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Revision 0

Central Plateau Inner Area Cleanup Principles and Parameters

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
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Approved for Public Release;
Further Dissemination Unlimited

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Terms

bgs	below ground surface
BRA	baseline risk assessment
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CMS	corrective measures study
COPC	contaminant of potential concern
CSM	conceptual site model
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ERA	ecological risk assessment
FS	feasibility study
HHRA	human health risk assessment
IRIS	Integrated Risk Information System
K_d	distribution coefficient
MTCA	Model Toxics Control Act
OU	operable unit
PPRTV	provisional peer reviewed toxicity values
PRG	preliminary remediation goal
RCRA	*Resource Conservation and Recovery Act of 1976*
RESRAD	RESidual RADioactive
RFI	RCRA facility investigation
RI	remedial investigation
SMDP	scientific-management decision point
SSL	soil screening level
SST	single-shell tank
STOMP	Subsurface Transport Over Multiple Phases
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*

UCL	upper confidence limit
WMA	waste management area

1 Central Plateau Inner Area Cleanup Principles

In 2013 and 2014, the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) (together referred to as the Tri-Parties) undertook an initiative to develop a set of cleanup principles for the Inner Area of the Central Plateau. Text describing those principles was incorporated into several approved remedial investigation/feasibility study (FS) work plans for operable units (OUs) on the Central Plateau (200-SW-2, 200-DV-1, and 200-WA-1). In 2019 and 2020 the Tri-Parties updated the text describing those principles into this document (DOE/RL-2019-46) so that the standardized text could be efficiently incorporated into future work plans. In the 2019-2020 update, the Tri-Parties also modified the previously approved text so that it could be used for both OU work plans and work plans for single-shell tank (SST) waste management areas (WMAs) (Figure 1).

The objective of this initiative is to provide consistent methods and approaches for remediation of contaminated soil and vadose zone media across the Inner Area. These methods would apply to contaminated soils, including deep vadose zone contamination that are assigned to a waste site within an OU, or located within and underneath SST WMAs.

The outcome of this initiative is the establishment of an overarching and consistent set of cleanup principles that the Tri-Parties have agreed are the foundation for evaluating waste sites and making cleanup decisions in each of the OUs and corrective action decisions for each of the SST WMAs within the Inner Area pursuant to Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement).

The overarching goals of the principles are to (1) provide a consistent approach for assessment of risks to human health and the environment and evaluation of remedial alternatives within the Inner Area; and (2) identify and implement regulatory strategies that will optimize assessment resources, streamline documentation requirements, and promote consistency in decisions.

The substantive components of these principles related to land use, baseline risk assessment (BRA), cleanup levels, points of compliance, and regulatory strategies are defined below. The principles, as they apply to the OUs and SST WMAs located within the Hanford Site, are stated in the remainder of this chapter. Chapter 2 includes risk assessment parameters that are based on the principles in Chapter 1.

1.1 Land Use

- Inner Area land use is industrial.
- The Tri-Parties are in agreement that current 25.9 km^2 (10 mi^2) Inner Area footprint will not be reduced further.

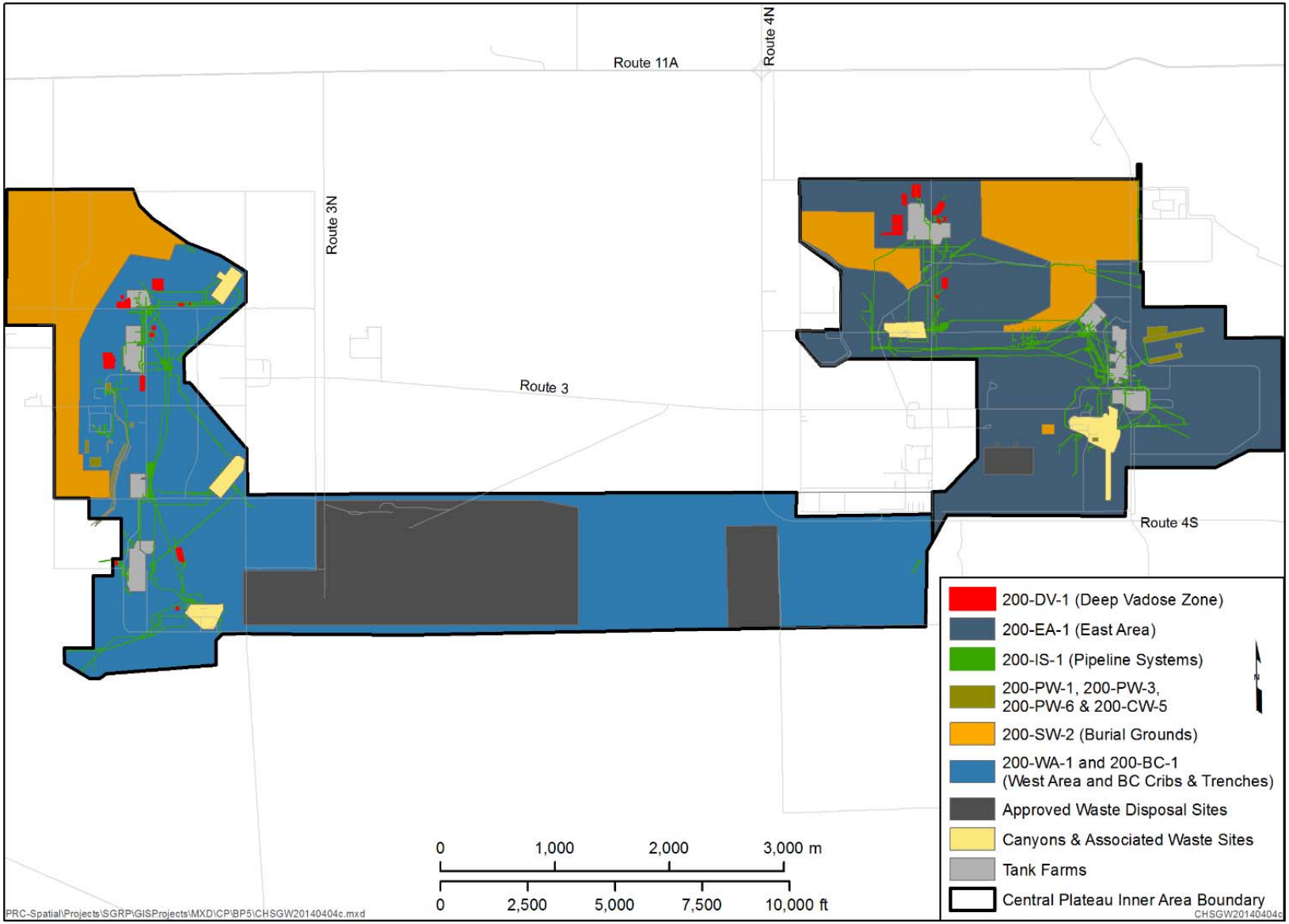

Figure 1. OUs and SST WMAs in the Central Plateau Inner Area

1.2 Baseline Risk Assessment

- The BRA for direct contact will use the default EPA industrial scenario (multiple pathways as specified in Section 2.2.1.1) to determine need for action at the following points of departure:
  - Cumulative cancer risk level of 1 in 10,000 for radionuclides
  - Cumulative cancer risk level of 1 in 100,000 for carcinogenic effects of chemicals
  - A hazard index of 1 for noncarcinogenic effects of chemicals
- Once a basis for action is determined, cleanup standards for chemicals will be based on Model Toxics Control Act (MTCA) (WAC 173-340, "Model Toxics Control Act—Cleanup") Method C industrial cleanup levels for direct contact[1]. For WMAs, the WAC 173-303-610, "Dangerous Waste Regulations," "Closure and Post-Closure," clean closure performance standards for contaminated soils use the MTCA method B cleanup levels. However, once landfill closure is required, MTCA Method C is an appropriate closure performance standard for contaminated soils direct contact, in accordance with WAC 173-303-64620, "Requirements."
- The BRA for direct contact will not include a residential scenario.
- The BRA for soils will be done on OU-by-OU or WMA-by-WMA basis.
- The BRA for groundwater and groundwater protection will be based on beneficial use (drinking water).
- Groundwater protection evaluation will consider upgradient contamination as evaluated through a cumulative risk evaluation tool that incorporates present and future groundwater contamination and contaminant sources in the vadose zone.

1.3 Cleanup Levels

- Preliminary remediation goals (PRGs) for human health direct contact with radionuclides will be risk based.
- PRGs for chemicals will be based on MTCA Method C (direct contact). For WMAs, the WAC 173-303-610 clean closure performance standards for contaminated soils use the MTCA Method B clean levels. However, once landfill closure is required, MTCA Method C is an appropriate closure performance standard for contaminated soils direct contact, in accordance with WAC 173-303-64620.

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[1] DOE/ORP-2014-02-SUPP1, *Supplemental Information to the Clean Closure Practicability Demonstration for the Single-Shell Tanks*, states:

> "DOE has also determined that the tradeoffs regarding short-term impacts and resources, including worker exposure, and technical uncertainties outweigh the potential groundwater benefits that may be obtained by clean closure of the SST system. Therefore, DOE has determined landfill closure of the SST system, which would include corrective/mitigation actions that may require soil removal or treatment of the vadose zone, is a more appropriate approach for SST system closure than clean closure."

- The approach to terrestrial ecological risk assessments (ERAs) will be the same as for upland areas within the River Corridor (DOE/RL-2010-95, *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units*) as described in Section 2.2.2.
- Groundwater protection modeling will be based on natural recharge and will not consider irrigation within the Inner Area.
- Groundwater protection modeling and PRG development will be based on the process defined in DOE/RL-2011-50, *Regulatory Basis and Implementation of a Graded Approach to Evaluation of Groundwater Protection* (hereinafter referred to as the graded approach document). DOE identified specific parameters in DOE, 2005, *Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses* (DOE/EIS-0391, *Draft Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland Washington*) that will be applied or make adjustments where appropriate.

1.4 Conditional Point of Compliance for Groundwater

FSs and corrective measures studies (CMSs) will present an evaluation for protection of groundwater directly beneath each waste site or facility under consideration. DOE may also choose to perform an analysis in an Inner Area FS/CMS to evaluate groundwater protectiveness with respect to a conditional point of compliance for groundwater cleanup level attainment at the boundary of the Inner Area. The basis for groundwater protectiveness decisions will be established in a corresponding OU decision document. Discussions for other OUs may reference the evaluation and/or established basis and include an overview of similarities and differences in application for the subject OU to justify comparable application for groundwater protectiveness evaluations and decisions. The application of a groundwater conditional point of compliance under WAC 173-340-720, “Groundwater Cleanup Standards,” will be established with a groundwater OU decision.

Ecology will establish a point of compliance for regulated units that is separate from a groundwater point of compliance established consistent with WAC 173-340-720. Ecology may establish the point of compliance for regulated units in accordance with WAC 173-303-645(6), “Releases from Regulated Units,” or may establish the point of compliance for regulated units based on alternative requirements for groundwater monitoring and corrective action in lieu of any or all of the standards set forth in WAC 173-303-645. With regard to the area surrounding the 100- and 200-series tanks, there will be an evaluation of the point of highest projected dose or concentration beyond a 100 m buffer zone, as set forth in the Tri-Party Agreement, Appendix I, Section 2.5, “Performance Assessment” (Ecology et al., 1989). An evaluation of the point of highest projected dose or concentration at a buffer zone that is either larger or smaller than the 100 m buffer zone may be used if DOE determines that adequate justification is provided.

1.5 Human Health and Ecological Depth Point of Compliance

FSs and CMSs will present one or more alternative that will evaluate compliance with human health (direct contact) and ecological PRGs at the standard point of compliance of 4.6 m (15 ft). DOE may also choose to present alternatives in the first Inner Area FS/CMS to evaluate a conditional point of compliance for the terrestrial ecological evaluation. In addition, DOE may also choose to evaluate an alternative for which the soil cleanup levels will not be met at the point of compliance specified in WAC 173-340-740(6)(b through e) for soil cleanup actions (human health (direct contact)). DOE will demonstrate compliance with cleanup standards in accordance with WAC 173-340-740(6)(f).

A framework for decisions will be developed in the first FS/CMS, but all OUs/WMAs will need to justify the decisions. All OUs/WMAs in the Central Plateau are expected to present this comparison of alternatives to ensure all potential remedies are protective of human health and the environment.

Unlike in the River Corridor, engineered structures and/or mass of contamination will not be removed unless it is a risk management decision.

1.6 Regulatory Strategies

IAMIT Determination 2020-006 (IAMIT, 2020-006 “Representative Analogous Site Coordinating Agency Liaisons (RASCAL) Recommendations for Expediting Remedial Cleanup on the Hanford Central Plateau”) provides the following agreement:

> The representative and analogous waste site approach premise is waste sites with analogous conceptual site models (CSM) are likely to have similar response actions. Characterization information from a “representative” waste site is applied across analogous waste sites to support decision-making, resulting in less pre-ROD characterization. The post-ROD characterization is focused on confirming current CSM group assignment or assisting in assignment to another CSM group.
>
> “During the RI and FS phases of the projects, the OU project teams should collaborate on the following to ensure consistency in their application of the representative and analogous waste site approach:
>
> - Share representative site data and align with any necessary reassignment of waste sites to CSM groups and, or select a different representative waste site
> - Define basis for action for CSM group’s representative site and apply the bases to the group’s analogous waste sites
> - Develop alternatives for CSM groups, including defining the range of alternatives necessary to facilitate waste sites plugging in/out of CSM groups without revisiting the FS evaluations
> - Analyze alternatives for CSM groups
>
> During the selection and implementation of final remedies, the OU project teams should collaborate on the following to ensure that similar waste sites have consistent remedies:
>
> - Post-ROD characterization approaches focused on key parameters that confirm actual site conditions meet the profile for the assigned CSM group.

- Explanation in public meetings and in the PP as to how the representative and analogous waste site approach works, including how post-ROD confirmation sampling could result in an explanation of significant differences or ROD amendment
- Explanation of the potential for the decision documents to accommodate the reassignment of waste sites (e.g., confirmatory sampling waste site may plug out to a more appropriate CSM group and/or OU)
- Implementation and prioritization of remedial actions in geographic areas (i.e., SQUIDS) showing integration across multiple OUs

2 Central Plateau Inner Area Parameters

2.1 Conceptual Exposure Models

This chapter presents a qualitative understanding of conceptual exposure models used to evaluate risks to human health and the environment for Central Plateau waste sites, unplanned releases, and similar contaminants within the surface soils and the vadose zone located at OUs and SST WMAs.

