DOE/RL-2008-46
Revision 0

Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan

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

U.S. DEPARTMENT OF ENERGY | Richland Operations Office

P.O. Box 550
Richland, Washington 99352

100-DR-1 100-DR-2 100-HR-2 100-HR-3
100-KR-1 100-KR-2 100-KR-4 100-BC-1
100-BC-2 100-BC-5 100-FR-1 100-FR-2 100-FR-3
100-IU-2 100-IU-6 100-NR-1 100-NR-2

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Date

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Executive Summary

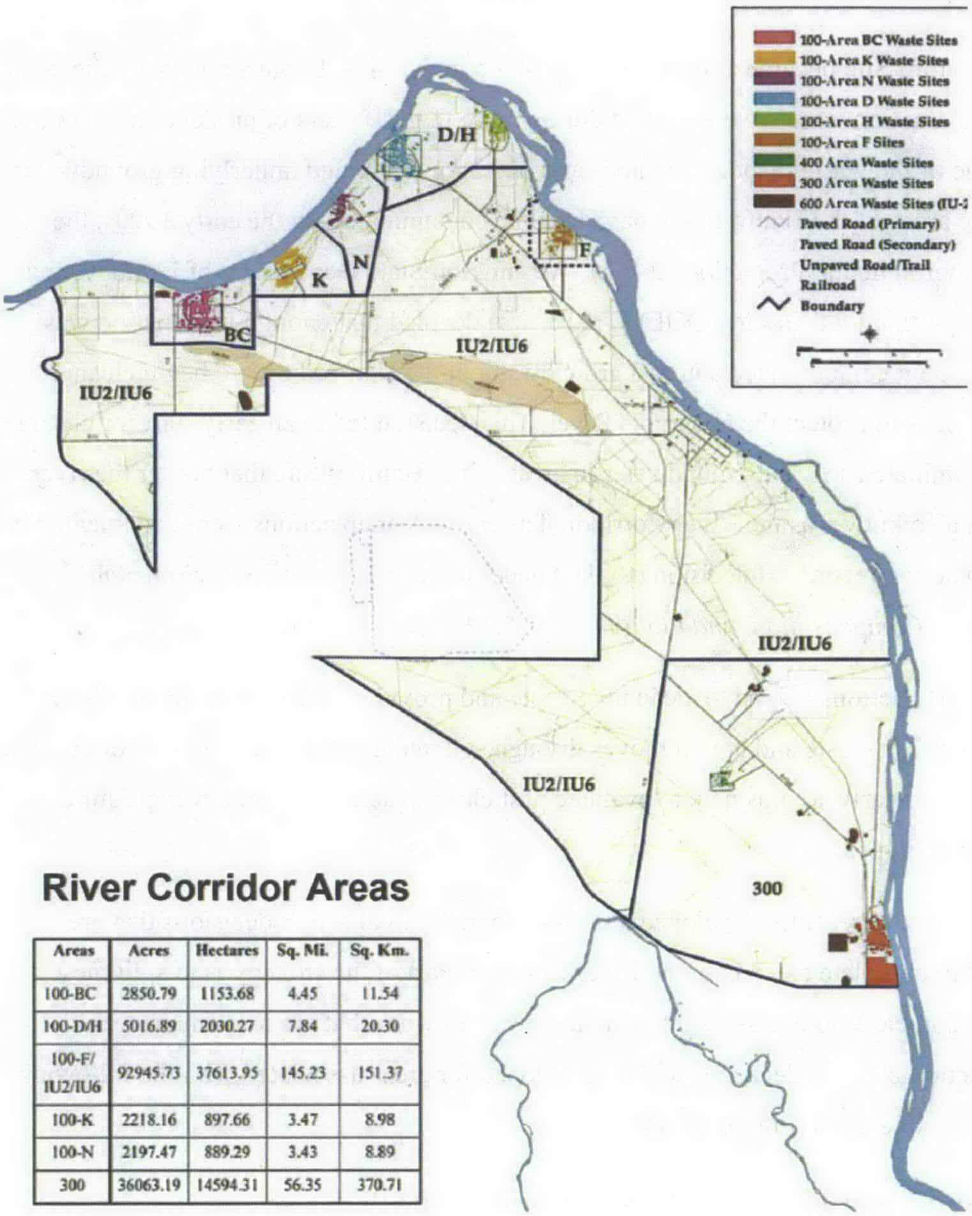
The Hanford Site became a federal facility in the mid-1940s. Large amounts of chemical and construction wastes were created during more than 40 years of production operations. Because of the waste disposal methods and operations, soil and underlying groundwater in some areas of the Hanford Site have become contaminated. In the early 1990s, the U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy (DOE) (Tri-Parties) decided that enough information was known about contaminated soil and groundwater at the Hanford Site to begin cleanup with a focus to protect the Columbia River. This decision led to an early start for cleanup of contaminated soil and groundwater in areas of the Hanford Site that border the river, an area also known as the River Corridor. The early cleanup actions were documented in interim action records of decision (RODs) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[1] (CERCLA).

These early actions helped to clean up the site and provided information about where contamination exists and how it moves through soil and groundwater. Observations made during these early actions help to evaluate past cleanup activities and develop future cleanup activities.

The Tri-Parties recently developed a strategy to make final action decisions that are needed to complete cleanup in the River Corridor. Part of the strategy is to split these final action cleanup decisions into smaller pieces of work that are more manageable. Final action cleanup decisions will be developed for areas associated with the following areas operable units (Figure ES-1):

- 100-BC Operable Units: 100-BC-1, 100-BC-2, 100-BC-5
- 100-K Operable Units: 100-KR-1, 100-KR-2, 100-KR-4
- 100-N Operable Units: 100-NR-1, 100-NR-2
- 100-D/H Operable Units: 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-HR-3
- 100-F/IU-2/IU-6 Operable Units: 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, 100-IU-6
- 300 Area Operable Units: 300-FF-1, 300-FF-2, 300-FF-5

1 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC 9601, et.seq. Available at: http://www4.law.cornell.edu/uscode/42/usc_sec_42_00009601-000-.html.



Areas	Acres	Hectares	Sq. Mi.	Sq. Km.
100-BC	2850.79	1153.68	4.45	11.54
100-D/H	5016.89	2030.27	7.84	20.30
100-F/ IU2/IU6	92945.73	37613.95	145.23	151.37
100-K	2218.16	897.66	3.47	8.98
100-N	2197.47	889.29	3.43	8.89
300	36063.19	14594.31	56.35	370.71

Figure ES-1. River Corridor Boundaries

Final action decisions for the operable units will address the cleanup of contaminated soil, solid waste burial grounds, groundwater, and releases from and/or due to reactor buildings. The objective for all these decisions is to protect human health and the environment.

The CERCLA process for making final action decisions about the actions needed to complete cleanup involves the following activities:

- Gathering information about the site
- Conducting risk characterizations
- Identifying goals for the cleanup
- Evaluating different options and the associated costs to meet the cleanup goals
- Selecting the cleanup option that provides the best fit

This document, the addenda, and the sampling and analysis plans (SAPs) identify the data gaps and the data to be collected. This data will then be used to develop the remedial investigation/feasibility study (RI/FS). Selection of the final action cleanup that will be performed is documented in a ROD.

Cleanup of the Hanford Site is also subject to the *Resource Conservation and Recovery Act of 1976*[2] (RCRA). RCRA is a federal law that establishes requirements to treat, store, and dispose of hazardous wastes. The State of Washington has a federally authorized state RCRA program. RCRA also has a cleanup phase, similar to CERCLA, called corrective action. The Tri-Parties intend that cleanup in RODs will also fulfill state requirements for corrective action.

For sites undergoing cleanup under CERCLA, it is DOE policy to integrate the *National Environmental Policy Act of 1969* (NEPA) values into the procedural and documentation requirements of the RI/FS process. For the 100 Area operable units, the NEPA value analysis will be documented in conjunction with the CERCLA criteria in each FS specific to the operable units and in the resulting CERCLA ROD.

Scope and Objectives

Objectives of the work plan are to document information that is currently known about the site and to identify the additional information that needs to be gathered before final action cleanup decisions can be made. The approach to collect this information is written into the SAP.

This work plan proposes collection of additional information that is needed to support final action cleanup decisions. The data collected under this work plan will be combined

[2] Resource Conservation and Recovery Act of 1976, 42 USC 6901, et seq. Available at: http://www.epa.gov/lawsregs/laws/rcra.html.

with historical data, data collected during continued implementation of interim action RODs, routine site monitoring activities, and specific studies to assess the potential applicability of treatment technologies. Data and results will be reported in an RI/FS report, which will lead to alternatives for final action site cleanup.

Relationship of Integrated 100 Area Work Plan, Addenda and RODs

This integrated 100 Area CERCLA RI/FS work plan has been developed to identify activities needed to gather additional data to make an integrated final action decision for all contaminated soil, sediment, and groundwater. Each 100 Area encompassing the operable units within that area will have an addendum to this work plan. The addendum for each area documents the development of the site-specific conceptual model, areas of uncertainty that require resolution to support decisions, and the SAP, which will direct the collection of new information to address these uncertainties.

After the data have been gathered and analyzed, an individual RI/FS will be prepared for each area to summarize and analyze the remedial investigation work completed and to identify and evaluate remedial alternatives. A proposed plan for each 100 area encompassing the operable units within that area, that will contain a summary of the investigation and evaluation, and includes the preferred remedial alternative, will be issued to the public for review and comment. After completion of this review and comment cycle, a final action ROD will be developed and approved by the Tri-Parties. The final action remedies will then be implemented. Appropriate land management controls and monitoring requirements will be identified in the final action cleanup plan as needed. Completed remedies are subject to reviews every 5 years to verify long-term effectiveness and protection.

Summary of Actions and Assessments

The following characterization and investigation activities were conducted to support sound interim action cleanup decisions and ongoing cleanup activities:

- Technical baseline reports summarized existing process and contamination information.
- Limited field investigations collected additional characterization data and supported qualitative risk assessments.
- Focused feasibility studies selected interim action remedial actions.

- Other routine monitoring activities evaluated air emissions and monitored environmental radiation.
- Excavated contaminated soil and sent it to a large lined landfill on the Hanford Site.
- Pumped contaminated groundwater to the surface, treated it to remove contamination, and pumped it back into the ground.
- Removed contaminated facilities and disposed of them in the large lined landfill on the Hanford Site.

Soil and groundwater cleanup actions and assessments have been performed since the early 1990s. Much of the information needed to understand contamination at the site already has been gathered and is well understood. In order to support final action cleanup decisions, the focus of this work plan is to identify the additional information needed to fill knowledge gaps regarding contamination at the site and determine how the contamination moves in the environment. Table ES-1 summarizes the current and historical work that already has been accomplished. The specific information needed for each operable unit is outlined in the addenda to this work plan.

Table ES-1. Examples of Activities Providing Information and Data to Support Development of Remedial Investigation/Feasibility Study Work Plans (Through December 2008)

Activity Name	Accomplishments/Investigations
Facility D4 Actions	Over 300 structures have been demolished in the 100 Area. In addition, five 100 Area reactors have been placed in ISS.
Waste Site Remediation Program	Remediation in accordance with the interim action RODs occurred at more than 155 waste sites, including 78 of 82 high-priority liquid waste sites*, which have been backfilled with clean soil. Approximately, a total of 8 million tonnes (9 million tons) of contaminated soil have been disposed at the ERDF.
Spent Nuclear Fuel and Related Sludge Removal Actions	Approximately 2,100 tonnes (2,300 tons) of spent nuclear fuel and up to 30 cubic meters (40 cubic yards) of sludge, 9.1 million liters (2.4 million gal.) of water, and hundreds of tons of debris and fuel racks (solid waste) were removed from two basins that are located less than a quarter-mile from the Columbia River.
Orphan Site Evaluation Program	Orphan site evaluations have been completed across 25 percent of the River Corridor. Most of the remaining area is within the "inter areas." Over 14,190 ha (35,058 ac) have been assessed through the orphan site evaluations to identify new waste sites.
River Corridor Baseline Risk Assessment	The assessment provided an analysis of human health and ecological risk in the River Corridor.

Table ES-1. Examples of Activities Providing Information and Data to Support Development of Remedial Investigation/Feasibility Study Work Plans (Through December 2008)

Activity Name	Accomplishments/Investigations
Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River	This plan described efforts to collect data for an evaluation of the nature and extent of contamination and current risk to humans, animals, and plants exposed to Hanford Site related contaminants. Samples of pore water, sediment, surface water, fish, and island soil collected in 2008 and 2009.
100-K, 100-D, 100-H, and 100-N Areas Pump-and-Treat Systems	The 100-K, 100-D, and 100-H large pump-and-treat systems have treated over 7.6 billion L (2 billion gal.) of groundwater and removed nearly one ton of CrVI from the aquifer. The 100-N Pump-and-Treat system has removed 1.8 curies of Sr-90 and is currently in cold standby.
Remediation Process Optimization	This process provides a systematic evaluation and enhancement of the current site remediation actions to foster improved cleanup performance and reduce cost.
Groundwater Monitoring	All HEIS groundwater monitoring data available through December 2008 from all groundwater monitoring wells constructed in the River Corridor will be evaluated.
Aquifer Tube Sampling	More than 400 aquifer tubes have been installed at the Hanford Site since 1997. These aquifer tubes are sampled to provide data on the nature and extent of contaminants in groundwater at locations adjacent to the Columbia River.
Biostimulation Test	Molasses was injected at the 100-D Area biostimulation treatability test site to nourish bacteria that can reduce CrVI to trivalent chromium, which is less toxic and less mobile than CrVI.
Electrocoagulation Test	New technology enabled cost-effective remediation of CrVI contaminated groundwater.
In Situ Redox Manipulation	By injecting non-toxic chemicals into an aquifer, ISRM can successfully immobilize contaminants to aquifer sediments, or reduce contaminants to a less toxic form (e.g., reduce CrVI to trivalent chromium).
Fortifying ISRM Barrier with Iron	Maintaining the ISRM barrier depends on the presence of naturally occurring iron. Studies have shown that fortifying the barrier with more iron offers a sustainable long-term repair.
Apatite Barrier Installation	The barrier removes Sr-90 from groundwater and allows it to radioactively decay in the soil by binding Sr-90 from the groundwater into the apatite mineral matrix.
Petroleum Hydrocarbon Remediation at 100-N Area	Installed boreholes and wells for ongoing monitoring, natural attenuation, and bioremediation of groundwater and vadose zone.
Polysulfide Injection	New technology was tested to reduce CrVI within groundwater.
Phytoremediation Field Demonstration	Phytoremediation, using the Coyote willow (a common plant that grows along the banks of the Columbia River), can be used to extract Sr-90 from the groundwater prior to its migration to the Columbia River.

* High priority waste sites are identified in limited field investigation (LFI) reports and interim action RODs that pose risk(s) through one or more pathways sufficient to recommend streamlined action via an interim action remedial measure.

D4 = deactivation, decontamination, decommissioning, and demolition
CrVI = hexavalent chromium
ERDF = Environmental Restoration Disposal Facility
HEIS = Hanford Environmental Information System
ISRM = in situ redox manipulation
ISS = interim safe storage
ROD = record of decision
Sr-90 = strontium-90

Schedule

The RI/FS work plan and addenda for each of the River Corridor Operable Unit areas will be submitted for regulatory review, and distributed to Tribal Nations and stakeholders throughout 2009. Following approval of the work plan and associated addenda, a 6- to 12-month field investigation will be conducted within each of the areas to collect the additional information needed to support final action decision making.

A proposed plan leading to a final action ROD will be prepared for each area's operable units that will address final action remedies for both source and groundwater operable units (OU). The proposed plan and ROD will incorporate completed remedial actions under interim action RODs. The six final action RODs are scheduled to be issued in 2013. The selected final action remedies contained in each ROD will address the respective suite of contamination for each operable unit. Each final action ROD will be comprehensive and address contamination and will establish agreed upon remedial actions. 100 area's operable units specific schedules are provided in each work plan addenda.

Integration with Remedial Investigation of Hanford Site Releases to the Columbia River

In 2008, the Tri-Parties established a plan for remedial investigation of Hanford Site releases to the Columbia River (DOE/RL-2008-11, *Remedial Investigation Work Plan for Hanford Site Releases to Columbia River*[3]). The purpose of the investigation work plan is to describe the initial work to accomplish the following goals:

- Collect and analyze samples to identify what Hanford Site related contaminants are present in the Columbia River, their concentrations, and their locations.
- Use the sample results to estimate the current risk to humans, animals, and plants if they are exposed to Hanford Site related contaminants while they use or live in the Columbia River.
- Determine whether any cleanup actions are needed to lower the risk to humans, animals, and plants from being exposed to Hanford Site related contaminants.

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3 DOE/RL-2008-11, 2008, *Remedial Investigation Work Plan for Hanford Site Releases to Columbia River*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://www.washingtonclosure.com/projects/EndState/docs/Rem_Invest/rl08-11.pdf.

Sample collection activities for the investigation began in October 2008 and will continue through late 2009. More than 1,200 samples, including river water, sediment from the river bottom and shoreline, soil from islands, groundwater, and fish, will be collected as part of this effort. The results of the laboratory tests performed on the samples will be evaluated as they are returned and summarized in a report after all the tests are complete. These results then will be combined with existing data from the river, used to estimate the potential risk to plants and animals, and help decision makers determine if additional investigation is needed. This decision point is anticipated to occur in 2011.

Evaluating the impact of the Hanford Site releases to the Columbia River is an integral piece of final action cleanup decisions for the River Corridor and Hanford Site. If contamination requiring remedial action is identified in the river and it originated from the Hanford Site, then it will be addressed by DOE through a cleanup decision. Such a cleanup decision may be associated with one or more of the river corridor operable units or it may be a separate remedial action in the river. This will depend on the source and location of the contamination.

Relationship to the Overall Plan for Hanford Site Cleanup

The DOE has developed a Hanford Site cleanup plan to protect the Columbia River. Three major plan components are the River Corridor, Central Plateau, and tank farms (Figure ES-2). The plan provides a set of principles and goals that help guide the sequence of cleanup actions to achieve this protection. The plan's goals recognize that the Columbia River is a critical resource for the people, animals, and plants of the Pacific Northwest.

Following the implementation of cleanup actions, there will be disposal facilities and other areas that will necessitate long-term management activities. Long-term stewardship activities will be required for portions of the Hanford Site to ensure protection of human health and the environment.

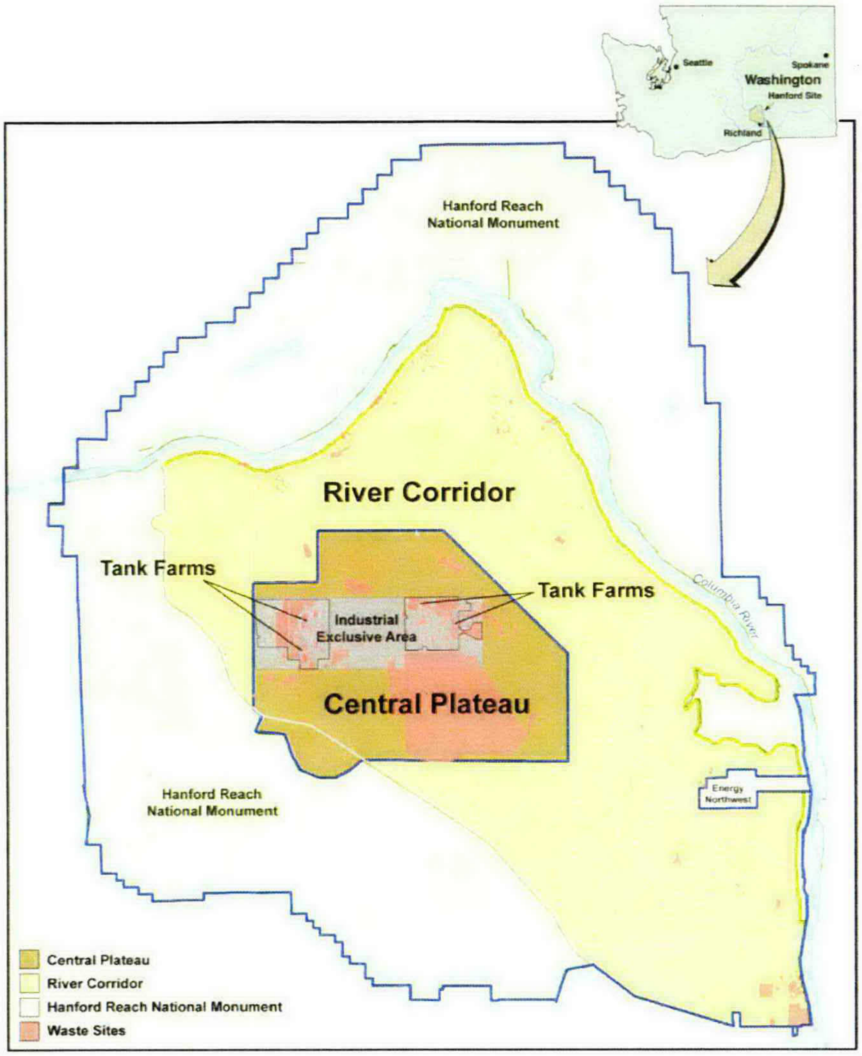

Figure ES-2. River Corridor, Central Plateau, and Tank Waste Components

Path Forward

Historical information, ongoing site clean-up and monitoring results, and remedial investigation data will be integrated into RI/FS reports for the River Corridor. Proposed plans leading to final action RODs for each of the 100 area's operable units will address remedies for both source and groundwater OUs. These final action decisions will incorporate remedial actions completed under existing interim action RODs. Each final ROD will be comprehensive and address contamination found in the operable units and will establish remedial actions.

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Contents

Appendices

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Figures

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Terms

AEA	*Atomic Energy Act of 1954*
ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
COPC	contaminant of potential concern
CrVI	hexavalent chromium
CSM	conceptual site model
CVP	cleanup verification package
D4	deactivation, decontamination, decommissioning, and demolition
DOE	U.S. Department of Energy
DOH	Washington State Department of Health
DQO	data quality objective
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant difference
FS	feasibility study
HAB	Hanford Advisory Board
HEIS	Hanford Environmental Information System
HHRA	human health risk assessment
ISS	interim safe storage
ISRM	in situ redox manipulation
LFI	limited field investigation
MCL	maximum contaminant level
MRDL	maximum residual disinfectant level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

NEPA	*National Environmental Policy Act of 1969*
NPL	National Priorities List
nZVI	nano zero valent iron
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PCB	polychlorinated biphenyl
PRG	preliminary remediation goal
Pu	plutonium
QRA	qualitative risk assessment
RAG	remedial action goal
RAO	remedial action objective
RCBRA	River Corridor Baseline Risk Assessment
RCRA	*Resource Conservation and Recovery Act of 1976*
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RL	U.S. Department of Energy, Richland Operations Office
ROD	record of decision
RPO	remediation process optimization
RSVP	remaining site verification process
RTD	removal, treatment, and disposal
RUM	Ringold Upper Mud
SAP	sampling and analysis plan
SFY	state fiscal year
Sr-90	Strontium-90
TMP	technology maturation plan
TRA	technology readiness assessment
Tri-Parties	DOE, EPA, and Ecology
Tri-Party Agreement	Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*
Trustees	Hanford Natural Resources Trustee Council
TSCA	*Toxic Substances Control Act of 1976*

TSD	treatment, storage, and disposal
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WCH	Washington Closure Hanford, LLC
WIDS	Hanford Waste Information Data System
ZVI	zero valent iron

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1 Introduction

In 1989, representatives from Washington State Department of Ecology (Ecology), U.S. Environmental Protection Agency (EPA), and U.S. Department of Energy (DOE) signed the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement [Ecology et al., 1989a]). The agreement created a cohesive regulatory framework, schedule, and adjudication process to administer environmental remediation activities at the Hanford Site for both *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) response action and *Resource Conservation and Recovery Act of 1976* (RCRA) corrective action activities. This document presents the work plan for a remedial investigation/feasibility study (RI/FS) to support final action remedy selection under the CERCLA for the 100 Area operable units at the Hanford Site. This document explains the RI/FS project background and rationale and presents detailed plans for investigation of contaminated DOE sites in the 100 Area. The 100 Area operable units being investigated for the River Corridor or within or near the 100-B/C Area, 100-K Area, 100-D and 100-H Areas, 100-N Area, and the 100-F Area combined with the 100-IU-2/IU-6 Area. The River Corridor also has a 300 Area (including nearby 600 Area waste sites and the 400 Area). A 300 Area work plan will be developed as a separate document. The 100 Area sites and the groundwater are contaminated from releases and spills of radiological and/or chemical constituents, and historical solid waste disposal practices, and encompass the 100 Area sites that are on the National Priorities List (NPL) (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan (NCP)," Appendix B, "National Priorities List").

The 100 Area contains multiple source and groundwater operable units (OUs), as defined in Chapter 2.0 of this work plan, that are part of the Hanford Site River Corridor, which encompasses approximately 570 km^2 (220 mi^2) adjacent to the Columbia River. To date, significant remediation has occurred along the River Corridor using remedial actions as authorized under interim action records of decision (RODs), RCRA corrective actions, and other activities. Integral with these cleanup activities, data have been collected and analyzed regarding the nature and extent of residual contaminants. This RI/FS work plan and its associated addenda propose additional field work, analyses, and studies that are needed to support a final action ROD for each area's operable units.

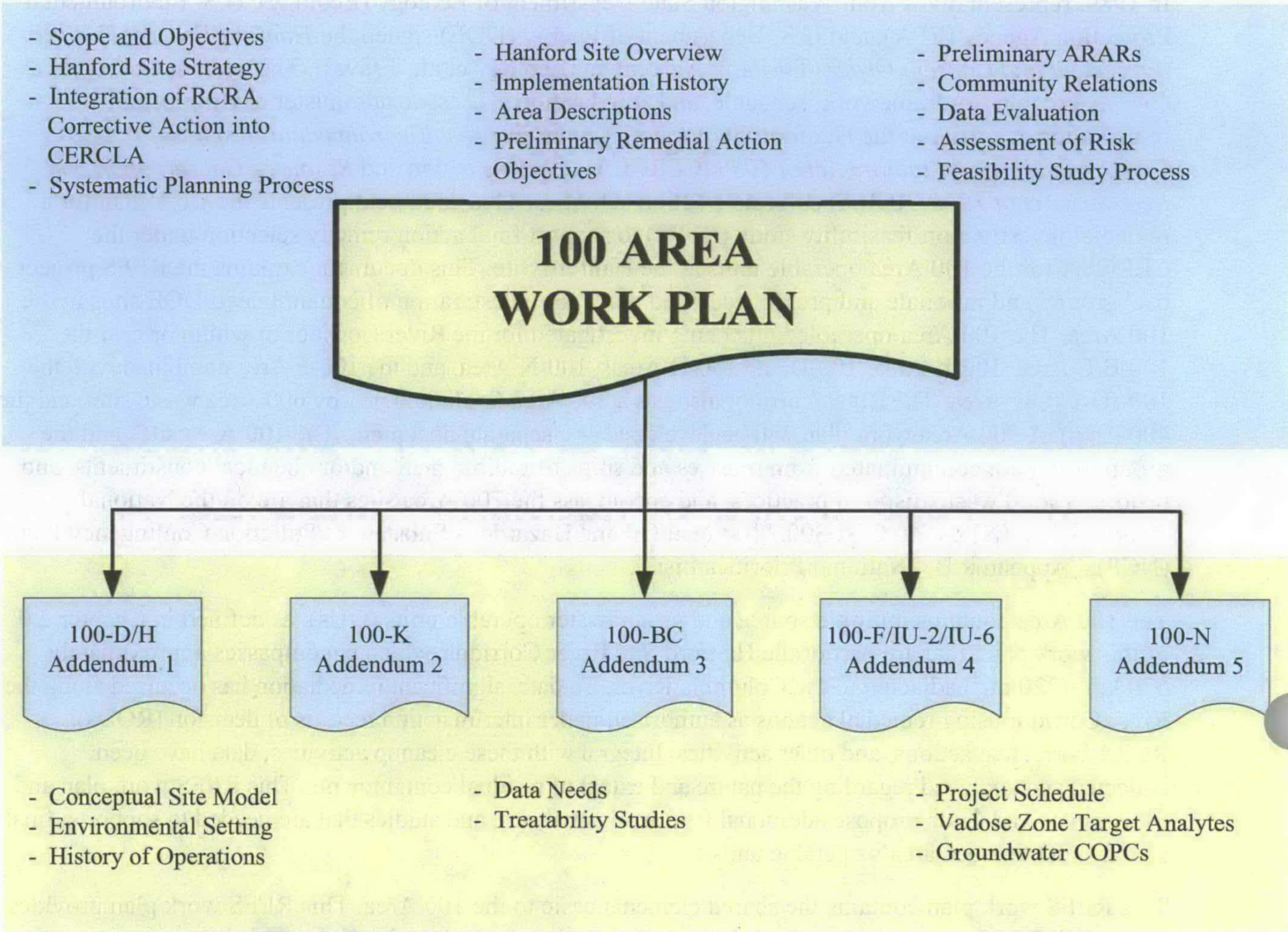
This RI/FS work plan contains the shared elements basic to the 100 Area. This RI/FS work plan provides the overall RI/FS project background, investigation rationale, and environmental setting common to the 100 Area, along with the project planning and management organization to be used. This document also includes a general overview of the investigation and remediation accomplishments in the 100 Area.

The work plan addendum for each 100 Area contains operable unit specific background, remedial investigation (RI) data needs, data collection plans, and associated sampling and analysis plans (SAPs). The SAP in each addendum includes a field sampling plan that provides the sampling strategy for a range of sampling techniques that will be used to obtain the supplemental data required for the RI. The SAP also provides a quality assurance project plan to ensure that data collected meet the appropriate quality assurance and quality control requirements.

