EPA, and Ecology 2016).

No cleanup decisions have been made for the remaining waste treatment, storage and disposal facilities such as WESF. Closure of facilities will be according to approved operating plans and closure plans (e.g., RCRA Closure Plans); consequently, cleanup actions will be determined and accomplished in accordance with applicable regulatory and permit/license requirements (DOE/RL-2015-10 2016). No information is currently available regarding the final D&D of the WESF facility and if it will be carried out in combination with or separate from the D&D of the B Plant canyons and other facilities.

Primary Risks: The greatest current risk is a seismic event of greater magnitude than the design basis. It was assumed to potentially cause failure of both the 221-B and 224-B canyon buildings, resulting in loss of the confinement function; complete failure of the 291-B retired filters and the sand filter; complete failure of the 212-B Cask Station; complete failure of the ACT filter; and shock/ vibration impacts to radioactive material in the canyon from seismic motions and displacement of equipment. The bulk of the canyon inventory at risk is adherent contamination confined in the process cells, and therefore the seismic event assumed an unfiltered ground level airborne release. The event frequency was conservatively assumed to be classified as "anticipated." The resulting combined Faclity Worker and Co-located Person dose is estimated to be 35.4 rem (High) and the combined dose to the Public is 0.019 rem (ND) (CHPRC 2013a,b).

U Plant (CP-DD-3)

The 221-U Facility (Figure 3-80) was originally constructed in 1944 as one of three chemical separation plants for the recovery of plutonium from spent nuclear fuel; however, its mission was modified to one of uranium recovery in 1952 (plutonium recovery activities were never conducted in the 221-U Facility). The facility was contaminated with hazardous substances used or generated during the uranium recovery process, and contained contaminated process equipment from other Hanford Site facilities that was brought into the facility and placed on the canyon deck or in process cells after termination of the recovery process. Prior to completion of interim D&D activities, the U Plant contained sufficient residual waste and contamination from former operations to result in an initial hazard classification as a Hazard Category 2 nuclear facility (DOE/RL-2011-80 2011).

Based on the completion of interim D&D activities in 2011 per the U Plant Facility ROD, the removal of Tank D-10, and the completion of grouting activities in the canyon, the U Plant Facility structure was downgraded to a less than Hazard Category 3 classification. The canyon exhaust air ventilation tunnel up to the inlet of the sand filter and the sand filter exhaust up to the inlet of the 291-U stack exhaust system were grouted as part of these interim D&D activities, isolating the sand filter, which remains a Category 2 segment of the facility.

Figure 3-80. Aerial Photo of U Plant Facility.

Current Status: In September 2005, EPA issued a CERCLA ROD for the final remediation of the Hanford Site U Plant Facility. The five major components of the remedy selected include:

1. Equipment size reduction and placement
2. Cell 30 Tank D-10 contents disposition
3. Canyon void space grouting
4. Canyon demolition
5. Engineered barrier construction

Interim D&D activities completed the first three components in 2011. The equipment size reduction and placement remedy component involved consolidation of equipment from the canyon deck into process cells and the hot pipe trench. The Cell 30 Tank D-10 contents disposition remedy component involved removal of Tank D-10, along with its contents, from Cell 30 and shipment to the CWC for interim storage pending final treatment, packaging, and shipment to the WIPP, near Carlsbad, New Mexico. The canyon void space grouting remedy component filled the process cells, hot pipe trench, piping and electrical galleries, drain header, process sewer, and ventilation tunnel and ducts with grout. Approximately 76,000 ft^2 of fixative was applied in the canyon (floor and 8 ft up the walls) and 9,000 ft^2 in the railroad tunnel (floor and 8 ft up the walls) were covered with the polymeric barrier system fixative. The canyon deck floor received two applications of the fixative. Radiological surveys of the upper walls (above 8 ft) and ceilings of the canyon and railroad tunnels determined that application of fixative was not required (DOE/RL-2011-80, 2011).

The primary current activity at the site is S&M while it awaits final D&D.

Primary Contaminants: The 221-U Building bounding inventory is primarily Cs-137 and Sr-90 that has been stabilized by encapsulating the cells' contents with grout and applying a fixative over 8 ft of wall surface above the operating deck, to equipment removed from the canyon deck, and to the exposed floor area where equipment was removed.

The inventory for the 291-U sand filter is primarily Cs-137, Sr-90, and Pu-239 and is based on known U Plant stack emissions, a comparison to REDOX Plant stack emissions and an assumed sand filter efficiency of 99.95%. All alpha contamination was assumed to be Pu-239 as a worst-case scenario.

This EU also includes three waste sites consisting of underground French drains, which combined contain less than 1 curie of radiological contamination.Table 3-66 and Table 3-67 list the primary radionuclide and chemical contaminants present and estimated quantities in the U Plant (CP-DD-3) EU**.**

Table 3-66. U Plant (CP-DD-3) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	0.32
Carbon-14	A	0.015
Chlorine-36	A	NR[(b)]
Cobalt-60	C	0.0066
Cesium-137	D	32,000
Europium-152	D	9.9E-10
Europium-154	D	7.6E-08
Tritium	C	0.32
Iodine-129	A	2.6E-10
Nickel-59	D	3.9E-09
Nickel-63	D	0.00000037
Plutonium-Total Rad[(c)]	D	42
Strontium-90	B	26,000
Technetium-99	A	0.00000025
Uranium-Total Rad[(d)]	B	0.0023

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-67. U Plant (CP-DD-3) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	0.50
Chromium-VI	A	NR
Mercury	D	0.013
Nitrate	C	180
Lead	D	0.30
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	3.0

a. Inventory details and references are found in the corresponding EU appendix.

REDOX (CP-DD-4)

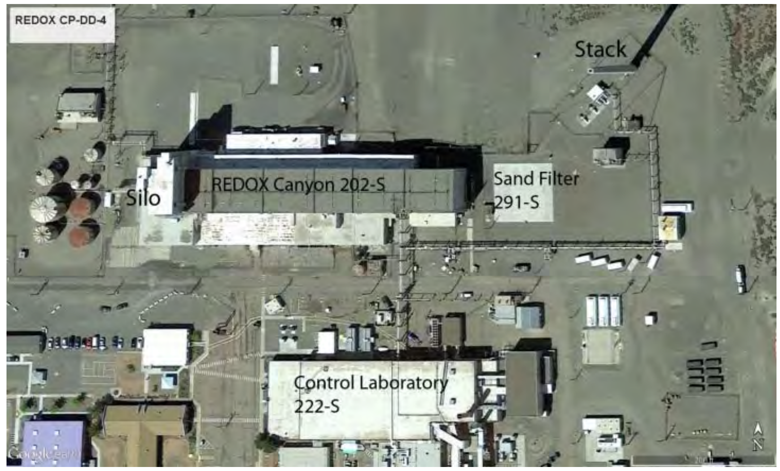

Figure 3-81. Aerial photo of REDOX Facility.

The REDOX Facility (Figure 3-81) was constructed between 1950 and 1952, was the fourth processing "canyon" constructed at Hanford and was the last one built in the 200 West Area. It looked different than earlier models, as it wasn't as long (470 ft) as its predecessors, but it was wider at 160 ft. In comparison to earlier processing canyons like T and B Plants, REDOX produced much less waste in its processing of irradiated fuel rods than earlier models. It was the first large-scale, continuous-flow, solvent-extraction process plant built in the United States for recovering plutonium from irradiated uranium fuel.

The extraction process, which replaced the batch precipitation methods first used at the Hanford Site, was designed to separate uranium, plutonium, and neptunium as individual product streams from associated fission products in the irradiated fuel. REDOX was able to recover both the plutonium for weapons and the uranium from the fuel rods during processing where earlier models could not. The recycled uranium could be used again to make more fuel rods. The plant operated from 1952 until 1967, and processed approximately 24,000 tons of uranium fuel rods. Deactivation started in 1967 and was completed in 1969, when it was transferred to S&M status. The REDOX Plant is classified as a Hazard Category 2 facility based on the quantity, form, and location of the radioactive material.

Current Status: Deactivation started in 1967 and was completed in 1969, when the REDOX facility was transferred to S&M status. In November 2016, DOE issued an Engineering Evaluation/Cost Analysis for the REDOX Complex (EE/CA) (DOE/RL-2016-16, Rev 0) for public review and comment. The document proposes four non-time critical removal alternatives, which are intended, with the exception of the No Action alternative, to offer a combination of actions to prevent or reduce the risk of release of hazardous substances including continued S&M, hazard abatement, demolition preparation, demolition, and grouting. The REDOX buildings/structures in the scope of the EE/CA have severely degraded. Spread of contamination has been observed throughout the buildings and it is believed that it will intensify as the facilities continue to degrade. It is proposed that implementation of this removal action would commence in 2017, but would receive only partial funding over the 15-year period before a final ROD is expected to be issued.

Primary Contaminants: The REDOX canyon, north sample gallery, and the exhaust system contain the significant inventories of the residual radiological contamination remaining after flushing, draining, and other inventory-reduction activities, as well as contamination in the sand filter. Together, the 202-S Canyon building and the 291-S exhaust system (exhaust tunnel, sand filter, and stack and condensate ancillary) are classified as a Hazard Category 2 facility based on the quantity, form, and location of the radioactive material.

The REDOX S&M Plan for the Canyon Building and DSA for the REDOX Facility both contain statements concerning the accuracy of the available inventory information. "The list of hazardous materials remaining at REDOX is as complete as knowledge allows but the list was not developed at the time it was deactivated by personnel who worked at and deactivated the facility. The estimates are largely based on historical published data, the basis of which is unknown" (DOE/RL-98-19 2008). "In general, detailed radionuclide characterization data (i.e., form, quantity, and location) for the 202-S Canyon Building do not exist…. Because of this uncertainty, highly conservative assumptions are used when applying the limited inventory data. In any undertaking that involves intrusive activities into the REDOX Facility, caution must be exercised, recognizing that higher-than-predicted levels of contamination or materials may be encountered" (CHPRC 2015b). The estimated radiological inventories used in the DSA assume a total 1,980 Ci alpha and 17,840 Ci beta, with alpha activity assumed to be Pu-239 and beta activity to be Sr-90[120]. These are lower than the inventories estimated for the B Plant, U Plant, and PUREX facilities, all of which also had large amounts of Cs-137.

This EU also includes five Unplanned Release-Surface/Near Surface Waste sites. Inventories are only available for one, UPR-200-W-61, which is ground contamination caused by a fire hose rupturing while flushing the H-10 to 241-SX transfer line. Back flow from the transfer line contaminated an outside ground area. The primary contaminants are Cs-137 (62.5 Ci) and Sr-90 (2.06 Ci). The area is not currently marked or posted.

Table 3-68 and Table 3-69 list the primary radionuclide and chemical contaminants present and estimated quantities in the REDOX (CP-DD-4) EU.

Table 3-68. REDOX (CP-DD-4) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	0.0056
Carbon-14	A	0.0013
Chlorine-36	A	NR[(b)]
Cobalt-60	C	0.0017
Cesium-137	D	63
Europium-152	D	0.00025
Europium-154	D	0.017
Tritium	C	0.023
Iodine-129	A	0.000035
Nickel-59	D	0.00015
Nickel-63	D	0.013
Plutonium-Total Rad[(c)]	D	2,000
Strontium-90	B	9,800
Technetium-99	A	0.022
Uranium-Total Rad[(d)]	B	0.000018

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

[120] The DSA may have used bounding activity values resulting in higher reported values than included in inventory estimates.

Table 3-69. REDOX (CP-DD-4) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	2.4
Chromium-VI	A	NR
Mercury	D	0.00027
Nitrate	C	120
Lead	D	2.6E-11
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	0.026

a. Inventory details and references are found in the corresponding EU appendix.

Final Cleanup and Disposition: The 1996 Agreement in Principle (DOE-RL 1996) among the Tri-Parties of DOE, EPA, and Ecology established that the CERCLA Remedial Investigation/Feasibility Study process would be followed, on a case-by-case basis, to evaluate potential cleanup remedies and identify preferred alternatives for the final end state for the five major canyon buildings in the 200 Area of the Hanford Site. The 221-U Facility was selected as a pilot project for this effort. Its final remedial investigation/feasibility study evaluated five remedial action alternatives, one of which was "Full Removal and Disposal." In this alternative, the 221-U Facility structure and contents would be removed and demolished, including the foundation below existing grade level. Structural material, facility contents, and associated soil above risk-based standards would be disposed at the ERDF. The selected remedy was "Close in Place-Partially Demolish Structure," under which equipment on the canyon deck will be consolidated into the process cells and hot pipe trench; equipment, process cells, and other open areas will be filled with grout; the structure will be partially demolished; and the remaining structure will be buried under an engineered barrier. This alternative was determined to be more protective of remedial action workers and provide somewhat greater long-term effectiveness and permanence when compared to full removal and disposal of the facilities. It was also determined to provide somewhat greater long-term effectiveness and permanence at a lower cost than the two Entombment alternatives considered (CHPRC 2008).The REDOX Facility and U Plant are very different with respect to their prior uses and levels of residual radiological contamination, but their canyon structures and the primary location of radiological contaminants are similar.

The Tri-Party agencies approved a new TPA milestone in May 2016 that requires DOE to submit a Remedial Investigation/Feasibility Study Work Plan for the 200-CR-1 Operable Unit (OU - REDOX) to EPA by September 30, 2021. The primary focus of this OU is the REDOX 202-S Canyon Building, along with associated waste sites.

Primary Risks: A seismic event is assumed, resulting in the total failure of the 202-S Canyon Building structure with resulting ground level release of material. A previous structural study of the 202-S Canyon Building concluded that the building could withstand seismic events only up to a peak ground acceleration of 0.03 g versus the more current 0.20 g required of Safety Class I facilities such as REDOX. The likely failure mode of the building would be a collapse of the roof into the canyon area. The vast majority of the estimated 1,640 Ci of Pu-239 and 9,840 Ci of Sr-90 source term is thought to be inside process equipment and piping located within the process cells. The estimated dose to the Facility Worker and Co-located Person is 108 rem (High) and to the Public it is 0.0943 rem (ND).

In addition, there is a possibility of a canyon load drop accident and a product receiver cage fire, which could cause Medium rated risks to the Facility Worker and Co-located Person (19.6 rem and 12.1 rem doses, respectively). The risk to the Public would be ND in both instances. Nearby T Plant is an operating facility and an historic site that is eligible for inclusion in the Manhattan Project National Historical Park Act, which establishes the park at Hanford Site (National Defense Authorization Act of 2015, H.R. 3979, section 3039 [2014]). The National Park Service and DOE have agreed to consider including the T Plant in the park at the earliest feasible time after current mission use is complete. At the point in the future, the T Plant is included in the Park, the risk to visitors will be significantly increased as they will be located in closer proximity than assumed by the current site boundaries and access.

The November 2016 EE/CA document indicates that in addition to current radiological and chemical hazards, structural hazards exist due to the degradation in the structural integrity of the buildings and structures. Structural degradation could result in partial or total loss of radiological material, confinement, and/or worker injury.

Plutonium Finishing Plant (CP-DD-5)

From 1949 into early 1989 the Plutonium Finishing Plant complex (Figure 3-82) was used to process plutonium nitrate solution into hockey puck-sized plutonium metal "buttons" or oxide powder for shipment to the nation's weapons production facilities or for the fabrication of mixed-oxide reactor fuel. PFP also produced machined plutonium metal parts up until the late 1960s. The plutonium fabrication lines were previously removed in the 1975-1976 timeframe. In 1991, PFP's mission changed to stabilizing and storing reactive plutonium-bearing materials, completing terminal cleanout, and providing long-term vault storage. In 1996, DOE issued a formal shutdown order for the PFP.

Figure 3-82. Aerial photo of PFP Facility.

The PFP became highly contaminated while recovering plutonium from scrap materials and producing plutonium metal and oxide powder and machined plutonium metal components for nuclear weapons for 40 years (1949 to 1989). When processing ended, approximately 20 tons of plutonium-bearing material remained and needed to be removed as TRU or LLW. Stabilization and packaging of the material was completed in 2004. Bulk special nuclear material shipments to the Savannah River Site were completed in 2010. PFP is categorized as a Hazard Category 2 nuclear facility.

The operational history of the complex indicates that former waste management practices, failures of equipment, accidents, and spills resulted in the release of radionuclides in the facilities and surrounding soils. Based on the potential threat posed to human health and the environment by the residual plutonium in the buildings and external piping, DOE determined that it is appropriate to remove facilities and structures to slab-on grade, and stabilize the sub-grade structures and sites within the complex (CHPRC 2015c).

This EU also includes the 231-Z Isolation Building/Plutonium Metallurgy Facility, which is located in the 200 West Area, about 600 ft north of the PFP 234-5 Building. The 231-Z Building was constructed in 1944 and was originally designated the 231-Z Isolation Building, housing the final step of the plutonium extraction process that began at T Plant. Its original purpose was to purify and dry the plutonium nitrate solution produced at the 224-T Bulk Reduction Building. It operated in this capacity from 1945 until 1957, when the function of the building shifted to plutonium metallurgy. Plutonium metallurgical research, fabrication development, and metallurgy work for weapons development were carried out until 1975. A major cleanout of gloveboxes and other plutonium-contaminated equipment was undertaken from 1978 to 1982. Small quantities of Pu-239 and Am-241 remain as holdup within the building and equipment, and it is categorized as a Hazard Category 3 nuclear facility.

Current Status: The PFP complex is in the process of being cleaned out and demolished to “slab-on-grade” prior to transitioning the footprint to RL-0040 for S&M and final waste site remediation. ”Slab-on-grade” is a concrete slab (typically the first floor of a building resting on grade) that is free of dispersible radiological contamination. Many of the initial large nuclear source term and material at risk-reducing activities have been completed. The completed activities were associated with the prior plutonium vault storage of plutonium metal and oxides and other S&M, storing slightly irradiated and un-irradiated nuclear reactor fuels, packaging and handling plutonium-bearing materials, and shipping the materials and fuels to other DOE-owned facilities.

The remaining PFP D&D phases of the mission include decontamination of equipment and facilities, removal of remaining process equipment, waste packaging, deactivation of facility systems, and demolition of the facilities, primarily centered on Buildings 234-5Z, 236-Z, 242-Z, and 291-Z, and their supporting structures.

Primary Contaminants: The primary hazardous substances of concern are transuranics, including various plutonium isotopes (Pu-238 through Pu-240) and their decay products (americium-241, uranium isotopes U-234 through U-238, and neptunium-237) and lesser amounts of mixed fission products (cobalt-60, strontium-90, and cesium-137). Contaminants are found in the form of adherent films and residues in deactivated process vessels, piping, equipment, and ventilation system ductwork. These contaminants also might exist because of releases throughout the decades of PFP operations that could have affected the immediate release area (e.g., spills of liquid or heavy materials), or also could have affected a wider area and rooms or areas connected to the downstream ventilation system (e.g., releases of plutonium oxide or fluoride powders). There is also a potential for beryllium contamination in E4 ductwork, filter boxes, drain lines, and E3 and E4 filter rooms. The radioactive contamination of concern for the PFP Building demolition is located on surfaces, under paint and tiles, within ducts, and in other inaccessible places.

A major cleanout of gloveboxes and other plutonium-contaminated equipment at the 231-Z Isolation Building/Plutonium Metallurgy Facility was undertaken from 1978 to 1982. Small quantities of Pu-239 and Am-241 remain as holdup within the building and equipment

Table 3-70 and Table 3-71 list the primary radionuclide and chemical contaminants present and estimated quantities in the Plutonium Finishing Plant (CP-DD-5) EU**.**

Final Cleanup and Disposition: The PFP facilities are undergoing final deactivation and preparation for demolition. This includes staging of gloveboxes and filter boxes that will include interior cleanout, application of fixative, and installation of scaffolding and lifting slings, as required. Other pre-demolition phase activities may include grouting TRU piping in the 234-5Z tunnels, grouting the 236-Z canyon floor, removal of hazardous waste, and removal of all energy sources so that the facilities may be declared Cold and Dark. Each PFP above-grade structure will then be demolished to within 6 in. of the slab and foundation, with the exception of the 4-ft-high walls and roof of Building 291-Z, PFP Exhaust Fan and Compressor House. Structures with below-grade areas, such as basements, tunnels, and vaults, will be left in place, as well as the below-grade slab and foundation. Equipment, piping, and ducting remaining in accessible below-grade areas will be such that the remaining material may be dispositioned as LLW with the building rubble during the final remediation of the PFP zone, which is the selected alternative in DOE/RL-2004-05, *Engineering Evaluation/Cost Analysis for the Plutonium Finishing Plant Above-Grade Structures.* Below-grade voids left by this work will be backfilled as needed, after any required sampling or surveys, with clean fill or gravel.

Table 3-70. Plutonium Finishing Plant (CP-DD-5) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	3,600
Carbon-14	A	NR[b]
Chlorine-36	A	NR
Cobalt-60	C	0.00069
Cesium-137	D	8.9
Europium-152	D	0.0000027
Europium-154	D	0.00030
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	30,000
Strontium-90	B	8.7
Technetium-99	A	0.00017
Uranium-Total Rad[d]	B	0.00041

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-71. Plutonium Finishing Plant (CP-DD-5) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	590
Cyanide	B	NR
Chromium	B	50
Chromium-VI	A	NR
Mercury	D	8.4
Nitrate	C	40,000
Lead	D	25
TBP	---	61
Trichloroethene	B	NR
Uranium	B	0.59

a. Inventory details and references are found in the corresponding EU appendix.

For structures with basements, tunnels, vaults, etc., the below-grade walls would be left standing as well as the below-grade slab and foundation. Exposed areas such as the 234-SZ tunnels or 241-Z vaults that exist below-grade would be filled and covered with a suitable material to grade level to prevent water accumulation but not preclude any future remedial activity. Each PFP above-grade structure footprint would be stabilized to prevent migration of any residual contamination to the environment, if needed. This migration prevention could include adding a cover (of compacted fill, gravel, asphalt, or other appropriate material with an engineered slope), if needed, to the slab to prevent run-on/run-off (DOE/RL-2005-13 2005).

The Removal Action Work Plan (DOE/RL-2011-03, Rev. 0) governing these activities was amended through TPA Change Notice TPA-CN-681 in November 2015 to include removal of the 236-Z and 242-Z slabs, along with the soil necessary to complete slab removal (approximately 1 m below the slab) to reduce the overall radiological inventory of the PFP complex. However, this expansion of D4 work at the site is to be carried out as part of the S&M phase, as opposed to revising the current program of demolishing all of the buildings to slab on grade.

Primary Risks: There are several potential high-risk events at PFP discussed in the April 2015 *Control Decision Document for the Plutonium Finishing Plant Safety Basis* (HNF-58375, Rev. 0), which is based on the following documents:

- HNF-15500, Rev. 12, *Plutonium Finishing Plant Deactivation and Decommissioning Documented Safety Analysis* (PFP DSA)
- HNF-15502, Rev. 12, *Plutonium Finishing Plant Deactivation and Decommission Technical Safety Requirements* (PFP TSR)

These documents include:

- Design basis earthquake or aircraft crash, which assumes release of all mixed actinide residue in the facilities. The Facility Worker and Co-located Person dose would be 890 rem and the Public dose would be 7.3 rem (Medium).

- 234-5Z first floor fire involving contaminated equipment. A multiple glovebox fire is not expected because of the distance between units. The Facility Worker and Co-located Person dose would be 710 rem and Public dose would be 5.9 rem (Medium).
- Internal equipment explosion in 242-Z: The mixed actinide residue for Building 242-Z is assumed to consist of 300 g of Am-241 and 1,000 g of the plutonium mixture with >10% Pu-240. The Facility Worker and Co-located Person dose would be 300 rem and Public dose 2.4 rem (Medium).
- Internal equipment explosion in 234-5Z: Facility Worker and Co-located Person dose is 240 rem and Public dose 2.0 rem (Medium).
- A High rating is associated with a drop of equipment in Buildings 234-5Z and 242-Z. For the equipment drop occurring inside a confinement facility, a bounding case was considered whereby a glovebox in 242-Z contaminated with 5kg of plutonium holdup is dropped. The Facility Worker and Co-located Person dose would be 100 rems and Public dose 0.85 rem (Low).

There are also multiple initiating events that could impact PFP and the 231-Z Building, which would have Medium risk to the Facility Worker and Co-located Person and Low risk to Public.

COMPARATIVE SUMMARY

Comparison of Inventories and physical/chemical states of wastes & contaminants, barriers and risks

There are significant differences in the primary radiological inventories currently present at the nine D4 EUs described above, as well as the long-term integrity of current barriers to release or dispersion of the contaminates (

Table 3-72) and the potential unmitigated radiological dose impact to the Co-located Person and Public (Table 3-73 and Table 3-74) of various initiating events. The highest risks to human health are as follows:

- Plutonium Finishing Plant facilities: There are several initiating events associated with the current D4 work being carried out at PFP that have the potential to cause High (acute) consequences to Facility Workers and Co-located Persons. Fires represent one of the greatest threats, with one on the first floor involving contaminated equipment causing an estimated acute dose of as much of 710 rems to both. Internal equipment explosions represent similarly high dose impact events. The Public, which in this case is an individual located about 7.4 miles from the site, could receive an acute dose of from 2.0 rems to as much as 7.3 rems from one of these events because the contaminants would be released rapidly into the air. These high risks will continue to exist until the current D4 activities are completed.
- PUREX Canyon Building and two tunnels: A seismic or other natural phenomenon event could cause structural failure of the 202-A Building and/or the tunnels, which would release much of the dispersible radiological contaminates in these three facilities. An equally high risk is a fire in Tunnel 1 due to the extensive use of timbers as tunnel structural material that would result in a similar release. The structural timber materials in Tunnel 1 are also degrading from continued exposure to the gamma radiation from equipment being stored there and were the likely cause of the recent collapse of a 20-foot section of the Tunnel. A follow-on engineering evaluation of the second tunnel found that Tunnel 2 also has a potential high risk of localized collapse.
- REDOX Canyon Building: A seismic event could result in the total failure of the 202-S Canyon Building structure, with resulting ground level release of material. A previous structural study of the 202-S Canyon Building concluded that the building could withstand seismic events only up to a peak ground acceleration of 0.03 g versus the more current 0.20 g required of Safety Class I facilities such as REDOX. In general, detailed radionuclide characterization data (i.e., form, quantity, and location) for the 202-S Canyon Building do not exist and an estimated 1,640 Ci of Pu-239 and 9,840 Ci of Sr-90 source term is thought to be inside process equipment and piping located within the process cells. These are lower than the inventories estimated for the B Plant, U Plant, and PUREX facilities, all of which also have large amounts of Cs-137. As noted in the most recent DSA (CHPRC 2015b), "caution must be exercised in any undertaking that involves intrusive activities into the REDOX Facility."

  Although the current risk to the Public from a seismic event at REDOX would be ND, the T Plant is nearby. T Plant is eligible for inclusion as part of in the Manhattan Project National Historical Park, but is currently excluded because of ongoing mission needs of the DOE. At the point in the future, the T Plant is included in the Park, the risk to visitors will be significantly increased as they will be located in closer proximity than assumed by the current site boundaries and access.
- Seismic event at Hanford: A greater-than-design seismic event across the Hanford Site could cause the release of significant amounts of airborne radiological contaminants from damages to all of the canyon processing facilities, as well as the PFP, FFTF, Building 324, and other buildings storing such materials.

B Plant has the largest radiological inventory of any of the canyon processing facilities at Hanford, a total of 358,000 Ci of Cs-137 and Sr-90; however, this inventory is contained within thick concrete walled buildings and often located in structures that are below ground level. This inventory represents very low risk to the human health of Facility Workers and Co-located Persons as long as it is not disturbed. The same can be said about the current risk posed by the substantial Cs-137 and Sr-90 inventories currently contained in soils below B-Cell of the Building 324.

Considerations for Timing of the Cleanup Actions

Safely completing the D4 to at least slab-on-grade of the PFP facilities is of high priority, and delays will leave the potential for the several natural phenomena hazard events and accidents mentioned earlier to occur with resulting large aerial releases of contaminants.

Delays in completing a "Close in Place-Partially Demolish Structure" type D4 action on the PUREX 202-A. REDOX 202-S, and B Plant 221-B Canyon Buildings, and some type of grout in place and more permanent sealing of the two PUREX tunnels will leave the potential for the several natural phenomena hazard events and accidents mentioned earlier to occur with resulting large aerial releases of contaminants. As noted above, the timber walls and ceiling of Tunnel 1 are weakening and have recently collapsed, and Tunnel #2 is at risk of failure as well, which could cause a similar release of contaminants.

The general consensus is that there is no short-term threat of the Cs-137 and Sr-90 contaminants beneath Building 324's B Cell migrating to groundwater levels, but that could change if a driving force such as a large source of water (e.g., from a water main break) pushes the contamination lower. Conversely, there are potential benefits to near-term measures that prevent infiltration to the soils (e.g., covers or *in situ* grouting) and allow time for an order of magnitude decrease in radiation levels due to natural decay (ca. 90 years) or allowing natural attenuation to achieve long-term environmental safety.

With the K Reactors, physical maintenance of the building structures will become a priority if there is long delay in constructing the safe storage enclosures (holes in roof, etc.). The timing of construction of the K-East SSE is partially linked to the desire to do the work on the K-West Reactor Building near the same time to make efficient use of personnel and other resources. However, a long-term delay could cause residual contaminants in exposed soils to migrate toward groundwater. D4 and waste site cleanup work on K-West cannot begin until the sludge is removed from the K-West used fuel basin and the fuel basin is demolished, which is a separate project.

Table 3-72. Radiological inventories, form, and barriers to release (activities in Ci).

Evaluation Unit	Cs^{137}	Sr^{90}	Pu (total)	Am^{241}	Form	Containment/Barriers
Building 324:						
Building	42,000	23,000	NR[a]	NR	Fixed and dispersible	Concrete walled A and B Cells and room containing HLV & LLV[d] tanks.
Soils	460,000	200,000	NR	NR	Mobile	3 m under B Cell & 10 m. above groundwater
K Reactors	17	6	4	<1	Fixed	Concrete and cast iron reactor block
N Reactor	37.5	19.9	1.4	<1	Fixed	Concrete and cast iron reactor block
Other SSE Reactors[b]	25.0	7.5	2.3	<1	Fixed	Concrete and cast iron reactor block
Fast Flux Test Facility[c]	90	NR	NR	NR	Fixed and dispersible	Cesium trap and primary cover gas system
PUREX:						
202-A Building	11,000	8,940	8,134	1,210	Fixed and dispersible	Concrete walled canyon
Tunnel #1	10,127	8,175	2,460	442	Fixed and dispersible	Wood tunnel walls covered by 8 ft of soil
Tunnel #2	330,873	170,611	7,178	334	Fixed and dispersible	Concrete/metal tunnel walls covered by 8 ft of soil
B Plant:						
221-B Canyon	81,000	44,000	<1	NR	Fixed and dispersible	Concrete walled canyon
Filters	158,000	75,000	1	NR	Fixed and dispersible	Below-grade concrete vaults
U Plant:						
221-U Building	25,000	25,000	<1	<1	Fixed	Encapsulated in grout or fixative in concrete canyon
291-U Sand Filters	6,800	790	41	NR	Fixed and dispersible	Below ground level concrete/grout enclosure
REDOX:						
202-S Building	NR	9,800	1,640	NR	Fixed and dispersible	Concrete walled canyon
291-S Sand Filter	NR	8,000	340	NR	Fixed and dispersible	Below-grade concrete vault
PFP:						
234-5Z & 291-Z	NR	NR	15,060	1,100	Fixed and dispersible	Concrete walled canyon
236-Z Building	NR	NR	14,930	1,100	Fixed and dispersible	Concrete walled canyon
241-Z-361 Tank	NR	NR	4,700	NR	Fixed in sludge	Underground concrete structure

a. NR = Not reported
b. Amounts are average of five reactors (C, D, DR, F, and H)
c. Large inventories of Fe-55 (1,151,000 Ci), Co-60 (701,740 Ci) and Ni-63 (202,390 Ci) in reactor hardware and core components not shown
d. Low level vault (LLV) and high level vault (HLV) tanks

Table 3-73. Unmitigated radiological dose (rems) impacts to Co-located Person (100 m from event).

Accident/Event Scenario	PUREX & Tunnels	Building 324	K Reactors	SSE Reactors	B Plant	U Plant	REDOX	PFP
Seismic (0.2 g)	130-250	11	0.22	0.22	35.4	5.6	108	890
Partial building collapse	25	NR	NR	NR	13	NR	NR	NR
Crane/equipment drop	14	10	NR	NR	7.1	0.6	19.6	100
Waste handling accidents	4	268	NR	NR	NR	NR	NR	89
Fires	14-70	4	0.24	0.24	7.9	6.7	12.1	710
Explosions	NR	24	NR	NR	NR	NR	NR	240-300

Table 3-74. Unmitigated radiological dose (rems) impacts to Public.

Accident/Event Scenario	PUREX & Tunnels	Building 324	K Reactors	SSE Reactors	B Plant	U Plant	REDOX	PFP
Seismic (0.2 g)	0.170	3	<0.01	<0.01	<0.02	<0.01	0.094	7.3
Partial building collapse	<0.02	NR	NR	NR	<0.01	NR	NR	NR
Crane /equipment drop	<0.01	NR	NR	NR	<0.01	<0.01	<0.02	0.85
Waste handling accidents	<0.01	79	NR	NR	NR	NR	NR	0.73
Fires	<0.05	1	<0.01	<0.01	<0.01	0.424	<0.02	5.9
Explosions	NR	7	NR	NR	NR	NR	NR	2.0-2.4

3.5. OPERATING FACILITY EVALUATION UNITS

The Hanford Site contains many facilities that are currently in active operations. These facilities are spread across the site and include many facilities to aid in cleanup, including both storage and treatment operations. Other types of onsite operating facilities are used to conduct research and testing for DOE programs.

An evaluation has been completed on the current condition and proposed actions of the operating facility evaluation units that are part of the SWOC, liquid waste TSD, and other facilities with ongoing activity and operations. An additional evaluation unit, the “Retained Facilities,” includes a summary in this section, but does not have an accompanying EU evaluation within the Appendices. Figure 3-83 is a map of the Hanford Site showing the location of each of these facilities, with stars identifying the EUs evaluated as part of the final report.

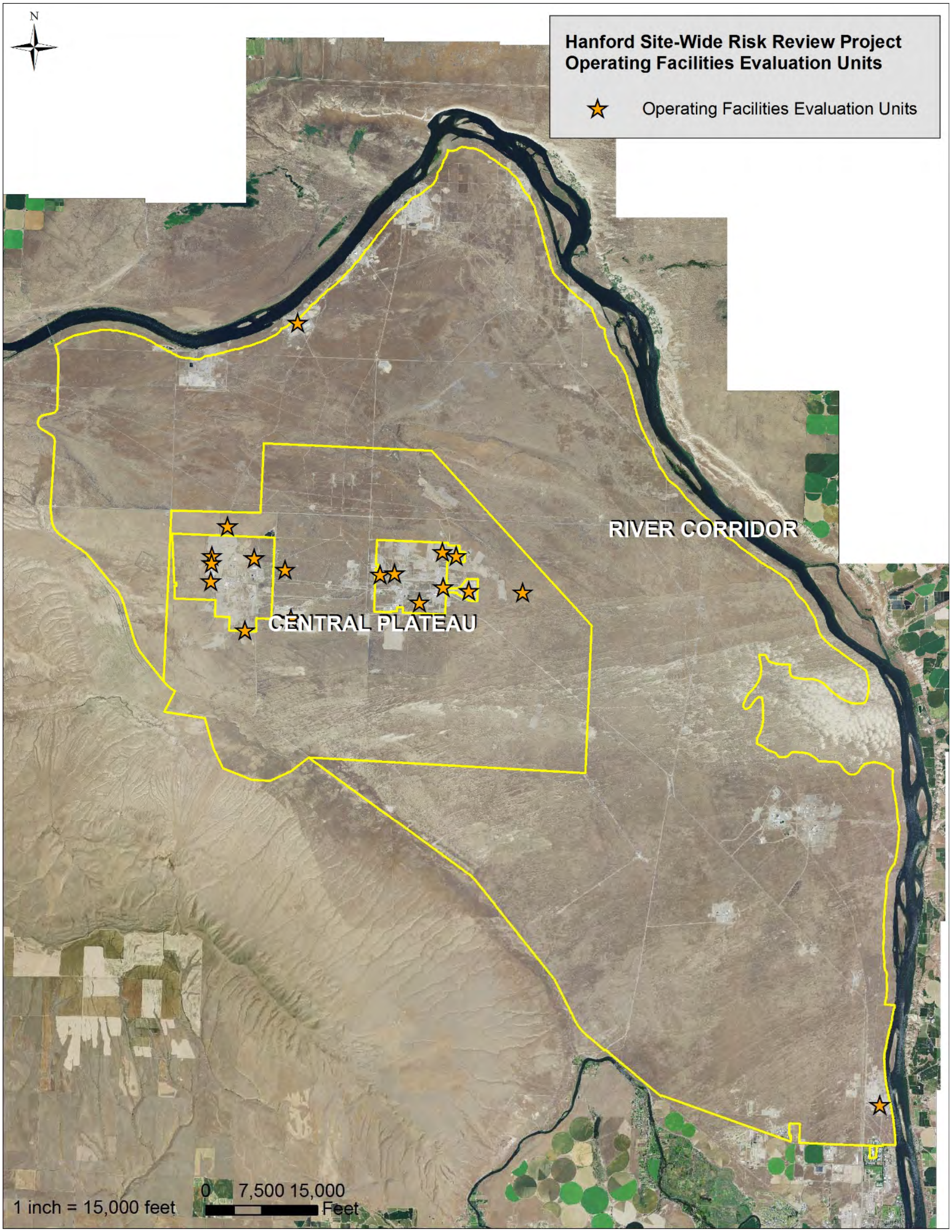

Figure 3-83. Map of operating facilities with Hanford.

DESCRIPTION OF OPERATING FACILITIES

The following are short overview summaries of the following Hanford operating facility group of EUs:

- K-West Basin Sludge (RC-OP-1)
- Retained Facilities (RC-OP-2)
- CWC (CP-OP-1)
- T Plant (CP-OP-2)
- WESF (CP-OP-3)
- WRAP (CP-OP-4)
- CSB and ISA (CP-OP-5)
- ERDF (CP-OP-6)
- IDF (CP-OP-7)
- Mixed Waste Trenches (CP-OP-8)
- Naval Reactors Trench (CP-OP-9)
- 242-A Evaporator (CP-OP-10)
- ETF and LERF (CP-OP-11 (includes CP-OP-16)
- TEDF (CP-OP-12)
- SALDS (CP-OP-13)
- WTP (CP-OP-14)
- 222-S Laboratory (CP-OP-15)
- WSCF (CP-OP-17)

K-WEST BASIN SLUDGE (RC-OP-1)

The K-East and K-West Basins (Figure 3-84) were constructed in the early 1950s to support K Reactor operations. After irradiation, fuel was pushed from the horizontal fuel channels in the reactors into the discharge chutes and then sorted, canned, and queued underwater in the basins. This process allowed for decay of radionuclides with short half-lives prior to reprocessing the fuel at either the 202-S REDOX or the 202-A PUREX facilities for plutonium and uranium recovery. The basins originally had a 20-year design life and were deactivated when the K-West and K-East Reactors were shut down. The K-West Basin was reactivated later as supplemental storage for irradiated N Reactor fuel. The basin superstructures are not sealed from the environment, which allowed sand, dirt, and organic material (weeds, bugs, etc.) to be deposited in the basins.

Figure 3-84. K-West Basin sludge.

Current Status and Interim Cleanup: The present condition of the K-West Basin Sludge Project is safe storage of K-West sludge and sludge retrieved from K-East basin in engineered containers in the K-West Basin. Typical operations in the basin include the operation of the water treatment system; management of fuel fragments; retrieval, storage, movement, and containerization of sludge; sorting and removal of debris (e.g., dust and sand); removal and disposition of equipment no longer in use; handling and interim storage of waste; and the construction of the K-West Basin Annex, which will house the Engineered Container Removal and Transfer System (ECRTS), the next phase of the K-West Basin Sludge Project.

Primary Contaminants: The sludge in the K-West Basin is classified as remote handled TRU. This waste consists primarily of sludge retrieved from the K-East Basin and contains aluminum cladding shards, oxidized fuel, and metal fuel particles as well as windblown sand and environmental debris, spalled concrete from the basin walls, iron and aluminum corrosion products, and ion exchange resin beads. The liquid was also removed from K-East basin and crews have completed demolition of the K-East basin structure. Sludge retrieved from the K-West Basin floor and the pit sludge stream prior to the retrieval and packaging of spent nuclear fuel for its removal, iron and aluminum corrosion products, flexible graphite, limited amounts of uranium oxides, and uranium fuel particles.

Table 3-75 and Table 3-76 list the primary radionuclide and chemical contaminants present and estimated quantities in the K-West Basin Sludge (RC-OP-1) EU**.**

Primary Risks: The primary or highest risks to Facility Workers and Co-located Persons at the K Basins during the current phase are (1) deflagration of accumulated hydrogen that has been generated through radiolysis and fuel corrosion accumulating in the headspace of the annular filter vessel while the Integrated Water Treatment System is out of service for an extended period (a leak allows air to enter, and a deflagration results); and (2) industrial accidents that might cause a fire. The hazardous operations study for the ECRTS phase identified 13 events that are anticipated and have high consequences, including uncontrolled releases from initiating events.

Table 3-75. KW Basin Sludge (RC-OP-1) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	2,100
Carbon-14	A	NR[b]
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	13,000
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	15,000
Strontium-90	B	17,000
Technetium-99	A	9.0
Uranium-Total Rad[d]	B	17

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-76. KW Basin Sludge (RC-OP-1) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Final Cleanup and Disposition: Cleanup of the K-West Basin Sludge Project involves closing several facilities: K-West Basin, K Basin Modified Annex, T Plant, and the future sludge treatment system facility.

In terms of the K-West Basin, the removal of sludge is integral to the D&D process. When the sludge has been removed from the K-West Basin, the K-East and K-West Basins will continue with D&D procedures, including the K Basin Modified Annex.

At the conclusion of the ECRTS activities, the sludge will be stored in T Plant in the sludge transportation and storage containers. These will eventually be removed from T Plant for Phase 2 of sludge processing, from which point the treated and packaged sludge will be stored and eventually shipped to WIPP. The emptied remaining sludge transportation and storage containers will be disposed of at a location TBD.

RETAINED FACILITIES (RC-OP-2)

Current Status and Interim Cleanup: The four complexes within the 300 Area of the Hanford Site, referred to as "Retained Facilities" for this review, include the 318, 325, 331, and 350 complexes—all of which support the long-term Hanford Site mission of environmental cleanup and restoration. Currently, these four complexes support the long-term mission is to support the Hanford Site environmental

cleanup and restoration activities.

Figure 3-85. Radiochemical Processing Laboratory [Building 325].

The 318 Building facility was originally a test reactor facility and was converted to the Radiological Standards and Calibration Laboratory in 1984. The Radiological Standards and Calibration Laboratory at PNNL performs instrument and dosimetry calibrations, maintains reference standards necessary to trace the Hanford Site programs and other research programs to national standards, and conducts performance evaluations to qualify the health physics instrumentation. The work routinely includes calibrations of personnel dosimeters, health physics instrumentation, and radioactive photon-, neutron-, beta- and alpha-particle sources. Radiation and Health Technology, a part of PNNL, occupies Building 318 and 331. The 331 Building is used for high dose studies and the performance of in vivo measurements of radioactive materials in the human body. Several of the rooms are equipped with specialized detectors for measuring radioactive materials.

Also known as the Radiochemical Processing Laboratory (Figure 3-85), the Building 325 is located in Hanford's 300 Area. It provides space for radiochemical research to support Hanford projects and programs. Current work at the facility includes analytical activities related to radioactive and hazardous waste, nuclear fuel, work associated with the Hanford Site characterization and remediation effort, tritium extraction and permeation tests, and medically usable radioisotope studies.

Building 350 on the Hanford Site is used as an operations and maintenance facility that includes a paint shop, storage building unit, oil storage facility, and a maintenance shop. Building 350 supports Buildings 318, 325, and 331.

Primary Contaminants: Contaminant inventories were not tracked for the Retained Facilities

Primary Risks: Primary risks and hazards were not evaluated for the Retained Facilities

Final Cleanup and Disposition: At present, there are no specific plans for D&D of these facilities.

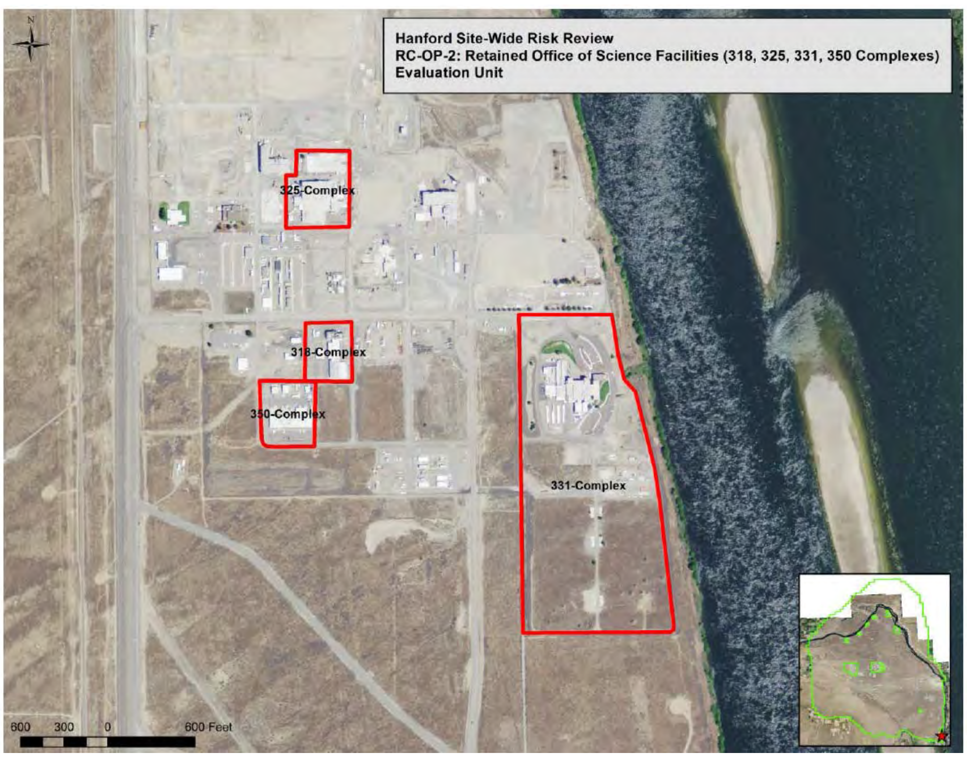

Figure 3-86. RC-CP-2 Retained Facilities site location map.

CENTRAL WASTE COMPLEX (CP-OP-1)

Current Status and Interim Cleanup: The CWC (Figure 3-87) provides storage, inspection (as required), limited processing, and staging for waste containers that are awaiting waste processing operations or disposal at other waste management facilities. The CWC receives waste from both onsite and offsite generators. Four types of waste are processed or stored at the CWC: low-level radioactive waste, mixed low-level radioactive waste, TRU waste, and TRU mixed waste. The CWC can receive, as necessary, unvented containers from retrieval operations for staging prior to venting (for example, at T Plant).

Personnel receive and inspect waste packages at the Waste Receiving and Staging Area. In accordance with all applicable procedures, transport offloading operations are performed using handtrucks, forklifts, or cranes operated by qualified personnel. Packages are transferred from the offloading area to the appropriate CWC storage building or other storage area. Alternatively, waste packages may be received, inspected, and unloaded at the specific CWC building or storage area where the waste would be stored. Typical stored waste packages include 208-L (55-gal) drums; 322-L (85-gal) overpacks; and fiberglass-reinforced plywood, plywood, or metal boxes. Atypical packages include, but are not limited to, radioisotopic thermoelectric generators, vault tank filter assemblies, blanked-off gloveboxes, overpacks, and pipe overpacks in 208-L (55-gal) drums.

Primary Contaminants: In the *Master Documented Safety Analysis for Solid Waste Operations Complex* (HNF-14741), the bounding drum and array analysis assumptions of the DOE-STD-3009-2014 and SARAH (HNF-8739) are used. In that bounding drum, the radionuclides are assumed to be Pu-238, Pu-239 (more than 80% by activity), Pu-240, Pu-241, and Pu-242, along with the Pu decay product Am-241. Debris from D&D and operational wastes, notably from PNNL and tank farms, WRAP, Low-Level Burial Grounds (LLBG), and T Plant also contain fission products (Cs-137, Sr-90). However, the majority of presently stored waste is classified as remote handled or contact handled TRU. The waste also contains some RCRA-classified dangerous waste as well as pyrophoric materials including sodium.

Figure 3-87. Central Waste Complex.

Table 3-77 and Table 3-78 list the primary radionuclide and chemical contaminants present and estimated quantities in the Central Waste Complex (CP-OP-1) EU**.**

Primary Risks: The primary hazards at the CWC are radiological and chemical hazards to the workers, both remediation and co-located, as well as the environment, including near-surface soils and groundwater. Several waste containers at the facility have been determined to have leaks or have the potential to develop leaks in the near future. Leaking waste containers are the primary source of the hazards described above. Along with potential leaks, there is an exposure pathway for some radiation to workers performing daily activities around the waste. Accident scenarios with High consequences to Co-Located Persons have an unlikely frequency. These include two fire scenarios (small inside fire, small outside fire) and a seismic building collapse (design basis seismic event).

Final Cleanup and Disposition: Addendum H of the RCRA Permit for the CWC outlines closure activities as follows: (1) remove waste inventory, (2) decontaminate structural surfaces and equipment, (3) analyze decontamination waste to determine proper methods of treatment/disposal, and (4) dispose of decontamination waste based on results of waste analysis. The cleanup phase is expected to take 180 days. The DSA states that D&D and cleanup activities have yet to be planned. Future uses would await post-D&D condition assessment; however, CWC is located on the Central Plateau, an area presently scheduled for continued federal custody.

Table 3-77. CWC (CP-OP-1) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[(b)]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[(c)]	D	53,000
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[(d)]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-78. CWC (CP-OP-1) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	11,000
Cyanide	B	NR
Chromium	B	2,000
Chromium-VI	A	1.4
Mercury	D	NR
Nitrate	C	2,600
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

T PLANT (CP-OP-2)

Current Status and Interim Cleanup: T Plant (Figure 3-88) is located in the 200 West Area, and is used as a decontamination, maintenance, and storage facility for several solid waste management projects. In addition to the buildings, there are several storage pads both indoor and outdoor that store LLW. The T Plant Complex includes several major buildings, storage buildings and outside storage areas, as well as a rail tunnel. The main building, 221-T, is a reinforced concrete structure that was the location of the original reactor fuel reprocessing facility that began operation in 1944 using the bismuth phosphate chemical separation process. Fuel reprocessing was discontinued in 1965 and the T Plant mission changed to primarily repackaging, treatment, decontamination, and storage of LLW, LLMW, TRU, and remote handled wastes. In the near-term, T Plant will become the intermediate storage area for the K Basins Sludge while it awaits further treatment and disposition.

Current T Plant operations consist primarily of repackaging, treatment, decontamination, and storage of LLW, LLMW, TRU, and remote handled wastes. The facility may also be used for equipment repair and maintenance, as required. In the near future, T Plant will receive the sludge from the K Basins in sludge transportation and storage casks (STSCs). This phase of operation will consist of storage of the material, along with annual monitoring for water loss and hydrogen concentration.

Primary Contaminants: The T Plant operations normally stage or store about 500 drums or 100 standard waste boxes at any given time, at various receiving and storage areas and pads. Pieces of equipment awaiting decontamination, disposal, or storage can be staged in several cells. STSCs and large diameter containers containing radioactive sludge may be brought to the T Plant for storage. In

Figure 3-88. T Plant.

addition, several systems at the T Plant, such as decontamination waste systems and ventilation systems including HEPA filters, are contaminated with radioactive material—not to mention legacy contamination in deactivated systems from 20 years of nuclear fuel processing.

Mixed waste containers contain varying amounts of hazardous chemicals, including corrosive, reactive, and toxic materials. The hazardous material inventory in the Preliminary Hazards Analysis[121] indicates the presence of large amounts of caustics and acids. There are three hazardous material storage modules at T Plant for segregated storage of some of these hazardous materials.

Table 3-79 and Table 3-80 list the primary radionuclide and chemical contaminants present and estimated quantities in the T Plant (CP-OP-2) EU**.**

Primary Risks: There are several events postulated in the DSA (HNF-14741) that have a high impact on the Co-located Person and the Facility Worker related to a postulated fire event. All events postulated for T Plant have a Low consequence rating to the Public.

Final Cleanup and Disposition: In the near-term future, T Plant will receive STSCs with the K Basins sludge, as discussed above. At present, there are no specific plans for D&D of this facility. The 200 West Area is slated to meet Industrial/Exclusive Land Use requirements after ultimate D&D.

T Plant is an historic site that is eligible for inclusion in the Manhattan Project National Historical Park Act, which establishes the park at Hanford Site (National Defense Authorization Act of 2015, H.R. 3979, section 3039 [2014]). The National Park Service and DOE have agreed to consider including the T Plant in the park at the earliest feasible time after current mission use is complete (US Department of the Interior, National Park Service 2017).

[121] Fluor Hanford 2002 (HNF-13179, Rev. 0 , *Hazards Analysis for the Waste Management Facilities*); CHPRC 2012a (HNF-15589, Rev. 8, *Consolidated Hazards Analysis for the Master Documented Safety Analysis*)

Table 3-79. T Plant (CP-OP-2) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	34
Carbon-14	A	0.012
Chlorine-36	A	0.0
Cobalt-60	C	0.24
Cesium-137	D	760
Europium-152	D	0.0011
Europium-154	D	0.10
Tritium	C	1.4
Iodine-129	A	0.00032
Nickel-59	D	0.0041
Nickel-63	D	0.32
Plutonium-Total Rad[c]	D	51
Strontium-90	B	180
Technetium-99	A	0.31
Uranium-Total Rad[d]	B	0.21

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-80. T Plant (CP-OP-2) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	0.0
Carbon Tetrachloride	A	0.0
Cyanide	B	0.0
Chromium	B	2,600
Chromium-VI	A	0.0
Mercury	D	0.0063
Nitrate	C	62,000
Lead	D	180
TBP	---	0.0
Trichloroethene	B	0.0
Uranium	B	140

a. Inventory details and references are found in the corresponding EU appendix.

WASTE ENCAPSULATION AND STORAGE FACILITY (CP-OP-3)

The WESF (Figure 3-89) was designed and constructed to process, encapsulate, and store Sr-90 and Cs-137 separated from wastes generated during the chemical processing of used fuel on the Hanford Site. Hanford produced 1,577 cesium capsules and 640 strontium capsules for a total of 2,217 capsules. However, during the years since their production, some capsules have been removed from WESF and sent elsewhere for a range of purposes under a range of conditions. The capsules that have been returned are in storage currently (1,959 total capsules). A total of 187 capsules were not returned to WESF; these capsules were deconstructed and the material inside was vitrified in glass logs, and the remaining 71 capsules were destructively examined.

Figure 3-89. Waste Encapsulation Storage Facility.

The construction of WESF lasted from 1971 to 1973. Cesium processing was shut down in October 1983 and strontium processing was shut down in January 1985. Final overall process shutdown was accomplished in September 1985.

Current Status: Current WESF operations consist of essentially one task: safely storing cesium and strontium capsules within a series of interconnected pools within the WESF building. The current scope of the WESF mission is limited to facility maintenance activities: inspection, decontamination, and movement of capsules; and storage and surveillance of capsules.

Primary Contaminants: Table 3-81 and Table 3-82 provide the currently estimated primary radiological contaminates at WESF (in curies). The majority of radioactive material (cesium chloride and strontium fluoride) at WESF is confined in doubly encapsulated stainless steel capsules. WESF currently stores 1,335 cesium capsules, 23 of which are single-contained Type W overpack capsules, and 601 strontium capsules in pool cells located in the 225-B Building. The radioactivity level contained within the Cs capsules is approximately 68 MCi (34 MCi of Cs-137 and 34 MCi of Ba-137m). The radioactivity level contained within the Sr capsules is approximately 30 MCi (15 MCi of Sr-90 and 15 MCi of Y-90). Contamination within the hot cells and connecting ventilation is approximately 300 kCi. The hot cells A through F (G is clean) contain around 55 kCi of Cs and 43 kCi of Sr. The connecting ventilation and ductwork to the hot cells contain around 2,800 Ci of Cs and 107,500 Ci of Sr.

Table 3-81. WESF (only Cs/Sr capsules) (CP-OP-3) radionuclide inventory[a].

Radionuclides	Group	Cs/Sr Capsules, Ci	Hot Cells, Ducts, Ci	Total Curies (Ci)
Americium-241	D	NP	NP	NR[b]
Carbon-14	A	NP	NP	NR
Chlorine-36	A	NP	NP	NR
Cobalt-60	C	NP	NP	NR
Cesium-137	D	34,000,000	57,000	34,000,000
Europium-152	D	NP	NP	NR
Europium-154	D	NP	NP	NR
Tritium	C	NP	NP	NR
Iodine-129	A	NP	NP	NR
Nickel-59	D	NP	NP	NR
Nickel-63	D	NP	NP	NR
Plutonium-Total Rad[c]	D	NP	NP	NR
Strontium-90	B	15,000,000	150,000	15,000,000
Technetium-99	A	NP	NP	NR
Uranium-Total Rad[d]	B	NP	NP	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-82. WESF (only Cs/Sr capsules) (CP-OP-3) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: The primary current risk is that the safe containment of the cesium chloride and strontium fluoride within the capsules could be compromised under design basis accident and beyond design basis accident conditions if the pool cells were to lose water. The second most potentially significant event that could impact human health is a hydrogen explosion in hot cell G and the connecting K3 duct that releases contamination from the hot cells and connecting contaminated ventilation ducts, thereby releasing contaminants that become airborne and also cause external gamma radiation doses.

Final Cleanup and Disposition: Future plans are divided into two phases. The first phase is to upgrade the ventilation system and stabilize the hot cell contaminants. The long-term, tentative plan is to remove the Cs and Sr capsules from the pools by packaging the capsules into dry storage overpacks and storing them on the Hanford Site. This movement into dry storage will allow the adjacent building (B Plant) to proceed with D&D plans tied to a TPA milestone.

WRAP (CP-OP-4)

Current Status and Interim Cleanup: The Waste Receiving and Processing Facility in Hanford's 200 West Area was constructed to process drums and boxes of lLLW and TRU waste for permanent disposal; these drums and boxes were placed in burial grounds in the 1970s and 1980s. WRAP (Figure 3-90) crews inspect, treat, characterize, and re-package, if necessary, these drums and boxes of waste. The main objective of WRAP is to confirm contents in waste, repackage (if necessary), certify, and/or treat waste for shipment to a treatment, storage, and/or disposal facility. At present, WRAP is in standby and no new shipments of waste are arriving.

Figure 3-90. Aerial view of WRAP

During active operation, waste containers determined by nondestructive evaluation to contain restricted waste (or those requiring additional verification) will be opened, sorted, sampled, and treated when confined by a process enclosure. Then, the restricted waste can be either processed in WRAP so that it was compliant or repackaged for storage, pending treatment at an appropriate facility. The remaining compliant waste would be repackaged, certified, and shipped for disposal.

Primary Contaminants: TRU, Mixed TRU, LLW, and MLLW waste were processed in the WRAP facility. The following wastes may be managed at the WRAP Operating Unit Group:

- Dangerous or mixed waste that is generated from processes at the Hanford Site.
- Waste that is specifically identified in Section II, paragraph 8 of the Settlement Agreement re: Washington versus Bodman, Civil No. 2:30-cv-05018-AAM, January 6, 2006.

Table 3-83 and Table 3-84 list the primary radionuclide and chemical contaminants present and estimated quantities in the WRAP (CP-OP-4) EU**.**

Primary Risks: There is one fire event considered in the DSA that would lead to a High rating for the Facility Worker and Co-located Person. This same event would produce an estimated Low consequence to the Public.