2.1.1 Exposure Pathways and Routes

The exposure pathways, exposure routes, exposure assumptions, and toxicity values that will be used for the human health exposure scenarios are described in Section 2.2.2.1. Human health risks will be assessed using an outdoor worker exposure scenario for the standard point of compliance (0 to 4.6 m [15 ft] below ground surface [bgs]). A construction worker exposure scenario will be used to evaluate radiological contamination below 4.6 m (15 ft) bgs (Section 2.2).

Ecological risks will be assessed for terrestrial receptors on the Central Plateau as described in Section 2.2.2. The ecological receptors, exposure pathways, exposure parameters, and toxicity reference values that will be used to conduct the assessment are also described in Section 2.2.2.

As stated in Section 1.5, DOE may also choose to evaluate an alternative for which the soil cleanup levels will not be met at the point of compliance specified in WAC 173-340-740(6)(b through e).

2.1.2 Contaminant Fate and Transport

The groundwater protection modeling approach will be based on the process defined in the graded approach document (DOE/RL-2011-50, Rev. 1). The modeling approach is detailed in Section 2.2.3.

2.2 Risk Assessment Approach

The purposes of a BRA are to assess potential risks associated with residual contamination at a site under baseline conditions (i.e., no further action), identify key radionuclide and chemical contributors to risk, identify key exposure pathways, and determine if there is a need to take an action to reduce risks. OSWER Directive 9355.0-30, *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, provides clarification of the role of the BRA in developing Superfund remedial alternatives and supporting risk management decisions. This directive states that the BRA is part of the RI. It further states the following:

> The baseline risk assessment should “characterize the current and potential threats to human health and the environment that may be posed by contaminants migrating to groundwater or surface water, releasing to air, leaching through soil, remaining in the soil, and bioaccumulating in the food chain” ([NCP] Section 300.430[d][4]). The primary

> purpose of the baseline risk assessment is to provide risk managers with an understanding of the actual and potential risks to human health and the environment posed by the site and any uncertainties associated with the assessment. This information may be useful in determining whether a current or potential threat to human health or the environment exists that warrants remedial action.

The methods and parameters outlined in this section are based on the Central Plateau Inner Area cleanup principles described in Chapter 1 as well as guidance from EPA (listed below) and the regulations promulgated by Ecology. These methods and parameters also are consistent with BRAs previously conducted at the Hanford Site that have been reviewed and approved by EPA and Ecology. The general methodology for conducting the BRA is described in the following sections.

2.2.1 Human Health Risk Assessment Approach

Human health risk assessment (HHRA) methods and parameters are drawn from EPA/540/1-89/002, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A): Interim Final*.

2.2.1.1 Definition of Human Health Exposure Scenario

Human health risks in the Inner Area will be assessed using the outdoor worker exposure scenario for chemicals and radionuclides within the standard point of compliance (0 to 4.6 m [15 ft] bgs). The basis for the outdoor worker scenario and source of equations used to calculate cancer risks and noncancer hazards will be drawn from the most recent versions of EPA's Regional Screening Level guidance (EPA, 2020b, Regional Screening Levels (RSLs) – User's Guide website. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide) for chemicals, and from EPA's Radionuclide PRG guidance (EPA, 2020a, Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites, Users Guide website. Available at: https://epa-prgs.ornl.gov/radionuclides/) for radionuclides. The exposure parameters for the outdoor worker scenario[2] for chemicals and radionuclides are defined in Appendix A, Table A-1. The exposure parameters listed in Table A-1 reflect the EPA guidance from EPA/600/R-090/052F, *Exposure Factors Handbook 2011 Edition (Final Report)*, and earlier guidance, as appropriate.

Key assumptions for the outdoor worker are as follows:

- Exposure pathways selected for the outdoor worker scenario are based on the assumption that direct contact exposure is potentially complete to contaminants in soil.
  - Exposure pathways for chemicals in shallow soil include incidental soil ingestion, inhalation of dust and volatiles, and dermal contact with soil. (Groundwater protection is also evaluated as detailed in Section 2.2.3.)
  - Exposure pathways for radionuclides include incidental soil ingestion, inhalation of dust, and direct (external) exposure[3].

[2] In the case of WAC 173-303-665, landfill closure, there are presumed to be institutional controls with no direct contact.

[3] The direct (external) exposure pathway for radionuclides is analogous to the dermal pathway for chemicals. EPA risk assessment guidance (EPA/540/1-89/002) states (Page 10-26): "Exhibits 6-13 and 6-15 illustrate the dermal uptake of contaminants resulting from immersion in water or contact with soil. This route of uptake can be important for many organic chemicals; however, dermal uptake is generally not an important route of uptake for radionuclides, which have small dermal permeability constants. External radiation exposure due to submersion in water contaminated with radionuclides is possible and is similar to external exposure due to immersion in air……..".

Exposure point concentrations (EPCs) for soil will include the standard point of compliance (i.e., 4.6 m [15 ft bgs]) based on MTCA (WAC 173-340-740(6)(d)) as well as any additional evaluations in support of alternatives for which the soil cleanup levels will not be met at the point of compliance specified in WAC 173-340-740(6)(b through e), as described in Section 1.5.

A construction worker exposure scenario will be used to evaluate radiological contamination below 4.6 m (15 ft) bgs to inform decisions about selection of remedial alternatives, specifically site controls and the length of time site access would need restrictions. Note that the construction worker will be evaluated in accordance with DOE O 435.1, Chg. 1, *Radioactive Waste Management*, via its reference to DOE O 458.1, Chg. 3, Radiation Protection of the Public and the Environment, and associated changes. The basis for the construction worker scenario and source of equations used to calculate cancer risks will be drawn from the most recent version of EPA's radionuclide PRG guidance[4] (EPA, 2020a). The exposure parameters for the construction worker scenario for radionuclides are defined in Appendix A, Table A-2. Key assumptions are as follows:

- Exposure pathways selected for the construction worker scenario are based on the assumption that direct contact exposure is potentially complete to contaminants in soil.
  - Exposure pathways for radionuclides include incidental soil ingestion, inhalation of dust, and direct (external) exposure, which is analogous to the dermal pathway for chemicals as stated before.

In addition, the BRA will present risk characterization results for the two Native American (tribal) scenarios. Exposure assumptions for these scenarios are based on information provided in exposure scenario documents developed by the Confederated Tribes of the Umatilla Indian Reservation (Harris and Harper 2004, *Exposure Scenario for CTUIR Traditional Subsistence Lifeways*; Harris, 2008, *Application of the CTUIR Traditional Lifeways Exposure Scenario in Hanford Risk Assessments*) and the Yakama Nation (Ridolfi, 2007, *Yakama Nation Exposure Scenario for Hanford Site Risk Assessment Richland, Washington*).

2.2.1.2 Basis for Action

For protection of human health (direct contact), the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)-defined basis for action for radionuclides is 1 in 10,000 cumulative excess lifetime cancer risk. The basis for action for chemicals is based on the EPA Regional Screening Levels calculation at 1 in 100,000 for cancer risks[5] or a hazard index of 1.0 for noncancer hazards. The BRA will use the outdoor worker exposure scenario to determine if remedial action is warranted. Ecological risk and groundwater protection will also be considered to determine if remedial action is warranted, as discussed in Sections 2.2.2 and 2.2.3, respectively.

2.2.1.3 Identification of Contaminants of Potential Concern

For protection of human health (direct contact), a contaminant of potential concern (COPC) is defined as an analyte suspected of being associated with site-related activities that represents a potential threat to human health and for which data are of sufficient quality for use in a quantitative HHRA. A broad list of contaminants (radionuclides and chemicals) will initially be evaluated in a quantitative HHRA.

---

[4] Construction worker PRGs will be the lower of the risk-based concentration (1 × 10-4 target risk) or 500 mrem/yr. The risk coefficients, dose conversion factors, and equations in EPA's Radionuclide PRG guidance are consistent with those provided in DOE-STD-1196-2011, *Derived Concentration Technical Standard*, or more recent versions of this report.

[5] As stated in Section 1.2, the need for action for nonradionuclides will also be evaluated at a cumulative cancer risk of between 1 in 10,000 and 1 in 100,000 and a hazard index of 1 for noncarcinogenic effects.

The characterization strategy for each OU/WMA will be used to identify the list of contaminants. Identification of COPCs will take into consideration existing site characterization data, process knowledge, and inventory estimates.

The risk characterization will discuss contaminants whose measured concentrations are elevated above their corresponding soil background levels and their contribution to site risks as well as naturally occurring elements that are not CERCLA hazardous substances, pollutants, and contaminants. The contribution from naturally occurring metals and radioisotopes as well as widespread anthropogenic radioisotopes will be evaluated in accordance with OSWER Directive 9285.7-41, *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites.*

The approach used for the evaluation of soil background will be the same as that used in the BRA in the River Corridor OUs. A summary of the 90th percentile and maximum Hanford Site soil background concentrations is provided in Appendix A, Table A-3. It is important to note that some of the background concentrations in this table might be updated in the future when available information and/or improvements in analytical methods warrant updating any of these values.

Analytes that are not related to Hanford Site waste or will not contribute significantly to human health risks are not carried into a quantitative risk assessment. The analytes include (1) radionuclides with a half-life of less than 3 years; (2) essential nutrients; (3) soil physical property measurements; and (4) background or naturally occurring radionuclides such as potassium-40, thorium-232, and radium-226 and daughters as applicable. This approach is the same as used in the River Corridor OUs.

Quantitative risks will be assessed for analytes with toxicity values from the sources presented in Section 2.2.1.5. Analytes without toxicity values will be discussed qualitatively as part of the risk characterization.

2.2.1.4 Exposure Assessment

The exposure assessment will address methods for (1) developing EPCs in soil, and (2) calculating concentrations in air from EPCs in soil using EPA's screening models, as described below.

Development of Exposure Point Concentrations in Soil

During the data quality objective process, spatial exposure areas will be defined, and sampling and analytical data will be grouped for calculating EPCs, taking into consideration factors such as the nature and extent of contamination and process knowledge. Depths in soil will be identified for grouping samples based on the characterization strategy. In general, the data quality objective process will define how soil samples collected from small waste sites will be grouped into a single exposure area, whereas soil samples from large waste sites (e.g., ponds) may be separated into more than one exposure area.

The EPA software ProUCL version 5.1 or later (available at https://www.epa.gov/land-research/proucl-software) shall be used to calculate EPCs for the statistical sample design. The highest "suggested upper confidence limit (UCL) to use" provided in the ProUCL output file shall be used as the EPC, unless the software provides a warning indicating that the "recommended UCL exceeds maximum observation." When this warning is provided or when ProUCL cannot calculate a UCL value or does not provide a "suggested UCL to use," the maximum observed concentration will be used as the EPC.

For judgmental samples, risk characterization will be performed on a sample-by-sample basis, unless the corresponding RI/RFI work plan specifies some other method of data analysis.

Development of Exposure Point Concentrations in Air from Soil
Particulate emission factors for windblown dust and volatilization factors for volatile organic compounds (when appropriate) will be calculated in accordance with EPA guidance (OSWER Directive 9355.4-24, *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*).

2.2.1.5 Toxicity Assessment

The toxicity criteria used for the human health cancer risk and noncancer hazard calculations will be obtained from the sources described in the following subsections.

Toxicity Values for Nonradionuclides
For nonradionuclides, the analyte-specific toxicity values are determined using the recommended reference hierarchy as described in OSWER Directive 9285.7-53, *Human Health Toxicity Values in Superfund Risk Assessments*. The hierarchy is the same as used in the BRAs for the River Corridor OUs:

- Tier 1 – EPA Integrated Risk Information System (IRIS)
- Tier 2 – EPA Provisional Peer Reviewed Toxicity Values (PPRTVs)
- Tier 3 – Other Toxicity Values

Tier 1 – IRIS. The preferred source of toxicity data is the EPA IRIS database (available at: https://www.epa.gov/iris). Expert toxicologists at EPA have derived the values in this database, and the values have undergone thorough review and validation to develop slope factors and reference dose values both within and outside of the EPA. If a toxicity value is available in IRIS, that value is used in preference to values published in Tier 2 and Tier 3 sources.

Tier 2 – PPRTVs. If a toxicity value is not available in IRIS, the next source is the EPA PPRTVs. This source includes toxicity values that have been developed by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center. This database is available to the general public (http://hhpprtv.ornl.gov) and is also accessible to EPA risk assessors via the EPA intranet. These values are also published at the EPA Regional Screening Levels website (available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables). Tier 2 values are used in preference to Tier 3 values.

Tier 3 – Other Toxicity Values. Tier 3 includes additional EPA and non-EPA sources of toxicity information, including the following:

- The California EPA Toxicity Criteria Database (available at: http://oehha.ca.gov/tcdb/index.asp) provides toxicity values that are peer reviewed and address both carcinogenic and noncarcinogenic effects.

- The Agency for Toxic Substances and Disease Registry minimal risk levels (available at: http://www.atsdr.cdc.gov/mrls/index.html) for hazard substances are peer-reviewed estimates of the daily human exposure to hazardous substances that is likely to be without appreciable risk of adverse noncarcinogenic health effects over a specified duration of exposure.

- Toxicity values from *Health Effects Assessment Summary Tables (HEAST), FY 1997 Update* (available at: https://epa-heast.ornl.gov).

- National Center for Environmental Assessment toxicity values found in the Risk Assessment Information System (available at: http://rais.ornl.gov).

Toxicity Values for Radionuclides

The software and data package DC_PAK (Dose Coefficient File Package) (DCFPAK 3.02 or present version) later morbidity risk factors within the RESidual RADioactive (RESRAD) dose model (available at: http://resrad.evs.anl.gov/) will be used for selecting the risk coefficients for radiological COPCs.

2.2.1.6 Risk Characterization

Risk estimates will be presented by exposure area and depth in soil. The BRA will also discuss risk estimates relative to Hanford Site background levels. The risk characterization identifies the COPCs that are risk drivers.