The addenda correspond to the operable units, as follows, and will undergo phased development:

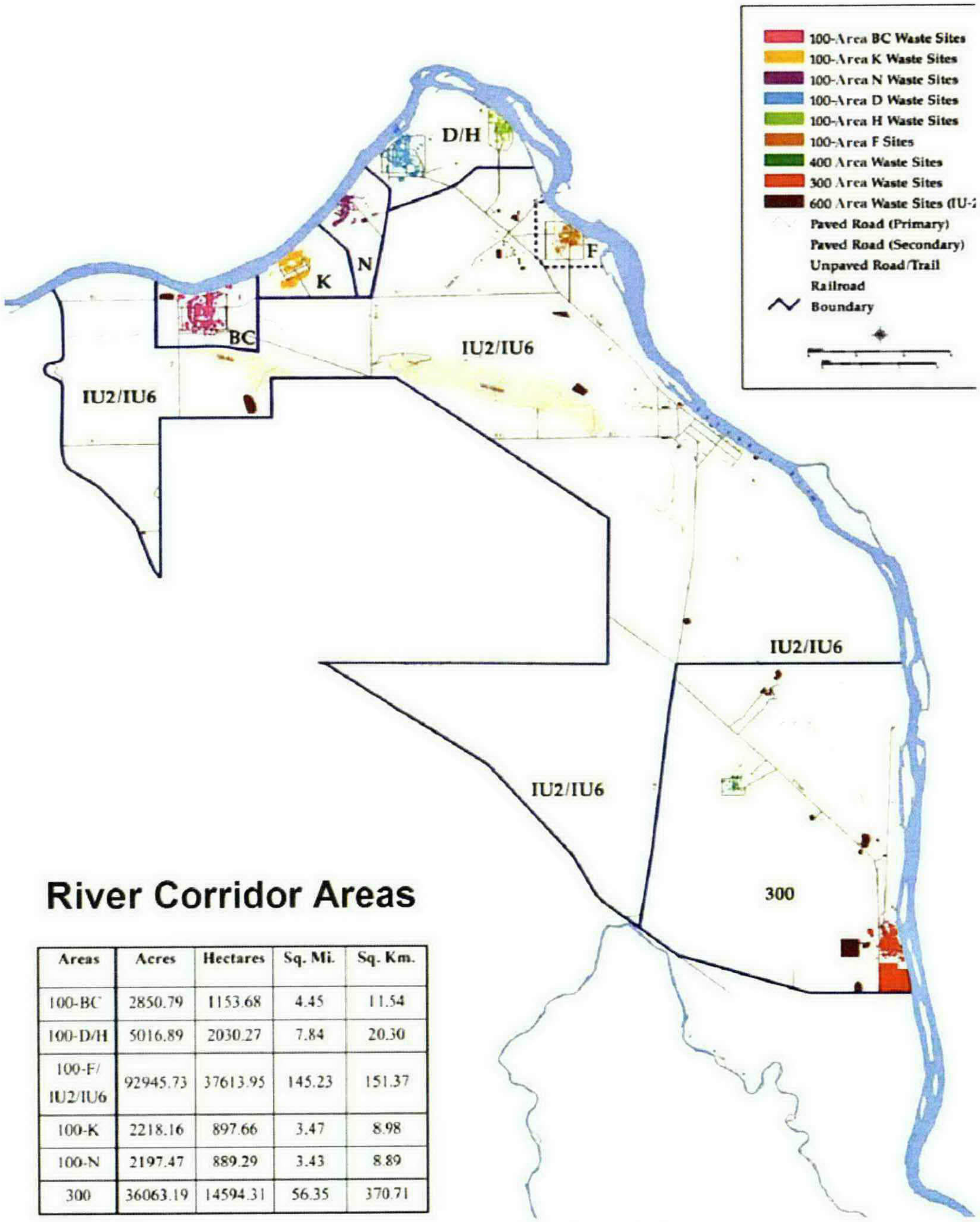
- Addendum 1: 100-DR-1, 100-DR-2, 100-HR-2, 100-HR-3 Operable Units
- Addendum 2: 100-KR-1, 100-KR-2, 100-KR-4 Operable Units
- Addendum 3: 100-BC-1, 100-BC-2, 100-BC-5 Operable Units
- Addendum 4: 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, 100-IU-6 Operable Units
- Addendum 5: 100-NR-1, 100-NR-2 Operable Units

Figure 1-1 illustrates the relationship between the work plan and each addendum. Figure 1-2 shows the boundaries of the 100 and 300 Areas of the River Corridor.



ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COPC	contaminant of potential concern
RCRA	*Resource Conservation and Recovery Act of 1976*

Figure 1-1. Relationship Between the Work Plan and Addenda



River Corridor Areas

Areas	Acres	Hectares	Sq. Mi.	Sq. Km.
100-BC	2850.79	1153.68	4.45	11.54
100-D/H	5016.89	2030.27	7.84	20.30
100-F/ IU2/IU6	92945.73	37613.95	145.23	151.37
100-K	2218.16	897.66	3.47	8.98
100-N	2197.47	889.29	3.43	8.89
300	36063.19	14594.31	56.35	370.71

Figure 1-2. River Corridor Boundaries

This work plan is prepared in accordance with the following guidance documents:

- EPA/540/G-89/004, Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, OSWER Directive 9355.3-01
- DOE/EH-94007658, Remedial Investigation/Feasibility Study (RI/FS) Process, Elements and Technical Guidance
- EPA/240/B-06/001, Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4

1.1 Scope and Objectives

The scope of this integrated 100 Area RI/FS work plan includes waste sites (e.g., trenches, pipelines) associated with 100 Area source and groundwater OUs. Source and groundwater OUs, as identified in Ecology et al., 1989b, *Hanford Federal Facility Agreement and Consent Order Action Plan*, are evaluated together. The scope of this work plan does not include the decommissioning and demolition of 100 Area buildings, which is addressed under CERCLA removal authority through use of action memoranda.

This work plan describes key data collection and analysis elements identified during a systematic planning process that support final remediation decisions in each of the five 100 Areas.

The systematic planning process includes results of past and ongoing remediation activities; describes the remaining uncertainties in the context of a conceptual site model (CSM)[4] to support remedial decisions; and justifies the type, location, and quantity of data needed to reduce or eliminate the identified uncertainty. Area-specific details are provided in the individual addendum.

1.2 CERCLA Process in the 100 Area

The process to remediate and close each operable unit consists of the following major activities, as defined by CERCLA guidance:

- Develop an RI/FS work plan
- Implement and complete RI/FS work
- Develop an RI report, including risk assessment
- Develop a feasibility study (FS) report
- Develop a proposed plan
- Provide an opportunity for public comment on Proposed Plan
- Complete final action ROD
- Develop a final action remedial design/remedial action work plan
- Implement the final action remedy
- Develop remedial action report
- Develop and implement a monitoring program (if required)
- Provide a 5-year review of the effectiveness of the remedy (if required)

This integrated 100 Area CERCLA RI/FS work plan has been developed to identify activities needed to gather additional data (as determined by the systematic planning process) to make an integrated final decision for all media. Each area will have an addendum to the overall CERCLA RI/FS work plan, which will include a SAP to gather data specific to that area. After the data have been gathered and analyzed, and the CSM has been updated, an FS will be performed for each area to identify and evaluate alternatives. A proposed plan that contains a summary of the investigation and evaluation and includes the preferred remedial alternative will be issued to the public for review and comment for each area encompassing the operable units within that area. After completion of this review and comment cycle, a final action ROD for

[4] A conceptual site model is a set of hypotheses and assumptions about the physical characteristics (e.g., media properties) and phenomena (e.g., model of fluid flow) that describe and postulate the behavior of contamination. The conceptual site model describes contaminant sources and receptors, and the interactions linking them. CSM is used to identify uncertainties and provide a framework to identify data and information needed to resolve each uncertainty. Conceptual site models evolve as new data and information are developed.

each area will be developed and approved by the Tri-Parties. The remedies then will be implemented. Should the remedies leave contamination in place, monitoring requirements will be identified in the monitoring program. The completed remedy that does not achieve unlimited use/unrestricted exposure is subject to a reviews every 5-years to verify long-term effectiveness and protection.

1.2.1 Integration with Ongoing Cleanup Activities

A feature of each area is the ongoing implementation of interim action RODs, CERCLA removal actions, RCRA corrective actions, treatability tests, and other activities (Section 1.4) to remediate contaminated areas or to develop more effective methods that advance remediation.

Implementation of these interim action ROD activities is generating information that allows an improved understanding of site complexity, supports refinement of the CSM, and documents the effectiveness of the remedial actions.

Cleanup of waste sites in accordance with the interim action RODs and focused FSs is ongoing and expected to continue until final action RODs are in place. As remedial actions under interim action RODs are completed, verification sampling and laboratory analyses are performed to document the extent to which remedial action goals (RAGs) established under the interim action RODs have been met. This information will be essential to supporting final action RODs.

There are many buildings and structures in the 100 Area. The buildings and structures are evaluated for removal, usually using a CERCLA removal action. Once these structures are demolished and decommissioned under CERCLA non-time-critical removal actions, samples of the residual soil may be collected for analysis. If the analytical results indicate that the area is contaminated, the area is considered a potential waste site. The area is then evaluated, and a remedy is selected in accordance with the interim action ROD.

Characterization data and information developed through implementation of remedial actions under interim action RODs and this work plan will be coordinated to reach a final action ROD. To support a final action remedy at each operable unit, the current remedial actions under interim action RODs for the 100 Area OUs will continue. While these remedial actions are underway, data will be generated to support final action decision making through the CERCLA process.

The 100 Area integrated RI/FS process will be concluded with a data summary for all media (i.e., surface soil, vadose zone, groundwater, and surface water) documented in the RI report, and evaluated through alternative analyses in the FS. The final action remedy selection completes the RI/FS process. Under CERCLA, 5-year reviews continue to be required to evaluate the effectiveness of remedial actions.

1.2.2 Past and Ongoing Risk Assessments

Past and ongoing risk assessments support the development of the final action RODs for the 100 Area operable units. Risk assessment supports development of preliminary remediation goals (PRGs) used to determine the need for a remedial action. Under this final action ROD process, the risk assessment process and results of the various risk assessments (completed or ongoing) will be evaluated and summarized to help make informed risk management decisions for each operable unit. Sources of information for risk characterization supporting the final action RI/FS include the following:

- Data collected during implementation of an interim action ROD
- Data packages developed as part of completion of a soil removal action
- Sampling conducted specifically for assessment of human health and ecological risk

- New and historical characterization activities
- New and historical groundwater monitoring activities

Past risk assessments include the qualitative risk assessment (QRA) supporting the interim action RODs and the River Corridor Baseline Risk Assessment (RCBRA), which were performed to evaluate protection of human health and the environment, including ecological receptors. Further details about these risk assessment activities, as well as the ongoing RIs for Hanford Site releases to the Columbia River, are provided in Chapter 4.0 of this work plan.

1.2.3 CERCLA Implementation History

In 1989, representatives from Ecology, EPA, and DOE signed the Tri-Party Agreement (Ecology et al., 1989a), which created a cohesive regulatory framework, schedule, and adjudication process to administer environmental remediation activities at the Hanford Site for both CERCLA response action and RCRA corrective action activities.

The Tri-Party Agreement (Ecology et al., 1989a) is composed of a Legal Agreement, an Action Plan, and several appendices. The Legal Agreement, Part 3, describes the legal requirements under which CERCLA will be applied. The Action Plan contains a description of the CERCLA remedial action process and its application at the Hanford Site. Specifically, Section 7 of the Action Plan describes the steps in the CERCLA process to address inactive waste sites and associated groundwater contamination. Section 8 describes the use of the CERCLA response action process to disposition inactive key facilities that have a potential to release CERCLA hazardous substances.

Appendices A and B to the Tri-Party Agreement Action Plan (Ecology et al., 1989b) also provide important context for implementing CERCLA at the Hanford Site. Appendix C of the Action Plan provides a list of all known past-practice waste sites to be addressed under CERCLA or RCRA corrective action and their grouping to form OUs. These OUs are groups of past-practice waste sites that can be characterized, assessed, and remediated as a group. In addition to source OUs, several Hanford Site groundwater contaminant plumes have been defined as groundwater OUs. Each OU is assigned to either EPA or Ecology as the lead regulatory agency. Appendix D of the Tri-Party Agreement (Ecology et al., 1989a) provides a list of milestones and schedules for implementing various CERCLA investigations and actions.

The 100 Areas have been subdivided into 18 OUs, including 13 source and 5 groundwater OUs, for the purpose of implementing the CERCLA process. Table 1-1 lists the OUs. Interim action RI/FS work plans were developed starting in early 1990.

Table 1-1. 100 Area Operable Units

Areas	Operable Units	Reactors
100-BC	100-BC-1 OU, 100-BC-2 OU, 100-BC-5 Groundwater OU	B Reactor C Reactor
100-D/H	100-DR-1 OU, 100-DR-2 OU, 100-HR-1 OU, 100-HR-2 OU, 100-HR-3 Groundwater OU	D Reactor DR Reactor H Reactor
100-F/IU-2/IU-6	100-FR-1 OU, 100-FR-2 OU, 100-FR-3 Groundwater OU, 100-IU-2 OU, 100-IU-6 OU	F Reactor
100-K	100-KR-1 OU, 100-KR-2 OU, 100-KR-4 Groundwater OU	KE Reactor KW Reactor
100-N	100-NR-1 OU, 100-NR-2 Groundwater OU	N Reactor

OU = operable unit

For each reactor area, interim action RI/FS work plans were prepared initially for a source OU containing liquid waste sites that constitute primary sources of groundwater contamination and the corresponding groundwater OU. Once the RI/FS process was underway for these OUs, additional interim action RI/FS work plans were prepared to investigate burial ground and other less-significant waste-site-based OUs.

For those OUs with the "isolated unit" designation, an approach and plan was developed (DOE/RL-95-108, *Approach and Plan for Cleanup Actions in the 100-IU-2 and 100-IU-6 Operable Units of the Hanford Site*, Rev. 0). This plan was a "focus package" that presented plans and schedules for addressing waste sites. Waste sites in these OUs were addressed through a combination of CERCLA removal and remedial actions.

The "key facilities" (as identified in Section 8 of the Tri-Party Agreement [Ecology et al., 1989a]) in the 100 Area include the 105-B, 105-C, 105-D, 105-DR, 105-F, 105-H, 105-KE, 105-KW, and 105-N Reactor Buildings. The CERCLA removal actions have been used to disposition these key facilities (with the exception of the B Reactor, which is a designated National Historic Landmark) into a safe and stable configuration known as "interim safe storage (ISS)," pending final decommissioning in the future.

For other 100 Area facilities, the CERCLA removal action process has been used for decommissioning. These facilities are smaller and far less complex than the key facilities subject to the requirements of Section 8 of the Tri-Party Agreement (Ecology et al., 1989a).

As a result of enacting the Tri-Party Agreement (Ecology et al., 1989a), several expedited response and interim remedial actions were implemented. Table 1-2 lists the decisions for remedial actions that have been issued for the 100 Area. The responses/actions resulting from the interim action RODs addressing contaminated soil consist principally of excavating contaminated soil for treatment (as required) and disposal. The responses for contaminated groundwater are designed as interim actions to keep selected principal threat contaminants from reaching the Columbia River. The action memorandums directed the efforts to place the reactors in ISS condition.

Table 1-2. List of Decisions for the 100 Area

ROD Fiscal Year	ROD Type	Operable Units Affected	ROD Number	Internet Link
2009	ESD	100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, 200-CW-3	See note 1	http://www5.hanford.gov/arpir/?content=findpage&AKey=0908240150.
2007	ESD	Source units in the 100 Areas	See note 2	http://www5.hanford.gov/arpir/?content=findpage&AKey=DA06144408.
2005	AMD	100-KR-2	See note 3	http://yosemite.epa.gov/R10/CLEANUP.NSF/9f3c21896330b4898825687b007a0f33/af62704e19f69e868825652c007e9288/$FILE/K%20Basins%20ROD%20Amendment%209June2005%20-Final.pdf.

Table 1-2. List of Decisions for the 100 Area

ROD Fiscal Year	ROD Type	Operable Units Affected	ROD Number	Internet Link
2004	ESD	Source units in the 100 Areas	See note 4	http://www5.hanford.gov/arpir/?content=findpage&AKey=D4855290/
2003	ESD	100-NR-1 and 100-NR-2	EPA/ESD/R10-03/605	http://www.epa.gov/superfund/sites/rods/fulltext/e1003605.pdf.
2003	ESD	100-HR-3	EPA/ESD/R10-03/606	http://www.epa.gov/superfund/sites/rods/fulltext/e1003606.pdf.
2000	ROD	100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 (100 Area Burial Grounds)	EPA/ROD/R10-00/121	http://www.epa.gov/superfund/sites/rods/fulltext/r1000121.pdf.
2000	ESD	100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2, 100-IU-2, 100-IU-6, and 200-CW-3 (100 Area Remaining Sites)	EPA/ESD/R10-00/045	http://www.epa.gov/superfund/sites/rods/fulltext/e1000045.pdf.
2000	ROD	100-NR-1	EPA/ROD/R10-00/120	http://www.epa.gov/superfund/sites/rods/fulltext/r1000120.pdf.
2000	AMD	100-HR-3	EPA/AMD/R10-00/122	http://www.epa.gov/superfund/sites/rods/fulltext/a1000122.pdf.
1999	ROD	100-NR-1 and 100-NR-2	EPA/ROD/R10-99/112	http://www.epa.gov/superfund/sites/rods/fulltext/r1099112.pdf.
1999	ROD	100-KR-2	EPA/ROD/R10-99/059	http://www.epa.gov/superfund/sites/rods/fulltext/r1099059.pdf.
1999	ROD	100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3	EPA/ROD/R10-99/039	http://www.epa.gov/superfund/sites/rods/fulltext/r1099039.pdf.
1997	AMD	100-BC-1, 100-DR-1, and 100-HR-1	EPA/AMD/R10-97/044	http://www.epa.gov/superfund/sites/rods/fulltext/a1097044.pdf.
1996	ROD	100-HR-3 and 100-KR-4	EPA/ROD/R10-96/134	http://www.epa.gov/superfund/sites/rods/fulltext/r1096134.pdf.
1996	ROD	100-IU-1, 100-IU-3, 100-4, and 100-IU-5	EPA/ROD/R10-96/151	http://www.epa.gov/superfund/sites/rods/fulltext/r1096151.pdf.
1995	ROD	100-BC-1, 100-DR-1 and 100-HR-1	EPA/ROD/R10-95/126	http://www.epa.gov/superfund/sites/rods/fulltext/r1095126.pdf.

Table 1-2. List of Decisions for the 100 Area

ROD Fiscal Year	ROD Type	Operable Units Affected	ROD Number	Internet Link

Notes:

Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision, August 2009. No document number has been issued.

Explanation of Significant Difference for the Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units (100 Area Burial Grounds), October 2007. No document number has been issued.

June 2005 ROD amendment (no document number) was issued for the K Basins and is not included as part of the 100 Areas RI/FS Work Plan scope.

Explanation of Significant Differences for 100 Area Remaining Sites Interim Remedial Action Record of Decision, February 2004. No document number has been issued.

Source: "Record of Decision System (RODS) Hanford 100-Area (USDOE)," EPA, 2009a

AMD = Amendment

EPA = U.S. Environmental Protection Agency

ESD = explanation of significant difference

RI/FS = Remedial Investigation/Feasibility Study

ROD = record of decision

TBD = to be determined

Appendix A of this work plan provides a summary of the CERCLA process implementation to date for 100 Area source and groundwater OUs. Figure 1-3 provides a timeline of 100 Area CERCLA decisions. For source OUs, the cleanup strategy for the remedial action remedy under the interim action RODs was removal, treatment (as required), and disposal (RTD) of contaminated soil from liquid waste disposal sites responsible for groundwater contamination. Additional cleanup decisions and ROD amendments were implemented in subsequent years to address additional waste sites and radioactive waste burial grounds in other OUs.

Figure 1-3 also provides a chronology of groundwater OU decisions. The 100 Area groundwater OU decisions addressed contaminants that represent a principal threat through the groundwater pathway. Hexavalent chromium (CrVI) and Strontium-90 (Sr-90) were identified as principal threats to the Columbia River and aquatic receptors. Actions to mitigate the impacts of CrVI were initiated in the 100-HR-3 and 100-KR-4 Groundwater OUs. In the 100-NR-2 OU, actions were undertaken to reduce the amount of Sr-90 entering the river through riverbank springs.

Each of these decisions resulted in interim action remedial activities (e.g., pump-and-treat systems, waste site excavation, facility demolition, reactor ISS, groundwater treatability studies) that were designed to mitigate potential risks, protect groundwater, and protect the Columbia River.

All but one of the RODs *(EPA Superfund Record of Decision: Hanford 100-Area [USDOE] EPA ID: WA3890090076, OU 21 Benton County, WA*, EPA/ROD/R10-96/151) issued for the 100 Area are interim action RODs. The process to incorporate these remedial actions into the final action CERCLA process for the 100 Area is illustrated in Figure 1-4. The interim action ROD remedial activities have provided further data for use, and also identified additional uncertainties to address during the final action RI/FS process.

1.2.4 Regulatory Path Forward for the Hanford Site

The 1993 NEPA *Record of Decision: Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington* (58 FR 48509) documents DOE's decision of ISS followed by one-piece removal to a Central Plateau disposal facility. N Reactor was not included in the environmental impact statement (EIS) as it was not available for decommissioning at the time of the *National Environmental Policy Act of 1969* (NEPA) EIS and would be addressed by a subsequent NEPA or CERCLA decision process. In August 2005, an Engineering Evaluation (DOE/RL-2005-45, *Surplus Reactor Final Disposition Engineering Evaluation*, Rev. 0) evaluated the NEPA ROD decision and determined that the NEPA alternatives remained viable. B Reactor has been designated as a National Historic Landmark and will be placed in a configuration consistent with that use for the foreseeable future. For all reactors except B, ISS actions, selected through the CERCLA removal action process, are designed to prevent deterioration and release of contamination from the reactors for up to 75 years.

The NEPA ROD for the reactors also indicated DOE's intent to complete these reactor-decommissioning actions consistent with the proposed cleanup schedule for CERCLA remedial actions. DOE will evaluate the coordination of the final decommissioning actions with the completion of remaining actions in each area within the CERCLA RI/FS report for each area (Table 1-3). DOE will also evaluate, in those RI/FS reports, remedial alternatives for waste sites in close proximity to the reactors: i.e., waste sites that underlie or are so close to the reactors that they cannot be remediated by remove-treat-dispose prior to final reactor decommissioning.

Final reactor decommissioning actions could be established through either a NEPA ROD and implemented through DOE's *Atomic Energy Act of 1954* (AEA) authority, or through a CERCLA decision and action. Until reactor removal is complete, DOE will continue to conduct routine maintenance, surveillance, and radiological monitoring activities to ensure continued protection of human health and the environment during the interim storage period. Actions needed to address potential environmental releases associated with reactor footprints before reactors are removed will be specified in the CERCLA decision. The RI/FS for each area will include a discussion and analysis of both the options for reactor removal and a strategy for coordinating reactor removal activities with other cleanup activities in the CERCLA final action ROD.

Table 1-3. Hanford Reactor Status and Final Disposition

Reactor	Current Status*	Area	Final Disposition
B	National Historic Landmark 2008	100-BC	ROD for Decommissioning of Eight Surplus Production Reactors EIS (58 FR 48509).
C	ISS since 1998		
D	ISS since 2004	100-D/H	
DR	ISS since 2002		
H	ISS since 2005		

Table 1-3. Hanford Reactor Status and Final Disposition

Reactor	Current Status*	Area	Final Disposition
F	ISS since 2003	100-F/IU-2/IU-6	
KE	ISS to be completed	100-K	
KW	ISS to be completed		
N	ISS to be completed	100-N	Final disposition will be addressed by NEPA or CERCLA decision.

* ISS decisions made through CERCLA removal action authority.

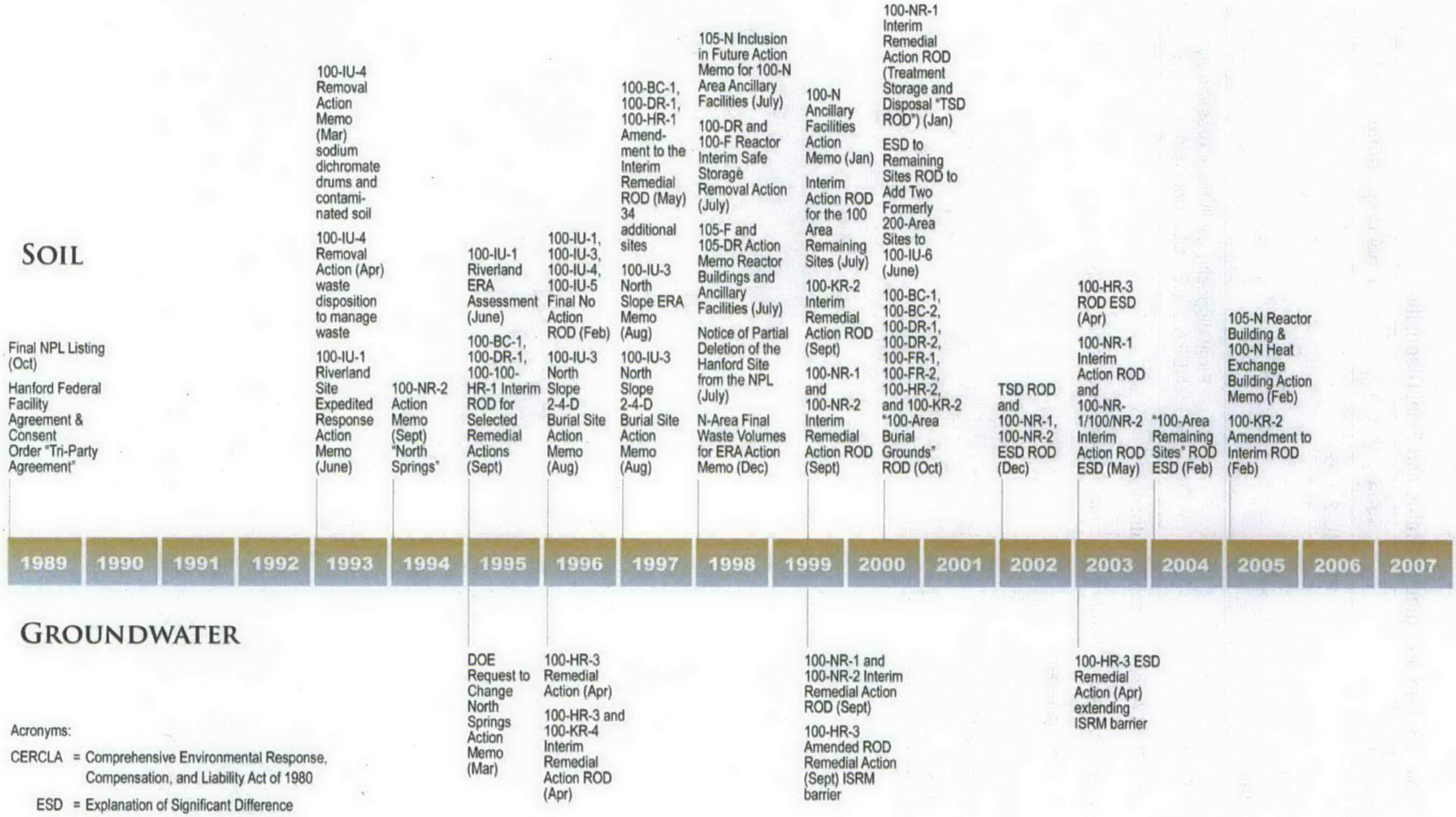
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*

EIS = environmental impact statement

ISS = interim safe storage

NEPA = *National Environmental Policy Act*

ROD = Record of decision



Acronyms:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980

ESD = Explanation of Significant Difference

ERA = Expedited Response Action

ISRM = In Situ Redox Manipulation

NPL = National Priorities List

ROD = Record of Decision

RCBRA = River Corridor Baseline Risk Assessment

ES062008001SEA_373458.A1.02.02_Fig02-2 HistoricTimeline.ai 5/14/09 dk

Figure 1-3. Historic Timeline of CERCLA Decisions

The process is defined as a combination of interim cleanup actions (involving concurrent characterization), field investigations for final remedy selection where interim actions are not clearly justified, and feasibility/treatability studies.

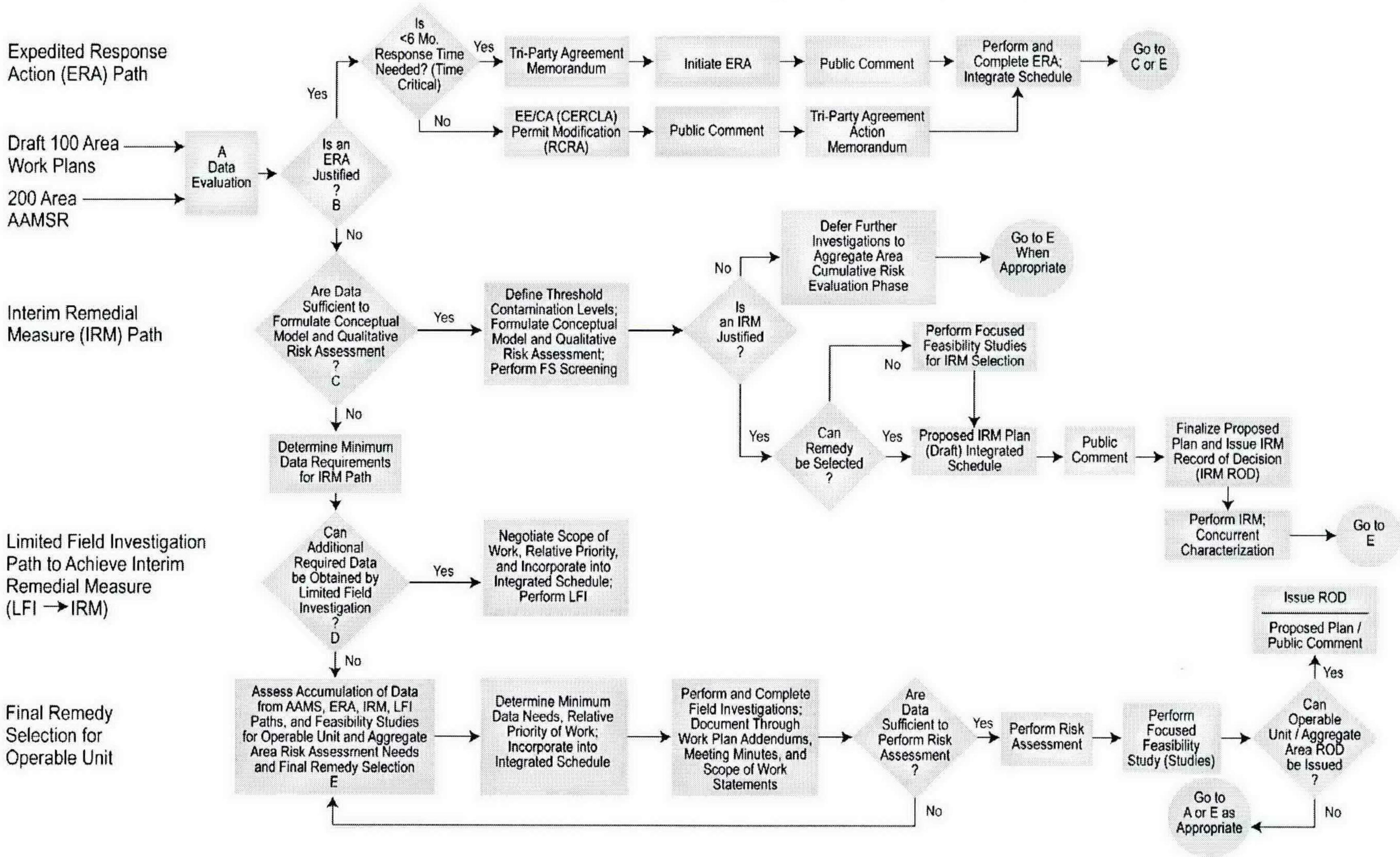


Figure 1-4. Hanford Site Past-Practice Remedial Investigation/Feasibility Study Process

1.3 Hanford Site Cleanup Completion Framework – Summary

The key elements of Hanford Site Cleanup Completion framework are summarized in this section. The framework defines the principal components of cleanup – River Corridor, Central Plateau, and tank waste – and provides the context for individual cleanup actions by establishing the approaches and key principles for those decisions needed to complete the cleanup mission.