Final Cleanup and Disposition: WRAP is currently in

Figure 3-91. WRAP facility.

operational standby (Figure 3-91). In the near-term, the WRAP facility could be reopened for testing and repackaging of waste. At present, there are no specific plans for D&D of this facility. The 200 West Area is slated to meet Industrial/Exclusive Land Use requirements after ultimate D&D.

Table 3-83. WRAP (CP-OP-4) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	29
Carbon-14	A	0.0
Chlorine-36	A	0.0
Cobalt-60	C	0.0
Cesium-137	D	0.0
Europium-152	D	0.0
Europium-154	D	0.0
Tritium	C	0.0
Iodine-129	A	0.0
Nickel-59	D	0.0
Nickel-63	D	0.0
Plutonium-Total Rad[c]	D	NR[b]
Strontium-90	B	0.0
Technetium-99	A	0.0
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-84. WRAP (CP-OP-4) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	0.15
Carbon Tetrachloride	A	71
Cyanide	B	0.0
Chromium	B	0.081
Chromium-VI	A	0.0
Mercury	D	0.013
Nitrate	C	0.0
Lead	D	190
TBP	---	0.078
Trichloroethene	B	0.0078
Uranium	B	0.0

a. Inventory details and references are found in the corresponding EU appendix.

CANISTER STORAGE BUILDING (CSB) AND THE INTERIM STORAGE AREA (ISA) (CP-OP-5)

Figure 3-92. Canister Storage Building.

Current Status and Interim Cleanup: The Canister Storage Building (Figure 3-92) is a 42,000 ft^2 (3,906 m^2) facility located in the 200 East Area; it stores about 2,300 tons (2,086 metric tons) of spent nuclear fuel, packaged in approximately 400 multi-canister overpacks (MCOs), contained within in 220 carbon steel tubes, in a below-grade concrete vault. The irradiated fuel was cleaned, packaged, dried, and relocated to the CSB beginning in 2004 to provide safe interim storage in a consolidated location. CSB has a design life of 40 years, and will safely store the MCOs until they are permanently placed in a national repository for HLW. Adjacent to the CSB is the ISA, which also contains spent nuclear fuel packaged in various containers. This spent nuclear fuel will be subsequently repackaged and sent to a national repository for HLW. Currently, CSB stores scrap/fuel MCOs and shippingport spent fuel canister (SSFC) MCOs (no found fuel containers (FFCs) or transuranic multiple barrier containers [TMBCs]). ISA stores only eight (8) types of spent fuel: FFTF, Neutron Radiography Facility, Training Reactor Isotopes General Atomics (TRIGA), Oregon State University (OSU) TRIGA, Commercial Light-Water Reactor, single-pass reactor (SPR)/N Reactor, EBR-II, and Los Alamos Molten Plutonium Reactor Experiment.

CSB is authorized to receive, sample, weld, and store MCOs containing K Basin fuel assemblies, scrap pieces and associated material, and SSFC containing Shippingport Pressurized Water Reactor Core 2 blanket fuel assemblies. CSB is also authorized to receive, handle, weld, and temporarily store SPR/N-Reactor type fuels in FFCs, and ceramic oxide fuel specimens from General Electric Vallecitos Nuclear Center in TMBCs. The CSB Facility provides sampling, welding, monitoring, and interim storage of MCOs; interim storage of SSFCs; and receiving, handling, welding, and temporary storage of FFCs and TMBCs. CSB is not authorized to transport MCOs out of CSB facility. Currently, CSB stores scrap/fuel MCOs and SSFC MCOs (no FFCs or TMBCs). The FFCs and TMBCs will be transferred and stored at a later date.

The 200 Area ISA is a separate facility located inside the CSB yard area and is missioned with safely storing eight different authorized dry storage systems: FFTF fuel, Neutron Radiography Facility TRIGA fuel,[122] OSU TRIGA fuel, Commercial Light-Water Reactor fuel, SPR/N Reactor-Type fuels, EBR-II casks, General Electric Vallecitos fuel, and Los Alamos Molten Plutonium Reactor Experiment fuel. The ISA is a relatively simple facility consisting of boundary security fences with gates, perimeter lighting, and concrete and gravel pads on which the dry storage containers are placed. The 200 Area ISA is a radiological material and radiation area, and is a protected area for physical security purposes. The 200 Area ISA is nominally 240,000 ft^2 and is located just west of the CSB, and will operate up to 40 years until materials are shipped offsite to a disposal facility.

Primary Contaminants: Any radionuclides present at CSB and ISA are associated with Spent Nuclear Fuel.

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[122] TRIGA = Training Reactor Isotopes, General Atomics (registered trademark name): http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/27/044/27044785.pdf, p.5

Table 3-85 and Table 3-86 list the primary radionuclide and chemical contaminants present and estimated quantities in the Canister Storage Building (CSB) and the Interim Storage Area (ISA) (CP-OP-5) EU.

Table 3-85. CSB (CP-OP-5) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	1.0E+06
Carbon-14	A	1,300
Chlorine-36	A	NR[(b)]
Cobalt-60	C	10,000
Cesium-137	D	2.2E+07
Europium-152	D	1,900
Europium-154	D	270,000
Tritium	C	61,000
Iodine-129	A	12
Nickel-59	D	72
Nickel-63	D	7,900
Plutonium-Total Rad[(c)]	D	1.7E+07
Strontium-90	B	1.6E+07
Technetium-99	A	5,000
Uranium-Total Rad[(d)]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-86. CSB (CP-OP-5) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	4,900

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: CSB: There are three accident scenarios resulting in High consequence levels to the Co-located Person in the DSA. Unmitigated dose to the MOI for these three accident scenarios was rated as ND.

ISA: Unmitigated doses to the Co-located Person for the two analyzed accident scenarios resulted in a Low to ND rating related to accidents involving material stored at the ISA. The human health ratings for the two scenarios were considered ND for the Public.

Final Cleanup and Disposition: At present, there are no specific plans for D&D of this facility. The spent nuclear fuel, stored in these facilities, is in sealed containers, and when these containers are removed, residual contamination of the facility should be minimal. The 200 East Area is slated to meet Industrial/Exclusive Land Use requirements after ultimate D&D.

ERDF (CP-OP-6)

Figure 3-93. Aerial view of ERDF.

The ERDF (Figure 3-93) is composite-lined waste disposal facility located on the Central Plateau area of the Hanford Site between the 200 West and 200 East Areas.[123] ERDF was constructed to permanently dispose of all wastes generated by remediation of Hanford Site past-practice and CERCLA waste sites in an environmentally protective manner. Waste disposal at ERDF predominantly consists of high-volume slightly contaminated soils and debris delivered by truck from remediation sites which is then spread in ERDF cells and compacted to minimize void space and limit future waste volume subsidence. However, other demolition wastes are also placed in ERDF, and when necessary, wastes are grouted to fill void spaces that could lead to compression and settlement over the long term.

ERDF is lined with a state-of-the-art double composite barrier system that has been shown to transmit virtually no leakage. The final cover proposed for ERDF also employs a composite barrier and an overlying water balance cover that will result in *de minimis* percolation. This high level of containment is complemented by a thick vadose zone (geologic zone above the water table) that is 80 to 100 m thick and provides the greatest possible distance to the water table compared to other Hanford waste sites. In addition, because ERDF is located in the middle of the Central Plateau, contaminants from ERDF have the longest distance to travel to Columbia River.

Current Status: ERDF was constructed in a modular fashion so that additional disposal space can be built as needed. The first eight disposal cells were built in pairs located at the west end of the site. Each cell is approximately 152 m by 152 m at the bottom, approximately 21 m deep, and has a 3:1 (horizontal to vertical ratio) side slope that extends 64 m horizontally from the base of the cells. The latest cell

[123] ERDF is constructed to RCRA sub-title C design standards but is permitted under CERCLA as a corrective action management unit.

construction toward the east (supercells 9 and 10) combines the cell pairings into larger cells, approximately the same size as each two-cell pair. Cells 1 through 4 have been filled, cells 5 through 8 are nearly filled, and supercells 9 and 10 are receiving waste. As of July 2013, approximately 13.6 million metric tons of waste has been disposed at ERDF since the facility started operations in July 1996 (an average of 800,000 metric tons per year).

Primary Contaminants: Table 3-87 and Table 3-88 includes the currently estimated primary radiological contaminants at ERDF (in curies) and total uranium (in kg) and the amounts projected at closure.

Table 3-87. ERDF (CP-OP-6) radionuclide inventory[a] (2014) and projected at closure.

Radionuclides	Group	Curies (Ci) – (2014)	Curies (Ci) – at closure
Americium-241	D	550	
Carbon-14	A	1,900	< 45,000
Chlorine-36	A	0.0	< 300
Cobalt-60	C	5,500	< 30,000
Cesium-137	D	15,000	< 2,000,000
Europium-152	D	4,800	
Europium-154	D	1,400	
Tritium	C	7,800	< 160,000
Iodine-129	A	0.019	< 10
Nickel-59	D	190	
Nickel-63	D	14,000	< 110,000
Plutonium-Total Rad[c]	D	5,500	
Strontium-90	B	11,000	< 1,200,000
Technetium-99	A	21	< 860
Uranium-Total Rad[d]	B	100	

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-88. ERDF (CP-OP-6) chemical inventory[(a)] (2014) and projected at closure.

Chemical	Group	kg – (2014)	kg at Closure
Beryllium	---	NR	
Carbon Tetrachloride	A	NR	
Cyanide	B	NR	
Chromium	B	NR	
Chromium-VI	A	NR	
Mercury	D	NR	
Nitrate	C	NR	
Lead	D	NR	
TBP	---	NR	
Trichloroethene	B	NR	
Uranium	B	200,000	< 870,000

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: The primary risks at ERDF are associated with radiation exposure through worker contact with waste of much higher activity than expected when unloading trucks and placing waste in the disposal cell, and physical accidents associated with trucks and machinery within or entering/exiting the ERDF area.

Final Cleanup and Disposition: ERDF is intended for permanent disposal and isolation of wastes. No cleanup approaches are needed after the facility is filled and the final cover is installed. The only "clean up" activity is installation of the final cover.

INTEGRATED DISPOSAL FACILITY (CP-OP-7)

Current Status and Interim Cleanup: Located near the center of the 586-square-mile Hanford Site is the Integrated Disposal Facility (IDF) (Figure 3-94), which is a landfill similar to the Environmental Restoration Disposal Facility (CP-OP-6). However, IDF is built to a much smaller total capacity (approximately 1 million cubic meters) than ERDF[124]. The IDF in its current configuration was completed in April of 2006 and consists of two disposal areas called cells, although the facility can be expanded as needed to a total of six cells. One of the first two current cells is designed to accept mixed low-level wastes, possibly including the treated low-level/low-activity waste processed through the Hanford Waste Treatment and Immobilization Plant (WTP). The second current cell is being considered to accept low-level waste that has come from Hanford cleanup activities that not go through the WTP.

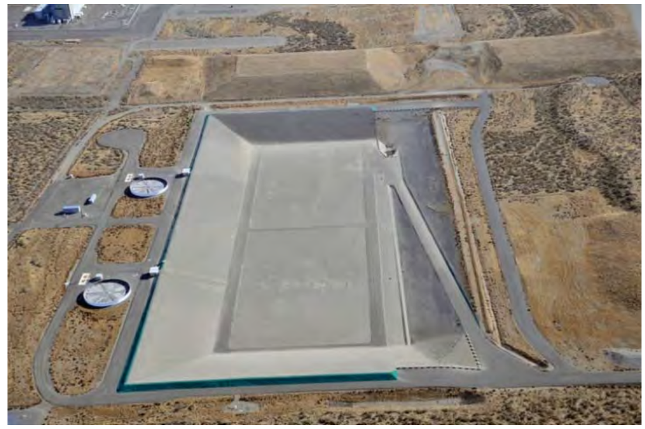

Figure 3-94. Integrated Disposal Facility (IDF).

As at ERDF, the dimensions of the IDF cells are massive; the current facility is about 1500 feet wide, 765 feet long, and 42 feet deep with a capacity of nearly 165,000 cubic meters. A seven-foot-thick liner at the base of the IDF is designed to catch any liquid that may seep through the waste to prevent contamination of the soil beneath the disposal cells. Any liquid that reaches the liner will be removed and taken to a facility for treatment. While ERDF has been accepting waste for several years, the IDF has not yet done so.

Primary Contaminants: The IDF will receive low-level waste (LLW) and mixed low-level waste (MLLW) that will be generated by the WTP resulting from treatment processes (RPP-ENV-58562, Rev. 2). The WTP is not yet operating and no waste has been emplaced in the IDF to date. Anticipated IDF waste streams include:

- Immobilized Low-Activity Waste (ILAW) glass[125]
- Low-Activity Waste (LAW) melters
- Secondary Solid Waste[126]
- Effluent Treatment Facility (ETF)-generated secondary solid waste.

Additional waste streams are also expected to be disposed of at IDF that will not be a result of the WTP process. These additional waste streams include:

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[124] http://www.hanford.gov/page.cfm/IDF

[125] The selection process for the Supplemental LAW treatment process is currently underway and could, like Secondary solid waste, use a cementitious waste form for a significant amount of the low activity fraction of tank waste at the Hanford Site. However, this option was not considered in the development of the inventory used in this evaluation. It is considered unlikely that the selection of a cementitious waste form would have an order-of-magnitude impact on the results of the evaluation in this Appendix where the rough-order-of-magnitude metric is that posed for the Risk Review (CRESP 2015a).

[126] Hanford secondary waste includes a wide variety of waste: failed or replaced equipment, decontamination, protective clothing, and HEPA filters from common sources; evaporator condensate from tank farms; and routine solid waste, special case solid wastes (e.g., failed melters), and (solidified) liquid wastes from waste treatment facilities. (http://www.hanford.gov/files.cfm/EducationalForumSlides.pdf)

- Fast Flux Test Facility (FFTF) decommissioning waste
- Secondary waste management LLW and MLLW
- Onsite Non-Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) non-tank LLW and MLLW.

The primary contaminants listed in the Draft IDF Inventory Summary (RPP-ENV-58562, Rev. 2, Tables 10-1 and 10-2) include:

- *Radionuclides*: C-14, Cs-137/Ba-137m, tritium (H-3), I-129, Sr-90/Y-90, Tc-99, U-All isotopes, and Pu-All isotopes
- *Chemicals*: Cr/Cr-VI, Hg, nitrate (NO_3), Pb, and U-Total

Inventory information is provided in Table 3-89 and Table 3-90.

Primary Risks: When the IDF is in operation, hazards would potentially include industrial hazards, hazardous materials, radiological materials, radioactive and/or mixed waste, and physical hazards (HNF-39904, Rev. 4). However, because the IDF is currently in a ready-to-serve status awaiting permitting and authorization from DOE (RPP-20691, Rev. 1), no waste is being emplaced in the facility and thus the only risks to workers is from industrial risks (i.e., “slips, trips, and falls”) related to characterization and monitoring activities. The workforce involved with characterization activities (denoted a Facility worker) would thus have an unmitigated *Not Discernible* (ND) risk rating as would the Co-located Person and members of the Public.

Final Cleanup and Disposition: Closure and D&D risks and potential impacts will depend on final cleanup decisions and closure plans that have not been made and thus *insufficient information* (IS) is available to evaluate.

Table 3-89. IDF (CP-OP-7) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	NR
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU

c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-90. IDF (CP-OP-7) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Mixed Waste Trenches (CP-OP-8)

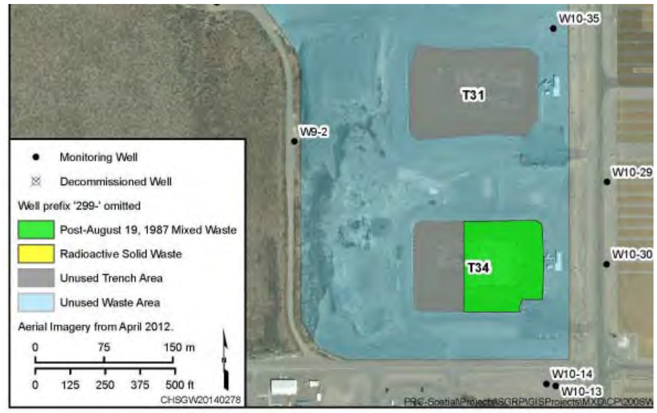

Figure 3-95. Mixed Waste Trenches.

Current Status and Interim Cleanup: The Mixed Waste Trenches (Trenches 31 & 34) (Figure 3-95) in the LLBG, are located in the 200 West Area, are part of the SWOC, which includes a combination of TSD operating unit groups consisting of the CWC, WRAP, and T Plant. Trenches 31 & 34 and the associated container storage units are located in the southern part of the 218-W-5 Burial Ground. These trenches provide storage and disposal for Land Disposal Restriction compliant mixed waste and treatment of certain waste (LLW and mixed low-level waste [MLLW]). The trenches are RCRA-compliant and incorporate a liner and leachate collection systems for the disposal of MLLW. The activities at these trenches, whether for LLW or MLLW, involve several common steps: waste transfer to a disposal trench area; waste receipt and tracking; container handling; inspection and survey; staging and disposal; trench construction, backfilling, and capping; stabilization and grouting; and waste treatment.

Waste acceptance processes for the LLBG Trenches 31 & 34 and the associated container storage units exist for newly generated waste, SWOC transfers (include T Plant, CWC, and WRAP facilities), Waste Retrieval Project (WRP) waste[127], LLBG Trenches 31 & 34 generated waste, and offsite generators. As of 2015, Trench 34 is partially filled and Trench 31 is still awaiting use.

Primary Contaminants: The first receipts were in 1986 for the Mixed Waste Trenches. Several different trench designs (cross-sections) have been constructed in this burial ground. Trench 34 contains post-August 19, 1987, RCRA and state-regulated MLLW. There is no retrievable TRU in this burial ground. The majority of disposed LLW and MLLW has occurred in the 200 West Area (124,094 m^3 [4,382,342 ft^3]) compared to the 200 East Area LLBGs (31,986 m^3 [1,129,575 ft^3]), as reported in calendar year 2014. Annual waste volume receipts continue to be in the range of about 100 to 1,000 m^3 (10,594 to 35,315 ft^3). MLLW has been stored and disposed in active LLBGs in various containers including drums and boxes made of steel, wood, and cardboard. Bulk contaminated equipment and soils have also been disposed in LLBG trenches.

Table 3-91 and Table 3-92 list the primary radionuclide and chemical contaminants present and estimated quantities in the Mixed Waste Trenches (CP-OP-8) EU.

[127] The LLBG Trenches 31 & 34 does not accept WRP waste transfers. WRP waste will be transferred and processed at other SWOC TSD units or an off-site TSD facility. Any acceptance of WRP waste at LLBG Trenches 31 & 34 will occur as newly generated waste or as a SWOC transfer (CHPRC 2012, p. 21).

Table 3-91. Mixed Waste Trenches (CP-OP-8) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	14
Carbon-14	A	0.86
Chlorine-36	A	0.0055
Cobalt-60	C	9,100
Cesium-137	D	5,800
Europium-152	D	10
Europium-154	D	8.9
Tritium	C	6,800
Iodine-129	A	0.0064
Nickel-59	D	85
Nickel-63	D	9,900
Plutonium-Total Rad[(c)]	D	310
Strontium-90	B	100,000
Technetium-99	A	140
Uranium-Total Rad[(d)]	B	NR[(b)]

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-92. Mixed Waste Trenches (CP-OP-8) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	120
Carbon Tetrachloride	A	350
Cyanide	B	0.82
Chromium	B	220
Chromium-VI	A	0.044
Mercury	D	250
Nitrate	C	860
Lead	D	470,000
TBP	---	1.2
Trichloroethene	B	27
Uranium	B	830,000

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: The following accidents are analyzed in the HA with only qualitative rankings of consequences provided.[128] Two accidents resulted with estimated High unmitigated impacts to Facility Workers and Co-located Persons and Low unmitigated impacts to a member of the Public.

Criticality accident: Exposure of workers to radiation due to criticality due to the any of the following postulated occurrences: relocation of fissile material due to movement, addition of reflector, introduction of moderator, operator error

Earthquake: Release of radioactive material from containers to environment due to earthquake.

Final Cleanup and Disposition: At present, there are no specific plans for D&D of this facility. No cleanup decisions have been made to remediate the 200-SW-2 OU, including the LLBG Trenches 31 & 34. Because the mixed waste trenches are RCRA-regulated facilities, they will require RCRA-clean closure standards to be met.

NAVAL REACTORS TRENCH (CP-OP-9)

Current Status and Interim Cleanup: The Naval Reactors Trench (NR Trench, also known as Trench 94) (Figure 3-96) is a part of the Hanford's 200 East Area. It receives and provides final disposition for decommissioned LLBG, defueled reactor compartments from nuclear-powered submarines and surface ships of the US Navy. To accommodate these large waste packages, the trench is about 15 m (50 ft) deep, 490 m (1,600 ft) long, and 120 m (400 ft) wide. Through the end of FY 2014, 127 reactor compartments have been disposed of in Trench 94. The NR Trench is currently receiving reactor compartments. The Department of the Navy and its contractors perform the reactor compartment transport and placement operations. The trench is managed as a mixed waste disposal unit by agreement with Ecology and has a Waste Permit. There are two main duties involved at Trench 94: *General Waste Management Duties*-- prepare and certify waste movement documentation for shipments of mixed waste (reactor compartments) on roadways; and *Landfill Management Duties*-- conduct weekly inspections of the landfill management and collect and transport groundwater samples.

Figure 3-96. Naval Reactors Trench.

Primary Contaminants: The NR Trench was designed for the receipt and final disposal of decommissioned, defueled reactor compartments from submarines and surface ships. The reactor compartments contain isotopes commonly found in activated metal, which is the primary waste material of reactor compartments contents. They include cobalt-60, niobium-94, and nickel-63; the most abundant contaminants were cobalt-60 and nickel-63. The primary radionuclide for dose consequence purposes is Co-60 (half-life of 5.2 years) from activation of the materials of reactor construction during power operations. Radiological contamination levels are low, and there is some hazardous waste

[128] CHPRC 2012a (HNF 15589, Rev. 8, Criticality (pages A-156, A-157), Earthquake (pages A-168, A-169), Fire (pages A-2, A-3), Spill (page A-115)).

contamination from PCBs. The reactor compartments are welded closed, and there is minimal risk of a release except through long-term (geological time) corrosion, by which time there will be only low levels of source term remaining—due to radioactive decay.

Table 3-93 and Table 3-94 list the primary radionuclide and chemical contaminants present and estimated quantities in the Naval Reactors Trench (CP-OP-9) EU**.**

Primary Risks: Only events postulated specifically for the Naval Reactors Trench in the HA are considered.[129] The following accidents are analyzed in the Hazards Assessment and specifically mention reactor compartments or Trench 94[130]: *Spill* - Reactor Compartments *Drop* - Release of surface contamination due to drop of Navy ship or sub-compartment in Trench 94 (Qualitative Ranking of Consequences: Co-located Person: Low; Public: Low) and *Spill - Package Contamination* - Exposure of worker to radiation due to external package contamination (Qualitative Ranking of Consequences: Co-located Worker: Low; Public: Low).

Final Cleanup and Disposition: The Naval Reactors Trench will continue to receive reactor compartments until the waste stream is exhausted. At present, there are no specific plans for the closure of this burial ground; however, it can be anticipated that it will be back-filled and capped similar to other shallow land burial facilities for LLW. The 200 East Area is slated to meet Industrial/Exclusive Land Use requirements after ultimate D&D.

Table 3-93. Naval Reactors Trench (CP-OP-9) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	2.2
Carbon-14	A	130
Chlorine-36	A	0.0056
Cobalt-60	C	1,000,000
Cesium-137	D	50
Europium-152	D	0.0
Europium-154	D	0.0
Tritium	C	1,100
Iodine-129	A	0.0029
Nickel-59	D	5,100
Nickel-63	D	960,000
Plutonium-Total Rad[(c)]	D	NR[(b)]
Strontium-90	B	20
Technetium-99	A	0.81
Uranium-Total Rad[(d)]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

[129] HNF 15589 Pages A-96 and A-109
[130] HNF 15589 Pages A-96 and A-109

Table 3-94. Naval Reactors Trench (CP-OP-9) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	0.0
Carbon Tetrachloride	A	0.0
Cyanide	B	0.0
Chromium	B	0.0
Chromium-VI	A	0.0
Mercury	D	0.0
Nitrate	C	0.0
Lead	D	1.2E+07
TBP	---	0.0
Trichloroethene	B	0.0
Uranium	B	0.0

a. Inventory details and references are found in the corresponding EU appendix.

242-A Evaporator (CP-OP-10)

Current Status and Interim Cleanup: The 242-A Evaporator (Figure 3-97) in the 200 East Area is a critical component of the Hanford cleanup mission because space is limited in the Hanford double-shell tanks, there are no current plans to build additional waste storage tanks, and the 242-A Evaporator is the process by which the space is created in existing tanks to retrieve wastes from aging single-shell tanks. The space will be an even more critical need when Waste Treatment Plant operations commence.

Figure 3-97. 242-A Evaporator.

The facility was originally built for a ten-year mission; however, major upgrades were made to the facility in 1987 as well as between 1989 and 1994[131]. Upgrades have been made and additional upgrades will be made to extend the life of the 242-A Evaporator into the early 2050's to support the WTP mission to treat tank wastes. Since the 242-A Evaporator began operations in 1977, it has reduced the volume of waste in Hanford storage tanks by more than 65,000,000 gallons.

Primary Contaminants: The 242-A Evaporator manages mixed wastes from the Hanford DSTs (WA7890008967 Part III, Operating Unit Group 4; 242-A Evaporator). The liquid wastes in the DST tank systems (see Appendix E.9 and Appendix E.10) are radioactive aqueous solutions containing dissolved inorganic salts, including sodium, potassium, aluminum nitrates and nitrites, and hydroxides. The wastes in some Hanford tanks have detectable levels of heavy metals, including lead, chromium, and cadmium. Radionuclides include fission products (e.g., Sr-90 and Cs-137) and actinide series elements (e.g.,

131 http://www.hanford.gov/page.cfm/242AEvaporator

uranium and plutonium). Small quantities of ammonia and organics (e.g., acetone, butanol, and tri-butyl phosphate) may be present in some tank waste. Furthermore, small incidental amounts of insoluble solids may be transferred to the 242-A Evaporator as the result of waste mixing during the transfer process (WA7890008967 Part III, Operating Unit Group 4; 242-A Evaporator). Inventory information is provided in Table 3-95 and Table 3-96.

Primary Risks: Both a Hazard Analysis (HNF-13117, Rev. 0) and Documented Safety Analysis (DSA) (HNF-14755, Rev. 4-C) have been performed on the 242-A Evaporator facility. Two bounding accidents (design basis) were primarily based on the onsite radiological consequences; these accidents were the flammable gas accident (detonation in the C-A-1 vessel) and the waste leak and misroute accident (fine spray leak during a transfer using slurry pump P-B-2) (HNF-14755, Rev. 4-C, p. 3.3.2.3.1-2). The qualitative analysis in the DSA indicated that without mitigation there was significant potential impact to the facility worker (i.e., could result in prompt death, serious injury, or significant radiological or chemical exposure) and thus a High rating is assessed. The selected bounding accidents were also analyzed for on-site radiological consequences. For flammable gas accidents, a TED of 16.6 rem was calculated (RPP-48050, Rev. 1, p. 2) that would translate to a Medium rating (CRESP 2015a, Table 2-4). An analysis of the waste leak and misroute accident, the TED of less than 100 rem was calculated[132] (HNF-14755, Rev. 4-C, p. ES-9), which if the TED exceeded 25 rem would translate to a High rating. Thus the rating for the co-located person would be Medium-High.

The selected bounding accidents were also analyzed for off-site radiological consequences. The off-site doses for the flammable gas accident and waste leak and misroute accident were 0.15 and 0.03 rem, respectively (HNF-14755, Rev. 4-C), which translates to *Not Discernible* (ND)-Low ratings (CRESP 2015a, Table 2-4). Note that no safety-class SSCs are required for the 242-A Evaporator (HNF-14755, Rev. 4-C, p. 3.4.2-2)[133].

Final Cleanup and Disposition: Final cleanup and closure decisions have been deferred to future decision-making processes (DOE/RL-2014-11, Rev. 0, p. B-17; Appendix B); therefore, these risks and future impacts cannot be evaluated (i.e., there is insufficient (*IS*) information to evaluate).

[132] The actual calculation is found in in RPP-13750, *Waste Transfer Leaks Technical Basis Document*. If the driving pressure is hydrostatic head (e.g., waste in the C-A-1 vessel, waste recirculated by recirculation pump P-B-1), the consequences are based on analyses in RPP-CALC-47411, *Technical Basis for Release Events due to Vessel Failure for the 242-A Evaporator Facility*. These reports were not available at the time of the evaluation.

[133] The accident analysis of the DBAs was compared with DOE/EIS-0189, Tank Waste Remediation System, Hanford Site, Richland, Washington, Final Environmental Impact Statement, and no significant discrepancies were identified.

Table 3-95. 242-A Evaporator (CP-OP-10) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	99
Carbon-14	A	NR[(b)]
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	150,000
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[(c)]	D	16
Strontium-90	B	22,000
Technetium-99	A	NR
Uranium-Total Rad[(d)]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-96. 242-A Evaporator (CP-OP-10) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

EFFLUENT TREATMENT FACILITY (ETF) AND THE LIQUID EFFLUENT RETENTIONS FACILITY (LERF) (CP-OP-11)

Current Status and Interim Cleanup: The ETF and LERF are two of the four facilities for processing and disposing of Hanford liquid waste. The other two are the SALDS and the TEDF. Collectively, they store, treat, and dispose of large volumes of liquid waste containing chemical contamination and low levels of radioactive contamination received from a variety of onsite projects and programs. ETF and LERF were restarted in May 2016 after being shutdown because of the secondary treatment train heat exchanger failure.

The LERF was designed to provide interim storage for 242-A Evaporator process condensate and dilute liquid waste streams from other Hanford Sites as low-level liquid waste prior to treatment at the 200 East Area ETF. An additional transfer system to LERF is available for future use by the WTP.

Figure 3-98. ETF Building.

The ETF (Figure 3-98) was constructed in the early 1990s and went into operation in 1995. ETF receives liquids from interim storage at the LERF. The ETF is categorized as a “Less than Category 3 Nuclear Facility,” or “Radiological Facility” and is also a RCRA-permitted facility. Several treatment processes at ETF remove radioactive and hazardous contaminants from wastewater. Once the wastewater has been treated through ETF, it is stored until tests confirm that various radioactive and hazardous contaminants have been removed or lowered to levels that make it acceptable for discharge to a state-approved disposal site in Hanford’s 200 Area. Solids generated by ETF processes are drummed and disposed at the ERDF. ETF is a state RCRA-permitted facility. It treats up to 28 million gallons of wastewater each year, but the stated maximum capacity is a 56-million-gallon per year design capacity.

Primary Contaminants: The ETF and LERF contain the same primary contaminants: low-activity liquid waste.

Table 3-97 and Table 3-98 list the primary radionuclide and chemical contaminants present and estimated quantities in the Effluent Treatment Facility (ETF) and the Liquid Effluent Retentions Facility (LERF) (CP-OP-11) EU**.**

Table 3-97. LERF + ETF (CP-OP-11) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	0.13
Carbon-14	A	140
Chlorine-36	A	NR[b]
Cobalt-60	C	210
Cesium-137	D	890
Europium-152	D	NR
Europium-154	D	870
Tritium	C	21,000
Iodine-129	A	160
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	4.1
Strontium-90	B	3,700
Technetium-99	A	1,600
Uranium-Total Rad[d]	B	0.025

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-98. LERF + ETF (CP-OP-11) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: An uncontrolled release at LERF of radioactive material could adversely affect human receptors located 30 m and 100 m away from the release of low-hazard material via either a pipe failure spray release or basin leakage. The human receptor located 30 m was considered within this review to be equivalent to the Facility Worker; the calculated unmitigated doses for these two scenarios were 4.16 rem and 3.95 rem, respectively. The human health rating is considered Low for the Facility Worker if the unmitigated dose calculated is less than 5 rem. The unmitigated doses to the potential human receptor located 100 m away was taken to be the Co-located Person receptor at LERF for the two accident scenarios are 1.85 rem and 1.77 rem, respectively, and both resultant doses are considered Low is less than 5 rem. No unmitigated dose to the offsite member of the public is calculated, nor is any significant off-site dose expected, based on the above calculations.

There are no unmitigated doses to human receptors analyzed within ETF's Auditable Safety Analysis (Brown 2011); therefore, the risk ratings for the combined LERF + ETF EU are based on the provided doses within the LERF's Auditable Safety Analysis and Final Hazard Categorization (Huth 2001; Koerner and McCullough 1995). Both facilities are low-hazard and are categorized as Radiological Facilities.

Final Cleanup and Disposition: At present, there are no specific plans for D&D of either facility. The 200 East Area is slated to meet Industrial/Exclusive Land Use requirements after ultimate D&D.

TREATED EFFLUENT DISPOSAL FACILITY (TEDF) (CP-OP-12)

Current Status and Interim Cleanup: The TEDF (Figure 3-99) is one of four primary facilities for processing and disposing of Hanford liquid waste. The other three are the ETF, LERF, and the SALDS. Currently, the TEDF mission is to support the Hanford Site environmental cleanup and restoration activities. The TEDF facility provides a collection, conveyance, and disposal system for treated liquid effluents from numerous 200 Area facilities. After being sampled at the facility of origin, the treated waste is pumped to one of two adjacent State-approved infiltration basins. TEDF handles treated waste only.


Figure 3-99. TEDF.

Treated non-hazardous and non-radioactive liquid wastes are collected and then disposed of through the systems at the TEDF. More than 12 miles of polyvinyl chloride piping connects facilities throughout the Site to TEDF's State-permitted disposal basin in the 200 East Area of Hanford. TEDF has the ability to collect and safely dispose of 5.5 million gallons per day as a monthly average (nearly 2 billion gallons of liquid per year) in accordance with its State discharge permit.

From December 1994 to September 2009, the 300 Area TEDF operated under the miscellaneous liquid waste discharge permit ST-4511 and accepted liquid waste that met water quality standards from industrial operations within the 300 Area. The 300 Area TEDF has completed terminal cleanout and all process systems have been deactivated in preparation for decommissioning and destruction. Only the 200 Area TEDF remains as part of the operating facilities EU CP-OP-12.

Primary Contaminants: None/Not-Applicable, TEDF only disposes treated non-hazardous and non-radioactive liquid wastes equivalent to sanitary/municipal liquid wastes.

Table 3-99 and Table 3-100 list the primary radionuclide and chemical contaminants present and estimated quantities in the Treated Effluent Disposal Facility (TEDF) (CP-OP-12) EU**.**

Table 3-99. TEDF (CP-OP-12) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	NR
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-100. TEDF (CP-OP-12) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: The estimated impacts to the Facility Worker, Co-located Person, and member of the Public are ND due to the nature of the facility and the material handled at TEDF. TEDF only disposes treated non-hazardous and non-radioactive liquid wastes.

Since the 300 Area TEDF has completed terminal cleanout and all process systems have been deactivated, in preparation for decommissioning and destruction, but no safety documentation is currently available, the estimated impacts to the Facility Worker, Co-located Person, the Public are ND. Estimated impacts to the groundwater and the Columbia River are Low due to the nature of the facility and the material that was handled at TEDF. Although the 300 Area TEDF is in preparation for D&D, no cleanup decisions have been made for the Liquid Waste Disposal Facilities (including 300 Area TEDF).

Final Cleanup and Disposition: In the near term, 200 Area TEDF will continue to accept treated non-hazardous and non-radioactive liquid waste to discharge through infiltration at its two permitted disposal basins. At present, there are no specific plans for D&D of this facility. The designated future use of the TEDF location is categorized as Conservation (Mining) land use.

State-Approved Land Disposal Site (SALDS) (CP-OP-13)

Current Status and Interim Cleanup: The SALDS (Figure 3-100) is one of the four facilities for processing and disposing of Hanford liquid waste. The other three are the ETF, LERF, and the TEDF. SALDS is also known as the 616-A Crib. It is a rectangular infiltration gallery measuring 116 by 200 ft. The drain field pipes are 6-in. below the surface of a 6-ft-deep gravel basin. The gravel basin is covered by at least 12 in. of natural, compacted cover soil.

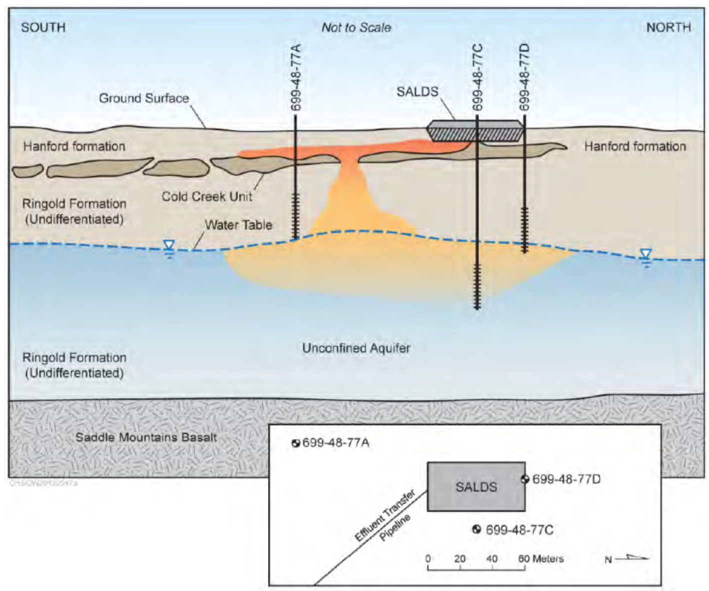

Figure 3-100. State-Approved Land Disposal Site.

Treated effluent is discharged under Washington State Waste approved Water Discharge Permit Number ST-4500. Treated effluent is pumped to SALDS from the ETF verification tanks, where the effluent is sampled prior to transfer to confirm the effluent meets permit (i.e., delisting) requirements. Treated effluent discharged at SALDS is required to meet the requirements to be delisted; i.e., is no longer a dangerous waste subject to the hazardous waste management requirements of RCRA with the exception of tritium. Currently, the chosen alternative for handling tritium in the ETF effluent is to discharge this water to the subsurface and allow the tritium to decay into non-radioactive helium before it reaches the Columbia River. Discharge to the subsurface is the only cost effective method to handle tritium in feed to the ETF. The SALDS location was selected to avoid potential mobilization of contaminants from historical disposal practices, as well as to give any groundwater a long travel time to the Columbia River. SALDS employs a series of groundwater monitoring wells to keep track of the tritium concentrations, and submits a Tritium Tracking and Groundwater Monitoring Plan to Ecology annually.

SALDS began operations in late 1995, but operations were temporarily curtailed in January 2014 due to a shutdown at ETF caused by a major failure of the evaporator heat exchanger. Replacement of the heat exchanger has been completed, along with other upgrades, and SALDS, ETF, and LERF were restarted in May 2016.

Primary Contaminants: Not accounting for radioactive decay, the total tritium inventory discharged via the SALDS facility from late 1995 to current day (2016) was estimated to be approximately 430 Ci. If decay is accounted for with the 12.3-year half-life of tritium, then approximately 175 Ci remain due to approved discharges from the SALDS facility.

Table 3-101 and Table 3-102 list the primary radionuclide and chemical contaminants present and estimated quantities in the State-Approved Land Disposal Site (SALDS) (CP-OP-13) EU.

Table 3-101. SALDS (CP-OP-13) radionuclide inventory[a].

Radionuclides	Group	Curies (Ci)
Americium-241	D	NR[b]
Carbon-14	A	NR
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	NR
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	170
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[c]	D	NR
Strontium-90	B	NR
Technetium-99	A	NR
Uranium-Total Rad[d]	B	NR

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

Table 3-102. SALDS (CP-OP-13) chemical inventory[(a)].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	NR

a. Inventory details and references are found in the corresponding EU appendix.

Primary Risks: Human Health: The SALDS is not considered a Nuclear Facility or even a "Less than Category 3 Nuclear Facility" (commonly referred to as a "Radiological Facility"). SALDS only poses standard industrial hazards (e.g., noise, common slips, trips, and falls). It is not analyzed within the Liquid Waste and Fuel Storage, Industrial Hygiene Baseline Hazard Assessment (Gasper 1993). No data are presently available to estimate of human health risks; however, due to the nature of the material present at this facility and the nature of the operations, it could be assumed that the human health hazards and risks are Low to ND.

Groundwater and Columbia River: Tritium discharges associated with the SALDS are considered as a "Group C Primary Contaminant" according to the CRESP methodology (CRESP 2015b). Using the CRESP-developed algorithm from the methodology, tritium is considered a "Group C" contaminant and the area of contamination directly related to SALDS is small at 0.20 km^2 (albeit greater than the 0.1 km^2 threshold defined in the methodology); thus, the rating for impacts to the groundwater and the Columbia River is Medium.

Final Cleanup and Disposition: At present, no cleanup decisions have been made for the Remaining Liquid Waste Disposal Facilities.

HANFORD TANK WASTE TREATMENT AND IMMOBILIZATION PLANT (WTP) (CP-OP-14)

Bechtel National, Inc. is designing, constructing, and will commission the world's largest radioactive waste treatment plant. When complete, the Hanford Tank Waste Treatment and Immobilization Plant (WTP) will process and treat 56 million gallons of radioactive and chemical tank waste currently stored at the Hanford Site.[134]

The waste is a byproduct of national defense plutonium-production during World War II and the Cold War. This waste currently resides in 149 single-shell and 28 double-shell underground tanks. Of these, more than one-third are suspected of leaking, which has contaminated the Hanford subsurface, including groundwater, and threatens the nearby Columbia River. Both groundwater and the Columbia River are protected resources.

Figure 3-101. Hanford Tank Waste Treatment and Immobilization Plant (WTP)

The plant will initially use vitrification, which involves blending the waste with glass-forming materials and heating it to 1,150 degrees Celsius to produce a glass waste form. The resulting molten mixture will be poured into stainless steel canisters to cool and solidify. The glass waste form is stable in the environment, and its radioactivity will safely dissipate over hundreds to thousands of years. Alternate waste forms are being considered for Hanford tank wastes, including low-activity and secondary wastes.

While vitrification has been employed successfully at other radioactive waste clean-up sites, including West Valley and Savannah River, it has never been attempted at the scale of or on waste as complex as that stored at Hanford. The WTP Project is the largest undertaking of its kind and one of DOE's most technically challenging clean-up projects.

Primary Contaminants: The wastes and contaminants that will be processed through the WTP are the tank wastes previously described as part of the aforementioned tank waste and farms EUs (Section 3.2) and detailed in Appendix E.1 through E.11.

Primary Risks: Preliminary Documented Safety Analyses to Support Construction Authorization have been issued135. The Pretreatment (PT) Facility is classified as a Hazard Category 2 Facility and consists of 15 black cells (inaccessible areas after waste is introduced) and one hot cell (remote operations/remote change-out of equipment). A set of 23 bounding unmitigated design basis accidents, including vessel spills, sprays, leaks, PJM overblows, hydrogen explosions in vessels, PJMs, seismic events. Hydrogen explosion in vessel and seismic hydrogen explosion accidents exceed public evaluation guidelines requiring safety-class controls. The High Level Waste Facility (HLW) is also classified as a Hazard Category 2 Facility where high-level waste concentrate from PT Facility is delivered to melter feed preparation vessels where it is blended with glass formers to form a blended feed slurry that is

[134] http://www.hanford.gov/page.cfm/WTP

[135] http://www.hanford.gov/files.cfm/Attachment_3_WTP_PDSAs.pdf

vitrified. The worst accident is a hydrogen explosion in the melter feed preparation vessel that exceeds public evaluation guideline. The Low Activity Waste Facility (LAW) is currently classified as a Hazard Category 3 Facility. No accidents have radiological consequences above guidelines.

222-S LABORATORY (CP-OP-15)

Current Status and Interim Cleanup: Currently, the 222-S Laboratory is an operating nuclear facility with a long-term mission to support the Hanford Site environmental cleanup and restoration activities. The 222-S Laboratory Complex, located in the 200 West Area, provides analytical chemistry services for the site projects, operations, and environmental cleanup activities.

Figure 3-102. 222-S Laboratory.

The 222-S Laboratory is a 70,000 ft^2 full-service analytical facility that handles highly radioactive samples for organic, inorganic, and radio-chemistry analyses. It contains 11 hot-cells, which gives the lab the capability to remotely handle highly radioactive samples of tank waste while minimizing radiation doses to workers. Laboratory personnel complete organic, inorganic, and radioisotope analysis of liquid and solid samples brought to the 222-S by the Hanford Site customers. The present programs at the laboratory include testing waste compatibility and physical characteristics to support tank to tank transfers, performing corrosion rate studies and chemical testing to support tank corrosion inhibition, providing input to the engineering specifications for each of the 242-A Evaporator campaigns, determining the physical and chemical characteristics of waste necessary to enable waste retrievals and tank closures, and Vadose Zone Program support. An estimated 15,000 to 25,000 analyses are performed annually on individual samples, field blanks, and calibration standards. The sampling includes receiving, logging, tracking, analyzing, archiving, storing, and disposing of radioactive waste samples.

Primary Contaminants: To keep 222-S Lab below the Category 2 thresholds with respect to radioactivity of various radionuclides, the radioactive inventory within 222-S Lab, at any one time, must remain below the threshold planning quantities. Historically, the laboratory source term included 15 isotopes. Conclusions presented in HNF-10754 indicate that plutonium, americium, cesium, and strontium account for approximately 97% of the DE-Ci for accident analysis. Therefore, the incremental contribution to dose consequences of all the other isotopes is considered negligible. The 222-S Laboratory does not routinely generate TRU waste; however, future commitments cannot preclude having both TRU and LLW at the facility.

Table 3-103 and Table 3-104 list the primary radionuclide and chemical contaminants present and estimated quantities in the State-Approved Land Disposal Site (SALDS) (CP-OP-13) EU**.**

Primary Risks: An uncontrolled release of radioactive material could adversely affect the Facility Worker. No quantitative dose value was provided in the 222-S HA or DSA, but a Consequence Category of “A” was designated by the 222-S Lab DSA[136] that represents a prompt fatality or serious injury from falling debris caused by a collapsing part of the structure from the building-wide fire. A building-wide fire that starts in the 222-S Laboratory Building is selected as the bounding accident for the 222-S Laboratory

[136] Buane 2012 (HNF-12125, Rev. 11, Appendix C on pg. C-19 and HNF-12652, Rev. 0, within Appendix A on p. A-20. The Consequence Categories and descriptions are found within Table 3-3 in HNF-12125 (Rev. 11)).

Complex. The resulting estimated unmitigated dose to the Co-located Person is approximately 8.3 rem.[137] The human health rating is considered Medium for a Co-located Person if the unmitigated dose calculated is between 5 and 25 rem.

The hazard and accident analysis for the 222-S Laboratory considers the closest offsite member of the Public to be 13.0 km (8.1 miles) directly west of the laboratory. The resulting estimated unmitigated dose to a member of the offsite Public is approximately 0.01 rem. The human health rating is considered "ND" for an offsite member of the Public if the unmitigated dose calculated is less than 0.1 rem.

Table 3-103. 222-S Laboratory (CP-OP-15) radionuclide inventory[(a)].

Radionuclides	Group	Curies (Ci)
Americium-241	D	14
Carbon-14	A	NR[(b)]
Chlorine-36	A	NR
Cobalt-60	C	NR
Cesium-137	D	720
Europium-152	D	NR
Europium-154	D	NR
Tritium	C	NR
Iodine-129	A	NR
Nickel-59	D	NR
Nickel-63	D	NR
Plutonium-Total Rad[(c)]	D	260
Strontium-90	B	1,900
Technetium-99	A	NR
Uranium-Total Rad[(d)]	B	0.00023

a. Inventory details and references are found in the corresponding EU appendix.
b. NR = Not reported for the indicated EU
c. Sum of plutonium isotopes 238, 239, 240, 241, and 242
d. Sum of uranium isotopes 232, 233, 234, 235, 236, and 238

[137] Buane 2012 (HNF-12125, Rev 11, Table 3-10, pg. 3-24.)

Table 3-104. 222-S Laboratory (CP-OP-15) chemical inventory[a].

Chemical	Group	kg
Beryllium	---	NR
Carbon Tetrachloride	A	NR
Cyanide	B	NR
Chromium	B	NR
Chromium-VI	A	NR
Mercury	D	NR
Nitrate	C	NR
Lead	D	NR
TBP	---	NR
Trichloroethene	B	NR
Uranium	B	0.69

a. Inventory details and references are found in the corresponding EU appendix.

Final Cleanup and Disposition: In the near term, 222-S Laboratory will continue to provide analytical laboratory services, but several upgrades and maintenance tasks were identified to support the 222-S Laboratory mission through fiscal year 2052. Major upgrades include continuous improvements to the laboratory equipment, facilities, and supporting infrastructure. Many of the proposed 222-S Laboratory upgrades are necessary to maintain and restore the facility to operate safely and in compliance with current requirements, standards, and practices for nuclear and hazardous waste analysis. Some of the upgrades will be required to meet anticipated future analytical requirements. At present, there are no specific plans for D&D of this facility. The 200 West Area is slated to meet Industrial/Exclusive Land Use requirements after ultimate D&D.

COMPARISON OF RADIOLOGICAL INVENTORIES, CONTAINMENT, AND POTENTIAL IMPACTS

Table 3-105 summarizes the radiological inventories associated with each operating facility EU. Table 3-106 through Table 3-109 compare the estimated unmitigated doses to a Co-located Person from postulated event scenarios. Table 3-110 through Table 3-113 compare the ratings for each operating facility EU.

Table 3-105. Radiological inventories, form, and barriers to release for operating facility EUs.

Operating Facility EU Name (Barrier Type) [Contaminant: Fixed (F), Dispersible (D), Mobile(M)]	Cs-137 [Ci]	Sr-90 [Ci]	Tc-99 [Ci]	H-3 [Ci]	Pu (total) [Ci]	U (total) [Ci]	Sum of all other radio-nuclides [Ci]	Isotope Names
KW Sludge Treatment Project (b) [F and D]	13,000	17,000	9		15,000	17	2,100	Am-241
Central Waste Complex (e) [F and D]					53,000			
WESF (Cs/Sr capsules) (b) [F and D]	34,000,000	15,000,000					49,000,000	Ba-137m, Y-90
WESF (Hot Cells, Ducts) (b) [F and D]	57,000	150,000						
ERDF (CY2014) (d) [F]	15,000	11,000	21	7,800	5,500	200,000 kg	28,000	Am-241, C-14, Co-60, Eu-152, Eu-154, I-129, Ni-59, Ni-63
ERDF (Closure) (d) [F]	<2,000,000	<1,200,000	<860	<160,000		<870,000 kg	<190,000	C-14, Co-60, I-129, Ni-63
T Plant (b) [F and D]	760	180	0.31	1.4	51	0.21	35	Am-241, C-14, Co-60, Eu-152, Eu-154, I-129, Ni-59, Ni-63
WRAP (e) [F and D]	0	0	0	0			29	Am-241
CSB+ISA (b and e) [F and D]	22,000,000	16,000,000	5,000	61,000	17,000,000	4,900 kg	1,300,000	Am-241, C-14, Co-60, Eu-152, Eu-154, I-129, Ni-59, Ni-63
Mixed Waste Trenches (d) [F and D]	5,800	100,000	140	6,800	310	830,000	19,000	Am-241, C-14, Cl-36, Co-60, Eu-152, Eu-154, I-129, Ni-59, Ni-63
Naval Reactors Trench (d) [F and D]	50	20	0.81	1,100			2,000,000	Am-241, C-14, Cl-36, Co-60, I-129, Ni-59, Ni-63
ETF+LERF (b) [F and D]	890	3,700	1,600	21,000	4.1	0.025	1,400	Am-241, C-14, Co-60, Eu-154, I-129
TEDF (b) [D and M]								
SALDS (b) [D and M]				170				
222-S Lab (b) [F and D]	720	1900			260	0.00023	14	Am-241

Notes: If there is a blank cell, then values are not available. Barrier type indicated by letter within parentheses after operating facility EU name: (a) None, (b) Bldg. & Engr. System, (c) Soil Cover & Veg., (d) Liner, (e) Packaging, (f) Packaging post-2004, (g) Tank Constr. (Single-Shell Tank), (h) Tank Constr. (Double-Shell Tank), (i) Remedial Process in Place.

Table 3-106. Unmitigated radiological dose (rem) impacts to Co-located Person and Public.

Accident/Event Scenario	CWC		K Basins Sludge		WESF[(a)]		ERDF	
	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public
Seismic (0.2g)	285	0.75	NR	NR	21	0.006	NR	NR
Loss of Water	NR	NR	0.0044	0.0002	277	0.21	NR	NR
Water Release (Spray)	NR	NR	0.68	0.033	3.1	0.0028	NR	NR
Waste Handling Accidents	53.5	0.05	13.4	1.23	NR	NR	<1	NR
Fires	770	0.73	5.7	0.28	7.8	0.006	NR	NR
Explosions	NR	NR	3.2	0.15	102	0.031	NR	NR

a. The beyond design basis event earthquake is not evaluated in the DSA, but a separate analysis was performed, titled *WESF Beyond Design Basis Accident Conditions and Plans* (CHPRC-02047, Rev. 0). The unmitigated doses were estimated to be 380 rem for the Co-located Person (380 rem) and 0.24 rem for a member of the Public. Note that the design basis earthquake cannot cause the loss of pool cell water by itself; a combination of operational (human-caused) errors and conditions is required that is, in effect, a ***beyond*** design basis event. The difference is that the design basis earthquake only releases material from the hot cells and connecting ventilation system and the beyond design basis event earthquake releases material from the capsules stored in the pool cells at WESF.

Table 3-107. Unmitigated radiological dose (rem) impacts to Co-located Person and Public.

Accident/Event Scenario	CSB+ISA		222-S Lab		Naval Reactors Trench		Mixed Waste Trenches	
	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public
Seismic (0.2g)	NR	NR	NR	NR	NR	NR	NR High	NR Low
Loss of Water	NR	NR	NR	NR	NR	NR	NR	NR
Water Release (Spray)	NR	NR	NR	NR	NR	NR	NR	NR
Waste Handling Accidents	49	0.055	NR	NR	NR	NR	NR	NR
Fires	35.6	0.021	8.3	0.01	NR	NR	NR	NR
Explosions	54	0.06	NR	NR	NR	NR	NR	NR

Table 3-108. Unmitigated radiological dose (rem) impacts to Co-located Person and Public.

Accident/Event Scenario	ETF+LERF		TEDF		SALDS	
	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public
Seismic (0.2g)	NR	NR	NR	NR	NR	NR
Loss of Water	3.95	1.77	NR	NR	NR	NR
Water Release (Spray)	4.16	1.85	NR	NR	NR	NR
Waste Handling Accidents	NR	NR	NR	NR	NR	NR
Fires	NR	NR	NR	NR	NR	NR
Explosions	NR	NR	NR	NR	NR	NR

Table 3-109. Unmitigated radiological dose (rem) impacts to Co-located Person and Public.

Accident/Event Scenario	T Plant		WRAP	
	Co-located Person	Public	Co-located Person	Public
Seismic (0.2g)	NR	NR	NR	NR
Loss of Water	NR	NR	NR	NR
Water Release (Spray)	NR	NR	NR	NR
Waste Handling Accidents	NR	NR	NR	NR
Fires	NR	NR	770	0.73
Explosions	NR	NR	643	0.02

Table 3-110. Unmitigated radiological risk rating impacts to Co-located Person and Public.

Accident/Event Scenario	CWC		K Basins Sludge		WESF		ERDF	
	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public
Seismic (0.2g)	High	Low	NR	NR	Medium	ND	NR	NR
Loss of Water	NR	NR	ND	ND	High	Low	NR	NR
Water Release (Spray)	NR	NR	Low	ND	Low	ND	NR	NR
Waste Handling Accidents	High	ND	Medium	Medium	NR	NR	Low	NR
Fires	High	Low	Medium	Low	Medium	ND	NR	NR
Explosions	NR	NR	Low	Low	High	ND	NR	NR

Table 3-111. Unmitigated radiological risk rating impacts to Co-located Person and Public.

Accident/Event Scenario	CSB+ISA		222-S Lab		Naval Reactors Trench		Mixed Waste Trenches	
	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public
Seismic (0.2g)	NR	NR	NR	NR	NR	NR	High	Low
Loss of Water	NR	NR	NR	NR	NR	NR	NR	NR
Water Release (Spray)	NR	NR	NR	NR	NR	NR	NR	NR
Waste Handling Accidents	High	ND	NR	NR	Low	Low	Med	Low
Fires	High	ND	Med	ND	NR	NR	Med	Low
Explosions	High	ND	NR	NR	NR	NR	NR	NR

Table 3-112. Unmitigated radiological risk rating impacts to Co-located Person and Public.

Accident/Event Scenario	ETF+LERF		TEDF		SALDS	
	Co-located Person	Public	Co-located Person	Public	Co-located Person	Public
Seismic (0.2g)	NR	NR	NR	NR	NR	NR
Loss of Water	Low	Low	ND	ND	Low	Low
Water Release (Spray)	Low	Low	ND	ND	Low	Low
Waste Handling Accidents	NR	NR	NR	NR	NR	NR
Fires	NR	NR	NR	NR	NR	NR
Explosions	NR	NR	NR	NR	NR	NR

Table 3-113. Unmitigated radiological risk rating impacts to Co-located Person and Public.

Accident/Event Scenario	T Plant		WRAP	
	Co-located Person	Public	Co-located Person	Public
Seismic (0.2g)	NR	NR	NR	NR
Loss of Water	NR	NR	NR	NR
Water Release (Spray)	NR	NR	NR	NR
Waste Handling Accidents	NR	NR	NR	NR
Fires	High	Low	High	Low
Explosions	NR	NR	High	Low

DEPENDENCE ON OTHER FACILITIES AND CONSIDERATIONS FOR TIMING OF THE CLEANUP ACTIONS

The K-West Basin Sludge Treatment Project has direct ties to several other facilities and processes, including the D&D of the K-West Reactor facility, and an interim period of operations at T Plant. The project also involves a future facility to treat the sludge, the location of which has yet to be determined.

The K-West Basin Sludge Treatment Project is multi-phase, and delay would have different impacts, depending on when it occurred. These will be addressed in chronological order:

1. **Delay in removing the sludge from the K-West Basin** – The sludge stored in engineered containers at the K-West Basin is the last significant quantity of nuclear material in the K Area. Transportation of this material out of the K Area to T Plant is on the critical path to enable completion of environmental restoration activities on the K Area.
2. **Delay in design and construction of the Phase 2 Sludge Treatment System** – T Plant is intended to be only an interim stop for the sludge material from K Basins. CH2M Hill Plateau Remediation Company (CHPRC) has completed alternatives analysis and recommended a warm water oxidation system to stabilize the remaining uranium in the sludge (along with some limited development of backup/enhancement technologies). The DOE Richland Operations Office has approved this path forward, and CHPRC has developed a preliminary technology development plan to mature the technologies to support design of the Phase 2 treatment system. Delays in design and construction of the Phase 2 treatment system, or the technology development program to support it, would result in the sludge being stored for longer than currently planned in T Plant. Such a delay could make retrieval of the sludge for processing problematic. (Note: The aging properties of the sludge materials while in storage at T Plant is a line of inquiry in the technology development planning.)

The CWC has ties to WRAP, the LLGB, and T Plant. For the CWC, there are two foreseeable delays: (1) overall delays that that result in the risks and hazards of the operating facility continuing as they are, without moving into a cleanup phase; and (2) problems with WIPP or other long-term storage that would require the CWC to remain available to store TRU for an extended period, which would result in the continuation of operating risks and hazards.