2.2.1.7 Discussion of Uncertainties

Uncertainties will be identified for each step of the HHRA process (i.e. data analysis, exposure assessment, toxicity assessment, and risk characterization); sensitivity analysis or probabilistic tools could be used to provide additional information. Further, IAMIT Determination 2018-001 (IAMIT, 2018-001, "Tri-Party Program Managers' Agreement on the Use and Application of the Most Recent Version of the EPA-Approved ProUCL Software") requires additional information to be presented in the uncertainty evaluation section of the BRA for some UCL calculation occurrences. The discussions will identify whether risks from contaminants in soil are likely overstated or understated.

2.2.1.8 Methods for Calculating Human Health Cleanup Levels

Cleanup levels for direct contact with radionuclides in soil, structures (including pipelines), and debris will be developed using parameters for the outdoor worker scenario identified in Section 2.2.1.1, as well as the toxicity values identified in Section 2.2.1.5. The outdoor worker PRGs will be used to represent reasonable maximum exposure for the industrial worker exposure to contaminated soil. For pipelines, structures and debris, the two-dimensional outdoor worker external exposure will be used to represent reasonable maximum exposure. The two-dimensional method is developed to evaluate risks from exposure to structures with surface radioactive contamination. In this method, the outdoor worker is exposed to radioactively contaminated dust settled on finite slabs. The only pathway considered is external exposure to ionizing radiation (EPA, 2020a). Table A-1 provides the exposure parameters that will be used. PRGs corresponding to a 10^{-4} acceptable cancer risk level will be used for radionuclides. The methodology used to calculate soil PRGs for radionuclides is consistent with the methodology used for the BRAs for the River Corridor OUs.

Cleanup levels for direct contact with chemicals in soil will be based on MTCA Method C industrial cleanup levels for direct contact (WAC 173-340), along with toxicity values identified in Section 2.2.1.5. Cleanup levels for structures (including pipelines), and debris will be set on a case-by-case basis. In the case of landfill closure under WAC 173-303-665, "Landfills," there are presumed to be institutional controls with no direct contact. In the case of clean closure of a *Resource Conservation and Recovery Act of 1976* (RCRA) unit, MTCA Method B will be used or alternative requirements as applicable.

The PRGs will be developed based on a 10^{-5} acceptable cancer risk level or a noncancer hazard quotient of 1. MTCA equations will be used to calculate PRGs based on direct contact (soil ingestion) and, where relevant, the PRG value will be based on the inhalation exposure pathway when it is lower than soil ingestion. The cumulative cancer risk threshold for chemicals is also 10^{-5}, so adjustment to cleanup levels based on cumulative risk may be relevant. Adjustments for multiple contaminants having similar mode of action or multiple pathways of exposure will be made.

2.2.2 Ecological Risk Assessment Approach

The ERA approach will follow EPA guidance and the terrestrial ecological evaluation procedures developed by Ecology (MTCA). The ERAs will include explanations of how the methodology conforms to guidance and requirements identified in MTCA. The ERA approach is the same as that used in the BRAs in the River Corridor OUs.

2.2.2.1 Identification of Contaminants of Potential Ecological Concern

Contaminants of potential ecological concern will be identified using the same process developed for the HHRA (Section 2.2.1.3) but will consider ecological pathways and screening levels.

2.2.2.2 Conceptual Site Model for Ecological Exposure

The CSM for ecological exposure pathways will include the elements described by OSWER Directive 9285.7-25, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments – Interim Final*. Although not specifically referred to as a CSM, these same elements are also part of the simplified terrestrial ecological evaluation procedures (WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures") and site-specific terrestrial ecological evaluation procedures under MTCA (WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures"). Previously developed evaluations will be used, including the conceptual model of ecological exposure pathways and receptors developed for the most recent versions of Tier 1 and Tier 2 ecological PRGs (CHPRC-00784, *Tier 1 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site* [hereinafter referred to as Tier 1 ecological soil screening levels (SSLs)]; Tier 2 wildlife PRGs [CHPRC-01311, *Tier 2 Risk-Based Soil Concentrations Protective of Ecological Receptors at the Hanford Site*]; ECF-HANFORD-11-0158, *Tier 2 Terrestrial Plant and Invertebrate Preliminary Remediation Goals (PRGs) for Nonradionuclides for Use at the Hanford Site* [hereinafter referred to as Tier 2 plant/invertebrate PRGs]).

2.2.2.3 Evaluation of Biointrusion

The ERA may include a discussion of the depth of soil to which ecological receptors are exposed. This discussion will use the analysis presented in CHPRC-00651, *Evaluation of Biointrusion at the Hanford Site for Protection of Ecological Receptors*, Draft B. If a conditional point of compliance for soil depth is proposed, both the standard point of compliance and the conditional point of compliance will be presented as remedial action alternatives in the FSs (and CMSs, as applicable). For SST WMAs and other areas that will be placed under engineered surface barriers, a conditional point of compliance for soil depth will not be evaluated.

2.2.2.4 Exposure Assessment

The exposure assessment will use exposure parameters, representative species, and transfer factors found in the most recent versions of Tier 1 ecological SSLs (CHPRC-00784) and Tier 2 wildlife PRGs (CHPRC-01311) that have already been evaluated and used in ERAs in the River Corridor OUs. Estimation of EPCs in soil will use the same data and parallel the methods as presented for the HHRA.

2.2.2.5 Effects Assessment

The ecological effects assessment consists of an evaluation of available toxicity or other effects information to evaluate the significance of exposure to contaminants relative to potential adverse effects to ecological receptors. The effects data used in the ERA are represented by single-chemical toxicity data for radionuclides and nonradionuclides. These effects levels are then used either directly (for plants and invertebrates) or within exposure dose models (for wildlife) to establish concentrations in exposure media (e.g., soil) that are protective of plant and invertebrate communities and wildlife populations. The effects assessment will use the same approach that has been used for terrestrial ERAs across the Hanford Site

River Corridor (e.g., DOE/RL-2010-95). In this approach, the assessment will use toxicity reference values for wildlife that have been developed in the most recent versions of Tier 1 ecological SSLs (CHPRC-00784) and Tier 2 wildlife PRGs (CHPRC-01311)[6]. The same soil thresholds protective of wildlife that were developed from these toxicity reference values will be used for wildlife in the Central Plateau. For nonradiological contaminants, effect values for terrestrial plants and invertebrates will be the soil threshold concentrations presented in the most recent versions of Tier 1 ecological SSLs (CHPRC-00784) and Tier 2 plant/invertebrate PRGs (ECF-HANFORD-11-0158). The DOE's biota concentration guidelines for terrestrial plants and animals represent the radiological ecological screening levels for radionuclides in soil.

2.2.2.6 Risk Characterization

Ecological risk characterization will use standard methods and approaches already employed along the River Corridor, including the following:

- Calculation of ecological hazard quotients.
- Evaluation of risk relative to established background levels to aid in identifying risk drivers.
- Methods for characterizing risks when a scientific-management decision point (SMDP) is reached.

The SMDP is reached when exposures are higher than an ecological hazard quotient of 1 (i.e., an EPC is higher than a PRG). The potential for population-level risks to wildlife and community-level risks to plants and invertebrates will be evaluated, and a risk management decision will be made using the SMDP. The approach is the same as was used for the River Corridor OU BRAs. The SMDP will consider the following:

- Spatial characteristics of the waste site (area and depth of the waste site)
- Proximity and size of other waste sites and unaffected habitat
- Extent of site characterization (sample density, characterization of lateral extent of contamination)
- Data quality (presence of qualifiers, adequacy of detection limits)
- Frequency that risk based thresholds are exceeded and the location(s) of those exceedances
- Chemical-specific properties of each contaminant of potential ecological concern (potential to biomagnify, persistence)
- Ecological receptors specific details
- Feeding guild that is affected (plants; insects; omnivorous, herbivorous, insectivorous, or carnivorous wildlife)
- Proportion of receptors affected
- Likelihood of population- or community-level effects
- Home range of the receptors at risk relative to the area exceeding PRG

[6] The referenced documents can be updated as new information becomes available. If any of the documents are updated and referenced in a decision document, the updated documents will be available for review concurrent with the decision document. For example, the previous versions of CHPRC-00784 and CHPRC-01311 were reviewed by the Washington State Department of Ecology during their review of the 100-DH RI/FS document (DOE/RL-2010-95). The regulators' comments were dispositioned and their concurrence was obtained through that process. The current version of these two documents was then revised to reflect these dispositions.

- Evaluation of PRG (level of confidence, basis, relation to other PRGs such as those for human health or groundwater protection)

In the preparation of the ERA, risk assessors will evaluate potential risks to populations of mammals and birds and to communities of plants and invertebrates. Uncertainties will be identified for each step of the ERA process (i.e., data analysis, effects assessment, exposure assessment, and risk characterization); sensitivity analysis or probabilistic tools could be used to provide additional information. Risk assessors will then propose conclusions through the SMDP. Risk managers from DOE and the regulatory agencies will review and concur or revise the SMDP conclusions.

2.2.2.7 Methods for Calculating Ecological Cleanup Levels

PRGs have been developed for individual feeding guilds (for birds and mammals) and for plants and invertebrates. The PRGs for chemicals are based on lowest observed affect exposure levels and are found in the most recent versions of Tier 2 wildlife PRGs (CHPRC-01311) and Tier 1 ecological SSLs (CHPRC-00784) (for birds and mammals) and Tier 2 plant/invertebrate PRGs (ECF-HANFORD-11-0158). Tables A-4 through A-8 list the SSLs and PRGs for plants, invertebrates, and wildlife (birds and mammals).

Based on guidance from ICRP-60, *1990 Recommendations of the International Commission on Radiological Protection*; IAEA 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*; and UNSCEAR, 2000, *Sources and Effects of Ionizing Radiation*, two radiological effect threshold criteria were considered during the development of both generic and Tier 1 SSLs:

1. Radiological doses to aquatic animals and to terrestrial plants should not exceed 1.0 rad/d.
2. Radiological doses to terrestrial animals should not exceed 0.1 rad/d.

It should be noted that DOE has adopted these effect thresholds and integrated them into DOE-STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. RESRAD-BIOTA is the software tool used to implement the screening and analysis methods in DOE-STD-1153-2002 or associated updates.

No Tier 2 PRGs for radionuclides were calculated. Hence, the most recent version of Tier 1 ecological SSLs (CHPRC-00784) will be used for decision making.

2.2.3 Evaluation of Groundwater Protection

The evaluation of groundwater protection will be based on the graded approach document (DOE/RL-2011-50). The development of SSLs and PRGs for groundwater protection will be based on protecting groundwater directly below each waste site. In addition, cumulative impacts from all waste sites and other sources within the Central Plateau will also be evaluated as described in DOE/RL-2018-69, *Cumulative Impact Evaluation Technical Approach Document*. The evaluation will be based on available information and initial CSMs. Additional information from source and groundwater investigations, remedy implementation, and long-term monitoring will become available as characterization efforts and remedy decisions are implemented. This information (and interpretations) may lead to revisions of the CSMs.

The graded approach document (DOE/RL-2011-50) establishes the use of Subsurface Transport Over Multiple Phases (STOMP) (PNNL-12030, *STOMP: Subsurface Transport Over Multiple Phases Version 2.0: Theory Guide*) as the fate and transport model to be used for groundwater protection evaluations. To facilitate the modeling approach for the Central Plateau, five hydrogeologic provinces were identified in the graded approach document based on vadose zone hydrogeologic similarity.

The characteristics, thickness, and vertical distribution of the vadose zone sediments of the five provinces are provided in the graded approach document, and can be updated as additional information is gathered for waste sites and WMAs across the Central Plateau. Other parameter values used for the groundwater protection evaluation include ranges of distribution coefficient (K_d) values and net infiltration rates.

For evaluation of groundwater protection for soil and vadose zone contamination within the Central Plateau, K_d values identified for the River Corridor (DOE/RL-2010-95) will be used.
Because DOE/RL-2010-95 did not identify a K_d value for uranium, a K_d value of zero will be used for all waste sites unless site-specific information is available. However, when additional information gathered during characterization of vadose zone contamination becomes available, some of these K_d values can be updated or a different sorption model can be applied when supported by characterization information.

Long-term net infiltration rates will be defined as documented in the graded approach document (DOE/RL-2011-50). To summarize, 4 mm/yr will be used as the long-term infiltration rate for two scenarios based on two future end states:

- **Native land cover scenario:** Assumes revegetation with native plants that will mature within about 30 years of remediation and vegetation, consistent with the graded approach document (DOE/RL-2011-50). While revegetation is an important part of waste site remediation, the timeframe for Central Plateau habitat restoration to pre-disturbance conditions is uncertain.

- **Evapotranspiration barrier scenario:** Assumes installation of an evapotranspiration barrier at the waste site(s). After the barrier is installed, the effective infiltration rate will be reduced to 0.5 mm/yr. The barrier will be assumed to have a design life of 500 years. After that net infiltration rates will return to the natural land cover rate of 4 mm/yr.

During the CMS/FS, a sensitivity analysis may be conducted in accordance with IAMIT, 2019-004, "Tri-Party Program Managers Agree to Maintain the 4.0 mm/year Long-Term Recharge Rate for the 200-EA-1 Operable Unit (OU) RFI/RI Groundwater Protection Evaluations, and to Perform a Sensitivity Analysis During the 200-EA-1 OU CMS/FS Remedial Alternatives Evaluations, as Described in this Determination." The sensitivity analysis will be limited to waste sites with COCs having a groundwater protection basis for action. DOE will consult with the lead regulatory agency on waste site selection, considering site-specific uncertainties, for the sensitivity analysis. The sensitivity analysis will evaluate potential impacts to groundwater resulting from changes in recharge rates associated with different land surface vegetation conditions. The results will provide information regarding remedy performance associated with post-remediation changes in land surface vegetation conditions under a bounding scenario where invasive species dominate the landscape. Results of the sensitivity analysis will be discussed in the CMS/FS.