The DOE, in cooperation with EPA and Ecology, is developing a strategy to achieve final cleanup decisions for the River Corridor portion of the Hanford Site. The DOE, Richland Operations Office (RL) and DOE, Office of River Protection have prepared the completion framework (DOE/RL-2009-10, *Hanford Site Cleanup Completion Framework*) to describe that strategy and to begin developing the approach to complete the remainder of the cleanup mission.

The overarching goals for cleanup are stated in Figure 1-5. These goals embody more than 20 years of consultation with the Tribal Nations, 17 years of consultation with the Hanford Natural Resource Trustees (Trustees) and dialogue between the Tri-Parties, stakeholders, and the public. The goals consider key values captured in forums such as the Hanford Future Site Uses Working Group, Tank Waste Task Force, Hanford Summits, Tribal Nation values statements, and Hanford Advisory Board (HAB) Exposure Scenario Workshops, as well as more than 200 pieces of advice issued by the HAB. These goals provide a set of principles that guide all aspects of Hanford Site cleanup. Cleanup activities at various areas of the site support the achievement of one or more of these goals. These goals help set priorities to apply resources and sequence cleanup efforts for the greatest benefit.

Goal 1: Protect the Columbia River.

Goal 2: Restore groundwater to its beneficial use* to protect human health, the environment, and the Columbia River.

Goal 3: Clean up River Corridor waste sites and facilities to:

- Protect groundwater and the Columbia River
- Shrink the active cleanup footprint to the Central Plateau
- Support anticipated future land uses

Goal 4: Clean up Central Plateau waste sites, tank farms, and facilities to:

- Protect groundwater and the Columbia River
- Minimize the footprint of areas requiring long-term waste management activities
- Support anticipated future land uses

Goal 5: Safely manage and transfer legacy materials scheduled for offsite disposition including special nuclear material (including plutonium), spent nuclear fuel, transuranic waste, and immobilized high-level waste.

Goal 6: Consolidate waste treatment, storage, and disposal (TSD) operations on the Central Plateau.

Goal 7: Develop and implement institutional controls and long-term stewardship activities that ensure protection of human health and the environment after cleanup activities are completed.

* EPA expects to return usable groundwaters to their beneficial uses wherever practical, within a period that is reasonable given the particular circumstances of the site. When restoration of groundwater to beneficial uses is not practical, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater and evaluate further risk reduction" 40 CFR 300.430(a)(1)(iii)(F). The state requirements, RCRA and MTCA (WAC 173-340), establish that groundwater cleanup levels shall be based on the estimates of the highest beneficial use. For most sites, the use of groundwater as a source of drinking water is the beneficial use requiring the highest quality of groundwater. [WAC 173-303-64620(4), WAC 173-340-720(1)(a), WAC 173-303-610(2)(b)(i)].

Figure 1-5. Overarching Goals for Cleanup

These goals recognize that the Columbia River (Figure 1-6) is a critical resource for the people and ecology of the Pacific Northwest. As one of the largest rivers in North America, its waters support a multitude of uses that are vital to the economic and environmental well being of the region. Cleanup actions must protect this river.

Figure 1-6. Columbia River

The Hanford Site cleanup consists of three major components: (1) River Corridor, (2) Central Plateau, and (3) tank waste (note that the tank waste component is contained within the Central Plateau). Each component of cleanup is in itself a complex and challenging undertaking involving multiple projects and contractors and requiring many years and billions of dollars to complete. These components are shown in Figure 1-7.

River Corridor Cleanup. The River Corridor includes more than 518 km^2 (200 mi^2) of the Hanford Site as shown in Figure 1-7. The River Corridor portion of the Hanford Site includes the 100 and 300 Areas along the south shore of the Columbia River. The 100 Area contains nine retired plutonium production reactors, numerous support facilities, solid and liquid waste disposal sites, and contaminated groundwater. The 300 Area, located north of the city of Richland, contains fuel fabrication facilities, nuclear research and development facilities, associated solid and liquid waste disposal sites, and contaminated groundwater. For the purposes of this completion strategy and ensuring that cleanup actions address all threats to human and environmental health, the River Corridor includes the contiguous areas that extend from the 100 Area and 300 Area to the Central Plateau.

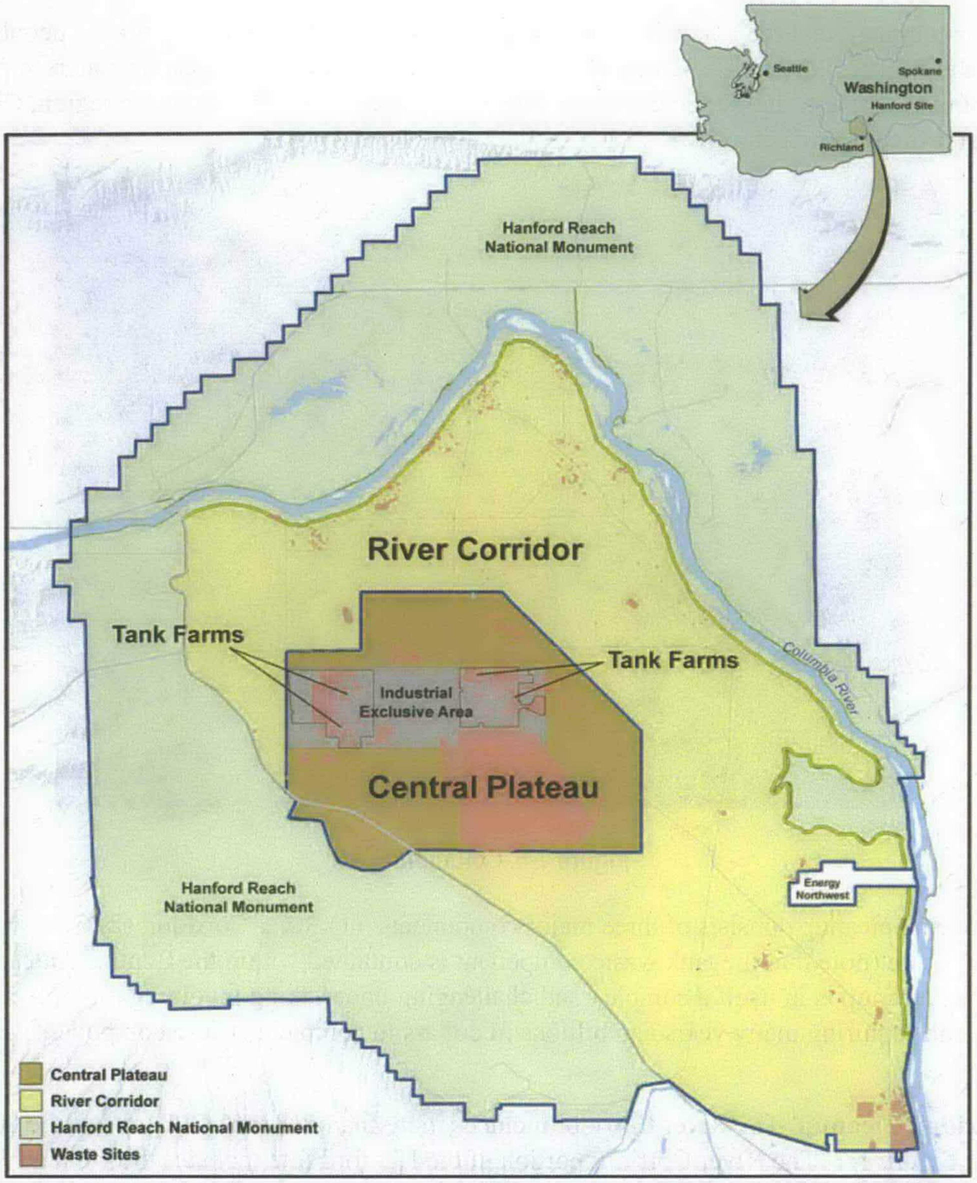


Figure 1-7. Principal Components of Hanford's Cleanup Completion Framework: River Corridor, Central Plateau, and Tank Waste

For sites in the River Corridor, remedial actions are expected to restore groundwater to drinking water standards and to ensure that the aquatic life in the Columbia River is protected by achieving ambient water quality standards where there are ecological receptors, including the hyporheic zone. It is intended that these objectives be achieved, unless technically impracticable, within a reasonable time frame. In those instances where remedial action objectives (RAOs) are not achievable in a reasonable time frame or are determined to be technically impracticable, programs will be implemented to prevent further migration of the plume, prevent exposure to contaminated groundwater, and evaluate further risk reduction opportunities as new technologies become available. River Corridor cleanup work also removes sources of contamination that are close to the Columbia River to the Central Plateau for final disposal or to other disposal facilities as appropriate. The intent is to shrink the footprint of active cleanup to within the 194 km^2 (75 mi^2) area of the Central Plateau by removing excess facilities and remediating waste sites. Cleanup actions will support anticipated future land uses.

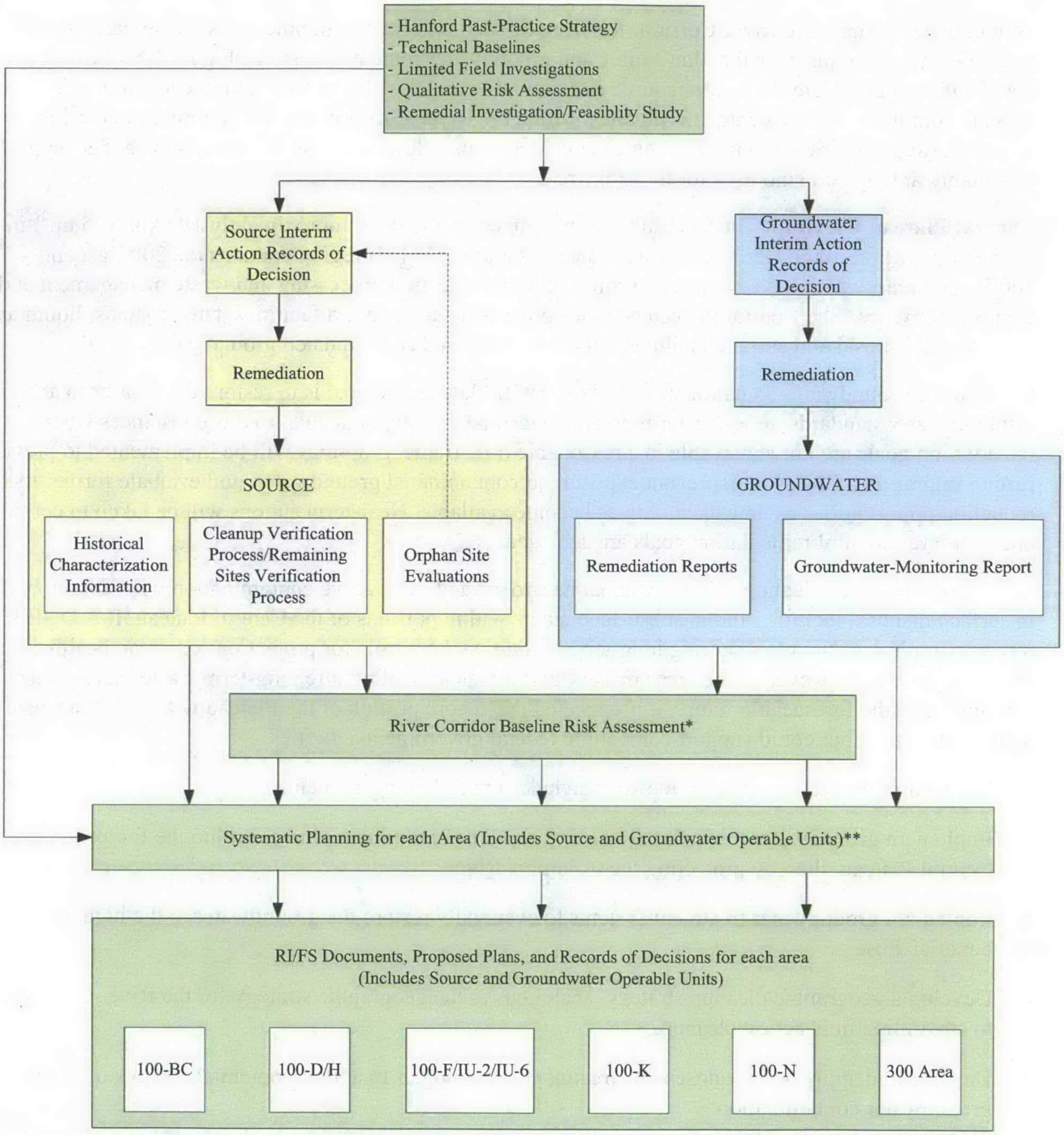
To complete cleanup, the River Corridor has been divided into six geographic areas encompassing all operable units to achieve final action source and groundwater remedy decisions. Figure 1-8 illustrates how DOE will complete RI/FSs for source and groundwater OUs. These final action decisions will provide comprehensive coverage for all areas within the River Corridor and will incorporate interim action cleanup activities into final action cleanup decisions. Cleanup levels will be achieved that support reasonably anticipated land uses for the 100 Area.

Central Plateau Cleanup. The Central Plateau component includes approximately 194 km^2 (75 mi^2) in the central portion of the Hanford Site as shown in Figure 1-7. This region contains the 200 East and 200 West Areas, which have been used primarily for nuclear fuel processing and waste management and disposal activities. The Central Plateau contains processing and support facilities, tank systems, liquid and solid waste disposal and storage facilities, utility systems, and contaminated groundwater.

For areas of groundwater contamination in the Central Plateau, the goal is to restore the aquifer to achieve drinking water standards, unless determined to be technically impracticable. In those instances where remediation goals are not achievable in a reasonable time frame, programs will be implemented to prevent further migration of the plume, prevent exposure to contaminated groundwater, and evaluate further risk reduction opportunities as new technologies become available. Near-term actions will be taken to control plume migration until remediation goals are achieved.

At the completion of cleanup efforts, residual hazardous and radioactive contamination will remain, both in surface disposal facilities and in subsurface media within portions of the Central Plateau. It is DOE's intent to minimize the area requiring long-term institutional controls for protection of human health and the environment. However, some areas of the Central Plateau will require long-term waste management activities. For the foreseeable future, it is expected that a core portion of the Plateau will remain a waste management area but could support compatible federal government activities.

- The Central Plateau cleanup framework includes the following elements:
- Implement groundwater treatment systems to contain contaminant plumes within the footprint of the Central Plateau, thereby protecting the Columbia River.
- Implement groundwater treatment systems to eventually restore the groundwater to the highest beneficial use.
- Develop a geographic cleanup strategy, analogous to the geographic strategy for the River Corridor, to streamline final action cleanup.
- Develop and apply deep vadose zone treatment technologies to address potential sources of future groundwater contamination.
- Remediate the outer portion of the Central Plateau to further reduce the active cleanup footprint of the Hanford Site.
- Remediate the inner portion of the Plateau to minimize the area requiring long-term waste management activities.
- Implement cleanup decisions to support anticipated future land use.
- Regularly evaluate new and improved cleanup technologies to assess their potential to improve cleanup effectiveness and to allow for greater footprint reduction.



* Ecological evaluations were performed at 20 sites, human health evaluations were performed at 164 sites and groundwater evaluations were based on samples from 320 groundwater monitoring wells between 1998 and 2008.
** Information from completed treatability tests was also used during the systematic planning process.

Figure 1-8. Strategy for Alignment of Records of Decision for the River Corridor

Tank Waste Cleanup. Within the Central Plateau, the efforts of the Tank Waste component are responsible for retrieving and treating the Hanford Site's tank waste and for closing or remediating tank farms (Figure 1-7) to protect the groundwater on the Central Plateau, thereby protecting the Columbia River. The tank farms include 177 underground storage tanks (149 single-shell tanks and 28 double-shell tanks) containing approximately 200 million L (53 million gal.) of chemically hazardous radioactive waste from past nuclear processing operations. Sixty-seven of the Hanford Site tanks are confirmed or presumed to have leaked up to 3,780,000 L (1 million gal.) of contamination into the ground.

The tank waste cleanup strategy includes the following elements:

- Complete construction of the Waste Treatment Plant.
- Provide sufficient treatment capacity to enable mission completion.
- Begin treatment and immobilization of tank waste to enable tank retrieval to proceed at a rate that supports treatment capacity.
- Store tank waste safely until it is retrieved for treatment.
- Implement remedies that protect the groundwater and environment from past tank farm releases – in conjunction with surrounding waste sites and groundwater OUs.
- Complete closure of tank farms in coordination with, and consistent with, the Central Plateau cleanup completion strategy.

Long-Term Stewardship and Legacy Management. Following the implementation of site cleanup actions, there will be disposal facilities and other areas that will necessitate long-term management activities. Natural resource restoration activities and long-term stewardship activities will be required for portions of the Hanford Site to ensure protection of human health and the environment. If the completion of cleanup will not result in the total restoration of all natural resources injured by a release, the United States is required to resolve natural resource damage liability.

The DOE is committed to maintaining the protection of human health and the environment and to meeting its long-term, post-cleanup obligations in a safe and cost-effective manner. The completion of cleanup and the transition to long-term stewardship are approaching. Therefore, actions are being considered and taken today to minimize natural resource concerns and ensure long-term stewardship considerations are incorporated into the cleanup decisions.

1.4 100 Area Remediation Overview

Environmental remediation under CERCLA was first initiated on the Hanford Site in 1996 and continues today. Since that time, DOE has taken actions to characterize groundwater plumes and their potential sources, evaluate alternative treatment methods, and remediate groundwater and soil. All these activities provide data and information to support the development of work plans. Table 1-4 provides a list and brief summary of selected activities and investigations that have been conducted to date in the 100 Area. Further details on these activities are provided in Chapter 3.0.

Table 1-4. Examples of Activities Providing Information and Data to Support Development of Remedial Investigation/Feasibility Study Work Plans (Through December 2008)

Activity Name	Accomplishments/Investigations
Facility D4 Actions	Over 300 structures have been demolished in the 100 Area. In addition, five 100 Area reactors have been placed in ISS.
Waste Site Remediation Program	Remediation in accordance with the interim action RODs occurred at more than 155 waste sites, including 78 of 82 high-priority liquid waste sites*, which have been backfilled with clean soil. Approximately, a total of 8 million tonnes (9 million tons) of contaminated soil have been disposed at the ERDF.
Spent Nuclear Fuel and Related Sludge Removal Actions	Approximately 2,100 tonnes (2,300 tons) of spent nuclear fuel and up to 30 cubic meters (40 cubic yards) of sludge, 9.1 million liters (2.4 million gal.) of water, and hundreds of tons of debris and fuel racks (solid waste) were removed from two basins that are located less than a quarter-mile from the Columbia River.
Orphan Site Evaluation Program	Orphan site evaluations have been completed across 25 percent of the River Corridor. Most of the remaining area is within the 100-F/IU-2/IU-6 "inter areas." Over 14,190 ha (35,058 ac) have been assessed through the orphan site evaluations to identify new waste sites.
River Corridor Baseline Risk Assessment	The assessment provided an analysis of human health and ecological risk in the River Corridor.
Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River	This plan described efforts to collect data for an evaluation of the nature and extent of contamination and current risk to humans, animals, and plants exposed to Hanford Site related contaminants. Samples of pore water, sediment, surface water, fish, and island soil collected in 2008 and 2009.
100-K, 100-D, 100-H, and 100-N Areas Pump-And-Treat Systems	The 100-K, 100-D, and 100-H large pump-and-treat systems have treated over 7.6 billion L (2 billion gal.) of groundwater and removed nearly one ton of CrVI from the aquifer. The 100-N Pump-and-Treat system has removed 1.8 curies of Sr-90 and is currently in cold standby.
Remediation Process Optimization	This process provides a systematic evaluation and enhancement of the current site remediation actions to foster improved cleanup performance and reduce cost.
Groundwater Monitoring	All HEIS groundwater monitoring data available through December 2008 from all groundwater monitoring wells constructed in the River Corridor will be evaluated.
Aquifer Tube Sampling	More than 400 aquifer tubes have been installed at the Hanford Site since 1997. These aquifer tubes are sampled to provide data on the nature and extent of contaminants in groundwater at locations adjacent to the Columbia River.
Biostimulation Test	Molasses was injected at the 100-D Area biostimulation treatability test site to nourish bacteria that can reduce CrVI to trivalent chromium, which is less toxic and less mobile than CrVI.
Electrocoagulation Test	New technology enabled cost-effective remediation of CrVI contaminated groundwater.
In Situ Redox Manipulation	By injecting non-toxic chemicals into an aquifer, ISRM can successfully immobilize contaminants to aquifer sediments, or reduce contaminants to a less toxic form (e.g., reduce CrVI to trivalent chromium).
Fortifying ISRM Barrier with Iron	Maintaining the ISRM barrier depends on the presence of naturally occurring iron. Studies have shown that fortifying the barrier with more iron offers a sustainable long-term repair.

Table 1-4. Examples of Activities Providing Information and Data to Support Development of Remedial Investigation/Feasibility Study Work Plans (Through December 2008)

Activity Name	Accomplishments/Investigations
Apatite Barrier Installation	The barrier removes Sr-90 from groundwater and allows it to radioactively decay in the soil by binding Sr-90 from the groundwater into the apatite mineral matrix.
Petroleum Hydrocarbon Remediation at 100-N Area	Installed boreholes and wells for ongoing monitoring, natural attenuation, and bioremediation of groundwater and vadose zone.
Polysulfide Injection	New technology was tested to reduce CrVI within groundwater.
Phytoremediation Field Demonstration	Phytoremediation, using the Coyote willow (a common plant that grows along the banks of the Columbia River), can be used to extract Sr-90 from the groundwater prior to its migration to the Columbia River.

* High priority waste sites are identified in limited field investigation (LFI) reports and interim action RODs that pose risk(s) through one or more pathways sufficient to recommend streamlined action via an interim action remedial measure.

CrVI = hexavalent chromium

D4 = deactivation, decontamination, decommissioning, and demolition

ERDF = Environmental Restoration Disposal Facility

HEIS = Hanford Environmental Information System

ISRM = In situ redox manipulation

ISS = interim safe storage

ROD = record of decision

Sr-90 = strontium-90

1.5 Systematic Planning

The EPA *Policy and Program Requirements for the Mandatory Agency-Wide Quality System* (CIO 2105.0) requires that a process be used in a systematic fashion for projects involving environmental data. EPA recommends a data quality objective (DQO) process for a systematic planning tool. The systematic planning process used for the 100 Area RI/FS work plan consisted of the following steps:

1. For the 100-D, 100-H, 100-K, and 300 Area, interviews were conducted with interested parties including DOE, EPA, Ecology, Tribal Nations, Natural Resource Trustees, and stakeholders to generate a list of concerns to guide development of project components.

2. Presentation plates of CSM components were developed to identify principal study questions, supporting information, and resulting data gaps requiring further evaluation.

3. Work sessions were held with the Tri-Parties to present, discuss, and collect comments on the plates. These comments primarily took the form of uncertainties that were further evaluated in smaller agency and contractor groups (uncertainty teams).

4. Input from both the working sessions and uncertainty teams supported updating of the CSM plates, which included both principal study questions and data gaps. A process of collecting and responding to regulator comments was conducted.

Upon the completion of the CSM plates, the data needs and proposed sampling approaches were developed and outlined in the 100 Area addenda. This development utilized the CSM plates, outcomes of the working sessions, outcomes of the uncertainty teams, and existing data.

A summary table (provided in Chapter 4.0 of the addenda) is included to link proposed sampling to each data need.

Tribal Nations, Trustees, and stakeholders were informed of progress via traditional mechanisms, such as the Hanford Advisory Board's River and Plateau Committee and the Natural Resource Trustee Council.

2 Background and Setting

This chapter provides a brief overview of the Hanford Site 100 Area, identifies the areas, and describes the environmental setting of the 100 Area.

2.1 100 Area Overview

The 100 Area is located in the northern portion of the Hanford Site, along the southern shore of the Columbia River (Figure 2-1). The Hanford Site, managed by DOE, encompasses approximately 1,517 km^2 (586 mi^2) in the Pasco Basin of south-central Washington State. The Hanford Site was selected for plutonium production in 1942 as part of the Manhattan Project because of the availability of water from the Columbia River and access to power from Bonneville and Grand Coulee Dams.

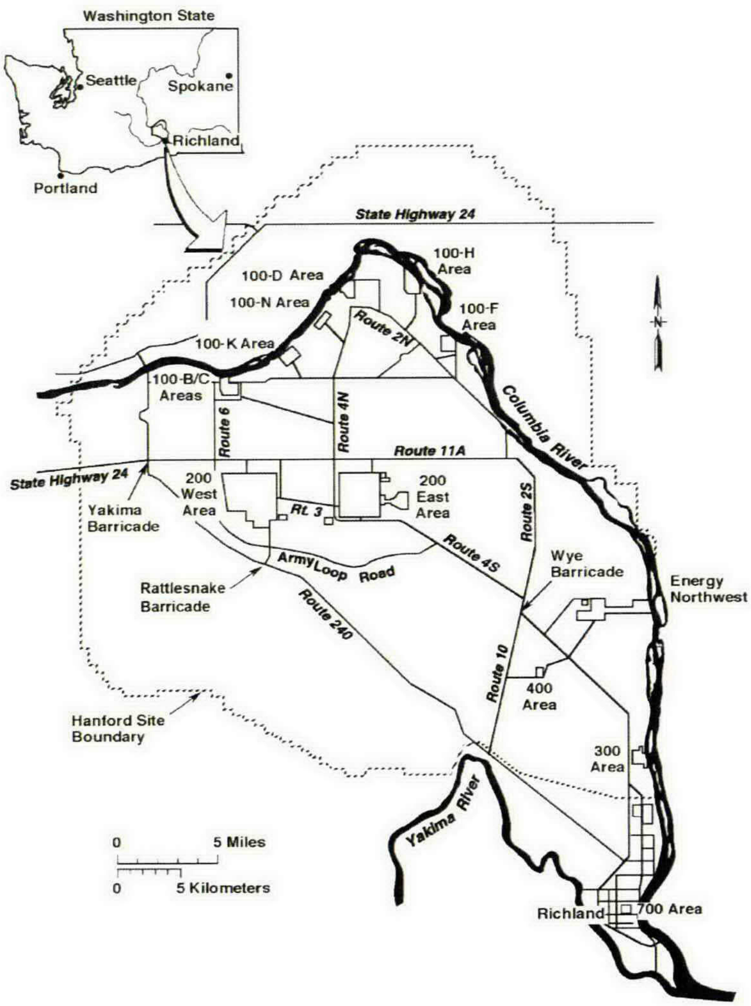


Figure 2-1. Location of the Hanford Site and the 100 Areas

Between 1943 and 1964, nine plutonium (Pu) production reactors were built along the Columbia River in six areas: the 100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F (Table 2-1). Operations began with the B Reactor, followed in chronological order by D, F, H, DR (built as a replacement for D Reactor), C, KW and KE, and N Reactors. Only the N Reactor was constructed with a closed loop coolant circuit and a secondary use of steam production for power generation at the Hanford Generating Plant.

Table 2-1. Construction and Operational Periods for 100 Area Reactors

Reactor	Construction Start	Operations Start	Operations Stop
B	Aug 1943	Sep 1944	Feb 1968
D	Nov 1943	Dec 1944	Jun 1967
F	Dec 1943	Feb 1945	Jun 1965
DR	Dec 1947	Oct 1950	Dec 1964
H	Mar 1948	Oct 1949	Apr 1965
C	Jun 1951	Nov 1952	Apr 1969
KW	Nov 1952	Dec 1954	Feb 1970
KE	Jan 1953	Feb 1955	Jan 1971
N	May 1959	Mar 1964	Jan 1987

Production of special nuclear materials (principally Pu-239 and tritium) was the primary function of the reactors. All the reactors have been retired from service. Each area consists of OUs for liquid and solid waste disposal (called source OUs), as well as an OU for groundwater related contamination (DOE/RL-92-11, *100 Area Feasibility Study, Phases 1 and 2*). The reactors are located in their corresponding areas (e.g., 100-B/C Area contains B Reactor and C Reactor). Table 1-1 identifies the source and groundwater OUs contained in a particular area.

Liquid wastes from reactor operations and associated facilities were released to the soil column and the Columbia River. Solid wastes were disposed in burial grounds associated with the facilities. Wastes released to or buried within the environment created sources of contamination, such as liquid waste sites (ponds, trenches, cribs, and French drains), burial grounds and numerous miscellaneous small waste sites scattered throughout the river corridor.

- **Ponds**: Unlined, high volume, surface liquid waste sites, designed primarily as percolation sites to receive low concentration waste streams (Figure 2-2). Pond depths ranged from 1 to 9 m (3.28 to 29.5 ft), and their surface areas typically were more than 2,600 m^2 (27,934 ft^2).

Figure 2-2. 100-D Area Ponds (1992)

- **Trenches**: Shallow, narrow, unlined surface liquid waste sites of variable length that received limited quantities of sludge and/or liquid wastes (cooling water, contaminated water and sludge, sodium dichromate, fuel rupture effluent, and decontamination solutions [i.e., citric acid, nitric acid, and solvents]). Trenches typically were 15 to 40 m (50 to 130 ft) long, 3 to 5 m (10 to 16.5 ft) wide, and 2 to 6 m (6 to 20 ft) deep.
- **Cribs**: Subsurface liquid waste disposal sites for percolating wastewater into the ground without exposure to the atmosphere. The "cribs" typically were 3 by 3 by 3 m (10 by 10 by 10 ft) boxes, shored with wooden railroad ties, and filled with gravel. Early waste management practices used cribs to receive low-level radioactive waste for disposal and to provide a physical barrier against surface exposure. Cribs received contaminated water and sludge, contaminated process tube effluent, fuel storage effluent, spent laboratory solutions, and potassium borate solutions.
- **French drains**: Subsurface liquid waste disposal sites designed to percolate wastewater into the ground without exposure to the atmosphere; usually constructed with a 1 m (3-ft) diameter, open or gravel filled pipe placed vertically to less than 5 m (less than 16 ft) below ground surface. French drains typically received low-level radioactive waste for disposal.
- **Solid waste burial grounds**: Areas used for near surface disposal of solid waste containing hazardous substances (radioactive and nonradioactive), and received construction debris (e.g., steel, concrete, and wood) from reactor modifications, contaminated construction equipment, contaminated soil, irradiated reactor parts, thimbles, gun barrels, potential spent fuel, and low level radioactive combustible material (WHC-EP-0087, *Estimates of Solid Waste Buried in 100 Area Burial Grounds*; RL-REA-2247, *Historical Events – Reactors and Fuels Fabrication*). Figure 2-3 shows the 118-H-1 Burial Ground during excavation.