WESF is a multi-phase project and delay would have different impacts, depending on when it occurred. These impacts are addressed below:

6. **Delay in completion of the WESF Stabilization and Ventilation Modification Project** – This will result in a longer period in which (1) a substantial (~300,000 Ci) source term is available for potential dispersion during a beyond design basis event, and (2) the ventilation system at WESF is not in compliance with requirement for confinement ventilation systems, thus increasing the potential for an inadequately filtered release from WESF.
7. **Delay in removal of the Cs and Sr capsules** – The Waste Management EIS[138] mentions two potential options for addressing the HLW present in the capsules at WESF: (1) designing and building a facility that would be an adjunct to the WTP, which would allow the capsules to be opened, prepared, and fed to the HLW vitrification melter; and (2) more recently, due to the age of WESF and schedule challenges at WTP, the retrieval of the capsules from the storage pool in WESF and placement in dry cask storage, similar to commercial spent nuclear fuel, to await disposition in a geologic repository. Both options require the design and construction of new facilities. Delay in either option extends storage of the capsules in the 40-year-old WESF.
8. **Continued need to perform surveillance and maintenance on WESF systems and Cs and Sr capsules** – The timeliness of moving capsules out of WESF does impact the progress of the D&D timeline of B Plant and milestone TPA M-092-05 (Ecology, EPA, and DOE 1998).

[138] DOE 2012 (DOE-EIS-0391-2012)

Four primary facilities for processing and disposing of Hanford liquid waste: TEDF, ETF, LERF, and SALDS. If any of the four facilities' operations are shutdown, it would cause delays in treating onsite liquid wastes. This also has the potential to impact other treatment trains (e.g., solids) if the resultant production of contaminated liquid wastes cannot be treated and disposed.

ERDF, Mixed Waste Trenches, and the Naval Reactors Trench provide the end-state from other projects both on site and off. The activities at ERDF can scale up or down depending on the level of activity at the projects that supply waste. ERDF, the Mixed Waste Trenches, and the Naval Reactors Trench will continue to operate until all other projects at Hanford are complete, when the waste source is exhausted, and/or when completely filled, and then will undergo final closure as the last active construction-related project at Hanford.

Clarification of Stages for Each Facility

The Sludge Treatment Project consists of three phases. The following two of which are discussed in this report: (1) storage and transfer of sludge from K-West Basin to T Plant and (2) treatment of sludge and shipment for disposal. Each phase has several stages. Phase 1 stages include (1) storage of sludge in K-West Basin, (2) the ECRTS, and (3) storage of sludge in T Plant. Phase 2 stages include sludge treatment. A third phase, processing of knock out pot material, has been completed and will not be discussed in this review.

The CWC does not have several operational phases; however, the D&D processes and ultimate disposition of the land will involve processes that are yet to be determined.

Future plans for WESF are divided into two phases. The first phase is to upgrade the ventilation system and stabilize the hot cell contaminants. The long-term, tentative plan is to remove the Cs and Sr capsules from the pools by packaging the capsules into dry storage overpacks and storing them on the Hanford Site. This movement into dry storage will allow the adjacent building (B Plant) to proceed with D&D plans that are tied to a Tri-Party Agreement milestone.

ERDF has three stages: filling, final closure, and long-term surveillance. ERDF is currently in the filling stage. During filling, additional cells are constructed to support disposal at the Hanford Site. Ten cells currently exist, with expansion possible for two more cells. However, given the available space surrounding ERDF, much more expansion beyond 12 cells could be provided. New cells are added as existing cells are filled and demand exists for more disposal volume. Once filling is complete, the final closure stage will be undertaken, followed by long-term surveillance.

Comparative Summary

Although DOE and its contractors employ active and passive safety class and safety significant systems and controls to mitigate the potential adverse impacts of virtually all but some natural phenomena events, identifying differences between the four operating facilities EUs requires consideration of the unlikely but possible failure of one or more of these controls and thus the unmitigated radiological dose exposures to onsite and offsite persons as represented by a hypothetical individual located 100 m from the EU boundary (Co-located Person) and another individual located at Hanford Site controlled access boundary (Public or MOI). As revealed by the comparison of these four operating facility sites, human health risks are driven by the following factors:

- Quantity (in kg) or activity (in curies) of the contaminant
- Form of the contaminant (fixed, dispersible, mobile)
- Whether cleanup work is going on that could cause accidents

- For the Public or MOI, the distance between the initiating event and the Hanford boundary

The operating facilities that contain the highest level of contained radioactivity are WESF and CSB (and ISA), but it is beyond extremely unlikely that an initiating event would cause a release from the capsules stored at WESF and spent fuel canisters at CSB and ISA. The integrity of the capsules is tested regularly and the structural analysis of the pool cell concrete has estimated that even with a very conservative estimate of 50% concrete strength degradation, the pool cell structure would still survive a design basis earthquake. Measures in place to protect spent fuel at CSB and ISA are the containers themselves holding the spent fuel.

By far, the highest unmitigated dose to the Co-located Person (770 rem) is associated with a fire in the CWC or the WRAP accident scenario involving either a glovebox deflagration or a fire involving eight drums of radioactive material (770 rem). The second highest unmitigated dose to the Co-located Person (704 rem) is associated with a fire inside a 221-T Perma-Con igniting repackaged radioactive waste. The third highest unmitigated dose to the Co-located Person (285 rem) is associated with the design basis event for the CWC. The fourth highest unmitigated dose (277 rem) is estimated to be associated with the loss of all pool cell water resulting from a combination of external events and human response failures at WESF.

The highest unmitigated dose to the Public (1.23 rem) is associated with a waste handling accident at the K Basins Sludge facility. The second highest unmitigated dose to the Public (0.75 rem) is associated with a design basis earthquake affecting the CWC. A fire at the CWC would result with the third highest unmitigated dose to the member of the public (0.73 rem). A glovebox deflagration or fire involving 8 drums at WRAP could also result with an unmitigated dose of 0.73 rem. A fire inside a 221-T Perma-Con waste package could produce an unmitigated dose of 0.29 rem. Interestingly, WESF unmitigated doses to the hypothetical member of the public at the Hanford Site boundary are much lower for other operating facility EUs.

The only potential hazard to the Co-located Person or the Public at the ERDF site is associated with a waste handling accident (radiological or non-radiological, although the former is dominant). Such accidents are considered as anticipated but unlikely and would have a Low consequence to the Co-located Person 100 m from the ERDF boundary.

CHAPTER 4. RESULTS FROM REVIEW FOR EACH RECEPTOR CATEGORY

4.1. INVENTORIES

Figure 4-1 through Figure 4-14 summarize the inventories of selected radionuclides and chemical contaminants for comparison across EUs; these radionuclides and chemical contaminants represent important constituents that drive risk at the Hanford Site. On a total curie basis, Cs-137 and Sr-90 dominate the total inventory of radionuclides across all EUs evaluated. The largest inventories of Cs-137 and Sr-90 as measured in Curies (Ci) (Figure 4-1 and Figure 4-2) are in the WESF capsules, Canister Storage Building (CSB), 200 East DSTs, and the S-SX and A-AX tank waste and farm EUs. Lesser, but still significant inventories are in the 200-East Burial Ground; TX-TY, U and B-BX-BY Tank Waste and Farm; Building 324; 200-West Burial Ground; and the PUREX and B Building EUs. ERDF is expected to have similar levels of Cs-137 and Sr-90 at the time it reaches closure. The Cs-137 and Sr-90 inventory in the soils underlying Building 324 is the dominant contributor to the overall Building 324 EU and PUREX Tunnel #2 is the dominant contributor to the overall PUREX EU. The largest inventory of Tritium (H-3) (Figure 4-3) is in the 200-West Burial Ground, with smaller amounts in the PUREX cribs & trenches, 200-East groundwater plume, and the CSB EUs.

The most significant amount of Pu (total) is located in the Canister Storage Building (CSB) EU, with lower amounts in the CWC (packaged wastes), tank wastes, 200-West Miscellaneous Waste Site, the Pu-Contaminated Waste Sites, PUREX (distributed between the 202-A Building and the tunnels), and the Plutonium Finishing Plant (PFP) which is currently undergoing decontamination and demolition (Figure 4-4).

The largest inventory of U (total) Figure 4-5) is located in the 200-West Burial Ground, with lesser amounts primarily associated with the tank waste and farms EUs.

Tc-99 (Figure 4-6) is primarily associated with the Tank Waste and Farms, CSB, Liquid Effluent Retention Facility (LERF), 200 East Area Effluent Treatment Facility (ETF) EUs and legacy disposal practices at BC Cribs and Trenches. At the time of closure, the Integrated Disposal Facility (IDF) is expected to have the largest site-wide total inventory and ERDF will have an amount comparable to LERF & ETF today (Figure 4-6). LERF & ETF have the largest inventories of I-129 (Figure 4-7).

The largest aggregate inventories of all other radionuclides are found primarily in the Tank Waste and Farms, with lesser amounts at the LERF & ETF EUs (Figure 4-8).

For chemical contaminants (Figure 4-9 through Figure 4-14), substantial inventories of total chromium are associated with the Tank Waste and Farm EUs, 200-East Burial Ground, and BC Cribs and Trenches. Lesser amounts are associated with the U&S Ponds, 200-West Burial Ground, PUREX cribs & trenches, and T Plant cribs & trenches. Carbon tetrachloride is primarily associated with legacy disposal practices that originated in the Pu-contaminated waste sites but then migrated in the groundwater in the 200 West Area. Significant quantities of TCE are only present in one of the River Corridor EUs. The largest inventories of carbon tetrachloride (CCl_4) and mercury (Hg) are located in the PU Contaminated Waste sites, with lesser amounts of CCl4 located in the U&S Pond and 200-West Groundwater Plume EUs.

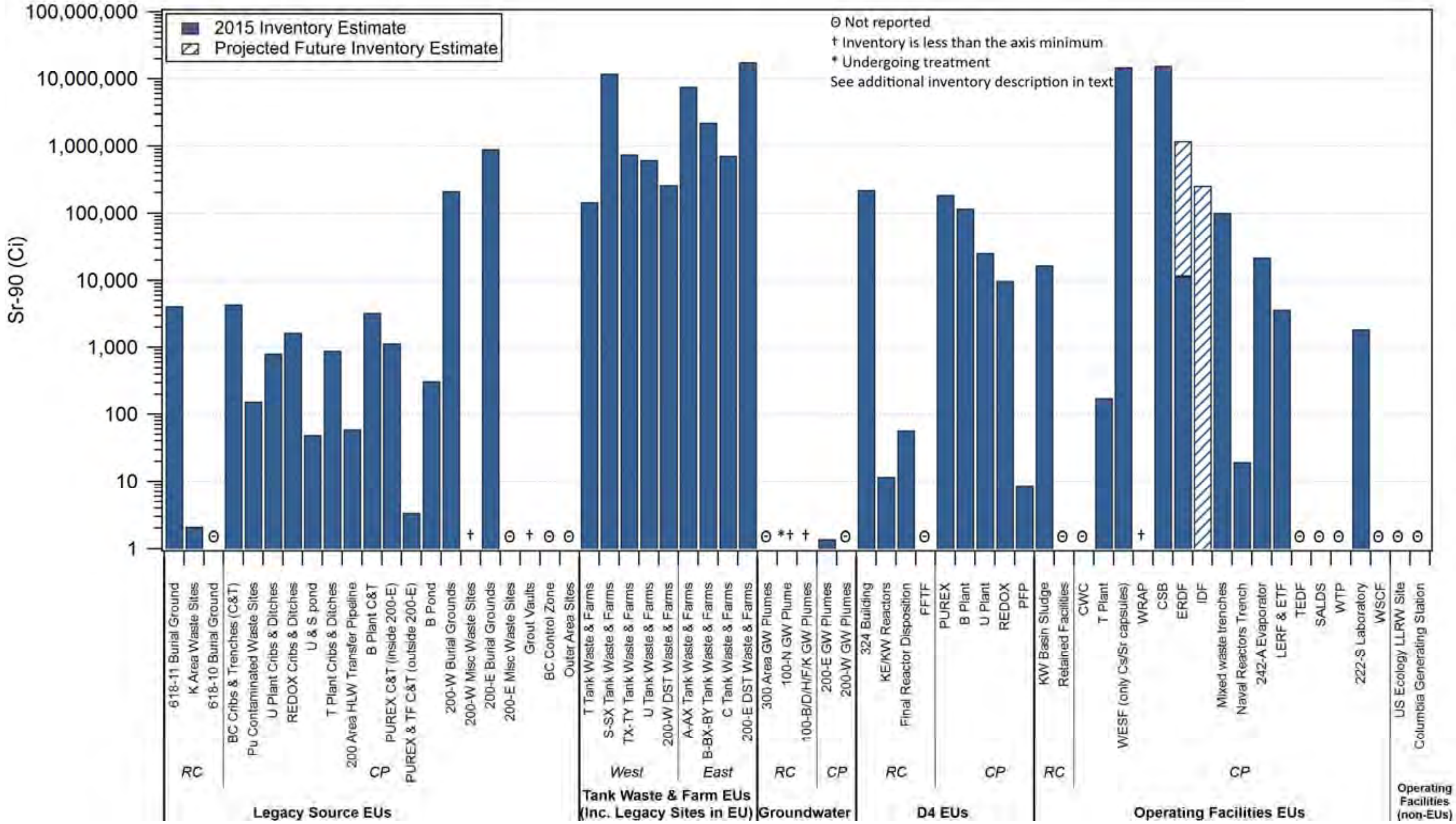

Figure 4-1. Radionuclide inventories – Sr-90: Comparison of inventories for each EU.

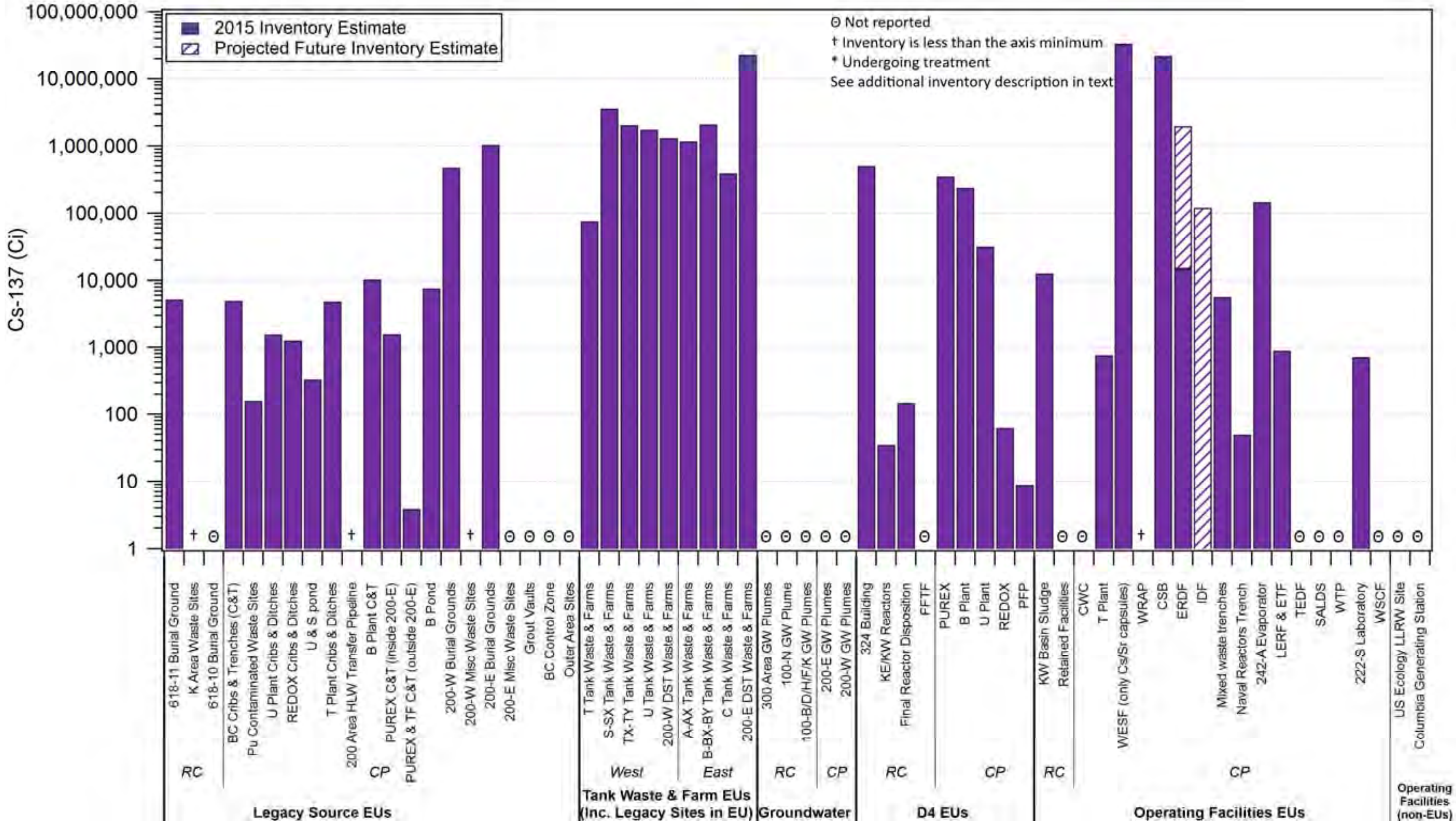

Figure 4-2. Radionuclide inventories – Cs-137: Comparison of inventories for each EU.

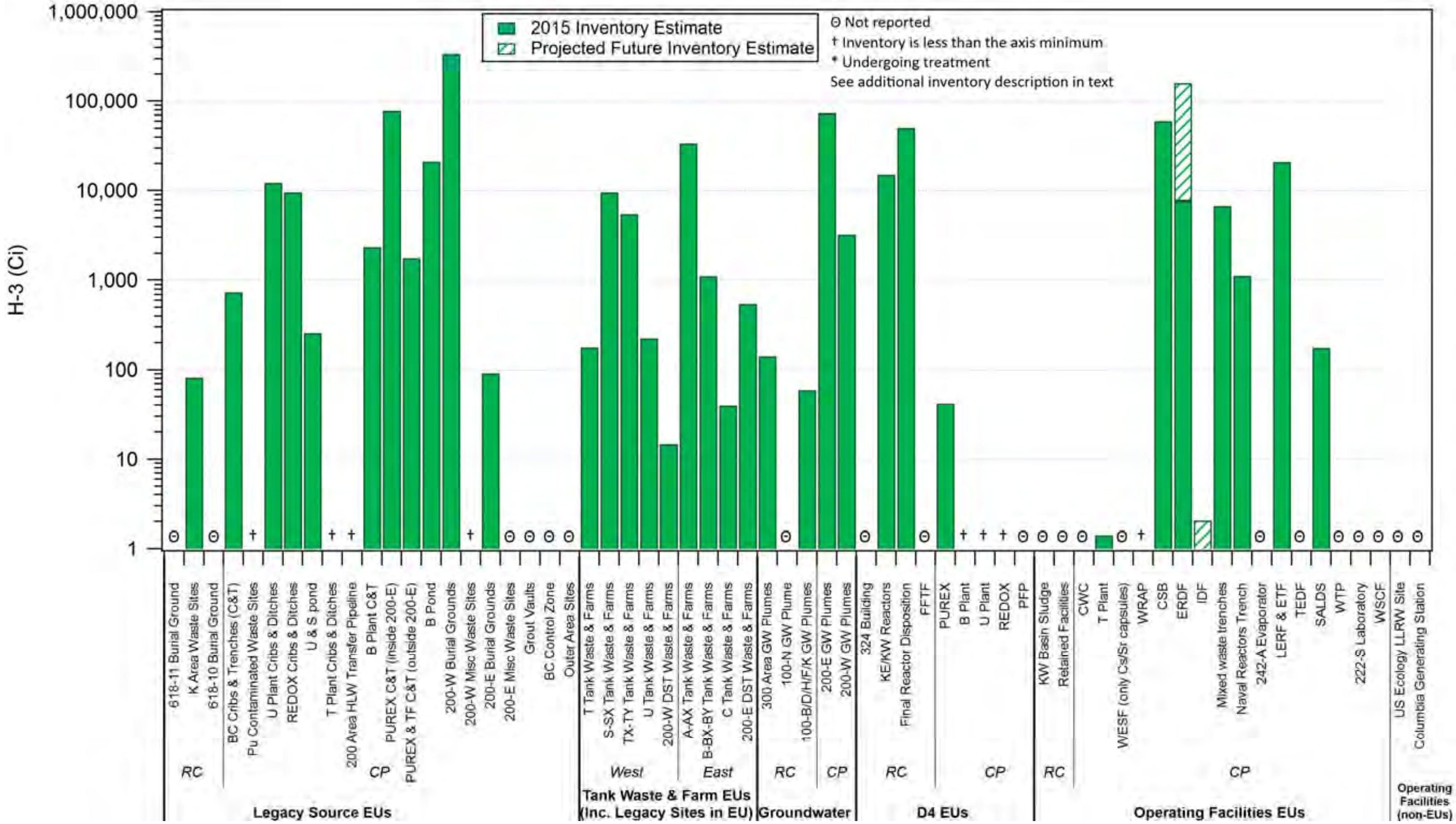

Figure 4-3. Radionuclide inventories – tritium (H-3): Comparison of inventories for each EU.

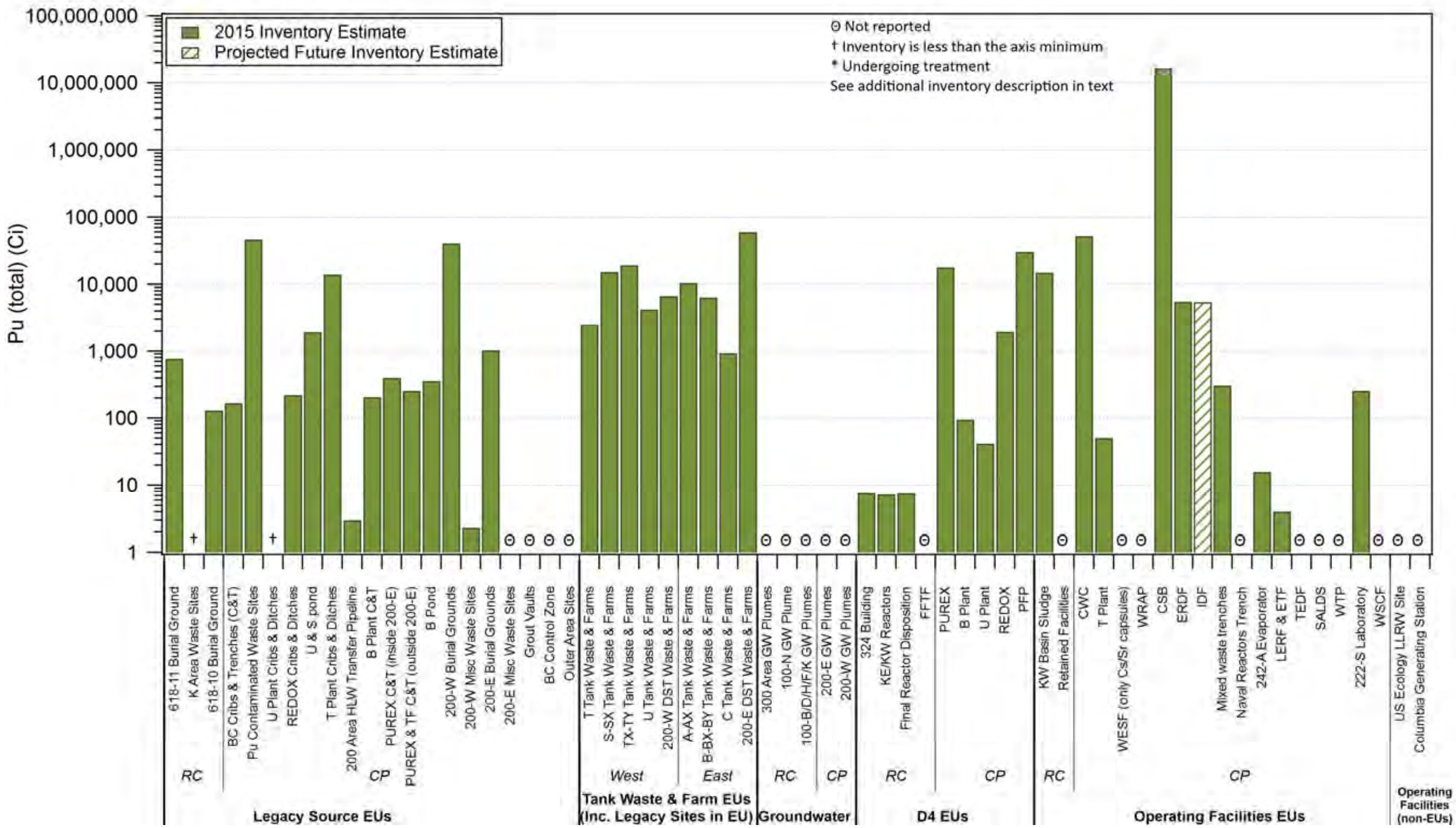

Figure 4-4. Radionuclide inventories – Pu (total): Comparison of inventories for each EU.

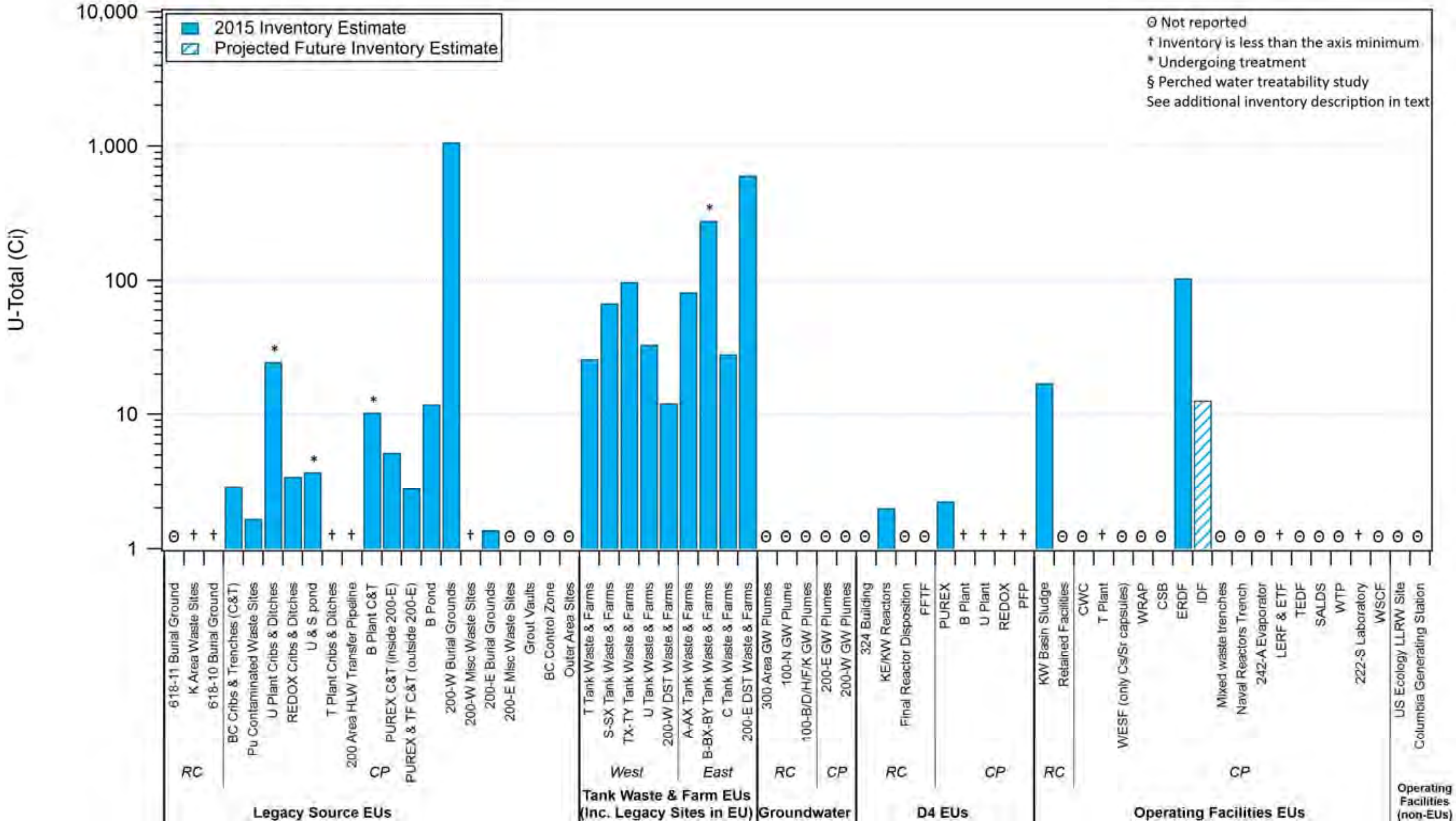

Figure 4-5. Radionuclide inventories – U (total): Comparison of inventories for each EU.

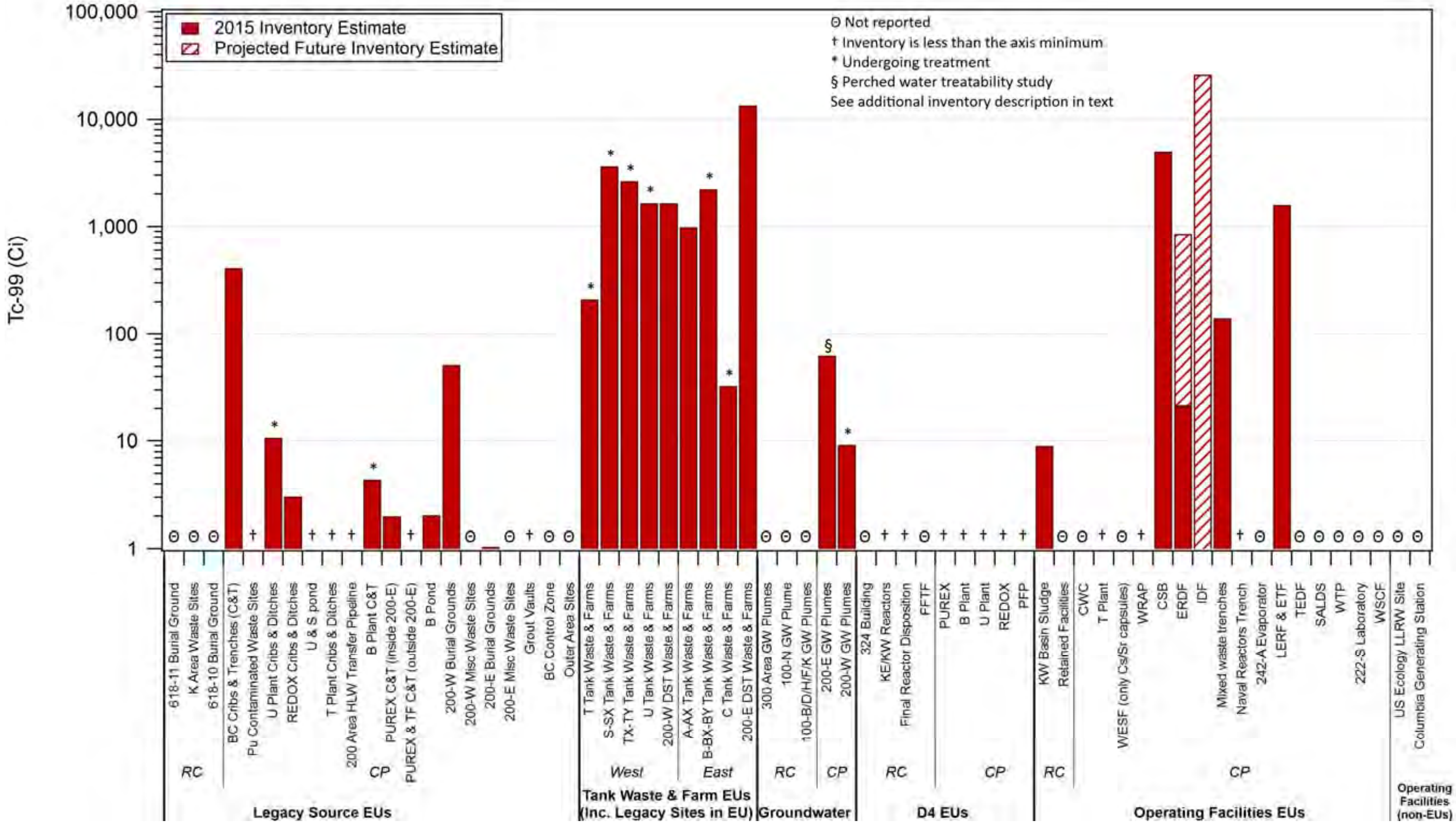

Figure 4-6. Radionuclide inventories – Tc-99: Comparison of inventories for each EU.

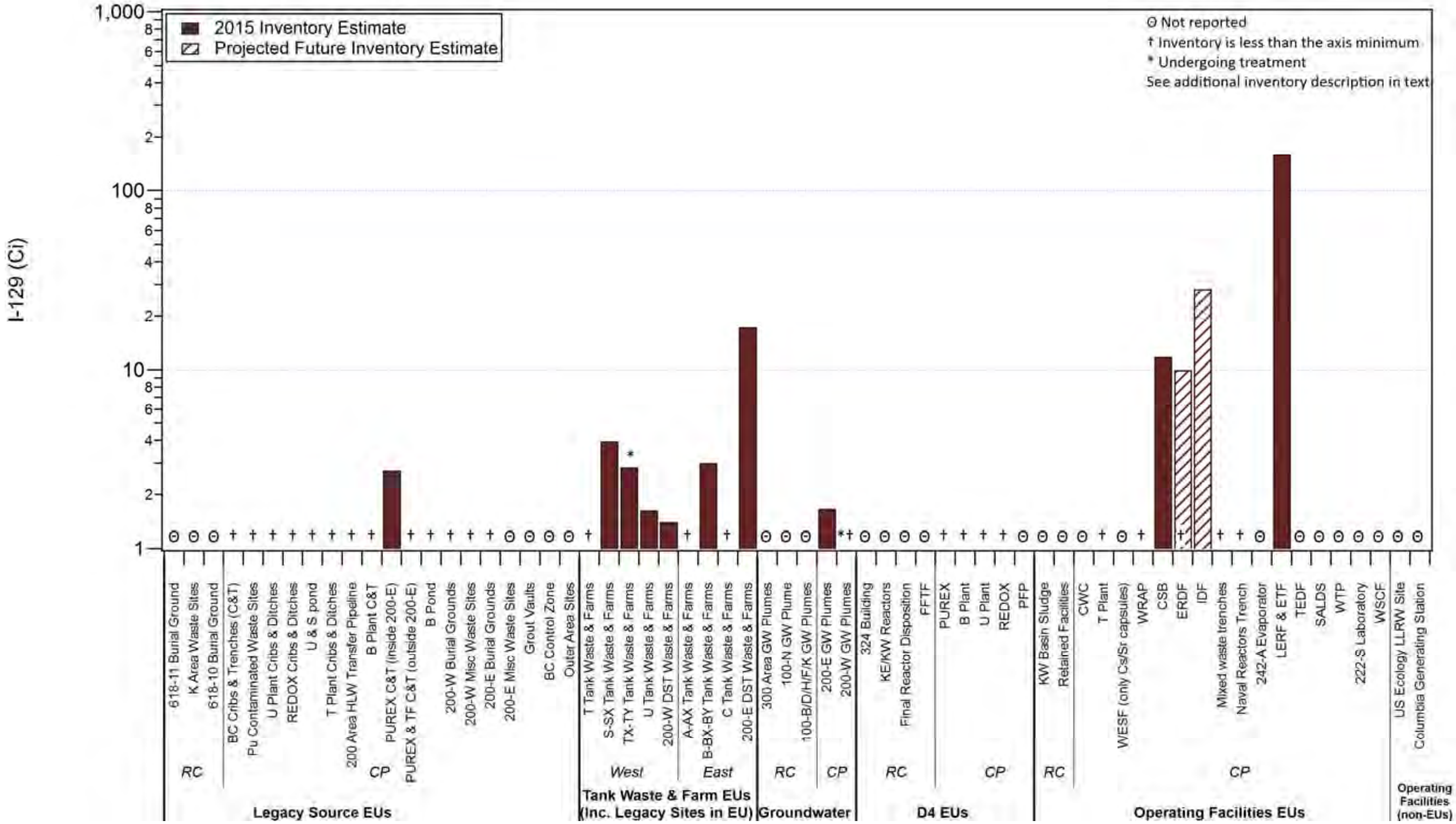

Figure 4-7. Radionuclide inventories – I-129: Comparison of inventories for each EU.

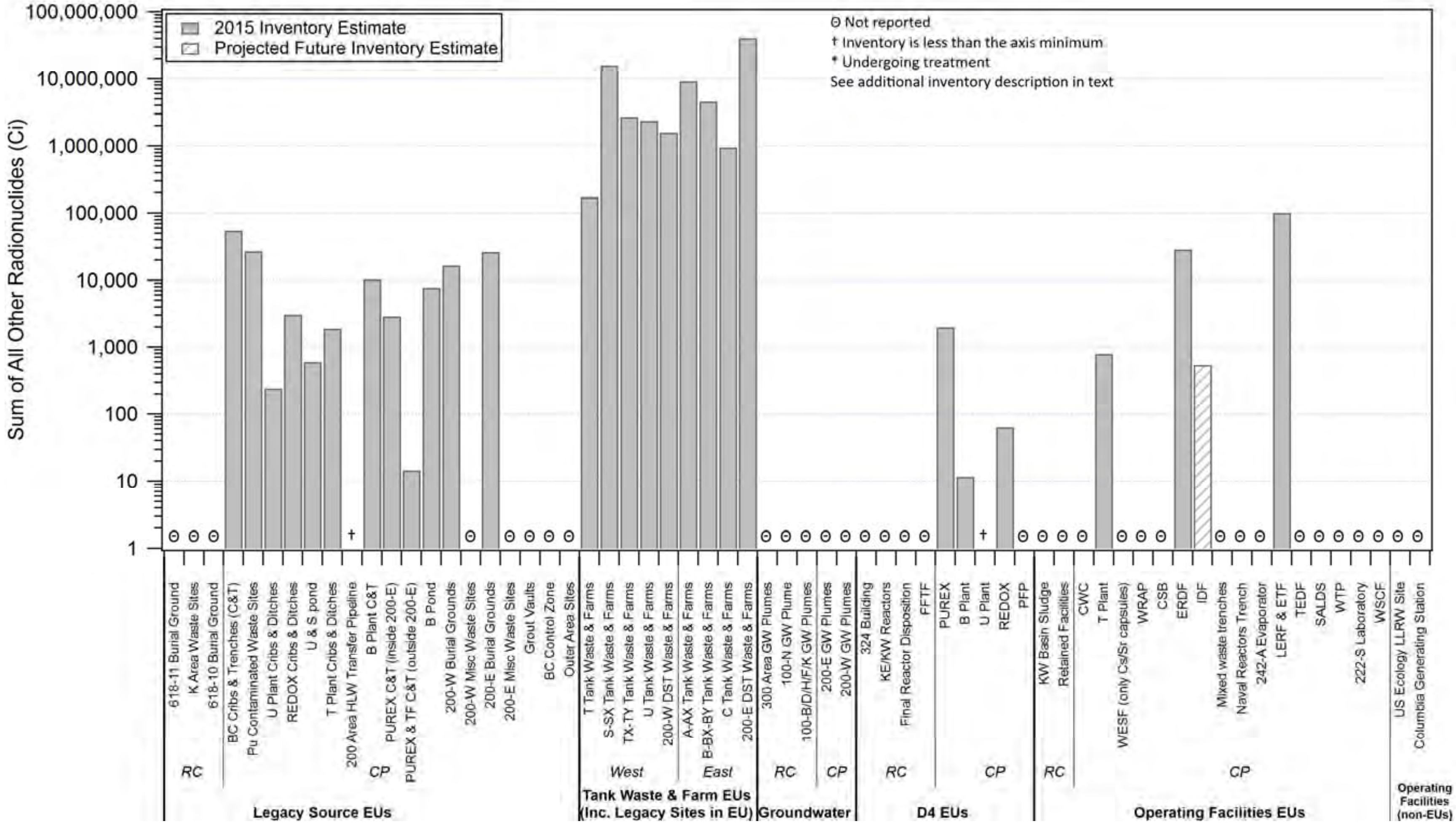

Figure 4-8. Radionuclide inventories – Sum of all other radionuclides: Comparison of inventories for each EU.

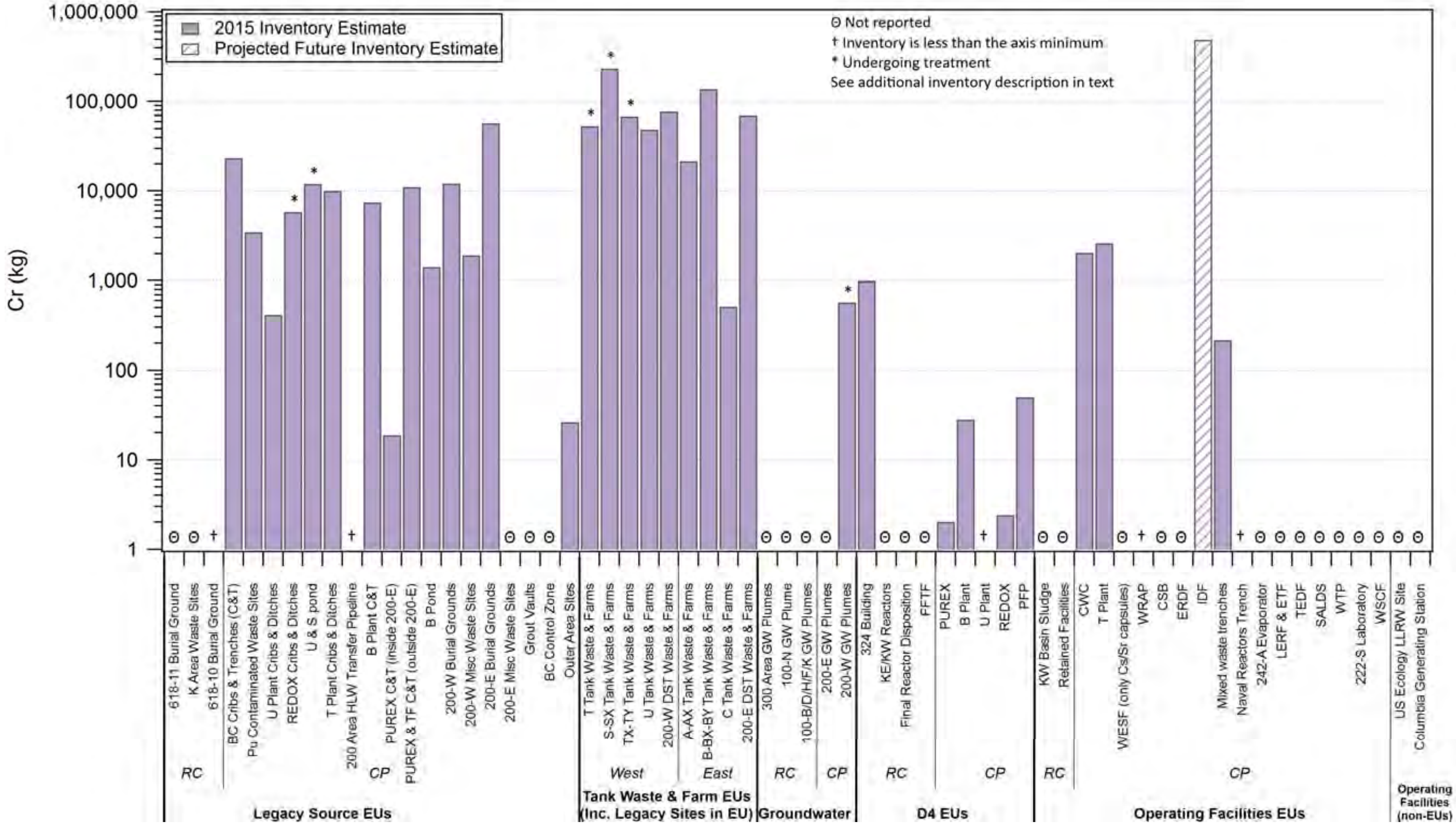

Figure 4-9. Chemical inventories – Cr(total): Comparison of inventories for each EU. Inventories shown are those reported as total chromium and contain both Cr-III and Cr-VI. The distribution between the valence states not known. Figure 4-10 shows inventories reported as hexavalent chromium.

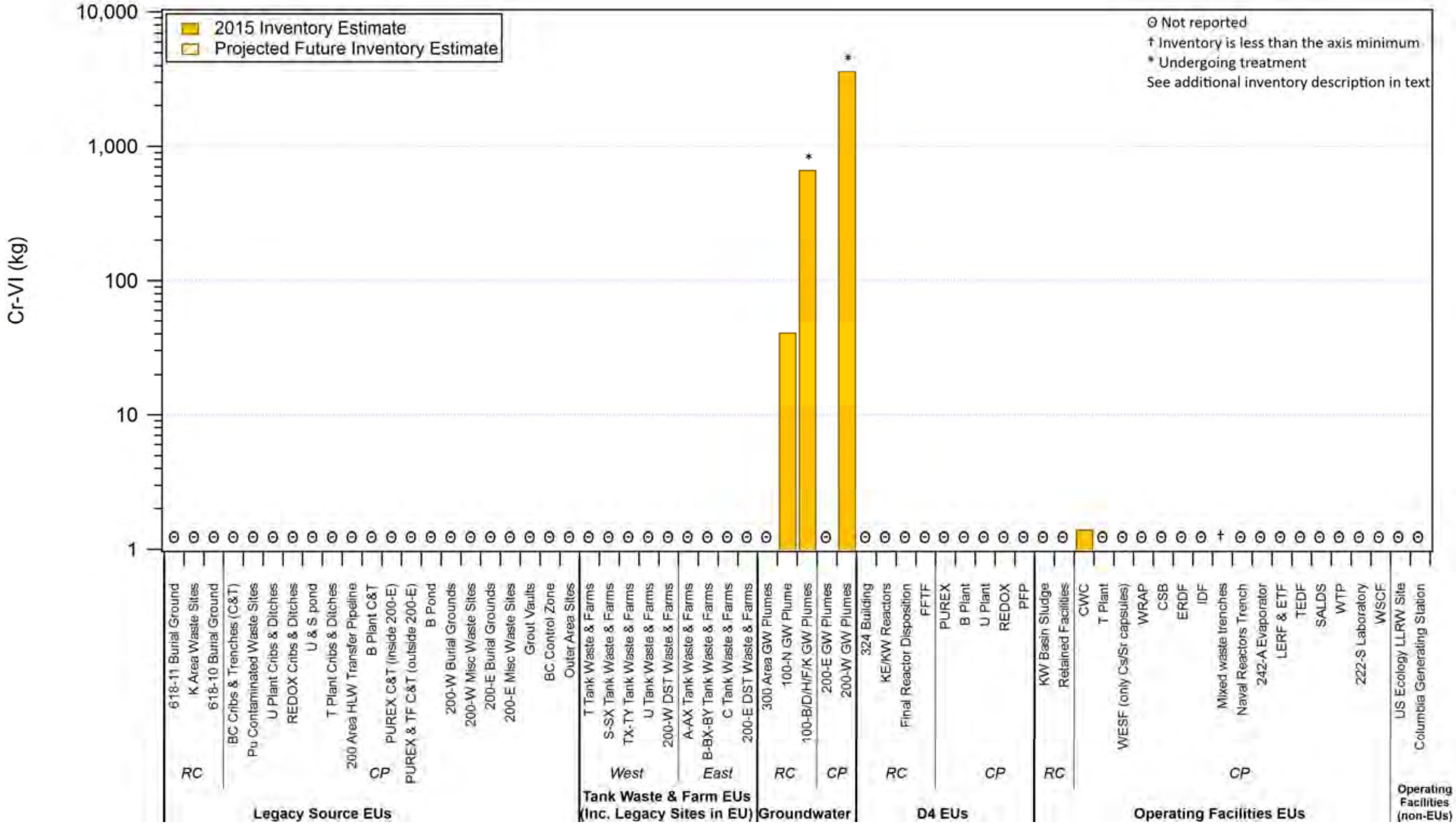

Figure 4-10. Chemical inventories – Cr-VI: Comparison of inventories for each EU. Inventories are those reported as hexavalent chromium. Figure 4-9 shows inventories reported as total chromium.

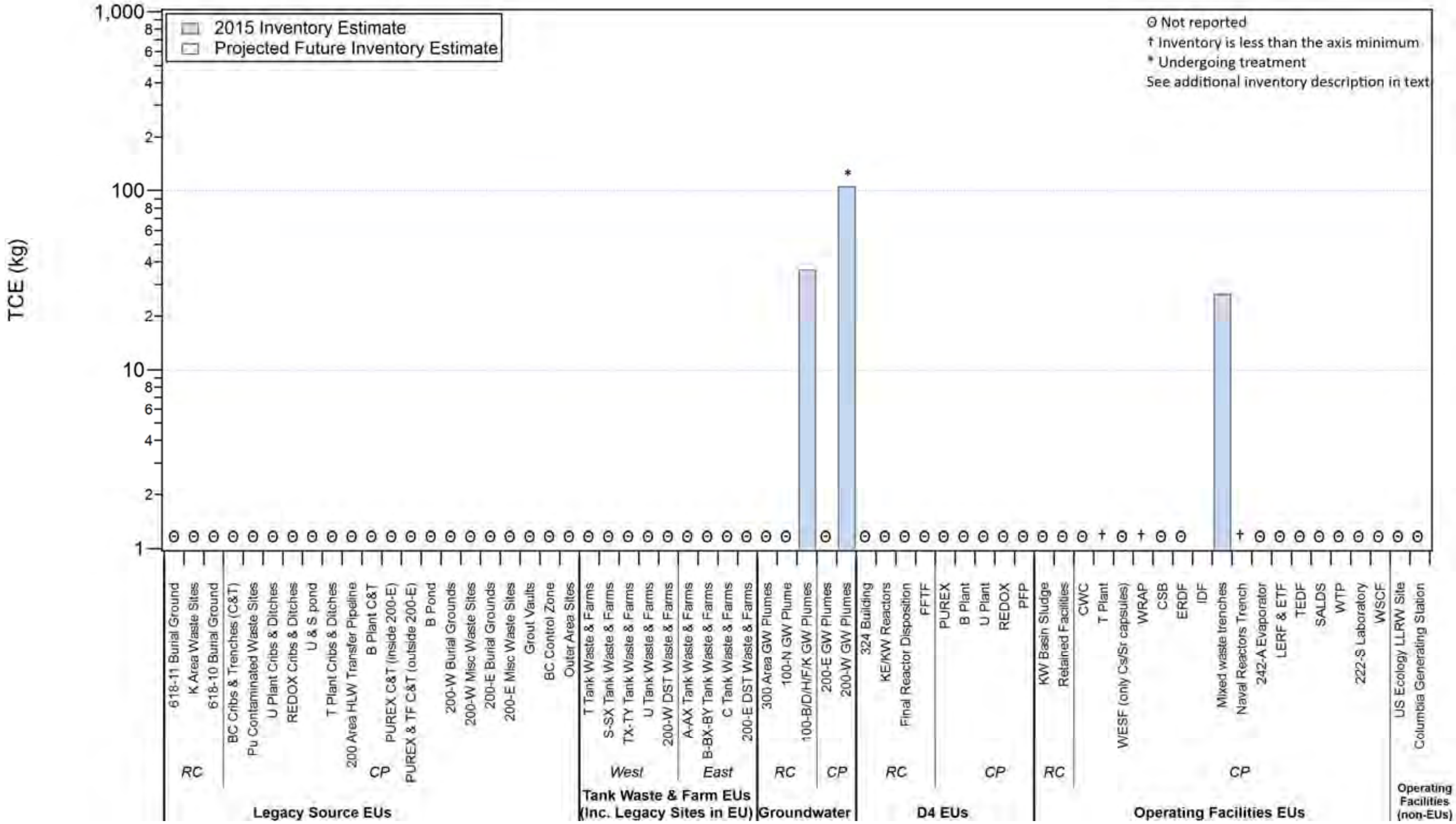

Figure 4-11. Chemical inventories – TCE: Comparison of inventories for each EU.

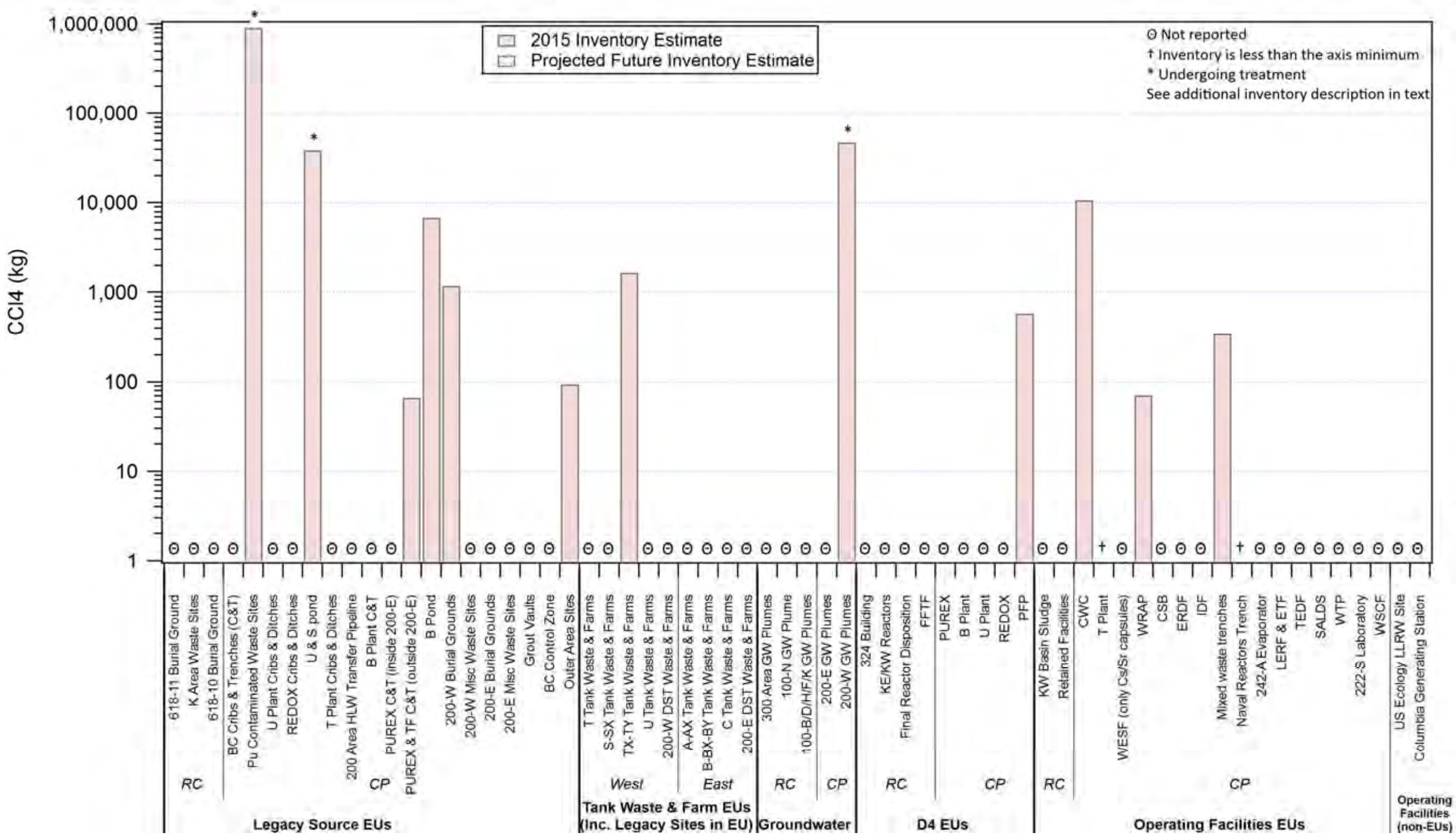

Figure 4-12. Chemical inventories – carbon tetrachloride: Comparison of inventories for each EU.

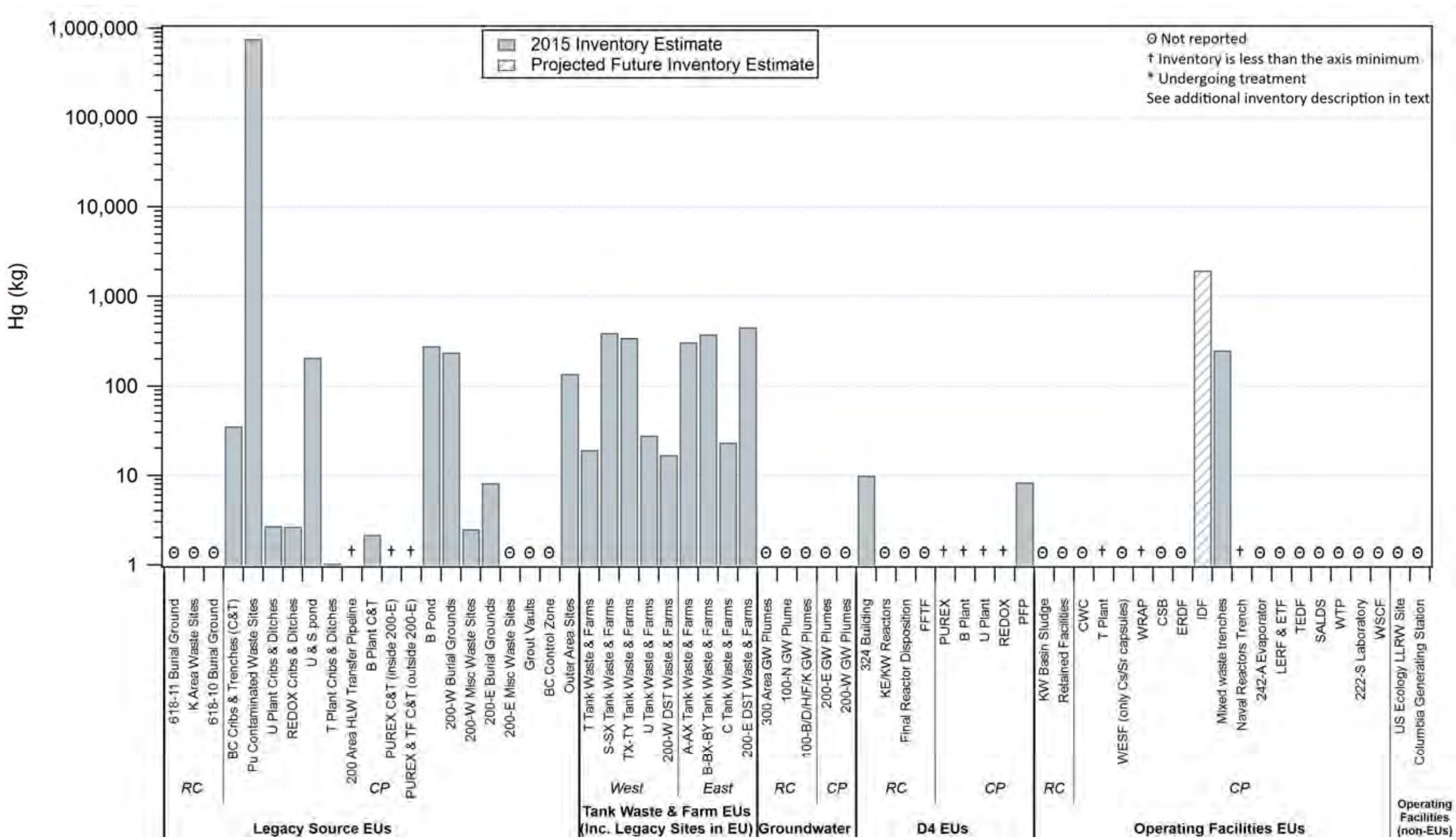

Figure 4-13. Chemical inventories – mercury: Comparison of inventories for each EU.