Table A-4/Figure A-1, and Table A-5/Figure A-2 illustrate the native vegetation and infiltration barrier scenarios for waste sites and WMAs, respectively, based on the input and evaluations provided in the graded approach document (DOE/RL-2011-50). To establish compliance of the groundwater protection evaluation approach with the requirements of WAC 173-340-747(8), "Deriving Soil Concentrations for Groundwater Protection," a single crosswalk for waste sites applicable across the Central Plateau will be developed. This crosswalk will follow the structure documented in DOE/RL-2010-95. Following this development, and within each of the OUs or WMAs, each risk assessment will identify unique application aspects for waste sites and demonstrate how the *Washington Administrative Code* requirements are met.

2.2.3.1 Basis for Calculation of Screening Levels and Preliminary Remediation Goals

The evaluation of groundwater protection approach involves the evaluation of the potential for groundwater contamination from a given waste site (with known or assumed waste geometry) or the

calculation of SSLs or PRGs. The SSLs and PRGs are soil and vadose zone concentrations that would not impact groundwater above pre-defined levels. Consistent with the graded approach document (DOE/RL-2011-50; Figure 3-1), the SSLs will be used to identify COPCs, and the PRGs will be used to set cleanup levels.

For the SSLs calculation, these soil concentrations would not impact groundwater concentrations above the lowest value from the following:

- Chemicals; concentrations calculated for the EPA tap water scenario based on carcinogenic effects calculated at target risk level of 1×10^{-6}, as applicable
- Radionuclides; concentrations calculated for the EPA tap water scenario based on carcinogenic effects calculated at target risk level of 1×10^{-5}
- Concentrations calculated for the EPA tap water scenario based on noncarcinogenic effects calculated at a hazard quotient value of 0.1, as applicable

The groundwater protection PRGs would be calculated as concentrations that would not impact groundwater concentrations above the lowest value from the following:

- The federal and state maximum contaminant level values, where available
- EPA screening levels for radionuclides for which no maximum contaminant level is available; groundwater cleanup level is calculated using the tap water scenario at an individual target risk level of 1×10^{-4}
- MTCA Method B cleanup level for groundwater based on carcinogenic effects calculated at target risk level of 1×10^{-6}, as applicable, with downward adjustment to maintain cumulative risk below 1×10^{-5} for multiple contaminants in accordance with WAC 173-340-708(5) and (6), "Human Health Risk Assessment Procedures"
- MTCA Method B cleanup level for groundwater based on noncarcinogenic effects calculated at a hazard quotient value of 1, as applicable, with downward adjustment to maintain a total hazard index of 1 for multiple contaminants in accordance with WAC 173-340-708(5) and (6)

2.2.3.2 Evaluation of Cumulative Impacts and Approach for Evaluation of Conditional Point of Compliance

An alternative can be developed in the FS (and CMS, as applicable) that considers a conditional point of compliance in groundwater. The detailed evaluation of this alternative will consider the evaluation of cumulative impacts, taking into consideration the upgradient groundwater contamination through the same comprehensive approach as PNNL-11800, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, and the cumulative impact analysis conducted for the Tank Closure and Waste Management Environmental Impact Statement (DOE/EIS-0391). The following considerations will be defined for this evaluation:

- The conditional point of compliance process will define a model domain (in space and time) that covers all the source waste sites within the boundary as well as existing groundwater contamination. An example of this boundary is shown in Figure 2. This example boundary encompasses all of the liquid effluent disposal sites and the existing concentrated groundwater contamination areas within the Central Plateau. The actual boundary will be determined through the RI/FS process (and RFI/CMS, as applicable) for source OUs/WMAs. The evaluation will be conducted for 1,000 years.

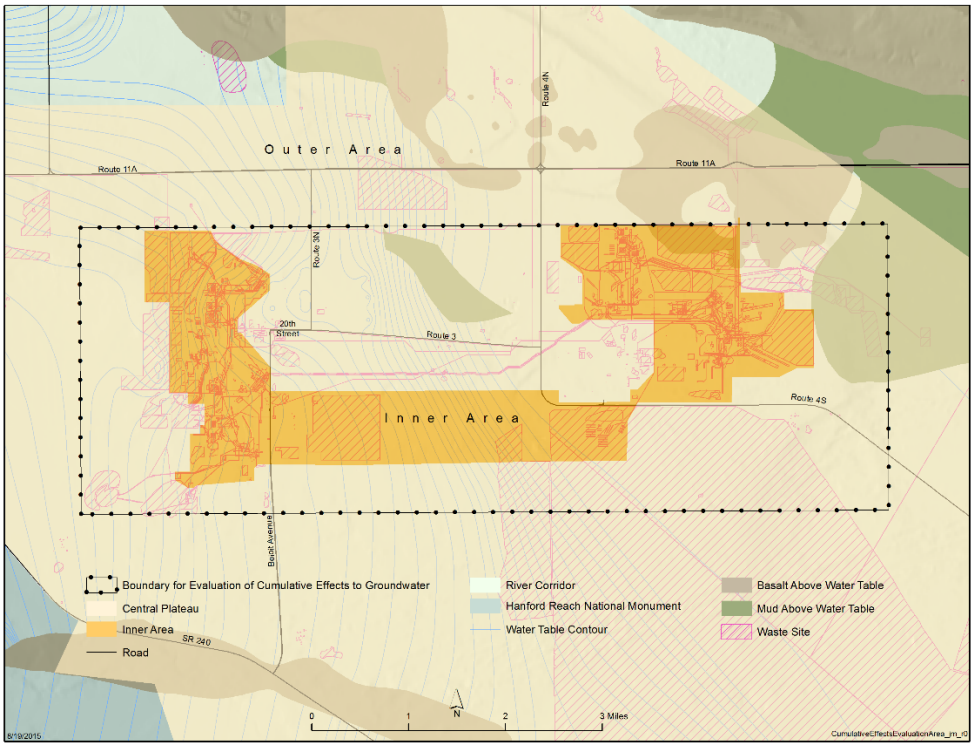

Figure 2. Example Boundary for the Evaluation of Conditional Point of Compliance for Groundwater Protection

- Inventory estimates for waste sites will include measurements for surface soils and the vadose zone, as well as the following sources:
  - **Liquid disposal sites:** Hanford Site soil inventory model mean values (PNNL-16940, *Hanford Soil Inventory Model (SIM) Rev. 2 Software Documentation – Requirements, Design, and Limitations*) will be used for the base case. Ranges of effluent volumes and associated contaminant concentrations provided by the soil inventory model will be used to evaluate the uncertainties.
  - **Solid waste disposal sites:** Inventory estimates will be developed based on available information and available characterization measurements.
  - **Single-shell tank waste management area sources:** Data will be obtained from the most recent leak assessment reports and tank waste and ancillary equipment inventory estimates.
- A range of end-state conditions for waste sites and groundwater will be evaluated using the same approach documented in PNNL-14027, *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*, which will be updated to reflect the current decisions and response actions that have already been implemented for the groundwater contamination on the Central Plateau, including perched water removal.

The approach for evaluation of cumulative impacts from waste sites, SST WMAs, and other sources within the Central Plateau is described in DOE/RL-2018-69. Future decision documents for OUs and SSWT WMAs will reference this document and update the utilized tools and information as necessary to

reflect CSM updates, and the required evaluations. That is, the cumulative impact evaluation tools, models, and databases will be continually updated as additional source and groundwater information is obtained through characterization and remediation efforts and as waste sites and WMAs advance through the regulatory process.

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Appendix A

Human Health Scenarios Exposure Factors, Soil Background Values, Ecological Cleanup Levels, and Recharge Scenarios

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A1 Introduction

This appendix provides human health scenarios exposure factors, soil background values, ecological cleanup levels, and recharge scenarios (Tables A-1 through A-10). Figure A-1 shows the Central Plateau Inner Area Native Vegetation Recharge Scenario, and Figure A-2 shows the Central Plateau Inner Area Infiltration Barrier Recharge Scenario.

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Table A-1. Summary of Outdoor Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Radiological		Chemicals	
			Value	Source	Value	Source
Excess lifetime cancer risk	Risk	unitless	Isotope-specific	Calculated	Analyte-specific	Calculated
Hazard quotient	HQ	unitless	N/A	N/A	Analyte-specific	Calculated
Chronic daily intake	CDI	Varies[a]	Isotope-specific	Calculated	Analyte-specific	Calculated
Soil concentration	Cs	mg/kg or pCi/g	Isotope-specific	Measured value	Analyte-specific	Measured value
Averaging time – carcinogens	ATc	days	N/A	—	25,550	Default; EPA/540/1-89/002
Averaging time – noncarcinogens	ATnc	days	N/A	—	9,125	Default; EPA/540/1-89/002
Body weight – adult	BW_a	kg	N/A	—	80	EPA/600/R-090/052F, Table 8-3
Exposure frequency	EF_{OW}	days/year	225	OSWER Directive 9200.1-120, Attachment 1	225	OSWER Directive 9200.1-120, Attachment 1
Exposure duration	ED_{OW}	year	25	OSWER Directive 9200.1-120, Attachment 1	25	OSWER Directive 9200.1-120, Attachment 1
Exposure time	ET_{OW}	hr/day	8	OSWER Directive 9200.1-120, Attachment 1	8	OSWER Directive 9200.1-120, Attachment 1
Soil ingestion rate	IRS_{OW}	mg/day	100	OSWER Directive 9200.1-120 Attachment 1	100	OSWER Directive 9200.1-120, Attachment 1
Area correction factor	ACF	unitless	Isotope-specific	ORNL, 2014	N/A	N/A
Gamma shielding factor	GSF	unitless	1	OSWER Directive 9355.4-16A	N/A	N/A
Dermal absorption fraction	ABSd	unitless	N/A	N/A	Analyte-specific	EPA/540/R/99/005
Skin surface area	SA_{OW}	cm^2	N/A	N/A	3,527	OSWER Directive 9200.1-120, Attachment 1
Soil adherence factor	AF_{OW}	mg/cm^2-day	N/A	N/A	0.12	OSWER Directive 9200.1-120, Attachment 1
Gastrointestinal absorption factor	ABS_{GI}	unitless	N/A	N/A	Analyte-specific	EPA/540/R/99/005
Inhalation rate – adult	INH_a	m^3/day	20	OSWER Directive 9285.6-03	N/A	N/A
Particulate emission factor	PEF	m^3/kg	7.30E+10	OSWER Directive 9355.4-24	7.30E+10	OSWER Directive 9355.4-24
Volatilization factor	VF	m^3/kg	N/A	N/A	Analyte-specific	EPA[b]
Carcinogenic slope factor for soil ingestion	SF_{si}	Risk/pCi	Isotope-specific	EPA[b]	N/A	N/A
Carcinogenic slope factor for external exposure	SF_x	Risk/year per pCi/g	Isotope-specific	EPA[b]	N/A	N/A
Carcinogenic slope factor for inhalation	SF_{inh}	Risk/pCi	Isotope-specific	EPA[b]	N/A	N/A
Oral carcinogenic slope factor	SF_o	$(mg/kg\text{-}day)^{-1}$	N/A	N/A	Analyte-specific	EPA[b]
Oral reference dose	RfD_o	(mg/kg-day)	N/A	N/A	Analyte-specific	EPA[b]
Inhalation unit risk factor	IUR	$(\mu g/m^3)^{-1}$	N/A	N/A	Analyte-specific	EPA[b]
Reference concentration	RfC	mg/m^3	N/A	N/A	Analyte-specific	EPA[b]
Decay constant	λ	unitless	0.693	OSWER Directive 9355.4-16A	N/A	N/A
Time	T_{OW}	years	25	OSWER Directive 9285.6-03	N/A	N/A

Note: Complete reference citations are provided in Section A2.

a. The units for chronic daily intake values vary based on exposure route and contaminant type (chemical or radionuclide).

b. Values will be obtained from the sources described in Section 2.2.1.5, "Toxicity Assessment."

EPA = U.S. Environmental Protection Agency

N/A = not applicable

Table A-2. Summary of Construction Worker Scenario Exposure Parameters

Exposure Parameter	Symbol	Units	Value	Source
Excess lifetime cancer risk	Risk	Unitless	Isotope-specific	Calculated
Chronic daily intake	CDI	Varies[a]	Isotope-specific	Calculated
Soil concentration	Cs	pCi/g	Isotope-specific	Measured value
Exposure frequency – construction worker	EF_{CW}	days/year	30	Site-specific assumption (5 days per week for 6 weeks); DOE/RL-2007-27; Section A3.3.1
Exposure duration – construction worker	ED_{CW}	year	1	OSWER Directive 9355.4-24, Exhibit 5-1
Exposure time – construction worker	ET_{CW}	hr/day	8	Site-specific assumption, 8 hours per 24-hour day
Soil ingestion rate – construction worker	IRS_{CW}	mg/day	330	OSWER Directive 9200.1-120, Attachment 1
Inhalation rate – construction worker	INH_{CW}	m^3/day	60	EPA/600/P-95/002Fa (page 5-11), based on a rate of 2.5 m^3/hr for 24 hours
Area correction factor – soil volume	$ACF_{ext\text{-}sv}$	Unitless	Isotope-specific	ORNL/TM-2013/00
Gamma shielding factor	GSF	Unitless	1	OSWER Directive 9355.4-16A
Subchronic particulate emission factor	PEF_{sc}	m^3/kg	1.28×10^{-6}	OSWER Directive 9355.4-24
Carcinogenic slope factor for soil ingestion	SF_{si}	Risk/pCi	Isotope-specific	EPA[b]
Carcinogenic slope factor for external exposure	SF_x	Risk/year per pCi	Isotope-specific	EPA[b]
Carcinogenic slope factor for inhalation	SF_{inh}	Risk/pCi	Isotope-specific	EPA[b]
Decay constant	λ	Unitless	0.693	OSWER Directive 9355.4-16A
Time – construction worker	t_{cw}	years	1	OSWER Directive 9355.4-24, Exhibit 5-1

Note: Complete reference citations are provided in Section A2.

a. The units for chronic daily intake vary based on exposure route.

b. Values will be obtained from the sources described in Section 2.2.1.5, “Toxicity Assessment,” in the main text of this document.