Figure 2-3. 118-H-1 Burial Ground Excavation (2007)

Wastes unintentionally released to the environment created sources of contamination referred to as unplanned release sites. In general, an unplanned release site is the result of an unintentional airborne, liquid, or solid release of contaminants to the environment. Waste sites in this group typically were caused by liquid waste spills.

- **Retention basins**: Large, open, reinforced concrete structures designed to temporarily hold cooling water from reactor operations, then discharged to the Columbia River after cooling and decay of short-lived radioactive contaminants. Although retention basins are sometimes considered liquid waste sites because they leaked substantially to the surrounding soil column, they were not designed to percolate liquids into the soil column.
- **Pipelines**: Closed transfer lines to, between, and from facilities or structures that periodically leaked or were compromised and released contaminants to the environment.
- **Spills/leaks**: Waste sites that were generated via broken valves to or on mobile tanks, trucks, or transfer lines, and the sites are generally small. Figure 2-4 depicts an unplanned release site.

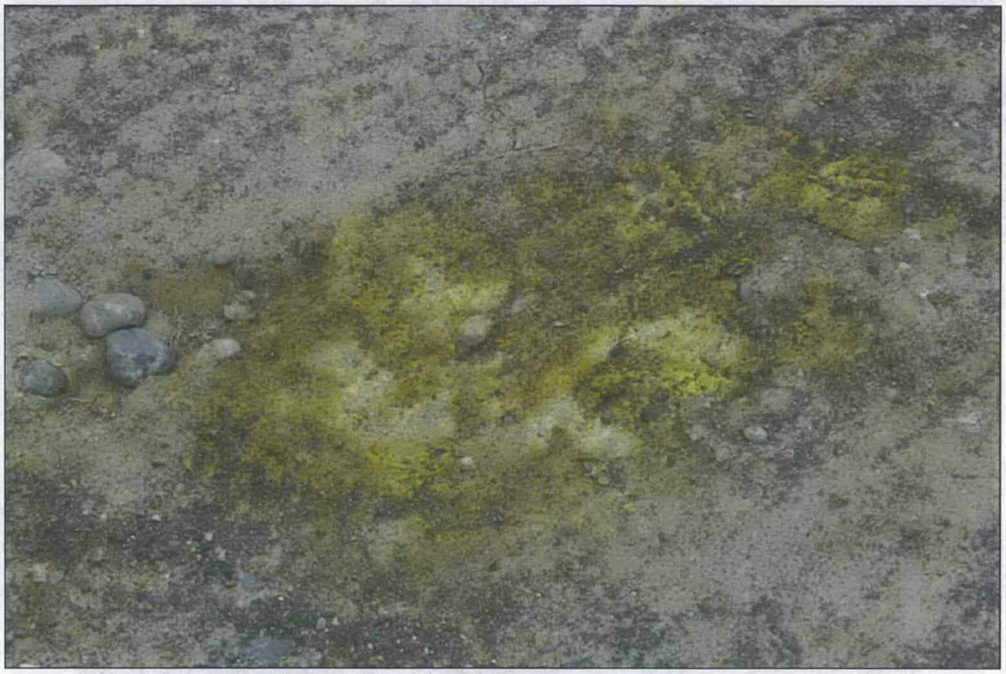


Figure 2-4. Chromium Soil Contamination Near Well 100-D-12

Waste sites are identified in the official Hanford Waste Information Data System (WIDS) database, which is the source for information of known and suspected waste sites. Waste sites are defined as any location that may require action to mitigate a potential environmental impact (RL-TPA-90-0001, *Tri-Party Agreement Handbook Management Procedures*, Guideline Number TPA-MP-14). Within WIDS, waste sites and suspected waste sites are assigned a classification/reclassification category to designate the status of a site. The types of waste site classification/reclassification status are accepted, consolidated, not accepted, interim closed out, closed out, no action, and discovery. These terms are defined in RL-TPA-90-0001, TPA-MP-14, as follows:

- **Discovery**: An initial classification status indicating evidence of a potential waste site; assessment not yet complete. This is the classification of a newly discovered WIDS site.
- **Not accepted**: A classification status indicating an assessment was made that a WIDS site is not a waste management unit and is not within the scope of the Tri-Party Agreement Action Plan, Section 3.1. This classification requires lead regulatory agency approval.
- **Accepted**: A classification status indicating an assessment has been made that a WIDS site is a waste management unit as defined in the Tri-Party Agreement Action Plan, Section 3.1.
- **Consolidated**: A reclassification status indicating that a WIDS site is a duplicate of, physically located within, or adjacent to another WIDS site and will be dispositioned as part of the other WIDS site. Note: A consolidated WIDS site has no future updates in WIDS after reclassification. All updates are limited to the WIDS site with which it was consolidated.
- **No action**: A reclassification status indicating a waste site does not require any further remedial action under RCRA Corrective Action, CERCLA, or other cleanup standards based on an assessment of quantitative data collected for the waste site.
- **Interim closed out**: A reclassification status indicating due to actions taken, a waste management unit meets cleanup standards specified in an interim action ROD or action memorandum but for which a final action ROD has not been issued.
- **Closed out**: A reclassification status indicating that due to actions taken, a waste management unit meets applicable cleanup standards or closure requirements. (Note: Many remediation waste sites were identified as "Closed Out" based on a previous classification scheme. Since all the associated RODs are interim action RODs, these waste sites are considered "Interim Closed Out" based on current definitions.)
- **Rejected**: A reclassification status indicating a waste site does not require remediation under RCRA Corrective Action, CERCLA, or other cleanup standards based on qualitative information such as a review of historical records, photographs, drawings, walkdowns, ground penetrating radar scans, and shallow test pits. Such investigations do not include quantitative measurements.

Table 2-2 presents the numbers of waste sites by their classification/reclassification within each area. The status of waste site classification/reclassification fluctuates as wastes sites are closed, discovered, etc. More up-to-date details on waste sites' status will be made available in the area-specific addenda.

Table 2-2. Waste Site Status (as of 2009)

Waste Site Classification	Sites
100-BC Area	
Accepted	13
Discovery	7
Closed out	2
Interim closed out	58
Not accepted/Rejected	19
No action	17

Table 2-2. Waste Site Status (as of 2009)

Waste Site Classification	Sites
Waste site total:	**116**
100-D/H Area	
Accepted	102
Discovery	21
Closed out	5
Interim closed out	64
Not accepted	29
No action	5
Waste site total:	**226**
100-F/IU-2/IU-6 Area	
Accepted	40
Discovery	43
Closed out	1
Interim closed out	69
Not accepted	74
No action	26
Waste site total:	**253**
100-K Area	
Accepted	96
Discovery	14
Closed out	1
Interim closed out	12
Not accepted	26
No action	0
Waste site total:	**149**
100-N Area	
Accepted	89
Discovery	3
Closed out	1
Interim closed out	15
Not accepted	35
No action	1
Waste site total:	**144**
TOTAL WASTE SITES	**888**

2.2 Descriptions

Because of changing data collection needs, decision logic, and current understanding of 100 Area conditions, the various remedial activities will be conducted by area rather than by individual OU. Coordinated decisions for contiguous source and groundwater OUs will be made to achieve final action cleanup decisions for given portions of the 100 Area. Figure 1-2 shows the River Corridor boundaries and Table 1-1 provides information on each of the operable units within the 100 Area.

2.3 Environmental Setting

The Hanford Site occupies a small portion of the Columbia River drainage system in the Pasco Basin of south-central Washington State. The area is relatively low relief, which resulted from river and stream sedimentation filling the valleys and basins in the Pasco Basin. Hanford Site elevations range from approximately 100 m (330 ft) to nearly 1,100 m (3,600 ft) above sea level (DOE/RL-91-50, *Environmental Monitoring Plan United States Department of Energy Richland Operations Office*). The 100 Area reactors and associated facilities are on steep bluffs overlooking the river. The bluff heights range from 9.2 m (30 ft) at the 100-B/C Area to approximately 21 m (70 ft) at the 100-N Area.

2.3.1 Meteorology

The Hanford Site is characterized by a semi-arid, shrub steppe climate, and is the driest and warmest portion of the Columbia Basin. The Hanford Site's large size and complex topography can accommodate substantial spatial variations in wind, temperature, precipitation, and other meteorological parameters, which are further affected by mountain barriers (PNNL-6415, *Hanford Site National Environmental Policy Act [NEPA] Characterization*). The Cascade Range, to the west, creates a rain shadow effect on the Hanford Site climate, while the Rocky Mountains and ranges in southern British Columbia protect it from the more severe polar air masses from Canada (PNNL-15160, *Hanford Site Climatological Summary 2004 with Historical Data*).

Surface winds blow predominantly from the northwest during winter and summer and from the southwest during spring and fall. In the 100 Area and along the Columbia River, local winds are strongly influenced by near river topography (PNNL-6415). Average monthly wind speeds are the lowest during winter, averaging 10 to 11 km/h (6 to 7 mi/h), and highest during summer, averaging 14 to 16 km/h (8 to 10 mi/h). High-speed surface winds in the summer from the southwest can generate regional dust storms that sometimes lead to onsite work terminations.

Climatic data are monitored at the Hanford Meteorological Station and 28 monitoring locations throughout the Hanford Site and local area (PNNL, 2008, "Hanford Meteorological Station (HMS), Monthly and Annual Temperatures [°F]"). From 1946 through 2004, the recorded maximum temperature was 45°C (113°F) during July 2002 and August 1961, and the recorded minimum temperature was 30.6°C (–23°F) during February 1950 (PNNL-6415). The monthly average temperature from 1946 through 2004, ranged from a low of –0.24°C (31.7°F) in January to a high of 24.6°C (76.3°F) in July. The monthly and annual minimum temperatures and the monthly and annual maximum temperatures are shown in Tables 2-3 and 2-4). The annual average relative humidity is 54 percent (PNNL-6415).

Table 2-3. Monthly and Annual Minimum Temperatures from 1945 through 2004

1945-2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average (°F)	7	12	21	29	35	44	49	49	39	27	17	9	28
Lowest (°F)	-22	-23	6	21	28	37	39	41	30	7	-13	-14	-23
Highest (°F)	24	29	32	37	48	52	58	56	48	34	28	23	58

Note: Data from PNNL, 2008, "Hanford Meteorological Station (HMS), Monthly and Annual Temperatures (ºF)"

Table 2-4. Monthly and Annual Maximum Temperatures from 1945 through 2004

1945-2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average (°F)	57	62	70	81	93	99	105	103	95	81	65	57	81
Lowest (°F)	36	46	63	71	81	86	96	96	86	73	57	39	36
Highest (°F)	72	72	83	94	104	111	113	113	106	89	76	69	113

Note: Data from PNNL, 2008 "Hanford Meteorological Station (HMS), Monthly and Annual Temperatures (ºF)"

Annual precipitation measurements historically recorded at the Hanford Site have varied from approximately 8.7 to 28.8 cm/year (3.4 to 11.3 in/year) since 1947, with an average of 19.5 cm/year (7.7 in/year). Most precipitation occurs during late autumn and winter, with more than half of the annual amount occurring from November through February. Snowfall accounts for approximately 38 percent of precipitation from December through February (PNNL-6415). Winter monthly average snowfall ranges from 0.8 to 13.5 cm (0.3 to 5.3 in.) (March and January, respectively).

2.3.2 Geologic Setting

The Hanford Site lies within the Pasco Basin, a sub-basin of the Columbia River Basin. The Columbia River Basin comprises much of eastern Washington and northeastern Oregon and is framed by the Cascade Mountains to the west and the Rocky Mountains to the east.

The Columbia River Basalt Group consists mainly of continental basalts derived approximately 6 to 17 million years ago from north to northwest-trending fissures in eastern Washington, north-central and northeastern Oregon, and western Idaho. The Columbia River Basalt Group underlies the sedimentary deposits in the Pasco Basin, as shown in the generalized stratigraphic column in Figure 2-5. These suprabasalt sediments are laterally extensive Neogene deposits of the Ringold Formation and the Hanford formation, an informal designation (PNNL-14202, *Mineralogical and Bulk-Rock Geochemical Signatures of Ringold and Hanford Formation Sediments*). The sediments play a major role in contaminant transport in the subsurface environment.

This section of the work plan focuses on the following suprabasalt sediments from oldest to youngest:

- Ringold Formation (coarse- to fine-grained sediment)
- Hanford formation (coarse- to fine-grained sediment)
- Holocene surficial deposits (aeolian sediment)

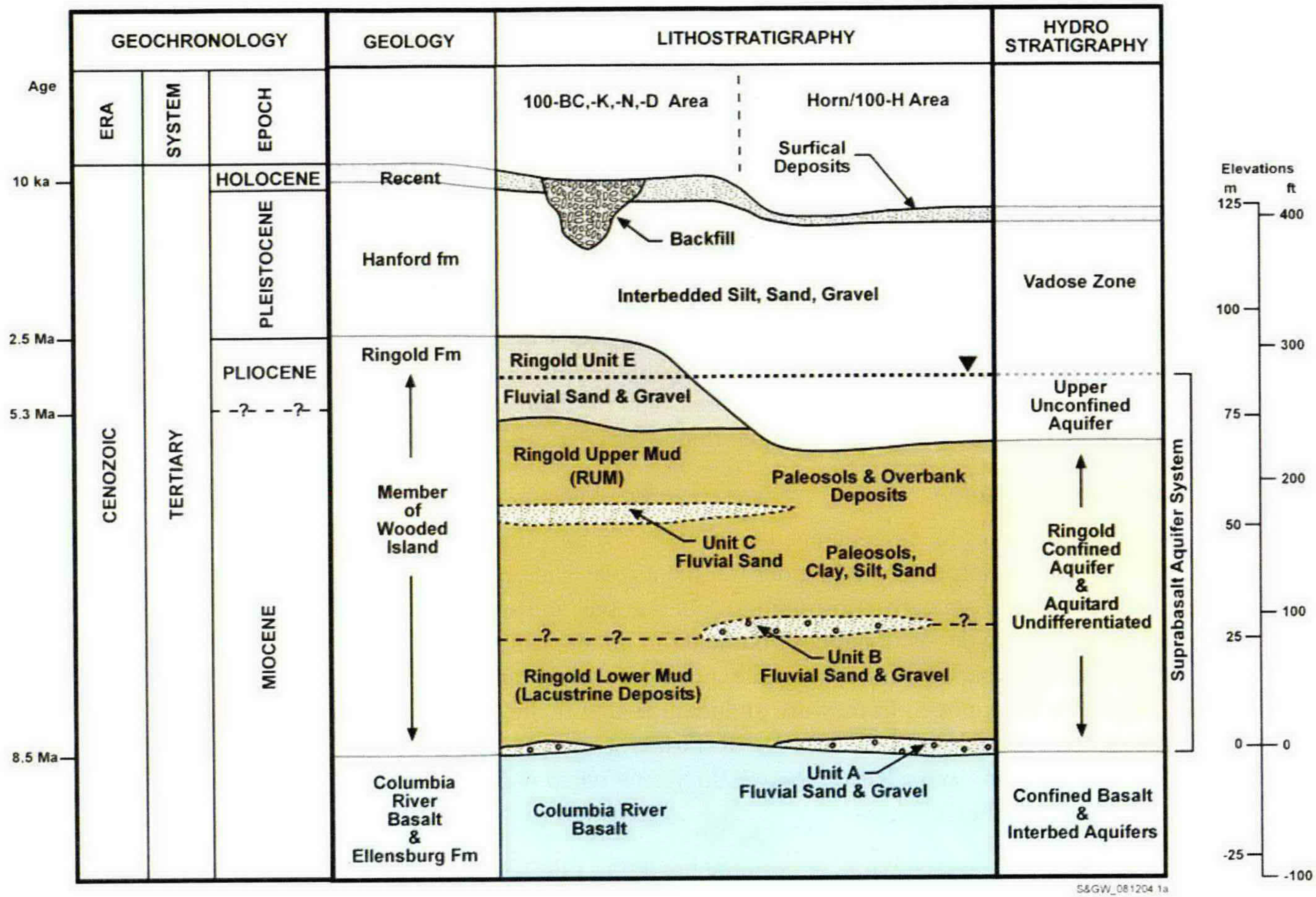


Figure 2-5. Generalized Hydrogeology of the 100 Area

2.3.2.1 Ringold Formation

The Ringold Formation[5] consists of six lithofacies units distinguished by grain size laboratory data and borehole geophysical responses (WHC-SA-0740-FP, *Sedimentology and Stratigraphy of the Miocene-Pliocene Ringold Formation, Hanford Site, South-Central Washington*):

- Mud
- Mud and sand
- Sand
- Sand and gravel
- Gravel
- Cobble and boulder

5 The Ringold Formation initially was described as five, laterally traceable lithostratigraphic units of an interstratified sequence of unconsolidated clay, silt, sand, and granule to cobble gravel (DOE/RW-0164, *Consultation Draft Site Characterization Plan: Reference Repository Location, Hanford Site, Washington*; RHO-BWI-ST-4, *Geologic Studies of the Columbia Plateau: A Status Report*.

The Ringold Upper Mud (RUM) Unit forms the base of the unconfined aquifer at the Hanford Site and acts as an aquitard (less permeable sediment) that separates the confined aquifer in the underlying Ringold Unit A from the unconfined aquifer. The RUM is covered by the extensive Unit E sand and gravel sequence in the 100 Area. Unit E comprises those portions of the Ringold Formation that are most easily observed or that have been most commonly logged in boreholes or test pits (USGS-PP-717, *Geology and Groundwater Characteristics of the Hanford Reservation of the U.S. Atomic Energy Commission, Washington*). Where present, Unit E displays accumulations of more than 50 m (164 ft) in thickness, with a maximum thickness of 260 m (820 ft) near the center of the Hanford Site.

The late stage catastrophic flooding that deposited the Hanford formation also eroded the underlying Ringold Formation. In some areas, all material overlying the Ringold Unit E was removed, while in other areas, scouring removed portions of the upper Ringold Unit E. Locally, the Ringold Unit E was removed down to the RUM Unit, such as at the 100-H Area. The Cold Creek Unit was either not deposited or was removed through erosion during the late stage flooding events.

2.3.2.2 Hanford Formation

The Hanford formation is heterogeneous. It is characterized by both coarse and fine-grained units including large to very large cobble boulder fragments/clasts in open framework gravel in massive bedding. The grains are typically sub-round to round gravel and sub-angular to round in the sand grain faction; the high-energy depositional environment did not deposit very fine to clay sized particles. The particles are typically felsic (granite, quartzite, gneiss, or schist) and mafic (basalt or andesite) in all size ranges. These gravels are open framework and identified with the high-energy environment of cataclysmic flood channel ways (WHC-SD-ER-TI-003, *Geology and Hydrology of the Hanford Site: A Standardized Text for Use in Westinghouse Hanford Company Documents and Reports*) and are the dominant materials in the 100 Area.

Cataclysmic floods, associated with the periodic breakup of the Cordilleran ice sheet during the Pleistocene, are well known for having scoured the channeled scablands and creating flood deposits behind hydraulic constrictions at Wallula Gap. Up to 100 m (330 ft) of fine to coarse-grained flood deposits incrementally accumulated as the Hanford formation at the Hanford Site (Bjornstad et al., 2001, "Long History of Pre-Wisconsin, Ice Age Cataclysmic Floods: Evidence from Southeastern Washington State"). These deposits make up the most extensive and voluminous part of the Hanford formation and are less common in the 100 Area.

2.3.2.3 Holocene Surficial Deposits

Holocene surficial deposits are composed of silt, sand, and gravel that were deposited by a mix of Aeolian and alluvial processes. No thicker than approximately 5 m (16 ft), these deposits are observed as a thin veneer across much of the Hanford Site, where the surface has not been disturbed or altered by construction.

2.3.3 Hydrogeology

The groundwater flow system beneath the Hanford Site remains a primary pathway for some contaminants to migrate from source areas, and for some contaminants to discharge to the Columbia River. Hydrogeologic characterization for the100 Area requires an understanding of the properties and behavior of the vadose zone, groundwater, and surface water sources, interfaces, and interactions. The Pasco Basin supports a multiple aquifer system corresponding to the upper Columbia River Basalt Group and the suprabasalt sediments (WHC-SD-ER-TI-003).

Evidence suggests that the most significant recharge events are associated with rapid melts of large snowpacks, (PNNL-14744, *Recharge Data Package for the 2005 Integrated Disposal Facility Performance Assessment*). While evapotranspiration and transpiration account for most of the remaining precipitation loss (net infiltration is less than 5 mm per year [PNNL-16688, *Recharge Data Package for Hanford Single-Shell Tank Waste Management Areas*]), some precipitation infiltrates into the soil and eventually recharges the groundwater flow system. The amount of recharge varies spatially, based primarily on soil texture, vegetation type, and vegetation coverage (PNL-10285, *Estimated Recharge Rates at the Hanford Site*). Recharge also varies temporally with the majority occurring in the winter and spring.

A significant source of recharge is from infrastructure losses (e.g., leaking water lines, leaking water storage structures) as water migrates through more permeable backfill materials placed along piping trenches and around buried storage tanks, or placed in remediated excavation areas. Additional infiltration occurs as the result of water used for dust suppression during source remediation activities.

2.3.3.1 Vadose Zone Transport

Contaminant transport through the vadose zone may occur in multiple types of phases over intermittent periods. Contaminant materials may enter the soil periodically in rainwater solution, be precipitated within the upper portions of the soil as solids, deposited as airborne particulate, be transported in the subsurface by biomechanical transport mechanisms (burrowing animals), or be part of an infrastructure loss (leaks and spills).

Vadose zone moisture content changes with location, along with changes in soil matrix potential, and the corresponding anisotropy (ratio of horizontal to vertical hydraulic conductivity) varies in unsaturated flow. Thus, as saturation decreases, anisotropy increases, resulting in a dominance of lateral flow. This condition is unlike saturated flow where, with no changes in saturation (saturation is constant), anisotropy is a constant (saturation dependent anisotropy). Extensive moisture content data have been collected that show evidence for variable anisotropy for unsaturated media.

2.3.3.2 Saturated Zone Transport

Groundwater flow through aquifers beneath the Hanford Site is a major mechanism for transporting radioactive and hazardous wastes constituents discharged to various locations on the Site since 1944 (PNNL-14058, *Prototype Database and User's Guide of Saturated Zone Hydraulic Properties for the Hanford Site*). Radioactive and hazardous contaminants have been identified within the unconfined and confined aquifer systems (PNNL-13788, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*) that are mainly derived from high-volume wastewater discharges during nuclear materials production. Additional wastes and waste constituents present in surface facilities and the vadose zone have the potential to be continuing sources of contamination to the unconfined aquifer. Remediation of the sources in the vadose zone and the aquifer are necessary to limit impact to human health and the environment (PNNL-14058).

Within the saturated zone (aquifer), transport is usually less complex than transport through the vadose zone. Groundwater contaminant transport is a function of confined or unconfined conditions, as well as groundwater flow parameters.

2.3.3.3 Groundwater Flow

The hydraulic properties that most affect groundwater flow are hydraulic conductivity, specific storage, and aquifer thickness. For unconfined aquifers, both the storativity associated with aquifer response and the specific yield (calculated during extraction well testing or aquifer dewatering) are important. Effective porosity is an additional parameter in determining groundwater flow velocity and rates of contaminant transport (PNNL-14058).

In combination with the previous parameters, information such as boundary conditions and hydraulic gradient provide a description of the groundwater flow system. Aquifer thickness is most commonly determined from a combination of borehole geophysics and geologic logging during well drilling.

Groundwater discharges from the uppermost aquifer to the Columbia River via the riverbed, and to a lesser extent via riverbank springs. Rates of flow are typically several tenths of a meter per day (0.5 to 1.0 ft/day) (PNNL-13674, *Zone of Interaction Between Hanford Site Groundwater and Adjacent Columbia River: Progress Report for the Groundwater/River Interface Task Science and Technology Groundwater/Vadose Zone Integration Project*). In the 100 Area, groundwater movement is primarily perpendicular to the shoreline, with a minor component of alongshore flow.

2.3.3.4 Groundwater and River Water Interaction

Intermingling groundwater and river water in the zone of interaction and locations of groundwater discharges into the river channel are key issues to understanding the rate and magnitude of contaminants potentially entering the Columbia River. Discharge into the river environment may occur across the riparian zone as seeps and within the river channel substrate. Riverbank seepage creates a potential human health risk through exposure to contaminants and the introduction of contaminants to the food chain. Upwelling of groundwater into the channel substrate poses a potential risk to aquatic organisms that may create an introduction of contaminants to the food chain.

Groundwater flow (especially near the river), is strongly influenced by river stage, which is directly controlled by the upstream Priest Rapids Dam. The rise and fall of river stage creates a dynamic zone of interaction between groundwater and river water, and it influences flow patterns, transport rates, contaminant concentrations, and attenuation rates within the system (PNNL-13674). Columbia River elevations have varied up to 4.6 m (15 ft) over the course of one year and have varied by as much as 2.7 m (9 ft) in a single day (PNL-9437, *Monitoring Groundwater and River Interaction Along the Hanford Reach of the Columbia River*).

In the 100 Area, there are cases, such as for CrVI, when the ambient water quality criteria (AWQC) is more stringent than the drinking water standard. The aquatic receptor exposure point of concern is within the river substrate at depths up to 18 inches (46 centimeters), where embryonic salmon and fry would be present during parts of the year. Under the interim action RODs, it is considered impractical to routinely monitor the river substrate; therefore, groundwater has been monitored at near-river on-shore locations above the common high river mark. To account for dilution within the aquifer between the monitoring location on-shore and the aquatic receptor exposure point of concern within the river substrate, a preliminary dilution factor of 1:1 was selected based on the available data at the time the interim RODs were written (i.e., under the interim RODs, 20 μg/L CrVI in on-shore near-river well points is considered equivalent to 10 μg/L CrVI in the river substrate). Groundwater sampling has been conducted in the fall when river levels are low and dilution by river water at the compliance monitoring point is minimal (reference 100-HR-3 and 100-KR-4 ROD). However, for final action RODs, the appropriate method for determining compliance with AWQC for CrVI in the 100 Areas has not yet been determined.

Groundwater upwelling data collected using the Trident Probe[6] as part of the remediation investigation for Hanford Site releases to the Columbia River may be a source of information for this evaluation (Section 3.6.4).

Physical, chemical, and biological processes occur within the zone of interaction that potentially alter the characteristics of approaching groundwater. Data suggest physical processes are the primary influences on contaminant concentrations and fluxes where groundwater discharges into the free flowing river. Chemical processes may render contaminants less mobile as they adsorb to sediments or precipitate.

An expert panel of scientists was convened in April 2008 to review existing information and provide observations and suggestions to improve the current understanding of groundwater-surface water interactions in the 100 Area, primarily focusing on 100-D Area. The panel was asked to recommend any improvements on current approaches and methods used to understand interactions between the groundwater and the Columbia River, evaluate the current monitoring network and data collection methods, and evaluate the role played by modeling. The panel produced a report (SGW-39305, *Technical Evaluation of the Interaction of Groundwater with the Columbia River at the Department of Energy Hanford Site, 100-D Area*) containing their observations and suggestions for enhancing understanding of these interactions.

2.3.3.5 Surface Water Hydrology

The Columbia River has played a major role in the depositional and erosional processes that helped produce the sedimentary and geologic features across the Hanford Site. The river is noted for its very low suspended load, its low nutrient content, and an absence of microbial contaminants (DOE/RW-0164).

Columbia River flows typically peak from April through June during spring run-off from regional and high elevation snowmelt, and flows are lowest from September through October. Significant spring run-off rates can occur from the melting of larger than normal snowpacks. Fluctuations of daily discharge rates from upstream dams cause river depths to change rapidly. As a result of fluctuation in discharges, the depth of the river varies significantly over time (PNL-10698, *Hanford Site Ground-Water Monitoring for 1994*). Hanford Reach river width can vary from approximately 300 to 1,000 m (1,000 to 3,300 ft). Varying with flow rate, river width fluctuations cause repeated wetting and drying of the shoreline area (PNNL-6415).

Along the 100 Area is the only remaining, free flowing portion of the Columbia River in the United States (Figure 2-6). This stretch of the river is referred to as the "Hanford Reach," and it extends from Priest Rapids Dam to the headwaters of Lake Wallula. In May 2000, the Hanford Reach was incorporated into the 70,820 ha (175,000-ac) Hanford Reach National Monument (PNNL-13125, *Evaluation of the Potential for Agricultural Development at the Hanford Site*). River flows here are managed mainly for generating power, controlling floods, and promoting salmon egg and embryo survival.

2.3.3.6 Columbia Riverbank Seeps

Riverbank seep discharges to the river are visible during low river stage. Conversely, during high river stage, the seeps are submerged as river water infiltrates the riverbanks and forms either a layered system or a mixture during interaction with approaching groundwater. Data from the seeps and along the riverbank indicate the riverbank storage water composition oscillates dramatically from nearly completely river water during high river stage to primarily groundwater during low river stage (PNNL-13674). Figure 2-7 shows an illustrated model of river bank seepage.

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[6] The Trident Probe has a patent pending for Coastal Monitoring Associates.