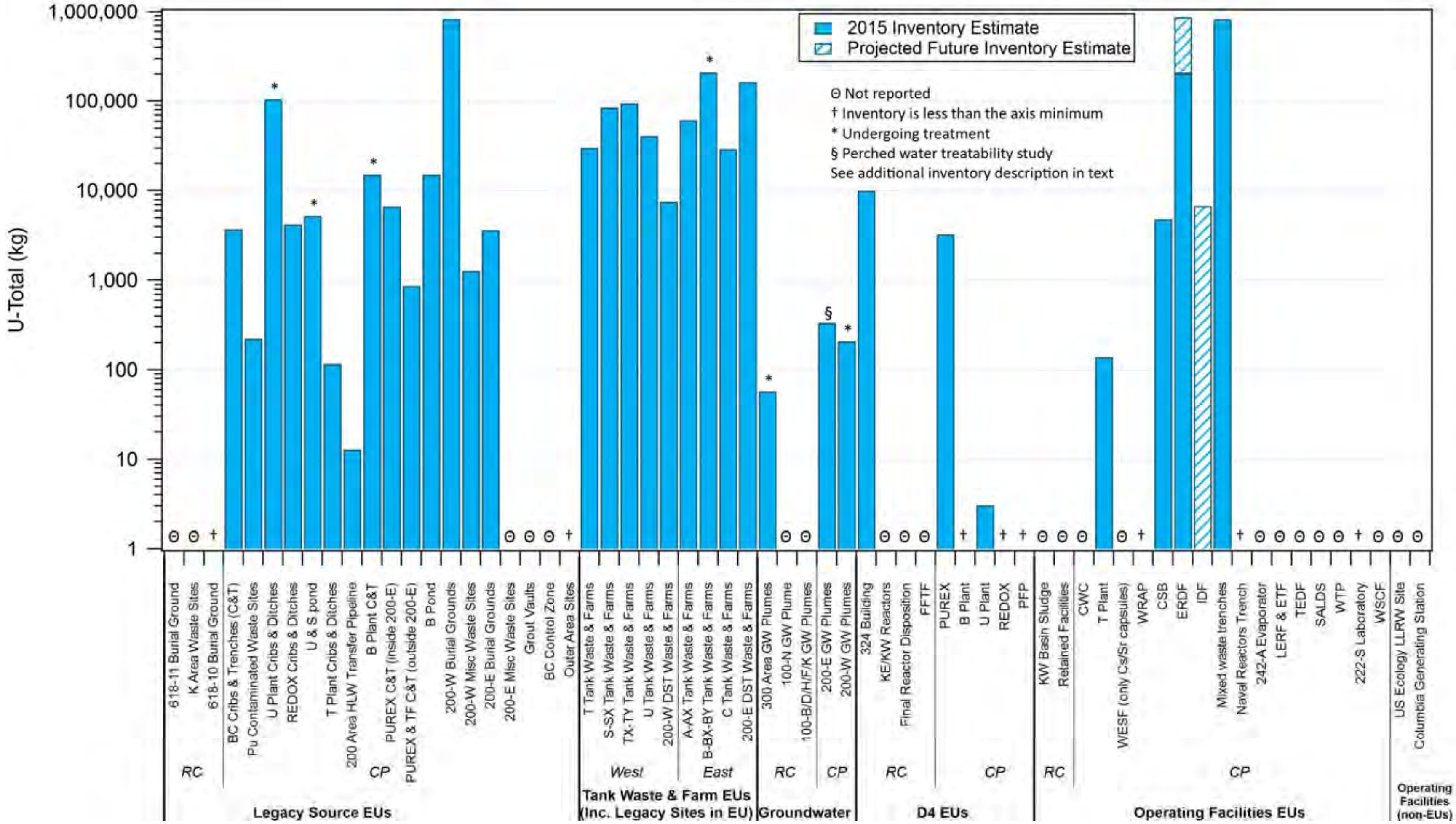

Figure 4-14. Chemical inventories – U (total): Comparison of inventories for each EU.

4.2. HUMAN HEALTH (MITIGATED AND UNMITIGATED)

This section provides risk review ratings for Facility Workers, Co-located Persons, and the Public. The ratings are based on unmitigated risks except where otherwise stated.

Figure 4-15 provides a comparison of estimated unmitigated dose to the Co-located Person for the highest dose nuclear safety accident scenarios associated with each EU. Significant potential doses from operational accidents are associated with the Building 324, the Central Waste Complex, WESF ducts, PUREX and 618-11 Burial Grounds. Estimated doses from natural phenomenon and external events may occur as a consequence of a severe seismic event, fire, or loss of active controls (e.g., ventilation or cooling water) associated with an extended period of loss of power. Further discussion of each of these scenarios can be found in the related appendices that provide the EU Template for each facility.

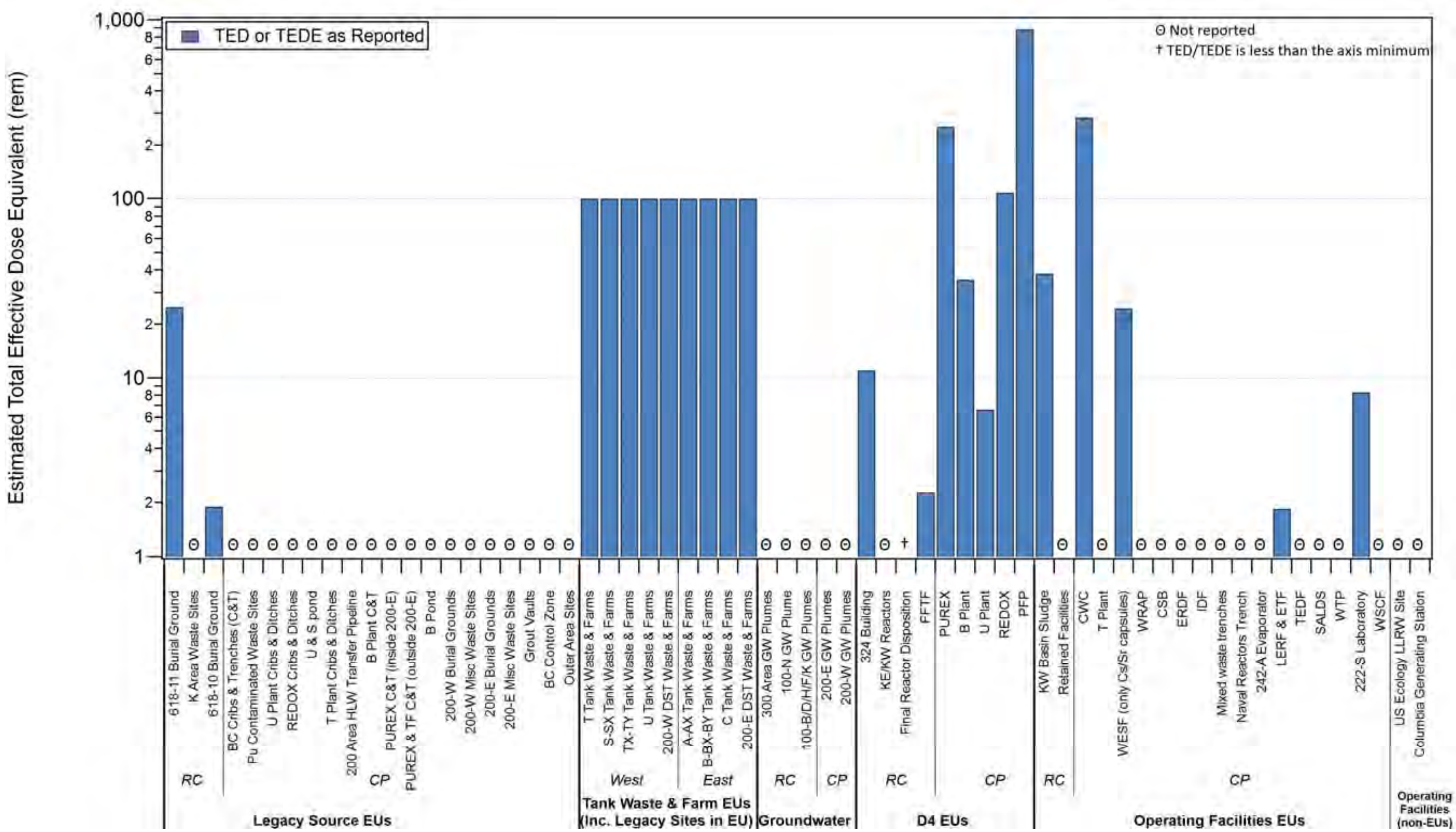

Figure 4-15. Unmitigated dose to Co-located Person (rem): Comparison of dose estimates for each EU from Type 1 events. The calculated TED for the 242-A Evaporator was not available for this Review but was less than 100 rem as decribed in Appendix H.16.

Table 4-1 through Table 4-4 provide the summary ratings for the EUs with respect to human health. Three types of events or accidents affecting worker health and safety are recognized and detailed in the methodology (CRESP 2015b). Type 1 consists of nuclear safety accident scenarios, including collapses, fire, explosions, and seismic events, resulting in acute blast injuries, burns, or chemical and radiologic exposure. Type 2 consists of subacute, chronic or recurrent exposure to site-specific toxic chemical or radiologic inventory. Type 3 consists of industrial accidents, not specific to a particular EU, including heat stress, 'slips, trips and falls', struck-by injuries, machine injuries, ergonomic, and other physical trauma.

Type 1 events or accidents are captured in the HA/DSA documents. These documents generally ignore Type 2 exposures, and specifically exclude Type 3 events unless they serve as an initiating event. Type 2 and 3 events are specifically worker-related, hence are not relevant for Controlled Access Persons, Co-located Persons or the Public. Risks for Type 1 events are addressed specifically in the EU templates. Risks for Type 2 events are inferred from reviewing the inventory and conditions of the EU. Risks for Type 3 events depend on the types of work to be performed, for example, D4.

DOE has multiple programs to prevent events or mitigate their consequences. Assessment and prevention of Type 1 events are the domain of nuclear safety. Assessment and prevention of Type 2 events are the domain of industrial hygiene. Assessment and prevention of Type 3 events are the domain of safety specialists.

Table 4-1 summarizes the ratings for Type 1, 2, and 3 risks for Facility Workers only. The Type 1 rating reflects the highest rating for Facility Workers across the Current and Active Cleanup periods. The ratings for Type 2 and Type 3 were determined by EU type based on the methodology (CRESP 2015a). Table 4-2 summarizes the ratings for Type 1 nuclear accident risks for Facility Workers for the three evaluation periods (current, active cleanup, and near-term post-cleanup). Table 4-3 summarizes the ratings for the same evaluation period breakdown for Type 1 risks to Co-located Persons. Table 4-4 summarizes the ratings for the same evaluation period breakdown for the Public from a Type 1 event. Risks to Controlled-access Persons are not separately estimated because their location could be close to the release-site or far away, and their exposure and risk would vary accordingly.

Review of these ratings clearly indicates worker safety threats are predominantly from the cleanup activities, although some worker safety threats are present from maintenance and monitoring activities both before and after cleanup. Furthermore, nuclear safety event scenarios are the most important differentiator between ratings of specific EUs, followed by the type of EU (e.g., Legacy Sources vs. D4 EUs).

For threats to public health (Table 4-4), operational accidents at the Legacy Source waste site 618-11 and the D4 EU Building 324 are the only cases where the Risk Review Project ratings are above "Low."

Table 4-1. Summary of Risk Review Project Ratings: Facility Worker from Type 1, 2, and 3 worker safety events or accidents. (See symbology legend p. xxv)

EU Name	EU #	Type 1 - Acute threats from sudden events or nuclear safety accident scenarios		Type 2 - Subacute or chronic threats from occupational exposures to chemicals or radiation		Type 3 - Threats from industrial-type accidents (heat stress, physical trauma, etc.)	
Legacy Sources							
618-11 Burial Grounds	RC-LS-1	Med		Low to Med		Med	
K Area Waste Sites	RC-LS-2	Low		ND to Low		Low to Med	
Orchard Lands	RC-LS-3[a]	Evaluation Template was not developed.[a]					
618-10 Burial Ground	RC-LS-4	Low		Low to Med		Low to Med	
BC Cribs and Trenches	CP-LS-1	High		ND to Low		Low to Med	
Plutonium Contaminated Waste Sites	CP-LS-2	Med		ND to Low		Low to Med	
U Plant Cribs and Ditches	CP-LS-3	High		Low		Low to Med	
REDOX Cribs and Ditches	CP-LS-4	High		Low		Low to Med	
U and S Ponds	CP-LS- 5	Med		Low		Low to Med	
T Plant Cribs and Ditches	CP-LS-6	High		Low		Low to Med	
200 Area HLW Transfer Pipeline	CP-LS-7	Low		Low		Low to Med	
B Plant Cribs and Ditches	CP-LS-8	High		Low		Low to Med	
PUREX Cribs and Trenches (inside 200 E)	CP-LS-9	High		Low		Low to Med	
PUREX and Tank Farm Cribs and Trenches (outside 200 E)	CP-LS-10	Low		Low		Low to Med	
B Pond	CP-LS-11	Med		Low		Low to Med	
200 West Burial Grounds	CP-LS-12	Low		Low		Low to Med	
200 West Miscellaneous Waste Sites	CP-LS-13	Low		Low		Low to Med	
200 East Burial Grounds	CP-LS-14	Low		Low		Low to Med	
200 East Miscellaneous Waste Sites	CP-LS-15	Low		Low		Low to Med	

EU Name	EU #	Type 1 - Acute threats from sudden events or nuclear safety accident scenarios	Type 2 - Subacute or chronic threats from occupational exposures to chemicals or radiation	Type 3 - Threats from industrial-type accidents (heat stress, physical trauma, etc.)
Grout Vaults	CP-LS-16	ND	Low	Low to Med
BC Control Zone	CP-LS-17	Low	Low	Low to Med
Outer Area Sites	CP-LS-18	ND	Low	Low to Med
Tank Waste and Farms				
T Tank Farm	CP-TF-1	High	Low to Med	Low to Med
S-SX Tank Farms	CP-TF-2	High	Low to Med	Low to Med
TX-TY Tank Farms	CP-TF-3	High	Low to Med	Low to Med
U Tank Farm	CP-TF-4	High	Low to Med	Low to Med
A-AX Tank Farms	CP-TF-5	High	Low to Med	Low to Med
B-BX-BY Tank Farms	CP-TF-6	High	Low to Med	Low to Med
C Tank Farms	CP-TF-7	High	Low to Med	Low to Med
200 East (DSTs)	CP-TF-8	High	Low to Med	Low to Med
200 West (DSTs)	CP-TF-9	High	Low to Med	Low to Med
Groundwater				
300 Area GW Plumes	RC-GW-1	Low	ND to Low	Low
100-N GW Plumes	RC-GW-2	Low	ND to Low	Low
100-B/D/H/F/K Area GW Plumes	RC-GW-3	Med	ND to Low	Low
200 East Groundwater	CP-GW-1	Med	ND to Low	Low
200 West Groundwater	CP-GW-2	Med	ND to Low	Low
D4				
Building 324	RC-DD-1	High	Low to Med	Med to High
KE/KW Reactors	RC-DD-2	Low	ND	Med to High
Final Reactor Disposition	RC-DD-3	Low	Med to High	Med to High
FFTF	RC-DD-4	High	Med	Med to High
PUREX	CP-DD-1	High	Low to High	Med to High
B Plant	CP-DD-2	High	Low to Med	Med to High

EU Name	EU #	Type 1 - Acute threats from sudden events or nuclear safety accident scenarios		Type 2 - Subacute or chronic threats from occupational exposures to chemicals or radiation		Type 3 - Threats from industrial-type accidents (heat stress, physical trauma, etc.)	
U Plant	CP-DD-3	Med		Low to Med		Med to High	
REDOX	CP-DD-4	High		Low to Med		Med to High	
PFP	CP-DD-5	High		Low to Med		Med to High	
Operating Facilities							
KW Basin Sludge	RC-OP-1	High		ND to Low		Low to Med	
Retained Facilities	RC-OP-2[a]	Evaluation Template was not developed.[a]					
CWC	CP-OP-1	High		Low to Med		Low to Med	
T Plant	CP-OP-2	High		Med to High		Med to High	
WESF (Cs/Sr capsules)	CP-OP-3	High		ND to Med		Low to Med	
WRAP	CP-OP-4	High		Med		Med	
CSB	CP-OP-5	High		Low to Med		Low to Med	
ERDF	CP-OP-6	Med		Low to Med		Low to Med	
IDF	CP-OP-7	Low		Low to Med[c]		Low to Med[c]	
Mixed Waste Trenches	CP-OP-8	High		Low to Med		Low to Med	
Naval Reactors Trench	CP-OP-9	Low		Low to Med		Low to Med	
242-A Evaporator	CP-OP-10	High		Low to Med		Low to Med	
LERF + ETF[b]	CP-OP-11	Low		Low to Med		Low to Med	
TEDF	CP-OP-12	ND		ND to Low		Low	
SALDS	CP-OP-13	ND		Low		Low	
WTP	CP-OP-14	Evaluation Template was not developed.[a]					
222-S Laboratory	CP-OP-15	High		Low to Med		Low to Med	
WSCF	CP-OP-17	Evaluation Template was not developed.[a]					

a. Evaluation Templates for four of the EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.

b. EU CP-OP-16 (ETF) was incorporated into and evaluated under EU CP-OP-11 (LERF + ETF). These are wastewater facilities for non-hazardous effluent that may include tritium.

c. The Integrated Disposal Facility (IDF) has not yet received waste. Its Type 2 and Type 3 risks will ultimately mirror those at ERDF.

Table 4-2. Summary of Risk Review Project ratings: human health: Facility Worker from Type 1 nuclear safety accident ratings for three evaluation periods. (See symbology legend p. xxv)

EU Name	EU #	Current	Active Cleanup	Near-Term Post-Cleanup
Legacy Sources				
618-11 Burial Grounds	RC-LS-1	ND	Med[a]	Low
K Area Waste Sites	RC-LS-2	Low	Low	ND to Low
Orchard Lands	RC-LS-3[b]	Evaluation Template was not developed.[b]		
618-10 Burial Ground	RC-LS-4	ND to Low	ND to Low	ND
BC Cribs and Trenches	CP-LS-1	Low	Low to High[c]	Low
Plutonium Contaminated Waste Sites	CP-LS-2	ND to Low	Low to Med[d]	ND to Low
U Plant Cribs and Ditches	CP-LS-3	ND to Low	Proposed Alternatives[e]: ND to Low (No Action) to Low to High (RTD)	ND to Low
REDOX Cribs and Ditches	CP-LS-4	ND to Low	Proposed Alternatives: ND to Low (No Action) to Low to High (RTD)	ND to Low
U and S Ponds	CP-LS-5	ND to Low	Med	ND
T Plant Cribs and Ditches	CP-LS-6	ND to Low	Proposed Alternatives: ND to Low (No Action) to Low to High (RTD)	ND to Low
200 Area HLW Transfer Pipeline	CP-LS-7	ND to Low	ND to Low	ND to Low
B Plant Cribs and Ditches	CP-LS-8	ND to Low	Proposed Alternatives: ND to Low (No Action) to High (RTD)	ND to Low
PUREX Cribs and Trenches (inside 200 E)	CP-LS-9	ND to Low	Proposed Alternatives: ND to Low (No Action) to High (RTD)	ND to Low
PUREX and Tank Farm Cribs and Trenches (outside 200 E)	CP-LS-10	ND to Low	ND to Low	ND to Low

EU Name	EU #	Current	Active Cleanup	Near-Term Post-Cleanup
B Pond	CP-LS-11	ND to Low	Med	ND
200 West Burial Ground	CP-LS-12	ND to Low	IS(f)	IS
200 West Miscellaneous Waste Sites	CP-LS-13	ND to Low	IS	IS
200 East Burial Grounds	CP-LS-14	ND to Low	IS	IS
200 East Miscellaneous Waste Sites	CP-LS-15	ND to Low	IS	IS
Grout Vaults	CP-LS-16	ND	ND	ND
BC Control Zone	CP-LS-17	ND to Low	ND to Low	IS
Outer Area Sites	CP-LS-18	ND	ND	ND
Tank Waste and Farms				
T Tank Farm	CP-TF-1	Low to High ǂ	High ǂ	Low
S-SX Tank Farms	CP-TF-2	Low to High ǂ	High [ ]ǂ	Low
TX-TY Tank Farms	CP-TF-3	Low to High ǂ	High [ ]ǂ	Low
U Tank Farm	CP-TF-4	Low to High ǂ	High [ ]ǂ	Low
A-AX Tank Farms	CP-TF-5	Low to High ǂ	High [ ]ǂ	Low
B-BX-BY Tank Farms	CP-TF-6	Low to High ǂ	High [ ]ǂ	Low
C Tank Farms	CP-TF-7	Low to High [ ]ǂ	High [ ]ǂ	Low
200 East (DSTs)	CP-TF-8	Low to High [ ]	High [ ]	Low
200 West (DSTs)	CP-TF-9	Low to High	High [ ]	Low
Groundwater				
300 Area GW Plumes	RC-GW-1	Low	Low [ ]	Low
100-N GW Plumes	RC-GW-2	Low [ ]	Low [ ]	Low
100-B/D/H/F/K Area GW Plumes	RC-GW-3	Low to Med [ ]	Low to Med [ ]	Low
200 East Groundwater	CP-GW-1	Low to Med	Low to Med [ ]	Low
200 West Groundwater	CP-GW-2	Low to Med [ ]	Low to Med [ ]	Low
D4				
Building 324	RC-DD-1	High(g)	High(g) [ ]	ND
KE/KW Reactors	RC-DD-2	Low	Low [ ]	ND to Low

EU Name	EU #	Current	Active Cleanup	Near-Term Post-Cleanup
Final Reactor Disposition	RC-DD-3	Low	Proposed method: ND Alternative: Low	ND to Low
FFTF	RC-DD-4	Low to High	Low to High	ND
PUREX	CP-DD-1	High[h]	High[h]	ND
B Plant	CP-DD-2	Med to High	Med to High	ND
U Plant	CP-DD-3	Low to Med	Low to Med	ND
REDOX	CP-DD-4	Med to High	Med to High	Low
PFP	CP-DD-5	High	Med to High	ND to Low
Operating Facilities				
KW Basin Sludge	RC-OP-1	Med	High[i]	NA[j]
Retained Facilities	RC-OP-2[b]	Evaluation Template was not developed.[b]		
CWC	CP-OP-1	High[k]	NA[l]	NA[l]
T Plant	CP-OP-2	High	IS	IS
WESF	CP-OP-3	High[m]	High[m]	IS
WRAP	CP-OP-4	High	IS	IS
CSB	CP-OP-5	High	IS	IS
ERDF	CP-OP-6	Med[n]	Med[n]	ND
IDF	CP-OP-7	ND	ND to Low	IS
Mixed Waste Trenches	CP-OP-8	High	IS	IS
Naval Reactors Trench	CP-OP-9	Low	IS	IS
242-A Evaporator	CP-OP-10	High	High	IS
LERF + ETF[o]	CP-OP-11	Low	IS	IS
TEDF	CP-OP-12	ND	IS	IS
SALDS	CP-OP-13	ND	IS	IS
WTP	CP-OP-14[b]	Evaluation Template was not developed.[b]		
222-S Laboratory	CP-OP-15	High	IS	IS
WSCF	CP-OP-17[b]	Evaluation Template was not developed.[b]		

a. 618-11 Burial - Medium for sampling pit accident.

b. Evaluation Templates for four of the EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.

c. BC Cribs - High for significant action associated with removal treatment and disposal.
d. Pu-Contaminated - Medium for removal of heavily Pu contaminated soils.
e. RTD is Retrieve, Treat, Dispose, which drives the highest risks. The no action alternative, which is not feasible, was evaluated to represent the current state.
f. IS - Insufficient information.
g. Building 324 - High for waste handling accident, Hydrogen deflagration, and seismic events.
h. PUREX - High for seismic caused collapse of Building 202-A and fire in Tunnel #1.
i. K-West Basin Sludge - High in phase 2 (ECRTS) under multiple scenarios.
j. K-West Basin - D&D to be done with K-West Reactor.
k. CWC - High for fire scenarios and seismic event.
l. D&D of facility not yet planned.
m. WESF - High for loss of pool cell water, hydrogen explosion in hot cell G or K3 duct, hydrogen explosion in ion exchange module (WIXM) and design basis seismic event.
n. ERDF - Medium for contact with waste of much higher activity than expected.
o. EU CP-OP-16 (ETF) was incorporated into and evaluated under EU CP-OP-11 (LERF + ETF).

Table 4-3. Summary of Risk Review Project ratings: human health: Co-located Person from Type 1 nuclear safety accident ratings for three evaluation periods. (See symbology legend p. xxv)

EU Name	EU #	Current	Active Cleanup	Near-Term Post-Cleanup
Legacy Sources				
618-11 Burial Grounds	RC-LS-1	ND	Med[a]	ND
K Area Waste Sites	RC-LS-2	Low	Low	ND
Orchard Lands	RC-LS-3[b]	Evaluation Template was not developed.[b]		
618-10 Burial Ground and 316-4 Waste Site	RC-LS-4	ND to Low	ND to Low	ND
BC Cribs and Trenches	CP-LS-1	ND to Low	Low to Med[c]	Low
Plutonium Contaminated Waste Sites	CP-LS-2	ND to Low	Low	ND
U Plant Cribs and Ditches	CP-LS-3	ND to Low	ND to Low	ND
REDOX Cribs and Ditches	CP-LS-4	ND to Low	ND to Low	ND
U and S Ponds	CP-LS-5	ND	ND	ND
T Plant Cribs and Ditches	CP-LS-6	ND to Low	ND to Low	ND
200 Area HLW Transfer Pipeline	CP-LS-7	ND to Low	ND to Low	ND
B Plant Cribs and Ditches	CP-LS-8	ND to Low	ND to Low	ND
PUREX Cribs and Trenches (inside 200 E)	CP-LS-9	ND to Low	ND to Low	ND
PUREX and Tank Farm Cribs and Trenches (outside 200 E)	CP-LS-10	ND to Low	ND to Low	ND
B Pond	CP-LS-11	ND	ND	ND
200 West Burial Ground	CP-LS-12	ND to Low	IS[d]	IS
200 West Miscellaneous Waste Sites	CP-LS-13	ND to Low	IS	IS
200 East Burial Grounds	CP-LS-14	ND to Low	IS	IS
200 East Miscellaneous Waste Sites	CP-LS-15	ND to Low	IS	IS
Grout Vaults	CP-LS-16	ND	ND	ND
BC Control Zone	CP-LS-17	ND	ND	IS

EU Name	EU #	Current	Active Cleanup	Near-Term Post-Cleanup
Outer Area Sites	CP-LS-18	ND	ND	ND
Tank Waste and Farms				
T Tank Farm	CP-TF-1	Low to Med	Low to Med	Low
S-SX Tank Farms	CP-TF-2	Low to Med	Low to Med	Low
TX-TY Tank Farms	CP-TF-3	Low to Med	Low to Med	Low
U Tank Farm	CP-TF-4	Low to Med	Low to Med	Low
A-AX Tank Farms	CP-TF-5	Low to Med	Low to Med	Low
B-BX-BY Tank Farms	CP-TF-6	Low to Med	Low to Med	Low
C Tank Farms	CP-TF-7	Low to Med	Low to Med	Low
200 East (DSTs)	CP-TF-8	Low to Med	Low to Med	Low
200 West (DSTs)	CP-TF-9	Low to Med	Low to Med	Low
Groundwater				
300 Area GW Plumes	RC-GW-1	Low	Low	Low
100-N GW Plumes	RC-GW-2	Low	Low	ND
100-B/D/H/F/K Area GW Plumes	RC-GW-3	Low to Med	Low to Med	ND to Low
200 East Groundwater	CP-GW-1	Low to Med	Low to Med	ND to Low
200 West Groundwater	CP-GW-2	Low to Med	Low to Med	ND
D4				
Building 324	RC-DD-1	High[(e)]	High[(e)]	ND
KE/KW Reactors	RC-DD-2	Low	Low	ND
Final Reactor Disposition	RC-DD-3	Low	Proposed method: ND Alternative: Low	ND to Low
FFTF	RC-DD-4	ND to Low	ND to Low	ND
PUREX	CP-DD-1	High[(f)]	Med	ND
B Plant	CP-DD-2	Med to High	Med to High	ND
U Plant	CP-DD-3	Low to Med	Low to Med	ND
REDOX	CP-DD-4	Med to High	Med to High	ND
PFP	CP-DD-5	High	Med to High	ND to Low

EU Name	EU #	Current	Active Cleanup	Near-Term Post-Cleanup
Operating Facilities				
KW Basin Sludge	RC-OP-1	Med	High(g)	NA(h)
Retained Facilities	RC-OP-2(b)	Evaluation Template was not developed.(b)		
CWC	CP-OP-1	High(i)	NA(j)	NA(j)
T Plant	CP-OP-2	High	IS	IS
WESF	CP-OP-3	High(k)	Med(l)	IS
WRAP	CP-OP-4	High	IS	IS
CSB	CP-OP-5	High	IS	IS
ERDF	CP-OP-6	Low(m)	Low(m)	ND
IDF	CP-OP-7	ND	ND to Low	IS
Mixed Waste Trenches	CP-OP-8	High	IS	IS
Naval Reactors Trench	CP-OP-9	Low	IS	IS
242-A Evaporator	CP-OP-10	Med to High	Med to High	IS
LERF + ETF(n)	CP-OP-11	Low	IS	IS
TEDF	CP-OP-12	ND	IS	IS
SALDS	CP-OP-13	ND	IS	IS
WTP	CP-OP-14(b)	Evaluation Template was not developed.(b)		
222-S Laboratory	CP-OP-15	Med	IS	IS
WSCF	CP-OP-17(b)	Evaluation Template was not developed.(b)		

a. 618-11 Burial - Medium for Sampling Pit accident
b. Evaluation Templates for four of the EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.
c. BC Cribs - Medium for significant action associated with removal treatment and disposal
d. IS - Insufficient information
e. Building 324 - High for waste handling accident
f. PUREX - High for seismic caused collapse of Building 202-A and fire in Tunnel #1
g. KW Basin Sludge - High in phase 2 (ECRTS) under multiple scenarios
h. KW Basin - D&D to be done with K-West Reactor
i. CWC - High for fire scenarios and seismic event
j. D&D of facility not yet planned
k. WESF - High for loss of pool cell water and hydrogen explosion in hot cell G or K3 duct
l. WESF - Medium for design basis seismic event, crane drop through roof and hydrogen explosion K3 filter
m. ERDF - Low for contact with waste of much higher activity than expected
n. EU CP-OP-16 (ETF) was incorporated into and evaluated under EU CP-OP-11 (LERF + ETF)

Table 4-4. Summary of Risk Review Project ratings: human health: Public from Type 1 nuclear safety accident ratings for three evaluation periods. (See symbology legend p. xxv)

EU Name	EU #	Current	Active Cleanup	Near-term Post-cleanup
Legacy Sources				
618-11 Burial Grounds	RC-LS-1	ND	Med[a]	ND
K Area Waste Sites	RC-LS-2	Low	Low	ND
Orchard Lands	RC-LS-3[b]	Evaluation Template was not developed.[b]		
618-10 Burial Ground and 316-4 Waste Site	RC-LS-4	ND	ND	ND
BC Cribs and Trenches	CP-LS-1	ND	ND to Low	ND
Plutonium Contaminated Waste Sites	CP-LS-2	ND	ND	ND
U Plant Cribs and Ditches	CP-LS-3	ND	ND	ND
REDOX Cribs and Ditches	CP-LS-4	ND	ND	ND
U and S Ponds	CP-LS-5	ND	ND	ND
T Plant Cribs and Ditches	CP-LS-6	ND	ND	ND
200 Area HLW Transfer Pipeline	CP-LS-7	ND	ND	ND
B Plant Cribs and Ditches	CP-LS-8	ND	ND	ND
PUREX Cribs and Trenches (inside 200 E)	CP-LS-9	ND	ND	ND
PUREX and Tank Farm Cribs and Trenches (outside 200 E)	CP-LS-10	ND	ND	ND
B Pond	CP-LS-11	ND	ND	ND
200 West Burial Ground	CP-LS-12	ND	IS[c]	IS
200 West Miscellaneous Waste Sites	CP-LS-13	ND	IS	IS
200 East Burial Grounds	CP-LS-14	ND	IS	IS
200 East Miscellaneous Waste Sites	CP-LS-15	ND	IS	IS
Grout Vaults	CP-LS-16	ND	ND	ND
BC Control Zone	CP-LS-17	ND	ND	IS

EU Name	EU #	Current	Active Cleanup	Near-term Post-cleanup
Outer Area Sites	CP-LS-18	ND	ND	ND
Tank Waste and Farms				
T Tank Farm	CP-TF-1	Low	Low	ND
S-SX Tank Farms	CP-TF-2	Low	Low	ND
TX-TY Tank Farms	CP-TF-3	Low	Low	ND
U Tank Farm	CP-TF-4	Low	Low	ND
A-AX Tank Farms	CP-TF-5	Low	Low	ND
B-BX-BY Tank Farms	CP-TF-6	Low	Low	ND
C Tank Farms	CP-TF-7	Low	Low	ND
200 East (DSTs)	CP-TF-8	Low	Low	ND
200 West (DSTs)	CP-TF-9	Low	Low	ND
Groundwater				
300 Area GW Plumes	RC-GW-1	ND	ND	ND
100-N GW Plumes	RC-GW-2	ND	ND	ND
100-B/D/H/F/K Area GW Plumes	RC-GW-3	ND to Low	ND to Low	ND
200 East Groundwater	CP-GW-1	ND to Low	ND to Low	ND
200 West Groundwater	CP-GW-2	ND to Low	ND to Low	ND
D4				
Building 324	RC-DD-1	High(d)	High(d)	ND
KE/KW Reactors	RC-DD-2	Low	Low	ND to Low
Final Reactor Disposition	RC-DD-3	ND	Proposed method: ND Alternative: Low	ND to Low
FFTF	RC-DD-4	ND	ND	ND
PUREX	CP-DD-1	ND to Low	ND to Low	ND to Low
B Plant	CP-DD-2	ND	ND	ND
U Plant	CP-DD-3	ND to Low	ND to Low	ND
REDOX	CP-DD-4	ND	ND	ND
PFP	CP-DD-5	Low to Med	Low	ND
Operating Facilities				

EU Name	EU #	Current	Active Cleanup	Near-term Post-cleanup
KW Basin Sludge	RC-OP-1	Low	Low	NA[e]
Retained Facilities	RC-OP-2[b]	Evaluation Template was not developed.[b]		
CWC	CP-OP-1	Low	IS[f]	IS[f]
T Plant	CP-OP-2	Low	IS	IS
WESF	CP-OP-3	Low	Low	IS
WRAP	CP-OP-4	Low	IS	IS
CSB	CP-OP-5	ND	IS	IS
ERDF	CP-OP-6	ND to Low	ND to Low	ND
IDF	CP-OP-7	ND	ND	ND
Mixed Waste Trenches	CP-OP-8	Low	IS	IS
Naval Reactors Trench	CP-OP-9	Low	IS	IS
242-A Evaporator	CP-OP-10	ND to Low	ND to Low	IS
LERF + ETF[g]	CP-OP-11	IS	IS	IS
TEDF	CP-OP-12	ND	IS	IS
SALDS	CP-OP-13	ND	IS	IS
WTP	CP-OP-14[b]	Evaluation Template was not developed.[b]		
222-S Laboratory	CP-OP-15	ND	IS	IS
WSCF	CP-OP-17[b]	Evaluation Template was not developed.[b]		

a. 618-11 – Med for sampling and retrieval accident, including impacts at Energy Northwest Columbia Generating Station.
b. Evaluation Templates for four of the EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.
c. IS - Insufficient information.
d. Building 324 - High for waste handling accident.
e. K-West Basin - D&D to be done with K-West Reactor.
f. D&D of facility not yet planned.
g. EU CP-OP-16 (ETF) was incorporated into and evaluated under EU CP-OP-11 (LERF + ETF).

4.3. GROUNDWATER AND COLUMBIA RIVER

Many of the EUs being considered involve discharges of contaminants into the environment that either have resulted in current groundwater contamination or may in the future impact groundwater. In addition, groundwater may serve as a contaminant transport pathway for threats to the Columbia River. Table 4-5 through Table 4-7 provide the Risk Review Project ratings related to current and potential future groundwater contamination. Threats to groundwater evaluated are:

1. Groundwater currently contaminated and the potential for increased extent of contaminated groundwater from the spread of contaminants already in groundwater (Table 4-5)
2. The potential for existing environmental contamination in the near surface or vadose zone to increase the extent of contaminated groundwater (Table 4-6)
3. The potential for contaminants currently in engineered facilities (i.e., tank wastes) to increase the extent of contaminated groundwater.

The primary focus was on Group A and Group B primary contaminants because of their persistence and mobility.

Threats considered to the Columbia River from discharges of contaminated groundwater through springs and upwellings are (Table 4-7):

1. Threats to the riparian zone ecology
2. Threats to the Columbia River benthic zone ecology
3. Threats to the free stream ecology

Current threats to human health from groundwater are ND because contaminated groundwater is not currently being used. The Central Plateau EUs present no discernible risk to the Columbia River during the period of time evaluated in this Risk Review. The most sensitive receptors are (1) groundwater (as a protected resource) because of the large volumes of groundwater currently contaminated above resource protection thresholds, and (2) the riparian zone as part of the rating of threats to the Columbia River because of elevated contaminant concentrations in an area of sensitive ecosystems. Most of the groundwater EUs with elevated Risk Review Project ratings (in the River Corridor and the Central Plateau) are currently being treated, with the notable exception of groundwater and vadose contamination in the 200 East Area. The current state of groundwater contamination in the River Corridor suggests that current active treatment actions (e.g., groundwater pump and treat) should be evaluated for optimization and consideration of appropriate end-points (i.e., when to stop treatment and reallocate resources to other remedial activities).

Table 4-5. Summary of Risk Review Project ratings: threats to groundwater as a resource from existing groundwater contamination. (See symbology legend p. xxv)

EU Name	EU #	Risk Driver	Current	Active Cleanup	Near-Term Post-Cleanup
Groundwater					
300 Area GW Plumes	RC-GW-1	U-Total	Low	ND	ND
100-N GW Plumes	RC-GW-2	Sr-90	Medium	Medium	Medium
100-B/D/H/F/K Area GW Plumes	RC-GW-3	Cr-VI	Medium	Medium	Medium
200 East Groundwater	CP-GW-1	I-129	Very High	Very High	Very High
200 West Groundwater	CP-GW-2		Very High (CCl4)	Very High (CCl4)	Medium (I-129)

Table 4-6. Summary of Risk Review Project ratings threats to groundwater from contaminants currently in the vadose zone (includes current vadose zone inventory in Tank Farm and Waste EUs but not inventory within the tanks themselves). (See symbology legend p. xxv)

EU Name	EU	Risk Driver	Current	Risk Driver	Active Cleanup	Risk Driver	Near-term Post-cleanup
Legacy Site EUs							
618-11 Burial Grounds	RC-LS-1	H-3, NO_3[(a)]	Med	H-3, NO_3[(a)]	Low		ND
K Area Waste Sites	RC-LS-2	C-14	High	C-14	High	C-14	High
Orchard Lands	RC-LS-3[(b)]	Evaluation Template was not developed.[(b)]					
618-10 Burial Ground and 316-4 Waste Site	RC-LS-4	Cr[(c)], U-Total	Low	Cr[(c)], U-Total	Low	Cr[(c)], U-Total	Low
BC Cribs and Trenches	CP-LS-1	I-129, Tc-99, Cr[(c)]	High	I-129, Tc-99, Cr[(c)]	High	I-129, Tc-99, Cr[(c)]	High
Plutonium Contam-inated Waste Sites	CP-LS-2	CCl4	Very High	CCl4	Very High	CCl4	Very High
U Plant Cribs and Ditches	CP-LS-3	U-Total	High	U-Total	High	Various[(d)]	Low

EU Name	EU	Risk Driver	Current	Risk Driver	Active Cleanup	Risk Driver	Near-term Post-cleanup
REDOX Cribs and Ditches	CP-LS-4	I-129	High	I-129	High	I-129	High
U and S Ponds	CP-LS-5	CCl_4	Very High	CCl_4	Very High	CCl_4	Very High
T Plant Cribs and Ditches	CP-LS-6	Cr-VI	High	Cr-VI	High	Cr-VI	High
200 Area HLW Transfer Pipeline	CP-LS-7	Various[e]	Low	Various[e]	Low	Various[f]	Low
B Plant Cribs and Ditches	CP-LS-8	Cr-VI, Sr-90	High	Cr-VI	High	Cr-VI	High
PUREX Cribs and Trenches (inside 200 E)	CP-LS-9	I-129, Sr-90	High	I-129, Sr-90[g]	High	I-129	High
PUREX and Tank Farm Cribs and Trenches (outside 200 E)	CP-LS-10	Cr[c]	High	Cr[c]	High	Cr[c]	High
B Pond	CP-LS-11	CCl_4	Very High	CCl_4	Very High	CCl_4	Very High
200 West Burial Ground	CP-LS-12	Various[h]	High	Various[h]	High	Various[h]	High
200 West Miscellaneous Waste Sites	CP-LS-13	I-129, Cr[c]	Medium	I-129, Cr[c]	Medium	I-129, Cr[c]	Medium
200 East Burial Grounds	CP-LS-14	Cr-VI	Very High	Cr-VI	Very High	Cr-VI	Very High
200 East Miscellaneous Waste Sites	CP-LS-15		ND		ND		ND

EU Name	EU	Risk Driver	Current		Risk Driver	Active Cleanup		Risk Driver	Near-term Post-cleanup	
Grout Vaults	CP-LS-16		ND			ND			ND	
BC Control Zone	CP-LS-17		ND			ND			ND	
Outer Area Sites	CP-LS-18	CCl_4	Medium		CCl_4	Medium		CCl_4	Medium	
Tank Waste and Farms										
T Tank Farm	CP-TF-1	Cr(c)	High	ǂ	Cr(c)	High	ǂ	Cr(c)	High	
S-SX Tank Farms	CP-TF-2	Cr(c)	High	ǂ	Cr(c)	High	[ ]ǂ	Cr(c)	High	
TX-TY Tank Farms	CP-TF-3	Tc-99, CCl4, Cr(c)	High	ǂ	Tc-99, CCl4, Cr(c)	High	[ ]ǂ	Tc-99, CCl4, Cr(c)	High	
U Tank Farm	CP-TF-4	Various(e)	Low	ǂ	Various(e)	Low	[ ]ǂ	Various(f)	Low	
A-AX Tank Farms	CP-TF-5	Cr(c)	Medium	ǂ	Cr(c)	Medium	[ ]ǂ	Cr-IV	Medium	
B-BX-BY Tank Farms	CP-TF-6	Tc-99, Cr(c)	High	ǂ	Tc-99, Cr(c)	High	[ ]ǂ	I-129, Tc-99, Cr(c)	High	
C Tank Farms	CP-TF-7	I-129, Tc-99	Medium	[ ]ǂ	I-129, Tc-99	Medium	[ ]ǂ	I-129	Medium	
200 East (DSTs)	CP-TF-8	Various(e)	Low	[ ]	Various(e)	Low	[ ]	Various(f)	Low	
200 West (DSTs)	CP-TF-9		ND			ND	[ ]		ND	
D4										
Building 324	RC-DD-1	Sr-90	Low		Sr-90	Low	[ ]	Sr-90	Low	
KE/KW Reactors	RC-DD-2		ND			ND	[ ]		ND	
Final Reactor Disposition	RC-DD-3		ND			ND			ND	
FFTF	RC-DD-4		ND			ND			ND	
PUREX	CP-DD-1	Various(e)	Low		Various(e)	Low	[ ]	Various(f)	Low	
B Plant	CP-DD-2	Various(e)	Low		Various(e)	Low		Various(f)	Low	
U Plant	CP-DD-3	Various(e)	Low		Various(e)	Low		Various(f)	Low	
REDOX	CP-DD-4	Various(e)	Low		Various(e)	Low		Various(f)	Low	

EU Name	EU	Risk Driver	Current	Risk Driver	Active Cleanup	Risk Driver	Near-term Post-cleanup
PFP	CP-DD-5	CCl_4	High	CCl_4	High	CCl_4	High
Operating Facilities							
KW Basin Sludge	RC-OP-1		ND		ND		ND
Retained Facilities	RC-OP-2[b]	Evaluation Template was not developed.[b]					
CWC	CP-OP-1		ND		ND		ND
T Plant	CP-OP-2	Various[e]	Low	Various[e]	Low	Various[f]	Low
WESF	CP-OP-3		ND		ND		ND
WRAP	CP-OP-4		ND		ND		ND
CSB	CP-OP-5		ND		ND		ND
ERDF	CP-OP-6		ND		ND		ND
IDF	CP-OP-7		ND		ND		ND
Mixed Waste Trenches	CP-OP-8		ND		ND		ND
Naval Reactors Trench	CP-OP-9		ND		ND		ND
242-A Evaporator	CP-OP-10		ND		ND		ND
LERF + ETF[i]	CP-OP-11		ND		ND		ND
TEDF	CP-OP-12		ND		ND		ND
SALDS	CP-OP-13	H-3[j]	Med	H-3[j]	Med	H-3[j]	Low
WTP	CP-OP-14[b]	Evaluation Template was not developed.[b]					
222-S Laboratory	CP-OP-15		ND		ND		ND
WSCF	CP-OP-17[b]	Evaluation Template was not developed.[b]					

a. There are no Group A or B primary contaminants in the vicinity of 618-11. Tritium and nitrate (Group C) current plumes area corresponds to a Medium rating. Decay and dispersion is expected to reduce the rating to Low and ND for the Active Cleanup and Near-Term Post Cleanup periods, respectively.

b. Evaluation Templates for four of the EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste

Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.

c. Cr represents both total and hexavalent chromium
d. The various non-zero inventory PCs are C-14, I-129, Tc-99, Cr[c], U-Total
e. The various non-zero inventory PCs are C-14, I-129, Tc-99, Cr[c]
f. The various non-zero inventory PCs are C-14, I-129, Sr-90, Tc-99, Cr[c], U-Total
g. As described in Part V of Appendix F.6 (PUREX Cribs and Trenches, CP-LS-9), the rating for Sr-90 is not changed during this period because the impact of radioactive decay on the large remaining vadose zone source is insufficient when accounting for uncertainty.
h. The various non-zero inventory PCs are C-14, I-129, CCl_4, Cr[c]
i. EU CP-OP-16 (ETF) was incorporated into and evaluated under EU CP-OP-11 (LERF + ETF)
j. There are no Group A or B primary contaminants in the vicinity of SALDS. Tritium (Group C) current plume area corresponds to a Medium rating.

Table 4-7. Summary of Risk Review Project ratings: threats to the Columbia River through groundwater contaminant transport. (See symbology legend p. xxv)

EU Name	EU	Receptor	Current	Active Cleanup	Near-Term Post-Cleanup
Groundwater (from existing groundwater contamination)					
300 Area GW Plumes	RC-GW-1	Benthic (all)	High (U-Total)[a]	ND[b]	ND
		Riparian (all)	High (U-Total)[a]	ND[b]	ND
		Free-flowing (all)	ND	ND	ND
100-N GW Plumes	RC-GW-2	Benthic (all)	Medium (Sr-90)	Medium (Sr-90)	Medium (Sr-90)
		Riparian (all)	Medium (Sr-90)	Medium (Sr-90)	Medium (Sr-90)
		Free-flowing (all)	ND	ND	ND
100-B/D/H/F/K Area GW Plumes	RC-GW-3	Benthic (all)	Medium (Cr-VI)	Medium (Cr-VI)	Medium (Cr-VI)
		Riparian (all)	Medium (Cr-VI)	Medium (Cr-VI)	Medium (Cr-VI)
		Free-flowing (all)	ND	ND	ND
200 East Groundwater	CP-GW-1	Benthic (all)	ND	ND	ND
		Riparian (all)	ND	ND	ND
		Free-flowing (all)	ND	ND	ND
200 West Groundwater	CP-GW-2	Benthic (all)	ND	ND	ND
		Riparian (all)	ND	ND	ND
		Free-flowing (all)	ND	ND	ND
Legacy Site EUs					
618-11 Burial Grounds	RC-LS-1	Benthic (all)	ND	ND	ND
		Riparian (all)	ND	ND	ND
		Free-flowing (all)	ND	ND	ND
K Area Waste Sites	RC-LS-2	Benthic (all)	ND[c]	ND[c]	Low (C-14)[d]
		Riparian (all)	ND[c]	ND[c]	Low (C-14)[d]
		Free-flowing (all)	ND	ND	ND
Orchard Lands	RC-LS-3[e]	Evaluation Template was not developed.[e]			

EU Name	EU	Receptor	Current		Active Cleanup		Near-Term Post-Cleanup	
BC Cribs and Trenches	CP-LS-1	Benthic –						
		(radionuclides)	ND	○	ND	[○]	ND	◎
		(chemicals)	ND	○	ND	[○]	ND	◎
		Riparian –						
		(radionuclides)	ND	○	ND	[○]	ND	◎
		(chemicals)	ND	○	ND	[○]	ND	◎
		Free-flowing (all)	ND	○	ND	[○]	ND	◎
Plutonium Contam-inated Waste Sites	CP-LS-2	Benthic (all)	ND	○	ND	[○]	ND	◎
		Riparian (all)	ND	○	ND	[○]	ND	◎
		Free-flowing (all)	ND	○	ND	[○]	ND	◎
U Plant Cribs and Trenches	CP-LS-3	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
REDOX Cribs and Ditches	CP-LS-4	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
U and S Ponds	CP-LS-5	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
T Plant Cribs and Ditches	CP-LS-6	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
200 Area HLW Transfer Pipeline	CP-LS-7	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
B Plant Cribs and Ditches	CP-LS-8	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○

EU Name	EU	Receptor	Current		Active Cleanup		Near-Term Post-Cleanup	
PUREX Cribs and Trenches (inside 200 E)	CP-LS-9	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
PUREX and Tank Farm Cribs and Trenches (outside 200 E)	CP-LS-10	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
B Pond	CP-LS-11	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
200 West Burial Ground	CP-LS-12	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
200 West Miscellaneous Waste Sites	CP-LS-13	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
200 East Burial Grounds	CP-LS-14	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
200 East Miscellaneous Waste Sites	CP-LS-15	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
Grout Vaults	CP-LS-16	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
BC Control Zone	CP-LS-17	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○

EU Name	EU	Receptor	Current		Active Cleanup		Near-Term Post-Cleanup	
Outer Area Sites	CP-LS-18	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
Tank Waste and Farms								
200 West SSTs								
T Tank Farm	CP-TF-1	Benthic (all)	ND	○ ǂ	ND	○ ǂ	ND	◎
		Riparian (all)	ND	○ ǂ	ND	○ ǂ	ND	◎
		Free-flowing (all)	ND	○ ǂ	ND	○ ǂ	ND	◎
S-SX Tank Farms TX-TY Tank Farms U Tank Farm	CP-TF-2 CP-TF-3 CP-TF-4	Benthic (all)	ND	◌ ǂ	ND	[◌] ǂ	ND	◎
		Riparian (all)	ND	◌ ǂ	ND	[◌] ǂ	ND	◎
		Free-flowing (all)	ND	◌ ǂ	ND	[◌] ǂ	ND	◎
200 East SSTs								
A-AX Tank Farms B-BX-BY Tank Farms	CP-TF-5 CP-TF-6	Benthic –						
		(radionuclides)	ND	◌ ǂ	ND	[◌] ǂ	ND	◌
		(chemicals)	ND	◌ ǂ	ND(f)	[◌] ǂ	ND(f)	◌
		Riparian –						
		(radionuclides)	ND	◌ ǂ	ND	[◌] ǂ	ND	◌
		(chemicals)	ND	◌ ǂ	ND(f)	[◌] ǂ	ND(f)	◌
		Free-flowing (all)	ND	◌ ǂ	ND	[◌] ǂ	ND	◌
C Tank Farms	CP-TF-7	Benthic –						
		(radionuclides)	ND	[◌] ǂ	ND	[◌] ǂ	ND	◎
		(chemicals)	ND	[◌] ǂ	ND(f)	[◌] ǂ	ND(f)	◎
		Riparian –						
		(radionuclides)	ND	[◌] ǂ	ND	[◌] ǂ	ND	◎
		(chemicals)	ND	[◌] ǂ	ND(f)	[◌] ǂ	ND(f)	◎
		Free-flowing (all)	ND	[◌] ǂ	ND	[◌] ǂ	ND	◎
200 East DSTs	CP-TF-8	Benthic (all)	ND	[⊚]	ND	[⊚]	ND	⊚
		Riparian (all)	ND	[⊚]	ND	[⊚]	ND	⊚
		Free-flowing (all)	ND	[⊚]	ND	[⊚]	ND	⊚
200 West	CP-TF-9	Benthic (all)	ND	◉	ND	[◉]	ND	◉

EU Name	EU	Receptor	Current		Active Cleanup		Near-Term Post-Cleanup	
DSTs		Riparian (all)	ND	⦾	ND	[⦾]	ND	⦾
		Free-flowing (all)	ND	⦾	ND	[⦾]	ND	⦾
D4								
Building 324	RC-DD-1	Benthic (all)	ND	◌	ND	[◌]	ND	⦾
		Riparian (all)	ND	◌	ND	[◌]	ND	⦾
		Free-flowing (all)	ND	◌	ND	[◌]	ND	⦾
KE/KW Reactors	RC-DD-2	Benthic (all)	ND	◎	ND	[◎]	ND	○
		Riparian (all)	ND	◎	ND	[◎]	ND	○
		Free-flowing (all)	ND	◎	ND	[◎]	ND	○
Final Reactor Disposition	RC-DD-3	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
FFTF	RC-DD-4	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
PUREX	CP-DD-1	Benthic (all)	ND	◎	ND	[◎]	ND	⦾
		Riparian (all)	ND	◎	ND	[◎]	ND	⦾
		Free-flowing (all)	ND	◎	ND	[◎]	ND	⦾
B Plant	CP-DD-2	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
U Plant	CP-DD-3	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
REDOX	CP-DD-4	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
PFP	CP-DD-5	Benthic (all)	ND	○	ND	○	ND	○

EU Name	EU	Receptor	Current		Active Cleanup		Near-Term Post-Cleanup	
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
Operating Facilities								
KW Basin Sludge	RC-OP-1	Benthic (all)	ND	◎	ND	◎	ND	○
		Riparian (all)	ND	◎	ND	◎	ND	○
		Free-flowing (all)	ND	◎	ND	◎	ND	○
Retained Facilities	RC-OP-2[e]	Evaluation Template was not developed.[e]						
CWC	CP-OP-1	Benthic (all)	ND	◎ (dashed)	ND	◎ (dashed)	ND	◎
		Riparian (all)	ND	◎ (dashed)	ND	◎ (dashed)	ND	◎
		Free-flowing (all)	ND	◎ (dashed)	ND	◎ (dashed)	ND	◎
T Plant	CP-OP-2	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
WESF	CP-OP-3	Benthic (all)	ND	◎	ND	◎	ND	◎
		Riparian (all)	ND	◎	ND	◎	ND	◎
		Free-flowing (all)	ND	◎	ND	◎	ND	◎
WRAP	CP-OP-4	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
CSB	CP-OP-5	Benthic (all)	ND	○	ND	○	ND	○
		Riparian (all)	ND	○	ND	○	ND	○
		Free-flowing (all)	ND	○	ND	○	ND	○
ERDF	CP-OP-6	Benthic (all)	ND	◎	ND	◎	ND	◎
		Riparian (all)	ND	◎	ND	◎	ND	◎
		Free-flowing (all)	ND	◎	ND	◎	ND	◎
IDF	CP-OP-7	Benthic (all)	ND	○	ND	○	ND	○

EU Name	EU	Receptor	Current		Active Cleanup		Near-Term Post-Cleanup	
		Riparian (all)	ND	◯	ND	◯	ND	◯
		Free-flowing (all)	ND	◯	ND	◯	ND	◯
Mixed Waste Trenches	CP-OP-8	Benthic (all)	ND	◯	ND	◯	ND	◯
		Riparian (all)	ND	◯	ND	◯	ND	◯
		Free-flowing (all)	ND	◯	ND	◯	ND	◯
Naval Reactors Trench	CP-OP-9	Benthic (all)	ND	◯	ND	◯	ND	◯
		Riparian (all)	ND	◯	ND	◯	ND	◯
		Free-flowing (all)	ND	◯	ND	◯	ND	◯
242-A Evaporator	CP-OP-10	Benthic (all)	ND	◯	ND	◯	ND	◯
		Riparian (all)	ND	◯	ND	◯	ND	◯
		Free-flowing (all)	ND	◯	ND	◯	ND	◯
LERF + ETF[g]	CP-OP-11	Benthic (all)	ND	◯	ND	◯	ND	◯
		Riparian (all)	ND	◯	ND	◯	ND	◯
		Free-flowing (all)	ND	◯	ND	◯	ND	◯
TEDF	CP-OP-12	Benthic (all)	ND	◯	ND	◯	ND	◯
		Riparian (all)	ND	◯	ND	◯	ND	◯
		Free-flowing (all)	ND	◯	ND	◯	ND	◯
SALDS	CP-OP-13	Benthic (all)	ND	◯	ND	◯	ND	◯
		Riparian (all)	ND	◯	ND	◯	ND	◯
		Free-flowing (all)	ND	◯	ND	◯	ND	◯
WTP	CP-OP-14[e]	Evaluation Template was not developed.[e]						
222-S Laboratory	CP-OP-15	Benthic (all)	ND	◯	ND	◯	ND	◯
		Riparian (all)	ND	◯	ND	◯	ND	◯
		Free-flowing (all)	ND	◯	ND	◯	ND	◯

EU Name	EU	Receptor	Current	Active Cleanup	Near-Term Post-Cleanup
WSCF	CP-OP-17[e]	Evaluation Template was not developed.[e]			

a. Organics (including trichloroethene (TCE) and *cis*-1,2-dichloroethene (DCE)) are locally present in deeper sediments; however, plume extents and shoreline impacts cannot be determined from current data (DOE/RL-2016-09, Rev. 0). These omissions represent data gaps for the analysis of potential groundwater and Columbia River impacts related to 300-FF.
b. Modeling indicates that the uranium will fall below the drinking water standard (DWS) by ca. 2040 assuming no remedial actions and that tritium would decline below the DWS by ca. 2031 assuming no additional tritium to the groundwater (EPA et al., 2013). Nitrate above the DWS is due to off-site sources and was not evaluated ROD, and thus further potential impact is not related to the GW EU.
c. There are potential K Area Waste Sites EU sources for the hexavalent chromium (Cr-VI) and trichloroethene (TCE) (DOE/RL-2016-09, Rev. 0) but reported inventories are unavailable making it impossible to rate these PCs, which represent data gaps in the evaluation. The 100-K plumes associated with these PCs (including the hexavalent chromium plume currently in contact with the Columbia River) are evaluated in Appendix D.4.
d. The C-14 plume is not currently intersecting the Columbia River; however, due to uncertainties associated with the transport of C-14, which does not decay quickly, a Low rating is given.
e. Evaluation Templates for four of the EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.
f. The information from Appendix P from the TC&WM EIS would suggest that hexavalent chromium would have Medium and High ratings for benthic and riparian zone impacts, respectively. However, current well data suggest that chromium is moving much more slowly than predicted in the TC&WM EIS evaluation resulting in *Not Discernible* (ND) ratings.
g. EU CP-OP-16 (ETF) was incorporated into and evaluated under EU CP-OP-11 (LERF + ETF).

4.4. ECOLOGICAL RESOURCES

Plants and animals belong to communities and ecosystems, which in turn are part of larger geographical units or ecoregions. The value of ecological resources depends not only on resources at a specific site, but on their relationship to adjacent areas, the region, and the greater ecoregion, as well as to human communities. For this Risk Review Project, ecological resources at Hanford Site were evaluated on three landscape scales: (1) the Columbia Basin Ecoregion, (2) Hanford-wide, and (3) site-specific with respect to EUs and a buffer area around the EU.

In general, the habitats most at risk are those that currently are in short supply both at Hanford Site and in the Columbia Basin Ecoregion, as well as those habitats that have been declining most rapidly on site or in the ecoregion. Bluebunch wheatgrass is a unique habitat that increased on Hanford over the last centuries, but decreased markedly in the ecoregion (see Chapter 7 of the methodology report [CRESP 2015b]). Big sagebrush steppe is also of concern because Hanford has a significant component of this habitat in the ecoregion, and it has decreased both at Hanford and in the ecoregion (although it is still the dominant and largest habitat on the Hanford Site). Sagebrush is a priority habitat in the State of Washington.