EPA = U.S. Environmental Protection Agency

Table A-3. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Anthropogenic Radionuclides[a]					
Cesium-137	RAD	pCi/g	1.1	1.6	DOE/RL-96-12
Cobalt-60	RAD	pCi/g	0.0084	0.039	DOE/RL-96-12
Europium-154	RAD	pCi/g	0.033	0.079	DOE/RL-96-12
Europium-155	RAD	pCi/g	0.054	0.098	DOE/RL-96-12
Gross beta	RAD	pCi/g	23	25	DOE/RL-96-12
Plutonium-238	RAD	pCi/g	0.0038	0.019	DOE/RL-96-12
Plutonium-239/240	RAD	pCi/g	0.025	0.033	DOE/RL-96-12
Radium-228	RAD	pCi/g	1.8	2.3	DOE/RL-96-12
Strontium-90	RAD	pCi/g	0.18	0.37	DOE/RL-96-12
Thorium-228	RAD	pCi/g	1.4	1.6	DOE/RL-96-12
Total beta radiostrontium	RAD	pCi/g	0.18	0.37	DOE/RL-96-12
Naturally Occurring Radionuclides					
Potassium-40	RAD	pCi/g	17	20	DOE/RL-96-12
Radium-226	RAD	pCi/g	0.82	1.2	DOE/RL-96-12
Thorium-232	RAD	pCi/g	1.3	1.6	DOE/RL-96-12
Uranium-233/234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12
Uranium-234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12
Uranium-235	RAD	pCi/g	0.11	0.39	DOE/RL-96-12
Uranium-238	RAD	pCi/g	1.1	1.2	DOE/RL-96-12
Metals					
Aluminum	METAL	mg/kg	11,800	28,800	DOE/RL-92-24, Vol. 1
Antimony	METAL	mg/kg	0.13	0.385	ECF-HANFORD-11-0038
Arsenic[b]	METAL	mg/kg	6.47	27.7	DOE/RL-92-24, Vol. 1
Barium	METAL	mg/kg	132	480	DOE/RL-92-24, Vol. 1
Beryllium	METAL	mg/kg	1.51	10	DOE/RL-92-24, Vol. 1
Boron	METAL	mg/kg	3.89	5.86	ECF-HANFORD-11-0038

Table A-3. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Cadmium	METAL	mg/kg	0.563	2.98	ECF-HANFORD-11-0038
Calcium	METAL	mg/kg	17,200	105,000	DOE/RL-92-24, Vol. 1
Chromium	METAL	mg/kg	18.5	320	DOE/RL-92-24, Vol. 1
Cobalt	METAL	mg/kg	15.7	110	DOE/RL-92-24, Vol. 1
Copper	METAL	mg/kg	22	61	DOE/RL-92-24, Vol. 1
Iron	METAL	mg/kg	32,600	68,100	DOE/RL-92-24, Vol. 1
Lead	METAL	mg/kg	10.2	74.1	DOE/RL-92-24, Vol. 1
Lithium	METAL	mg/kg	13.3	19.2	ECF-HANFORD-11-0038
Magnesium	METAL	mg/kg	7,060	32,300	DOE/RL-92-24, Vol. 1
Manganese	METAL	mg/kg	512	1,110	DOE/RL-92-24, Vol. 1
Mercury	METAL	mg/kg	0.013	0.029	ECF-HANFORD-11-0038
Molybdenum	METAL	mg/kg	0.47	3.17	ECF-HANFORD-11-0038
Nickel	METAL	mg/kg	19.1	200	DOE/RL-92-24, Vol. 1
Potassium	METAL	mg/kg	2,150	7,900	DOE/RL-92-24, Vol. 1
Selenium	METAL	mg/kg	0.78	0.84	ECF-HANFORD-11-0038
Silver	METAL	mg/kg	0.167	0.273	ECF-HANFORD-11-0038
Sodium	METAL	mg/kg	690	6.06E+03	DOE/RL-92-24, Vol. 1
Thallium	METAL	mg/kg	0.185	0.523	ECF-HANFORD-11-0038
Uranium	METAL	mg/kg	3.21	4.04	Isotopic activity conversion based on DOE/RL-96-12 values
Vanadium	METAL	mg/kg	85.1	140	DOE/RL-92-24, Vol. 1
Zinc	METAL	mg/kg	67.8	366	DOE/RL-92-24, Vol. 1
Anions					
Ammonia	ANIONS	mg/kg	9.23	26.4	DOE/RL-92-24, Vol. 1, Rev. 4
Chloride	ANIONS	mg/kg	100	1,480	DOE/RL-92-24, Vol. 1, Rev. 4
Fluoride	ANIONS	mg/kg	2.81	73.3	DOE/RL-92-24, Vol. 1, Rev. 4
Nitrate	ANIONS	mg/kg	52	906	DOE/RL-92-24, Vol. 1, Rev. 4
Phosphate	ANIONS	mg/kg	0.785	225	DOE/RL-92-24, Vol. 1, Rev. 4

Table A-3. Hanford Site Soil Background Concentrations

Analyte Name	Analyte Class	Units	90th Percentile Background Value	Maximum Background Value	Source of Background Value
Sulfate	ANIONS	mg/kg	237	12,600	DOE/RL-92-24, Vol. 1, Rev. 4

Note: Complete reference citations are provided in Section A2.

a The background values listed for fission products that are related to global fallout are only for shallow soils (less than 4.6 m [15 ft] below ground surface). Background values listed for naturally occurring radionuclides and nonradionuclides apply to the entire vadose zone.

b. Ecology, 2013, "Issues Associated with Establishing Soil Cleanup Levels for Arsenic," indicates that the Method A soil cleanup level of 20 mg/kg can be used to define natural background levels when developing soil cleanup levels for the Hanford Site.

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Table A-4. Soil Screening Levels in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA EcoSSLs			ORNL- ES/ER/fM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington State Dept. of Ecology - 2013 MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type			Background Soil Concentrations[a]	SSL for Plants and Soil Invertebrates[b]	Basis
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark			
Radionuclides	Americium-241	pCi/g	—	—	—	—	—	21,500	3,890	—	—	21,500	—	21,500	—	21,500	Benchmark
	Antimony-125	pCi/g	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Carbon-14	pCi/g	—	—	—	—	—	60,700	4,760	—	—	60,700	—	60,700	—	60,700	Benchmark
	Cesium-134	pCi/g	—	—	—	—	—	1,090	11.3	—	—	1,090	—	1,090	—	1,090	Benchmark
	Cesium 137	pCi/g	—	—	—	—	—	2,210	20.8	—	—	2,210	—	2,210	1.05	2,210	Benchmark
	Cobalt-60	pCi/g	—	—	—	—	—	6,130	692	—	—	6,130	—	6,130	0.00842	6,130	Benchmark
	Curium-244	pCi/g	—	—	—	—	—	153,000	4,060	—	—	153,000	—	153,000	—	153,000	Benchmark
	Europium-152	pCi/g	—	—	—	—	—	14,700	1,520	—	—	14,700	—	14,700	—	14,700	Benchmark
	Europium-154	pCi/g	—	—	—	—	—	12,500	1,290	—	—	12,500	—	12,500	0.0334	12,500	Benchmark
	Europium-155	pCi/g	—	—	—	—	—	153,000	15,800	—	—	153,000	—	153,000	0.0539	153,000	Benchmark
	Hydrogen-3 (tritium)	pCi/g	—	—	—	—	—	1,680,000	174,000	—	—	1,680,000	—	1,680,000	—	1,680,000	Benchmark
	Neptunium-237	pCi/g	—	—	—	—	—	8,150	3,860	—	—	8,150	—	8,150	—	8,150	Benchmark
	Nickel-63	pCi/g	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Plutonium-238	pCi/g	—	—	—	—	—	17,500	5,270	—	—	17,500	—	17,500	0.00378	17,500	Benchmark
	Plutonium-239/240	pCi/g	—	—	—	—	—	12,700	6,110	—	—	12,700	—	12,700	0.0248	12,700	Benchmark
	Radium-226	pCi/g	—	—	—	—	—	288	50.6	—	—	288	—	288	0.815	288	Benchmark
	Radium-228	pCi/g	—	—	—	—	—	245	43.9	—	—	245	—	245	—	245	Benchmark
	Strontium-90	pCi/g	—	—	—	—	—	3,580	22.5	—	—	3,580	—	3,580	0.178	3,580	Benchmark
	Technetium-99	pCi/g	—	—	—	—	—	21,900	4,490	—	—	21,900	—	21,900	—	21,900	Benchmark
	Thorium-232	pCi/g	—	—	—	—	—	23,500	1,510	—	—	23,500	—	23,500	1.32	23,500	Benchmark
	Uranium-234	pCi/g	—	—	—	—	—	51,600	5,130	—	—	51,600	—	51,600	1.1	51,600	Benchmark
	Uranium-235	pCi/g	—	—	—	—	—	27,400	2,770	—	—	27,400	—	27,400	0.109	27,400	Benchmark
	Uranium-238	pCi/g	—	—	—	—	—	15,700	1,580	—	—	15,700	—	15,700	1.06	15,700	Benchmark
Metals	Aluminum	mg/kg	Narrative Statement		OSWER Dir. 9285.7-60	50	—	—	—	50	—	50	—	50	11,800	11,800	Background
	Antimony	mg/kg	—	78	OSWER Dir. 9285.7-61	—	—	—	—	—	—	5	78	5	5.2	5.2	Background
	Arsenic, total all valence states	mg/kg	18	—	OSWER Dir. 9285.7-62	10	60	—	—	—	—	10	60	10	6.47	10	Benchmark
	Arsenic (III)	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Arsenic (V)	mg/kg	—	—	—	—	—	—	—	10	60	10	60	10	—	10	Benchmark
	Barium	mg/kg	—	330	OSWER Dir. 9285.7-63	500	—	—	—	500	---	500	330	330	132	330	Benchmark
	Beryllium	mg/kg	—	40	OSWER Dir. 9285.7-64	10	—	—	—	10	---	10	40	10	1.51	10	Benchmark
	Bismuth	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Boron	mg/kg	—	—	—	0.5	—	—	—	0.5	—	0.5	—	0.5	—	0.5	Benchmark

Table A-4. Soil Screening Levels in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA EcoSSLs			ORNL- ES/ER/fM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington State Dept. of Ecology - 2013 MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type			Background Soil Concentrations[a]	SSL for Plants and Soil Invertebrates[b]	Basis
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark			
	Cadmium	mg/kg	32	140	OSWER Dir. 9285.7-65	4	20	—	—	4	20	4	20	4	0.78	4	Benchmark
	Chromium (total)[c,d]	mg/kg	—	—	OSWER Dir. 9285.7-66	1	0.4	—	—	42	42	1	0.4	0.4	18.5	18.5	Background
	Chromium(III)	mg/kg	—	—	OSWER Dir. 9285.7-66	1	0.4	—	—	42	42	1	0.4	0.4	—	0.4	Benchmark
	Chromium(VI)	mg/kg	—	—	OSWER Dir. 9285.7-66	—	—	—	—	—	—	—	—	—	—	—	—
	Cobalt	mg/kg	13	—	OSWER Dir. 9285.7-67	20	—	—	—	20	—	13	—	13	15.7	15.7	Background
	Copper	mg/kg	70	80	OSWER Dir. 9285.7-68	100	50	—	—	100	50	70	50	50	22	50	Benchmark
	Lead	mg/kg	120	1700	OSWER Dir. 9285.7-70	50	500	—	—	50	500	50	500	50	10.2	50	Benchmark
	Lithium[d]	mg/kg	—	—	—	2	—	—	—	35	—	2	—	2	33.5	33.5	Background
	Manganese[d]	mg/kg	220	450	OSWER Dir. 9285.7-71	500	—	—	—	1,100	—	220	450	220	512	512	Background
	Mercury	mg/kg	—	—	—	0.3	0.1	—	—	0.3	0.1	0.3	0.1	0.1	0.33	0.33	Background
	Molybdenum	mg/kg	—	—	—	2	—	—	—	2	—	2	—	2	6	6	Background
	Nickel	mg/kg	38	280	OSWER Dir. 9285.7-76	30	200	—	—	30	200	30	200	30	19.1	30	Benchmark
	Selenium	mg/kg	0.52	4.1	OSWER Dir. 9285.7-72	1	70	—	—	1	70	0.52	4.1	0.52	0.78	0.78	Background
	Silver	mg/kg	560	—	OSWER Dir. 9285.7-77	2	—	—	—	2	—	2	—	2	0.73	2	Benchmark
	Strontium	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Thallium	mg/kg	—	—	—	1	—	—	—	1	—	1	—	1	—	1	Benchmark
	Tin	mg/kg	—	—	—	50	—	—	—	50	—	50	—	50	—	50	Benchmark
	Uranium	mg/kg	—	—	—	5	—	—	—	5	—	5	—	5	3.21	5	Benchmark
	Vanadium	mg/kg	—	—	OSWER Dir. 9285.7-75	2	—	—	—	2	—	2	—	2	85.1	85.1	Background
	Zinc[d]	mg/kg	160	120	OSWER Dir. 9285.7-73	50	200	—	—	86	200	50	120	50	67.8	67.8	Background
General inorganics	Ammonia/ammonium	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	9.23	9.23	Background
	Chloride	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	100	100	Background
	Cyanide	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Fluoride	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	2.81	2.81	Background
	Iodine	mg/kg	—	—	—	4	—	—	—	4	—	4	—	4	—	4	Benchmark
	Nitrate/nitrite	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	52	52	Background
	Phosphate	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	0.785	0.785	Background
	Sulfate/sulfite	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	237	237	Background
	Total organic carbon	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	—	—	—
Volatile organics	1,1-dichloroethane	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	—	—	—
	1,1-dichloroethene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	—	—	—
	1,1,1-trichloroethane	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	—	—	—