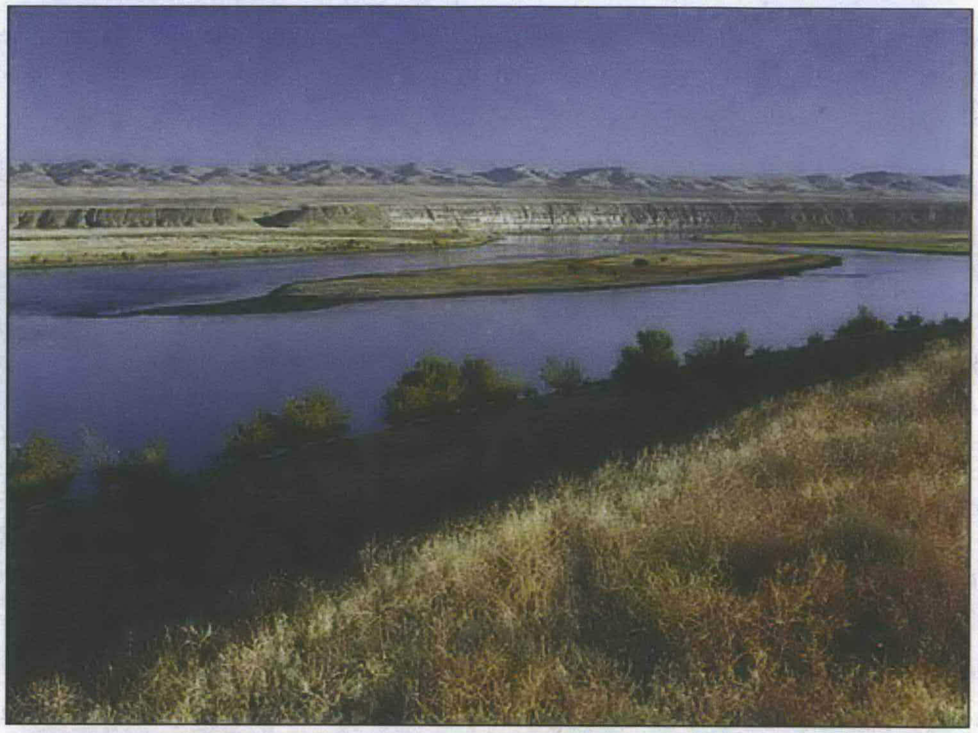
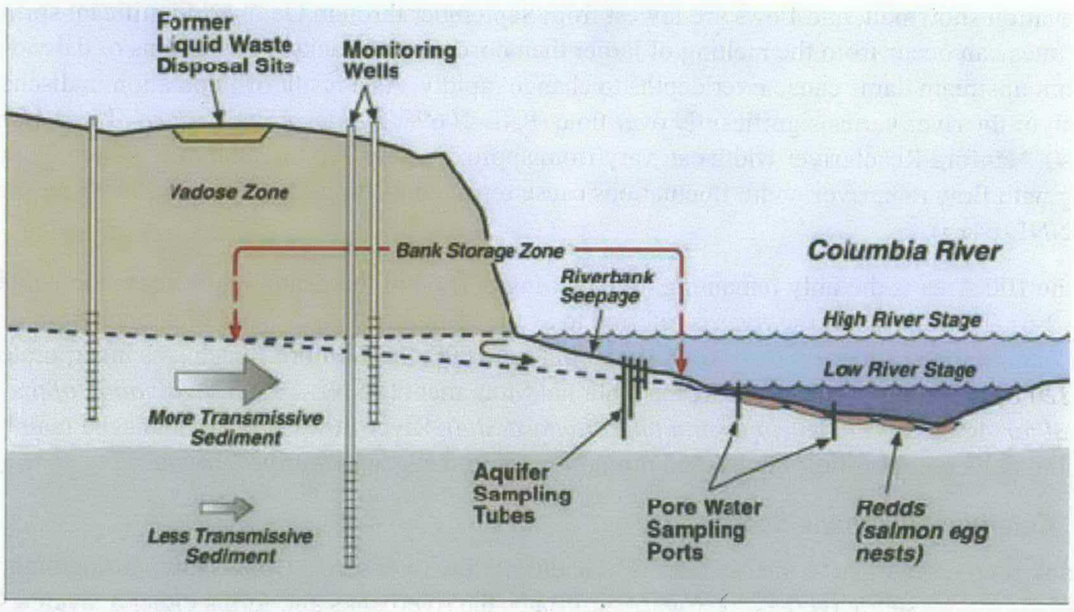


Figure 2-6. 100 Areas – The Last Free Flowing Portion of the Columbia River



Modified from PNNL-13674

Figure 2-7. Illustration of River Bank Seepage

Riverbank seeps are contaminated when in hydrologic contact with contaminated groundwater, and they create potential pathways for groundwater contamination to enter the river (PNL-5289, *Investigation of Ground-Water Seepage from the Hanford Shoreline of the Columbia River*). Potential mixing of river water with groundwater may produce lower contaminant concentrations in the seep discharges than can be found in upgradient groundwater. These lower contaminant concentrations may be attributed to the bank storage phenomenon, where infiltrated river water stored in the riverbank during high river stage returns to the river via seeps during spring flow, low river stage (PNNL-17603, *Hanford Site Environmental Report for Calendar Year 2007*).

The areas of groundwater discharges along the riverbank are in the vicinities of the 100-N Area, the former Hanford townsite, and the 300 Area. During operations, seeps and springs were often observed to emerge as hydrological conditions near the river changed. These changes in hydrology and their consequent impacts on current conditions are discussed in detail in the individual addenda. However, the current estimated flow volumes for groundwater along the entire Hanford Site are very small (3.00E+08 ft^3/yr; PNL-10285) compared to those of the receiving river waters (3.71E+12 ft^3/yr; estimated from PNNL-6415). Groundwater monitoring in the unconfined aquifer is the most effective method for determining potential groundwater discharges to the river. However, because most of the seeps are accessible only during low river conditions, year-round routine access is not possible (PNL-5289).

2.3.3.7 Flooding

The greatest influence on river stage is attributed to the seasonal melting of the regional and higher elevation winter snowpack, mainly from April to June. When combined with above normal precipitation, peak flow occurs. While the river has produced large, episodic floods in the past, the construction of multiple dams on the Columbia River has considerably reduced the likelihood of future large-scale flooding (DOE/EIS-0113, *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Wastes: Hanford Site Richland, Washington*). Hourly to daily release rates of the Priest Rapids Dam further manage river stage to control the potential for flooding from the Columbia River at the Hanford Site. Real-time data are available at: http://waterdata.usgs.gov/usa/nwis/uv?site_no=12472800.

2.3.3.8 Non-Riverine Surface Water

A groundwater mound created by the Gable Mountain Pond (Waste Site 216-A-25) may have had some contact with groundwater in the 100-KR-4 Groundwater OU. In addition, an encroachment of tritium and other contaminants from the 200 Area to the 100-BC Area may have occurred. Other than the retention basins and naturally occurring ponds previously described, no other naturally occurring surface water bodies are noted at the Hanford Site.

2.3.4 Environmental Resources

Environmental resources are widespread across the Hanford Site, with significant cultural and historical heritage resources established from the riverfront environment to the ridge tops (DOE/EIS-0119F, *Addendum [Final Environmental Impact Statement]: Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington*). The Hanford Reach National Monument was formed to place high priority on shrub-steppe community habitat maintenance and enhancement for native species throughout the Monument. The State of Washington has designated shrub-steppe communities as priority habitat because of their significance to a number of wildlife species and the scarcity of this habitat type. In addition, the U.S. Department of the Interior has identified native shrub and grassland steppe in Washington and Oregon as an endangered ecosystem.

2.3.4.1 Flora

Native pre-settlement vegetation consisted primarily of shrubs, perennial bunchgrasses, a variety of forbs, and a living soil crust composed of lichens, moss, and algae. Much of the native flora in the 100 Area has been disturbed by agricultural and livestock practices from Euro-American settlement in the early 20th Century and later by Hanford Site construction, operation, and post-operation activities, resulting in the introduction of non-native plant species. Large tracts of land adjacent to the 100-K Area and the other reactor areas that were farmed are now dominated by stands of cheatgrass (*Bromus tectorum*). Despite these "old fields," many places on the Hanford Site are relatively free of non-native species and are extensive enough to retain characteristic populations of shrub-steppe plants and animals. Unaffected areas support desert shrubs and drought resistant grasses and forbs. The predominant plant community in the 100 Area is sagebrush/Sandberg's bluegrass/cheatgrass. Other shrub communities are dominated by bitterbrush, hopsage, and rabbitbrush (PNNL-6415). A relatively narrow riparian zone supports grasses, sedges, and scattered deciduous shrubs and trees such as willow, mulberry, and Siberian elm along the banks of the river.

There are no plant species on the Hanford Site that are currently listed as threatened or endangered under the *Endangered Species Act of 1973*. However, two species of plants are candidates for federal protection: Umtanum desert buckwheat (*Eriogonum codium*), which occurs in several small, highly localized populations on Umtanum Ridge, and the White Bluffs bladderpod (*Lesquerella tuplashensis*), which occurs on White Bluffs. Additional plant species are listed as threatened or endangered by Washington State. Several of these, including the awned halfchaff sedge (*Lipocarpha aristulata*), grand redstem (*Ammannia robusta*), lowland toothcup (*Rotala ramosior*), and persistent sepal yellowcress (*Rorippa columbiae*), are restricted to wetlands in the riparian zone of the Columbia River (PNNL-6415). Table 2-5 lists the threatened or endangered plant species.

Table 2-5. Threatened or Endangered Plant Species

Plants	Scientific Name	State
Awned halfchaff sedge	*Lipocarpha (= Hemicarpha) aristulata*	Threatened
Desert dodder	*Cuscuta denticulata*	Threatened
Geyer's milkvetch	*Astragalus geyeri*	Threatened
Grand redstem	*Ammannia robusta*	Threatened
Loeflingia	*Loeflingia squarrosa var. squarrosa*	Threatened
Great Basin gilia	*Gilia leptomeria*	Threatened
Lowland toothcup	*Rotala ramosior*	Threatened
Persistent sepal yellowcress	*Rorippa columbiae*	Endangered
Rosy pussypaws	*Calyptridium roseum*	Threatened
Umtanum desert buckwheat	*Eriogonum codium*	Endangered
White Bluffs bladderpod	*Lesquerella tuplashensis*	Threatened
White eatonella	*Eatonella nivea*	Threatened

Notes:

Reference: PNNL-17603, *Hanford Site Environmental Report for Calendar year 2007, September*

2.3.4.2 Fauna

The shrub and grassland habitat of the Hanford Site supports many groups of terrestrial wildlife. Species include large animals like Rocky Mountain elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*); predators such as coyote (*Canis latrans*), bobcat (*Lynx rufus*), and badger (*Taxidea taxus*); and herbivores including deer mice (*Peromyscus maniculatus*), harvest mice (*Riethrodontonomys megalotis*), ground squirrels (*Spermophilus* spp.), voles (*Lemmiscus curtatus*, *Microtus* spp.), and black-tailed jackrabbits (*Lepus californicus*). The most abundant mammal on the Hanford Site is the Great Basin pocket mouse (*Perognathus parvus*). Many of the rodent species and some predators (badgers) construct burrows on the Site. Other non-burrowing animals including cottontails (*Sylvilagus nutalli*), jackrabbits, snakes, and burrowing owls (*Athene cunicularia*) may use abandoned burrows of other animals.

The height of the steep bluffs along the river in the 100 Area and the location of most of the facilities back from the edge of the bluff minimize the line-of-sight effect that human activity might otherwise have on eagles and other nesting birds (DOE/RL-94-150, *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington*). In addition, few trees remain close to the reactor areas, which further limit the potential of line-of-sight effects. However, the trees immediately upriver of the 100-K Area are an exception, and roosting eagles can be seen in these trees from the west end of the 100-K Area.

Human occupancy at the Hanford Site has had great effect on wildlife populations. To support agricultural development, wildlife species (i.e., mule deer and coyote) were believed to threaten crops and livestock and were targeted for population reduction. On the other hand, trees planted for use as windbreak by early settlers have since survived to provide much needed nesting and perch sites for raptors and some waterfowl (Rickard et al., 1982, "The Non-Fisheries Biological Resources of the Hanford Reach of the Columbia River"). Seasonal populations of Canada geese and other birds forage in the riparian zones and old (cultivated) fields, which are now dominated by cheatgrass (Eberhardt et al., 1989, "Survival of Juvenile Canada Geese During the Rearing Period").

The aquatic ecosystem is an accessory to the Columbia River. This aquatic ecosystem supports a large and diverse community of plankton, benthic invertebrates, fish, and other communities. Organisms in these communities in turn provide food sources to other species.

Important game species that inhabit the Columbia River are Chinook salmon, steelhead, Coho salmon, sockeye salmon, smallmouth bass, largemouth bass, sturgeon, walleye, yellow perch, and channel catfish. Most importantly, the river supports a healthy population of fall spawning Chinook salmon, whose spawned out carcasses attract bald eagles in the fall and winter. Fall Chinook spawning areas are described in DOE/EIS-0113 and PNNL-6415.

2.3.4.3 Critical Habitats

Two species of federal endangered fish, the Upper Columbia River spring run Chinook salmon and steelhead, occur in the Hanford Reach. The spring run Chinook salmon do not spawn in the Hanford Reach but use it as a migration corridor. Steelhead (Figure 2-8) spawning has been observed near mid-channel gravel bars in the Hanford Reach, from the downstream edge of the 100-BC Area, to Wooded Island, downstream of Energy Northwest (DOE/RL-2000-27, *Threatened & Endangered Species Management Plan: Salmon and Steelhead*). The bull trout is listed as threatened by the National Marine Fisheries Service but is not considered a resident species and is rarely observed in the Hanford Reach (DOE/RL-2005-40, *100-B/C Pilot Project Risk Assessment Report*, Vol. 1).

Figure 2-8. Columbia River Steelhead

DOE employs the following protective measures for endangered salmon and steelhead:

- Water diversions meet state screening criteria or appropriate administrative controls. Discharges meet National Pollutant Discharge Elimination System permit requirements. Removal of native riparian or emergent vegetation is minimized. Where possible construction projects will not simplify shoreline structures, final construction will produce banks at a 3:1 slope.
- Silt loaded surface runoff will be minimized along the shoreline, and disruptive activities in the river or on the shoreline will be avoided from April to November.

Although the bald eagle has been removed from the list of federally endangered species, it is still protected under the *Bald and Golden Eagle Protection Act of 1940*. In addition, DOE has decided to continue to protect nest and roost sites on the Hanford Site under DOE/RL-94-150. This plan is currently under revision to account for the de-listing of the bald eagle. Changes have been made to reduce the buffer zones surrounding winter night roosts and nest sites from 800 m (874 yd) to 400 m (437 yd).

The bald eagle is a regular winter resident and forages on dead salmon and waterfowl along the Columbia River. Hanford Site bald eagle habitat includes perch sites, night roosts, foraging areas, and nesting areas that can occur anywhere along the Columbia River. Continued eagle-use pattern observations at the Hanford Site will help protect nesting sites or primary roosts through updating DOE/RL-94-150 and adjusting protection levels, as warranted.

While bald eagles do not currently nest successfully at the Hanford Site, past and attempted nest sites exist (PNNL-6415). Nest sites are built in groves of trees (e.g., black locust, white poplar, and Siberian elm) along the Hanford Reach. Buffer zones around primary night roosts and nest sites have been established in consultation with the U.S. Fish and Wildlife Service (USFWS). While the night-roost locations are consistent from year to year, the nesting sites have varied and are readjusted in consultation with the USFWS each year. Maps of current bald eagle nesting sites are not publicly available because of the birds' sensitivity of disturbance.

The Washington State Department of Fish and Wildlife has declared protection of roosting trees for bald eagle habitat and foraging areas (WAC 232-12-292, "Bald Eagle Protection Rules").

2.3.4.4 Land Use Characteristics

Land uses at the Hanford Site are strictly controlled to preserve public health and safety and to support national security. Federal control is asserted throughout Hanford Site planning processes for Site development. Typical local land uses around the Hanford Site include irrigated and dry land farming, livestock grazing, and urban and industrial development. Industrial development typically supports either agriculture or energy production (DOE/RL-98-10, *Hanford Cultural Resources Management Plan*). The land around the reactor areas is buffered from development by land use restrictions imposed at the 78,914 ha (195,000-ac) Hanford Reach National Monument.

2.3.4.5 Beneficial Water Use Characteristics

Ecology requires that groundwater be restored to its "highest beneficial use," which is defined as the beneficial use requiring the highest quality. For water, Ecology has determined that at most sites, the use of groundwater as a drinking water source is the beneficial use of a resource generally requiring the highest quality in the resource (WAC 173-303-64620, WAC 173-340-720(1)(a), WAC 173-303-610(2)(b)(i)). Beneficial use may include discharged surface water, and cleanup levels will need to protect aquatic life in the Columbia River.

Ecology requires that surface water cleanup levels be based on the "highest beneficial use" and the reasonable maximum exposure expected to occur under both current and potential future site conditions. The highest beneficial use is determined in accordance with WAC 173-340-730 (1)(a), "Surface Water Cleanup Standards." Institutional controls will be in place until such time that cleanup standards are achieved.

Water users withdraw water in the Hanford Reach for offsite irrigation, for use at the Washington Public Power Supply System Nuclear Project 2, and for Hanford Site water use (PNNL-16623, *Hanford Site Environmental Report for Calendar Year 2006*). In addition, the Columbia River is used extensively for recreation, including fishing, hunting, boating, sailing, waterskiing, diving, and swimming. The Columbia River also supplies water for public and domestic use, irrigation, barge transportation, and industry, and supports wildlife habitat (DOE/RL-2005-40). Ecology requires that surface water cleanup levels be based on the "highest beneficial use" and the reasonable maximum exposure expected to occur under both current and potential future site conditions. The highest beneficial use is determined in accordance with WAC 173-340-730 (1)(a).

2.3.4.6 Sensitive Environments

Potential remedial activities would protect the Columbia River's beneficial uses and maintain it as a recreational resource, drinking and irrigation water resources, and habitat for waterfowl, fish, and transitory endangered and threatened wildlife. Because of critical bald eagle habitat, many areas of the Hanford Site may be declared a federal sensitive environment (40 CFR 300, Appendix A, "The Hazard Ranking System").

2.3.5 Human Resources

The Hanford Site contains some of the most important archaeological sites in the region. Many of these sites are listed on the National Register of Historic Places in accordance with 36 CFR 60, "National Register of Historic Places." In addition, other natural resources and sacred sites important to the present cultures of the regional Tribal Nations are preserved at the Hanford Site (PNL-9785, *Data Compendium for the Columbia River Comprehensive Impact Assessment*). Long-term (i.e., more than 50 years) restricted access has minimized looting and vandalism of historic, cultural, and archaeological sites. Furthermore, hydroelectric and agricultural development have not destroyed these culturally significance sites, as has been experienced elsewhere in the Columbia River Basin.

While rapid Hanford Site development did not accommodate protection of important Native American locations, current and future Hanford Site planners, onsite construction activity directors, and Tribal Nations leaders work together for the protection of important Native American locations.

2.3.5.1 Cultural Resources

The cultural resources of the Hanford Site area are important to many people interested in their historic preservation. The National Register of Historic Places criteria (DOE/RL-97-02, *National Register of Historic Places Multiple Property Documentation Form Historic, Archaeological and Traditional Cultural Properties of the Hanford Site, Washington*) offer three convenient categories for chronicling historic, archaeological, and traditional cultural properties of the Hanford Site:

- Pre-historic era (10,000 years before present to common era 1805; pre-Lewis and Clark)
- Homestead and townsite era (1805 to 1945)
- Manhattan Project and Cold War era (post-1945 to 1990)

These categories are represented across the Hanford Site.

RL has undertaken a comprehensive preservation planning effort for the Hanford Site that is ongoing. The results of these efforts have implemented protective programs for conserving cultural resources (DOE/RL-96-77, *Programmatic Agreement Among the U.S. Department of Energy, Richland Operations Office, the Advisory Council on Historic Preservation, and the Washington State Historic Preservation Office for the Maintenance, Deactivation, Alteration, and Demolition of the Built Environment on the Hanford Site, Washington*; DOE/RL-97-02; DOE/RL-98-10). Cultural resource surveys are routinely conducted as part of site evaluation and preparation prior to excavation to protect culturally sensitive areas. The results of these surveys are used in the site selection process and applied in the various sampling and analysis plans. Additionally, the creation of the Hanford Reach National Monument (DOI, 2008, *Hanford Reach National Monument, Final Comprehensive Conservation Plan & EIS August 2008;* 73 FR 72519, "Hanford Reach National Monument; Adams, Benton, Franklin and Grant Counties, WA") provides an additional means for the preservation and maintenance of the wide range of cultural resources present along the river.

2.3.5.2 Archaeological Resources

Because the Hanford Site was closed to the public for over 50 years, Hanford Site archeological resources have been particularly well preserved compared to locations elsewhere in the mid-Columbia River Basin. A high density of archaeological resources at the Hanford Site is associated with the legacy of the Native American and early settler cultural settings. The locales are identified in terms of function based on surface evidence, features, artifacts, or a combination of these (DOE/RL-97-02). Many of these sites are located along the 100 Area near the Columbia River.

Artifacts discovered across the Hanford Site provide evidence on Site occupational characteristics, use durations and periods, and multiple land use (e.g., ceremonial and religious sites, and burial grounds). Evidence of older archaeological uses ranges from abundant deer and mountain sheep bones, projectile points, scatterings of fire-cracked rock, rock flakes, and net weights, and high densities of shell fragments that date as far back as 2,500 to 4,500 years ago (PNL-8143, *Fiscal Year 1991 Report on Archaeological Surveys of the 100 Areas, Hanford Site, Washington*). Even older artifacts have been discovered that date to the period from 4,500 to 11,000 years before present (Lohse, 1985, "Rufus Woods Lake Projectile

Point Chronology"; PNL-8143; BHI-01556, *Archaeological Excavation Report for Extraction Well C3662 in Support of the 100-KR-4 Pump-and-Treat Project*).

Historic era sites of archaeological importance include locations such as the Hanford Irrigation Canal, the remains of the Haven Railroad Station, many homesteads, the Hanford and White Bluffs townsites, docks, and other relatively recent documented facilities and features.

2.3.5.3 Traditional Cultural Places

Hanford Site cultural resources are diverse, ranging from early prehistoric times to the Atomic Age. Native American archaeological sites are associated with prehistoric and ethnographic villages and activities, as well as sacred and ceremonial areas such as mountains and rivers, where food and medicinal plants were gathered and are dispersed across the landscape (PNNL-14237, *U.S. Department of Energy's Hanford Cultural Resources Laboratory Oral History and Ethnography Task Annual Report*).

Many sites and natural features along the Columbia River are regarded as sacred or important to the cultural heritage of members of the Confederated Tribes of the Umatilla Indian Reservation, Yakama Indian Nation, the Nez Perce Tribe, and the Wanapum People. Nearby features culturally important to Tribal Nations members include Rattlesnake Mountain, Gable Mountain, Gable Butte, and Goose Egg Hill.

Data collection and remedy selection in the RI/FS process will be guided by preserving these locations for exercising customary cultural resource rights. Similar to other areas across the Hanford Site, disturbance maps and reports have been prepared for many areas. The locations and potential impacts to these resources are reviewed by Tribal Nations leaders before site activities begin (DOE/RL-98-10).

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3 Historical Information

Since the early 1990s when interim action cleanup began in earnest in the River Corridor, DOE has accomplished major goals in the investigation and remediation of contaminated sites. More than 35,000 environmental samples, (including more than 20,700 groundwater 5,900 surface water, 1,400 sediment, and 7,000 biota samples) have been collected to provide key risk assessment information that will be further augmented by current human health and ecological risk assessments. In addition, 200 to 363 wells per year have been sampled from 1992 to 2008. These studies have been undertaken to determine the nature and extent of the contamination, support risk assessment activities, and identify opportunities for early cleanup actions at NPL sites for the River Corridor. More than 300 structures have been demolished, along with ISS of five plutonium production reactors; over 155 waste sites have been remediated and 78 of 82 high-priority sites cleaned up; and over 5,500 ha (13,600 ac) evaluated to identify newly discovered waste sites. Over 7.6 billion L (2 billion gal.) of groundwater has been treated and nearly 907 kg (1 ton) of CrVI removed from the aquifer.

This chapter summarizes previous investigations, remediation, and risk assessment activities conducted to support sound interim action cleanup decisions and to refine the CSMs. DOE has thoroughly examined a number of sources of information. Information collected in previous investigations has been combined with the information gathered during the implementation of interim remedial actions and removal actions to provide an understanding of the nature and extent of contamination at each area (Figure 3-1). Results from these activities have differentiated between contaminated and uncontaminated areas throughout the River Corridor.

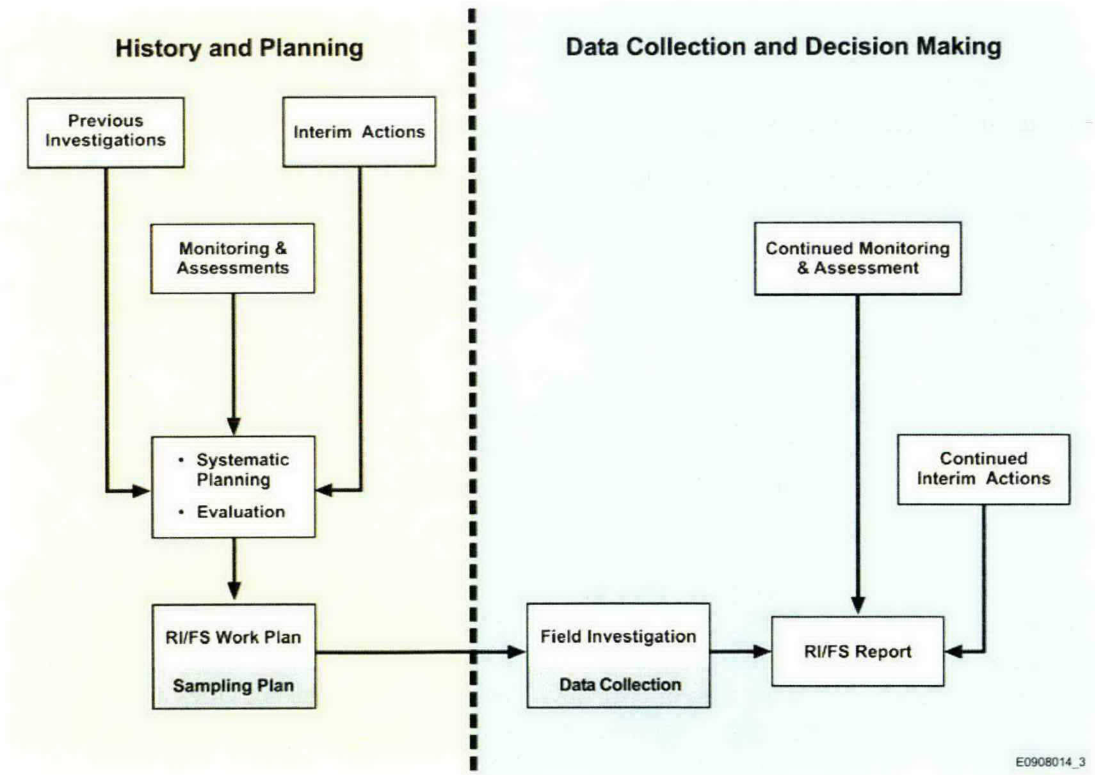


Figure 3-1. Information Sources for Development of the Remedial Investigation/Feasibility Study

Early cleanup actions have helped sharpen the focus of data collection efforts in recent years to fine tune remedial actions. Efforts to understand the nature and extent of contamination beyond the areas adjacent to reactors have been extensive and have demonstrated that the focus of early actions on waste sites associated with reactor areas has been instrumental in addressing the highest priority environmental risks.

This work plan and addenda propose collection of additional information that is needed to support final action cleanup decisions. When combined with historical data, data collected during continued implementation of interim action RODs, routine site monitoring activities, and specific studies to assess the potential applicability of treatment technologies, this information will be integrated in the RI/FS report to support final action cleanup decisions for sites in the River Corridor (Figure 3-1).

3.1 Facility Deactivation, Decontamination, Decommissioning, and Demolition Actions

Since 1995, more than 300 structures (including several treatment, storage, and disposal [TSD] units) have been demolished in the 100 Area. These actions have cleared the way for remedial action at underlying waste sites and provided opportunity for the discovery of new waste sites.

The removal of a contaminated facility involves the following sequenced deactivation, decontamination, decommissioning, and demolition (D4) steps:

- **Deactivation:** Involves halting the operations or processes of the facility. For example, in one of the early efforts in 1992, corroding radioactive fuel was removed during the 100-K Basin deactivation.
- **Decontamination:** Includes removing and stabilizing radioactive and hazardous materials.
- **Decommissioning:** Involves shutting off and removing all facility energy sources, such as electricity, steam, and water.
- **Demolition:** Consists of destroying, removing, and disposing the building materials.

In compliance with RCRA, a number of TSD units were addressed as part of the D4 work, including the following:

- 183-H Solar Evaporation Basins
- 100-D Ponds
- 186-D Waste Acid Reservoir
- 105-DR Large Sodium Fire Facility
- 1706-KE Waste Treatment System
- 1324-N Surface Impoundment
- 1324-NA Percolation Pond

Considerable progress has been achieved since the mid-1990s, with five reactors (D, DR, H, C, and F) placed in ISS between August 1996 and October 2005. ISS protects the reactor from environmental degradation and prevents the spread of contamination by "cocooning," or providing an upgraded, weather-resistant shell to isolate the reactor core until final action remedial activities are conducted (Figures 3-2 and 3-3). This action also minimizes the facility footprint by removing all peripheral reactor buildings and equipment and properly disposing the debris.

Figure 3-2. C Reactor in 1992 before Cocooning

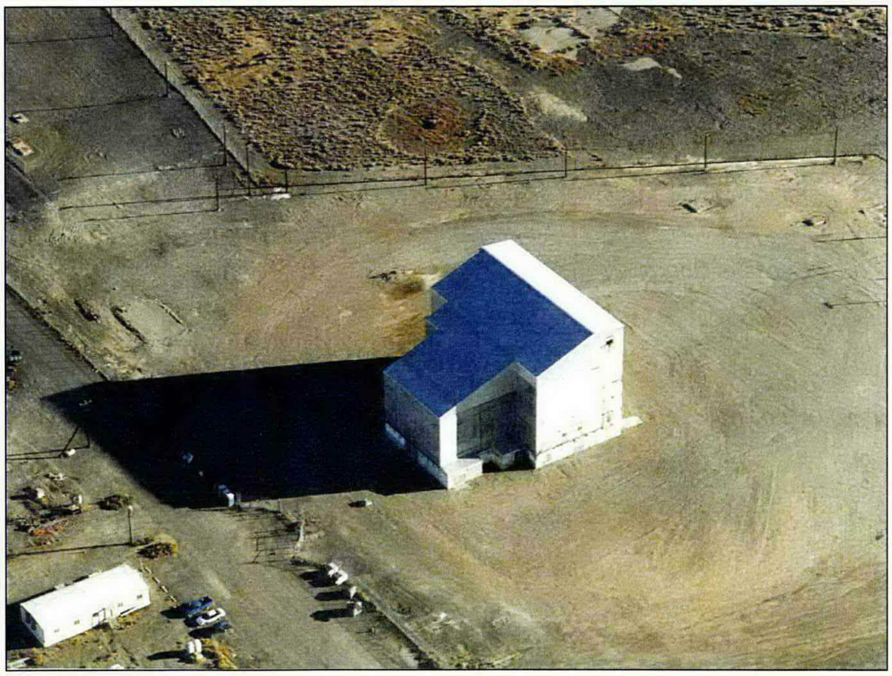


Figure 3-3. C Reactor as it Looks Today

3.2 Previous Investigation

Previous investigations and characterization activities conducted to support sound interim action cleanup decisions and to refine CSMs included the following:

- Technical baseline reports summarized existing process and contamination information.
- Limited field investigations (LFIs) were conducted to collect additional characterization data and support QRAs.
- Focused FSs were prepared to select interim remedial actions.