On the Hanford Site, big sagebrush habitats are considered at risk even though they are common, partly because large areas of sagebrush can be destroyed by fire, reducing its availability for decades. Further, the value of a habitat type increases with the size of the patch; many small, separate sagebrush patches are of less value than a single patch that has similar amount of sagebrush. Large patches have less edge to interior and are less likely to be invaded by non-native, noxious species. Aquatic habitats embedded within the terrestrial environment at the Hanford Site are critical because they are so limited in space, and act as habitat islands for many species. That is, some species are limited to these regions, and the dry steppe habitat that surrounds them serves as a barrier to movement. Sensitive and irreplaceable habitats on the Hanford Site include cliffs, lithosols, dune fields, ephemeral streams and vernal ponds, and fall Chinook salmon and steelhead spawning areas (DOE/RL-96-32 2013, Chapter 7 of the methodology report [CRESP 2015b).

The most highly valued habitats on the Hanford Site are in the riparian zone along the Columbia River (DOE/RL-96-32 2013, Chapter 7 of the methodology report [CRESP 2015b]). The riparian zone (1) only occurs in a narrow band along the Columbia River; (2) is the interface zone between land and water, and biota living there have adapted to that narrow habitat band; (3) is a zone of relatively high species diversity; (4) has plants that can withstand inundation by flood waters, and dry out during low water; (5) is vulnerable to stressors from both the land and Columbia River; (6) is vulnerable to disturbance because of the vertical gradient sloping down to the Columbia River; (7) provides the exposure pathway from land to the Columbia River to physical, biological, and chemical/radiological contamination stressors; and (8) is the region most used by humans for thousands of years because of its proximity to the Columbia River. Thus, the resources in the riparian zone are critical and highly valued (Level 5 resources, DOE/RL-96-32 2013, Chapter 7 of the methodology report [CRESP 2015b] by the State of Washington and federal agencies (the U.S. Fish and Wildlife Service and Army Corps of Engineers) that manage the land/water interface.

Currently, there are three federally endangered/threatened species (all fish), and four Washington State endangered (threatened) species on the Hanford Site (reviewed in Chapter 7 of the methodology report [CRESP 2015b]). The state endangered animal species are Ferruginous hawk, Sage Grouse, Sandhill crane, and American White pelican. The federally endangered fish are spring Chinook salmon (spring run), and threatened fish are steelhead and bull trout. Although bull trout have been reported on the Hanford Reach, their natural habitat is mountain streams, so they are likely passing through the Hanford

Site at the time they are reported. Although many species are being monitored or are of special concern, few are actually listed as endangered or threatened by the U.S. Fish and Wildlife Service or Washington State at any one time.

The most critical component of determining risk to ecological resources is the evaluation of the EUs and their buffer areas (defined as 1X the greatest diameter of the EU, Chapter 7 of the methodology report [CRESP 2015b]). Sixty-one EUs were evaluated for risks to ecological resources. This ecological evaluation of each EU and its buffer involved using GIS-based data, previous resource level designations (DOE/RL-96-32 2013), field data collected in 2014 and 2015 (Appendix J), a table of disposition options for EUs (Appendix B), and a risk rating for each EU (see Chapter 7 of the methodology report [CRESP 2015b]).

There are six levels of ecological resources (DOE/RL-96-32, 2013) described briefly below (see Chapter 7 of the methodology report [CRESP 2015b] for a full description).

Levels of Ecological Resources (DOE/RL-96-32, 2013)

Level 5 = Irreplaceable habitat or federal threatened and endangered species (including proposed species, and species that are new to science or unique to Washington state)

Level 4 = Essential habitat for important species

Level 3 = Important habitat

Level 2 = Habitat with high potential for restoration (ecologically, not legally)

Level 1 = Industrial or developed

Level 0 = Non-native plants and animals

Three caveats should be noted: (1) many of these resources have not been evaluated for a decade or more (and so may have changed), (2) no invasive species inventory has been completed, and (3) while much of Hanford Site was evaluated for resource level, not all areas were evaluated; thus, evaluations are valid where given. If a site is blank on the resource map, it may not indicate lack of a value, but rather that it was not surveyed. This is another reason why the field evaluations from data collected in 2014 and 2015 as part of this Risk Review Project were of value (see below).

The Risk Review Project uses the following five risk ratings. Full definitions and explanations for how the ratings are applied at each EU are found in Chapter 7 of the methodology report (CRESP 2015b).

ND = Not discernible from the surrounding conditions; no additional risk.

Low = Little risk to disrupt or impact Level 3-5 ecological resources.

Medium = Potential to disrupt or impair Level 3-5 ecological resources, but the remedial action is not expected to disrupt communities permanently.

High = Likely to disrupt and impair Level 3-5 ecological resources of high value or resources that have restoration potential, and can cause permanent disruption.

Very High = Very high probability of impairing (or destroying) ecological resources of high value (Levels 3-5) that have typical (and healthy) shrub-steppe species, low percent of exotic species, and may have federally listed species. The remediation likely results in permanent destruction or degradation of habitat.

The lowest risk ratings are self-explanatory, but High and Very High require some comment. High is applied when there are high-level resources (Levels 3 to 5) that can be disrupted permanently. Very High is reserved for EUs where there is high probability of impairing or destroying resources of very high value. This is especially true of Level 5 resources. For example, the entire riparian zone along the Columbia River was designated as Level 5 resources because the riparian zone is limited and in addition was rated the highest value resource on the Hanford Site (DOE/RL-96-32, 2013). Thus, if there is currently, or could be as a result of remediation, degradation to the riparian zone along the Columbia River, the rating would be Very High.

Using the designated remediation options, functional remediation types or categories were designed that range from the least invasive (personnel traffic through the buffer zone adjacent to EUs), to the most invasive (soil removal in the EU). Some of the ecological effects are illustrated in Table 4-8.

Table 4-8. Effects from functional remediation types on ecosystems. Functional remediation types increase in intensity from top to bottom, and effects increase from left to right. If 'Yes' is capitalized that indicates the effect is high.

Functional Remediation Types	Displace MOBILE Wildlife on EU	Displace Less Mobile Species	Damage Algal Mat	Damage Native Vegetation	Spread Invasive Seeds	Alter Surface Water Flow	Destroy Soil Invertebrate Communities	Compac-tion	Remove Seedbank	Remove Living Ecosystem
Personnel traffic through non-target area	Yes	Yes	Yes							
Personal traffic through target area	Yes	Yes	Yes							
Car and pick-up traffic adjacent to the site	Yes	Yes	Yes	Yes	Yes					
Car and pick-up truck traffic through remediation site	Yes	Yes	Yes	Yes	Yes	Yes				
Truck traffic on roads through non-target area	Yes	Yes	Yes	Yes	Yes	Yes	Yes			
Truck traffic on paved roads and pads through remediation site	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Heavy equipment	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Heavy wide-hoses	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Drill rigs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Construct buildings	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
Caps, other containment	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Soil Removal	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The results of the evaluations to ecological resources are provided in Tables 4-9, 4-10, and 4-11. Table 4-9 summarizes the ratings; Table 4-10 compiles the number of ratings (e.g., Low) within each source grouping (e.g., Legacy Source); Table 4-11 provides the risk ratings, along with brief comments.

Below is a summary table of the ratings for each EU (Table 4-9). The EUs not evaluated (e.g., Pre-Hanford Orchard Lands, RC-OP-2) are described more fully in Chapter 3. Note that CP-OP-11 and CP-OP-16 were combined for this analysis.

Table 4-9. Summary of risk ratings for ecological resources.

EU Name	EU #	Current		Active Cleanup		Near-Term Post-Cleanup	
Legacy Source EUs							
618-11 Burial Grounds	RC-LS-1	ND		Low to Med	[ ]	Low to Med	
K Area Waste Sites	RC-LS-2	ND to Low		ND to Med	[ ]	Low to Med	
Orchard Lands	RC-LS-3[a]	Evaluation Template was not developed.[a]					
618-10	RC-LS-4	Low to Med		Med to High		Low to High	
BC Cribs and Trenches	CP-LS-1	ND to Low		Low to Med	[ ]	ND to Low	
Plutonium Contaminated Waste Sites	CP-LS-2	ND to Low		Low to Med	[ ]	Low	
U Plant Cribs and Ditches	CP-LS-3	Low		Low to Med		Low	
REDOX Cribs and Ditches	CP-LS-4	Low		Low to Med		Low	
U and S Pond	CP-LS-5	Low		Med to Very High		Low to Med	
T Plant Cribs and Ditches	CP-LS-6	Low		Low to High		Low to Med	
200 Area HLW Transfer Pipeline	CP-LS-7	Low		Low to High		Low to Med	
B Plant Cribs and Trenches	CP-LS-8	Low		Med to High		Low to Med	
PUREX Cribs and Trenches	CP-LS-9	Low		Low to Med		Low	
PUREX and Tank Farm Cribs and Trenches	CP-LS-10	Low to Med		Med to High		Low	
B Pond	CP-LS-11	Low to Med		Low to High		ND to Med	
200 West Burial Grounds	CP-LS-12	ND to Low		Low to Med		ND to Low	
200 West Miscellaneous Waste Sites	CP-LS-13	Low		Low to High		Low	
200 East Burial Grounds	CP-LS-14	ND to Low		Med to High		ND to Low	

EU Name	EU #	Current		Active Cleanup		Near-Term Post-Cleanup	
200 East Miscellaneous Waste Sites	CP-LS-15	Low		Med to High		Low to Med	
Grout Vaults	CP-LS-16	ND		Low to Med		Low to Med	
BC Control Zone	CP-LS-17	Low		Very High		Med to High	
Outer Area Sites	CP-LS-18	Low		Very High		Med to High	
Tank Waste and Farms							
T Tank Farm	CP-TF-1	ND to Low		Low to Med		ND to Low	
S-SX Tank Farms	CP-TF-2	ND to Low		Low to Med		ND to Low	
TX-TY Tank Farms	CP-TF-3	ND to Low		Low to Med		ND to Low	
U Tank Farm	CP-TF-4	ND to Low		Low to Med		ND to Low	
A-AX Tank Farms	CP-TF-5	ND to Low		Low to Med		ND to Low	
B-BX-BY Tank Farms	CP-TF-6	ND to Low		Low to Med		ND to Low	
C Tank Farms	CP-TF-7	ND		ND to Med		ND to Low	
200 East (DSTs)	CP-TF-8	ND		ND to Med		ND to Low	
200 West (DSTs)	CP-TF-9	ND		ND to Med		ND to Low	
Groundwater							
300 Area GW Plumes	RC-GW-1	Low to Med		Very High		Low to Med	
100-N GW Plumes	RC-GW-2	Low to Med		Very High		Low to Med	
100-B/D/H/F/K Area GW Plumes	RC-GW-3	Low to Very High		Very High		Low to Med	
200 East Groundwater	CP-GW-1	Low		Very High		Low	
200 West Groundwater	CP-GW-2	ND to Low		ND to Low		ND to Low	
D4							
Building 324	RC-DD-1	ND		ND		ND to Low	
KE/KW Reactors	RC-DD-2	ND		ND		ND to Low	
Final Reactor Disposition	RC-DD-3	Low to Med		High to Very High		Low to High	
FFTF	RC-DD-4	Low		Low to Med		Low to Med	

EU Name	EU #	Current		Active Cleanup		Near-Term Post-Cleanup	
PUREX	CP-DD-1	ND to Low		Low to Med	[ ]	ND to Low	
B Plant	CP-DD-2	ND		ND to Low		ND to Low	
U Plant	CP-DD-3	ND		ND to Low		ND to Low	
REDOX	CP-DD-4	ND		ND to Low		ND to Low	
PFP	CP-DD-5	ND		ND to Low		ND to Low	
Operating Facilities							
KW Basin Sludge	RC-OP-1	ND		ND		ND to Low	
Retained Facilities	RC-OP-2[a]	Evaluation Template was not developed.[a]					
CWC	CP-OP-1	ND		ND to Low		ND to Low	
T Plant	CP-OP-2	ND		ND to Low		ND to Low	
WESF	CP-OP-3	ND		ND		ND	
WRAP	CP-OP-4	ND		Low to Med		ND to Low	
CSB	CP-OP-5	ND		ND to Low		ND to Low	
ERDF	CP-OP-6	Low to Med		Low to High		ND to Low	
IDF	CP-OP-7	ND		ND to Low		ND to Low	
Mixed Waste Trenches	CP-OP-8	ND		Low to Med		ND to Low	
Naval Reactors Trench	CP-OP-9	Low		Med		Low	
242-A Evaporator	CP-OP-10	ND		Low		ND to Low	
LERF + ETF[b]	CP-OP-11	ND to Low		Low to High		ND to Med	
TEDF	CP-OP-12	Low		Med		Low to Med	
SALDS	CP-OP-13	ND		ND to Low		ND	
WTP	CP-OP-14	Low		Med to High		Low to Med	
222-S Laboratory	CP-OP-15	ND		Low		ND to Low	
WSCF	CP-OP-17	Low		Low to Med		ND to Low	

a. Evaluation Templates for four of the EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.

b. EU CP-OP-16 (ETF) was incorporated into and evaluated under EU CP-OP-11 (LERF + ETF)

A compilation of the risk ratings follows (**Table 4-10**). The number of EUs in each category is summed in each source category by evaluation period (current, active cleanup, near-term post cleanup).

Table 4-10. Summary of risk ratings for ecological resources on EUs as a function of source type. Percent was based on the ratings within a category (e.g., ND) for EUs with known remediation options. EUs with no current remediation designation were rated on the basis of resource value and likely remediation: ratings are shown on the right side of the Table.

						No Remediation Decision		
EUs	**ND**	**Low**	**Medium**	**High**	**Very High**	**Low**	**Medium**	**High**
Current								
Legacy Source	2	16	3					
Tank Waste and Farms	3	6						
Groundwater		2	2		1			
D4	6	2	1					
Operating Facilities	12	4	1					
Totals (%)	23 (38%)	30 (49%)	7 (11%)	0	1 (2%)	0	0	0
Active Cleanup								
Legacy Source			7	7	3		2	2
Tank Waste and Farms			9					
Groundwater		1			4			
D4		6	2		1			
Operating Facilities	2	3	3	2		4	2	1
Totals (%)	2 (4%)	10 (20%)	21 (42%)	9 (18%)	8 (16%)	4	4	3
Near-Term Post-Cleanup								
Legacy Source		8	6	3		2	2	
Tank Waste and Farms		9						
Groundwater		2	3					
D4		7	1	1				
Operating Facilities	2	7	1			5	2	
Totals (%)	2 (4 %)	33 (66%)	11 (22%)	4 (8%)	0	7	4	0

Several observations are clear from the data (tables above and Table 4-11 and Table 4-12 at end of this section):

1. Risk to ecological receptors is highest during cleanup and lowest after. This is primarily due to the large area needed for support equipment to conduct the cleanup, and the general practice of clearing the vegetation away from a waste site during remediation.
2. Groundwater EUs pose the greatest risk before cleanup (current condition), largely because of risk of contaminated groundwater reaching the ecological receptors in the riparian zone and the Columbia River.
3. The highest risk to ecological receptors during remediation is from the groundwater EUs, followed by the legacy source EUs.
4. After remediation (near-term post-cleanup), the greatest risk to ecological receptors is from the groundwater and legacy source EUs.
5. Variability in cleanup options is expressed as variation in the risk ratings. The percent of EUs with a range of risk ratings (e.g., ND to Low, ND to Medium) was 44% during the current evaluation period, 78% during active cleanup period, and 78% in the near-term post-cleanup period. Since the table reflects the highest range given, the risk may be lower (depending on cleanup method selected during active cleanup, and restoration after active cleanup).
6. For some EUs, the risk rating is higher in the near-term post cleanup period because during cleanup many sites will undergo restoration. This is the effect from creating a higher resource level than existed before cleanup. In other words, when DOE has improved the habitat on an EU, there will be a higher risk to those new resources than existed when the EU had no ecological resources.
7. For some legacy source and operating facilities EUs, the preferred remediation is unknown. For these EUs, the risk ratings may range from Low to High, depending upon the value of the resources and the possible remediation options (see **Table 4-10**, e.g., B Plant Cribs and Trenches (CP-LS-8).

A summary of the ratings for each of the EUs is given in Table 4-9 and **Table 4-10**. The complete ratings are in Table 4-11.

Summary of Risk Rating for Ecological Resources

Overall, the current risks to ecological resources range from ND to Very High, with the highest part of the range associated with the high value resources in the riparian zone that are vulnerable to both contamination and physical disruption. Ecological resources are most vulnerable during active cleanup when the risk is Medium to Very High for 76 % of the EUs. After active cleanup, only 30 % of the EUs have a Medium or High risk rating, and they are mainly the groundwater and legacy source EUs because of revegetation that will occur in areas that are surrounded by Level 3 and 4 resources, and the continued potential for disruption and disturbance (especially in the riparian zone).

The change in risk for the 61 EUs rated is illustrated in Figure 4-16. It summarizes the ratings for the three evaluation periods. Only 34% were rated higher after cleanup before cleanup; the ratings usually ranged from ND to ND-Low. The reason for this change is that currently there are no resources on the EU (e.g., the site is covered in gravel or consists entirely of buildings), but during cleanup, restoration of the EU will include revegetation and native vegetation will grow at the site. This vegetation (not currently present) could then be at risk if the EU site is exposed to monitoring or other activities during the near-term post-cleanup period, and non-native seed propagules could invade or other degradation of the EU site could happen. It is thus an indication of additional habitat created by DOE during the cleanup phase.

In contrast, the high risks currently present or during cleanup are all reduced in the near-term post-cleanup evaluation period. Thus, risk to ecological resources is highest during cleanup, and decreases after cleanup. Also, DOE will have created new ecological resources on some EUs from restoration activities during cleanup.

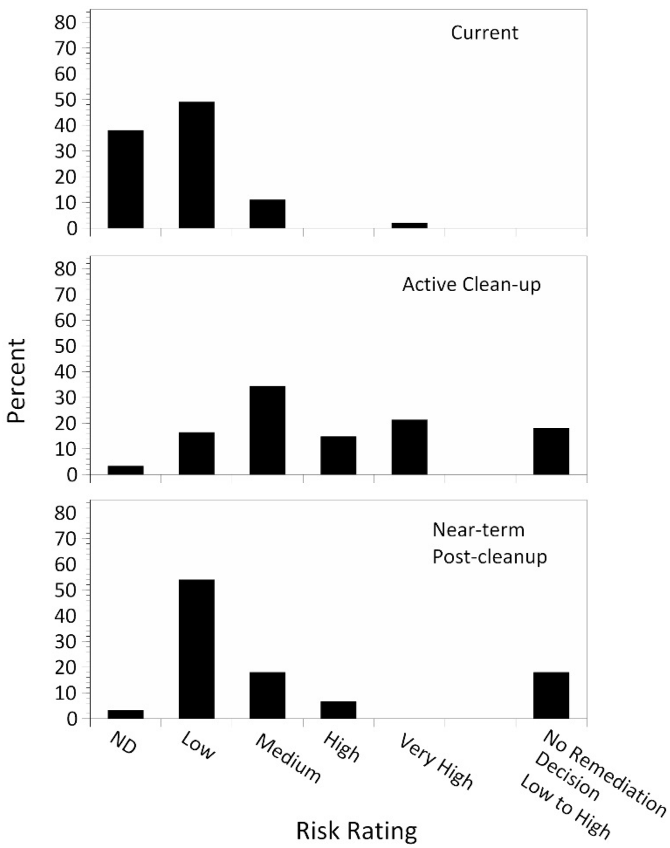

Figure 4-16. Summary of risk to ecological resources during the different evaluation periods (current, active cleanup, near-term post-cleanup).

The ratings for the different evaluation periods are shown in the beginning of this section of this chapter for all the EUs completed, along with a brief explanation of the ratings. Full explanations can be found in the individual EU templates.

Informing Cleanup Sequencing

It is easier to protect existing ecosystems than it is to restore damaged ones. Thus, all cleanup should involve planning and management to reduce the size of the area that is disrupted. Overall, the risk to ecological resources is highest during the cleanup phase and lowest after. The riparian zone along the Columbia River is the most sensitive. The variability in the risk ratings for some EUs is due to the range of cleanup options being considered. Cleanup of EUs in the riparian corridor along the river should occur earlier with as many safety controls as possible. This would allow the maximum time for ecosystem recovery before land use is changed. Adverse effects on ecological resources can be partly ameliorated by planning early for protecting ecological resources.

For all EUs, minimizing laydown areas will reduce the risk to ecological and eco-cultural resources on the EU and on the buffer regions. Most EUs currently have Low risk to ecological resources, and the risk is highest during remediation. If remediation occurs, all efforts should be made to reduce the increase in the number and density of invasive species. One way to reduce the effect of invasive species is to do all the cleanup activities in a contiguous area at the same time, rather than doing them over several years (which provides additional opportunities for increases in invasive species).

The EUs with the highest risk during the active cleanup period (BC Control, Outer Sites Area, 300 Area groundwater plumes, 100-N groundwater plumes, 100-B/F/H/F/K area groundwater plumes, 200 East groundwater, Final Reactor disposition, ERDF, WTP, and LERF/ETF) should be completed as soon as possible because any resources damaged during cleanup will recover more quickly to the natural shrub-steppe habitat. This will allow these valuable ecosystems to have the maximum time to recover before they are used by the Tribes, public, or others. The area between the 200 East and 200 West Areas contains high-level resources that are contiguous with other medium and high-level resources, and protection of this area should be attempted early and often.

The risk to ecological resources after cleanup is completed is largely a function of the variability in cleanup options. Conducting cleanup sooner rather than later will provide a maximum opportunity for recovery. All cleanup operations should include restoration ONLY with native species, with careful attention to reducing the potential for invasive species.

Ecological risk ratings can be used to inform cleanup sequencing in the following ways:

1. Seasonality affects the severity of cleanup activities on ecological and eco-cultural resources. For example, birds and many other organisms are less vulnerable in the winter months because many migrate away from the area or hibernate (reptiles).
2. Cleanup activities along the River Corridor should not be conducted during periods of the year when salmon are spawning, nor when key benthic organisms are breeding. Further, water level significantly affects the life cycles of organisms, and cleanup activities should be avoided during periods of high water levels.
3. The risk ratings, and their possible effects on sequencing of cleanup activities, are time dependent. Since the ratings were determined in 2015-2016, the ratings become less accurate as time passes. This is because cleanup activities (and restoration) will affect resource levels, which are dynamic.
4. Ecological resources suffer the least damage if cleanup is completed on EUs in the same vicinity, reducing the temporal risk to ecological resources and allowing maximum time for restoration of native ecosystems (and protecting eco-cultural resources).

The three major conclusions that are extremely important from the ecological resources evaluation are as follows:

- It is far easier to protect existing ecosystems than to restore those that have been damaged. Not enough is known to successfully restore sensitive shrub-steppe habitats.
- Reducing the area of disruption from laydowns and other activities is the easiest method of reducing ecological impacts. This would involve using the same laydown areas for adjacent EUs.
- Trained ecologists with experience at Hanford Site should always be involved in cleanup planning and execution, particularly of EUs with resources at Level 3-5.

Table 4-11. Risk and potential impacts ratings for ecological summary.

Active cleanup refers to the period of 50 years or until 2064; near-term post-cleanup is from 2064 to 2164. High-level or high-quality resources are resource Levels 3 to 5.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
618-11 Burial Grounds	RC-LS-1	Current	ND	ND because currently there is no disturbance to site, although 10% of EU consists of Level 3 resources and over half of buffer area consists of Level 4 resources.
		Active Cleanup	Low to Medium	Low in EU because only about 10% consists of Level 3 resources (none higher), but Low to Medium in buffer zone because 65% consists of Level 3 and 4 resources. Disturbance could result during soil removal.
		Near-Term Post-Cleanup	Low to Medium	Revegetation in EU will potentially place additional Level 3 and 4 resources at risk because of disturbance, especially from invasive species and change of species composition. Similar effects in buffer zone.
K Areas Waste Sites	RC-LS-2	Current	ND to Low	Most of the EU is non-vegetated, but risk is Low (rather than ND) because part of the EU falls in an eagle roosting area, which is a species of concern, and 8% consists of Level 4 resources.
		Active Cleanup	ND to Medium	ND to Low in EU because of eagle roosting, but Low to Medium in buffer because of high percent of Level 3 and 4 resources (78% consists of Level 3 and 4 resources), and it is close to the riparian habitat (all of which is Level 5 habitat). Removal of dirt will result in disturbance and disruption.
		Near-Term Post-Cleanup	Low to Medium	Revegetation in EU will result in additional Level 3 resources, and potentially creation of Level 4 resources potentially at risk because of disturbance, especially from invasive species. Similar effects in buffer zone.
618-10	RC-LS-4	Current	Low to Medium	Both the EU and buffer have over 40% Level 3 or greater resources. Loggerhead shrikes are present within the EU. Washington State candidate species coyote tobacco is present in EU and maybe in the buffer; coyote tobacco has not been observed in other places on the Hanford Site. The high value resources within the EU is continuous with Level 4 resources within the buffer area (31%) and beyond the buffer.
		Active Cleanup	Medium to High	Remediation has the high potential to impact the resources (population of coyote tobacco, State-sensitive species) within the EU and adjacent buffer. Protection of sensitive species needs to be considered during remediation activities; revegetation with sensitive species is very difficult. Exotic species introduction can preclude the survival of existing native populations. Construction activity and noise can disrupt loggerhead shrike and other sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
				Care should be taken to place the temporary buildings away from sensitive resources. Revegetation of area after remediation needs to consider the potential for competition with other Level 4 resources.
		Near-Term Post-Cleanup	Low to High	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory birds and loggerhead shrike. Past revegetation efforts with introduced species will likely not be replaced by native species over time. High impacts would occur if remediation activities affect the coyote tobacco population.
BC Cribs And Trenches	CP-LS-1	Current	ND to Low	ND to Low in EU because nearly 30% is Level 3 and 4 resources, along with the buffer area. There is the potential for disturbance and invasion of exotic species in both EU and buffer area.
		Active Cleanup	Low to Medium	Depending on remediation option, could result in disturbance and disruption to Level 3 and 4 resources (30% of EU and 77% of buffer), including increases in exotic species and changes in species composition of native species.
		Near-Term Post-Cleanup	ND to Medium	Depending on remediation options, it could be ND, but it may be Medium in both EU and buffer areas because of high percent of Level 3 and 4 resources, uncertainty about remediation options, disturbance, and potential for invasion by exotic species, changes in species composition of native species.
Plutonium Cont. Waste Sites	CP-LS-2	Current	ND to LOW	ND to Low in the EU due to low resource value (only 5% Level 3 resources), but Low in buffer area because there is a small finger with 3% Level 3 vegetation, which could be disturbed by traffic.
		Active Cleanup	Low to Medium	The risk depends on the importance of some of the Level 3 habitat in buffer area (5% of EU). The range of remediation options being considered results in both activity and potential of disruptive activity, changing species composition of vegetation in EU and buffer.
		Near-Term Post-Cleanup	Low to Medium	There are two waste sites with contamination in place, which will have continued monitoring, which leads to disturbance, and the potential for exotic species to invade and disrupt native habitat.
U Plant Cribs and Ditches	CP-LS-3	Current	Low	4% of EU and 33% of the buffer are Level 3 or greater. Low impacts are based on truck traffic and herbicide applications.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated	No cleanup decisions have been made for deep vadose zone, and as a result, the potential effects of cleanup on ecological resources is uncertain for the active cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone and as a result, the potential effects of cleanup on ecological

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
			to be Low to Medium	resources is uncertain for the active cleanup evaluation period. The range of plausible remediation options increases the uncertainty in estimating the impacts to ecological resources. Reducing impacts to Medium risk is possible if cleanup activity is focused within in the existing EUs, and staying away from the eastern portion of the buffer area.
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone. Monitoring activities for post-closure conditions are expected to occur. Low impacts are likely if exotic species are introduced to buffer area with Level 3 and 4 resources.
REDOX Cribs and Ditches	CP-LS-4	Current	Low	0% of EU and 45% of the buffer are Level 3 or greater. Higher resource in the buffer are continuous, with large patches of Level 3 and 4 resources. Low impacts are based on truck traffic and herbicide applications.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low to Medium	No cleanup decisions have been made for deep vadose zone, and as a result, the potential effects of cleanup on ecological resources is uncertain for the active cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone. The range of plausible remediation options increases the uncertainty in estimating the impacts to ecological resources. Reducing impacts to Medium risk is possible if cleanup activity is focused within in the existing EUs, and staying away from the eastern portion of the buffer area.
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone. Monitoring activities for post-closure conditions are expected to occur. Low impacts are likely if exotic species are introduced to buffer area with Level 3 and 4 resources.
U and S Pond	CP-LS-5	Current	Low	The field evaluation of the EU indicates that the resources are higher quality than previously mapped, including a small region (2%) of level resources. The Level 5 resources are continuous with the the 19% Level 5 in the buffer. Further, the field evaluation identified loggerhead shrikes (federal species of concern and Washington State candidate species). The EU and buffer are recovering from a fire and now have a diverse plant species list, which suggests that plant succession is

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
				occurring and successful. Past revegetation has not increased quality habitat or added resource value to the area. Continued monitoring with vehicle traffic has the potential of introducing exotic species and disrupting bird activity.
		Active Cleanup	Medium to Very High	Remediation options could be conducted in a manner that minimizes the amount of disruption in the EU, but the uncertainty in the selection of the remediation options allows for the potential for Very High impacts to Level 3 or greater resources. Loss of biologically active soil will have long-term effects that impact revegetation and biological integrity of the region. Further disruption of the soil will impact the seed bank of high-quality species. Construction activity and noise can disrupt loggerhead shrike and other sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis.
		Near-Term Post-Cleanup	Low to Medium	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory birds and loggerhead shrike. Past revegetation efforts with introduced species will likely not be replaced by native species over time.
T Plant Cribs and Ditches	CP-LS-6	Current	Low	28% of EU and 15% of the buffer is Level 3 (there are no Level 4 and above resources). Black-tailed jack rabbit and sage sparrow were observed in the EU. Low impact rating is based on minimal activity and herbicide application.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low to High	No cleanup decisions have been made for deep vadose zone, and as a result, the potential effects of cleanup on ecological resources are uncertain for the active cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone. Multiple remediation actions will be used to address the diversity of waste sites. Remediation has the high potential to impact the resources (black-tailed jack rabbit and sage sparrow) within the EU and adjacent buffer. Protection of sensitive species needs to be considered during remediation activities. Loss of biologically active soil will have long-term effects that impact revegetation and biological integrity of the region. Further disruption of the soil will impact the seed bank of high-quality species. Construction activity and noise can disrupt loggerhead shrike and other sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car and truck traffic on a daily basis. Revegetation of area after remediation needs to consider the potential for competition with other Level 3

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
				resources. High impacts can be minimized by careful placement of remediation support systems away for high-quality resources.
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low to Medium	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone. Post-cleanup monitoring might pose a risk to Level 3 resources in the EU and buffer area.
200 Area Transfer Pipeline	CP-LS-7	Current	Low	23% of EU and 47% of the buffer are Level 4 resources, particularly in the region of the pipeline between 200 East and 200 West. Buffer areas along the pipeline were computed differently because the EU is long and narrow. While the pipeline corridor is not vegetated (herbicide applications allow invasive species), the width of the pipeline does not disrupt wildlife movement. The Level 4 resources on both sides of the pipeline are large continuous habitat.
		Active Cleanup	Low to High	Any remediation along the transfer pipeline where Level 4 resources are current will have a high potential for degradation due to the introduction of exotic species. Increased truck traffic will compact soil and will destroy biologically active soil. Backfill material lacks a seed bank, increases the potential for establishment of invasive species, and decreases the potential for establishment of native species. Revegetation of area after remediation needs to consider the potential for competition with other Level 4 resources.
		Near-Term Post-Cleanup	Low to Medium	Impact level depends on the remediation activities and the ability to keep activities from destroying existing high-quality resources.
B Plant Cribs and Trenches	CP-LS-8	Current	Low	17% of EU and 21% of the buffer are Level 3 or greater. There are smaller patches of Level 3 resources than other EUs in 200 East, yet there are areas of mature sagebrush in the north and west parts of the EU that support loggerhead shrikes. Low impact rating is based on minimal activity and infrequent application of herbicides.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be Medium to High	No cleanup decisions have been made for deep vadose zone. Cleanup decision for surface may change based on cleanup for deep vadose zone, and as a result, the potential effects of cleanup on ecological resources is uncertain for the active cleanup evaluation period. Multiple remediation actions will be used to address the diversity of waste sites. Remediation has the high potential to impact the resources (population of State-sensitive species, including Piper's daisy) within the

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
				EU and adjacent buffer. Protection of sensitive species needs to be considered during remediation activities; revegetation with sensitive species is very difficult. Exotic species introduction can preclude the survival of existing native populations. Construction activity and noise can disrupt loggerhead shrike and other sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis. Care should be taken to place the temporary buildings away from sensitive resources. Revegetation of area after remediation needs to consider the potential for competition with other Level 3 resources.
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low to Medium	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources are uncertain for the near-term post-cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone. Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory birds and loggerhead shrike.
PUREX Cribs and Trenches	CP-LS-9	Current	Low	29% of EU and 33% of the buffer are Level 3 (there are no Level 4 and above resources). There are small, isolated patches of Level 3 resources. Piper's daisy and sagebrush are found in the EU. Low impact rating is based on minimal activity and regular application of herbicides.
		Active Cleanup	Low to Medium	Multiple remediation actions will be used to address the diversity of waste sites. Remediation has the high potential to impact the resources (population of State-sensitive species, including Piper's daisy) within the EU and adjacent buffer. Protection of sensitive species needs to be considered during remediation activities; revegetation with sensitive species is very difficult. Exotic species introduction can preclude the survival of existing native populations. Construction activity and noise can disrupt sensitive wildlife. Revegetation of area after remediation needs to consider the potential for competition with other Level 3 resources.
		Near-Term Post-Cleanup	Low	Post-cleanup monitoring might pose a risk to Level 3 resources in the EU and buffer area.
PUREX and Tank Farm Cribs and Trenches	CP-LS-10	Current	Low to Medium	18% of Level 3 or greater resources in EU and 46% of Level 3 of greater in the buffer (including 43% of Level 4 resources). There have been impacts to the resources from current herbicide applications, which prevents further succession of the habitats in the area. Medium impacts are associated with continued use of herbicides.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Active Cleanup	Medium to High	Multiple remediation actions will be used to address the diversity of waste sites. Remediation has the high potential to impact the resources within the EU and adjacent buffer. Protection of sensitive species needs to be considered during remediation activities; revegetation with sensitive species is very difficult. Exotic species introduction can preclude the survival of existing native populations. Construction activity and noise can disrupt sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis. Care should be taken to place the temporary buildings away from sensitive resources. Revegetation of area after remediation needs to consider the potential for competition with other Level 3 resources.
		Near-Term Post-Cleanup	Low	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area.
B Pond	CP-LS-11	Current	Low to Medium	20% of EU and 79% of the buffer area are Level 3 or higher resources. The highest quality resources are on the eastern end of the EU, and those areas are continuous with similar or higher habitat quality outside the buffer. Black-tailed rack rabbits and Piper's daisy are common. Impact rating is dependent on the level of activity in the EU and the potential for disturbing nesting birds and other sensitive wildlife.
		Active Cleanup	Low to High	Uncertainties in the remediation activities makes it difficult to predict the extent and magnitude of impacts to the EU and buffer. Deposition of waste at the facility and future cleanup actions will increase truck traffic to the region. Increased traffic and herbicide application will impact Level 3 resources in the buffer. Potential for subsurface contamination is high and thus require more excavation and backfill/revegetation. High impacts are likely if excavation is required because of heavy equipment and potential to introduce exotic species.
		Near-Term Post-Cleanup	ND to Medium	Monitoring activities for post-closure conditions are expected to occur. Medium impacts are likely if exotic species are introduced to EU and buffer area with Level 3 resources.
200-W Burial Grounds	CP-LS-12	Current	ND to Low	7% of EU and 40% of the buffer are Level 3 or greater. Higher quality resources are only located in the northeast corner. Low impacts are based on truck traffic and herbicide applications.
		Active Cleanup	Low to Medium	Uncertainties in the remediation activities makes it difficult to predict the extent and magnitude of impacts to the EU and buffer. Excavation and capping options will include increased traffic. Medium impacts would occur

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
				from truck traffic, introduction of invasive species, compaction of soil, and loss of seed banks.
		Near-Term Post-Cleanup	ND to Low	Post-cleanup monitoring might pose a risk to higher level resources in the buffer area.
200-W Miscellaneous Waste Sites	CP-LS-13	Current	Low	13% of EU and 39% of the buffer are Level 3 or greater. Piper's daisy is within the EU. Black-tailed jack rabbit in buffer. Patches of mature sagebrush are in the EU. Low impacts are based on truck traffic and herbicide applications.
		Active Cleanup	Low to High	Uncertainties in the remediation activities makes it difficult to predict the extent and magnitude of impacts to the EU and buffer. Options include plans to allow natural attenuation for sites with presence of existing vegetated soil covers. Increased traffic and herbicide application will impact Level 3 resources in the buffer. Potential for excavation may be required and backfill/revegetation would occur. High impacts are likely if Level 3 sagebrush are lost during active cleanup.
		Near-Term Post-Cleanup	Low	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of sagebrush.
200-E Burial Grounds	CP-LS-14	Current	ND to Low	4% % of Level 3 or greater resources in the EU and 42% of Level 3 or greater in the buffer. Patches of Level 3 resources are not continuous and are small. In past Piper's daisy have been observed. Past revegetation efforts used introduced species, and herbicide applications continue.
		Active Cleanup	Medium to High	Multiple remediation actions will be used to address the diversity of waste sites. Remediation has the high potential to impact the resources (Piper's daisy within the EU and adjacent buffer). Protection of sensitive species needs to be considered during remediation activities; revegetation with sensitive species is very difficult. Exotic species introduction can preclude the survival of existing native populations. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis. Care should be taken to place the temporary buildings away from sensitive resources. Revegetation of area after remediation needs to consider the potential for competition with other Level 3 resources.
		Near-Term Post-Cleanup	ND to Low	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of Piper's daisy.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
200-E Main-tenance Waste Sites	CP-LS-15	Current	Low	37% of Level 3 or greater resources in the EU and 65% of Level 3 or greater in the buffer, including large patch sizes of Level 3 intermixed with industrial sites. Several of the patches are continuous with large patches of high-quality resources outside the buffer. The sagebrush habitat has further value because of the large patch size; these areas have been protected from fire in the industrial areas. Ecological resources include State-sensitive sagebrush obligate species, including black-tailed jack rabbits, loggerhead shrikes, and sage sparrows. Low impact rating is based on minimal increase of truck traffic.
		Active Cleanup	Medium to High	Multiple remediation actions will be used to address the diversity of waste sites. Remediation has the high potential to impact the resources (population of State-sensitive species, including Piper's daisy) within the EU and adjacent buffer. Protection of sensitive species needs to be considered during remediation activities; revegetation with sensitive species is very difficult. Exotic species introduction can preclude the survival of existing native populations. Construction activity and noise can disrupt loggerhead shrike and other sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis. Care should be taken to place the temporary buildings away from sensitive resources. Revegetation of area after remediation needs to consider the potential for competition with other Level 3 resources.
		Near-Term Post-Cleanup	Low to Medium	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory birds and loggerhead shrike. Past revegetation efforts with introduced species will likely not be replaced by native species over time.
Grout Vaults (GTF)	CP-LS-16	Current	ND	0% of EU and 21% of the buffer area are Level 3 or higher resources. No wildlife were observed in the EU.
		Active Cleanup	Low to Medium	Uncertainties in the remediation activities make it difficult to predict the extent and magnitude of impacts to the EU and buffer. Deposition of waste at the facility and future cleanup actions will increase truck traffic to the region. Increased traffic and herbicide application will impact Level 3 resources in the buffer. Potential for excavation may be required and backfill/revegetation would occur. Medium impacts are likely if excavation is required because of heavy equipment and potential to introduce exotic species.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Near-Term Post-Cleanup	Low to Medium	Monitoring activities for post-closure conditions are expected to occur. Medium impacts are likely if structures remain in place, inhibiting the recovery of resources.
BC Control Zone	CP-LS-17	Current	Low	Current activities can impact high-quality resources within the EU (59% of the resources are Level 3 or greater) by disruption of nesting birds, perching birds, and introduction of exotic species.
		Active Cleanup	Very High	Because of the high resource value within the EU, any remediation activity (pedestrian and truck traffic, excavation, etc.) will potentially fragment and degrade the high-level resources. Loss of biologically active soil will have long-term effects that impact revegetation and biological integrity of the region. Further disruption of the soil will impact the seed bank of high-quality species. Construction activity and noise can disrupt loggerhead shrike and other sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis. The EU and buffer area high-value ecological resources are a large patch, not fragmented, that serves as a corridor for ecological resources in the Central Plateau (including elk migration).
		Near-Term Post-Cleanup	Medium-High	Remediation options, which include soil removal, will disrupt the seed bank and the biologically active soil, and has the potential to hamper revegetation and natural succession from Level 5 resources. Remediation will introduce exotic species and disrupt an already functioning ecosystem.
Outer Area Sites	CP-LS-18	Current	Low	The EU is 100% Level 3 or higher resources (due to revegetation), and the buffer is predominantly Level 5, and the buffer area is connected to Level 5 resources. Thus, any activity within the EU has the potential to disrupt any valuable resources
		Active Cleanup	Very High	Because of the high resource value, any remediation involving frequent pedestrian and vehicle traffic will disrupt a high functioning landscape of valuable resources. The buffer is classified as an element occurrence, and the EU has the potential of succession into a higher resource level. Truck traffic could introduce exotic species. Loss of biologically active soil will have long-term effects that impact revegetation and biological integrity of the region. Further disruption of the soil will impact the seed bank of high quality species.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Near-Term Post-Cleanup	Medium-High	The uncertainty of remediation options for this EU makes it difficult to predict future risk to the resources. Given the high value of the resources in the EU and buffer, any continued disruption would have high potential risk of impact.
T Tank Farm	CP-TF-1	Current	ND to Low	Little habitat in EU (>1% Level 3 resources), but over 10% in buffer area consists of Level 3 resources. ND within EU itself, but may be Low in buffer due to truck disturbance.
		Active Cleanup	Low to Medium	Effects to resources are due to increased disturbance and potential for contaminant release, increases in exotic species, and potential loss of some nesting habitat in buffer area; vehicles could run over lizards and other wildlife during cleanup.
		Near-Term Post-Cleanup	ND to Low	Continued monitoring could disturb the EU and buffer lands. Remediation may improve habitat through revegetation (and increased monitoring may lead to increases in exotic species, and changes in species composition).
S-SX Tank Farms	CP-TF-2	Current	ND to Low	Little habitat in EU (Level 2 only), but over 10% in buffer consists of Level 3 resources. ND in buffer, unless there are trucks in the buffer, then it is Low.
		Active Cleanup	Low to Medium	Effects due to increased disturbance and potential for contaminant release, increases in exotic species, and could lose some nesting habitat; vehicles could run over lizards and other wildlife during cleanup.
		Near-Term Post-Cleanup	ND to Low	Continued monitoring could disturb the EU and buffer lands. Remediation may improve habitat (and increased monitoring may lead to increases in exotic species, changes in species composition).
TX-TY Tank Farms	CP-TF-3	Current	ND to Low	Some Level 3 resources in EU (4%) and in buffer area (9%). People and trucks are present, which could lead to increases in exotic species and changes in species diversity in Level 3 resource areas of EU and buffer.
		Active Cleanup	Low to Medium	Potential for continual disturbance levels with increasing number of trucks, which may cause changes in abundance and diversity in Level 3 resources in EU and buffer.
		Near-Term Post-Cleanup	ND to Low	It will be capped, which results in less frequent monitoring, but monitoring activities can cause some disruption and disturbance to EU and buffer areas. Remediation may improve habitat through revegetation (and increased monitoring may lead to increases in exotic species, and changes in species composition).
U TANK FARM	CP-TF-4	Current	ND to Low	Some Level 3 resources in EU (16%) and in buffer area (18%). People and trucks are present, which could lead to increases in exotic species and changes in species diversity in Level 3 resource areas of EU and buffer.
		Active	Low to	Potential for continual disturbance levels with increasing

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Cleanup	Medium	number of trucks, results may cause changes in abundance and diversity in Level 3 resource areas.
		Near-Term Post-Cleanup	ND to Low	It will be capped, which results in less frequent monitoring, but monitoring activities can cause some disruption and disturbance to EU and buffer resources. Remediation may improve habitat through revegetation.
A-AX Tank Farms	CP-TF-5	Current	ND to Low	High-quality habitat (22% Level 3) in EU, and 27% Level 3 and 4 in buffer suggests potential for disturbance even though truck traffic is low. Trucks can bring in seeds of exotic species, changing species composition. There is some nice sagebrush habitat on EU.
		Active Cleanup	Low to Medium	Remediation may result in some destruction of Level 3 habitat in EU (with sagebrush habitat); intense activity will result in loss of resources to EU and potentially buffer area (with 27% Level 3 and 4 resources).
		Near-Term Post-Cleanup	ND to Low	If capped and monitored, there could be some disturbance to EU and buffer habitat, but revegetation may increase resource value.
B-BX-BY Tank Farms	CP-TF-6	Current	ND to Low	Little habitat in EU, but over 10% in buffer consists of Level 3 resources. ND in buffer, unless there are trucks in the buffer, then it is Low. Habitat is fragmented, which increases disturbance and increases exotic species and potentially changes in species composition of vegetation.
		Active Cleanup	Low to Medium	Effects due to increased disturbance and potential for contaminant release, increases in exotic species, and could lose some nesting habitat, trucks could run over lizards and other wildlife during cleanup.
		Near-Term Post-Cleanup	ND to Low	Continued monitoring could result in some disturbance to EU and buffer lands. Remediation may improve habitat (and increased monitoring may lead to increases in exotic species or changes in vegetation species composition).
C Tank Farm	CP-TF-7	Current	ND	No resources on site, but about 15% Level 3 resources on buffer. If no trucks, ND effects.
		Active Cleanup	ND to Medium	No resources on EU, but about 15% Level 3 resources on buffer area. Remediation could result in truck disturbance, increases in exotic species, and changes in species composition in buffer.
		Near-Term Post-Cleanup	ND to Low	Likely monitoring of caps, with potential for disruption due to monitoring. Revegetation could result in higher quality habitat on EU.
200 East DSTs	CP-TF-8	Current	ND	No resources on site, but about 5% Level 3 resources on buffer. Assuming no trucks in buffer, it is ND.
		Active Cleanup	ND to Medium	No resources on EU, but about 5% Level 3 resources on buffer. Remediation could result in truck disturbance, increases in exotic species, changes in species composition in buffer, and contamination of sensitive species.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Near-Term Post-Cleanup	ND to Low	Likely monitoring of caps, with potential for disruption due to monitoring. Revegetation could result in higher quality habitat on EU, but there could be some residual contamination to sensitive resources.
200 West DSTs	CP-TF-9	Current	ND	No resources on site, but about 15% Level 3 resources on buffer. Assuming no trucks in buffer, it is ND.
		Active Cleanup	ND to Medium	No resources on EU, but about 7% Level 3 resources on buffer. Remediation could result in truck disturbance, increases in exotic species, changes in species composition in buffer, and contamination of sensitive species.
		Near-Term Post-Cleanup	ND to Low	Likely monitoring of caps, little disturbance, but potential for disruption due to monitoring, and some contamination of receptors. Revegetation could result in higher quality habitat on EU.
300 Area GW Plumes	RC-GW-1	Current	Low to Moderate	There are areas where groundwater plumes intersect the riparian vegetation. Monitoring shows concentrations of uranium exceeding aquatic water criteria in groundwater near shoreline. Potential for contaminant uptake by terrestrial vegetation. Sensitive animals and bird species use region and may be at risk.
		Active Cleanup	Very High	Remediation activities in the shoreline will need to be monitored to evaluate resources and seasonal use of shoreline.
		Near-Term Post-Cleanup	Low	Contamination remaining in areas for monitored natural attenuation may still result in uptake in biota, but is not likely to cause an effect to the biota. Continued long-term monitoring activities may disrupt riparian and terrestrial habitats. Revegetation in EU will result in additional Level 3 resources, and potentially creation of Level 4 resources potentially at risk because of disturbance, especially from invasive species.
100 N Area Groundwater Plumes	RC-GW-2	Current	Low to Moderate	There are areas where groundwater plumes intersect the riparian vegetation. Potential for contaminant uptake by terrestrial vegetation. Sensitive animals and bird species use region and may be at risk.
		Active Cleanup	Very High	Remediation activities in the shoreline will need to be monitored to evaluate resources and seasonal use of shoreline.
		Near-Term Post-Cleanup	Low	Contamination remaining in areas for monitored natural attenuation may still result in uptake in biota, but is not likely to cause an effect to the biota. Continued long-term monitoring activities may disrupt riparian and terrestrial habitats. Revegetation in EU will result in additional Level 3 resources, and potentially creation of Level 4 resources potentially at risk because of disturbance, especially from invasive species.
100	RC-GW-3	Current	Low to Very	There are areas where groundwater plumes intersect the

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
B/D/H/F/K Areas Ground-water Plumes			High	riparian vegetation. Monitoring shows concentrations of chromium exceeding aquatic water criteria in groundwater near shoreline. Potential for contaminant uptake by terrestrial vegetation. Sensitive animals and bird species use region and may be at risk.
		Active Cleanup	Very High	Remediation activities in the shoreline will need to be monitored to evaluate resources and seasonal use of shoreline.
		Near-Term Post-Cleanup	Low	Contamination remaining in areas for monitored natural attenuation may still result in uptake in biota, but is not likely to cause an effect to the biota. Continued long-term monitoring activities may disrupt riparian and terrestrial habitats. Revegetation in EU will result in additional Level 3 resources, and potentially creation of Level 4 resources potentially at risk because of disturbance, especially from invasive species.
200 East Groundwater Plumes	CP-GW-1	Current	Low	There are areas where groundwater plumes intersect the riparian vegetation. Monitoring does not show concentrations of plume contaminants exceeding aquatic water criteria in groundwater near shoreline. Potential for contaminant uptake by terrestrial vegetation. Sensitive animals and bird species use region and may be at risk.
		Active Cleanup	Very High	Remediation activities in the shoreline will need to be monitored to evaluate resources and seasonal use of shoreline.
		Near-Term Post-Cleanup	Low	Contamination remaining in areas for monitored natural attenuation may still result in uptake in biota, but is not likely to cause an effect to the biota. Continued long-term monitoring activities may disrupt riparian and terrestrial habitats. Revegetation in EU will result in additional Level 3 resources, and potentially creation of Level 4 resources potentially at risk because of disturbance, especially from invasive species.
200 West Groundwater Plumes	CP-GW-2	Current	ND to Low	Groundwater wells on Central Plateau are in sensitive ecological areas. There is the potential for disturbance and invasion of exotic species in EU. Ecological resources at locations of new wells are evaluated prior to activities to assess potential impacts.
		Active Cleanup	ND to Low	Remediation could degrade habitats, disturb wildlife and affect animal behavior, and introduce exotic plant species.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Near-Term Post-Cleanup	ND to Low	Contamination remaining in areas for monitored natural attenuation may still result in uptake in biota, but is not likely to affect the biota. Continued long-term monitoring activities may disrupt riparian and terrestrial habitats. Revegetation in EU will result in additional Level 3 resources, and potentially creation of Level 4 resources potentially at risk because of disturbance, especially from invasive species.
Building 324	RC-DD-1	Current	ND	Currently no ecological resources on EU or buffer area.
		Active Cleanup	ND	No ecological resources on EU or buffer area during active cleanup.
		Near-Term Post-Cleanup	ND to Low	Any risk depends on the quality and quantity of revegetation following remediation. Could be a risk from invasion of exotic species.
KE/KW Reactors	RC-DD-2	Current	ND	Currently no ecological resources on EU, and only 1 acre of Level 3 on buffer area.
		Active Cleanup	ND	No ecological resources on EU, and few on buffer.
		Near-Term Post-Cleanup	ND to Low	Any risk depends on the quality and quantity of revegetation following remediation. Could be a risk from invasion of exotic species.
Final Reactor Disposition	RC-DD-3	Current	Low to Medium	Past activities have degraded the resources within the EU and to some extent within the buffer area. The impacts are mitigated by creation of habitat for bats and roosting birds. Note, habitat restoration for bats is within the 100-F buffer area. While infrequent, the monitoring and surveillance of the reactor buildings has the potential to introduce exotic species. River bank habitat is within the EU and buffer zone of 100-N reactor.
		Active Cleanup	High to Very High	Remediation options will affect the River Corridor resources, such as disruption of ecological communities, introduction of exotic species, and disruption of soil communities (including invertebrates) due to soil compaction by heavy equipment and truck traffic. The potential for contamination in the soil and vadose zone below the reactors may require extensive excavation that would affect the River Corridor resources. Construction activity and noise can disrupt loggerhead shrike and other sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis. The widening of roads necessary for remediation and transport of reactors will result in disruption of ecological communities outside the EU and buffer area.
		Near-Term Post-Cleanup	Low to High	Uncertainties in the remediation activities and the potential for contamination of the subsurface below the reactors make it difficult to predict the extent and magnitude of impacts to the River Corridor. That is, if the

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
				remediation is similar to the excavations of the “big digs” in the 100 Areas, then the impacts will continue to be high in the footprint created by the excavation. If the remediation is less disruptive than excavation, then the impacts will be substantially reduced.
FFTF	RC-DD-4	Current	Low	EU has 26% of Level 3 or greater resources and the buffer has 69% of Level 3 or greater resources, of which 45% are Level 4 resources that are continuous with similar habitat beyond the buffer. Burrowing owls nest in the buffer and along the edge of the EU. Low impact based on low levels of pedestrian and vehicle traffic only in areas removed from the burrowing owl habitat.
		Active Cleanup	Low to Medium	Impact level depends on the remediation activities and the ability to keep activities away from burrowing owl habitat. Revegetation of area after remediation needs to consider the potential for competition with other Level 4 resources and minimize the introduction of exotic species along high value resource areas. Construction activity and noise can disrupt loggerhead shrike and other sensitive wildlife. Construction of temporary buildings associated with cleanup will increase pedestrian, car, and truck traffic on a daily basis.
		Near-Term Post-Cleanup	Low to Medium	Monitoring activities for entombment are expected to occur away from burrowing owl habitat. Medium impacts are likely if exotic species are introduced to buffer area with Level 4 resources.
PUREX	CP-DD-1	Current	ND to Low	Generally ND on EU because there are few ecological resources (5% Level 3 resources), Low because of possible contamination to ecological receptors on buffer area (31% Level 3 and 4 resources)
		Active Cleanup	Low to Medium	Few high-level resources in EU (5% Level 3 resources), but Low to Medium in buffer area because of high value resources (nearly a third of area has Level 3 and 4 resources).
		Near-Term Post-Cleanup	ND to Low	Remote chance of penetration of roots into contaminated site, allowing exposure to residual contamination.
B Plant	CP-DD-2	Current	ND	This area is completely disturbed with buildings, parking areas, and cleared graveled areas. Migratory birds could nest on buildings. Work would be done when birds are not nesting, or other mitigation activities would be implemented.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Active Cleanup	ND to Low	Removal of facility would include significant truck traffic/roadway disturbance to Level 3 and above resources in buffer area (16%). Removal of facility will decrease potential nesting sites, roost sites, and raptor hunting perches. Also, remediation activities may disrupt possible occurrence of Piper's daisy recorded in current evaluations.
		Near-Term Post-Cleanup	ND to Low	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory bird nesting and Piper's daisy.
U Plant	CP-DD-3	Current	ND	This area is completely disturbed with buildings, parking areas, and cleared graveled areas. Migratory birds could nest on buildings. Work would be done when birds are not nesting, or other mitigation activities would be implemented.
		Active Cleanup	ND to Low	Removal of facility would include significant truck traffic/roadway disturbance to Level 3 and above resources in buffer area (2%). Removal of facility will decrease potential nesting sites, roost sites, and raptor hunting perches.
		Near-Term Post-Cleanup	ND to Low	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory bird nesting and Piper's daisy.
REDOX	CP-DD-4	Current	ND	Currently, the area is completely disturbed with buildings and cleared areas. There could be migratory birds nesting on buildings. Work would be done when birds are not nesting, or other mitigation activities would be implemented.
		Active Cleanup	ND to Low	No cleanup decisions have been made for deep vadose zone, and as a result, the potential effects of cleanup on ecological resources is uncertain for the active cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone. Removal of facility would include significant truck traffic/roadway disturbance to Level 3 and above resources in buffer area (2%). Removal of facility will decrease potential nesting sites, roost sites, and raptor hunting perches. Also, remediation activities may disrupt possible occurrence of Piper's daisy recorded in current evaluations.
		Near-Term Post-Cleanup	ND to Low	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vadose zone. Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory birds and Piper's daisy.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
PFP	CP-DD-5	Current	ND	This area is completely disturbed with buildings, parking areas, and cleared graveled areas. Migratory birds could nest on buildings. Work would be done when birds are not nesting, or other mitigation activities would be implemented.
		Active Cleanup	ND to Low	Removal of facility would include significant truck traffic/roadway disturbance to Level 3 and above resources in buffer area (7%). Removal of facility will decrease potential nesting sites, roost sites, and raptor hunting perches. Also, remediation activities may disrupt possible occurrence of Piper's daisy recorded in current evaluations.
		Near-Term Post-Cleanup	ND to Low	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory birds and Piper's daisy.
KW Basin Sludge	RC-OP-1	Current	ND	Currently no ecological resources on EU, and only 1 acre of Level 3 on buffer area.
		Active Cleanup	ND	No ecological resources on EU, and few on buffer.
		Near-Term Post-Cleanup	ND to Low	Any risk depends on the quality and quantity of revegetation following remediation. Could be a risk from invasion of exotic species.
CWC	CP-OP-1	Current	ND	Few high-quality resources on EU or on buffer.
		Active Cleanup	ND to Low	Few high-quality resources on EU or on buffer, but remediation options unknown. Remediation options could result in contamination of the few resources on site (only 2% Level 3 resources in EU).
		Near-Term Post-Cleanup	ND to Low	Remediation options unknown; thus, whether area with be revegetated is unknown. If revegetated, risk could be Low (rather than ND) due to presence of higher quality resources (e.g. Level 3 or 4) created by revegetation.
T Plant	CP-OP-2	Current	ND	3% of EU and 32% of the buffer area are Level 3 resources (no Level 4 or 5). Currently, the area is mostly disturbed with buildings and cleared areas. There could be migratory birds nesting on buildings. Work would be done when birds are not nesting, or other mitigation activities.
		Active Cleanup	ND to Low	Impact level depends on the remediation activities. Revegetation of area after remediation needs to consider the potential for competition with higher level resources and minimize the introduction of exotic species along high-value resource areas. Construction activity and noise can disrupt sage sparrows and other sensitive wildlife in the buffer area.
		Near-Term Post-Cleanup	ND to Low	Monitoring activities for entombment are expected to occur away from any Level 3 resources.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
WESF	CP-OP-3	Current	ND	No resources on EU or buffer, mainly Level 2 or below.
		Active Cleanup	ND	No resources on EU or buffer to be disturbed during active cleanup.
		Near-Term Post-Cleanup	ND	Few ecological resources now, and likely none in the future. If there is revegetation, then continued activity and monitoring could result in minor disturbance in EU.
WRAP	CP-OP-4	Current	ND	9% of EU and 4% of the buffer area are Level 3 or higher resources. Small patch of sagebrush in EU, and the habitat is not connected to any Level 2 or higher resources. EU borders Level 2 resources (formerly burned area).
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low to Medium	No cleanup decisions have been made, and as a result, the potential effects of cleanup on ecological resources is uncertain for the active cleanup evaluation period.
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be ND to Low	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period. Cleanup decision for surface may change based on cleanup for deep vad
CSB	CP-OP-5	Current	ND	0% of EU and 32% of the buffer area are Level 3 or higher resources. Historical surveys recorded black-tailed jack rabbit. Currently, the area is completely disturbed with buildings and cleared areas. There could be migratory birds nesting on buildings. Work would be done when birds are not nesting, or other mitigation activities.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be ND to Low	No cleanup decisions have been made, and as a result, the potential effects of cleanup on ecological resources is uncertain for the active cleanup evaluation period.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be ND to Low	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period.
ERDF	CP-OP-6	Current	Low to Medium	Levels of frequent disturbance can result in increases in invasive species, particularly to high-quality habitat in buffer (80% consists of Level 3-5 resources). ERDF is one of only two EUs in interim progress report with Level 5 resources (about 9% of buffer is Level 5 resources, 0 in EU)
		Active Cleanup	ND to High	Because of high-quality of resources in buffer area (7% Level 3 resources in EU, 80% Level 3-5 in buffer), the potential for disturbance is Medium, which could disrupt native communities in buffer, and result in increases in exotic species. Continued dust suppression changes available water levels, which could affect native species diversity and abundance.
		Near-Term Post-Cleanup	ND to Low	Because of low level of monitoring expected in the near-term post-cleanup period, effect may be ND, but risk will depend upon disturbance, which may adversely affect the 80% Level 3-5 resources in buffer area.
IDF	CP-OP-7	Current	ND	3% of Level 3 or greater in the EU and 46% of Level 3 or greater resources in the buffer. The entire EU is surrounded by the 200 East Miscellaneous Waste Sites.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be ND to Low	No cleanup decisions have been made, and as a result, the potential effects of cleanup on ecological resources is uncertain for the active cleanup evaluation period.
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be ND to Low	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
Mixed Waste Trenches	CP-OP-8	Current	ND	12% of EU and 15% of the buffer area are Level 3 or higher resources. EU borders Level 2 resources (formerly burned area). Level 3 resources are from past revegetation effort, after large fire in 2000 (24 Command Fire).
		Active Cleanup	Low to Medium	Uncertainties in the remediation activities make it difficult to predict the extent and magnitude of impacts to the EU and buffer. Medium impacts would occur from truck traffic, introduction of invasive species, compaction of soil, and loss of seed banks.
		Near-Term Post-Cleanup	ND to Low	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area.
Naval Reactors Trench	CP-OP-9	Current	Low	1% of Level 3 or greater resources in the EU and 41% of Level 3 or greater resources in the buffer. There is a large patch of Level 4 resources in the buffer, which are continuous with similar quality habitat beyond the buffer. Currently using herbicide application within and around trench.
		Active Cleanup	Medium	Assuming that remediation 59% of the buffer is Level 2 resources or below; therefore, risk impacts will be reduced by putting laydown yards and other construction activities in these low resource areas and away from the Level 4 resources to the north of the site. If care is not taken, then introduced and exotic species can impact the high-quality resources in the vicinity of the buffer area.
		Near-Term Post-Cleanup	Low	Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area.
242-A Evaporator	CP-OP-10	Current	ND	0% of EU (1 acre) and 0% of the buffer area (6 acres) are Level 3 or higher resources. Currently, the area is completely disturbed with buildings and cleared areas. There are be migratory birds nesting on buildings. Work would be done when birds are not nesting, or other mitigation activities.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low	No cleanup decisions have been made, and as a result, the potential effects of cleanup on ecological resources is uncertain for the active cleanup evaluation period. Removal of facility and retrieval of subsurface contamination would include a lot of truck disturbance. Removal of facility will decrease potential nesting sites and roost sites. No information regarding final D&D of the facility, so no information available to evaluate those effects.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be ND to Low	No cleanup decisions have been made for this EU, and as a result, the potential effects of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period. Post-cleanup monitoring might pose a risk to Level 3 and above resources in the buffer area. Possible disruption of migratory birds. No information regarding final D&D of the facility, so no information available to evaluate those effects.
TEDF	CP-OP-12	Current	Low	21% of EU and 100% of the buffer area are Level 3 or higher resources. Higher quality resources are located along the perimeter of the EU (retention basins). Truck traffic and herbicide application are responsible for low impacts.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be Medium	No cleanup decisions have been made, and as a result, the potential effect of cleanup on ecological resources is uncertain for the active cleanup evaluation period.
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low to Medium	No cleanup decisions have been made for this EU, and as a result, the potential effect of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period.
SALDS	CP-OP-13	Current	ND	0% of EU and 17% of the buffer area are Level 3 or higher resources. EU is small, isolated, and surrounded by Level 2 resources (formerly burned area).
		Active Cleanup	ND to Low	Uncertainties in the remediation activities make it difficult to predict the extent and magnitude of impacts to the EU and buffer. However, even with soil excavation, the removal of soil and subsurface contamination is not likely to degrade the resources further.
		Near-Term Post-Cleanup	ND	Current Level 3 resources are on the edge of the buffer area and are not likely to be impacted by post-monitoring activities.
WTP	CP-OP-14	Current	Low	0% of EU and 63% of the buffer area are Level 3 or higher resources. Areas of high-quality habitat within the buffer is continuous with similar or higher quality habitat. Black-tailed jack rabbits are in the buffer. Truck traffic and herbicide application are on-going.
		Active Cleanup	Medium to High	Uncertainties in the remediation activities makes it difficult to predict the extent and magnitude of impacts

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
				to the EU and buffer. Deposition of waste at the facility and future cleanup actions will increase truck traffic to the region. Increased traffic and herbicide application will impact Level 3 and 4 resources in the buffer. Potential for subsurface contamination from pipeline transport of waste is high and thus requires more excavation and backfill/revegetation. High impacts are likely if excavation is required because of heavy equipment and potential to introduce exotic species.
		Near-Term Post-Cleanup	Low to Medium	Monitoring activities for post-closure conditions are expected to occur. Medium impacts are likely if structures remain in place, inhibiting the recovery of resources.
222-S Laboratory	CP-OP-15	Current	ND	0% of EU and 22% of the buffer area are Level 3 or higher resources. There are few resources in the buffer.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low	No cleanup decisions have been made, and as a result, the potential effect of cleanup on ecological resources is uncertain for the active cleanup evaluation period.
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be ND to Low	No cleanup decisions have been made for this EU, and as a result, the potential effect of cleanup on ecological resources is uncertain for the near-term post-cleanup evaluation period.
LERF/ETF	CP-OP-16	Current	ND to Low	2% of EU and 54% of the buffer area are Level 3 or higher resources. Current risk is related to vehicle traffic and herbicide use that can impact the buffer. Black-tailed jack rabbit observed in the buffer and along edges of the EU.
		Active Cleanup	No cleanup decisions have been made for this EU. Estimated to be Low to High	No cleanup decisions have been made, and as a result, the potential effect of cleanup on ecological resources is uncertain for the active cleanup evaluation period.