Table A-4. Soil Screening Levels in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA EcoSSLs			ORNL- ES/ER/fM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington State Dept. of Ecology - 2013 MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type			Background Soil Concentrations[a]	SSL for Plants and Soil Invertebrates[b]	Basis
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark			
	1,1,2-trichloroethane	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	—	—	—
	1,1,2,2-tetrachloroethane	mg/kg	—	—	—	—	—	—	—	—	—	—	—	---	—	—	—
	1,2-dichlorobenzene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1,2-dichloroethane (DCA)	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	1,3-dichlorobenzene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2-butanone (methyl ethyl ketone/MEK)	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2-hexanone	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Benzene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Butanol	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Carbon tetrachloride	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Chlorobenzene	mg/kg	—	—	—	—	40	—	—	—	40	—	40	40	—	40	Benchmark
	Chloroform	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	cis-1,2-dichloroethylene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Dichloromethane (methylene chloride)	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Ethyl benzene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Methyl isobutyl ketone	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	n-butyl benzene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Tetrachloroethylene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Toluene	mg/kg	—	—	—	200	—	—	—	200	—	200	—	200	—	200	Benchmark
	Trans-1,2-dichloroethylene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Trichloroethylene (TCE)	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Xylene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Polycyclic aromatic hydrocarbons	Acenaphthene	mg/kg	—	29	OSWER Dir. 9285.7-75	20	—	—	—	20	—	20	29	20	—	20	Benchmark
	Acenaphthylene	mg/kg	—	29	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	29	29	—	29	Benchmark
	Anthracene	mg/kg	—	29	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	29	29	—	29	Benchmark
	Benzo(a)pyrene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	Benzo(a)anthracene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	Benzo(b)fluoranthene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	Benzo(ghi)perylene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	Benzo[k]fluoranthene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	Chrysene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	Dibenz(ah)anthracene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark

Table A-4. Soil Screening Levels in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA EcoSSLs			ORNL- ES/ER/fM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington State Dept. of Ecology - 2013 MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type			Background Soil Concentrations[a]	SSL for Plants and Soil Invertebrates[b]	Basis
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark			
	Fluoranthene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	Fluorene	mg/kg	—	29	OSWER Dir. 9285.7-75	—	30	—	—	—	30	—	29	29	—	29	Benchmark
	Indeno[1,2,3-cd]pyrene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	2-methylnaphthalene	mg/kg	—	29	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	29	29	—	29	Benchmark
	Naphthalene	mg/kg	—	29	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	29	29	—	29	Benchmark
	Phenanthrene	mg/kg	—	29	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	29	29	—	29	Benchmark
	Pyrene	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
	Total PAHs	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Low molecular weight PAHs[e]	mg/kg	—	29	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	29	29	—	29	Benchmark
	High molecular weight PAHs[f]	mg/kg	—	18	OSWER Dir. 9285.7-75	—	—	—	—	—	—	—	18	18	—	18	Benchmark
Petroleum	Gasoline range organics	mg/kg	—	—	—	—	—	—	—	—	100	—	100	100	—	100	Benchmark
	TPH-diesel	mg/kg	—	—	—	—	—	—	—	—	200	—	200	200	—	200	Benchmark
	TPH-kerosene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Normal paraffin hydrocarbons	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Semivolatile organics	Phenol	mg/kg	—	—	—	70	30	—	—	70	30	70	30	30	—	30	Benchmark
	2-methylphenol (o-cresol)	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	4-methylphenol (p-cresol)	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	2,4-dinitrotoluene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Bis(2-ethylhexyl)phthalate[g]	mg/kg	—	—	—	100	—	—	—	100	—	100	—	100	—	100	Benchmark
	Polychlorinated biphenyls (PCB)[h,i]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
	Aroclor-1016[h,i]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
	Aroclor-1221[h,i]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
	Aroclor-1232[h,i]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
	Aroclor-1242[h,i]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
	Aroclor-1248[h,i]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
	Aroclor-1254[h,i]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
	Aroclor-1260[h,i]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
	Aroclor-1262[h,i,j]	mg/kg	—	—	—	40	—	—	—	40	—	40	—	40	—	40	Benchmark
Herbicide	Dichloroprop	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pesticides	Aldrin	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	beta-1,2 ,3,4,5,6-hexachlorocyclohexane[k,l]	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	alpha-chlordane[m]	mg/kg	—	—	—	—	—	—	—	---	1	—	1	1	—	1	Benchmark

Table A-4. Soil Screening Levels in Upland Soil for Plants and Soil Invertebrates

Group	Soil Constituent	Units	EPA EcoSSLs			ORNL- ES/ER/fM-85/R3, ES/ER/TM-126/R2		DOE BCGs		Washington State Dept. of Ecology - 2013 MTCA (WAC 173-340, Table 749-3)		Lowest Screening Benchmark by Receptor Type			Background Soil Concentrations[a]	SSL for Plants and Soil Invertebrates[b]	Basis
			Plants	Invertebrate	Reference	Plants	Invertebrate	Terrestrial Plant	Terrestrial Animal	Plant	Soil Biota	Plant	Inverts	Overall Lowest Screening Benchmark			
	gamma-chlordane[m]	mg/kg	—	—	—	—	—	—	—	---	1	—	1	1	—	1	Benchmark
	Dichlorodiphenyldichloroethylene	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Dichlorodiphenyltrichloroethane	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Dieldrin	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Endosulfan I	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Endosulfan II	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Endosulfan sulfate	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Endrin aldehyde	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Methoxychlor	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Sources: ES/ER/TM-85/R3, *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.*

ES/ER/TM-126/R2, *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision.*

2013 MTCA (WAC 173-340, "Model Toxics Control Act-Cleanup") .

a. Background soil concentrations are selected according to the following hierarchy: the 90th percentile of Hanford Site background; Washington State-wide background.

b. The selected PRG is the higher of either the background in soil or the overall lowest screening value between plants and soil invertebrates.

c. When chromium (total) was not available, the lower of either Cr(III) or Cr(VI) as available was used as a surrogate.

d. MTCA plant and soil biota benchmarks were replaced by Washington State natural background concentration.

e. The low molecular weight PAHs screening values from EPA (OSWER Directive 9285.7-78, *Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs): Interim Final*) represents the sum of the low molecular weight PAHs. For the purposes of this assessment, the benchmark was also applied to the individual low molecular weight PAHs.

f. The high molecular weight PAHs screening values from EPA (OSWER Directive 9285.7-78, *Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs): Interim Final*) represents the sum of the high molecular weight PAHs. For the purposes of this assessment, the benchmark was also applied to the individual high molecular weight PAHs.

g. Values for diethyl phthalate were used as a surrogate for bis(2-ethylhexy l)phthalate.

h. Aroclor-1254 value was used as surrogate.

i. MTCA values represent screening value for PCB mixtures.

j. MTCA Aroclor-1260 values used as surrogate for Aroclor-1262.

k. Form of HCB not identified in ES/ER/TM-126/R2.

l. MTCA value based on benzene hexachloride, including lindane.

m. MTCA values based on chlordane.

—	=	value not available	ORNL	=	Oak Ridge National Laboratory
BCG	=	biota concentration guide	PAH	=	polycyclic aromatic hydrocarbon
DOE	=	U.S. Department of Energy	PCB	=	polychlorinated biphenyl
EcoSSL	=	ecological soil screening level	PRG	=	preliminary remediation goal
EPA	=	U.S. Environmental Protection Agency	SSL	=	soil screening level
MTCA	=	Model Toxics Control Act	TPH	=	total petroleum hydrocarbons

Table A-5. Wildlife (Birds and Mammals) SSLs for Radionuclides

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadowlark	Killdeer	Red-Tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	NOAEL Lowest	California Quail	Meadowlark	Killdeer	Red-Tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grass-hopper Mouse	Badger	LOAEL Lowest
Radionuclides	Americium-241	pCi/g	—	—	—	—	—	—	—	—	—	28,900	25,000	11,900	17,800	72,100	48,700	41,400	4,840	4,840
	Carbon-14	pCi/g	—	—	—	—	—	—	—	—	—	54	60	56	50	61	60	135	32	32
	Curium-244	pCi/g	—	—	—	—	—	—	—	—	—	389,000	252,000	105,000	207,000	2,300,000	722,000	499,000	50,800	50,800
	Cobalt-60	pCi/g	—	—	—	—	—	—	—	—	—	805	805	805	863	805	805	806	1,000	805
	Cesium-134	pCi/g	—	—	—	—	—	—	—	—	—	1,140	1,190	1,200	854	1,160	1,180	1,270	562	562
	Cesium 137	pCi/g	—	—	—	—	—	—	—	—	—	2,390	2,700	2,800	1,430	2,510	2,630	3,280	924	924
	Europium-152	pCi/g	—	—	—	—	—	—	—	—	—	1,740	1,740	1,740	1,880	1,740	1,740	1,740	2,220	1,740
	Europium-154	pCi/g	—	—	—	—	—	—	—	—	—	1,610	1,610	1,610	1,740	1,610	1,610	1,610	2,060	1,610
	Europium-155	pCi/g	—	—	—	—	—	—	—	—	—	33,400	33,400	33,400	37,300	33,400	33,400	33,400	48,600	33,400
	Hydrogen-3 (tritium)	pCi/g	—	—	—	—	—	—	—	—	—	1,430	1,280	936	1,130	3,270	2,290	2,830	420	420
	Neptunium-237	pCi/g	—	—	—	—	—	—	—	—	—	8,190	8,140	7,880	9,150	8,250	8,170	8,180	11,200	7,880
	Nickel-63	pCi/g	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Plutonium-238	pCi/g	—	—	—	—	—	—	—	—	—	36,300	56,200	20,900	26,800	291,000	161,000	161,000	5,980	5,980
	Plutonium-239/240	pCi/g	—	—	—	—	—	—	—	—	—	38,800	60,300	22,300	28,400	324,000	175,000	176,000	6,270	6,270
	Radium-226	pCi/g	—	—	—	—	—	—	—	—	—	168	142	58	377	285	165	199	193	58
	Radium-228	pCi/g	—	—	—	—	—	—	—	—	—	169	140	55	418	306	165	203	193	55
	Antimony-125	pCi/g	—	—	—	—	—	—	—	—	—	4,580	4,580	4,580	5,040	4,580	4,580	4,580	6,130	4,580
	Strontium-90	pCi/g	—	—	—	—	—	—	—	—	—	521	302	151	112	706	519	413	91	91
	Technetium-99	pCi/g	—	—	—	—	—	—	—	—	—	5,360	11,500	137,000	280,000	8,670	12,100	412,000	128,000	5,360
	Thorium-232	pCi/g	—	—	—	—	—	—	—	—	—	5,070	12,900	5,340	12,400	34,400	32,500	86,200	4,560	4,560
	Uranium-234	pCi/g	—	—	—	—	—	—	—	—	—	12,700	21,800	6,370	40,900	30,300	24,800	51,600	14,200	6,370
	Uranium-235	pCi/g	—	—	—	—	—	—	—	—	—	6,340	7,810	4,360	10,200	8,600	8,130	9,630	8,060	4,360
	Uranium-238	pCi/g	—	—	—	—	—	—	—	—	—	8,020	10,400	5,150	22,100	11,900	11,000	13,900	13,400	5,150

Table A-6. Wildlife (Birds and Mammals) SSLs for Nonradionuclides

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadowlark	Killdeer	Red-Tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	NOAEL Lowest	California Quail	Meadowlark	Killdeer	Red-Tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	LOAEL Lowest
Metals	Bismuth	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Chromium (VI)	mg/kg	—	—	—	—	1,233.45	287.66	300.21	3,379.86	287.66	--	--	--	--	5,339 .59	1,245.29	1,299.60	16,583.35	1,245.29
General inorganics	Ammonia/ Ammonium	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Chloride	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Cyanide	mg/kg	—	—	—	—	27,970.79	20,692.77	78,122.51	38,060.72	20,692.77	—	—	—	—	—	—	—	—	—
	Fluoride	mg/kg	1,492.00	2,812.00	556.00	9,206.00	9,824.70	8,216.34	35,672.53	17,379.40	556.00	6,123.00	11,539 .00	2,281.00	37,771.00	16,520.65	13,816.13	59,984.89	29,224.21	2,281.00
	Iodine	mg/kg	—	—	—	—	159.37	183.40	1,557.90	759.00	159.37	—	—	—	—	1,593.68	1,834.00	15,579.01	7,589.98	1,593.68
	Nitrate/Nitrite	mg/kg	—	—	—	—	206,421.95	152,710.84	576,537.26	280,884.80	152,710.84	—	—	—	—	460,072.60	340,361.45	1,284,984.44	626,035.16	340,361.45
	Phosphate	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Sulfate/Sulfite	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Total Organic Carbon	%	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Volatile organics	1,1-dichloroethane	mg/kg	3,614.96	217.36	82.67	13,954.67	20,357.19	573.95	502.38	22,894.29	82.67	7,229.93	434.72	165.33	27,909.35	—	—	—	—	165.33
	1,1-dichloroethene	mg/kg	3,614. 96	217.02	82.54	11,432.85	12,214.32	343.83	300.94	12,238 .43	82.54	7,229.93	434.04	165 .08	22,865.71	—	—	—	—	165.08
	1,1,1-trichloroethane	mg/kg	3,614.96	216.69	82.42	8,935.68	407,143.89	11,443.76	10,015.86	349,074.28	82.42	7,229.93	433.38	164.84	17,871.35	—	—	—	—	164.84
	1,1,2-trichloroethane	mg/kg	3,614.96	217.23	82.62	12,031.27	407,143.89	11,472.08	10,041.41	420,572.26	82.62	7,229.93	434.46	16 5.24	24,062.54	—	—	—	—	165.24
	1,1,2,2 - tetrachloroethane	mg/kg	3,614.96	216.67	82.41	9,548.86	3,635.79	102.18	89.43	3,255.35	82.41	7,229.93	433.33	164.82	19,097.72	36,357.95	1,021.81	894.31	32,553.53	164.82
	1,2-dichlorobenzene	mg/kg	87.76	90.99	82.05	4,343.45	282.35	294.23	854.29	17,612.27	82.05	175.53	181.99	164. 11	8,686 .89	—	—	—	—	164.11
	1,2-dichloroethane (DCA)	mg/kg	3,614. 96	221.88	84.32	16,083. 77	20,357.19	585.79	513.07	24,709.56	84.32	7,229.93	443.75	168 .64	32,167.55	—	—	—	—	168.64
	1,3-dichlorobenzene	mg/kg	96.13	95.93	82.03	4,051.47	309.75	313.74	853.99	16,651.92	82.03	192.26	191.85	164.05	8,102.94	—	—	—	—	164.05
	2-butanone (Methyl Ethyl Ketone/MEK)	mg/kg	2,101.72	1,040.62	312.32	11,538.19	721,051.83	159,713.07	176,661.35	970,850.97	312.32	21,017.23	10,406.18	3,123.19	115,381.89	1,861,054.73	412,223.86	455,967.83	2,505,793.22	3,123.19
	2-hexanone	mg/kg	2,101.72	548.27	185.63	9,653.17	2,035.72	243.60	236.58	2,511.81	185.63	21,017.23	5,482.66	1,856 .29	96,531.69	14,697.89	1,758.76	1,708.10	18,135.29	1,708.10
	Benzene	mg/kg	8,554.00	513.00	195.00	27,053.00	285.00	8.02	7.02	285.56	7.02	—	—	—	—	2,850.01	80.23	70.22	2,855.63	70.22
	Butanol	mg/kg	—	—	—	—	50,892.99	2,906.16	2,625.73	67,048.62	2,625.73	—	—	—	—	203,571.95	11,624.66	10,502.90	268,194.47	10,502.90
	Carbon Tetrachloride	mg/kg	3,614.96	216.30	82.28	7,382.46	6,514.30	182.77	159.96	4,903.54	82.28	7,229.93	432.60	164.56	14,764.92	—	—	—	—	164.56
	Chlorobenzene	mg/kg	3,614.96	216.31	82.28	6,672.38	7,939.31	222.77	194.96	5,560.69	82.28	7,229.93	432.63	164.57	13,344.76	15,756.47	442.11	386.93	11,035.82	164.57
	Chloroform	mg/kg	3,614.96	217.17	82.60	13,002.94	6,107 .16	172.03	150.58	6,600.19	82.60	7,229.93	434.33	165.19	26,005.89	16,692.90	470.22	411.58	18,040.51	165.19
	Cis-1,2-dichloroethylene	mg/kg	3,614.96	217.05	82.55	13,446.00	18,402.90	518.11	453.49	20,270.86	82.55	7,229.93	434.10	16 5.11	26,892.00	—	—	—	—	165.11
	Dichloromethane (Methylene Chloride)	mg/kg	3,614.96	217.95	82.88	17,281.03	2,381.79	67.33	58.94	2,999.00	58.94	7,229.93	435.91	165.77	34,562.06	20,357.19	575.50	503.78	25,632.44	165.77
	Ethyl Benzene	mg/kg	159.00	182.00	194.00	12,721.00	342.00	383.68	1,357 .00	33,025.00	159.00	—	—	—	—	1,027.00	1,151.00	4,073.00	99,076.00	1,027.00
	Methyl Isobutyl Ketone	mg/kg	2,101.72	572.87	192.73	10,211.45	721,051.83	90,039.69	87,995.70	915,291.62	192.73	21,017.23	5,728.72	1,927.26	102,114.45	1,861,054.73	232,394.92	227,119.32	2,362,392.98	1,927.26
	n-butyl Benzene	mg/kg	301.00	263.25	193.00	7,857.00	529.53	484.77	1,091.54	18,135.28	193.00	—	—	—	—	1,588.60	1,454.30	3,274.62	54,405.85	1,454.30
	Tetrachloroethylene	mg/kg	3,614.96	215.72	82.07	7,733.34	570.00	15.95	13.96	443.18	13.96	7,229.93	431.44	164 .13	15,466.68	2,850.01	79.75	69.79	2,215.89	69.79