The following sections describe these reports.

3.2.1 Technical Baselines

Technical baseline reports were prepared for each operating area and provided DOE, regulatory agencies, and contractors with a "baseline" of technical information related to operational processes and resulting contaminated waste sites. A report was created for each River Corridor operating area (Table 3-1). The information in the reports was based on the evaluation of numerous Hanford Site reports, drawings, and photographs supplemented by site inspections and employee interviews. No intrusive field investigation or sampling was conducted during development of the technical baseline reports.

Table 3-1. Technical Baseline Reports

Report Title	Document Number
100-B Area Technical Baseline Report	WHC-SD-EN-TI-220
100-D Area Technical Baseline Report	WHC-SD-EN-TI-181
100-F Reactor Site Technical Baseline Report Including Operable Units 100-FR-1 and 100-FR-2	BHI-00031
100-H Area Technical Baseline Report	BHI-00127
100-IU-6 Operable Unit Technical Baseline Report	BHI-00146
100-K Area Technical Baseline Report	WHC-SD-EN-TI-239
100-N Area Technical Baseline Report	WHC-SD-EN-TI-251
300-FF-2 Operable Unit Technical Baseline Report	BHI-00012
White Bluffs, 100-IU-2 Operable Unit Technical Baseline Report	BHI-00448

Each 100 Area technical baseline report, with the exception 100-IU-2 and 100-IU-6, describes the industrial process history, which was similar from one area to another. Industrial processes were not conducted in the 100-IU-2 and 100-IU-6 Areas. There were variations in terms of years of operation and intensity of use, as well as containment failure events, process improvements, or research activities unique to a given area. The reports also describe the types of waste streams that resulted from the operations, with estimated volumes and suspected contaminants. The reports contain maps and photographs of the facilities cited in the reports and information on the environmental monitoring sampling conducted for each area. A detailed description is provided for each waste site within an area, describing known contamination and condition as of the time the report was written.

Work plan documents summarized and supplemented the technical baseline information for conducting field investigations. Table 3-2 lists the work plan documents for the River Corridor OUs.

Table 3-2. River Corridor Source and Groundwater OU Work Plan Reports

Report Title	Document Number
Remedial Investigation/Feasibility Study Work Plan for the 100-BC-1 Operable Unit, Hanford Site, Richland, Washington	DOE/RL/90-07
Remedial Investigation/Feasibility Study Work Plan for the 100-BC-2 Operable Unit	DOE/RL-91-07
Remedial Investigation/Feasibility Study Work Plan for 100-BC-5 Operable Unit, Hanford Site, Richland, Washington	DOE/RL-90-08
Remedial Investigation/Feasibility Study Work Plan for the 100-KR-1 Operable Unit	DOE/RL-90-20
Remedial Investigation/Feasibility Study Work Plan for 100-KR-4 Operable Unit, Hanford Site, Richland, Washington	DOE/RL-90-21
RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-1 Operable Unit	DOE/RL-90-22
RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-2 Operable Unit, Hanford Site, Richland, Washington	DOE/RL-91-46
RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-DR-1 Operable Unit, Hanford Site, Richland, Washington	DOE/RL/89-09
RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-1 Operable Unit Hanford Site, Richland, Washington	DOE/RL-88-35
RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-2 Operable Unit	DOE/RL-93-20
RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-3 Operable Unit, Hanford Site, Richland, Washington	DOE/RL-88-36
Remedial Investigation/Feasibility Study Work Plan for the 100-FR-1 Operable Unit	DOE/RL-90-33
Remedial Investigation/Feasibility Study Work Plan for the 100-FR-3 Operable Unit, Hanford Site, Richland, Washington	DOE/RL-91-53

Additional work plan documents supplementing the technical baseline information include the future RCBRA report and the DOE/RL-2008-11, *Remedial Investigation Work Plan for Hanford Site Releases to Columbia River*.

3.2.2 Limited Field Investigations and Qualitative Risk Assessments

The LFIs completed for the 100 Area OUs consisted of historical data compilation, nonintrusive investigations (e.g., geophysics), intrusive investigations (e.g., boreholes), and the 100 Area aggregate studies (i.e., ecological, river water, and sediment sampling). In addition, the LFIs provide information regarding historical sampling and analysis, which is useful in developing soil (deeper than the 4.6 m [15 ft] point-of-compliance depth) target analyte lists for further investigation.

The LFI reports completed for the 100 Area consisted of historical data compilation, nonintrusive investigations (e.g., geophysics), intrusive investigations (e.g., boreholes), and the 100 Area aggregate studies (i.e., ecological, river water, and sediment sampling) (DOE/RL-88-36, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-3 Operable Unit, Hanford Site, Richland, Washington*). The LFI reports completed for River Corridor waste sites are listed in Table 3-3.

Table 3-3. Limited Field Investigation Reports

Report Title	Document Number
Limited Field Investigation Report for the 100-BC-1 Operable Unit	DOE/RL-93-06
Limited Field Investigation Report for the 100-BC-2 Operable Unit	DOE/RL-94-42
Limited Field Investigation Report for 100-BC-5 Operable Unit	DOE/RL-93-37
Limited Field Investigation Report for the 100-KR-1 Operable Unit	DOE/RL-93-78
Limited Field Investigation Report for 100-KR-4 Operable Unit	DOE/RL-93-79
Limited Field Investigation Report for 100-NR-2 Operable Unit	DOE/RL-93-81
Limited Field Investigation/Qualitative Risk Assessment for the 100-DR-1 Operable Unit, Appendix D of *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-DR-2 Operable Unit*	DOE/RL-93-46
Limited Field Investigation Report for the 100-DR-2 Operable Unit	DOE/RL-94-73
Limited Field Investigation Report for the 100-HR-1 Operable Unit	DOE/RL-93-51
Limited Field Investigation Report for the 100-HR-2 Operable Unit	DOE/RL-94-53
Limited Field Investigation Report for 100-HR-3 Operable Unit	DOE/RL-93-43
Limited Field Investigation Report for the 100-FR-1 Operable Unit	DOE/RL-93-82
Limited Field Investigation Report for 100-FR-3-Operable Unit	DOE/RL-93-83
100-FR-3 Groundwater Soil Gas Supplemental Limited Field Investigation Report	DOE/RL-95-99

The LFIs recommended sites for interim remedial action and categorized them as high or low priority. High-priority sites were considered to have the highest potential to contribute to contamination of groundwater and the Columbia River. The reports also provided a preliminary summary of site characterization studies and identified contaminant-specific and location-specific applicable or relevant and appropriate requirements (ARARs). The data collection activities associated with the LFIs supplemented existing information (such as the compilation of waste site investigation results in UNI-946, *Radiological Characterization of the Retired 100 Areas*) to support formulation of conceptual models, as well as performance of QRA for each area.

The QRAs, listed in Table 3-4, included consideration of whether contaminant concentrations pose an unacceptable risk that warrants remedial action. This information is used as the basis for remedial actions completed to date as well as current and future remedial actions identified in the interim action RODs.

Table 3-4. Qualitative Risk Assessment Reports

Report Title	Document Number
Qualitative Risk Assessment for the 100-BC-1 Source Operable Unit	WHC-SD-EN-RA-003
Qualitative Risk Assessment for the 100-KR-1 Source Operable Unit	WHC-SD-EN-RA-009
Qualitative Risk Assessment for the 100-NR-1 Source Operable Unit	BHI-00054
Qualitative Risk Assessment for the 100-DR-1 Source Operable Unit	WHC-SD-EN-RA-005

Table 3-4. Qualitative Risk Assessment Reports

Report Title	Document Number
Qualitative Risk Assessment for the 100-HR-1 Source Operable Unit	WHC-SD-EN-RA-004
Qualitative Risk Assessment for the 100-FR-1 Source Operable Unit	BHI-00053

The high-priority sites were evaluated using the following criteria to help identify those recommended for remedial actions:

- Magnitude of risk identified in the QRA
- Exceedance of a chemical-specific ARAR
- Potential to contaminate groundwater
- Insufficient information for conceptual model
- Multiple exposure pathways
- Expected natural attenuation and radioactive decay

QRAs were performed for the high-priority sites in each OU. Conservative assumptions, such as highest reported contaminant levels from either the LFI or historical data from UNI-946, were used in the QRAs. The QRA provides estimates of human health risks, assuming frequent use and occasional use, and includes considerations such as the attenuation of external dose provided by layers of clean gravel fill that overlie many sites. The QRAs identify the human health risk to be primarily from external exposure to the radionuclides cobalt-60, cesium-137, europium-152, and europium-154. The QRAs were used to establish the basis for action for all waste sites identified in the River Corridor.

3.2.3 Focused Feasibility Studies

The purpose of the focused FSs performed in the 100 Area was to support selection of interim remedial actions for sites within the OUs. DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study Report*, provided the decision makers with the information they require from the investigation activities for selection of remedial actions. Focused FSs developed site profiles for the high-priority waste sites (as identified in the LFI reports) and made comparative analyses of the remedial action alternatives.

3.3 Monitoring and Assessment

During implementation of interim actions, other investigations and monitoring have been conducted to evaluate contamination and continue refinement of information within the 100 Area. These investigation and monitoring activities include the following:

- Environmental monitoring and surveys
- Air emissions evaluations
- Routine groundwater monitoring and remedy effectiveness monitoring
- Environmental Radiation Monitoring and Assessment Program

The following sections describe these activities.

In addition to monitoring and assessment activities, an inventory of known and potential waste sites has been maintained in the WIDS database since the early 1980s. The process of evaluating old land-based and aerial photographs, historical documentation, and area walkdowns has continued as part of many subsequent projects. The WIDS waste site list has grown to contain more than 2,800 sites. The list contains sites within the areas where plutonium production and research operations occurred and in areas of lower intensity use outside the operational boundaries. Even locations such as known borrow pits are tracked and evaluated for their potential to have received wastes in the past. Sites are not removed from WIDS after they are cleaned up, but the classification status and information concerning each site are updated.

In 2004, a longer term study called the orphan sites evaluations began. Extensive review of historical records, field walkdowns, interviews with current and former Hanford Site employees, and geophysical investigations are being conducted in the 100 and 300 Areas operations areas and surrounding lands. This process is anticipated to continue in the coming years for the remaining operations areas and the areas between the reactor areas. New waste sites identified during the orphan sites evaluation process typically include pipelines, dry wells associated with buildings, and dump sites/debris piles/landfills from former decontamination and demolition activities. These new sites are being added to the WIDS database for disposition under the proper remedial authority. Section 3.4.2 of this document provides more details.

3.3.1 Environmental Monitoring and Surveys

Much investigative work has been focused along the Columbia River because of the potential risk of exposure to people and the environment. DOE has completed routine radiological surveys of the river shore (PNL-3127, *Radiological Survey of Exposed Shorelines and Islands of the Columbia River Between Vernita and* the *Snake River Confluence*), as well as sampling of the riverbank springs and sediment (DOE/RL-92-12, *Sampling and Analysis of 100 Areas Springs*; WHC-SD-EN-TI-198, *100 Area Columbia River Sediment Sampling*; PNNL-13230, *Hanford Site Environmental Report for Calendar Year 1999 [Including Some Historical and Early 2000 Information*]). The annual environmental monitoring reports also document and evaluate surveillance sampling of many media on and off the Hanford Site (e.g., vegetation, terrestrial and aquatic wildlife, air, soil, and water) to quantify potential contaminant concentrations and to assess their environmental and human health significance.

Aerial radiological surveys were completed (EGG-10617-1062, *An Aerial Radiological Survey of the Hanford Site and Surrounding Area*) to define areas of radioactive contamination. The EGG-10617-1062 survey covered the Hanford Site and the banks of the Columbia River downriver to McNary Dam. The radiation levels over more than 95 percent of the site were reported to be due to normal levels of background radiation. Areas of elevated radionuclide activity outside of operational areas have been investigated and are identified in WIDS. Several slough areas along the Columbia River also showed elevated radioactivity; these areas were sampled and the radionuclide content shown to be only slightly above background (WHC-SD-EN-TI-198). This sampling also confirmed that the sensitivity of the aerial radiological survey equipment used was sufficient to detect low levels of radioactivity.

3.3.2 Air Emissions Evaluations

In 2005, an evaluation of the releases on the Hanford Site from air emissions stacks located in the 100 and 300 Areas was made (DOE/RL-2005-49, *RCBRA Stack Air Emissions Deposition Scoping Document*) using previous background soil sampling work, radiological surveys, and an evaluation of the materials (radionuclides and metals) emitted and their amounts. The report concluded that there were no locations of elevated radioactivity or metals in the 100, 300, or associated 600 Areas due to aerial deposition, other than those discrete areas already identified as waste sites in WIDS. This information was considered along with soil sampling results to evaluate the sites selected as reference or comparison sites for the baseline risk assessment.

3.3.3 Groundwater Monitoring

DOE monitors groundwater at the Hanford Site to fulfill a variety of state and federal regulations, including the AEA, RCRA, CERCLA, and the *Washington Administrative Code*. In fiscal year 2006, workers sampled 778 wells and 247 shoreline aquifer tubes to determine the distribution and movement of contaminants. A total of 307 of those wells are located in the 100 Area. An annual summary report is published to integrate information from multiple sources. PNNL-16346, *Hanford Site Groundwater Monitoring for Fiscal Year 2006*, discussed emerging issues, groundwater flow, groundwater monitoring and remediation, shoreline monitoring, well installation, maintenance and monitoring, vadose zone, and continued monitoring.

3.3.4 Environmental Radiation Monitoring and Assessment Program

The Washington State Department of Health (DOH), Division of Environmental Health has an oversight program to independently verify the quality of the DOE monitoring programs at the Hanford Site. The DOH performs this oversight by conducting split, co-located, and independent sampling at locations having the potential to release radionuclides to the environment or locations that may be impacted by such releases. DOH uses the oversight data to assess impacts to the public and to address public concerns related to radiation at the Hanford Site. The DOH publishes an annual Hanford Site environmental oversight program summary report.

3.4 Interim Actions

Interim actions for the 100 Areas were established in the 1990s. These actions were for both waste site and groundwater remediation. These interim actions and orphan site evaluations are discussed in the following sections.

3.4.1 Interim Action Waste Site Remediation

The earliest interim action ROD (EPA/ROD/R10-95/126, *EPA Superfund Record of Decision: Hanford 100-Area (USDOE) EPA ID: WA3890090076, OU 01, Benton County, WA*) established for the 100 Area covers interim actions in the 100-B/C-1, 100-DR-1, and 100-HR-1 OUs. DOE/RL-94-61 identified six general response actions that could have been applied to waste sites in these OUs. The six response actions (alternatives) evaluated for interim action remediation were:

1. No action
2. Institutional Controls
3. Containment
4. In Situ Treatment
5. Remove/Dispose
6. Remove/Treat/Dispose

Before the evaluation, a future unrestricted land use goal for the 100 Area lands was established. Because some of the evaluated actions would have imposed limitations on land use, and/or failed to meet other NCP criteria, the first five alternatives were rejected as a result of the evaluation process.

The selected remedy was the RTD for liquid radioactive effluent disposal site cleanup. The RTD activities included the following:

- Removing and stockpiling uncontaminated overburden for re-use as fill material. This includes dust suppression during excavation, transportation, and disposal.
- Treating soil through soil washing or thermal desorption before transport to the Environmental Restoration Disposal Facility (ERDF).
- Field screening contaminant levels during remediation.
- Adhering to site-specific soil excavation and management factors to determine the extent of remediation:
  - For soil contamination less than 4.6 m (15 ft), RAOs must be met at the achievement of residential *Model Toxics Control Act* (WAC 173-340) Method B levels and the 15 mrem/year residential dose level, and support protection of groundwater and the Columbia River.
  - For soil contamination that extends 4.6 m (15 ft) bgs and deeper, protection of groundwater and the Columbia River must be achieved. Additional factors may be considered, such as decay risks of short-lived radionuclides, protection of human health and the environment, remediation and monitoring costs, ERDF capacity, worker safety, presence of ecological and cultural resources, use of institutional controls, and compliance with maximum contaminate levels (MCLs) for groundwater protection and AWQC for river protection.
- Backfilling and revegetating at remediated sites.
- Implementing institutional controls and long-term monitoring, as needed.
- Conducting 5-year reviews.

For over a decade, large-scale cleanup at the Hanford Site has focused on liquid waste sites, which are the sites believed to have the greatest influence on groundwater quality. By 2004, 78 of the 82 high-priority liquid waste sites identified in the 100 Area had been cleaned up and work had begun on solid waste burial grounds and remaining miscellaneous waste sites as guided by interim action RODs. The remaining miscellaneous waste sites include the sodium dichromate handling, mixing, and distribution systems that may have contributed to groundwater contamination. The four remaining high-priority liquid waste sites are in the 100-K Area and are not accessible due to ongoing operations. Over 155 waste sites have been remediated in the 100 Area through cleanup actions that removed 8 million tonnes (9 million tons) of contaminated soil and debris. Twenty-six of the 45 burial grounds have been cleaned up/evaluated to date, with the remainder scheduled to be completed by the end of calendar year 2010. Figure 3-4 shows contaminated soil removed from the 100-D Area.

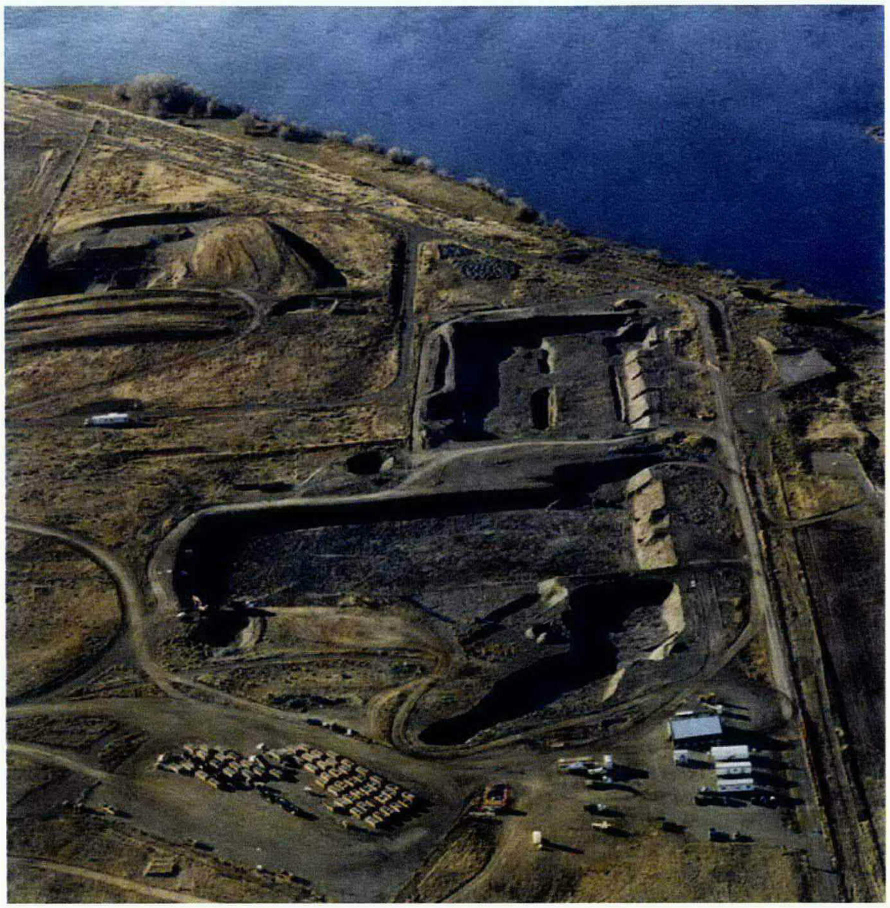


Figure 3-4. Contaminated Soil Removed from 100-D Area

The primary interim cleanup actions for waste sites involve removing soil, underground pipes (as shown in Figure 3-5), and debris that could endanger human health, groundwater, or the environment. Removal of soil and debris continues until field observations and data indicate that cleanup levels specified in the interim action RODs have been meet. Every remediated waste site then undergoes verification sampling and analysis as part of the cleanup verification package (CVP). Some waste sites also require an intermediate step called confirmation sampling. These sites are sampled and evaluated using designs that are approved by DOE and the lead regulators to determine if remediation is required. After DOE and the involved regulatory agency agree that remediation goals for the site have been achieved, the waste site is backfilled (as applicable) and reclassified to an interim closed out or no action status, and revegetated.

Figure 3-5. Pipe Removal from a Chromium-Contaminated Waste Site

3.4.2 Waste Site Identification

Past and present activities provide confidence that waste site locations in the River Corridor are known and processes have been established to address new discoveries when identified. Waste site identification activities in the River Corridor fall into two categories: systematic and observational. Various systematic programs have been conducted at different times, while observation-based identification activities can happen at any time and will continue into the future.

One of the key systematic processes used to identify waste sites was conducted between 1985 and 1988. Reviews of technical baseline reports, historical waste disposal records, occurrence reports, site investigation observations, release discoveries, and employee interviews were used to identify, organize, and rank sites with respect to potential environmental impacts. The results from this process provided information to support the addition of the 100 and 300 Areas to the NPL and subsequent listing of waste sites in Appendix C of the Tri-Party Agreement in 1989 (Ecology et al., 1989a). The RAOs for these waste sites were established in the CERCLA interim action RODs in 1996, which have guided cleanup actions in the River Corridor.

Supplementing past systematic efforts that led to identification of source waste sites in the existing RODs, a series of investigations to identify new potential waste sites in the River Corridor was initiated in 2004. The investigations, called "orphan site evaluations," are a systematic approach to review land parcels in the River Corridor to increase confidence that waste disposal or releases requiring characterization and cleanup within a given land parcel of the Corridor have been identified. Information collected through these evaluations also supports elements of the CERCLA Section 120(h)(4) requirements for review and identification of uncontaminated property at federal facilities. The progress of orphan site evaluations in the River Corridor through August 2009 is shown in Figure 3-6.

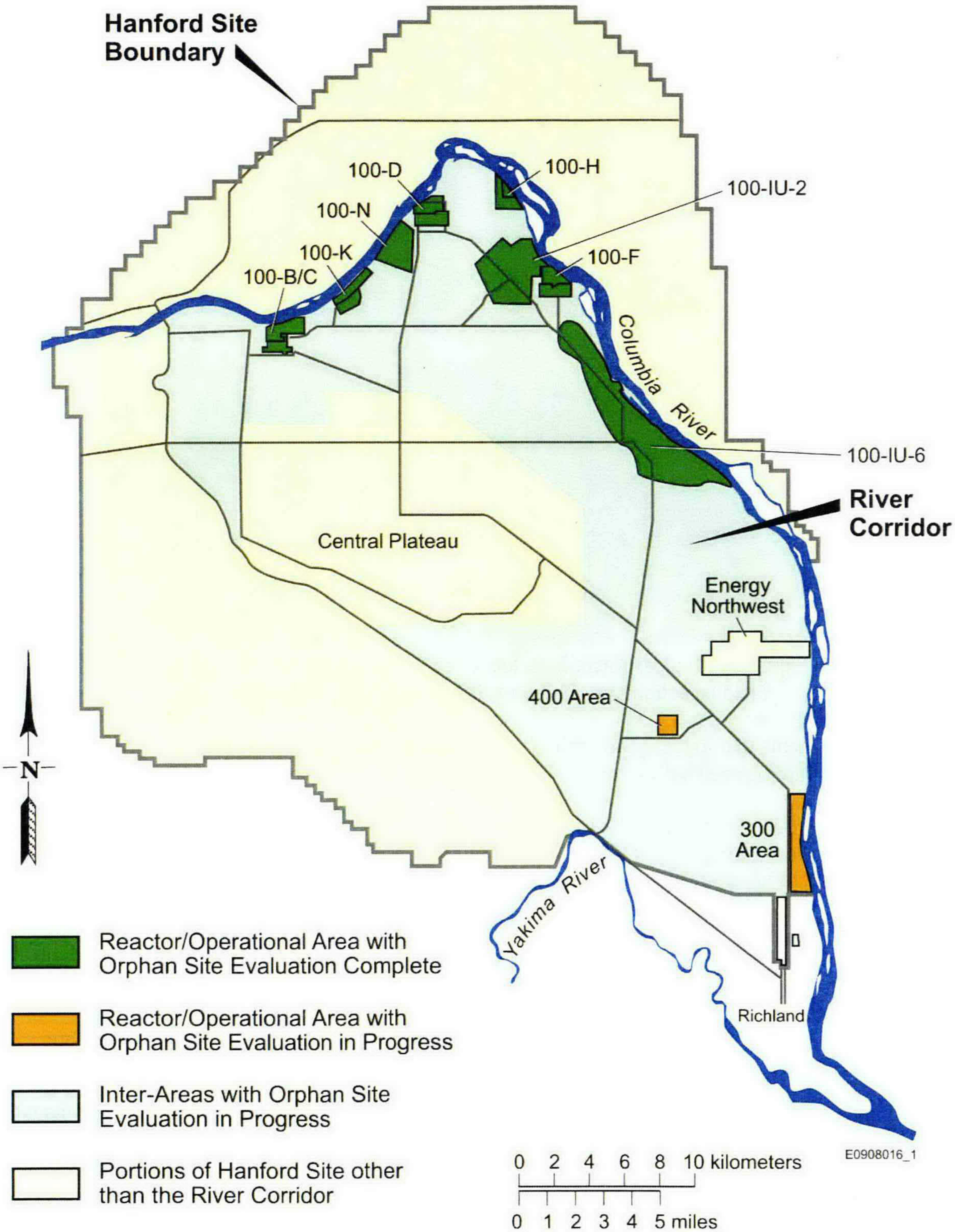


Figure 3-6. Orphan Site Evaluation Areas (through August 2009)

Results of the evaluations are reviewed with participation from the lead regulatory agency and are summarized in an orphan site evaluation report. New waste sites identified through this process (Figure 3-7) typically are added to the scope of one of the source OU RODs through issuance of an Explanation of Significant Difference (ESD).

Figure 3-7. Typical Waste Sites Identified During Orphan Sites Evaluation Field Investigation – Batteries, Discarded Paint, and a Burn Area

Two primary elements that make up an orphan sites evaluation include a historical review and field investigation, as summarized below.

- **Historical review:** Review historical information (e.g., documents, photographs, drawings, geophysical surveys) associated with facilities, piping systems, operational processes, and waste sites to identify potential orphan sites and target areas for field investigation.
- **Field investigation:** Conduct systematic foot-based land survey of operational area to document potential orphan sites (field-based observation) and to follow up on potential orphan sites identified from historical review. Geophysical surveys also may be conducted in target areas as part of the field investigation. Land surveys are conducted on a 30 by 30 m (98 by 98 ft) reference grid system. Hand-held global positioning system units and digital cameras are used to record locations and attribute information for observed items.

The field investigation for the inter-areas uses a graded approach based on the absence of Hanford Site operations and infrastructure. Digital high-resolution aerial photographs and light detection and ranging imagery of the River Corridor collected in 2008 are used to conduct "virtual walkdowns" of the inter-areas (Figure 3-8). Based on results of these virtual walkdowns, areas are selected to conduct foot-based surveys consistent with the approach for operational areas. Vehicle surveys along accessible roads and utility easements also are part of the field investigation for the inter-areas.

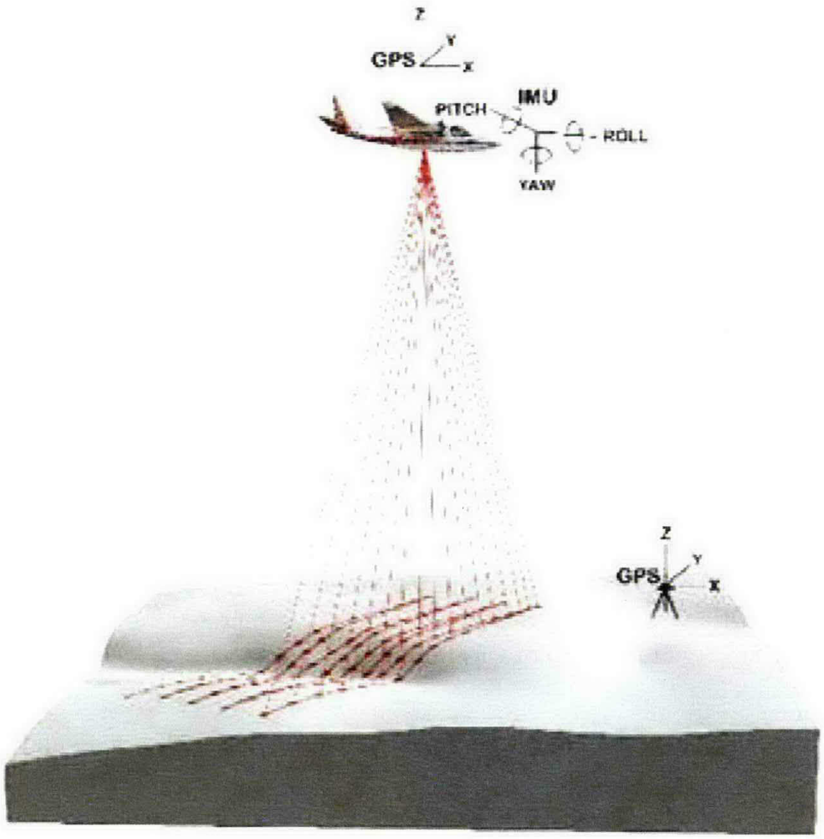


Figure 3-8. Schematic of Light Detection and Ranging Imagery Data Collection Using Fixed-Wing Aircraft

Following completion of the orphan sites evaluation for a given area, new waste sites identified by the process typically are "plugged-in" to an appropriate ROD for subsequent characterization and determination of the need for cleanup. If one or more of the new waste sites does not meet the criteria for "plug-in" under the provisions of an existing ROD, the Tri-Parties will determine the approach to establish the regulatory framework for selection of cleanup actions under an appropriate decision document.