EU Name	EU ID	Evaluation Period	Potential Risk or Impact Rating	Comments
		Near-Term Post-Cleanup	No cleanup decisions have been made for this EU. Estimated to be ND to Medium	No cleanup decisions have been made, and as a result, the potential effect of cleanup on ecological resources is uncertain for the active cleanup evaluation period.
WSCF	CP-OP-17	Current	Low	21% of EU is Level 4 resources and 87% of the buffer area are Level 3 or higher resources. EU is isolated, and surrounded by high-quality habitat. There is mature sagebrush within the EU as well as a diversity of wildlife species. Current impacts include vehicle traffic and herbicide application, which reduces the quality of the Level 4 resources.
		Active Cleanup	Low to Medium	Uncertainties in the remediation activities make it difficult to predict the extent and magnitude of impacts to the EU. The total acreage of the Level 4 resources is small (5 acres) and already impacted by herbicides. The impact could be low to medium, depending on the disturbances to the Level 4 resources in the buffer.
		Near-Term Post-Cleanup	ND to Low	Uncertainties in the remediation activities make it difficult to predict the extent and magnitude of impacts to the EU. The rating is based on the presence of Level 4 resources and the ability to mitigate the 17 acres (67%) of the evaluation unit.

4.5. CULTURAL RESOURCES

Cultural resources differ from the other receptors evaluated for this report in that temporal patterns of use reflect different resource values. The Hanford Site contains an extensive record of human occupation stretching over a period of more than 10,000 years. Archaeological remains and written accounts, together with the oral histories associated with the practices and beliefs of Tribes, document how people lived and used the area that is now the Hanford Site. As part of its responsibility for managing the Site's archeological, cultural, and historic properties and resources under federal law, DOE has identified the Site's cultural setting following overlapping cultural landscapes (DOE/RL-98-10, Rev. 0 2003). They are:

- **Native American (Pre-Contact): Approximately 10,000 Years before the Present to the Present –**Encompasses more than 700 archaeological sites, prehistoric artifacts and features, and TCPs[139] and other areas of significance to living communities of Native Americans. Native Americans continue to hold religious and cultural affinities for the entire Hanford Site. Maintaining the integrity of TCPs, including a view shed, is considered important to Native Americans.
- **Pre-Hanford Era: 1805 to 1943** – Encompasses evidence of settlement in the Columbia River Plateau by people mainly of European descent before the commencement of the Manhattan Project and includes explorers (e.g., David Thompson in 1811), traders, travelers, and settlers. Most structures in this landscape were razed to make way for the Manhattan Project, but evidence of past land use still exists in the form of farmsteads, homesteads, ranches, roads, orchards, town sites, irrigation features, and buildings (e.g., the old Hanford High School).
- **Manhattan Project/Cold War Era: 1943 to 1990** – Encompasses evidence of Manhattan Project construction, operations, buildings, structures, and artifacts associated with plutonium production, research and development, waste management, and environmental monitoring as well as military activities to defend the nuclear weapons development program. The primary purpose of the Manhattan Project was to build a nuclear bomb for use during World War II. The Era ended December 31, 1946. After the war, plutonium production for use as a military deterrent continued to be Hanford's primary mission until the Cold War Era ended in 1990.[140]

The objective of each evaluation conducted for this report was to determine whether a resource is or has been present within the unit being evaluated based on a thorough review of DOE and Washington State cultural resources records. The review was conducted by professional archaeologists. Afterward, a concise written report was prepared on the results of the literature review completed for the EU. An overall risk rating has not been completed for cultural resources because federal law requires that a review of cultural resources be completed in advance of any project or activity (16 U.S.C. 470 et. seq.) that is being contemplated at Hanford Site. In other words, cultural resource reviews must be conducted as required irrespective of any risk or impact rating that may be made under this Risk Review Project.

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[139]In the glossary for DOE's *Cultural and Historic Resources Management Plan*, DOE defines "traditional cultural places" rather than "traditional cultural property," which is the term used under the National Historic Preservation Act. The Hanford Site's term is a reflection of DOE-RL efforts to cooperatively manage the Hanford Site with the Tribes as those cultural landscapes, places, and objects having special significance to Native Americans and other ethnic groups were identified and protected. In the glossary, a TCP is defined as a place that is associated with cultural practices or beliefs of a living community that (1) are rooted in that community's history, and (2) are important in maintaining the continuing cultural identity of that community (NHPA Section 110 1998). (DOE/RL-98-10, Rev. 1, 1998; see also Neitzel 2004)

[140] Structures and other items erected or installed and used after 1990 to support the cleanup effort are not included as part of the evaluation.

Appendix K to this report provides a compilation of the literature reviews completed. Two EUs were not evaluated for cultural resources. They are Pre-Hanford Orchard Lands (RC-LS-3) and Retained Facilities (RC-OP-2) due to insufficient information about the extent of contamination at the EU to complete an evaluation of impacts to resources. (See Chapter 3 for summaries of both Eus.)

If the information gathered from the literature review established the presence of cultural resources, the impacts for the time periods that have been evaluated (current operations, during active cleanup, and during near-term post-cleanup) are considered to be **"Known,"** as shown in the table below. If the review revealed an uncertainty (e.g., reviews are incomplete or indicators are present but actual presence of a resource is not documented), the impacts are considered to be **"Unknown."** Finally, if the review established no presence of cultural resources, the impacts are considered to be **"None."** Consideration was also given to the anticipated remediation option for that EU (Evaluation Unit Disposition Table, Appendix B).

The analysis described above was made for all three cultural resource landscapes identified at the Hanford Site (Native American, Pre-Hanford Era, and Manhattan Project/Cold War Era), and for each landscape the same analysis was made to determine the **direct** and **indirect** impacts to cultural resources during the evaluation periods. As noted in this report and in Chapter 8 of the methodology document (CRESP 2015b), direct effects or impacts are derived from regulatory requirements prescribed under the National Historic Preservation Act and relate to physical destruction (all or part) or alteration such as diminished integrity (16 U.S.C. 470 et.seq.,36 CFR 800 (2004)). Indirect effects or impacts under the regulations include, but are not limited to, the introduction of visual, atmospheric, or audible elements that diminish the cultural resource's significant, historic features. Direct and indirect impacts were determined based on the literature and archeologists review and what is known about the remediation option for that EU (Evaluation Unit Disposition Table, Appendix B).

Table 4-12 summarizes the results for the EUs using the cultural resources methodology (Chapter 8, methodology document [CRESP 2015b]) and which are provided in the Evaluation Templates completed for this final report. Brief comments summarized from the literature review also are included. For more information regarding a specific EU, refer to the completed template for that EU (Appendices D-H) as well as the EU's written report, which reflects the results of the literature review (Appendix K).

It should be noted that in the table the assignation of **"Known"** or **"Unknown"** regarding direct impacts to cultural resources within the Native American and Pre-Hanford Era landscapes remains the same for current operations and near-term post-cleanup evaluation periods. Indirect effects could change from current operations to near-term post-cleanup depending, for example, on whether the view shed of a traditional cultural place considered and recognized as culturally important to living communities, including Native Americans, may be affected during active cleanup.

The Manhattan Project/Cold War Era landscape is well understood and has been thoroughly studied for cultural resources. Those surveys are documented in the literature reviews prepared for this Risk Review Project. In contrast, much less is known about the Native American and Pre-Hanford Era landscapes, as the literature reviews reveal that it is rare for an EU to have been entirely inventoried for cultural resources within either landscape. Additionally, even less is known about subsurface archaeological resources. For this reason then, in addition to knowing whether a cultural resource has been recorded within an EU and/or within 500 m of an EU, it is important to understand (1) whether any areas within an EU are considered culturally sensitive based on prehistoric, ethno-historic, and historic land use in the area and (2) what the geomorphology indicates about the potential for cultural resources within the area. This is particularly true when planning for remediation, as depending on the remediation activities being contemplated, cultural resources located in the subsurface (and on the surface) may be vulnerable to being disturbed or even destroyed depending on the remediation approach selected. Additionally, activities supporting remediation vary in intensity and level, and as such may vary in their potential impact to cultural resources, particularly those that would not be exposed until the remediation.

EUs that have been identified from the literature reviews (Appendix K) as being culturally sensitive also are highlighted in the comments column in the Table 4-12. Those EUs are K Area Waste Sites (RC-LS-2), U Plant Cribs and Trenches (CP-LS-3), and groundwater EUs due to the plumes' potential for affecting riparian zones (i.e., 300 Area Groundwater Plumes [RC-GW-1], 100-N Groundwater Plumes [RC-GW-2], 100-B/D/H/F/K [RC-GW-3], 200 East Area [CP-GW-1], and 200 West Area [CP-GW-2]). The geomorphologic indicators for most EUs are indicated and are highlighted in the comments column as well.

The written reports prepared from the literature review conducted on EUs (Appendix K) summarize for that EU the inventories completed on all three cultural resources landscapes. Descriptions of the archaeological site types, buildings and presence or absence of traditional cultural places both within the EU and 500 m from the EU are provided as are map and aerial photograph indicators, geomorphology indicators, and ground disturbance indicators.

Each written report (Appendix K) provides a snapshot of the entire EU and is offered as an accessible tool for better understanding the nature and extent of the EU's cultural resources as documented by professional archaeologists. This information may be of value when planning for remediation because it is during remediation (and the activities associated with remediation) when a cultural resource is particularly vulnerable.

Table 4-12. Compilation of evaluations for cultural resources for EUs.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
Legacy Sources				
618-11 Burial Grounds	RC-LS-1	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Unknown	There are no known recorded cultural resources located within or near this EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Unknown	There are no known recorded cultural resources located within or near this EU. Surface and subsurface investigations may be necessary prior to ground disturbance.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	No expectations for impacts to known cultural resources.
K Area Waste Sites	RC-LS-2	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Unknown	Manhattan Project/Cold War significant resources have already been mitigated. Area within the EU is heavily disturbed, but the entire area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Traditional cultural places are known to be located in the vicinity as well as National Register-eligible archaeological sites associated with all three landscapes.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Due to **high cultural sensitivity** of area, consultation may need to occur. Archaeological investigations or monitoring may also need to occur. Direct and indirect effects are likely to archaeological sites and traditional cultural places.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent direct and indirect effects are possible due to **high sensitivity** of area.
618-10 Burial Ground	RC-LS-4	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Known archaeological sites and traditional cultural places located within the EU and within the view shed. Historic land use indicates **low** potential for historic farming era archaeological resources. The geomorphology and lack of ground disturbance suggest, however, a **low** potential. Known National Register ineligible archaeological site located within 500 m of the EU. No Manhattan Project/Cold War Era buildings within, or within 500 m of, the EU.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Archaeological investigations and monitoring may need to occur prior to remediation. Large portions of the EU are undisturbed and based on the geomorphological indicators, there is a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources, if they are present in the subsurface. Permanent indirect effects to view shed are possible. No Manhattan Project/Cold War Era buildings within, or within 500 m of, the EU.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are likely from remediation.
BC Cribs and Trenches	CP-LS-1	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: Unknown Indirect: Known	There are unevaluated cultural resources located within this EU. Manhattan Project/Cold War significant resources have already been mitigated. Traditional cultural places in view shed.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: Known Indirect: Unknown	There is one unevaluated (for National Register) cultural resource. Traditional cultural places in view shed. Indirect effects are possible from capping.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
Plutonium Contaminated Waste Sites	CP-LS-2	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Unknown	There are no known recorded cultural resources located within or near this EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Unknown	There are no known recorded cultural resources located within or near this EU. Surface and subsurface investigations may be necessary prior to ground disturbance.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	No expectations for impacts to known cultural resources.
U Plant Cribs and Trenches	CP-LS-3	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Area is heavily disturbed and only small portions have been inventoried for archaeological resources; however, it has potential to contain intact archaeological resources on the surface and/or subsurface. Area is **culturally sensitive** based on historic land use in the area. National Register-eligible property within 500 m of the EU. Two TCPs within the view shed of the EU. Manhattan Project/Cold War significant resources have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. Although the area is heavily disturbed, based on geomorphological indicators, there is a **moderate** potential for intact archaeological resources. Remediation disturbance may result in impacts to archaeological resources, if they are present in the subsurface. Permanent indirect effects to view shed are possible from capping. Manhattan

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				Project/Cold War buildings have been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects from capping are likely. Permanent effects may be possible due to presence of contamination if capping occurs. Manhattan Project/Cold War buildings will be demolished.
REDOX Cribs and Trenches	CP-LS-4	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Area is heavily disturbed and has not been inventoried for archaeological resources. Geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. Traditional cultural places are visible from the EU. Two archaeological isolates are located within 500 m of the EU. National Register-eligible Manhattan Project/Cold War Era resources have been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Permanent indirect effects are possible if residual contamination remains after remediation. Manhattan Project/Cold War significant resources have been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. Manhattan Project/Cold War buildings will be demolished.
U and S Ponds	CP-LS-5	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Area is relatively undisturbed and only small portions have been inventoried for archaeological resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. Two traditional cultural places are visible from the EU. Known archaeological resources are located within the EU and within 500 m of the

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				EU. Manhattan Project/Cold War significant resources have been mitigated (located within 500 m of the EU). No Manhattan Project/Cold War Era buildings are located within the EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The area remains relatively undisturbed, suggesting a **high** potential for intact archaeological resources. Remediation disturbance may result in impacts to archaeological resources if they are present in the subsurface. Manhattan Project/Cold War significant resources have been mitigated (located within 500 m of the EU). No Manhattan Project/Cold War Era buildings are located within the EU.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. Manhattan Project/Cold War buildings (located within 500 m of the EU) will be demolished.
T Plant Cribs and Trenches	CP-LS-6	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Area is highly disturbed; however, only a very small portion has been inventoried for archaeological resources. Geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. A National Register-eligible historic/ethno-historic trail/road is located within the EU. Two TCPs are visible from the EU. National Register-eligible Manhattan Project/Cold War Era resources have already been mitigated. T Plant has been identified as eligible for inclusion in the Manhattan Project National Historical Park.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War:	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Direct: Known Indirect: Known	subsurface. Permanent indirect effects view shed are possible from capping. National Register-eligible Manhattan Project/Cold War Era resources have already been mitigated, except for T Plant, which has been identified as eligible for inclusion in the Manhattan Project National Historical Park.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: Known	Permanent indirect effects are possible if residual contamination remains after remediation. National Register-eligible Manhattan Project/Cold War Era buildings will be demolished except for T Plant, which has been identified as eligible for inclusion in the Manhattan Project National Historical Park.
200 Area HLW Transfer Pipeline	CP-LS-7	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Area is highly disturbed, with small pockets of undisturbed deposits, and portions of the EU have been inventoried for archaeological resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. There are no known recorded cultural resources within the EU. Three archaeological sites have been recorded within 500 m of the EU. Two traditional cultural places are visible from the EU. The EU traverses a National Register-eligible Manhattan Project/Cold War Era archaeological resource, which has been mitigated. Direct impacts to contributing components of the archaeological site have not been addressed and will be dealt with on a project-by-projects basis.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible if everything is left in place. Temporary indirect effects to view shed are possible during remediation.National Register-eligible Manhattan Project/Cold War Era

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				resources have already been mitigated. Direct effects to contributing components of the National Register-eligible archaeological resource may occur if remediation activities disturb these areas. Archaeological monitoring or mitigation may need to occur.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. Permanent indirect effects to view shed are possible if everything is left in place. National Register-eligible Manhattan Project/Cold War Era buildings will be demolished. Permanent direct impacts to contributing components of the Manhattan Project/Cold War Era archaeological resource are possible if remediation activities have resulted in the removal of the contributing components of the archaeological resource.
B Plant Cribs and Trenches	CP-LS-8	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Area is highly disturbed and most of EU has not been inventoried for archaeological resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. There are no known recorded archaeological resources within the EU or within 500 m of the EU. Two TCPs are visible from the EU. National Register-eligible Manhattan Project/Cold War Era resources have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from capping, installation of surface barriers, and from residual contamination that may remain. Temporary indirect effects to view shed are possible during remediation. National Register-eligible Manhattan Project/Cold War Era buildings will be demolished, but they have already been mitigated.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible if residual contamination remains after remediation. Permanent indirect effects to view shed are possible from capping, installation of surface barriers and from residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era buildings will be demolished, but they have already been mitigated.
PUREX Cribs and Trenches (inside 200 E)	CP-LS-9	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Area is highly disturbed and small portions of the EU have been inventoried for archaeological resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. There are no known recorded cultural resources within the EU. Two isolated finds associated with the Historic Pre-Hanford Landscape are located within 500 m of the EU. Two traditional cultural places are visible from the EU. There are no Manhattan Project/Cold War Era buildings located within the EU. The Manhattan Project/Cold War Era buildings located within 500 m of the EU have been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from capping. Temporary indirect effects to view shed are possible during remediation. National Register-eligible Manhattan Project/Cold war Era buildings located within 500 m of the EU will be demolished, but they have been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known	Permanent indirect effects to view shed are possible if contamination remains after remediation. Permanent indirect effects are possible from capping and from residual contamination that may remain.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Manhattan/Cold War: Direct: None Indirect: None	National Register-eligible Manhattan Project/Cold War Era buildings located within 500 m of the EU will be demolished, but they have been mitigated.
PUREX Cribs and Trenches (outside 200 E)	CP-LS-10	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	No known archaeological sites, inventoried historic buildings, or traditional cultural places located within the EU. Area is heavily disturbed and only portions of the EU have been inventoried for archaeological resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or in the subsurface. TCPs are visible from the EU. National Register-eligible Manhattan Project/ Cold War Era significant resources located within 500 m have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources. Remediation disturbance may result in impacts to archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from capping. Temporary indirect effects to view shed are possible during remediation. National Register-eligible Manhattan Project/Cold War Era building located within 500 m of the EU will be demolished, but they have already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible if residual contamination remains after remediation. Permanent indirect effects to view shed are possible from capping and from residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era buildings located within 500 m of the EU will be demolished, but they have already been mitigated.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
B Pond	CP-LS-11	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Known archaeological isolates (unevaluated for the National Register) located within the EU. Area is heavily disturbed and only portions of the EU have been inventoried for archaeological resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from EU. Known archaeological resources located within 500 m of the EU. National Register-eligible Manhattan Project/Cold War Era significant resources located within 500 m of the EU have been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from capping. Temporary indirect effects to view shed are possible during remediation. National Register-eligible Manhattan Project/Cold War Era buildings located within 500 m of the EU will be demolished, but they have already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible if contamination remains after remediation. Permanent indirect effects to view shed are possible from capping and from residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era building located within 500 m of the EU will be demolished, but they have already been mitigated.
200 West Burial Grounds	CP-LS-12	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	A National Register-eligible/ethno-historic trail/road is located within the EU. Area is heavily disturbed and only portions of the EU have been inventoried for archaeological resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				Known archaeological isolates (unevaluated for the National Register) located within 500 m of the EU. National Register-eligible Manhattan Project/Cold War Era building located within 500 m of the EU will be demolished, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from capping. Temporary indirect effects to view shed are possible during remediation. National Register-eligible Manhattan Project/Cold War Era buildings located within 500 m of the EU will be demolished, but they have already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible if contamination remains after remediation. Permanent indirect effects to view shed are possible from capping and from residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era buildings located within 500 m of the EU will be demolished, but they have already been mitigated.
200 West Miscellaneous Waste Sites	CP-LS-13	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Known archaeological site located within the EU, but associated landscape is undetermined. Area is heavily disturbed and only small portions of the EU have been inventoried for archaeological resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. A National Register-eligible historic/ethno-historic trail/road is located within 500 m of the EU. Manhattan Project/Cold War Era resources have been mitigated. A National Register-eligible Manhattan Project/Cold War Era archaeological

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				resource is located within 500 m of the EU, which has been mitigated. Direct impacts to contributing components fat the archaeological site have not been address and are dealt with on a project-by-project basis. National Register-eligible Manhattan Project/Cold War Era significant resources located within the EU and 500 m of the EU will be demolished, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low to moderate** potential for intact archaeological resources. Remediation disturbance may result in impacts to archaeological resources if they are present in the subsurface. Temporary indirect effects to view shed are possible during remediation. Permanent indirect effects to view shed are possible from capping and residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era resources have already been mitigated. Indirect effects to contributing components of the National Register-eligible archaeological resource within 500 m of the EU may occur if remediation activities disturb these areas. Archaeological monitoring or mitigation may need to occur.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. Permanent indirect effects to view shed are possible from capping and from residual contamination that may remain. Manhattan Project/Cold War buildings will be demolished.
200 East Burial Grounds	CP-LS-14	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known	Area is heavily disturbed and only small portions have been inventoried for archaeological resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. Traditional cultural places are visible from the EU. Archaeological

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Indirect: Known	resources that remain unevaluated for the National Register are located within the EU and within 500 m of the EU. A National Register-eligible Manhattan Project/Cold War Era archaeological resource is located within 500 m of the EU, which has been mitigated. Direct impacts to contributing components of the archaeological site have not been addressed and are dealt with on a project-by-project basis. National Register-eligible Manhattan Project/Cold War Era significant resources located within the EU and 500 m of the EU will be demolished, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources. Remediation disturbance may result in impacts to archaeological resources if they are present in the subsurface. Temporary indirect effects to view shed are possible during remediation. Permanent indirect effects to view shed are possible from capping and residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era resources have already been mitigated. Indirect effects to contributing components of the National Register-eligible archaeological resource within 500 m of the EU may occur if remediation activities disturb these areas. Archaeological monitoring or mitigation may need to occur.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. Manhattan Project/Cold War buildings (located within 500 m of the EU) will be demolished.
West Burial Grounds	CP-LS-15	Current	Native American: Direct: Unknown Indirect: Known	Area is heavily disturbed and about half of the EU has been inventoried for archaeological resources. The

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. Archaeological resources that remain unevaluated for the National Register are located within the EU and within 500 m of the EU. A National Register-eligible Manhattan Project/Cold War Era archaeological resource is located within 500 m of the EU, which has been mitigated. Direct impacts to contributing components of the archaeological site have not been addressed and are dealt with on a project-by-project basis. National Register-eligible Manhattan Project/Cold War Era significant resources located within the EU and 500 m of the EU will be demolished, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources. Remediation disturbance may result in impacts to archaeological resources if they are present in the subsurface. Temporary indirect effects to view shed are possible during remediation. Permanent indirect effects to view shed are possible from capping and residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era resources have already been mitigated. Indirect effects to contributing components of the National Register-eligible archaeological resource within 500 m of the EU may occur if remediation activities disturb these areas. Archaeological monitoring or mitigation may need to occur.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Unknown Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Permanent indirect effects are possible if contamination remains after remediation. Permanent indirect effects to view shed are possible from capping and from residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era buildings will be demolished.
Grout Vaults	CP-LS-16	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	No known archaeological sites, inventoried buildings, or TCPs are located within the EU. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. National Register-eligible Manhattan Project/Cold War Era significant resources located within the EU and 500 m of the EU will be demolished, but they have been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Unknown	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Temporary indirect effects to view shed are possible during remediation. National Register-eligible Manhattan Project/Cold War Era resources are located within the EU and within 500 m of the EU, some will be demolished, but they have already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Unknown	Permanent indirect effects are possible if residual contamination remains after remediation. National Register-eligible Manhattan Project/Cold War Era resources are located within the EU and within 500 m of the EU, some will be demolished, but they have already been mitigated. Manhattan Project/Cold War buildings will be demolished.
BC Control Zone	CP-LS-17	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford:	Known archaeological resources (that remain unevaluated for the National Register) are located within the EU. Several National Historic Preservation

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Act Section 106 reviews have been completed for the EU. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. Archaeological resources that remain unevaluated for the National Register are located within the EI and within 500 m of the EU. One National Register-eligible Manhattan Project/Cold War Era resource is located within the EU. Direct impacts to contributing components of the archaeological site have not been addressed and are dealt with on a project-by-project basis. Direct and indirect impacts may need to be considered to the 17 Manhattan Project/Cold War Era archaeological resources that are located within the EU and within 500 m of the EU. National Register-eligible Manhattan Project/Cold War Era buildings located within 500 m of the EU will be demolished, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Temporary indirect effects to view shed are possible during remediation. Permanent indirect effects to view shed are possible from residual contamination that may remain. Archaeological investigations and monitoring may need to occur prior to remediation. Direct and indirect effects to archaeological sites are possible during remediation from any residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era buildings located within 500 m of the EU will be demolished, but they have already been mitigated.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Permanent indirect effects are possible if residual contamination remains after remediation. Permanent direct and indirect effects to archaeological sites are possible from remediation and any residual contamination that may remain.
Outer Area Sites	CP-LS-18	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: None	Much of the land within the EU is extensively disturbed and most of the EU has been inventoried for cultural resources. A National Historic Preservation Act Section 106 review has been completed for the closure of the NRDWL/SWL. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. One archaeological site (that remains unevaluated for the National Register) is located within the EU and within 500 m of the EU. One historic road (determined not eligible for the National Register) is located within the EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: None	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Temporary indirect effects to view shed are possible during remediation. Permanent indirect effects are possible from evapotranspiration barrier/cover and if contamination remains after remediation. Remediation disturbance may impact archaeological resources.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: None	Permanent indirect effects are possible from evapotranspiration barrier/cover and if contamination remains after remediation. Disturbance associated with closure and monitoring activities is possible.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
Tank Waste and Farms				
T Tank Farm	CP-TF-1	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: None Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Historical evidence of National Register-eligible historic trail through the EU; however, extensive disturbance in area indicates **low** likelihood of remaining archaeological resources. Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there is no evidence of archaeological sites being recorded within the EU. There is evidence of ethno-historic and historic land use within the EU that has been destroyed by the tank farms.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: None Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Due to presence of historic and ethno-historic land use within this EU, consultation will be necessary. **Little to no** potential for intact surface or subsurface archaeological material to be present due to heavy disturbance throughout the EU.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: None Indirect: Unknown Manhattan/Cold War: Direct: None	Indirect effects to trail may be permanent. Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs.
S-SX Tank Farms	CP-TF-2	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Unknown	Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there are no known recorded archaeological resources within the EU. There is evidence of ethno-historic and historic land use.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Unknown	Because area has not been investigated on the surface or subsurface, archaeological investigations may need to occur within pockets of undisturbed land if any prior to remediation. Potential for intact archaeological material to be present is very **low**.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.
TX-TY Tank Farms	CP-TF-3	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Unknown	Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there are no known recorded archaeological resources within the EU. Traditional cultural places are visible from EU.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Unknown	Because area has not been investigated on the surface or subsurface, archaeological investigations may need to occur within pockets of undisturbed land if any prior to remediation. Potential for intact archaeological material to be present is very **low**.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.
U Tank Farms	CP-TF-4	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Unknown	Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there are no known recorded archaeological resources within the EU. Traditional cultural places are visible from EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown	Because area has not been investigated on the surface or subsurface, archaeological investigations may need to occur within pockets of undisturbed land, if any, prior to remediation.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Unknown	Potential for intact archaeological material to be present is very **low**.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.
A-AX Tank Farms	CP-TF-5	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there are no known recorded archaeological resources within the EU. Traditional cultural places are visible from EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Because area has not been investigated on the surface or subsurface, archaeological investigations may need to occur within pockets of undisturbed land if any prior to remediation. Potential for intact archaeological material to be present is very **low**.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.
B-BX-BY Tank Farms	CP-TF-6	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there are no known recorded archaeological resources within the EU. EU has not been investigated for archaeological resources (surface or subsurface). Traditional cultural places are visible from EU.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Because area has not been investigated on the surface or subsurface, archaeological investigations may need to occur within pockets of undisturbed land if any prior to remediation. Potential for intact archaeological material to be present is very **low**.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.
C Tank Farm	CP-TF-7	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there are no known recorded archaeological resources within the EU. Traditional cultural places are visible from EU.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Because area has not been investigated on the surface or subsurface, archaeological investigations may need to occur within pockets of undisturbed land if any prior to remediation. Potential for intact archaeological material to be present is very **low**.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
200 East DSTs	CP-TF-8	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there are no known recorded archaeological resources within the EU. TCPs are visible from EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Because area has not been investigated on the surface or subsurface, archaeological investigations may need to occur within pockets of undisturbed land, if any, prior to remediation. Potential for intact archaeological material to be present is very **low**.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.
200 West DSTs	CP-TF-9	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Manhattan Project/Cold War significant resources have already been mitigated. Area is very disturbed and there are no known recorded archaeological resources within the EU. Traditional cultural places are visible from EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Because area has not been investigated on the surface or subsurface, archaeological investigations may need to occur within pockets of undisturbed land if any prior to remediation. Potential for intact archaeological material to be present is very **low**.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.
Groundwater				
300 Area Ground-water Plumes	RC-GW-1	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Entire shoreline area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Upland areas where characterization and monitoring activities take place may be **culturally sensitive** regions as well. TCPs are known to be located nearby, along with National Register-eligible archaeological sites associated with all three landscapes.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Entire shoreline area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Upland areas where characterization and monitoring activities take place may be **culturally sensitive** regions as well. Traditional cultural places are known to be located inearby, along with National Register-eligible archaeological sites associated with all three landscapes.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Unknown Indirect: Unknown	Assuming no long-term monitoring of groundwater wells, then no further impact to known cultural resources. Residual contamination in groundwater will likely be of concern for Native American landscape. Permanent direct and indirect effects are possible due to **high sensitivity** of area.
100-N Ground-water Plumes	RC-GW-2	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Entire shoreline area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Upland areas where characterization and monitoring activities take place may be **culturally sensitive** regions as well. TCPs are known to be located nearby, along with National Register-eligible archaeological

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				sites associated with all three landscapes.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Entire shoreline area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Upland areas where characterization and monitoring activities take place may be **culturally sensitive** regions as well. Traditional cultural places are known to be located nearby, along with National Register-eligible archaeological sites associated with all three landscapes.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Unknown Indirect: Unknown	Assuming no long-term monitoring of groundwater wells, then no further impact to known cultural resources. Residual contamination in groundwater will likely be of concern for Native American landscape. Permanent direct and indirect effects are possible due to **high sensitivity** of area.
100-B/D/H/F/K	RC-GW-3	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Entire shoreline area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Upland areas where characterization and monitoring activities take place may be **culturally sensitive** regions as well. TCPs are known to be nearby, along with National Register-eligible archaeological sites associated with all three landscapes.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Entire shoreline area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Upland areas where characterization and monitoring activities take place may be **culturally sensitive** regions as well. TCPs are known to be located nearby, along with National Register-eligible archaeological sites associated with all three landscapes.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Unknown Indirect: Unknown	Assuming no long-term monitoring of groundwater wells, then no further impact to known cultural resources. Residual contamination in groundwater will likely be of concern for Native American landscape. Permanent direct and indirect effects are possible due to **high sensitivity** of area.
200 East Area	CP-GW-1	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Entire shoreline area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Upland areas where characterization and monitoring activities take place may be culturally sensitive regions as well. TCPs are known to be located nearby, along with National Register-eligible archaeological sites associated with all three landscapes.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Entire shoreline area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. Upland areas where characterization and monitoring activities take place may be **culturally sensitive** regions as well. TPCs are known to be located nearby, along with National Register-eligible archaeological sites associated with all three landscapes.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Unknown Indirect: Unknown	Assuming no long-term monitoring of groundwater wells, then no further impact to known cultural resources. Residual contamination in groundwater will likely be of concern for Native American landscape. Permanent direct and indirect effects are possible due to **high sensitivity** of area.
200 West Area	CP-GW-2	Current	Native American: Direct: Unknown Indirect: Unknown Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Unknown Indirect: Unknown	Groundwater plumes are not intercepting riparian areas; along river; vehicle traffic with monitoring and remediation wells could introduce exotic species that disrupt native communities, including biota of cultural importance.
		Active Cleanup	Native American:	Groundwater plumes are not

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Direct: Unknown Indirect: Unknown Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Unknown Indirect: Unknown	intercepting riparian areas; along river; vehicle traffic with monitoring and remediation wells could introduce exotic species that disrupt native communities, including biota of cultural importance.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Unknown Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Unknown Indirect: Unknown	Assuming no long-term monitoring of groundwater wells, then no further impact to known cultural resources. Residual contamination in groundwater will likely be of concern for Native American landscape.
D4 of Facilities				
Building 324	RC-DD-1	Current	Native American: Direct: Known Indirect: Unknown Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: None	Very disturbed, but close to important resources (near the river), Manhattan Era significant facility has already been mitigated. There are no known recorded archaeological sites or TCPs located within the EU; there are five archaeological sites located within 500 m of the EU.
		Active Cleanup	Native American: Direct: Known Indirect: Unknown Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: None	Very disturbed, but close to important resources (close to river).
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: None Manhattan/Cold War: Direct: None Indirect: None	No expectations for impacts to known cultural resources.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
KE/KW Reactors	RC-DD-2	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Manhattan Project/Cold War significant resources have already been mitigated. Area within the EU is heavily disturbed, but the entire area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. TCPs are known to be located nearby, along with National Register-eligible archaeological sites associated with all three landscapes.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Due to **highly sensitive cultural** resources near the EU, consultation is needed. Archaeological investigations or monitoring may also need to occur. Direct and indirect effects are likely to archaeological sites and TCPss near the EU.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent direct and indirect effects are possible due to **high sensitivity** of area.
Final Reactor Disposition	RC-DD-3	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Known eligible TCPs within the 100-N Area. Known National Register-eligible and listed archaeological sites, districts, and TCPs located within 500 m of various portions of the EU. Area within the EU is heavily disturbed, but the entire area is **extremely culturally sensitive** based on historic land use in the area. Known National Register-eligible archaeological sites associated with the farming landscape located within 500 m of the 100-F and 100-H Areas. Manhattan Project/Cold War Era significant resources have already been mitigated; B-Reactor (a National Historic Landmark) has been selected for perseveration and inclusion in the Manhattan Project National Historical Park.
		Active Cleanup	Native American: Direct: Known Indirect: Known	Due to **high cultural sensitivity** of area, consultation may need to occur. Archaeological investigations or

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	monitoring may also need to occur. Direct and indirect effects are likely to archaeological sites and TCPs. The widening of roads necessary for remediation and transport of reactors will result in disruption of ecological communities outside the EU and buffer area.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Permanent direct and indirect effects are likely due to high sensitivity of area. Manhattan Project/Cold War Era buildings will be demolished, except for the B Reactor (a National Historic Landmark).
FFTF	RC-DD-4	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: None	Area is heavily disturbed and even though the entire area has not been inventoried for archaeological resources, it has potential to contain intact archaeological resources on the surface or in the subsurface. Indirect effects (although unlikely) are unknown because it is uncertain if historic archaeological resources exist in the vicinity of FFTF area. Manhattan Project/Cold War Era significant resources have been mitigated. No Manhattan Project/Cold War Era buildings are present within 500 m of the EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: None	Archaeological investigations and monitoring may need to occur prior to remediation. Although the area is heavily disturbed, based on geomorphology indicators, there is a **moderate** potential for intact archaeological resources. Remediation disturbances may result in impacts to archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible Manhattan Project/Cold War Era significant resources have been mitigated. No Manhattan Project/Cold War Era buildings are present within 500 m of the EU.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: None	Permanent direct and indirect effects are likely from entombment of structure and the structure remaining in place for indeterminate amount of time. No Manhattan Project/Cold War Era buildings within 500 m of the EU.
PUREX	CP-DD-1	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: Known Indirect: None	Manhattan Project/Cold War significant resources have already been mitigated. Area is heavily disturbed and even though the entire area has not been inventoried for archaeological resources, it has very **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: Known Indirect: None	Area has not been investigated either on the surface or in the subsurface; archaeological investigations may need to occur within pockets of undisturbed land, if any, prior to remediation. Potential for intact archaeological material to be present is very **low**.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: None Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. No other expected cultural resources impacts.
B Plant	CP-DD-2	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: Known Indirect: Known	Area is heavily disturbed and most of the EU has not been inventoried for archaeological resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or in the subsurface. TCPs are visible from EU. National Register-eligible Manhattan Project/Cold War buildings have been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford:	Archaeological investigations and monitoring may need to occur prior to remediation. Based on the geomorphological indicators, there is a

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Direct: Unknown Indirect: None Manhattan/Cold War: Direct: Known Indirect: Known	l**ow** potential for intact archaeological resources. Remediation disturbance may result in impacts to archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from demolition, remediation, and entombment. National Register-eligible Manhattan Project/Cold War buildings have been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation.National Register-eligible Manhattan Project/Cold War buildings will be demolished.
U Plant	CP-DD-3	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: Known Indirect: Known	Area is heavily disturbed and the EU has not been inventoried for archaeological resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from EU. National Register-eligible Manhattan Project/Cold War buildings have been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. Based on the geomorphological indicators, there is a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from demolition, remediation, and entombment. National Register-eligible Manhattan Project/Cold War buildings will be demolished.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. National Register-eligible Manhattan Project/Cold War buildings will be demolished.
REDOX	CP-DD-4	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Area is heavily disturbed and the EU has not been inventoried for archaeological resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. Traditional cultural places are visible from EU. Two archaeological isolates are located within 500 m of the EU. National Register-eligible Manhattan Project/Cold War buildings have been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. Although the area is heavily disturbed, based on the geomorphological indicators, there is a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from demolition and remediation. National Register-eligible Manhattan Project/Cold War buildings have been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect are possible if residual contamination remains after remediation. National Register-eligible Manhattan Project/Cold War buildings will be demolished.
PFP	CP-DD-5	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known	Area is heavily disturbed and the EU has not been inventoried for archaeological resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Manhattan/Cold War: Direct: Known Indirect: Known	EU. A National Register-eligible historic/ethno-historic trail/road is located within 500 m of the EU. National Register-eligible Manhattan Project/Cold War buildings have been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. Based on the geomorphological indicators, there is a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. Permanent indirect effects to view shed are possible from demolition and remediation. National Register-eligible Manhattan Project/Cold War buildings will be demolished.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. National Register-eligible Manhattan Project/Cold War buildings will be demolished.
Operating Facilities				
KW Basin Sludge	RC-OP-1	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Area within the EU is heavily disturbed, but the entire area is **extremely culturally sensitive** based on prehistoric, ethno-historic, and historic land use in the area. TCPs are known to be located nearby, along with National Register-eligible archaeological sites associated with all three landscapes. Manhattan Project/Cold War significant resources have already been mitigated.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Due to **highly sensitive cultural** resources near the EU, consultation is needed. Archaeological investigations or monitoring may also need to occur. Direct and indirect effects are likely to archaeological sites and TCPs near the EU.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent direct and indirect effects are possible due to **high sensitivity** of area.
CWC	CP-OP-1	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	National Register-eligible historic trail runs through the EU. Two National Register ineligible sites/isolates are located within the EU. Potential for additional resources within pockets of undisturbed soil if it exists based on presence of Native American and Historic Era resources within 500 m of EU. TCPs are visible from the EU.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Both direct and indirect effects are likely on National Register-eligible trail. Other sites have been determined ineligible. Potential for additional archaeological resources where pockets of undisturbed soils exist.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Long-term protection measures may be in place to resolve adverse effects to National Register-eligible trail. Permanent effects possible due to presence of contamination.
T Plant	CP-OP-2	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: None Manhattan/Cold War: Direct: Known Indirect: Known	Much of the land within the EU is heavily disturbed and only small portions have been inventoried for cultural resources. The geomorphology indicates a **low to moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. A portion of a National Register-eligible historic/ethno-historic trail/road is located within the EU. Two archaeological resources are located within 500 m of the EU. National Register-eligible Manhattan Project/Cold War Era resource have been mitigated.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: None Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low to moderate** potential for intact archaeological resources. Remediation disturbance may impact to archaeological resources if they are present in the subsurface. Temporary indirect effects to view shed are possible during demolition and remediation. Permanent indirect effects to view shed are possible from capping and residual contamination that may remain. National Register-eligible Manhattan Project/Cold War Era resources located within the EU and within 500 m of the EU will be demolished, but they have already been mitigated. T Plant has been identified as eligible for inclusion in the Manhattan Project National Historical Park.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: None Manhattan/Cold War: Direct: Unknown Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. Manhattan Project/Cold War buildings located within the EU and within 500 m of the EU will be demolished, but they have already been mitigated.T Plant has been identified as eligible for inclusion in the Manhattan Project National Historical Park.
WESF	CP-OP-3	Current	Native American: Direct: Unknown Indirect: Unknown Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	This EU is located within a Manhattan Project/Cold War significant resource that has already been mitigated. There are no archaeological resources known to be located within this EU. Traditional cultural places are visible from this EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Unknown Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	Because no ground disturbance will occur, there should be no impact to archaeological resources.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Unknown Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	No expectations for impacts to known cultural resources.
WRAP	CP-OP-4	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Much of the land within the EU is heavily disturbed. Almost the entire EU has been inventoried for cultural resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. A portion of a National Register-eligible historic/ethno-historic trail/road is located within the EU. Three archaeological resources are located within 500 m of the EU. The National Register-eligible Manhattan Project/Cold War Era resource has already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low to moderate** potential for intact archaeological resources. Remediation disturbance may result in impacts to archaeological resources if they are present in the subsurface. Temporary indirect effects to view shed are possible during demolition and remediation. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation. The National Register-eligible Manhattan Project/Cold War Era resource located within 500 m of the EU has already been mitigated.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. National Register-eligible Manhattan Project/Cold War resource located within 500 m of the EU will be demolished, but has already been mitigated.
CSB	CP-OP-5	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Much of the land within the EU is extensively disturbed. The entire EU has been inventoried for cultural resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. A National Register-eligible Manhattan Project/Cold War Era archaeological resource is located within 500 m of the EU, which has been mitigated. National Register-eligible Manhattan Project/Cold War Era significant resources located within 500 m of the EU will be demolished, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low to moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include: temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation. A National Register-eligible Manhattan Project/Cold War Era archaeological resource located within 500 m of the EU has already been mitigated. National Register-eligible Manhattan Project/Cold War Era significant resources located within 500 m of the EU will be demolished, but they have already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known	Permanent indirect effects are possible if residual contamination remains after remediation.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
			Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	National Register-eligible Manhattan Project/Cold War resource located within 500 m of the EU will be demolished, but has already been mitigated.
ERDF	CP-OP-6	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	A few National Register-ineligible archaeological sites and isolated finds were recorded before construction of ERDF within this EU. None are likely present due to construction of ERDF and were addressed under the National Historic Preservation Act, Section 106 Review completed prior to ERDF construction. A Manhattan Project/Cold War Era eligible site is recorded within 500 m of ERDF as well as several other archaeological sites associated with various landscapes. TCPs are visible from this EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: Known Indirect: Known	All of the EU has been inventoried for archaeological resources on the surface. Because there are pockets of land where no disturbance has occurred, the potential for subsurface archaeological material to be present in these areas is **moderate**. Indirect effects to the Manhattan Project/Cold War eligible archaeological site are possible.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects to view shed are possible from capping. Permanent effects may be possible due to presence of contamination if capping occurs. No other expected cultural resources impacts.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
IDF	CP-OP-7	Current	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Much of the land within the EU is extensively disturbed. Small portions of the EU have been inventoried for cultural resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. Three archaeological resources are located within the EU. A National Register-eligible Manhattan Project/Cold War Era significant resource located within 500 m of the EU has already been mitigated.
		Active Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation. National Register-eligible Manhattan Project/Cold War Era significant resources located within 500 m of the EU will be demolished, but they have already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Known Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation.National Register-eligible Manhattan Project/Cold War resources located within 500 m of the EU will be demolished, but they have already been mitigated.
Mixed Waste Trenches	CP-OP-8	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Much of the land within the EU is extensively disturbed. A portion of the EU has been inventoried for cultural resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. TCps are visible from the EU. Three archaeological resources are located within 500 m of the EU. National Register-eligible Manhattan

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				Project/Cold War Era significant resources are located within 500 m of the EU, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation and from capping.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation and from capping. National Register-eligible Manhattan Project/Cold War resources located within 500 m of the EU will be demolished, but they have already been mitigated.
Naval Reaction Trench	CP-OP-9	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Much of the land within the EU is extensively disturbed. Small portions of the EU have been inventoried for cultural resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or subsurface. Traditional cultural places are visible from the EU. One archaeological resource is located within 500 m of the EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				are possible if contamination remains after remediation and from capping.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation and from capping.
242-A-Evaporator	CP-OP-10	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Known Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Much of the land within the EU is extensively disturbed. None of the EU has been inventoried for cultural resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. National Register-eligible Manhattan Project/Cold War resources located within 500 m of the EU will be demolished, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation. National Register-eligible Manhattan Project/Cold War resources located within 500 m of the EU will be demolished, but they have already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. National Register-eligible Manhattan Project/Cold War resources located within 500 m of the EU will be demolished, but they have already been mitigated.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
LERF & Effluent Treatment Facility (ETF)	CP-OP-11 and CP-OP-16 Com-bined	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	The EU is extensively disturbed. The entire EU has been inventoried for cultural resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. One archaeological resource is located within 500 m of the EU. The National Register-eligible Manhattan Project/Cold War significant resource located within 500 m of the EU will be demolished, but has already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **high** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation and from capping. The National Register-eligible Manhattan Project/Cold War significant resource located within 500 m of the EU will be demolished, but has already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation and from capping.
TEDF	CP-OP-12	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Much of the land within the EU is extensively disturbed. Almost the entire EU has been inventoried for cultural resources. The geomorphology indicates a **moderate** potential to contain intact archaeological resources on the surface and/or in the subsurface. TCPs are visible from the EU. One archaeological isolate is located within 500 m of the EU.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation and from capping.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation and from capping.
SALDS	CP-OP-13	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: Known	The central portion of the EU is extensively disturbed. Most of the EU has been inventoried for cultural resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. One archaeological isolate is located within 500 m of the EU. The National Register-eligible Manhattan Project/Cold War significant resource located within 500 m of the EU will be demolished, but has already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **moderate** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				after remediation and from capping. The National Register-eligible Manhattan Project/Cold War significant resource located within 500 m of the EU will be demolished, but has already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Unknown Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation and from capping. The National Register-eligible Manhattan Project/Cold War significant resource located within 500 m of the EU will be demolished, but has already been mitigated.
WTP	CP-OP-14	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	The EU is extensively disturbed. The entire EU has been inventoried for cultural resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or subsurface. TCPs are visible from the EU. One archaeological resource is located within 500 m of the EU. One archaeological site (not eligible for the National Register) is located within 500 m of the EU.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **low** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: None Manhattan/Cold War: Direct: None Indirect: Known	Permanent indirect effects are possible if residual contamination remains after remediation.

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
222-S Laboratory	CP-OP-15	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	The EU is heavily disturbed. The EU has not been inventoried for cultural resources. The geomorphology indicates a **high** potential to contain intact archaeological resources on the surface and/or in the subsurface. TCPS are visible from the EU. Three archaeological resources are located within 500 m of the EU. The National Register-eligible Manhattan Project/Cold War significant resources located within 500 m of the EU will be demolished, but they have already been mitigated.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **high** potential for intact archaeological resources. Remediation disturbance may impact archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during remediation; permanent indirect effects are possible if contamination remains after remediation and from capping. The National Register-eligible Manhattan Project/Cold War significant resources located within 500 m of the EU will be demolished, but they have already been mitigated.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: Known	Permanent indirect effects are possible if residual contamination remains after remediation and from capping. The National Register-eligible Manhattan Project/Cold War significant resources located within 500 m of the EU will be demolished, but they have already been mitigated.
WSCF	CP-OP-17	Current	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: None	The EU has been heavily disturbed with pockets of undisturbed sediments. Portions of the EU have been inventoried for cultural resources. The geomorphology indicates a **low** potential to contain intact archaeological resources on the surface and/or in the subsurface. TCPs are visible from the EU. One archaeological

EU Name	EU ID	Evaluation Period	Potential RISK OR IMPACT	Comments
				resource is located within 500 m of the EU. A National Register-eligible Manhattan Project/Cold War archaeological resource, which has been mitigated, is located within the EU. Direct impacts to contributing components of the archaeological site have not been addressed and are dealt with on a project-by-project basis.
		Active Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: Known Indirect: None	Archaeological investigations and monitoring may need to occur prior to remediation. The geomorphology indicates a **high** potential for intact archaeological resources. Remediation disturbance may impact to archaeological resources if they are present in the subsurface. No cleanup decisions have been selected; however, the potential range of impacts could include temporary indirect effects during demolition. National Register-eligible Manhattan Project/Cold War resources have already been mitigated. Direct effects to the contributing components of the National Register—eligible archaeological resources may occur if remediation activities disturb these areas. Archaeological monitoring or mitigation may need to occur.
		Near-Term Post-Cleanup	Native American: Direct: Unknown Indirect: Known Historic Pre-Hanford: Direct: Unknown Indirect: Known Manhattan/Cold War: Direct: None Indirect: None	Permanent indirect effects are possible if residual contamination remains after remediation. National Register-eligible Manhattan Project/Cold War buildings will be demolished. Permanent direct effects to the contributing components of the National Register-eligible archaeological resource are possible if remediation activities have resulted in the removal of the contributing components of the archaeological resource.

4.6. INTEGRATION WITHIN AND AMONG RECEPTOR CATEGORIES

Considerable effort was spent between 2014 and 2015 developing a methodology to evaluate risks and impacts to human health and resource receptors at the Hanford Site (Methodology (CRESP2015b). For this report, risks and impacts to groundwater, the Columbia River, and ecological resources from individual EUs have ranged from a rating of ND to Very High. Human health ratings do not use a risk rating of Very High to be consistent with DOE standards for determining risks to workers and the public.

Additionally, cultural resources have not been rated; however, information about the cultural resources within the EUs has been described and analyzed as known or unknown.

As discussed in Chapter 2.3, unique methodologies were developed to provide relative risk ratings within each receptor category (e.g., groundwater), which then were applied to all EUs rated. Development of a unique methodology for rating each receptor category was necessary because each required the use of different data, models, and discipline-specific expertise to arrive at the ratings. In addition, some risks resulted from lack of action (e.g., risks to ecology or groundwater from continuing contaminant migration or potential for disruptive natural events) while other risks resulted from actions to be taken (e.g., risks to ecological resources or worker safety from cleanup activities). Different risk types have different mitigation strategies. Risk ratings are not directly comparable across receptors and resources that were evaluated: for example, a rating of High with respect to human health does not have the same basis or meaning as a rating of High for groundwater. Another example, the ecological methodology was initially a stakeholder-driven evaluation of the ecological resource levels on different parts of the Hanford Site (DOE/RL-96-32, 2013). These initial evaluations were used to design and implement a field protocol to update the resource level evaluations and determine a risk rating with information on the cleanup options to be implemented. In contrast, the Columbia River methodology involved use of 2015 groundwater plume intersections with the riparian and benthic zones and maximum concentrations relative to thresholds (i.e., BCGs for radionuclides or AWQC for chemicals), as well as treatment options, to arrive at a risk rating. Importantly, the risk ratings for each receptor category were derived with data and discipline-dependent expertise and were meant to allow comparisons only within receptor categories (e.g., ecological, human, Columbia River, cultural) and not among receptor categories (e.g., comparing ecological ratings with human health ratings).

A goal of the Risk Review Project has been to provide a comprehensive understanding of the remaining cleanup challenges at the Hanford Site and a common, accessible foundation for dialogue regarding cleanup sequencing. Integration in risk ratings among receptor categories is a part of risk management, not risk evaluation, and informs the development of program objectives that also must consider other factors such as programmatic goals, legal requirements, near- and long-term cost-benefit tradeoffs, values and uses, and stakeholder input (including from the public, Tribes, and government officials at local, state and federal levels). The uses of the information developed through the Risk Review Project are context-dependent and the uses of this information are anticipated to change in response to objectives of specific decision making, as well as over time as cleanup progresses and decision making contexts changes. For example, different decision objectives and contexts may focus on near-term or long-term risk reduction, area-wide completion, workforce continuity, cost-benefit tradeoffs, short- or long-term benefits and/or different levels of emphasis on specific potential receptors or resources. Issues related to risk management are not within the purview of this Risk Review Project. As such, integration of results among receptor categories has not been completed, and it is also beyond the purview of the Risk Review Project. Instead, the highest ratings for each receptor category is provided (e.g., EUs where ecological resources risks were rated Very High). Summarizing the information in this way is offered only to help inform sequencing decisions and planning and execution of specific cleanup actions (See Table 6-3 and Table 6-4).

If, however, DOE, its regulators, and/or stakeholders were to integrate the risk information provided in this report, such an effort should involve a broad group of stakeholders, including the public and relevant local, state, federal, and Tribal entities. Different stakeholders may use different metrics to integrate the information provided by this report, depending on their objectives. Successful efforts that have been used previously are categorized as multi-criteria decision making (MCDM) approaches and are the subject of a broad and deep literature on theory and practice (e.g., Triantaphyllou 2000). There are a variety of different MCDM approaches that may be used.[141] A vital part of such efforts is the development of stakeholder input on the objectives of the evaluation and the criteria used to evaluate whether the objectives are being met.

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[141] MCDM tools are frequently used in optimizing solutions for complex problems. These tools are designed to tackle problems that depend on multiple factors that may interact in a complex manner. As a result of their usefulness, the incorporation of MCDM approaches has expanded in recent decades, including the application of energy and environmental decision-making (Akash 1999; Kostin 2012; Merkhofer 1987; Tucker 2003; Wang 2009). Several methods exist, probably the most frequently used in energy and environmental applications include the analytic hierarchy process (AHP) and multi-attribute utility analysis (MAUA). Even within individual methods, variations exist, and a number of studies have been performed that compare methodologies (Linkov 2006; Triantaphyllou 2000). Based on the preferences of the stakeholders and decision-makers, either AHP or MAUA can be used and both have an extensive background of use in energy and environmental decision-making; however, other methods exist (see Linkov 2006 and Triantaphyllou 2000). This report is not providing a recommendation whether to enter into an MCDM evolution—to inform risk management—nor are we recommending a methodology. The purpose of this short discussion is simply to introduce the concept.