Table A-6. Wildlife (Birds and Mammals) SSLs for Nonradionuclides

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadowlark	Killdeer	Red-Tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	NOAEL Lowest	California Quail	Meadowlark	Killdeer	Red-Tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	LOAEL Lowest
	Toluene	mg/kg	8,554.00	512.13	195.00	17,200.00	21,171.48	594.37	520.19	15,763.32	195.00	—	—	—	—	211,714.82	5,943 .66	5,201.85	157,633.17	5,201.85
	Trans-1 ,2-dich loroethylene	mg/kg	3,614.96	217.05	82.55	11,881.41	18,402.90	518.11	453.49	18,869.15	82.55	7,229.93	434.10	165.11	23,762.81	—	—	—	—	165.11
	Trichloroethylene (TCE)	mg/kg	3,614.96	216.77	82.45	7,497.82	285.00	8.01	7.01	216.87	7.01	7,229.93	433.53	164 .90	14,995.63	2,850.01	80.13	70.14	2,168.73	70.14
	Xylene	mg/kg	149.00	174.99	194.00	13,419.00	422.29	480.57	1,787.19	45,266.25	149.00	—	—	—	—	825.70	939.65	3,494.50	88,509.43	825.70
Polycyclic aromatic hydrocarbons	Acenaphthene	mg/kg	6,830.60	284.90	109.59	38,361.66	71,250.18	1,396.31	1,210. 97	96,952.35	109.59	68,306.01	2,849.00	1,095.94	383,616.62	142,500.36	2,792.63	2,421.93	193 ,904.70	1,095.94
	Acenaphthylene	mg/kg	3,505.79	18.59	7.36	38,361.66	24,320.69	91.39	77.90	96,952.35	7.36	43,765.65	186.19	73.61	383 ,616.62	54,131.54	182.92	155.81	193,904.70	73.61
	Anthracene	mg/kg	3,405.23	169. 72	67.83	38,361.66	178,810.67	4,783.60	4,213.42	554,013.42	67.83	43,404.77	1,716.22	678.31	38 3,616.62	—	—	—	—	678.31
	Benzo(a)pyrene	mg/kg	47.19	5.97	2.41	767.23	60.38	8.08	7.64	554.01	2.41	—	—	—	—	634.65	81.16	76.43	5,540.13	76.43
	Benzo(a)anthracene	mg/kg	117.98	5.21	2.03	767.23	306.8 1	7.26	6.40	554.01	2.03	—	—	—	—	3,635.53	73.37	64.00	5,540.13	64.00
	Benzo(b)fluoranthene	mg/kg	22.46	3.04	1.27	767.23	24.68	4.08	3.92	554.01	1.27	—	—	—	—	246.75	40.84	39.23	5,540.13	39.23
	Benzo(gh i)perylene	mg/kg	12.19	2.64	1.12	767.23	12.60	3.47	3.47	554.01	1.12	—	—	—	—	88.95	32.35	34.70	5,540.13	32.35
	Benzo[k]fluoranthene	mg/kg	136.25	3.25	1.27	767.23	405.73	4.56	3.92	554.01	1.27	—	—	—	—	4,069.49	45.63	39.23	5,540.13	39.23
	Chrysene	mg/kg	117.98	3.65	1.43	767.23	306.81	5.09	4.45	554.01	1.43	—	—	—	—	3,635.53	51.38	44.52	5,540.13	44.52
	Dibenz(ah)anthracene	mg/kg	43.63	3.54	1.42	767.23	54.29	4.86	4.41	554.01	1.42	—	—	—	—	542.86	48.58	44.13	5,540.13	44.13
	Fluoranthene	mg/kg	14.85	2.54	1.09	767.23	1,957.42	420.68	419.58	69,251.68	1.09	—	—	—	—	3,914.85	841.35	839.16	138,503.35	839.16
	Fluorene	mg/kg	6,830.60	44.59	17.54	38,361.66	50,892.99	156.71	133.55	69,251.68	17.54	68,306.01	445 .91	175.36	383,616.62	101,785.97	313.43	267.10	138,503.35	175.36
	lndeno[1,2,3- cd]pyrene	mg/kg	48.73	2.90	1.15	767.23	62.64	4.00	3.57	554.01	1.15	—	—	—	—	626.38	40.03	35.67	5,540.13	35.67
	2-Methylnaphthalene	mg/kg	5.04	5.69	154.74	38,361.66	5.02	5.47	500.36	27,866.87	5.02	8.37	9.46	1,547 .37	383,616.62	6.01	6.55	1,132.02	63,046.73	6.01
	Naphthalene	mg/kg	33.98	36.92	415.86	38,361.66	33.32	36.20	116.06	27,700.67	33.32	339.83	369.21	378.05	383,616.62	99.95	108.61	348.19	83,102.01	99.95
	Phenanthrene	mg/kg	4,329.17	235.76	94.31	38,361.66	301,134.27	6,731.36	5,919.25	554,013.42	94.31	56,061.03	2,405.58	943.13	383,616.62	—	—	—	—	943.13
	Pyrene	mg/kg	10.67	3.88	1.86	767.23	825.29	360.01	436.37	41,551.01	1.86	—	—	—	—	1,375.49	600.01	727.29	69,251.68	600.01
	Total PAHs	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Low MW PAHs	mg/kg	6,592.49	12,622.80	2,316.48	38,361.66	25,368 .94	19,169.51	74,597.33	36,343.28	2,316.48	67,599.94	128,678.69	23,164.80	383,616.62	130,652.20	97,560.30	372,986.63	181,716.40	23,164.80
	High MW PAHs	mg/kg	39.51	72.42	46.33	767.23	29.05	39.00	699.35	340.72	29.05	—	—	—	—	156.91	208.68	3,491.06	1,70 0.82	156.91
Petroleum	Gasoline Range Organics	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	TPH- Diesel	mg/kg	105,086.17	199,535.36	35,638.15	590, 179.41	407,143.89	30 1,204.82	I,137,154.37	554,013.42	35,638.15	1,050,861.71	1,995,353.63	356,381.52	5,901,794.15	610,715.84	451,807.23	1,705,731.55	831,020.12	356,381.52
	TPH - Kerosene	mg/kg	105,086.17	199 ,535.36	35,638.15	590, 179.41	407,143.89	301,204.82	I,137,154.37	554,013.42	35,638.15	1,050,861.71	1,995,353.63	356,381.52	5,901,794.15	610,715.84	451,807.23	1,705,731.55	831,020.12	356,381.52
	Normal paraffin hydrocarbons	mg/kg	170,870.11	324,444.50	57,947.64	959,631.73	407,143.89	301,204.82	1,137,154.37	554,013.42	57,947.64	—	—	—	—	610,715.84	451,807.23	1,705,731.55	831,020.12	451,807.23
Semivolatile organics	Phenol	mg/kg	—	—	—	—	4,885.73	526.11	503.73	5,918.74	503.73	—	—	—	—	14,657.18	1,578.34	1,511.20	17,756.23	1,511.20
	2-methylphenol (o-cresol)	mg/kg	—	—	—	—	127,436.04	10,037.62	9,293.33	134,503.46	9,293.33	—	—	—	—	—	—	—	—	—
	4-methylphenol (p-cresol)	mg/kg	—	—	—	—	127,436.04	10,101.66	9,357.99	136,360.50	9,357.99	—	—	—	—	—	—	—	—	—
	2,4-dinitrotoluene	mg/kg	0.29	0.30	0.20	7.17	13.78	13.46	35.58	285.89	0.20	38.14	39.15	26.35	932.00	28.79	28.13	74.35	597.39	26.35
	Bis[2-ethylhexyl] phthalate[a]	mg/kg	111.06	0.35	0.14	263.03	1,733.20	5.35	4.55	3,599.39	0.14	—	—	—	—	17,332.00	53.52	45.42	35,993.87	45.42

Table A-6. Wildlife (Birds and Mammals) SSLs for Nonradionuclides

Group	Soil Constituent	Units	NOAEL-Based Site-Specific SSLs									LOAEL-Based Site-Specific SSLs								
			California Quail	Meadowlark	Killdeer	Red-Tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	NOAEL Lowest	California Quail	Meadowlark	Killdeer	Red-Tailed Hawk	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	LOAEL Lowest
	Total PCBs[b]	mg/kg	10.01	0.65	0.33	25.09	2.92	0.30	0.27	8.47	0.27	100 .12	3.58	1.82	250.88	29.22	1.61	1.47	84.71	1.47
	Aroclor 1016[b]	mg/kg	6.45	0.64	0.33	21.75	35.21	2.75	2.47	150.41	0.33	64.48	3.55	1.82	217.53	88.14	5.30	4.85	376.56	1.82
	Aroclor 1221[b]	mg/kg	2.73	0.61	0.33	24.02	0.69	0.25	0.27	8.15	0.25	27.30	3.44	1.82	240.18	6.88	1.48	1.47	81.52	1.47
	Aroclor 1232[b]	mg/kg	2.19	0.59	0.33	26.24	0.55	0.24	0.27	8.81	0.24	21.94	3.40	1.82	262.36	5.48	1.44	1.47	88.10	1.44
	Aroclor 1242[b]	mg/kg	10.36	0.65	0.33	25.55	3.09	0.30	0.27	8.74	0.27	103.60	3.59	1.82	255.51	30.91	1.63	1.49	87.35	1.49
	Aroclor 1248[b]	mg/kg	9.41	0.65	0.33	24.33	0.35	0.06	0.06	1.06	0.06	94.05	3.58	1.82	243.35	3.47	0.35	0.32	10.55	0.32
	Aroclor 1254	mg/kg	11.52	0.65	0.33	27.26	3.48	0.30	0.27	9.11	0.27	115.21	3.59	1.82	272.65	34.76	1.62	1.47	91.11	1.47
	Aroclor 1260[b]	mg/kg	20.38	0.66	0.33	51.49	7.67	0.30	0.27	15.42	0.27	203.80	3.62	1.82	514.89	76.65	1.64	1.47	154.21	1.47
	Aroclor -1262[b]	mg/kg	37.83	71.83	12.83	212.46	27.69	20.48	77.33	37.67	12.83	378.31	718.33	128.30	2,124.65	276.86	204.82	773.26	376.73	128.30
Herbicide	Dichloroprop	mg/kg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pesticides	Aldrin	mg/kg	0.45	0.08	0.03	1.06	10.22	1.99	1.96	26.80	0.03	2.24	0.40	0.16	5.30	51.12	9.94	9.82	133.98	0.16
	beta-1,2,3,4,5,6-Hexachlorocyclohexa ne	mg/kg	4.11	3.65	2.72	112.24	1.87	1.73	3.97	66.95	1.73	6.17	5.47	4.08	168.46	9.36	8.67	19.87	334.76	4.08
	alpha-Chlordane	mg/kg	121.50	24.28	10.08	30 1.53	92.53	20.47	20.66	264.12	10.08	607.51	121.40	50.41	1,507.65	925.29	204.66	206.56	2,641.24	50.41
	gamma-Chlordane	mg/kg	121.50	24.19	10.04	301.53	92.53	20.40	20.57	264.12	10.04	607.51	120.97	50.22	1,507.65	925.29	203.98	205.75	2,641.24	50.22
	Dichlorodiphenyldichloroethy-lene	mg/kg	30.37	0.21	0.07	0.06	20.48	0.11	0.09	0.03	0.03	300.36	2.30	0.80	1.70	135.88	0.71	0.59	0.40	0.40
	Dichlorodiphenyltrichloro-ethane	mg/kg	30.37	0.30	0.10	2.53	20.48	0.16	0.14	1.41	0.10	300.36	3.47	1.19	46.28	135.88	1.05	0.88	12.68	0.88
	Dieldrin	mg/kg	1.93	0.06	0.02	1.64	0.28	0.01	0.01	0.35	0.01	6.07	0.20	0.08	5.16	0.57	0.02	0.02	0.69	0.02
	Endosulfan I	mg/kg	93.44	66.32	41.40	1,671.48	0.92	0.71	1.29	21.88	0.71	—	—	—	—	—	—	—	—	—
	Endosulfan II	mg/kg	93.44	66.32	41.40	1,671.48	0.92	0.71	1.29	21.88	0.71	—	—	—	—	—	—	—	—	—
	Endosulfan sulfate	mg/kg	62.89	55.40	41.40	2,159.84	0.61	0.56	1.29	27.15	0.56	—	—	—	—	—	—	—	—	—
	Endrin aldehyde	mg/kg	2.56	0.52	0.23	52.86	0.51	0.14	0. 1 4	14.04	0.14	—	—	—	—	5.13	1.36	1.41	140 .40	1.36
	Methoxychlor	mg/kg	—	—	—	—	59.78	11.20	10.92	441.01	10.92	—	—	—	—	119.56	22.39	21.84	882.02	21.84

Note: Shaded cells represent the lowest chemical specific NOAEL-based and LOAEL-based SSLs.

a. Values for diethyl phthalate and di-n-butyl phthalate were used as a surrogate for bis(2)ethylhexyl phthalate.

b. Aroclor-1254 threshold toxicity value was used as surrogate in the calculation of the SSL.