In addition to the systematic processes that have been conducted in the River Corridor to identify waste sites, observation-based discoveries can lead to identification of new waste sites (often referred to as discovery sites). Demolition and removal of retired facilities, cleanup of existing waste sites, and routine monitoring or area management activities provide new opportunities for discovery of potential waste sites. These discoveries can occur at any time and may be identified by any individual. Observation-based discoveries that become waste sites typically are added to the scope of existing RODs in the same way as sites identified through systematic processes. The opportunities for these type discoveries will continue throughout cleanup of the river corridor, including activities conducted after final action RODs are issued (e.g., CERCLA 5-year reviews).

3.4.3 Groundwater Remediation

The interim actions for groundwater in the 100 Area are pump-and-treat systems. Three areas have operations pump-and-treat systems. The systems and remediation process optimization are discussed in the following sections.

3.4.3.1 100-K, 100-D, and 100-H Areas Pump-and-Treat Systems

The pump-and-treat systems, which were one of the interim actions implemented from EPA et al., 1996, *Interim Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Hanford Site, Benton County, Washington*, were designed to remedy CrVI in the groundwater along the River Corridor. The current system network of 27 extraction wells and 11 injection wells draws the groundwater from the aquifer, processes the groundwater through an ion-exchange system to remove toxic CrVI, and returns the treated groundwater to the aquifer.

The interim action ROD specified three RAOs that the pump-and-treat operations were to achieve:

- **RAO 1:** Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.
- **RAO 2:** Protect human health by preventing exposure to contaminants in the groundwater.
- **RAO 3:** Provide information that will lead to a final action remedy.

Institutional controls implemented and maintained along the River Corridor already have been successful in protecting human health (RAO 2) by limiting access to the site and to the groundwater. As shown in Table 3-5, the pump-and-treat systems also have made progress in protecting the aquatic receptors (RAO 1) by removing 802 kg (1,769 lbs) of CrVI in the past decade.

Table 3-5. Status (2008) of the Pump-and-Treat Systems in the 100-K, 100-D, and 100-H Areas

System	Startup	Groundwater Treated Since Startup – December 2007 (million gal)	CrVI Removed Since Startup – December 2007 (lb)	Design Capacity (gal/min)	Current Average Process Flow (gal/min)	Number of Extraction Wells	Number of Injection Wells
100-HR-3	June 1997	845	717	300	167	10	3
100-DR-5	July 2004	60	392	50	38	4	1
100-KR-4	October 1997	1,054	614	300	252	9	5
100-KW	January 2007	45	46	100	97	4	2
Totals		**2,004**	**1,769**	**750**	**554**	**27**	**11**

The pump-and-treat systems continue to operate in the 100-K, 100-D, and 100-H Areas but are in the process of receiving upgrades to achieve the protection of the aquatic receptors objective. Plans to increase their capacity and area of influence are moving forward through a continuous improvement technique called "remedial process optimization." The four systems are being evaluated to determine what improvements and expansions might be needed to make them operate more efficiently, increase the area of influence, and increase the mass removal of CrVI. The present and planned remedial process optimization improvements and expansions of the pump-and-treat network (Table 3-6), in conjunction with other remedial actions, will accelerate achievement of the protection of the aquatic receptors objective.

Table 3-6. Ongoing and Planned Optimization and Expansion of the Pump-and-Treat-Systems in the 100-K, 100-D, and 100-H Areas

System	Scheduled Start	Additional Design Capacity (gal/min)	Number of Additional (New) Extraction Wells	Number of Additional (New) Injection Wells
HR-3 Optimization	November 2008, complete acceptance testing in April 2010	0*	~0	~0
HR-3 Expansion	November 2008, complete acceptance testing in May 2011	100	5	2
DX	November 2008, complete acceptance testing in May 2011	600	28	14
KX	Current, turnover to operations February 2009	400	10	8
KX/KR-4 realignment, Phase I	December 2008, complete acceptance testing in May 2009	~150	3	0
KX/KR-4 realignment, Phase II	February 2009, complete acceptance testing in January 2010	~50	1	2
KW expansion	October 2008, complete acceptance testing in May 2009	100	4	2
Totals by December 2011		**~1,400**	**~51**	**~28**

Notes:

The values shown are approximate based on current information and may change as further design of the systems and systems improvements occur.

*Existing wells will be used to increase the throughput of the 100-HR-3 Pump-and-Treat Facility up to its design capacity of 1,136 L/min (300 gal/min).

~ = approximately

In addition to supporting system efficiencies, the evaluation of the pump-and-treat systems and their effectiveness will contribute to the FS. This evaluation will provide input for the final action remedy, thus meeting RAO 3. Although pump-and-treat systems are in place, in some areas when used alone, they may not be able to remove enough CrVI to achieve cleanup goals. Other technologies are being considered to supplement the pump-and-treat systems.

3.4.3.2 Remediation Process Optimization

Remediation process optimization (RPO) leads to the formulation of remedial action alternatives that have a higher likelihood of achieving cleanup at reduced cost. By implementing a systematic evaluation and enhancing the current site remediation actions, remedial process optimization can foster help with cleanup performance and streamline cost. To determine how remedial actions could be improved, RL initiated a remedial process optimization effort for the 100-D/H Area in 2008 that is continuing into 2009. The RPO process will also occur at the 100-K Area.

The 100-D Area encompasses the operating areas of two former DOE production reactors (D and DR Reactors). While these reactors were operational, large volumes of river water were treated with sodium dichromate (to inhibit corrosion of the reactor piping) for use as coolant for the reactors. After a single pass through the reactor and before being discharged back to the river, the coolant water was sent to unlined retention basins to cool and allow short-lived radioactive isotopes to decay. This process created both contaminated vadose zone soils and large areas of contaminated groundwater. In addition, planned and inadvertent discharges of concentrated sodium dichromate stock solution led to "hot spots" of elevated levels of CrVI in the vadose zone and groundwater.

Despite the natural flushing of the aquifer that has occurred since the reactors were taken off-line and the installation and operation of treatment systems at the 100-D Area, elevated concentrations of CrVI have persisted in the groundwater in this area. The persistence of the CrVI plume, including localized "hot spot" areas containing substantially elevated concentrations, provides evidence that residual CrVI continues to provide a source of ongoing contamination.

The current remediation approaches for the plumes leverage a number of mechanisms. The initial treatment system, known as the 100-HR-3 system, extracts contaminated groundwater using four extraction wells that are located in the northeastern portion of the 100-D Area (Figure 3-9).

Between 2000 and 2003, the 100-HR-3 system was augmented by the phased installation of the passive in situ redox manipulation (ISRM) treatment zone (as previously discussed). Augmentation of the ISRM barrier is being considered because the degree of upgradient CrVI contamination is greater than previously believed.

Active treatment in the 100-D Area was expanded in 2004 with the addition of a second ion-exchange pump-and-treat system, the DR-5 System. The DR-5 system was designed to capture CrVI contamination located further south in the 100-D Area plume (and upgradient of the ISRM). Four groundwater extraction wells currently operate as part of the DR-5 System.

During 2008 and early 2009, the remedial process optimization team identified actions necessary to reduce cost and improve performance of existing remedial systems. The team also identified and evaluated promising new technologies (e.g., bioremediation) for CrVI remediation. The remedial process optimization results culminated in the development of a two-step, or "phased," approach for implementing proposed remedial alternatives to the 100-D Area, 100-H Area, and the "Horn" Area:

- **Phase 1:** Involved leaving existing institutional controls in place and continuing RTD and pump-and-treat operations. The RTD and pump-and-treat operations will be expanded to increase their coverage of the contaminated groundwater plume.

- **Phase 2:** Continues current actions, with the addition of the option to conduct in situ bioremediation or chemical remediation to accelerate remediation of soil and groundwater alternatives at the 100-D Area, 100-H Area, and the Horn Area as follows:

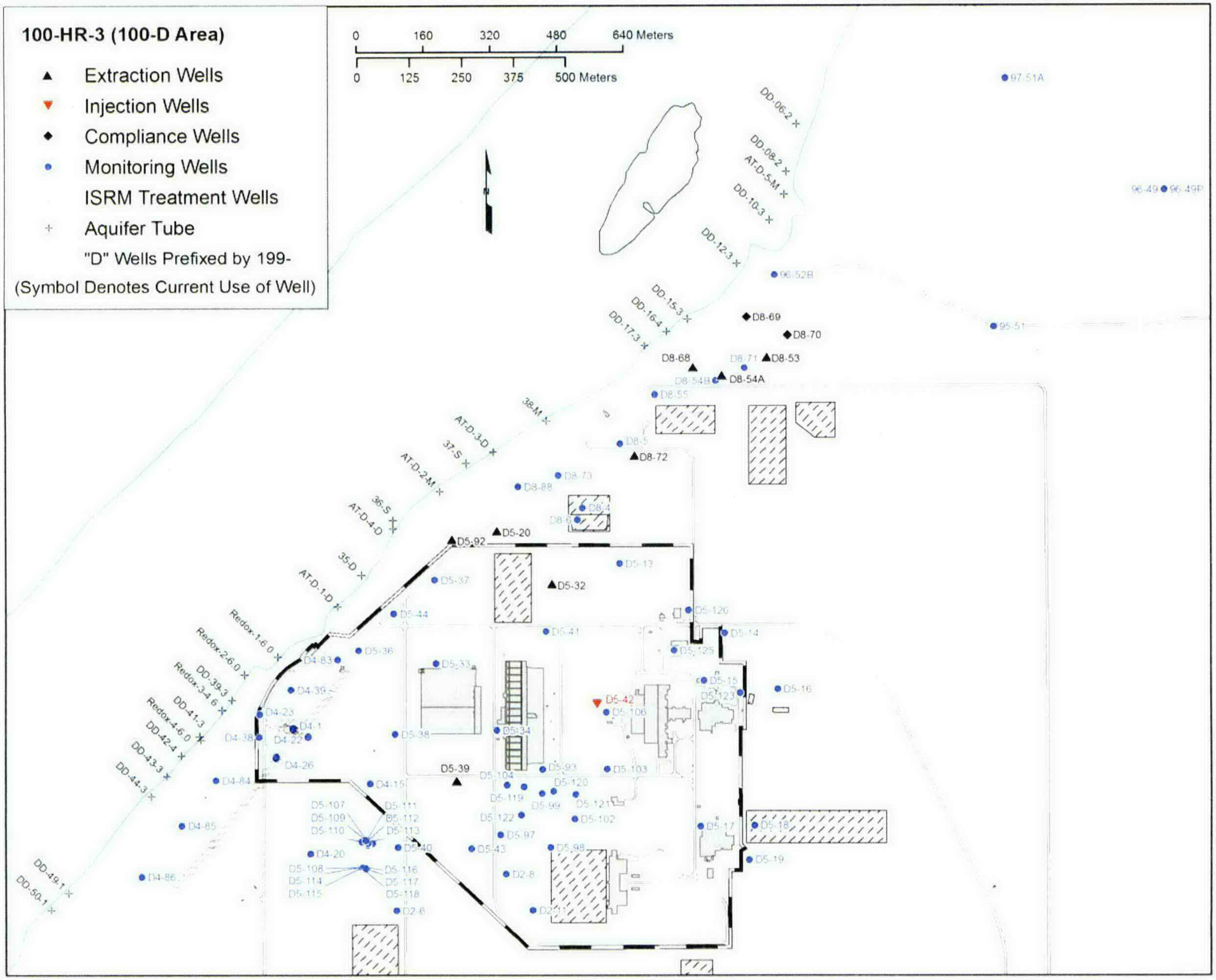


Figure 3-9. 100-D Area Treatment System Infrastructure

Specific work proposed through the remedial process optimization included the following multiple elements.

- Perform resin testing and DR-5 Regeneration System design testing.
- Identify optimal short-term remedial strategy for the DR-5 and 100-H treatment systems to be implemented pending startup of 100-DX system including status quo groundwater treatment and expediting "hot spot" treatment.
- Expedite the river protection strategy.
- Develop pre-conceptual designs and cost estimates for the aboveground components of a 2,271 L/min (600 gal/min), ion-exchange pump-and-treat system proposed for the 100-D Area.
- Develop an expanded well field design that will be implemented when the proposed 2,271 L/min (600 gal/min), 100-DX Plant has been built and is operational.
- Design the expansion of the 100-H Area treatment system capacity from 1,136 to 1,514 L/min (300 to 400 gal/min).
- Develop and implement a treatability test of a full-scale bioremediation as part of the remedial system for the 100-D Area.

These elements substantively augment the cleanup process and support the development of the RI/FS reports.

3.5 Treatability Tests

The DOE is also conducting various new technology treatment tests to explore the application and effectiveness of using the following:

- Native bacteria to remove contaminants from the groundwater.
- Electrical fields to remove a variety of pollutants from groundwater.
- Non-toxic chemicals to trap contaminants, rendering them immobile.
- Tiny iron particles to increase the effectiveness of a treatment.
- A stable mineral found in teeth and bones to adsorb and hold contamination and prevent further migration.
- A strong reducing chemical to change contaminants to a less mobile or toxic form.
- Plants to extract and/or sequester soil contaminants.

3.5.1 100-D Area Biostimulation Test

Molasses and vegetable oil are a powerful combination for groundwater treatment. When injected into the aquifer, these common food ingredients feed the bacteria that can breakdown contaminants in the groundwater (Figures 3-10 and 3-11). More importantly, these injections can work in tandem with other groundwater treatments, helping to protect human health and the environment.

Figure 3-10. Molasses Injected at 100-D Area Biostimulation Treatability Test Site to Nourish Contamination-Destroying Bacteria

Figure 3-11. Molasses from Large Tanker Truck Injected into Well that Delivers it to Contaminated Groundwater

Referred to as "in situ biostimulation," the technology has been used commercially at many contaminated sites. Whether it could be used at the Hanford Site to augment other remedial technologies was a question that a treatability study in the 100-D Area was designed to answer, and the results indicate that in situ biostimulation is a treatment option.

The study focused on determining whether in situ biostimulation could work at the 100-D Area in conjunction with the existing ISRM barrier, which was installed to reduce the amount of CrVI entering the Columbia River. The longevity of the ISRM barrier is currently being threatened by high levels of nitrate and dissolved oxygen in the groundwater. If the two technologies prove compatible, the in situ biostimulation could serve as an inexpensive method for supplementing the ISRM reduction of CrVI. Moreover, in situ biostimulation could increase the life of the ISRM barrier by decreasing the concentrations of CrVI, nitrate, and dissolved oxygen flowing into the ISRM barrier. In addition to these advantages, biostimulation can be designed to treat groundwater species over relatively long timeframes, via slow-release substrates, buildup of biomass, and/or relatively inexpensive reinjection of substrates.

Two phases of field testing for a biostimulation barrier were performed to examine two commercially available approaches: one approach using molasses (a soluble substrate), and the second approach using emulsified vegetable oil (an immiscible substrate). The first phase was initiated in September 2007 with the injection of molasses into the aquifer through a single injection well at the 100-D Area testing location. The injected molasses successfully formed a treatment zone about 30 m (100 ft) in diameter, and the treatment zone has effectively been treating nitrate and CrVI over the past 15 months of monitoring.

The molasses test provides information needed to assess biostimulation in terms of effectiveness, implementability, and cost, and the early results look promising. Implementation of the barrier was accomplished, thereby meeting the test goals for injecting the molasses and obtaining a treatment barrier of the targeted size. Data on equipment and operational requirements were obtained so full-scale costs can be estimated. However, continued monitoring is needed to establish the period of treatment provided by the initial molasses injection in order to estimate the reinjection frequency for use in full-scale cost estimates.

In August 2008, the second phase of field testing began with the injection of emulsified vegetable oil into the aquifer via a single injection well near the molasses test location. The emulsified vegetable oil was successfully injected to form a treatment zone about 15 m (50 ft) in diameter. The treatment zone has effectively been treating nitrate, and CrVI. Continued monitoring is expected to provide information needed to assess the effectiveness, implementability, and cost of this biostimulation approach. As was the case for the molasses test, implementation of the barrier was accomplished, thereby meeting the test goals for injecting the emulsified vegetable oil and obtaining a treatment barrier of the targeted size. Again, data on equipment and operational requirements were obtained so full-scale costs can be estimated. The information from continued monitoring will help establish the period of treatment provided by the initial injection so the reinjection frequency can be estimated and used in full-scale cost estimates.

A separate, but similar, smaller-scale field test of biostimulation was conducted at the 100-H Area. In this test, a commercial polylactate compound was injected into the aquifer. The injection formed a treatment zone for nitrate, oxygen, and CrVI that has been sustained near the injection well for about 3 years.

The studies show that biostimulation, by adding safe and relatively inexpensive organic compounds to the aquifer, can induce the bacteria in the 100-D Area groundwater to treat nitrate, dissolved oxygen, and CrVI. Similar success in testing biostimulation at the 100-H Area suggests that biostimulation is likely viable broadly within the 100 Areas groundwater. The results also demonstrate that biostimulation can function as a supplemental technology for groundwater remedies already treating CrVI in the 100-D Area. Using simple food sources, biostimulation applies natural processes to groundwater contamination. Combined with other treatment technologies, biostimulation can be part of the solution to treat the aquifer to protect the Columbia River.

3.5.2 Treatability Test of Ex Situ Electrocoagulation to Remove CrVI from Groundwater in the 100-D Area

In 2007, ex situ electrocoagulation (i.e., a water treatment process known to be able to remove a variety of suspended solid and dissolved pollutants from aqueous solutions) joined the ranks of new technologies being tested to remediate CrVI-contaminated groundwater in the 100 Area. With the potential to increase efficiency and reduce costs, compared to the present ion-exchange treatment, electrocoagulation showed promise as a treatment that could augment existing technologies.

In electrocoagulation, an electric field is applied to metal plates, which release ions into the water. To remove oxidized species like CrVI, iron plates typically are used. The iron ions reduce CrVI to an iron-chromium hydroxide, which then can be removed from the water. The 2007 treatability test allowed evaluation of the practicality of using this technology to expand the pump-and-treat system at the 100-D Area. The following test objectives focused on gaining information for that evaluation:

- Determine the operability, robustness, and treatment efficiency of an electrocoagulation system
- Characterize volume and composition of waste for proper waste classification
- Obtain design data for scaling the process from a 189 L/min (50 gal/min) to a 1,893 L/min (500 gal/min) system.

The treatment system included the electrocoagulation unit (Figure 3-12) and the water treatment system, and these components are shown in Figure 3-13. The electrocoagulation unit contained multiple charged plates through which the contaminated water passes. The water treatment system removed the precipitates and reoxygenated the water. Components of the water treatment system included a clarifier, filters, and a filter press to dewater the sludge.

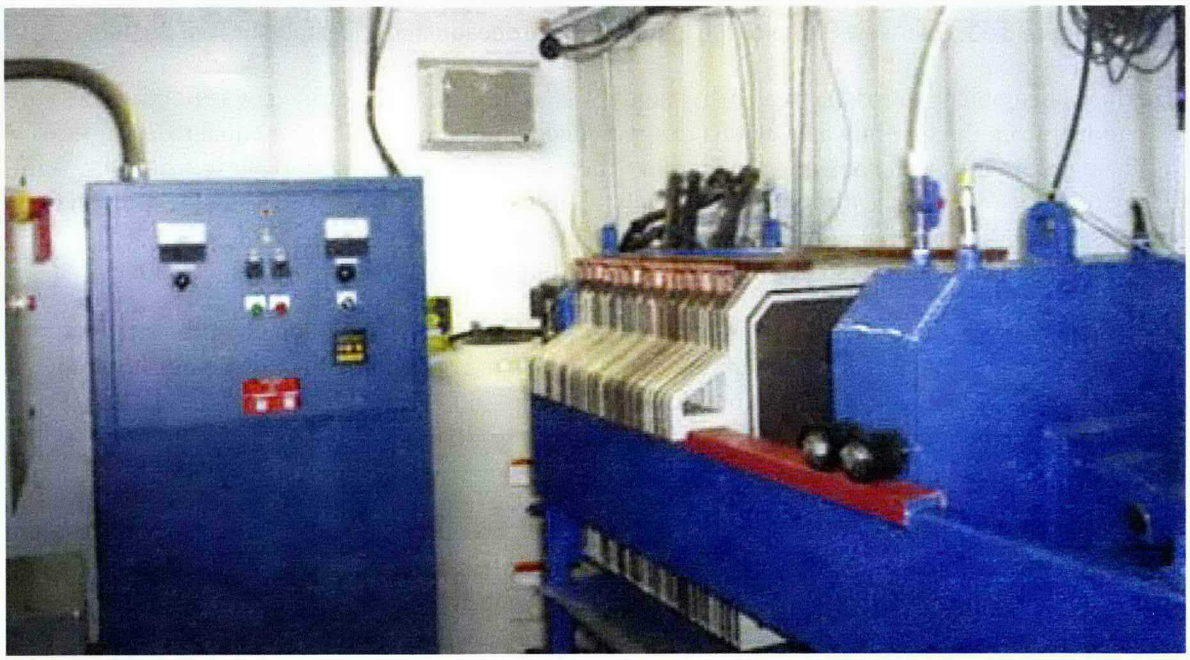
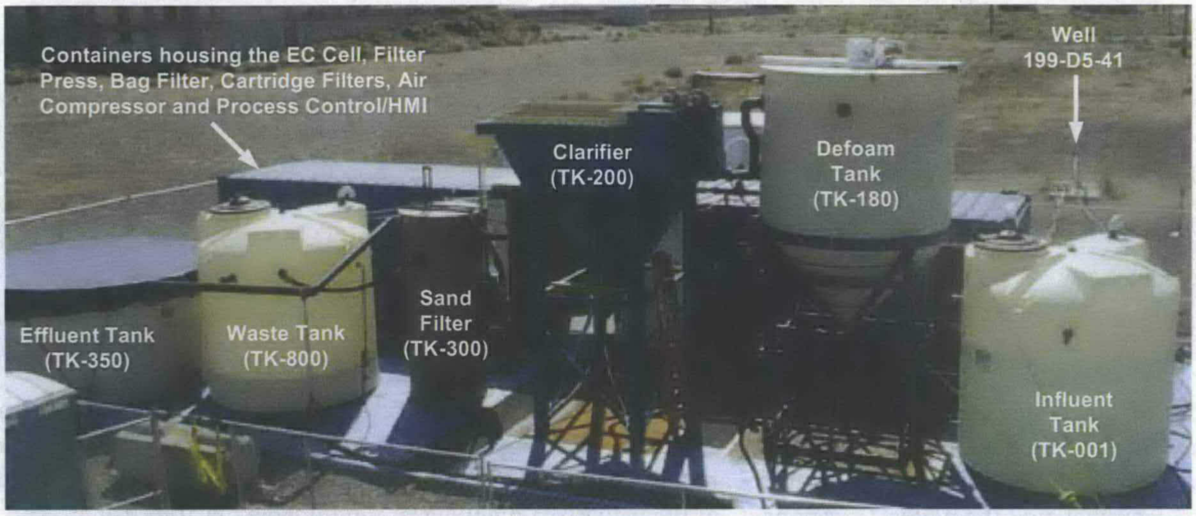


Figure 3-12. Electrocoagulation Unit (Electrode Plates Exposed)



EC = electrocoagulation
HMI = human-machine interface

Figure 3-13. Overview Photo of the Installed Electrocoagulation Treatability Test System

The performance objective for the treatability study was to determine the efficiency (effectiveness) of CrVI removal from the groundwater, with a desired concentration of less than or equal to 20 µg/L CrVI in the effluent before injection back into the aquifer. The test consisted of a startup phase from May 3 to July 20, 2007; a continuous testing phase from July 23 to October 12, 2007; and a final testing phase using groundwater augmented with higher concentrations of CrVI on October 16 and 17, 2007. Over the course of the test period, the test system treated 10.3 million L (2.8 million gal.) of groundwater.

The data evaluation at the conclusion of the test suggests that electrocoagulation could be an effective supplement to existing pump-and-treat approaches, but cost and operational factors do not favor the use of this technology. While the evaluations are discussed in detail in DOE/RL-2008-13, *Treatability Test Report for the Removal of Chromium from Groundwater at 100-D Area Using Electrocoagulation,* the main conclusions can be summarized as follows:

- **Chromium removal:** CrVI levels met the performance objective (less than or equal to 20 µg/L) in over 90 percent of the samples (Figure 3-14), although often the groundwater had to be passed through the treatment system more than once to achieve the objective. The electrocoagulation unit sometimes met the performance objective with a single pass through the system. All effluent CrVI samples during the batch testing with high influent CrVI concentrations (approximately 2,000 µg/L) met the performance objective.
- **Waste stream:** All solid-phase secondary waste streams exhibited levels below the limits for the toxicity characteristic and within the limits for the corrosivity characteristic.

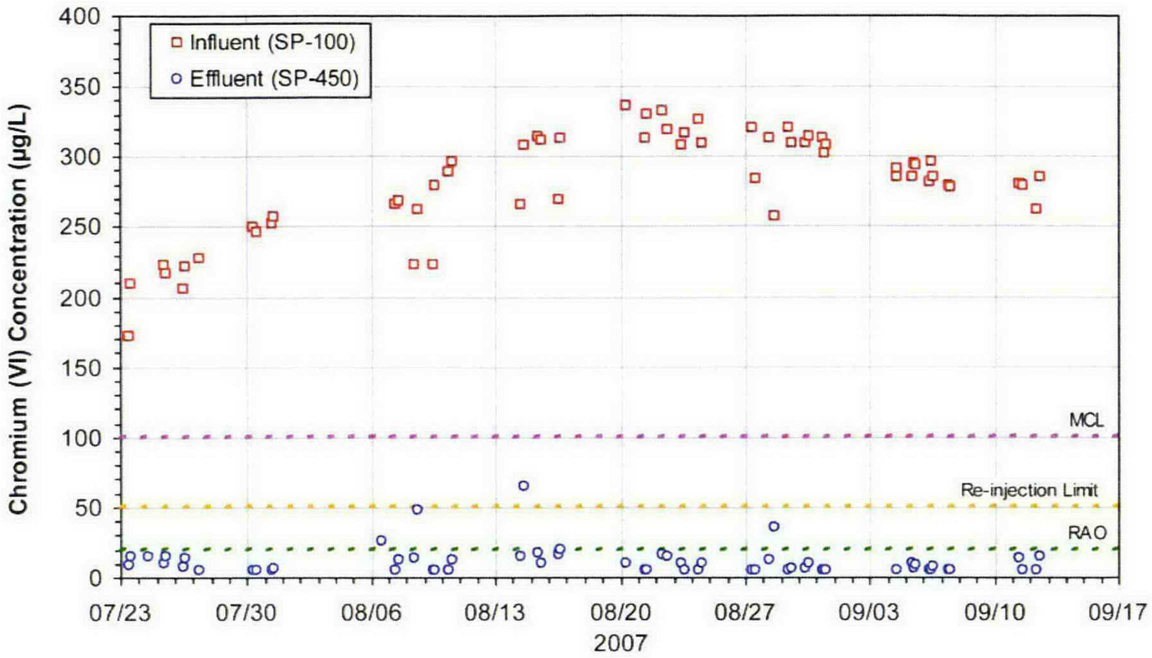


Figure 3-14. CrVI Influent and Effluent Concentrations Obtained During the Electrocoagulation Test

- **Operational reliability:** For the continuous operations testing period, the system could not operate unless it was attended. An extensive period of startup and adjustment preceded continuous operations but was unsuccessful in providing a suitable and robust operating condition. Primary operational reliability problems were related to the sensitivity of the solid separation process to operational conditions, so a robust operating procedure (e.g., chemical dosage) was not identified during the treatability test. Poor solids separation and high effluent iron concentrations also led to operational difficulties associated with injection well fouling. This was key information, as the application of the electrocoagulation technology with reinjection of the treated water into the aquifer via a well is a rigorous performance requirement for the technology. The technology is typically reliable and robust for operations in industrial settings where effluent standards are higher, the effluent can be discharged to the sewer rather than injected to a well, and influent CrVI concentrations are higher.

- **Treatment cost:** Including all capital cost elements, the estimated cost of treatment was \$0.21/L (\$0.78/gal). Neglecting capital costs, the operations cost is \$0.07/L (\$0.28/gal). This compares unfavorably to an average cost of \$0.005/L (\$0.02/gal) for the current treatment system at the 100-HR-3 OU.

In summary, the treatability study data suggest that electrocoagulation has the potential to meet the performance goal for use as the aboveground component of a pump-and-treat system at the Hanford Site. However, system operation during the test was problematic and costs were significantly higher than current treatment methods. Thus, evaluation of this technology should consider recommendations from the treatability test and potential implementability issues.

3.5.3 100-D Area In Situ Redox Manipulation

By injecting non-toxic chemicals into an aquifer, the ISRM groundwater remediation technology can successfully immobilize contaminants (Figure 3-15). Whether ISRM could be an effective method for remediating CrVI plumes at the Hanford Site has been a topic of research since 1994. After multiple studies and an initial treatability test showed the technology sound, ISRM was selected as the remedy of choice for the southern portion of the CrVI plume in the groundwater at the 100-D Area.

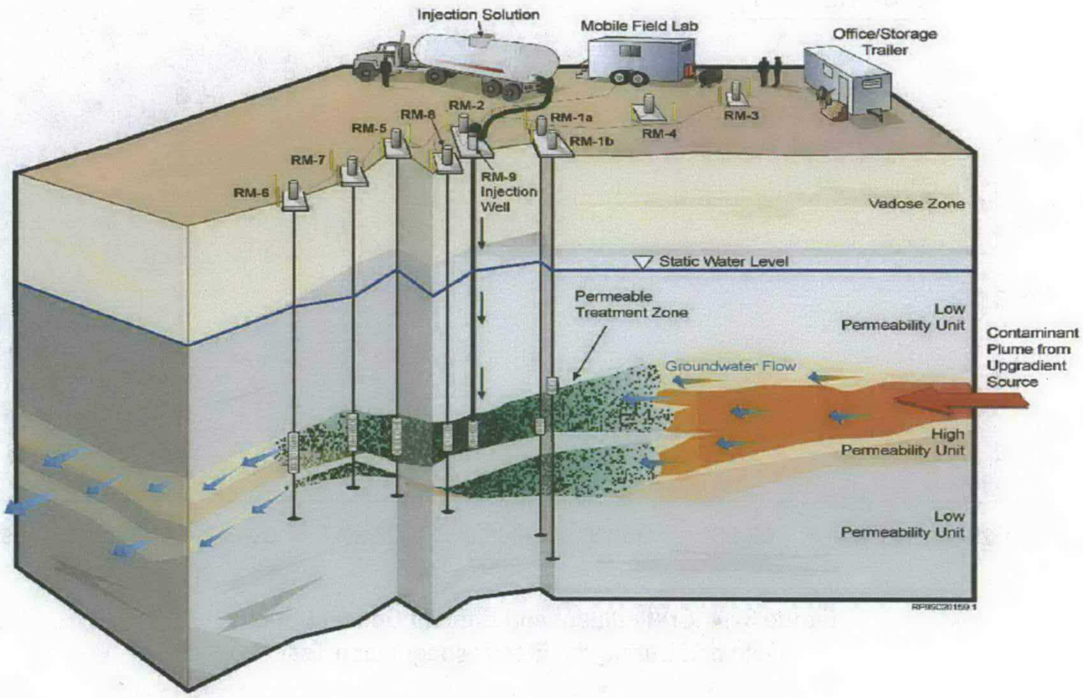


Figure 3-15. Illustration of how ISRM Works to Protect the Columbia River from Sodium Dichromate Contamination

Some of the CrVI plumes now affect the Columbia River. Although a pump-and-treat system is in place at the 100-D Area, used alone it is unlikely to be able to remove enough CrVI to achieve cleanup goals within a reasonable time limit. Conventional particulate permeable barriers that have been successful in other applications cannot be easily installed at the 100-D Area because of the depths involved. The ISRM technology provides the at-depth capability to support cleanup by using chemical processes to reduce the contamination.