AHP was developed in the 1970s by Thomas L. Saaty and is capable of considering multiple criteria and can incorporate the inputs of multiple users or stakeholders. The process involves stakeholders clearly defining the options of interest, and identifying the criteria that impact those options (Forman 2001). Criteria are most frequently weighted through stakeholder participation. AHP has the advantage that it is designed to accept both qualitative and quantitative inputs. Several software tools are available that facilitate the elicitation, calculations, and display of results.

MAUA is based on multi-attribute utility theory; in its overall framework, MAUA is similar to AHP in that involves clearly defining the options and criteria (generally called “attributes” in this case) of the problem (Wallenius 2008), frequently via stakeholder participation. However, unlike AHP, MAUA assumes that an underlying quantitative distribution exists, or can be estimated, for the criteria—a “utility” function. By combining utility functions, it is possible to construct a comprehensive multi-attribute utility function which represents the overall “value” of an option. Options can then be assessed by comparing their ultimate multi-attribute utility values. Similar to AHP, there are software tools available that facilitate the elicitation, calculations, and display of results.

CHAPTER 5. LOCAL AND REGIONAL CONTEXT AND PERSPECTIVES ON DIVERSIFYING TRI-CITIES REGIONAL ECONOMY

5.1. INTRODUCTION

This chapter considers the economic impact on the broader regional economy and the gradual emergence of a more diversified regional economy in the Tri-Cities region of southeastern Washington State. Diversification is a key to any region's economic health. Building an economic base that relies less on DOE as a primary source of funding for the Tri-Cities (Richland, Kennewick, and Pasco) can be beneficial to the region's long-term health. In 2016, DOE, its Hanford Site contractors, and Battelle/Pacific Northwest National Laboratory, employed a total of nearly 14,000 workers in the Tri-Cities area, accounting for about 15.5% of all non-farm employment in the region. DOE and the contractors it has involved in the cleanup of the Hanford Site employ as many workers as the five largest private organizations together (Kadlec Regional Medical Center, ConAgra Foods, Tyson Foods, Trios Health, and Boetje Orchards) and two-thirds more than the combined Kennewick, Pasco, and Richland School Districts.[142] In addition, DOE's prime contractors subcontracted work totaling more than $400 million in 2015 to local Tri-Cities businesses.[143] The full economic impact of DOE activities in the Tri-Cities is a multiple of the $2.3 billion Hanford annual budget, since thousands of restaurants and other local service businesses benefit from the spending of these well paid employees.

To show the various influences bearing on the region's economy, this chapter proviFd4

des a brief overview of the following: (1) the historical context for economic diversification; (2) definitions of key terms used in regional economic analysis; (3) the role of international, national, and state forces in the Tri-Cities regional economy; (4) the role of the Hanford Site during the last half-century; and (5) the role of local stakeholders in molding a more diversified economy. (See Appendix L for a more comprehensive essay on the regional economy.)

5.2. CONTEXT

In this century, a healthy economy is defined not only by increasing gross domestic product, income, jobs, and tax dollars, that is, the usual bottom-line measures of an economy, but also by economic diversification that can buttress a region against sudden and longer-lasting economic changes. Economic diversification is not a new topic; it was a subject of study in the late 1960s. Now, however, diversification as an economic objective has become increasingly important because of the unpredictability of national, state, and local economies, primarily due to evidence that companies once considered stable can quickly degrade, break up, close down, and/or relocate.

While much of the economic diversification literature focuses on developing nations, the concepts increasingly apply to urbanized ones (Vos 2011; Papgeorgiou 2016). Following the World War II, the United States was the world's major economic power, and manufacturing centers emerged in Michigan, Ohio, and other areas of the upper Midwest, epitomized by Detroit, which was touted as a world economic engine because of its production of automobiles (Thompson 1965). In those days, students of regional economics, economic geography and regional science studied how to create more economies like Detroit, Cleveland, and Akron that were manufacturing durable goods. These economic models had a large share of the world market, paid high wages, and generated high tax revenues, allowing their

[142] Tri-Cities Development Council (TRIDEC) 2016 Fact Sheet, https://www.tridec.org/fact-sheet/.
[143] DOE, Hanford Site Outlook, Tri-Cities Regional Economic Outlook, January 20, 2016.

communities to invest in art galleries, zoos, sports arenas, and other facilities that the public wanted. Regions also wanted to replicate the economic success of cities like Detroit.

Fast forward a generation. Globalization has begun and cities like Detroit, Cleveland, Akron, and many others in what was once known as the American Manufacturing Belt are now known by some as the American Rust Belt. These cities have lost much of their economic base and a great deal of their population, which has presented serious consequences for their ability to maintain much less to improve quality of life. Being the economic planner for a community that has lost much of its job base and more than half its population is challenging. Such a job requires the capacity to conceptualize and implement a plan that will work to diversify the economy in locations having massive amounts of sunken investment in facilities and jobs, which can be a drag on rebuilding a sustainable economy for the near- and longer-term.

With this as context, the need for local governments to adjust to gradual and sometimes sudden economic change, this chapter examines the economy of the Tri-Cities region for not only the standard metrics of economic health (e.g., jobs, income, taxes) but also for signs of economic diversification.[144]

5.3. DEFINITIONS AND MODELS

Before discussing influences on the study area, three key terms need to be defined: "direct," "indirect," and "induced" economic impacts (Greenberg 2007).

Direct impacts come about from earnings and economic output at a particular location, for example, on the Hanford Site. When the groundwater treatment facility was built, some local architects, engineers, and construction workers were involved. Since the facility was built, local operators, maintenance staff, security, inspectors, and others have been engaged in making sure that it is operating as designed. All of this work is considered a direct contribution to the local economy.

Indirect impacts are dollars associated with earnings and economic output that occurs off site, for example, business services, and many other products and services that employ people in the state and elsewhere as a result of Site activities. Some of the money and benefits that the employees, companies, and stockholders of private companies earn will create jobs for local barbers, grocery store operators, wholesalers, and many others. All of these expenditures will be taxed at the national, state, and local levels, and some of the taxes will be used to hire police, fire fighters, school teachers, and many other public service employees. As the money moves through the economy, it is creating new income, jobs, and tax revenues, which economists call a multiplier.

Induced economic impacts follow from changes in earnings and benefits. If Site activities add employees and raise salaries, then workers will be able to purchase more in the region. If people lose their jobs, they will reduce purchases. The ability of a city, region, or state to increase indirect and induced impacts

[144] Toward this end, heavy reliance has been placed on research by the State of Washington's Economic and Revenue Forecast Council, U.S. government reports, studies completed by PNNL and TRIDEC, documents prepared by Benton, Franklin, Grant, and Yakima counties, as well as work by CRESP. Several caveats are in order. This chapter was written by individuals who have visited the region on multiple occasions but are not residents of the area. In one way, this is an advantage insofar as it allows consideration of information without having a direct local stake in the outcome. The disadvantage is that external analysts do not have all the information available to local ones. This chapter is meant to identify key forces from existing literature. No new additional economic simulations were prepared to support this chapter.

is a critical issue and typically is considered a disadvantage in rural areas and smaller metropolitan areas (see further discussion below).

REGIONAL ECONOMIC INFLUENCE 1: GLOBALIZATION, THE NATIONAL ECONOMY, AND THE STATE OF WASHINGTON

Every local jurisdiction in the United States has been influenced by globalization. Globalization means increasing integration of economies across the globe through transportation and communication, as well as increasing the spread of ideas and movement of population. During the 1960s, regional economic analysis methods focused primarily on the impact of the United States on the world economy, using the then popular phrase: "When America sneezes the world catches a cold." This meant that the United States was "the" big world economic power, and when our economy would have a problem, other economies would get "sick" because Americans' would buy less goods and services from them. Fifty years later this statement remains true. However it is also now true that the United States is vulnerable to economic upsets in Europe, China, Japan, and other major economic powers. Economic problems in the United States, such as those that led to the recession in 2007-2009, reverberated across the globe, and today slowdowns in China's economy are felt in the United States, much as the oil embargo in 1973 shocked the U.S. and many other economies. As the world has globalized, the world's economies have felt the consequences, both good and bad.

Based on their organizational structure and publications, Washington's State Economic and Revenue Forecast Council (hereafter referred to as the Council) appears to be one of best state-level organizations tracking and updating information about the state's economy and providing it to elected officials, businesses, and residents. The Council maintains a set of sophisticated regional impact tools that few other states have (see below for examples).

The Council's reports are grounded in U.S. government data, which they add to, as well as their own analytical capabilities (Lerch 2016; State of WA 2014; Economic and Revenue Forecast Council 2016; Hughes 1994). For example, their reports show that the Washington gross domestic product grew 5.1% between 2013 and 2014, which was the tenth fastest in the United States. In regard to unemployment, Washington's unemployment rates exceeded U.S. rates from 2000 to the beginning of the recession in 2007. Since the beginning of the recession, however, Washington's unemployment has closely paralleled the U.S. as whole and was slightly lower. Indeed, the state's employment grew 2.8% from December 2014 to December 2015, which was the sixth fastest growth rate in the United States.

Washington State has been recovering from the recession that began in 2007 more rapidly than the U.S. as a whole. Positives include both a declining unemployment rate heading toward pre-recession levels and increasing wage rates. Lower oil prices helped stimulate the recovery and housing starts and sales have increased. But not all the recent international and national news has been good. The global economy has slowed, most notably in China, and U.S. gross domestic product growth has been less than hoped for, and hence economic estimates have been revised downward. The value of the U.S. dollar has increased, which has hurt exports of durable goods. The stock market's volatility signals a lack of clear markers explaining what is happening in the world's globalizing economy.

Despite declining exports to Canada, Japan and China, Washington State's major non-U.S. clients between 2009 and 2015, the Council expects the state's real personal income to grow more rapidly than the U.S. as a whole. However, it also notes that U.S. and Washington State expectations have been revised downward.

Like other states, Washington State's employment profile has gradually changed to increasing retail trade, leisure, and hospitality service employment, and its manufacturing has declined. The forces behind these changes are global and national, and while the State can adopt policies to adapt to global changes, it cannot singularly change global trends. Sometimes Washington's performance is better than other states and the country as a whole. Other times, it is not. Nevertheless, it is important to note that because of Washington State's strong organizational capacity in economic analysis and a process that brings these to the attention of elected officials, the state is in a good positon to understand and adapt to shocks and gradual changes to the extent that adaptation is feasible.

Monitoring and understanding relationships among nations and state economies is necessary but not sufficient to fully understand local economic health. The regional economics literature has explored core-periphery linkages within states. The essence of this economic theory is that as urban core areas increase their economic power, little of that growth goes to more remote areas, and indeed the core areas acquire jobs and income that otherwise would have gone to rural or smaller urban area. The alternative is that growth in core centers diffuses to peripheral locations.

Washington State has a core economic center consisting of Seattle-Tacoma, similar to Chicago in Illinois and New York City in New York. Because of its analytical modeling capacity, Washington State has been able to study this issue. Hughes and Holland (1994), for example, used Washington's economic input-output models to study the core, periphery, and transactions among them. They tested interactions using a decline in Boeing's aircraft sales as an illustration. The study found relatively little impact between the core and periphery, which means that the periphery will not reap the benefits of expansion, nor however, will it feel the burden when the core suffers a setback.

Another element of the core-periphery dichotomy is that small economic regions tend to leak jobs, income, and taxes to larger core regions. For example, CRESP examined the impact of building a new facility to manage nuclear wastes at the Savannah River Site (Greenberg 2002). Economic analysis showed that the region surrounding the Site would have received much less economic benefit than the cost of the project suggested because its design would not have been done in the region, and many of the workers would have been imported to construct the facility. Indeed, CRESP concluded that if the Savannah River Site budget was held constant, the region would have been better off economically continuing existing projects, which had a much larger local multiplier and less leakage to nearby core areas like Atlanta. This example is not meant to imply that any project currently underway or proposed for the Hanford Site has a great deal or little economic leakage because that issue has not been studied. The example is meant to underscore the fact that large metropolitan regions will be able to multiply investments into more local economic benefits than the same project in a smaller region, or looked at from another perspective, more federal economic stimulation is required to achieve the same economic benefit result in a rural or smaller metropolitan region than in a larger one.

The State of Washington's modeling capacity can be used to assess the core-periphery issue in regard to the Tri-Cities region. For example, even though the Council's data shows that Washington's unemployment has been falling faster than the U.S. as a whole, the Council data also show that the seasonal unemployment rates for December 2015 for the Tri-Cities and Yakima were 6.6% and 7.9%, respectively. This compares to 4.6% for Seattle. This notable difference would be valuable to better understand using Washington's sophisticated models. In other words, this issue would benefit from additional research.

Regional Economic Influence 2: The U.S. Department of Energy

During the last three plus decades, there have been several major sources of research on the economic impact of DOE Office of Environmental Management sites on their surrounding regions, including the Hanford Site. Scott et al. (1989) noted that Hanford is the major employer in the Tri-Cities region. From the perspective of the years 1987-1988, this study noted the closing of several key facilities and that the region is in a transition to a more diversified economy. Part of the transition is more housing construction, agriculture, tourism, and the growth of retirement communities in the region. Yet, the reality is in this region from September 30, 1987 through December 31, 1988 employment decreased by 2,200 jobs at a time when the State of Washington as a whole increased jobs by 4%. Scott et al. also reported decreases in earnings, housing prices, and school enrollments. They expected additional decreases. This early study is a snapshot of the Tri-Cities regions during a period when the national private funded economy was expanding while the government supported one was contracting in this location.

In *The Impact of DOE Sites on Their Local Economies* (DOE 2013b), a study done for the DOE, used Regional Input-Output Modeling System (RIMSII) multipliers derived from input-output tables for its economic impact analyses. This economic analysis tool is grounded in detailed knowledge of business transactions. The output measures are jobs, unemployment, and to a lesser extent income. The primary difference between the CRESP and DOE studies is that CRESP assessed the economic impacts of both job reduction and creation programs and followed them for 10 to 25 years.

The DOE report indicates that in fiscal year 2012 there were 427 DOE employees at Hanford Site, 10,398 prime contractors, and 1,197 non-DOE tenant employees. Also, there were 2,450 construction workers. All the facilities are not on the DOE site. The report indicates that there were 10 non-DOE facilities at the Hanford Site, including an observatory and an electricity generating station.

The RIMSII multipliers assume that every DOE onsite job creates another 0.583 jobs. In other words, DOE had 12,000 jobs and another 7,000 were indirectly created. Also, the report shows 2,500 construction jobs, which they calculate implies another 1,500 indirect jobs. These total to 22,700 jobs associated directly and indirectly with Hanford. In the context of the Hanford region, they are similar to the CRESP studies estimated for a decade earlier.

The DOE report notes that Site employment decreased from 11,651 in 2003 to 10,398 in 2012. This, the report asserts, increased unemployment by 1% (adding indirect impacts). One of the last sections of the report suggests that 2,000 jobs would be created by operating the WTP, and these jobs would partly compensate for the almost 2,500 construction jobs that would be lost. The net effect of building and then operating the WTP, they calculate, would be to decrease the estimated unemployment rate in 2016 from 10.9% to 9.3%. Of course, the plant is not yet operating, and so its operating economic impact cannot yet be measured. The current thinking is that as construction is completed on the WTP LAW Vitrification Facility, the workforce will shift to the HLW Vitrification Facility construction, and then to completion of the remaining parts of the WTP.

The socioeconomic status of a regional population is always important. The area this report calls the Hanford region has demonstrated wide variation in socioeconomic status of residents. For example, in 1989, Benton County ranked third in median household income among Washington's 39 counties. Estimates for 2012 and 2013 also place it third in the state. Benton's income is over 10% higher than Washington State's as a whole. In contrast, income in neighboring Walla Walla, Grant, Adams, and Klickitat counties was about 20% lower.

Summarizing, the CRESP and DOE economic studies depict a region that has had economic swings when measured by common indicators of employment, unemployment rate, job growth, income, and regional domestic product. Yet, overall the area that directly and indirectly benefits from DOE and PNNL's presence is doing better economically than most others.

Overall, there is considerable evidence that Washington State officials have the capacity and will to support the mid-Columbia River economic region. The state's economic group has an important role to play statewide and has economic tools that can support this effort. At the national scale Washington's governor and other elected officials have continued to assert a need for a large share of the DOE Office of Environmental Management's shrinking budget.

REGIONAL ECONOMIC INFLUENCE 3: LOCAL EFFORTS

Because of decades of cycles of growth and decline, the Tri-Cities region has been trying to build a diversified economy, one less dependent on DOE, while also continuing to argue for continuing DOE Office of Environmental Management support at the highest levels of government. In 2000, 2010, and 2015, the four counties (Benton, Franklin, Grant and Yakima) had a total population of 489,000, 585,000, and 620,000, respectively, an increase of 27%.

Documents prepared by the Tri-Cities Development Council, county planners, chambers of commerce, Tribal Nations, and others suggest a focus on natural assets and anthropogenic ones, at least partly acknowledging the legacy of the highly qualified and paid professionals drawn to the Hanford Site and the PNNL. Four potential local economic growth drivers appear to have wide, although not necessarily, complete support:

- Agriculture, including wine production
- Tourism
- Caring for senior citizens and health care
- Science and Technology

Agriculture has a long history in the region, including the production of wheat, corn, apples, and grapes for its wine industry. A challenge not only for irrigated agriculture but also for fishing, recreation, hydroelectric power, and other potentially competing consumptive water uses is how to use a limited supply of water. Barnett et al. (2005) identity the Columbia River system as one that by 2050 could be seriously impacted by both less and earlier snow melt, which in turn would force users along the river to make difficult decisions about priorities among agriculture, recreation, hydropower, and others.

Tourism is a logical choice in an area with a great deal of sunshine and not much rain. Even when temperatures exceed 100 °F during parts of the summer, the heat is dry, unlike that west of the mountains and in many other parts of the United States. The Tri-Cities region has many wineries, breweries, bed and breakfasts, hotels, fishing, water recreation, and other opportunities. County and local governments have been expanding a network of parks along more than 100 miles of rivers. As long as the tourist industry is not devastated by a major hazard event, gasoline prices do not increase to the point where people are reluctant to drive to this region, and a serious extended recession does not occur, the Tri-Cities region can draw people from all over Washington, Oregon, parts of California, and states to the east. The middle Columbia River basin should be able to continue to build and enhance a sustainable tourism industry.

The U.S. Census middle range population estimates are that the population of senior citizens[145] will double from 43 million in 2012 to 84 million in 2050, which represents an increase from 13.7% of the national population to 20.9% (Orttman 2016). Health care, including assisted living facilities, retirement communities, and similar facilities, is a logical growth industry for this area because of its location in a dry and sunny area within a relatively short distance from western Washington, Oregon, and California. Research shows that the current senior citizen population has accumulated a great deal of wealth and often chooses to live in areas with a high risk of tropical storms and other hazard events (Greenberg 2014). The Tri-Cities region of Washington State faces threats from earthquakes, fires, and floods, but

[145] Senior citizens are defined as anyone 65 years or older.

compared to other areas of the United States habitually at risk from tropical storms and tornadoes, this should be a relatively lower risk area.

Attracting more senior citizens will take considerable effort. The Milken Institute (Chatterjee 2014) compared 252 areas for what it called "Best Cities for Successful Aging." Using indicators such as health care, wellness, living arrangements, transportation convenience, and others, the Tri-Cities area ranked 188 for seniors. In other words, the Tri-Cities has work to do to raise its comparative position closer to cities like Madison (WI), Ithaca (NY), Lubbock (TX), Morgantown (WV), and Lincoln (NE). The high ranking areas typically are county seats or state capitals, and have major university facilities nearby.

Agriculture, tourism, and hosting seniors are three activities that should be cornerstones for the Tri-Cities region to help it survive the inevitable economic hiccups of the U.S. economy and the ups and downs in DOE funding. If there is a gamble in the plan, it is in the efforts to build the Tri-Cities region into a high-tech innovation center. It is hard to object to the goal. However, the competition is fierce. Nations, states, local governments, and private organizations all target this industry. Is there a good reason and evidence that a region centered around three cities with a population of about a quarter of a million can be successful in attracting high-tech industry? PNNL makes a strong case that southeastern Washington is already succeeding. PNNL asserts that, unlike most other technology clusters, this one is not grounded in computer software design and engineering, but rather in physics, chemistry, and materials engineering. It rates the region high in quality of life and in recent business growth. The major disadvantage PNNL points to is a lack of financial capacity to fund creative ideas and/or to receive support from key industry backers, unlike Silicon Valley, the Seattle region, and other high-tech magnets.

The Milken Institute's best city rankings suggest that the Tri-Cities have been doing really well in this effort. Out of 200 large cities, the Tri-Cities ranked 6 and 5 in 2009 and 2010, respectively, in creating and sustaining jobs, doing especially well in attracting high-tech industry. The 2015, update dropped their ranking to 83 out of 200. But in wage growth, the region ranked 16 and in high-tech Gross Domestic Product concentration, the Tri-Cities ranked 44. These fluctuations are not surprising in small regions, but a good start has been made in this area, as PNNL asserted in its 2010 report (PNNL 2010).

One reason for optimism is public support. In 2009, DOE presented the idea of turning some of its former weapons areas into high-tech energy research centers. CRESP conducted a survey of 3,103 U.S. residents living in six regions with DOE sites, finding the strongest support for new energy parks idea in the Hanford-centered area. Specifically, 29% of U.S. residents and of residents of five other DOE-centered regions favored an energy park in their area compared to 45% in the Hanford-centered region (Greenberg 2010).

5.4. DISCUSSION AND CONCLUSIONS

A 2012 article in the *Oregonian* (Cockle 2015) characterized the Tri-Cities region as the "nation's fastest-growing metro area." The author assumed the Tri-Cities will receive $3 billion a year from the DOE in the future. He noted that "no doubt the Tri-Cities would be smaller and poorer today had it not been for the 1945-1991 Cold War and the arms race between the United States and the Warsaw Pact nations." Cockle adds that it was the nation's fastest-growing metropolitan area from 2010 to 2011, adding a rating as one of the top 10 places in the nation to raise a family by Kiplinger and one of the top 10 likeliest places to make gains in housing values by CNN/Money. *Forbes Magazine* ranked the Tri-Cities as the "11th geekiest" community in America because of the concentration of well-educated residents. Noting that the area averages 300 days of sunshine a year and has multiple golf courses, marinas along the Columbia River, and few traffic problems, the article concluded that this is “a place with undeniable appeal.”

In essence, this article is a summary of the economic plan for the Tri-Cities.

- Expect the DOE Office of Environmental Management program to provide billions of dollars a year for the foreseeable future and expect PNNL to continue to be a strong presence in the area. These are twin regional cornerstones.
- Use natural resources wisely to stimulate selected areas with potential, i.e. agriculture, tourism, and attracting seniors and others currently living in less desirable and more expensive areas to this weather-friendly region.
- Press hard to continue to attract high technology industry that does not directly compete with existing clusters in Seattle and Silicon Valley by offering specialties built on existing work at Hanford Site and PNNL.

Assuming that the State of Washington’s elected officials continue to try to build up the Tri-Cities region, its congressional delegation continues to be as successful in obtaining federal funding for cleanup in the past, the State government maintains its strong economic research arm, and local groups continue to cooperate to build and press their agenda, there is every reason to believe (1) that a diversified regional economy can continue to be built and (2) the economy that emerges will be more resistant to economic shocks and destabilizing trends than the vast majority of other, similarly sized regions in the country.

CHAPTER 6. PROVIDING CONTEXT, SUMMARY DISCUSSION, AND FINAL OBSERVATIONS

6.1. CONTEXT FOR THE RISK REVIEW PROJECT RESULTS

Cleanup at the Hanford Site is a costly, long-term, and technically challenging mission that began in 1989. Major parts of the remaining cleanup effort include extensive nuclear waste inventories in tanks and other forms; heavily contaminated formerly used nuclear materials processing facilities; and near-surface, vadose zone, and groundwater contamination. It is anticipated that more than $100 billion will be spent on cleanup during the next 50 years. While earlier studies have evaluated portions of the Hanford Site and some receptors, a comprehensive, site-wide review of the risks to human health and resources from contamination, waste management, and cleanup activities has never occurred until this Risk Review Project.

The Risk Review Project has focused on anticipated cleanup work remaining to be completed as of October 2015. An interim progress report completed in September 2015 presented the results of the first set of 25 of the 64 EUs identified to be assessed as part of the Risk Review Project. Evaluations included all nine of the EUs for tank waste and farms, and all five of the EUs for groundwater plumes, but only three of nine major facilities for decommissioning and final disposition, 4 of 22 legacy source sites (former near-surface disposal areas), and 4 of 17 operating facilities supporting the cleanup mission. This final report presents the results of the remaining EUs identified to be assessed under the Risk Review Project and also provides final observations that emerged during the projects' execution.

The Risk Review Project is not intended to substitute for or preempt any requirement imposed under applicable federal or state laws or treaties. As important, the Risk Review Project is not intended to make or replace any decisions made under the Tri-Party Agreement and/or 2010 Consent Order, or amendments. Furthermore, the Risk Review Project is neither a CERCLA risk assessment nor a Natural Resources Damage Assessment evaluation. The Risk Review Project is not intended to interpret treaty rights that exist between the United States and Native American Tribes.

6.2. SUMMARY OF KEY ASSUMPTIONS AND RESULTS

The Risk Review Project has relied primarily on previously obtained primary data, safety analyses, risk analyses, environmental impact assessments, remedial investigations, and similar information sources. Tens of thousands of pages of information and even more data have been reviewed and integrated to form the basis for this report. The methodology used reflects input from state and federal regulatory agencies, Tribal Nations, non-governmental agencies, the public, and independent experts (CRESP 2015b). Still, important uncertainties and data gaps remain that require assumptions to carry out the project. The major general assumptions that have been used to guide the Risk Review Project are as follows:

1. The existing data and uncertainties regarding radionuclide and contaminant inventories, physical-chemical forms, and distribution of existing environmental contamination, as well as future events, allow for rough order of magnitude differentiation across EUs between radionuclide and chemical hazards (e.g., contained in engineered systems), existing environmental contamination, and potential impacts and risks to receptors.
2. Three evaluation periods have been selected, with assumed time frames to facilitate the Project's evaluation: active cleanup (50 years or until 2064), including during the current status

and during cleanup actions, and recognizing that all cleanup may not be completed within this period; near-term post-cleanup (100 years post-cleanup or 2064 to 2164); and long-term post-cleanup (1,000 years post-cleanup or 2164 to 3064, although impacts projected to occur beyond this time frame are also noted when indicated from prior studies).

3. Screening thresholds for groundwater and the Columbia River have been selected based on existing risk-informed regulatory criteria that reflect water quality associated with designated highest beneficial uses (e.g., drinking water quality for groundwater and ecological protection for the Columbia River).
4. Institutional controls are assumed to be effective for the duration of federal control of designated land areas and the EUs contained therein. Furthermore, institutional controls are assumed only to be effective for 100 years after the transfer of land areas from federal to non-federal control. Some areas of the Hanford Site are currently planned to be under federal control for very long periods (e.g., greater than 300 years for permitted disposal areas in the Central Plateau). Periods of planned federal control may change over time in response to changes in public policy or other decisions. Changes in assumptions of institutional controls may necessitate changes in the end-states of an EU (i.e., changes in final barriers or physical-chemical forms or amounts of remaining contaminants) and cannot be predicted. Failure of barriers or institutional controls may result in higher exposure, which may in the future require additional cleanup of residual contamination.

SUMMARY RESULTS

Current risks and impacts to the public are considered extremely unlikely. Public access to the Hanford Site is prohibited except under very limited circumstances, such as tours, which do not include contaminated areas or areas undergoing active cleanup.

Contaminated groundwater also is not considered a current threat to human health because groundwater is not being withdrawn for use or consumption. Ecological threats from groundwater contamination in the vicinity of the Columbia River are undergoing active remediation. Current groundwater remedies should be reevaluated to determine if they are efficiently resulting in risk reduction.

The only current risk to the public is from atmospheric dispersion of radioactive contaminants that may be released during a major fire or external event such as a severe earthquake. However, the probability of a contaminant release occurring that would threaten the public is remote. There are two reasons for this and both must apply. First, any risks to the public from airborne contaminants may occur **only** from facilities having large amounts of dispersible radioactive contaminants. Second, the risks would be realized **only** when the fire or event is so extreme that the extensive and monitored controls put in place to prevent the contaminant from becoming airborne or to contain the extent of the contamination found traveling the large distances to public areas, do not mitigate the risk. In the Plutonium Uranium Extraction Plant (PUREX) tunnels example, the risk to the public would be from a tunnel collapse accompanied by fire.[146] A fire may then lead to the widespread dispersal of radioactive contaminants in the air.

[146] Fortunately, the partial collapse of PUREX Tunnel # 1 that occurred in May 2017 did not result in radioactive contaminant dispersion, although the risks of tunnel collapse and concurrent fire were identified in the Risk Review Interim Progress Report (2015a). As of August 2018, PUREX Tunnel #1 has been stabilized with grout and planning is in progress to stabilize PUREX Tunnel #2 with grout.

Risks from different types and forms of contamination have the potential to be realized at very different time scales. Contamination releases associated with stored wastes or contamination in facilities that are subject to seismic events, fires, collapse or loss of active engineered controls (e.g., active ventilation to prevent hydrogen accumulation, or active cooling pools to maintain temperature and avoid air contact), albeit low probability, have the potential at unpredictable times to result in rapid dispersion of contamination requiring urgent responses if postulated initiating events occur and/or there is a loss of engineering controls. Examples include the Plutonium Uranium Extraction Plant (PUREX) waste storage tunnels B-complex ventilation ducts, cesium and strontium capsule storage, double shell waste tanks requiring active ventilation, etc. In contrast, most buried wastes do not have potential to cause significant impacts for decades or longer if not disturbed by remediation activities (whereby the remediation activities themselves often pose the greatest risks), and migration of remaining contamination from the vadose zone to groundwater and from groundwater to the Columbia River in most locations present risks that may be realized slowly over many decades to centuries. For example, under current and projected hydrologic conditions, release of contaminants currently present in tanks in the Central Plateau would take decades to centuries to reach groundwater, and then additional decades to centuries to reach the Columbia River.

Despite the breadth of information considered, important uncertainties and data gaps remain that required assumptions to be made in order to execute the Risk Review Project. These uncertainties encompass many issues surrounding cleanup, including: (1) the need to stagger projects to avoid workforce disruptions that may lead to additional worker training and infrastructure maintenance; (2) whether funding is sufficient to complete a cleanup project once started; and (3) the flexibility and readiness of the workforce to shift from one project to another as projects are completed, funding becomes available or priorities change. Maintaining a robust, transparent, and ongoing dialogue with the public, other stakeholders, Tribal Nations, and regulators is a key to clarifying and communicating uncertainties as they emerge during cleanup.

Major results of the Risk Review Project evaluations follow.

Tank Wastes

Wastes from defense material production accumulated in single shell and double shell tanks ("tank wastes") represent collectively the largest inventory of radioactivity at the Hanford site. Treating the tank waste is important for reducing the long-term risk to people and the environment, but the radionuclide inventory is not what drives the urgency. What drives the urgency are two attributes of the waste that remain in some tanks – (i) the potential for hydrogen accumulation in the event of loss of active ventilation (leading to fire or deflagration), and (ii) content of key radionuclides (technetium-99 and iodine-129) that are mobile in the subsurface and could contaminate large quantities of groundwater, which is a protected natural resource. Risks from hydrogen accumulation and to groundwater have been to a large extent mitigated by engineering measures, but nevertheless remain. Mitigation measures include redundancy in tank active ventilation systems to meet necessary DOE safety requirements and removal of pumpable liquids (supernatant and drainable liquids that are most likely to leak) from 147 of the 149 single shell tanks to minimize the potential for further leakage. Over the longer term, uncertainty about tank integrity and the need to safely and permanently dispose of the tank wastes drives the mission for waste retrieval, treatment, and disposal. During waste retrieval and processing, potential exposure to waste vapors and accidents are worker risk concerns.

The diverse set of chemical processes used at Hanford to produce defense nuclear materials and the extensive transfer and recovery processes for specific radionuclides (e.g., cesium-137 and strontium-90) carried out on tank wastes has resulted in a wide range of different radionuclide and chemical compositions, as well as physical characteristics, of waste contained in each tank. Thus, diversity in the properties of waste in tanks makes it potentially much more efficient to consider each tank or tank farm individually, rather than considering all tank wastes as a single collective problem with uniform urgency, retrieval, and treatment approaches.

Relative urgency for treating certain tank wastes with respect to potential for hydrogen accumulation can be evaluated based on the time to reach 25 percent of the lower flammability limit (a safety threshold) if a loss of ventilation occurs (Figure 6-1). At the time of preparation of this report, three tanks would reach 25% of the lower flammability limit within 14 days and an additional 13 tanks would reach this safety threshold within 30 days. All of these tanks are double shell tanks within the 200 East Area. Ten additional tanks would reach 25% of the lower flammability limit within 180 days, including one double shell tank (SY-103) and one single shell tank (T-201) in the 200-West Area. In addition, at the time of the preparation of this report retrieval of waste from tank AY-102 had not been completed.

Urgency for treating certain tank wastes with respect to potential for groundwater contamination can be evaluated based on the amount of groundwater that could potentially be contaminated by the technetium-99 and iodine-129 content in a tank should all of these two radionuclides become dispersed in groundwater (referred to as the groundwater threat metric (GTM), in millions of cubic meters, Mm^3, of groundwater). The greatest GTM is associated with the double shell tanks located in the 200 East Area (Figure 6-2). In addition, wastes in 40 single shell tanks are included in the set of both single shell and double shell tanks containing wastes that account for 90 percent of the total GTM from all tank wastes (Figure 6-3). Current focus on treating Low Activity Waste (LAW) is consistent with addressing the groundwater threat to Technetium (Tc-99) and Iodine (I-129) because both of these radionuclides are present predominately in the LAW fraction of tank waste. Thus, both the potential for hydrogen accumulation and the threat to groundwater emphasize the urgency of retrieval and treatment of wastes from 66 of the 177 single shell and double shell tanks (Figure 6-3). In addition, waste in only 55 single shell tanks (including 15 assumed leakers) comprises 90 percent of the groundwater threat metric posed by all the single shell tanks.

Groundwater Threat Metric (GTM)

GTM was developed as part of the risk review project and allows for comparison of threats to groundwater from different sources of potential contamination (e.g., tank wastes, contaminated soils, buried wastes).

GTM is the maximum volume of water that could be contaminated by the source amount of the primary contaminant if that contaminant was present in the groundwater at the water quality standard.

The extent of waste retrieval from each tank is also an important consideration for achieving risk reduction. Retrieving the same fraction of waste from 55 of the single shell tanks achieves much greater risk reduction with respect to groundwater threat than retrieving the same fraction of waste from the remaining single shell tanks. For example, retrieving 90 percent of the waste from the indicated 55 single shell tanks reduces groundwater threat by 81 percent, while the same extent of retrieval from the remaining single shell tanks only achieves an additional 8 percent reduction in groundwater threat.

Further factors that play a role in the residual risk from waste remaining in a tank after retrieval include: (i) the potential for remaining contaminants to migrate from the closed tank to groundwater, and (ii) the extent of contamination within the specific tank farm already in the vadose zone external to tanks. Currently, tank closure by filling with grout, remaining tank integrity, and final closure covers over a tank farm are not fully accounted for in assessments with respect to reducing or preventing radionuclides and other contaminants remaining in tanks after retrieval from impacting groundwater. Figure 6-4 compares by tank farm the groundwater threat from technetium-99 and iodine-129 contamination currently in tanks to the groundwater threat from the same contaminants currently in the co-located vadose zone. For example, retrieval of less than 90 percent of the waste would be needed from tanks in the T, TX-TY, and B-BX-BY tank farms to reduce the threat from residuals remaining in the tanks to less than the threat from contamination in the adjacent vadose zone.

A more risk informed approach to tank waste retrieval and treatment may result in more rapid retrieval and risk reduction, including by reducing the risks to workers from accidents and vapors.

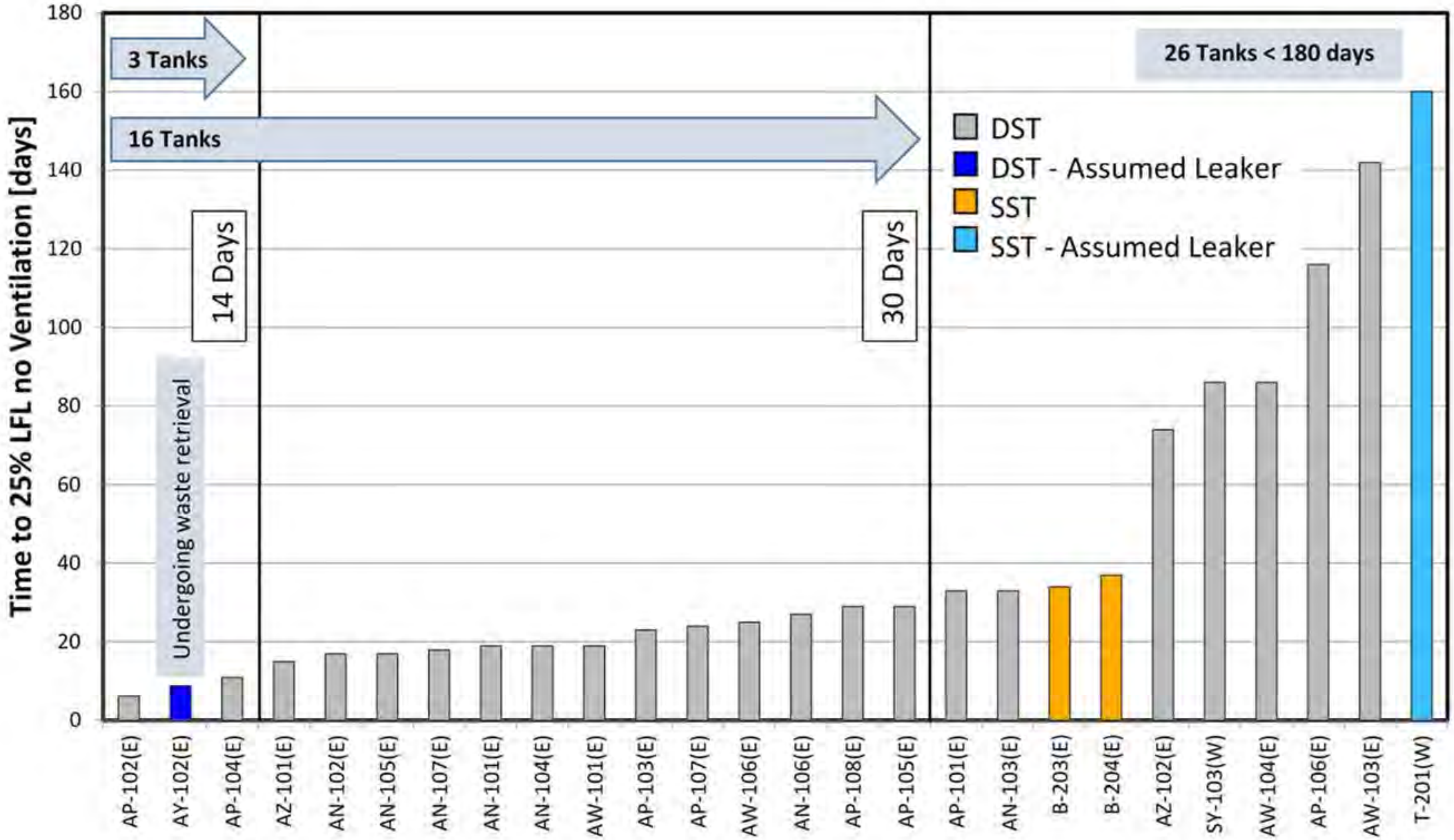

Figure 6-1. Current conditions: Time to 25% LFL for tanks with less than 6 months assuming loss of controls leads to no ventilation (after RPP-5926, Rev. 17). The location (E = 200 East and W = 200 West) is provided after each tank name.

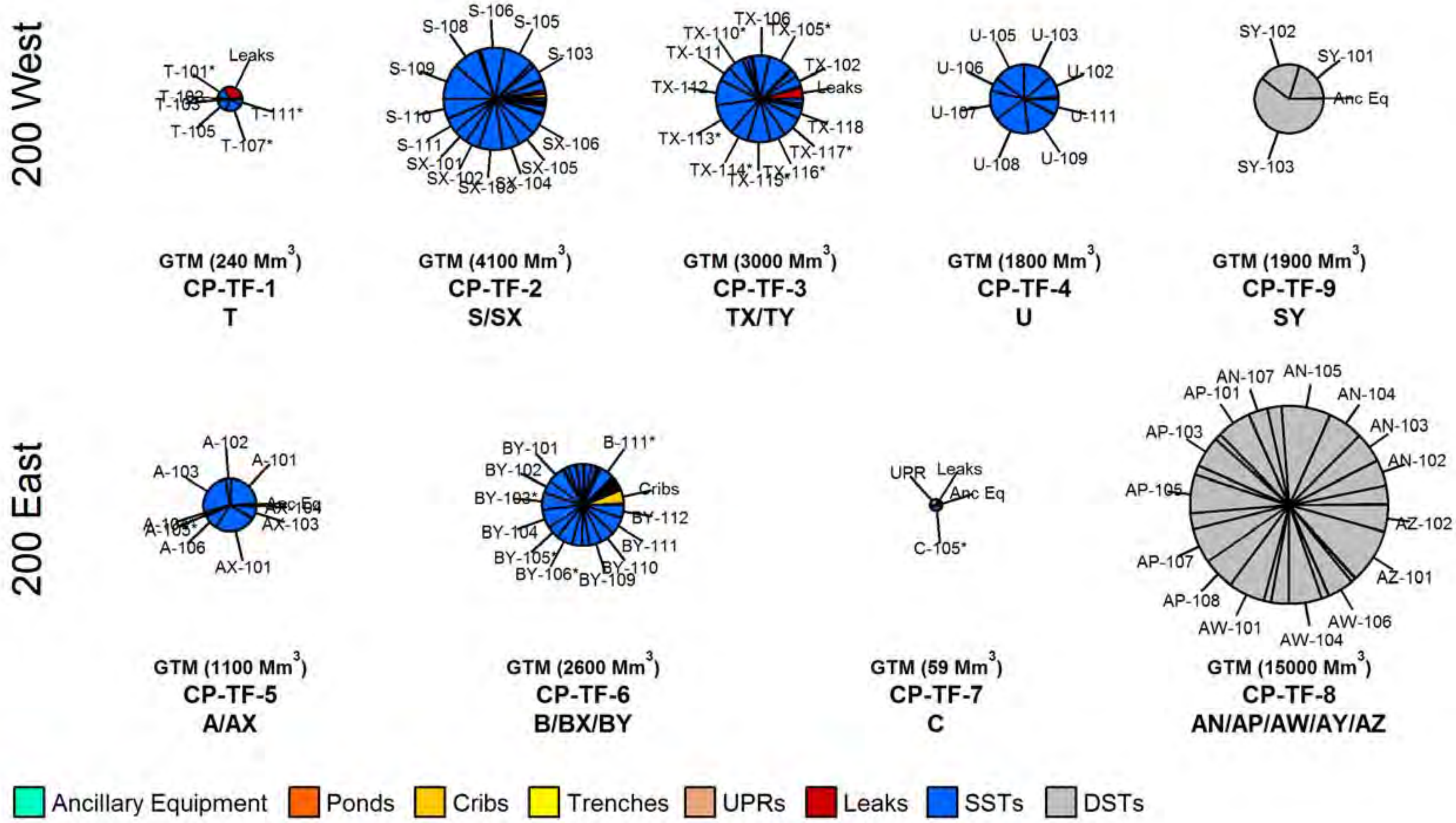

Figure 6-2. Groundwater threat metric (GTM) based on the maximum GTM between I-129 and Tc-99. The GTM distribution between waste within tanks and existing environmental contamination from past disposal practices (i.e., discharges to cribs and trenches), leaks, and UPRs. The relative GTM within each EU is scaled by relative area for each pie. Asterisk (*) indicates an assumed leaker tank.

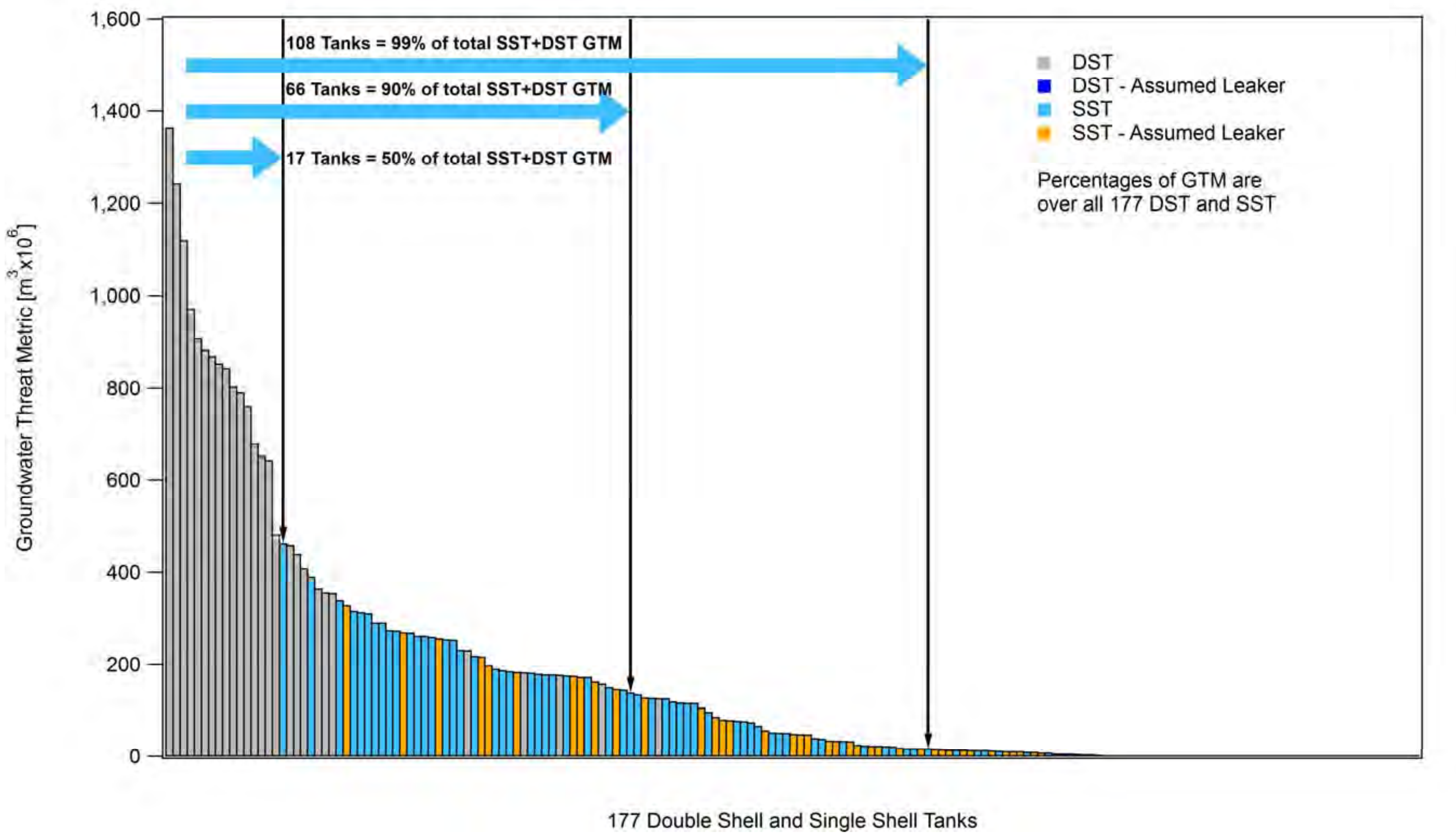

Figure 6-3. Groundwater threat: Which tanks are important? Comparison of the groundwater threat metric (GTM) within double shell tanks (DSTs) and single shell tanks (SSTs) by individual tank.

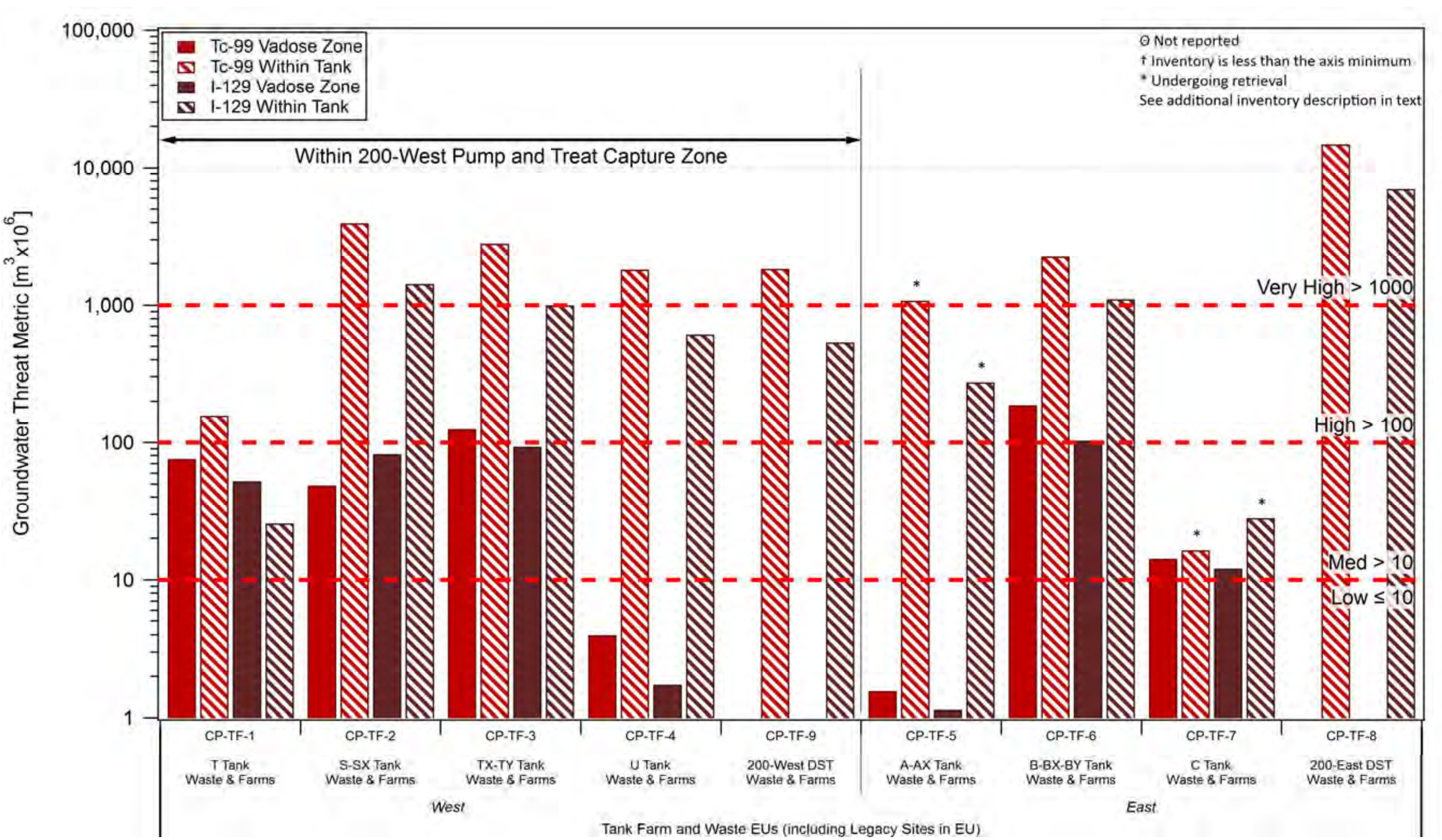

Figure 6-4. Comparison of the GTM (Mm^3) from existing contamination in the vadose zone to the GTM associated with the inventories in each tank waste and farms EU.

Highest Risks During the Current Evaluation Period

Two summary tables (Table 6-1 and Table 6-2) are provided showing the receptors considered to be at high or very high risk for the current time period. If the rating was medium, low, or not discernible, those results are not provided in the summary tables. Included in both tables are a list of primary contaminants that are present, the reasons for the ratings (risk drivers), and mitigation measures.

The current highest rated risks *to human health (Facility Workers and Co-located Persons)* are from (1) loss of nuclear safety controls from major natural hazards (seismic events, volcanic ashfall, or wildfire) or major external events (prolonged loss of power or water) until the source of the risk has been removed or permanently contained; (2) operational accidents (including facility fires). For workers, ratings are provided in Table 6-1 showing the evaluation units in which workers were rated high during the current time period. Risks to workers are based on the unmitigated dose estimates captured in DOE documentation for certain events or conditions (e.g., explosions, fires, earthquakes, structural failures). In some cases, high risks extend to people located outside the facility boundary but on the Hanford Site (i.e., co-located persons). Table 6-1 also highlights the evaluation units where risks to co-located persons were rated as high.

The current risks rated high or very high to groundwater, the Columbia River, and ecological receptors (i.e., as protected resources[147]) are from existing groundwater contaminant plumes (that could spread in the future) and from migration of contaminants from some legacy surface disposal sites and the vadose zone (e.g., secondary sources including unplanned releases of contaminants from engineered facilities (e.g., waste tanks)). Current significant threats to the Columbia River from contaminants in the River Corridor are being treated, and significant threats from groundwater contaminants to the Columbia River from the Central Plateau are either being treated or would not be realized for a long time and only be realized if they are not treated during the active cleanup period. Table 6-2 shows which protected resources (groundwater, Columbia River, and ecological) had high or very high ratings during the current time period when the methodology developed for that receptor was applied.

Summary tables showing high or very high rating also have been developed for two other time periods: Active Cleanup (to 2064) (Table 6-3) and Near-term Post-cleanup (to 2164) (Table 6-4). The drivers for the ratings of high or very high are provided as table notes.

[147] These ratings reflect threats to groundwater and the Columbia River as protected resources and not human or ecological risks related to direct use of these resources.

Table 6-1. Human Resource Receptors (Facility Workers and Co-located Persons) with High, Unmitigated Rating for Current Evaluation Time Period. All Current, Mitigated Ratings are Not Discernible, Low, or Insufficient Information to Rate.

Evaluation Unit	Location	Receptor(s)	Contamination Source(s) or Risk	Reasons for Rating (Risk Drivers)	Mitigation
D4 (See Appendix F for completed templates of Evaluation Units)					
Building 324 (RC-DD-1)	River Corridor	Facility Worker[(a)]	Cesium-137, Plutonium-239, Plutonium-240, Strontium-90, and Americium-241	Seismic event (earthquake) releasing hot cell contaminants and potential for building collapse.	Removal of contamination and contaminated materials, surveillance and maintenance programs, and DOE emergency preparedness program.
Fast Flux Test Facility (FFTF) (RC-DD-4)	River Corridor	Facility Worker	Argon (inert atmosphere)	Release of argon into personnel space, thus causing an oxygen deficient work area.	Argon supply piping structure is identified as defense-in-depth equipment important to safety.
PUREX Plant (CP-DD-1)	Central Plateau	Facility Worker and Co-located Person[(b)]	Cesium-137, Plutonium-238, Plutonium-239, Plutonium-240, Plutonium-241, Plutonium-242, Strontium-90, and Americium-241	(1) Seismic (earthquake) or other event causing structural failure in 202-A canyon and/or storage tunnels, or (2) fire in Storage Tunnel #1.	(1) Safety management and emergency response programs; (2) Storage tunnel is isolated with no access.
B Plant (CP-DD-2)	Central Plateau	Facility Worker and Co-located Person	Cesium-137, Plutonium-238, Plutonium-239, Plutonium-240, Plutonium-241, Plutonium-242, and Strontium-90	Seismic event causing collapse of both 221-B and 224-B canyon buildings.	Safety management and emergency response programs
REDOX Plant (CP-DD-4)	Central Plateau	Facility Worker and Co-located Person	Cesium-137, Plutonium-239, Plutonium-240, and Strontium-90	Seismic event causing total failure of the 202-S Canyon Building structure with ground release of material.	Safety management and emergency response programs
Plutonium Finishing Plant (PFP) (CP-DD-5)	Central Plateau	Facility Worker and Co-located Person	Plutonium-238, Plutonium-239, Plutonium-240, Plutonium-241, Plutonium-242, Americium-241, and Cesium-137	(1) Seismic event or airplane crash, (2) first floor fire involving contaminated equipment in 234-5Z building, (3) contaminated internal equipment explosion in either 242-Z building or 234-5Z building, or (4) accident causing contaminated equipment drop in either 242-Z building or 234-5Z building.	(1) Safety management and emergency response programs; (2) Safety management, confinement and fire sprinkler flow alarm; (3) Safety management and confinement; (4) Safety management and confinement.

Evaluation Unit	Location	Receptor(s)	Contamination Source(s) or Risk	Reasons for Rating (Risk Drivers)	Mitigation
Tank Waste & Farms (See Appendix E for completed templates of Evaluation Units)					
T (CP-TF-1) S-SX (CP-TF-2) TX-TY (CP-TF-3) U (CP-TF-4) A-AX (CP-TF-5) B-BX-BY (CP-TF-6) C (CP-TF-7) AN-AP-AW-AY-AZ (CP-TF-8) SY (CP-TF-9)	Central Plateau	Facility Worker	Tank waste contaminants (e.g., Cesium-137 and Strontium-90) and vapors from tanks	(1) Flammable gas deflagrations in vessels/containers, including single-shell tanks, (2) waste transfer leaks, (3) releases from contaminated facilities from fires, load handling accidents, or compressed gas system failures, (4) industrial accidents (e.g., heat stress, slips, trips, & falls), and (5) radiation and vapors from tank leaks and contaminated soil.	(1) safety-significant structures, systems & components (ventilation and piping systems); Specific Administrative Controls; & Limiting Conditions for Operations, (2-3) safety-significant structures, systems & components (piping & transfer line systems; isolation valves); Specific Administrative Controls; & Limiting Conditions for Operations (4) monitoring & controlling for environmental hazards, (5) radiological control program and sealing materials & barriers used to control spread of contamination.
Operating Facilities (See Appendix H for completed templates of Evaluation Units)					
Central Waste Complex (CWC) (CP-OP-1)	Central Plateau	Facility Worker and Co-located Person	Radioactive material and toxic chemicals	(1) Fires and (2) seismic building collapse	*Active:* Fire Protection and fire suppression systems; *Passive*: Storage container, Secondary Containment, Epoxy resin floor coating, Building stabilization and grading; Administrative: Vehicle Controls, Container Management and Venting Program, Waste Acceptance Criteria, Source Strength Controls, and Emergency Response.
T Plant (CP-OP-2)	Central Plateau	Facility Worker and Co-located Person	Radioactive materials and hazardous chemicals, including corrosive, reactive, and toxic materials.	Small inside fires (impacting a single container), T Plant Perma-con fire (inside Building 221-T involving waste being packaged), and large fires (impacting 8 drums and confinement structure).	Fire suppression systems, Building-active ventilation systems, including associated exhaust HEPA filters, Building Structure, Container Vents

Evaluation Unit	Location	Receptor(s)	Contamination Source(s) or Risk	Reasons for Rating (Risk Drivers)	Mitigation
Waste Encapsulation and Storage Facility (WESF) (CP-OP-3)	Central Plateau	Facility Worker and Co-located Person	Cesium-137 and Strontium-90	(1) Loss of Pool Cell Water Event, (2) Hydrogen Explosion in Hot Cell G and K3 Duct, and (3) Earthquake with Releases from Hot Cells, Ventilation Ductwork, and HEPA filters.	(1) Defense-in-depth strategies (configuration management), Technical Safety Requirements (radiation monitoring); (2) Active Safety Controls (backup power for ventilation systems) and Specific Administrative Controls (e.g., maximum cesium capsule inventory); (3) passive structures, systems & components (e.g., building components including hot cells and canyon); operational controls including maximum capsule inventory.
Waste Receiving and Processing Facility (WRAP) (CP-OP-4)	Central Plateau	Facility Worker and Co-located Person	Radioactive materials (Plutonium-239)	(1) Large fires (involving 8 drums resulting in breach of confinement structure) and small inside fires (impacting a single container) and (2) criticality.	(1) Fire suppression systems, Building active ventilation systems, including associated exhaust HEPA filters, Building Structure, Container Vents; (2) limited curbing height, minimal slope floor, Building height and obstructions limit stacking height, criticality safety program.
Canister Storage Building (CSB) (CP-OP-5)	Central Plateau	Facility Worker and Co-located Person	Radioactive materials from spent fuel (including various isotopes of Plutonium and Uranium, Cesium-137, Strontium-90)	(1) Internal hydrogen deflagration of multi-canister overpack, (2) mechanical damage of multi-canister overpack, and (3) fires.	Active technical safety requirements (handling machine and confinement systems), administrative controls (Nuclear Criticality Safety, Combustible Loading Limits, etc.) and specific administrative controls (Operational Controls, Intermediate Impact Absorbers, etc.). There are also multiple passive safety class (e.g., subsurface structures, storage tubes and assemblies) and safety significant features (e.g., tube plugs, structural components) and a defense-in-depth strategy.