LOAEL = lowest observed adverse effect level

NOAEL = no observed adverse effect level

SSL = soil screening level

Table A-7. Preliminary Remediation Goals for Wildlife (Birds and Mammals)

Analyte Group	Analyte	Units	California Quail	Western Meadowlark	Killdeer	Red-Tailed Hawk	Lowest Avian PRG	Great Basin Pocket Mouse	Deer Mouse	Grasshopper Mouse	Badger	Lowest Mammal PRG	Lowest Wildlife PRG
Metal	Silver	mg/kg	4,238	3,973	**983**	20,186	983	24,465	9,806	14,362	30,778	9,806	983
Metal	Aluminum	mg/kg	19,217	31,220	7,214	74,599	7,214	4,883	**3,988**	13,059	7,811	3,988	3,988
Metal	Arsenic	mg/kg	4,776	7,403	2,284	40,102	2,284	201	**127**	302	847	127	127
Metal	Boron	mg/kg	54	68	91	2,714	54	**32**	39	170	2,516	32	32
Metal	Barium	mg/kg	1,721	2,335	**1,687**	8,101	1,687	2,265	2,617	11,873	12,430	2,265	1,687
Metal	Beryllium	mg/kg	NTD	NTD	NTD	NTD	NTD	**14**	20	181	289	14	14
Metal	Cadmium	mg/kg	294	103	**29**	1,711	29	2,203	624	858	4,704	624	29
Metal	Cobalt	mg/kg	1,397	2,050	**484**	4,798	484	2,901	2,136	5,610	4,234	2,136	484
Metal	Chromium	mg/kg	193	221	**109**	610	109	544	517	1,424	1,765	517	109
Metal	Copper	mg/kg	423	461	**213**	1 2,881	213	233	193	1,217	4,631	193	193
Metal	Mercury	mg/kg	36	4.7	2	92	2	7.9	**1.6**	1.8	33	1.6	1.6
Metal	Lithium	mg/kg	—	—	—	—	—	**1,664**	1,797	8,347	6,522	1,664	1,664
Metal	Manganese	mg/kg	20,746	26,026	14,407	150,899	14,407	**3,322**	3,467	11,780	21,916	3,322	3,322
Metal	Molybdenum	mg/kg	125	117	95	515	95	5.9	**5.7**	14	38	5.7	5.7
Metal	Nickel	mg/kg	2,051	1,127	361	11,625	361	711	**247**	342	1,520	247	247
Metal	Lead	mg/kg	559	664	**156**	2,300	156	2,672	1,578	3,807	3,966	1,578	156
Metal	Antimony	mg/kg	NTD	NTD	NTD	NTD	NTD	97	**92**	366	325	92	92
Metal	Selenium	mg/kg	10	4.9	2.4	24	2	2.7	**1.4**	1.9	8.8	1.4	1.4
Metal	Strontium (Elemental)	mg/kg	—	—	—	—	—	**1,214**	1 ,449	6,540	8,256	1,214	1,214
Metal	Thallium	mg/kg	—	—	—	—	—	8.7	**6.2**	12	25	6.2	6.2
Metal	Uranium (Calculated Total)	mg/kg	2,002	339	139	82	82	371	59	57	**22**	22	22
Metal	Vanadium	mg/kg	81	107	**43**	505	43	260	297	4,531	3,596	260	43
Metal	Zinc	mg/kg	6,289	4,662	**856**	906	856	6,711	3,331	12,666	1,037	1,037	856

Notes: Bold values represent lowest PRG for that analyte.

Shaded values are based on no observed adverse effect levels because of the lack of lowest observed adverse effect levels.

NTD = no toxicity data

PRG = preliminary remediation goal

Table A-8. Final Recommended Soil Preliminary Remediation Goals for Plants and Invertebrates

Chemical	No Observed Effect Concentration	
	Plant (mg/kg)	Invertebrate (mg/kg)
Antimony	842	842
Arsenic	128	128
Barium	500	358
Beryllium	10	40
Boron	29.6	28.6
Cadmium	9.84	20
Chromium	259	149
Cobalt	15.7	15.7
Copper	70	58
Lead	9,090	1,700
Manganese	1,260	1,260
Mercury	0.3	12.5
Molybdenum	2	28
Nickel	38	280
Selenium	2.02	4.1
Silver	560	2.99
Thallium	1	0.459
Tin	838	838
Uranium	250	100
Vanadium	89.4	116
Zinc	621	8,980

Table A-9. Central Plateau Inner Area Native Vegetation Recharge Scenario Phases and Recharge Rates (mm/yr)

Surface Soil Type	Historic Simulation (Through 2014) (Initial Hydraulic Conditions)		Predictive Simulation (from 2015 Forward) (Calculation of Peak Groundwater Concentration)		
	Pre-Hanford Phase (Before 1944)	Hanford Operations Phase (1944–2014)	Bare Soil Phase (2015–2049)	Young Shrub-Steppe Phase (2050–2079)	Shrub-Steppe Phase (After 2080)
Hanford sand, disturbed	4.0[a]	63.0[b]	63.0[b]	8.0[c]	4.0[d]

Source: PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*.

a. PNNL-14702, Table 4.15; S (southern 200 West Area), T (northern 200 West Area), and A (southern 200 East Area) areas, shrub-steppe.

b. PNNL-14702, Table 4.15; all areas with soils disturbed by excavations; no vegetation.

c. PNNL-14702, Table 4.15; all areas with soils disturbed by excavations; young shrub-steppe.

d. PNNL-14702, Table 4.15; all areas with soils disturbed by excavations; shrub-steppe.

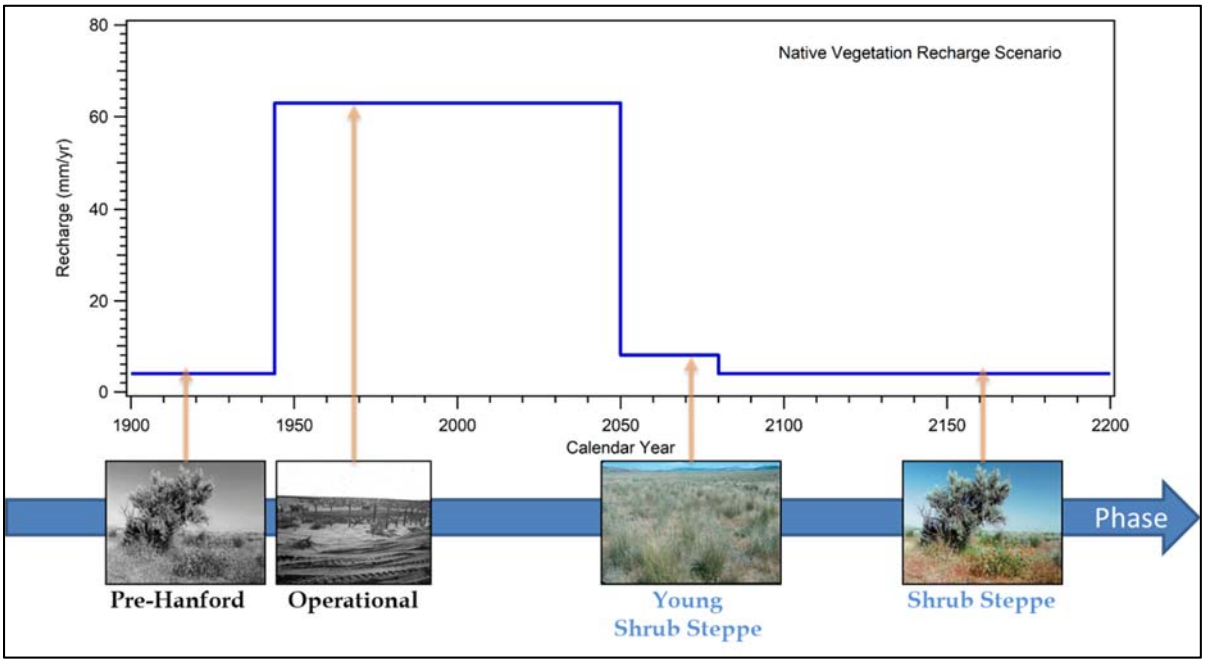

Figure A-1. Central Plateau Inner Area Native Vegetation Recharge Scenario

Table A-10. Central Plateau Inner Area Infiltration Barrier Recharge Scenario Phases and Recharge Rates (mm/yr)

Surface Soil Type	Historic Simulation (Through 2014) (Initial Hydraulic Conditions)		Predictive Simulation (from 2015 Forward) (Calculation of Peak Groundwater Concentration)		
	Pre-Settlement Phase (Before 1944)	Hanford Operations Phase (1944–2014)	Bare Soil Phase (2015–2049)	Barrier Design Life Phase[d] (2050–2549)	Post-Barrier Phase (Mature Shrub-Steppe) (After 2550)
Hanford sand, disturbed	4.0[a]	63.0[b]	63.0[b]	0.5[c]	4.0[e]

Sources: DOE, 2005, *Technical Guidance Document for Tank Closure Environmental Impact Statement Vadose Zone and Groundwater Revised Analyses*.

PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments*.

a. PNNL-14702, Table 4.15; S (southern 200 West Area), T (northern 200 West Area), and A (southern 200 East Area) areas, shrub-steppe.

b. PNNL-14702, Table 4.15; all areas with soils disturbed by excavations; no vegetation.

c. DOE, 2005, Section 4.4; barrier during design life.

d. Start of "Barrier Design Life Phase" is a working assumption for cumulative impact evaluation simulations to assess cumulative impacts. Closure plans for WMA SSTs have not yet been incorporated into the Hanford permit, including the specific design configuration and timeframes for placement of engineered surface barriers.

e. PNNL-14702, Table 4.15; all areas with soils disturbed by excavations; shrub-steppe.

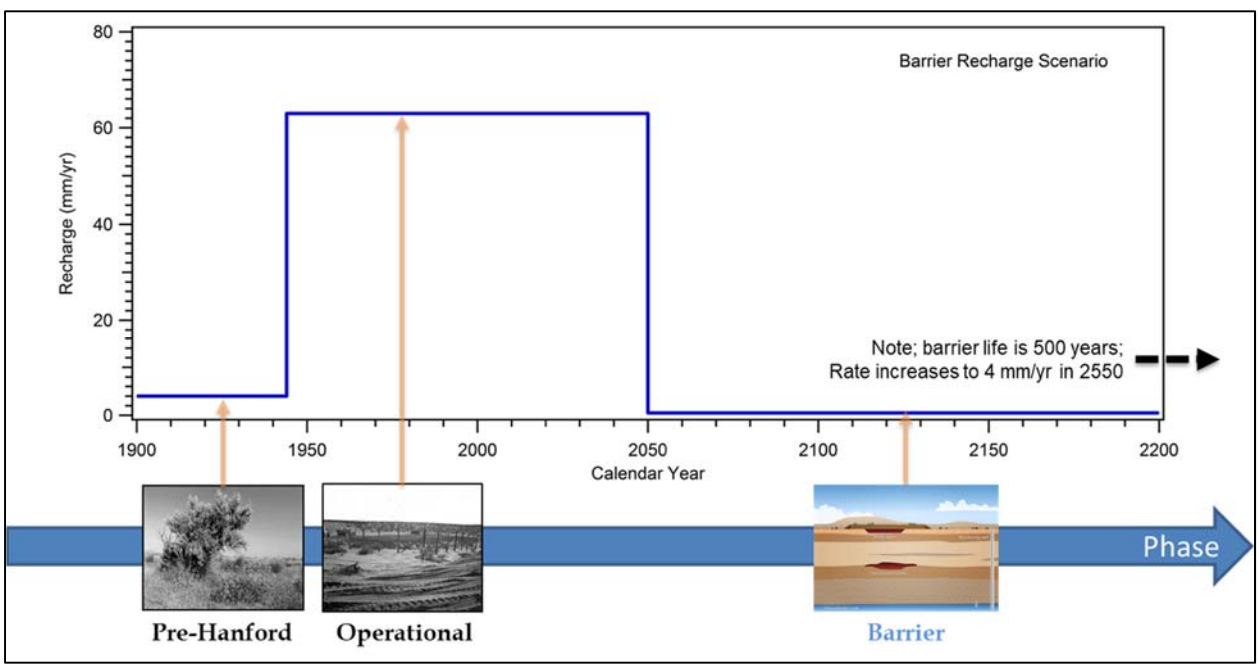

Figure A-2. Central Plateau Inner Area Infiltration Barrier Recharge Scenario

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