Evaluation Unit	Location	Receptor(s)	Contamination Source(s) or Risk	Reasons for Rating (Risk Drivers)	Mitigation
Mixed Waste Trenches (CP-OP-8)	Central Plateau	Facility Worker and Co-located Person	Radioactive material (e.g., Plutonium-238) and toxic chemicals	(1) Spills from Pu-238 drums breached during excavation, (2) criticality resulting in radiation exposure or release of materials (solid, liquid, radioactive, chemical), (3) natural phenomenon hazard (earthquake) resulting in the release of radioactive materials, and (4) standard industrial hazards (e.g., exposure of worker to hazardous material from operator error or failure)	(1) *Engineered*: container design; *Administrative*: Container Management, Hoisting & Rigging, Emergency Protection Plan, Source Strength Control, Vehicle Access, (2) *Administrative*: Criticality Safety, Container Management, Emergency Response Plan, Source Strength Control, Radiation protection; (3) *Engineered*: Container Bands / Straps; Container Design; Overburden; Standard Waste Box Design; Tie Downs; *Administrative*: Container Management, Emergency Response Plan, Source Strength Control; (4) *Administrative:* Work Planning process, Conduct of Operations, Fire Protection, etc.
242-A Evaporator (CP-OP-10)	Central Plateau	Facility Worker and Co-located Person	Radioactive and hazardous materials and prompt fatality or serious injury	(1) Flammable gas accidents and (2) waste leaks and misroutes	Work control, fire protection, training, occupational safety and industrial hygiene, emergency preparedness and response, and management and organization—which are fully integrated with nuclear safety and radiological protection.
222-S Laboratory (CP-OP-16)	Central Plateau	Facility Worker	Prompt fatality or serious injury	Building-wide fire causing part of the structure to collapse with falling debris	Fire protection and emergency preparedness and response.

a. Facility worker – any worker or individual within the facility (or within the activity geographic boundary as established for the DSA) and located less than 100 m from the potential contaminant release point. (See Terminology and Definitions section for additional details.)

b. Co-located Person – a hypothetical onsite individual (who may be a site worker not associated with the specific facility or activity, or may be a site visitor) located at a point equal to 100 m from the boundary of the facility (or activity or from the point of potential contaminant release), or beyond 100 m from the point at which maximum dose hypothetically occurs. or from the point of potential contaminant release). If the release is elevated (e.g., airborne), the person is assumed to be at the location of greatest dose, which is typically where the plume touches down. (See Terminology and Definitions section for additional details.)

Table 6-2. Protected Resource Receptors (Groundwater, Columbia River, and Ecological Resources) with High or Very High Rating for the Current Evaluation Time Period (Humans not considered at risk because groundwater is not available for use).

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
Legacy Sources **(See Appendix G for completed templates of Evaluation Units)**					
BC Cribs & Trenches (CP-LS-1)	Central Plateau (200 East)	Groundwater	**Radionuclides:** **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water) **Technetium-99 (Tc-99)** Half-life is very long (persistent); Very mobile (moves with water) **Hazardous Chemicals:** **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory that could impact groundwater; interim actions (soil removal) not sufficient to remove enough contamination to adequately reduce risk.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans; no plumes are being treated; and no final remedial decisions have been made involving treating vadose zone contamination.
Pu (Plutonium) Contaminated (CP-LS-2)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water)	Residual vadose zone inventory that could impact groundwater; current remedial action (pump & treat) effective for groundwater but does not address vadose zone contamination.	200 West Pump & Treat Facility is effectively treating contaminated groundwater; selected remedial actions will remove contaminated soil and reduce vadose zone source.
U Plant Cribs and Ditches (CP-LS-3)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** **Total Uranium (U)** Half-life is very long (persistent)[a]; Somewhat mobile (tied up in soil)	Residual vadose zone inventory; pump & treat used to treat uranium in groundwater but does not address existing vadose zone contamination.	Uranium in groundwater being treated using the U Plant area Pump & Treat system; soil cover is being maintained while alternatives are being considered to treat vadose zone.
REDOX Cribs and Ditches (CP-LS-4)	Central Plateau (200 West)	Groundwater	**Radionuclides:** **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water)	Residual vadose zone inventory; final action (pump & treat) for groundwater not effective for I-129; I-129 plume hydraulic control system active but not yet demonstrated effective; current treatment does not address vadose zone contamination.	I-129 plume hydraulic control system is active while alternatives for treating I-129 are being considered; soil cover is being maintained while alternatives are being considered to treat vadose zone, if necessary.

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
U and S Pond (CP-LS-5)[(b)]	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water) **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; final action (pump & treat) for groundwater effective but does not treat vadose zone contamination.	200 West Pump & Treat Facility is effectively treating contaminated groundwater; preferred actions have been defined to treat selected vadose zone areas.
T Plant Cribs and Trenches (CP-LS-6)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** **Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; final action (pump & treat) for groundwater effective but does not address vadose zone contamination.	200 West Pump & Treat Facility is effectively treating contaminated groundwater; soil cover is being maintained while alternatives are being considered to treat vadose zone, if necessary.
B Plant Cribs and Trenches (CP-LS-8)	Central Plateau (200 East)	Groundwater	**Radionuclides:** **Strontium-90 (Sr-90)** Half-life relatively short (not very persistent); Limited mobility (tied up in soil) **Hazardous Chemicals:** **Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim actions have been taken and no final remedial decisions have been made involving treating vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.
PUREX Cribs and Trenches (CP-LS-9)	Central Plateau (200 East)	Groundwater	**Radionuclides:** **Strontium-90 (Sr-90)** Half-life relatively short (not very persistent); Limited mobility (tied up in soil) **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim actions have been taken and no final remedial decisions have been made involving treating vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.
PUREX and Tank Farm Cribs and Trenches (Outside 200-East) (CP-LS-10)	Central Plateau (200 East)	Groundwater	**Hazardous Chemicals:** **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim actions have been taken and no final remedial decisions have been made involving treating vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
B Pond (CP-LS-11)[(b)]	Central Plateau (200 East)	Groundwater	**Radionuclides:** **Strontium-90 (Sr-90)** Half-life relatively short (not very persistent); Limited mobility (tied up in soil) **Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water)	Residual vadose zone inventory; preferred actions have been selected to treat some vadose zone areas in future.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans; preferred actions defined to treat selected vadose zone areas.
200-West Burial Ground (CP-LS-12)	Central Plateau (200 West)	Groundwater	**Radionuclides:** **Carbon-14 (C-14)** Half-life is long (persistent); Very mobile (moves with water) **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water) **Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water) **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; final action (pump & treat) effective for groundwater but does not address vadose zone contamination; no actions have been taken to address vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.
200-East Burial Grounds (CP-LS-14)	Central Plateau (200 East)	Groundwater	**Hazardous Chemicals:** **Total and *Hexavalent* Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim actions have been taken and no final remedial decisions have been made involving treating vadose zone contamination.	Existing soil covers are maintained to provide protection from intrusion by biological receptors and humans.
Tank Waste & Farms (See Appendix E for completed templates of Evaluation Units)					
T (CP-TF-1)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** **Total and *Hexavalent* Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory (not including tank waste); remedial actions (e.g., interim stabilization where pumpable liquids were transferred to double shell tanks) have not addressed vadose zone contamination.	Pumpable liquids in single shell tanks transferred to double shell tanks. A partial cover was emplaced over areas in and around the 241-T tank farms to limit water intrusion into areas contaminated with tank wastes (from leaks).

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
S-SX (CP-TF-2)	Central Plateau (200 West)	Groundwater	**Hazardous Chemicals:** **Total and *Hexavalent* Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory (not including tank waste); remedial actions (e.g., interim stabilization where pumpable liquids were transferred to double shell tanks) have not addressed vadose zone contamination.	Pumpable liquids in the 241-S-SX single shell tanks were transferred to double shell tanks. Groundwater extraction system is in operation to remove contaminants.
TX-TY (CP-TF-3)	Central Plateau (200 West)	Groundwater	**Radionuclide:** **Iodine-129 (I-129)** Half-life is very long (persistent); Very mobile (moves with water) **Hazardous Chemicals:** **Carbon Tetrachloride (CCl_4)** Little biological breakdown (persistent); Very mobile (moves with water) **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory (not including tank waste); remedial actions (e.g., interim stabilization where pumpable liquids were transferred to double shell tanks) have not addressed vadose zone contamination.	Pumpable liquids in the 241-TX-TY single shell tanks were transferred to double shell tanks.
B-BX-BY (CP-TF-6)	Central Plateau (200 East)	Groundwater	**Radionuclide:** **Technetium-99 (Tc-99)** Half-life is very long (persistent); Very mobile (moves with water) **Hazardous Chemicals:** **Total and Hexavalent Chromium (Cr)** No decay (persistent); Very mobile (moves with water)	Residual vadose zone inventory (not including tank waste); remedial actions (e.g., interim stabilization where pumpable liquids were transferred to double shell tanks) have not addressed vadose zone contamination.	Pumpable liquids in the 241-B-BX-BY single shell tanks were transferred to double shell tanks.
Groundwater (See Appendix D for completed templates of Evaluation Units)					
300 Area GW Plumes (RC-GW-1)	River Corridor (300 Area)	Columbia River	**BENTHIC and RIPARIAN ZONES:**[c] **Hazardous Chemicals:** **Total Uranium (U)** Half-life is very long (persistent)[a]; Somewhat mobile (tied up in soil)	Ratio of maximum concentration and ratio of upper 95% confidence limit to the value used to identify areas contaminated by the Hanford Site[d]; length of Columbia River shoreline and riparian zone area "impacted by uranium (i.e., above drinking water standard).	Enhanced attenuation of uranium using sequestration by phosphate application at the top of aquifer; groundwater monitoring; institutional controls.
100-B/D/H//F/K Area GW Plumes (RC-GW-3)	River Corridor (100 Areas)	Ecological	Low to *Very High*	Degree of physical disruption (and potential additional exposure to contaminants).	None identified.

Evaluation Unit	Location	Receptor(s) Affected	Source(s) of Contamination	Reason(s) for Rating (Risk Drivers)	Contamination Mitigation
200 East Plumes (CP-GW-1)	Central Plateau (200 East)	Groundwater	**200-BP Interest Area Radionuclides:** **Strontium-90 (Sr-90)** Half-life relatively short (not very persistent); Limited mobility (tied up in soil) **200-PO Interest Area Radionuclides:** ***Iodine-129* (I-129)** Half-life is very long (persistent); Very mobile (moves with water)	Residual vadose zone inventory; no interim or final actions have been taken to treat groundwater and no remedial decisions have been made involving treating vadose zone contamination that could contribute to additional groundwater contamination.	For 200-BP, an ongoing perched water treatability test is being conducted at WMA B-BX-BY to remove uranium and tank wastes are being retrieved from 241-C Tank Farm. Monitoring is taking place in 200-PO.
200 West Plumes (CP-GW-2)	Central Plateau (200 West)	Groundwater	**200-ZP Interest Area Hazardous Chemicals:** ***Carbon Tetrachloride (CCl_4)*** Little biological breakdown (persistent); Very mobile (moves with water)	Area of plume (that also corresponds to plume volume); final action (pump & treat) for groundwater effective but requires more time to adequately address contamination.	Final remediation decision (pump & treat) has been shown effective at treating groundwater contamination.

a. The risk to humans and biota from uranium is generally driven by its chemical toxicity not its radioactivity; the uranium isotopes considered in this Report are very long-lived.

b. Due to similarities between the Evaluation Units, the U and S Ponds (200 West) and B Pond (200 East) were evaluated together in Appendix G.6.

c. The drinking water standard is used to define both the shoreline and riparian zones impacted (i.e., impacts to biota). The total uranium plume does not present a High or Very High risk to groundwater as a protected resource. However, modeling suggests that the uranium concentration will fall below the drinking water standard before the beginning of the Active Cleanup period.

d. Note that there is a large uncertainty relative to the No Effects level for total uranium. As stated in the Columbia River Component Risk Assessment, "Effect levels span nearly three orders of magnitude (3 µg/L to 900 µg/L), reflecting considerable uncertainty in selection of a no-effect concentration. The value selected [12.9 µg/L] is a probable no effect concentration and is the 5th percentile of the toxicity data set" (DOE/RL-2010-117 Rev. 0, p. 6.2).

Highest Risks During the Active Cleanup Evaluation Period (until 2064)

The risks to workers rated high during cleanup are from (1) exposure to contaminants during removal actions or operational accidents (including facility fires) to human health receptors (Facility Workers and Co-located Persons); and (2) loss of nuclear safety controls from major natural hazards (seismic events, volcanic ashfall, or wildfire) or major external events (prolonged loss of power or water) until the source risk has been removed or permanently contained.

The risks to ecological resource receptors rated high or very high during cleanup are from (1) physical disruption or introduction of invasive species, either because of insufficient planning, selected cleanup methods, or lack of a prior knowledge about ecological resource receptors, including eco-cultural resources; (2) potential exposure of radionuclides and other contaminants because of physical disruption during cleanup; and (3) loss of nuclear safety controls from major natural hazards (seismic events, volcanic ashfall, or wildfire) or major external events (prolonged loss of power or water) until the source risk has been removed or permanently contained.

The risks to groundwater (i.e., as a protected resource) rated high or very high during cleanup are from existing vadose zone contamination (e.g., secondary sources) where interim or final remedial decisions have not been made that are thought to either sufficiently remove vadose zone contamination or sufficiently reduce infiltrating water. Current significant threats to groundwater and the Columbia River from contaminants already in groundwater are being treated, and significant threats from vadose zone contamination would not be realized for a long time and only be realized if they are not treated during the active cleanup period.

Table 6-3. Active cleanup risks rated high or very high for each receptor category.
A check (✓) indicates a High or Very High rating for the marked receptor category with the risk drivers indicated parenthetically or by table note. (*) indicates template not completed for evaluation unit.

EU Name	EU #	Human Health Facility Worker	Human Health Co-located Person	Groundwater	Ecological[1]
Legacy Sources					
618-11 Burial Ground	RC-LS-1				
K Area Waste Sites	RC-LS-2			✓ (C-14)	
Orchard Lands	RC-LS-3*				
618-10 Burial Ground	RC-LS-4				✓[t]
BC Cribs & Trenches	CP-LS-1	✓[a]		✓ (I-129, Tc-99, Cr-tot, Cr-VI)	
Plutonium Contaminated Waste Sites	CP-LS-2			✓ (CCl_4)	
U Plant Cribs and Ditches	CP-LS-3	✓[a]		✓ (U-tot)	
REDOX Cribs and Ditches	CP-LS-4	✓[a]		✓ (I-129)	
U & S pond	CP-LS-5			✓ (CCl_4, Cr-tot, Cr-VI)	✓[t]
T Plant Cribs & Ditches	CP-LS-6	✓[a]		✓ (Cr-VI)	✓[t]
200 Area HLW Transfer Pipeline	CP-LS-7				✓[t]
B Plant Cribs & Trenches	CP-LS-8	✓[a]		✓ (Cr-VI)	✓[t]
PUREX Cribs and Trenches (inside 200 E)	CP-LS-9	✓[a]		✓ (I-129, Sr-90)	
PUREX & TF Cribs & Trenches (outside 200-E)	CP-LS-10			✓ (Cr-tot, Cr-VI)	✓[t]
B Pond	CP-LS-11			✓ (CCl_4, Sr-90)	✓[t]
200 West Burial Grounds	CP-LS-12			✓ (CCl_4, C-14, I-129, Cr-tot, Cr-VI)	
200-W Miscellaneous Waste Sites	CP-LS-13				✓[t]
200-E Burial Grounds	CP-LS-14			✓ (Cr-tot, Cr-VI)	✓[t]
200-E Miscellaneous Waste Sites	CP-LS-15				✓[t]
Grout Vaults	CP-LS-16				
BC Control Zone	CP-LS-17				✓[t]
Outer Area Sites	CP-LS-18				✓[t]
Tank Waste & Farms					
T	CP-TF-1	✓[u]		✓ (Cr)	
S-SX	CP-TF-2	✓[u]		✓ (Cr)	
TX-TY	CP-TF-3	✓[u]		✓ (Tc-99, CCl_4, Cr)	
U Tank Farm	CP-TF-4	✓[u]			
A-AX Tank Farms	CP-TF-5	✓[u]			
B-BX-BY	CP-TF-6	✓[u]		✓ (I-129, Tc-99, Cr)	
C Tank Farms	CP-TF-7	✓[u]			
200 East Double-Shell Tanks (DSTs)	CP-TF-8	✓[u]			

EU Name	EU #	Human Health Facility Worker	Human Health Co-located Person	Groundwater	Ecological[1]
200 West DSTs	CP-TF-9	✓(u)			
Groundwater					
300 Area GW Plumes	RC-GW-1				✓(t)
100-N GW Plume	RC-GW-2				✓(t)
100-B/D/H/F/K Area GW Plumes	RC-GW-3				✓(t)
200-E Groundwater	CP-GW-1			✓ (I-129)	✓(t)
200-W Groundwater	CP-GW-2			✓ (CCl_4)	
D4					
Building 324	RC-DD-1	✓ (b)	✓ (b)		
K Reactors	RC-DD-2				
Final Reactor Disposition	RC-DD-3				✓(t)
FFTF	RC-DD-4	✓ (c)			
PUREX	CP-DD-1	✓ (d)	✓ (d)		
B Plant	CP-DD-2	✓ (e)	✓(e)		
U Plant	CP-DD-3				
REDOX	CP-DD-4	✓ (f)	✓(f)		
PFP	CP-DD-5	✓ (g)	✓ (g)	✓ (CCl_4)	
Operating Facilities					
K-West Basin Sludge	RC-OP-1	✓ (h)	✓(h)		
Retained Facilities (i)	RC-OP-2				
CWC	CP-OP-1	✓ (j)	✓ (j)		
T Plant	CP-OP-2	✓ (k)	✓(k)		
WESF	CP-OP-3	✓ (l)	✓(l)		
WRAP	CP-OP-4	✓ (m)	✓ (m)		
CSB and ISA	CP-OP-5		✓ (n)		
ERDF	CP-OP-6				✓(t)
IDF	CP-OP-7				
Mixed Waste Trenches	CP-OP-8	✓ (o)	✓ (o)		
Naval Reactors Trench	CP-OP-9				
242-A Evaporator (p)	CP-OP-10	✓ (v)	✓ (v)		
ETF and LERF (q)	CP-OP-11				✓(t)
TEDF	CP-OP-12				
SALDS	CP-OP-13				
WTP (r)	CP-OP-14				✓(t)
222-S Laboratory	CP-OP-15	✓ (s)			✓(t)
ETF	CP-OP-16				
WSCF	CP-OP-17*				

a. High unmitigated risk to Facility Worker could be caused by exposure to contaminants during removal action. Mitigated risk ratings are lower.
b. High risk to Facility Worker and Co-located Person from (1) accident during transfer of contaminated soils between cells (2) hydrogen deflagration, (3) dropping of a waste disposal box causing a fire, or (4) waste handling accident in the cask-handling area.
c. High risk to the Facility Worker could be caused by the release of argon into personnel space, thus causing an oxygen deficient work area.
d. High risk to Facility Worker and Co-located Person from (1) seismic event causing structural failure of 202-A Building and/or two Storage Tunnels, or (2) fire in Storage Tunnel #1.
e. High risk to Facility Worker and Co-located Person from seismic event causing collapse of both 221-B and 224-B canyon buildings.
f. High risk to Facility Worker and Co-located Person from seismic event causing total failure of 202-S canyon building.
g. High risk to Facility Worker and Co-located Person from (1) seismic event or airplane crash, (2) first floor fire involving contaminated equipment in 234-5Z building, (3) accident causing contaminated equipment drop in either 242-Z building or 234-5Z building, or (4) outdoor explosion of TRU waste drum.
h. The primary or highest risks to Co-located Persons at the K Basins during the current phase are (1) hydrogen deflagration, and (2) industrial accidents that might cause a fire.
i. Summary only provided. Evaluation was not performed of radiological inventories, ecological, cultural, or human health ratings.
j. Accident scenarios with High consequences to Co-located persons had an unlikely frequency. These included two fire scenarios (small inside fire, small outside fire) and a seismic building collapse (design basis seismic event).
k. There are several events postulated in the Documented Safety Analysis (DSA; HNF-14741-10. 2013.) that have a high impact on the Co-located Person and the Facility Worker related to a postulated fire event.
l. The primary current risk is that the safe containment of the cesium chloride and strontium fluoride within the capsules could be compromised under design basis accident and beyond design basis accident conditions if the pool cells were to lose water.
m. There is one fire event considered in the DSA that would lead to a High rating for the Facility Worker and Co-located Person.
n. There are three accident scenarios resulting in high consequence levels to the Co-located Person in the DSA due to an unintentional release of material from the waste packages stored at the CSB and ISA. The Facility Worker was not rated in the DSA and therefore not rated in the CSB and ISA EU.
o. Two accidents resulted with estimated High unmitigated impacts to Facility Workers and Co-located Persons: criticality accident or a seismic event releasing material disposed in the mixed waste trenches.
p. Summary only provided. Evaluation was not performed of radiological inventories, ecological, cultural, or human health ratings.
q. Previously, ETF and LERF were separate EUs but now have been combined into one EU.
r. Summary only provided. Evaluation was not performed of radiological inventories, ecological, cultural, or human health ratings.
s. An uncontrolled release of radioactive material could cause a prompt fatality or serious injury to a Facility Worker from falling debris caused by a collapsing part of the structure from the building-wide fire.
t. Ecological High and Very High ratings were based largely on having high-level ecological resources and remediation options that were physically disruptive.
u. There is the potential for radiological, toxicological, industrial impacts to facility workers and co-located persons from accidents during both normal operations and remedial activities (both under the preferred and other alternatives) in the Tank Farms.
v. The qualitative analysis in the 242-A Evaporator Documented Safety Analysis indicated that without mitigation there was significant potential impact to the facility worker (i.e., could result in prompt death, serious injury, or significant radiological or chemical exposure).

Highest Risks During the Near-term Post-Cleanup Evaluation Period (until 2164)

The risks rated high or very high remaining after cleanup are from potential failure of institutional or engineered controls to human health and groundwater, and ecological, including eco-cultural, resource receptors. In addition, ***safety of consumptive practices*** (such as those associated with some Tribal Nation cultural practices and some recreational activities) cannot be assured without both risk assessment and appropriate biomonitoring. For **threats to groundwater (as a protected resource)** ***remaining after cleanup***, ratings reflect where remedial actions have been made that would impact the vadose zone source or infiltrating water (i.e., from a surface barrier). Ratings (e.g., in 200 East) also reflect where remedial decisions are pending. For **threats to the Columbia River *remaining after cleanup***, ratings reflect that significant action has been taken in the River Corridor to address contamination and it is considered unlikely that contamination from the Central Plateau will impact the Columbia River.

Table 6-4. Near-Term Post-Cleanup risks rated high or very high for each receptor category. A check (✓) indicates a High or Very High rating for the marked receptor category with the risk drivers indicated parenthetically or by table note. (*) indicates template not completed for evaluation unit.

EU Name	EU #	Human Health Facility Worker	Human Health Co-located Person	Groundwater	Ecological
Legacy Sources					
618-11 Burial Ground	RC-LS-1				
K Area Waste Sites	RC-LS-2			✓ (C-14)	
Orchard Lands	RC-LS-3*				
618-10 Burial Ground	RC-LS-4				✓[a]
BC Cribs & Trenches	CP-LS-1			✓ (I-129, Tc-99, Cr-tot, Cr-VI)	
Pu Contaminated Waste Sites	CP-LS-2			✓ (CCl_4)	
U Plant Cribs and Ditches	CP-LS-3				
REDOX Cribs and Ditches	CP-LS-4			✓ (I-129)	
U & S pond	CP-LS-5			✓ (CCl_4, Cr-tot, Cr-VI)	
T Plant Cribs & Ditches	CP-LS-6			✓ (Cr-VI)	
200 Area HLW Transfer Pipeline	CP-LS-7				
B Plant Cribs & Trenches	CP-LS-8			✓ (Cr-VI)	

EU Name	EU #	Human Health Facility Worker	Human Health Co-located Person	Groundwater	Ecological
PUREX Cribs and Trenches(inside 200 E)	CP-LS-9			✓ (I-129)	
PUREX & TF Cribs & Trenches (outside 200-E)	CP-LS-10			✓ (Cr-tot, Cr-VI)	
B Pond	CP-LS-11			✓ (CCl_4)	
200 West Burial Grounds	CP-LS-12			✓ (CCl_4, C-14, I-129, Cr-tot, Cr-VI)	
200-W Miscellaneous Waste Sites	CP-LS-13				
200-E Burial Grounds	CP-LS-14			✓ (Cr-tot, Cr-VI)	
200-E Miscellaneous Waste Sites	CP-LS-15				
Grout Vaults	CP-LS-16				
BC Control Zone	CP-LS-17				✓[a]
Outer Area Sites	CP-LS-18				✓[a]
Tank Waste & Farms					
T	CP-TF-1			✓ (Cr)	
S-SX	CP-TF-2			✓ (Cr)	
TX-TY	CP-TF-3			✓ (Tc-99, CCl_4, Cr)	
U Tank Farm	CP-TF-4				
A-AX Tank Farms	CP-TF-5				
B-BX-BY	CP-TF-6			✓ (I-129, Tc-99, Cr)	
C Tank Farms	CP-TF-7				
200 East Double-Shell Tanks (DSTs)	CP-TF-8				
200 West DSTs	CP-TF-9				
Groundwater					
300 Area GW Plumes	RC-GW-1				
100-N GW Plume	RC-GW-2				
100-B/D/H/F/K Area GW Plumes	RC-GW-3				
200-E Groundwater	CP-GW-1			✓ (I-129)	
200-W Groundwater	CP-GW-2			✓ (I-129)	
D4					
Building 324	RC-DD-1				
K Reactors	RC-DD-2				
Final Reactor Disposition	RC-DD-3				✓[a]
FFTF	RC-DD-4				
PUREX	CP-DD-1				

EU Name	EU #	Human Health Facility Worker	Human Health Co-located Person	Groundwater	Ecological
B Plant	CP-DD-2				
U Plant	CP-DD-3				
REDOX	CP-DD-4				
PFP	CP-DD-5			✓ (CCl_4)	
Operating Facilities					
K-West Basin Sludge	RC-OP-1				
Retained Facilities [i]	RC-OP-2				
CWC	CP-OP-1				
T Plant	CP-OP-2				
WESF	CP-OP-3				
WRAP	CP-OP-4				
CSB and ISA	CP-OP-5				
ERDF	CP-OP-6				
IDF	CP-OP-7				
Mixed Waste Trenches	CP-OP-8				
Naval Reactors Trench	CP-OP-9				
242-A Evaporator [p]	CP-OP-10				
ETF and LERF [q]	CP-OP-11				
TEDF	CP-OP-12				
SALDS	CP-OP-13				
WTP [r]	CP-OP-14				
222-S Laboratory	CP-OP-15				
ETF	CP-OP-16				
WSCF	CP-OP-17*				

a. Ecological High and Very High ratings were based largely on having high-level ecological resources and remediation options that were physically disruptive

6.3. FINAL OBSERVATIONS

The comprehensive risk evaluations completed on the Hanford Site areas (divided into 64 evaluation units) either undergoing or awaiting cleanup as of October 1, 2015 and compiled for this report (Appendices D-H) are offered to provide a better understanding of the current status of the evaluation units evaluated and of the risks and impacts to receptors during three evaluation periods: cleanup (until 2064), near-term post-cleanup (until 2164), and long-term post-cleanup (until 3064).

Risk evaluation is a necessary predecessor to risk management decisions that ultimately determine the order of priority for and sequencing of cleanup activities. However, risk evaluation is only one of many inputs to risk management decisions. Risk management decisions are outside the scope of this project and involve many factors, including regulatory requirements, resource availability (e.g., workforce, funding and disposition pathway availability), project continuity, and stakeholder input. While risk management has not been an objective or considered part of the Risk Review Project, certain general themes emerged during the execution of the Risk Review Project that may bear on risk management.

At the Hanford Site, current hazard and risk conditions reflect the inventory, site access controls that are in place, and cleanup actions in progress or already completed. These controls and completed actions have greatly reduced threats to human health and ecological resources and have addressed the groundwater contamination that poses risk to the Columbia River and significant part of the groundwater contamination in the 200 West area of the Central Plateau. When considering future cleanup, hazard and risk conditions are important:

a. **To inform order and timing of cleanup activities –** *nuclear, chemical, and physical safety* (i.e., hazards, initiating events and accident scenarios) *and the threats to groundwater* and the Columbia River *are the primary risk considerations*.
b. **To inform selection, planning, and execution of specific cleanup actions –** *potential risks and impacts to worker safety, ecological resources, and cultural resources are the primary risk considerations*.
c. **To inform cleanup criteria** (i.e., cleanup levels to meet regulatory standards) **–** *future land use, protection of water resources, land ownership and control, durability of institutional and engineered controls, and legal/regulatory requirements are the primary considerations that influence future human health risk estimates*. Risks to human health should be considered in combination with risks to environmental and ecological resources for establishing cleanup criteria.

> When considering future cleanup, understanding hazard and risk conditions is important to inform
>
> *a.* order and timing of cleanup activities
> *b.* selection, planning, and execution of specific cleanup actions
> *c.* cleanup criteria
>
> *The Risk Review Project's primary focus is on items a and b above; CRESP is not making observations on specific cleanup criteria.*

The following observations are offered in the form of overarching and specific observations that may help inform decisions on order and timing of cleanup and/or planning for activities associated with cleanup.

Overarching Observations

1. Currently, members of the public, whether located at the official Hanford Site boundary or at the controlled access boundary (river and highways), usually have Low to Non Discernible risks, even if postulated radioactive contaminant releases from bounding scenarios[148] were to occur.

> Seasonal timing of cleanup can be used to reduce effects on ecological resources, including the Columbia River and eco-cultural resources.

2. Timing of cleanup of a specific evaluation unit **may reduce worker risk** (e.g., by radioactive decay) **or may increase worker risk** (e.g., by facility deterioration, insufficiently trained workforce availability, repetitive and chronic exposures due to continued operations and maintenance).
    a. Worker risk varies with respect to the nature of hazards, complexity, duration of project, technical approaches, and controls or mitigation measures in place to ensure worker health and safety.
    b. DOE documents promulgate a safety culture, and DOE and its contractors have accident rates that are lower than comparable non-DOE work. Ongoing vigilance will be necessary to sustain this culture and maintain this excellent record.
    c. Discontinuities in project execution lead to losses of trained workforce and institutional memory that may increase worker risks.

3. A major seismic event at the Hanford Site, which would likely affect multiple facilities simultaneously, may release large quantities of radiological contaminants from multiple inactive canyon processing and other facilities (e.g., Waste Encapsulation and Storage Facility, K West Basin, Central Waste Complex (CWC)) that can pose greater risks to human health than contaminants in the legacy sites on the Central Plateau.

4. The ecological resources on the Hanford Site are very important to the Columbia River Basin ecoregion, where its shrub-steppe habitat (Figure 6-5) has decreased at a far greater rate region-wide than on the Hanford Site. The Site also contains some federal and state threatened and endangered species. DOE stewardship has helped protect and enhance these resources.
    a. Since ecosystems are dynamic, including natural succession and spread of non-native species, up-to-date ecological evaluations (resource levels present) should be used to determine the best place for the laydown areas to minimize ecological risk.
    b. Since cleanup activities are dynamic and ongoing, the effect of such cleanup activities on evaluation unit and buffer area ecosystems needs to be reevaluated just prior to cleanup.

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[148] A “bounding scenario” is a sequence of events that includes assumptions that lead to a greater than realistically expected risk estimate.

Figure 6-5. Vulnerable and Valuable Hanford Site shrub-steppe ecosystem.

5. The historical and cultural significance of the Hanford Site to Tribal Nations stretches over 10,000 years. The Hanford Site also is considered to have important historical significance to Western settlement, which began in the early 1800s and only ended at the site to make way for the Manhattan Project. Finally, the site played a major role during the Manhattan Project Era and after World War II during the Cold War Era. DOE's stewardship helps ensure continued recognition of the site's historical and cultural significance.

Specific Observations that Inform Cleanup Order and Timing

1. **Reduce threats posed by tank wastes** (Appendix E.1 through E.11). There is considerable range in the composition and risks posed by wastes stored in tanks – thus, tank farms and tanks should be considered individually for waste retrieval sequencing, waste treatment and the extent of retrieval necessary to reduce risk. Hydrogen gas generation[149] poses a threat to nuclear safety and human health in some tanks through hydrogen flammability events that may result in atmospheric or subsurface release of waste or contaminants from containment (worker risk from tank vapors are discussed below) from natural events or loss of engineering controls. Tc-99 and Iodine-129, both being persistent and highly mobile in the subsurface, threaten groundwater through potential leakage from tanks.[150] Risks posed by hydrogen gas generation can be somewhat reduced through removal of water-soluble Cesium-137. Groundwater threats can be substantially reduced by removing water-soluble constituents of potential concern from a selected set of tanks.[151] This observation is consistent with the priority given by DOE to addressing hydrogen hazards in applicable safety analyses and the agency's decision to treat low-activity waste (LAW) at the Hanford Tank Waste Treatment and Immobilization Plant (WTP) as early as possible. However, the risk to groundwater will not be reduced significantly if Tc-99 and Iodine-129 are returned to the tanks during low-activity waste treatment. The risk from hydrogen may remain the same or be reduced if Cesium-137 is returned to the tanks during low-activity waste treatment, depending on the resulting distribution of Cesium-137 amongst the

[149] Hydrogen generation rate is primarily related to Cs-137 and Sr-90 content of the waste.
[150] The threat to groundwater from tank leakage has been mitigated in the near-term through interim stabilization of single-shell tanks (SSTs) where pumpable liquids were removed.
[151] For hydrogen generation, 200 East double-shell tanks (DSTs), 200 West DST SY-103, and SSTs East B-202, B-203, B-204, and West T-201 have times to 25% of the lower flammability limit of less than 6 months under unventilated conditions. Cs-137 removal would most significantly increase time to 25% of the lower flammability limit for tanks AZ-101, AN-102, AN-107, AP-101, AP-103, and AP-105. For groundwater threat, greater than 70% of the GTM is from 200 East DSTs, SY-101 and SY-103 (200 West DSTs), and SSTs AX-101, S-105, S-106, S-108, S-109, SX-106, TX-105*, TX-113*, TX-115*, U-109, and U-105 (*indicates assumed SST leaker).

tank wastes. DOE is also actively working to understand and protect workers from chemical vapors in the Hanford tank farms.

Selective waste retrieval targets should be considered for individual tanks within each tank farm, allowing for different amounts of retrieval while completing waste retrievals at an entire tank farm and achieving consistent risk-informed endpoints. If selective waste retrieval targets of 99% or the limits of multiple technologies are applied to the group of 26 double shell tanks (DSTs) and 42 single shell tanks (SSTs) that comprise 90% of the total Groundwater Threat Metric in all tanks (current approach), the result would be a residual Groundwater Threat Metric of 1% of the initial inventory. Waste retrieval targets of 90% of the Groundwater Threat Metric or the limits a single technology would result in a residual Groundwater Threat Metric of less than an additional 1% of the current Groundwater Threat Metric with a cumulative result that is indistinguishable from the current target of 99% across all tanks, considering inventory and retrieval uncertainties. Furthermore, the barriers to environmental release of contaminants from residual waste in tanks after retrieval, tank grouting and tank farm capping have not been robustly evaluated. Selective waste retrieval targets as discussed above may allow for significant acceleration of tank waste retrievals and much more rapid reduction in groundwater threats from tank wastes than currently planned. *Further evaluation of this concept is warranted. A tank farm waste retrieval and processing system plan evaluation of this approach is suggested (see Section 3.2 Waste Management Implications for Hanford Tank Farms)*.

Reduce dependence on active controls to maintain safety ...with large inventories of radionuclides.

2. **Reduce dependence on active controls (e.g., reliance on power, cooling water, active ventilation) to maintain safety for additional facilities with large inventories of radionuclides.** These conditions are (1) air-handling ducts at the Waste Encapsulation and Storage Facility, (2) sludge at K-Basins (sludge treatment project; Appendix H.2), and (3)T Plant.

    a. **For Waste Encapsulation and Storage Facility (WESF) – Hot Cells and Ventilation** (Appendix H.5): During the design basis event earthquake, contaminants from Waste Encapsulation and Storage Facility's hot cell and ventilation system are the hazard sources that could produce substantial radiation doses to the Co-located Person.

    b. **For Waste Encapsulation and Storage Facility – Cesium & Strontium Capsules Storage** (Appendix H.5): The primary scenario that could cause release of radionuclides from the capsules stored in the Waste Encapsulation and Storage Facility pool cells (Figure 6-6) is an accident that results in the loss of water from all pool cells, which provides cooling and radiation shielding. The design basis seismic event

Figure 6-6. DOE photo of cesium and strontium capsules in the WESF pools.

could not cause the loss of all pool cell water by itself: release of significant quantities of radionuclides could only result from multiple root causes (some in sequence, some in parallel) that include human errors, natural events, and external events. The storage pool structures have been exposed to high radiation fields for an extended period. An initial assessment indicated that the storage pools currently are safe, although the long-term integrity of the structures is uncertain.[152] DOE proposes to over-pack and then transfer cesium and strontium capsules to onsite dry storage.[153]

c. **For KW Basin Sludge** (Appendix H.2): Current safe storage relies on maintaining the K-Basin sludge submerged under water to reduce radiation exposure to workers and prevent fires of reactive metal fragments. Safe processing of K-Basin sludge also requires keeping it wet during retrieval, transfer, interim storage, and processing to prevent pyrophoric constituents from igniting.

d. **For T Plant** (Appendix H.4): As a part of the Solid Waste Operations Division, T Plant has a mission life that extends beyond the cleanup of the rest of the Site. However, delays in the waste package surveillance program, or extended delays in the ultimate disposition of the waste, may result in the degradation of the waste packages, which would lead to increased potential for leaks and exposure of workers or Co-located Persons unless the degraded waste storage containers were replaced.

3. **Consider interim actions to reduce or eliminate cleanup actions that could cause substantial human health risks**. The following cleanup activities themselves could cause substantial risks to human health and therefore warrant consideration of interim actions, and different cleanup approaches and timing (recognizing that mitigation measures would be both necessary and implemented before and during remedial actions):

    a. **Retrieval, treatment, and disposal of contaminated soils underlying Building 324 and disposal of the building after grouting the contaminated soils in the building** (Appendix F.2): Currently, no migration of soil contamination to groundwater has been identified, suggesting that required cleanup is not urgent. In addition, the excavation and transfer of the soils through the B-Cell floor may not be technically feasible currently and/or may present challenging risk scenarios. As a result, approaches that allow for immobilization and in situ decay of the soil contaminants (Cesium-137, Strontium-90) warrant further consideration.

    b. **Retrieval, treatment, and disposal of materials from 618-11 site within caissons, vertical pipe units, and burial grounds** (Appendix G.2): This is needed because of the characteristics of wastes (high activity, pyrophoric, poorly characterized) to be retrieved. The possible event of a fire and/or release from 618-11 site jeopardizes continued operations and worker safety at the Columbia Northwest Generating Station because of the proximity of the two facilities. The current cover over the buried wastes, but not present over the caissons and vertical pipe units, limits water infiltration to the wastes where the cover is present. These conditions warrant consideration of instituting

[152] A separate DOE-initiated review of the condition of the Waste Encapsulation and Storage Facility concrete structure and the reliability of the initial DOE estimate is in progress.

[153] The capsules may experience significantly higher temperatures in dry storage than in pool storage. The elevated temperatures, combined with the variable and uncertain chemical composition of some capsules, could raise concerns about the integrity of the capsules over time as storage is likely for at least decades (see Appendix H.4). This concern would be addressed as part of the safety analysis associated with the dry storage design process.

interim mitigation measures (e.g., improved cover to prevent infiltration to caissons and vertical pipe units) and delaying waste retrieval until closure of the generating station.

4. **Address portions of specific evaluation units first before the whole.** For several evaluation units, specific activities, hazards, or risk characteristics warrant being addressed before considering the evaluation unit as a whole; that is, parts of some evaluation units need to be managed before other parts of the same evaluation unit.
    a. **618-11 Burial Ground.** (Appendix G.2) Further sampling and characterization of the 618-11 site would improve DOE's knowledge and understanding of the site, which might enable it to develop a remediation plan that reduces the risk to workers and Energy Northwest Generating Station employees.
    b. **Building 324**. (Appendix F.2) The highly contaminated soils under Building 324 must be addressed before anything can be done to demolish the building
    c. **KE/KW Reactor**. (Appendix F.3) The removal of the K-West Fuel Basin (RC-OP-1) must be completed before the initial D4 phases of the K-West Reactor building can move forward. This may also delay plans to “cocoon” the K-East Reactor, as it would most likely be more cost-efficient to do the cocooning of the East and West Reactor buildings at the same time.
    d. **Plutonium Uranium Extraction Plant.** (Appendix F.6) The possible collapse of the tunnels at the Plutonium Uranium Extraction Plant facility should be addressed earlier than the long-term plans to D4 the entire facility.
    e. **Reduction-Oxidation Plant.** (Appendix F.9) Unoccupied since the mid-1960s, the structural deterioration and spread of contamination in the 202 S Building and Annex could result in an unacceptable release and risk to human health and the environment in the absence of any near-term hazard mitigation actions.

5. **Reduce or eliminate risks associated with external events and natural phenomena (fires, severe seismic events, loss of power for long duration).** These risks typically arise from very low probability but very high consequence events. Facilities affected are the Waste Encapsulation and Storage Facility (cesium and strontium capsules), Central Waste Complex, Plutonium Finishing Plant, Plutonium Uranium Extraction Plant waste storage tunnels, and the B Plant and Reduction-Oxidation Plant Canyon buildings. (see also **Reduce dependence on active controls**, item 2 above**)**
    a. **For the Central Waste Complex** (Appendix H.3): Estimated unmitigated doses from accident scenarios to the Co-located Person exposed to the worst design basis event at the Central Waste Complex is from a large fire, involving more than eight drums or 82.5 Ci (dose equivalent) of material, resulting in an estimated exposure of 770 rem. This risk may increase near-term because the Central Waste Complex continues to receive wastes, but currently is unable to ship wastes to off-site disposal, due to shipment availability to the Waste Isolation Processing Plant (WIPP) and because budgets have been insufficient to support repackaging wastes into standard containers. Localized accumulation of material at risk without a disposition pathway can also increase overall risk. Consideration also should include reductions in the amount of material at risk for similar facilities, if disposal options are available.
    b. **For the T Plant** (Appendix H.4): T Plant, as a part of the Solid Waste Operations Division, has a mission life that extends beyond the cleanup of the rest of the Hanford Site. However, delays in the waste package surveillance program, or extended delays in the ultimate disposition of the waste, may result in the degradation of the waste packages,

which would increase potential for leaks and exposure of Facility Workers or Co-located Persons. There are several events that have a high anticipated impact on the Co-located Person that relate to building fires. The highest of the unmitigated dose impacts to the Co-located Person is a building fire igniting a waste package (resulting estimated dose: 770 rem).

c. **For the Plutonium Finishing Plant** (Appendix F.10): A design basis earthquake or aircraft crash into the PFP facility prior to completion of the current D4 activities could cause an estimated unmitigated acute dose of 890 rem to the Co-located Person, and fires or explosions involving contaminated equipment could cause estimated unmitigated doses from 240 rem to 710 rem.

d. **For the Plutonium Uranium Extraction Plant.** (Appendix F.6):

    i. A design basis seismic event could lead to a total structural failure of the 202-A building and both tunnels, causing an estimated unmitigated combined 250 rem dose to the Co-located Person.

    ii. The wood ceiling and wall structure of Tunnel #1 are vulnerable to collapse due to ongoing degradation from continued exposure to the gamma radiation from equipment being stored. A collapse accompanied by fire could release a large fraction of the 21,200 Ci radiological inventory to the environment.[154]

e. **For the B Plant and Reduction-Oxidation Plant Canyon Buildings** (Appendices F.7 and F.9): A seismic event of greater magnitude than the design basis at the Hanford Site could cause failure of the 221-B, 224-B, and 202-S Canyon buildings, resulting in loss of the confinement function and shock/vibration impacts to radioactive material in the canyon from seismic motions and displacement of equipment. The results are estimated unmitigated acute doses to Co-located Persons from 35.4 rem to 108 rem. These risks could be significantly reduced if all equipment on the canyon decks were moved into the below-ground processing cells and fully grouted in place and the interior canyon walls were sprayed with a fixative, such as has already been done at the U Plant.

[154] The document safety analysis for this facility provides a detailed analysis of potential upset events (see Appendix F.4).

6. **Continue reducing groundwater threats** (Appendix D.1 through D.6): Many of the threats and current impacts to groundwater are being interdicted and/or treated although some plumes have increased in area even in 200 West where groundwater contamination is being actively treated. This phenomenon is not atypical of pump-and-treat systems where treated water is reintroduced into the saturated zone. Current groundwater remedial action should be evaluated to determine if they are efficiently achieving risk reduction. The greatest threats and impacts to groundwater are from the following:
   a. **Groundwater plumes not currently being actively addressed.** (Appendix D) Tc-99 and I-129 are already in groundwater in 200 East Area (200-BP-5; EU CP-GW-1). The 200-BP-5 I-129 plume extends to the southeast (200-PO-1; EU CP-GW-1) but may be too dispersed for effective remediation other than natural attenuation. However, remedial actions are currently being investigated for this contamination.

> Continue reducing groundwater threats:
>
> - The River Corridor and Central Plateau 200 West Area have active groundwater remediation systems that address their highest groundwater contamination risks.
> - The Central Plateau 200 East Area has contaminant plumes that are not currently being treated and are estimated to be a high risk to further contamination of groundwater.
> - Reduction of infiltration in areas of high levels of vadose zone contamination should be considered to reduce risks to groundwater.

   b. **Vadose zone threats to groundwater not currently being addressed.** (Appendix D) Technetium-99, Iodine-129, and Chromium(VI) are in the vadose zone associated with BC Cribs and Trenches (EU CP-LS-1; Appendix D.4) and the legacy sites associated with B-BX-BY tank farms (EU CP-TF-6; Appendix E.7), both located in the 200 East Area. Strontium-90 results in a Very High rating in B-BX-BY because of the large inventory; however, Strontium-90 is relatively immobile and will naturally decay. Infiltration control (e.g., capping) and other approaches may reduce the flux of these contaminants from the vadose zone into groundwater. Uranium currently is being extracted from the perched water zone in B-Complex.
   c. **Building 324, where relatively modest interim actions could reduce threat.** (Appendix F.2) The largest risk for migration of cesium-137 and strontium-90 from the soils until cleanup can be completed (through a combination of D4, soil treatment and/or removal, and natural attenuation) is from breakage of a main water pipe and infiltration of precipitation and runoff near the building. Building 324 is currently being maintained in a safe surveillance and maintenance mode pending completion and evaluation of a pilot project and assurances that resources are available to complete a multi-year soil remediation and D4 activities. Current risks from potential water infiltration and resultant

contaminant migration may be mitigated through water supply modifications, infiltration controls, and additional groundwater monitoring.[155]

d. **618-11 waste site, where relatively modest interim actions could reduce threat**. (Appendix G.2) At 618-11, the potential for release of additional contaminants to groundwater can be mitigated by installing a cover that prevents infiltration but maintains gas venting over the caissons and vertical pipe units (currently gravel-covered area).

7. **Unplanned changes in inventory in operating facilities have a time-dependent risk, which creates additional challenges that need to be addressed.** Unplanned changes in inventory can occur over time due to delays in planned processing and removal and storage of waste, which would result in increased risk. The hazard and risk profiles change as funding is available to implement identified plans as well as resulting from deterioration of infrastructure. For example, with ongoing waste processing delays, coupled with aging infrastructure (due to insufficient maintenance), waste storage conditions will deteriorate and additional waste will accumulate. In addition, operating facilities rely on interfaces with existing facilities (e.g., Waste Isolation Pilot Plant, T Plant, off-site processing and disposition facilities) and planned facilities (e.g., dry capsule storage for cesium and strontium capsules, Phase 2 K-Basin sludge processing). Outages or delays in availability of interfacing facilities will likely disrupt waste processing. For the 222-S Laboratory, the radiological inventory is limited by administrative controls and procedures such that it is considered a "less-than-Category-3" nuclear facility; as long as these safety-related administrative controls are in place, the facility should remain a low-hazard facility.

SPECIFIC OBSERVATIONS THAT INFORM PLANNING FOR, AND ACTIVITIES ASSOCIATED WITH, CLEANUP (NOT IN ANY SPECIFIC ORDER)

1. **Consider Selective Retrieval Targets for Tank Waste** (Appendix E.1 through E.11)**.** Selective waste retrieval targets as indicated may allow for significant acceleration of tank waste retrievals and much more rapid reduction in groundwater threats from tank wastes than currently planned. Recognizing that waste retrievals are most efficiently carried out on a tank farm by tank farm basis, selective extents of retrieval focusing on tanks with large inventories of contaminants that threaten groundwater can be accomplished for individual tanks within each tank farm, allowing for different extents of retrieval while completing retrievals at an entire tank farm. Retrieval targets also should consider the extent of retrieval for specific

PLANNING FOR CLEANUP

1. **Consider Selective Retrieval Targets for Tank Waste**
2. **Recognize that uptake and discharges of contaminants from groundwater threaten ecological resources**
3. **Expand consideration given to restoration of ecological resources**
4. **Reduce potential dispersal and/or transport of contaminants with re-vegetation at reactor sites**
5. **Expand consideration given to cultural resources**
6. **Decrease the footprint of cleanup activities**

[155] While groundwater monitoring does not prevent infiltration or contaminant migration, it does mitigate risks by providing early warning of a change in the subsurface contaminant spatial distribution.

contaminants that threaten groundwater rather than solely on volumetric-based or technology-based retrieval targets. Further evaluation of this concept is warranted. A tank farm waste retrieval and processing system plan evaluation of this approach is suggested.

2. **Recognize uptake and discharges of contaminants from groundwater can threaten ecological resources** (Chapter 4.4)**.** For almost all cases, the potential for adverse impacts to ecological resources from contaminants has already been mitigated, either by removal actions or by the presence of engineered barriers (e.g., cover materials, buildings, or engineered structures). Uptake of contaminants from groundwater in the riparian zone and groundwater discharge to the benthic zone of the Columbia River remain the most important pathways for contaminants to impact ecological resources. An additional potential future pathway includes irrigation and plant uptake associated with use of contaminated groundwater.
3. **Expand consideration given to restoration of ecological resources when planning cleanup activities** (Chapter 4.4)**.** Ecological restoration[156] is an important step in remediation, and should be carried out with native species. Monitoring to assess efficacy value, and rarity of the resource are critical to determining how to do restoration for future cleanup activities. The value of ecological resources at any given evaluation unit depends on the resources there and in the surrounding buffer, the historical presence of resources of high sources in comparison to off-site habitats, their cultural value, the remediation and restoration history on the evaluation unit and buffer, and chance/weather/fires. These factors affect the ecological restoration potential during remediation.
4. **Reduce potential dispersal and/or transport of contaminants with re-vegetation at reactor sites** (Appendix G). Remediation of the K Reactor Area Waste Sites evaluation unit (RC-LS-2) currently is uniquely a “work in progress” because it is a legacy source site where cleanup is continuously disrupted to await completion of D4 activities at the two reactors. Soil cover and vegetation have been removed in some areas, and active dust suppression is required, so there is increased potential for dispersal and/or transport to groundwater of contaminants remaining in the waste sites. Remediation and re-vegetation of the site will reduce infiltration and transport of residual vadose zone contamination to groundwater. Re-vegetation needs to consider topography and native plants.
5. **Expand consideration given to cultural resources when planning cleanup activities** (Chapter 4.5)**.** The Manhattan Project/Cold War Era built environment is well understood as extensive inventories have been completed to document the historical importance of the era’s buildings and structures and which of those buildings and structures will remain after remediation has ended. In contrast, less is known about the other two landscapes: the Native American and Historic Pre-Hanford Era. This is because very few evaluation units have been entirely inventoried for cultural resources within either landscape. Even less is known about subsurface archaeological resources. Physical exposure and disruption during remediation are the primary mechanisms for adverse impacts on cultural resources from activities associated with cleanup of specific evaluation units. Planning for remediation, particularly at the earliest stages, should include (1) how remediation activities, such as road traffic and heavy equipment through the cleanup area, could impact potential cultural resources that are, or could be, present within and adjacent to the area undergoing cleanup, and (2) the mitigation measures that could avoid or

[156] In this report, the term “restoration” does not refer to Natural Resource Damage Assessment considerations. Instead, as used here, ecological restoration refers to a process that includes such activities as environmental assessment, vegetation assessment, geographical and contour considerations, re-vegetation, and monitoring, among other processes.

limit the impact. Limiting the footprint of activities associated with remediation can decrease the chances of exposing or adversely impacting a cultural resource during cleanup. Additionally, limiting the footprint decreases the chance of an indirect impact, such as exposing an area of the site that Native Americans consider to be important to their culture. Close coordination with the state's historic preservation officer and affected Tribal Nations is also a key component.

6. **Decrease the footprint of cleanup activities** (Chapter 4.4)**.** Physical disruption and invasive species are the primary causes of adverse impacts on ecological resources at the Hanford Site. Patch size and interdiction of patches are important aspects of ecological value, and should be considered during cleanup. Decreasing the footprint of cleanup activities on the evaluation unit and buffer is one of the most important mechanisms of reducing risk to ecological resources. Planning for remediation requires careful consideration of how the activities will disrupt eco-receptors and ecosystems on the evaluation unit and surrounding areas (including vehicular traffic, people, roads, traffic routes, lay-down areas, and excess water), reducing effects where possible, and specifically avoiding high-quality ecological resource areas on or off the evaluation unit. Allowing non-native species to invade an evaluation unit or the surrounding buffer can disrupt and damage high-quality native resources and is preventable. If high-quality resources on the evaluation unit and buffer are disturbed, it may not be possible to restore them. Thus, protection of ecological resources during remediation is the best option and is superior to trying to repair damaged resources.

KEY INFORMATION GAPS

Information gaps emerged throughout the execution of the Risk Review Project and partially led to a determination to not complete templates on four of the evaluation units.[157] The remaining 60 evaluation units[158] were evaluated for risk, even though missing or incomplete information may have been identified during the analysis. These data gaps potentially have resulted in additional uncertainty in the risk evaluation provided in this final report. Three examples of how incomplete data affected the risk evaluations follow. (1) The exact extent and temporal trajectory of groundwater plumes is unknown, which could severely impact the riparian zone of the Columbia River (e.g. 100, 200, and 300 area groundwater evaluation units). (2) Verification of endangered species (including species of special concern to Washington) occurrence is incomplete for many evaluation units, particularly on buildings slated for demolition where ecological evaluation should be done immediately before demolition (e.g. bats recently removed from reactors). (3) Identification of vapor constituents in tanks causing respiratory and irritation is still under development; traditional 8-hour TWA sampling is insufficient to characterize exposures related from symptoms. More detail on information gaps may be found in the evaluation template for a specific evaluation unit (Appendices D-H).

Below are listed observations surrounding the key information gaps identified during the gathering of data for analysis of evaluation units. These data gaps may influence how risk is determined both currently and in the future.

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[157] Evaluation Templates for four of the 64 EUs have not been developed. They are: Pre-Hanford Orchard Lands (RC-LS-3) (lack of available relevant information; site assessment effort was underway during the preparation of this report), Retained Facilities (RC-OP-2) (supporting ongoing DOE mission and inventories and activities were not disclosed), Waste Treatment Plant (WTP) (CP-OP-14) (facility under design and construction), and Waste Sampling and Characterization Facility (WSCF) (CP-OP-17) (lack of available relevant information). Brief descriptions of these EUs are provided in Chapter 3.

[158] 60 EUs were evaluated. Two of the EUs (CP-OP-11 and CP-OP-16) were combined and evaluated as CP-OP-11 (LERF + EFT).

Affecting Current Risk Determinations

1. Contaminant inventories at many of the legacy sites, groundwater, and Reduction-Oxidation Plant facility evaluation units are highly uncertain. In addition, there is no reported inventory for the majority of the individual waste sites[159] within the legacy evaluation units. Contaminated or potentially contaminated areas need further characterization to the extent necessary to make informed cleanup decisions and to ensure that residual risks to human health, water resources, and ecological resources are below acceptable thresholds.
2. For worker health and safety during remediation within D4 facilities and at certain legacy source sites (e.g., 618-11), the conditions, containment, and stability of the contaminants need to be determined.
3. The condition of the Hanford Site infrastructure and the impacts of infrastructure challenges on the waste management and long-term cleanup efforts, and resulting risks, are not well known and are subjects of current evaluation and planning by DOE. Continuity of key infrastructure (e.g., water supply, electrical power, communications) is essential to risk mitigation.
4. Safety assessments do not evaluate risks between the facility boundary and the site boundary except for unmitigated risks to the maximally exposed co-located person. As site access and uses change, there will likely be a need to ensure that the changing boundaries and activities are reflected in existing and new risk assessments.
5. Exposure scenarios have not been established that link federal land use designations to risk assessment and cleanup requirements.
6. For many existing groundwater plumes and for many areas of contamination in the vadose zone, the vertical distribution of primary contaminants is highly uncertain because of limited characterization data.
7. For most evaluation units and areas on the Hanford Site, there has not been a recent evaluation or inventory of the ecological resource level (e.g., habitats). Planning and order and timing to reduce risk to eco-receptors depends on avoiding and protecting high-quality resources (especially large patches, or smaller patches close to large patches).
8. For most evaluation units and areas on the Hanford Site, there has not been any survey of the nature and extent of invasive species, especially on large patches of high-quality resources (Levels 3-5 resources, including habitat for important species and threatened or endangered species). There should also be monitoring in the years following cleanup to determine the extent of non-native species invasions and to determine the efficacy of measures to prevent invasion.
9. The majority of the Hanford Site has not been surveyed for cultural resources related to the Native American and Pre-Hanford Eras. There likely are cultural resources present from those eras, particularly those that are not directly visible. Cultural resources reviews are carried out on a case-by-case basis when cleanup actions or other activities may disrupt specific land areas or land transfers are being considered.
10. Existing cultural resources records often are not compiled or organized in ways that would be helpful during planning for cleanup at a particular location. Cultural resources reviews would benefit from a more streamlined process that provides information in a more timely fashion and with sufficient detail for planning and order and timing of remediation actions, while still protecting the cultural resources.

[159] The Hanford Site has been divided into more than 2500 individual contaminated areas (i.e., operable units) and RCRA permitted facilities for regulatory purposes.

Affecting Future Risk Determinations

1. As the use of the Hanford Site evolves, there will be a need for regular updating of assumptions within the DSA regarding where the maximum exposed individual (public) is located. This is particularly true for those locations that are included as part of the Manhattan Project National Historical Park and locations to which Tribal Nations seek to access.
2. Additional risk analyses will be needed to evaluate risks to human health as part of planning for new controlled access activities. Current analyses do not provide sufficient resolution to understand potential safety risks to a broader range of people present between 100 m from facility or activity boundaries to the Hanford Site security boundaries.
3. Additional risk analyses of ecological resources (including the Columbia River riparian zone) will be needed as part of planning for new controlled access activities. Mitigation measures, such as biomonitoring, may be necessary for controlled access that includes gathering or consumptive activities such as Tribal cultural activities**.**

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