In the first step of ISRM operations, sodium dithionite (a non-toxic chemical) is injected into the aquifer through a conventional 15.2 cm (6 in.) groundwater well. As the sodium dithionite disperses through the aquifer, it interacts with naturally occurring ferric iron in the aquifer sediments. Reacting to the sodium dithionite, ferric iron is reduced to ferrous iron. The reduced iron clings to sediment surfaces, becoming incorporated in the clay structure of the aquifer and producing a stationary, yet permeable, barrier to contamination. This barrier then acts as an in situ treatment zone. As contaminated groundwater passes through the barrier, the reduced iron interacts with the CrVI, converting it to a less-toxic form, and then trapping it in the sediments. Depending on contaminant concentrations, the barrier can be designed to operate passively for decades.

When the ISRM technology performed successfully during a 2-year treatability test in the 100-D Area, DOE and the regulatory agencies decided to fully deploy the technology by expanding the original test barrier. The design for the expanded ISRM barrier was based on the maximum CrVI plume concentrations detected, the dissolved oxygen content in the water, and the groundwater flow rate. In 2000, construction began on a 701 m (2,300 ft) long barrier that would stretch the width of the CrVI plume and treat the CrVI for an estimated 15 to 20 years. By 2003, the 66 wells needed to create and operate the barrier were in place, and the barrier had been installed parallel to the riverbank, approximately 152 m (500 ft) from the Columbia River.

To date, characterization data in the majority of wells indicate that ISRM operations are continuing to reduce CrVI; however, the performance of the overall barrier has been mixed. A widespread groundwater plume of nitrate may be aging the barrier faster than expected, reducing its longevity by 7 to 10 years. By 2006, 17 wells were showing some signs of performance deterioration. Specific wells (primarily in the eastern half of the barrier) show CrVI breakthrough, while adjacent wells show no breakthrough. The use of air-rotary drilling to place some of the injection wells is likely to have caused some of these operational difficulties.

In response to these complications, RL is testing two technologies that could potentially repair the wells and bring the barrier up to top performance: (1) a particulate iron injection method (discussed below), and (2) a biostimulation method (previously mentioned). In the meantime, the other 49 wells continue to function to reduce the CrVI and protect the river.

3.5.4 Fortifying the In Situ Redox Manipulation Barrier with Iron

The ISRM barrier depends on the presence of naturally occurring iron in the aquifer to create treatment zones that trap CrVI. When data indicated that CrVI was breaking through the ISRM treatment zones in several locations, scientists proposed that fortifying the barrier with additional iron could offer a sustainable long-term repair.

In 2008, DOE began a test to determine whether injections of tiny iron particles (only 70 nanometers [3 millionths of an inch] in diameter) could fortify the weaker portions of the ISRM barrier. The small size of the particles would allow them to flow into the aquifer, thus treating the water more effectively given the very large surface area of the material (30 m^2/g [150,000 ft^2/lb]). Higher surface area means that more of the iron would be available to react with and remediate the groundwater.

Selecting the right iron particles was critical to the success of the test, so the initial stages of the project focused on identifying potential zero valent iron (ZVI) (i.e., neither positively nor negatively charged) products for injection. This led to the development of laboratory tests to evaluate the geochemical and physical properties of ZVI, and then to the design and execution of an injection test, and finally to post-injection monitoring that would provide performance data.

The search to identify suitable materials yielded an original database of 30 separate ZVI materials. Each of these materials was ranked for injectability, geochemical properties, cost, and availability, which reduced the list to the six materials identified in Table 3-7. Laboratory tests, screening-level geochemical tests, and injection tests identified two candidate compounds, Polymetallix™ [7] and RNIP-M2™ [8], and both were tested further for field application. When the RNIP-M2 proved clearly superior in both compounds, its injection characteristics and its ability to sustain the treatment zone, it was chosen as the ZVI for the actual test at the ISRM barrier.

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7 Polymetallix is a trademark of Polyflon Company, Norwalk, Connecticut.

8 RNIP-M2 is a registered trademark of Toda Kogyo Corporation, Japan.

Table 3-7. List of Screened ZVI Materials Tested in the Laboratory

Zero Valent Iron Material Name	D50 (μm)	Surface Area (m^2/g)	Percent Iron	Cost/lb	Field Injection
EZVI	1	10	98	$16.00	Y
Polyflon Particles	0.15	37 to 58	greater than 99	$72.00	Y
NanoFe (Lehigh)	0.1	10 to 45	greater than 99	$50.00	Y
Zloy	0.2	15	40	$20.00	Y
H2OMet-XT	~10	--	78	$0.55	N
RNIP-M2	0.07	20.2	65	$32.35	Y

~ = approximately

The field injection test was conducted in August 2008 at the 100-D Area. The first goal was to inject enough ZVI into the more permeable portions of the barrier to ensure that the ZVI could disperse at least 7 m (23 ft) from the injection well. The second goal was to determine whether the selected ZVI could effectively reduce CrVI concentrations in the groundwater.

Over a period of approximately 5 days, 370,970 L (98,000 gal.) of the RNIP-M2 solution was injected into the Ringold Formation aquifer at a rate of 53 L/min (14 gal/min). The ZVI was communicated at least 3 m (9.8 ft) away from the injection well. A borehole was drilled 7 m (23 ft) from the injection well in March 2009 to evaluate the radius of influence. Analysis of aquifer materials showed that approximately 4 wt. percentage nano zero valent iron (nZVI) was present in the targeted permeable layer near the bottom of the aquifer. This verified that the goal of emplacing nZVI at least 7 m (23 ft) into the aquifer was successfully accomplished. Monitoring has shown that the area near the test is strongly reducing, and CrVI has been reduced to the immobile trivalent chromium.

To date, the test has demonstrated that RNIP-M2 could be an effective, easily injected ZVI product to fortify the ISRM barrier. While initial results suggest that such repair is possible, additional monitoring is needed before the long-term effectiveness can be demonstrated.

3.5.5 100-N Area Apatite Barrier Installation

At the 100-N Area, a newly developed method for treating Sr-90 in place is protecting the Columbia River by preventing contamination from reaching the river. Efforts to reduce the amount of Sr-90 entering the Columbia River from closed waste disposal sites at the 100-N Area began in the early 1990s. Ceasing liquid discharges to the ground in 1993 was a major step toward meeting this goal; however, Sr-90 already in the soil beneath the liquid waste disposal sites continued to contaminate groundwater and the Columbia River. Scientists realized from the beginning that pumping and treating contaminated groundwater was unlikely to be a long-term solution. The slow release behavior of Sr-90 present in the soil meant that pumping and treating groundwater would take decades, and groundwater sampling results have proven that theory. Accordingly, the first CERCLA 5-year review reemphasized the need to find other ways to reduce impacts on the Columbia River.

One innovative option was to create a permeable reactive barrier in the groundwater consisting of the mineral apatite. Apatite, a very stable mineral found in teeth and bones, is made up mostly of calcium and phosphate. Scientists proposed injecting those necessary building blocks to form the apatite directly in the groundwater. The apatite could then adsorb the Sr-90 contamination and hold it so it could not migrate further. Figure 3-16 shows the test site at the 100-N Area where the apatite barrier technology is being developed. If the technology continues to be successful, the test site may soon be expanded into a full-size barrier to protect the Columbia River from Sr-90 contamination.

Figure 3-16. Test Site at 100-N Area where Apatite Barrier Technology is being Developed

After reviewing the available information, the Tri-Parties agreed that using apatite to protect the river was a good long-term strategy. The Tri-Parties also agreed that an extra step should be included to protect the river; phytoremediation using natural occurring plants as a "polishing" step was added to the strategy. The use of plants and phytoremediation as treatment technologies is discussed below. Since that time, the Tri-Parties have worked together to develop a cost-effective plan to use apatite and phytoremediation treatments to reduce the amount of Sr-90 entering the Columbia River.

In July 2005, the plan to inject apatite-forming chemicals into the river shore soils between the closed waste sites and the Columbia River was completed. The plan focused on the soil and groundwater along approximately 91 m (300 ft) of the Columbia River bank where Sr-90 concentrations are highest. The first injections occurred in 2006.

Throughout 2006 and 2007, low-concentration, apatite-forming solutions were injected along the length of the barrier into the soil and groundwater through 10 injection (barrier) wells. The objective of the low-concentration, calcium-citrate-phosphate injections was to stabilize the Sr-90 in the aquifer at the test site. If the technology proved effective, the results could be used to help refine the treatment strategy, which could include high-concentration injections to provide for long-term Sr-90 treatment.

Initially, a tracer injection test and the first apatite injection pilot test were conducted at the upstream end of the test area, during high water conditions in the spring of 2006. A second pilot test was conducted at the downstream end of the test area during low river conditions in September 2006. Analysis of the operational and pilot test monitoring results helped refine the injection techniques, the chemical mix of the injection solution, and the amount of solution injected. Injections into the 10 barrier wells were conducted during two phases: the first phase in February through March 2007, which targeted low river conditions; and a second phase in June through July 2007, during high river-stage conditions. The results of the low-concentration injections are presented in an interim report (PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immoblization*).

The results and experience from the low-concentration injections led to the design for a series of higher concentration injections. Six more barrier (injection) wells were installed on the lower end of the existing barrier in the fall of 2007. During the summer of 2008, the 16 barrier wells were injected using adjusted techniques and chemical mixes. The results from these injections are still preliminary, and additional time and monitoring are needed to fully characterize the tests. Apatite is slow to incorporate Sr-90 under field conditions, and it may take up to a year before the results are definitive. In addition, the high strength of the chemical mixture has been slow to decrease in some areas. Some of the monitoring locations have been dry since the low river conditions of late last summer, and a few wells became partially plugged during testing.

Despite these issues, much of the monitoring data is encouraging, showing that apatite is being formed and Sr-90 is being adsorbed as designed. Concentrations of Sr-90, based on gross beta, fell below baseline levels in 19 of the 20 wells (Figure 3-17). Data indicate that Sr-90 in the one remaining well, while still exhibiting levels above baseline minimum values, is on a downward trend. Apatite technology is showing great promise as a remediation option. If the results continue to be positive, a plan to expand the method to a full-scale treatment option will move forward.

3.5.6 100-K Area Calcium Polysulfide Treatability Test

In a continuing search to identify new technologies for remediating CrVI in 100 Area groundwater, an in situ approach that could be a cost-effective supplement to the current pump-and-treat systems was tested in 2005 (DOE/RL-2006-17, *Treatability Test Report for Calcium Polysulfide in the 100-K Area*).

The tested technology involved injecting calcium polysulfide, a strong reducing chemical, into the aquifer. Once in the water, the calcium polysulfide was intended to reduce the mobile CrVI to its less mobile and less toxic trivalent form and create a permeable reactive barrier that will continue to remove CrVI.

The test was performed in the eastern part of the 100-K Area (Figure 3-18) to evaluate the potential practicality and cost of the technology. The test also determined vital hydrologic information for the 100-K Area aquifer, provided experience in designing systems to implement this type of technology, and revealed several lessons learned that will be valuable if this technology is implemented. Given these numerous aspects, the test had the following multiple objectives:

- Verify the ability to achieve in situ CrVI reduction using an active remediation system involving calcium polysulfide and a carbon source, which together reduce the groundwater and aquifer through both inorganic and microbiological processes.
- Determine whether aquifer constituents (e.g., manganese or arsenic) are mobilized because of this reduction, and how other parameters (e.g., nitrate or dissolved oxygen) are affected as a result of the groundwater treatment.
- Obtain operational experience in the treatment of CrVI-contaminated groundwater by the use of calcium polysulfide as the reducing medium.

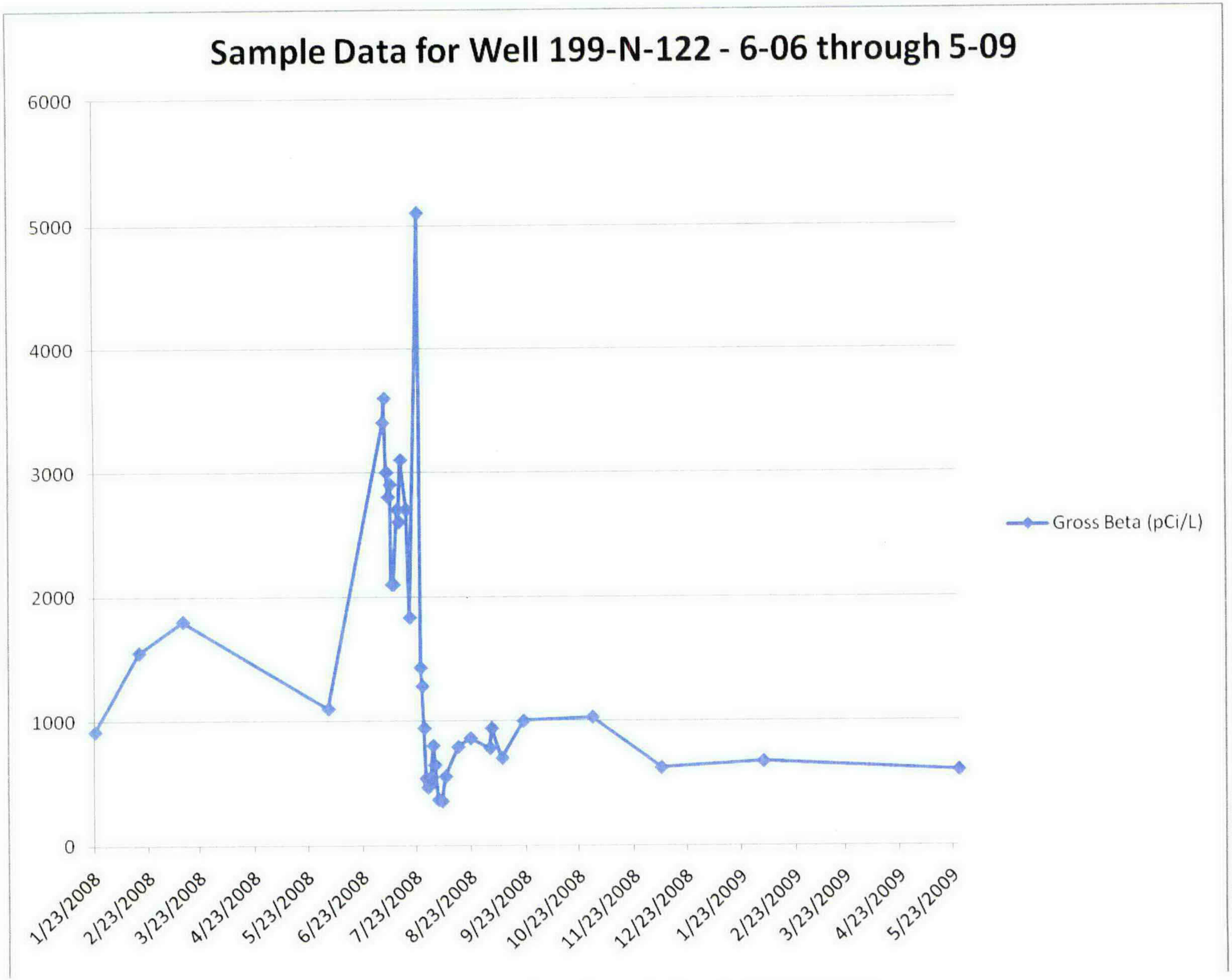

Figure 3-17. Gross Beta Concentrations in Well 199-N-122

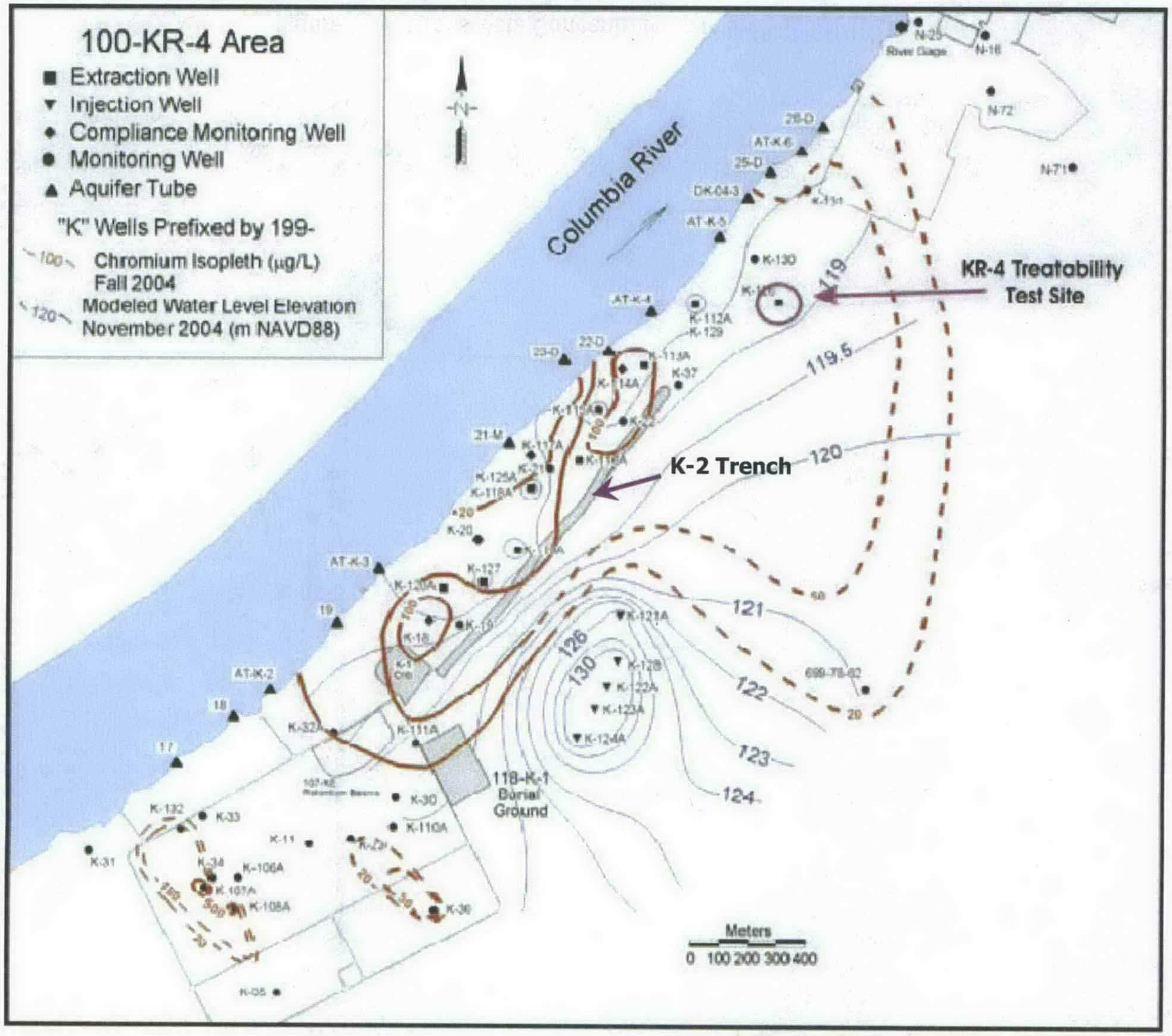

Figure 3-18. 100-KR-4 Plume Showing Treatability Test Site

Five wells were used for the treatability test, which included an extraction well surrounded by four injection wells drilled specifically for this test. During testing, groundwater was withdrawn and mixed with calcium polysulfide in an aboveground tank. This solution reacted for a minimum of 2 hours and then was pumped through the injection wells in approximately equal amounts to permeate the aquifer. This is typically called a "five-spot" configuration, and is ideal for a test of this type because it provides operational field experience and kinetics information in a manageable area and cleans up a section of the aquifer.

The treatability test began on June 28, 2005. Before startup, systems were tested for leaks and proper operation, and a tracer study was initiated. Water was circulated without calcium polysulfide on June 27, 2005 when a lithium bromide tracer was pumped into one of the injection wells. This tracer test (along with slug tests carried out in the extraction and injection wells before and after the treatability test was performed) served to quantify the hydraulic conductivity in the aquifer beneath the treatability test area. The slug tests were rerun after completion of the treatability test to determine if the test had degraded the aquifer.

During the treatability test, 25 samples were collected on a regular basis and analyzed for basic chemical properties (e.g., pH and oxidation-reduction potential) and major and trace element constituents. The amounts of water extracted and injected were recorded, as well as the volume of calcium polysulfide mixed with the water. Over 1,324,894 L (350,000 gal.) were treated during the test, which was completed on August 11, 2005.

All of the performance goals were met by the end of testing. The technology effectively reduced CrVI in the aquifer and created a permeable reactive barrier that continues to treat CrVI under natural groundwater flow conditions. Analysis of groundwater chemistry before, during, and after the test shows that manganese and iron were mobilized under the strongly reducing conditions in the aquifer, and that arsenic was at near-background conditions after test completion. The pre- and post-treatment aquifer tests showed that chemical injection did not degrade the permeability of the aquifer.

This test was considered successful, and the data collected are sufficient to scale-up the treatment technology. Groundwater monitoring in the treatment area shows that, two years after the test, dissolved oxygen is rebounding to near ambient conditions of 7,000 μg/L in the extraction well (199-K-126), but is being maintained at less than half of ambient concentrations in the injection well. Groundwater in a well approximately 200 m (656 ft) downgradient of the test area is also being monitored to evaluate migration of the reduced zone, but this well has yet to show any effects from the treatability test.

3.5.7 100-K Area Phytoremediation Field Demonstration

Through a safe and nonintrusive remedy called phytoremediation, the Coyote willow (which is a common plant that grows along the banks of the Columbia River) could potentially become part of a treatment that stops Sr-90 from entering the water. If early testing confirms that possibility, these natural shrubs (Figure 3-19) could help restore the natural balance of the environment.

Phytoremediation technology employs plants to extract and/or sequester soil contaminants. The Coyote willow is considered the most suitable plant for use along the Columbia River shore. Known for its rapid and robust regrowth abilities, Coyote willow is already used extensively along the Columbia and Yakima Rivers for bank stabilization and revegetation purposes. As part of a chain of remedial technologies aimed at treating Sr-90, phytoremediation using Coyote willow would be a polishing step in multiple processes protecting the river.

Figure 3-19. Coyote Willows Growing in Test Plot at 100-K Area

In the proposed configuration, the treatment system would first incorporate an apatite barrier (previously described). This technology would be designed to extract Sr-90 that is either present near the river now or is expected to move toward the river over the next 300 years. The phytoremediation treatment, designed as an extraction system along the riparian zone of the Columbia River, would be constructed to address Sr-90 in the vadose and saturated zones associated with the Columbia River riparian zone. Once the apatite barrier was fully functional and the Coyote willow had extracted the Sr-90 from the riparian zone, the phytoremediation component could be discontinued.

The key to using phytoremediation as part of the treatment, however, besides the volume of sediment to be treated, is biomass production, which is the focus of the study currently being conducted to determine whether the technology is usable. The study involves two major objectives: (1) determine the most efficient fertilization method for Coyote willow that will generate the greatest biomass possible while also protecting the Columbia River from excess nutrient run-off, and (2) demonstrate the efficacy of using Coyote willow as a phytoremediation tool along the riparian zone associated with the 100-N Area.

The study began in the late spring of 2007, with 50 Coyote willow starts being planted in a fenced area at the 100-K Area. This part of the study targeted plant growth rather than phytoremediation capabilities, so the 100-K site, which is not contaminated with Sr-90, was well suited as a host location. Often flooded by the annual high Columbia River stage well into June, this site is a severe test for the willow shrubs' ability to survive realistic field conditions.

During the first year of the test, there was relatively little growth while the plants became established and developed root systems. In October 2007, the plants were pruned down to the trunk plus primary branches. Forty-nine of the 50 plants survived the winter. In May and June 2008, the site was once again flooded, and serious growth began in July. The second year harvest was completed in October 2008. The average biomass was 369 percent greater than the first year at about 340 kg (750 lb) per acre, which was in line with predictions.

If the Coyote willows continue to perform over the coming year, the next step will be a test at the 100-N Area in actual Sr-90-contaminated soil. Methods for safely planting, tending, and harvesting the willows along the rip-rap that covers the 100-N Area shoreline will need to be developed; however, if the 100-N Area tests prove successful, phytoextraction could be incorporated as part of the treatment protecting the Columbia River from Sr-90 contamination.

In summary, greenhouse, laboratory (growth chamber), and field studies have shown that strontium is a nutritional analog of calcium, a plant macronutrient. As such, the Coyote willows will actively accumulate Sr-90 in their leaves and stems to levels over 70 times that present in the soil pore water surrounding their roots. Given the steadily increasing growth rate of the trees at 100-K following yearly harvests of their above-ground tissue, this type of plant would remove significant amounts of contamination from the riparian area of the 100-N shoreline while not disturbing the natural sediment structure. Laboratory studies have also shown that herbivorous insects such as aphids, or moth larvae, would not be a source of Sr-90 off-site transport from the trees. Further, controlled harvesting schedules, and engineered barriers (fencing and netting), would prevent animal intrusion and plant detritus release (PNNL-18294, *100-N Area Strontium-90 Treatability Demonstration Project: Food Chain Transfer Studies for Phytoremediation Along the 100-N Columbia River Riparian Zone*).

3.6 Assessment of Baseline and Residual Risks in the 100 Area

The following section summarizes the past and ongoing risk assessment activities within the 100 Area. These risk assessments have been conducted in support of remedial decision making, covering specific timeframes, OUs, or geographical areas within the 100 Area. The results from these risk assessments will support the development of remedial alternatives and final action cleanup levels.

3.6.1 Risk Assessments in Support of Interim Action Records of Decision

The cleanup of past-practice waste sites and groundwater at the Hanford Site initially focused on addressing releases to the environment that represent a near-term risk to the public or the environment. This resulted in the cleanup of contaminated waste sites and principal threats to groundwater using interim action RODs. This approach, presented in DOE/RL-91-40, *Hanford Past-Practices Strategy*, uses interim actions to achieve risk reduction sooner rather than later.

3.6.1.1 Qualitative Risk Assessments

QRAs were used to define the basis for remedial actions under interim action RODs. Assessment of human health risks in the QRAs was based on frequent-use and occasional-use scenarios, which reflected current guidance for that time. Onset of human exposure was delayed until 2018, which was used as a target date for completion of remediation in the 100 Area. Frequent and occasional uses were defined using residential and recreational exposure factors obtained from DOE/RL-91-45, *Hanford Site Risk Assessment Methodology*. The contaminants of potential concern (COPCs) were identified from the historical site data and data collected during the LFIs, taking into consideration Hanford Site background concentrations of radionuclides and inorganics in soil, and risk-based screening using residential exposure parameters (DOE/RL-91-45). Human health risks presented in the QRAs were based on the maximum concentrations detected in waste site soils and in groundwater. Human health risks were quantified for a limited set of exposure pathways (soil ingestion, fugitive dust or volatile inhalation, and external exposure). Ecological risks were estimated using a streamlined approach, focusing on a single organism, the Great Basin pocket mouse, using the assumption that the waste site was the home range.

3.6.1.2 Waste Site Cleanup Verification Package

Following completion of remedial actions at a waste site in accordance with the applicable interim action ROD, cleanup verification or confirmatory sampling and laboratory analysis are performed to confirm attainment of RAGs and, therefore, demonstrate that RAOs for interim site closure have been met. A RAG is a specific numeric goal against which cleanup verification data are evaluated to demonstrate attainment of RAOs. The RAGs for the protection of human health were developed using an unrestricted use scenario, which represented a rural residential exposure scenario.

During the remediation process, if waste site sampling shows that the RAOs for direct exposure, groundwater protection, or river protection have not been met throughout the vadose zone, further remedial action is performed, followed by additional verification sampling. If evaluation of the cleanup verification samples shows that the RAOs for a remaining site are met, compliance is documented in the appropriate closeout documentation.

The exposure factors and assumptions defining the rural residential scenario are defined in DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*. Soil RAGs for protection of groundwater also reflected unrestricted use and were intended to achieve state or federal drinking water standards. In addition, soil RAGs were developed to protect aquatic organisms in the Columbia River. However, soil RAGs were not developed for the protection of terrestrial ecological receptors due to the absence of regulatory guidance at that time.

3.6.2 River Corridor Baseline Risk Assessment

As described in the previous sections, the remedial actions completed to date in the River Corridor were implemented primarily under interim action RODs. There is a requirement under CERCLA to perform a baseline risk assessment to characterize current and potential threats to human health and the environment before final action RODs can be issued. These requirements include the following:

- A baseline risk assessment is required by regulation at 40 CFR 300.430, "Nine Criteria for Evaluation," with the purpose of characterizing current and potential threats to human health and the environment.

- EPA guidance states that interim action can occur without a completed baseline risk assessment and that, in such cases, a complete baseline risk assessment will be needed to support development of a final action ROD (OSWER Directive 9355.0-30, *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decision*).

EPA Region 10 guidance acknowledges that a focused risk assessment or QRA can be performed in lieu of a baseline risk assessment to support interim or early actions. A focused risk assessment or QRA should be followed by a complete baseline risk assessment to justify final action decisions. For partially remediated sites, the baseline risk assessment evaluates the site in its present physical condition (EPA 910-R-97-005, *EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund*).

The RCBRA is being conducted to address the regulatory requirement that a baseline risk assessment be performed and to support final cleanup decisions in the river corridor. The RCBRA has two key elements as shown in Figure 3-20: (1) the source and groundwater component (which addresses potential upland, shoreline, and groundwater risks), and (2) the Columbia River component (which addresses potential risks from Hanford Site releases to the Columbia River). The process of conducting the RCBRA has included input from the Tri-Parties, the Natural Resource Trustee Council, Tribal Nations, and stakeholders.

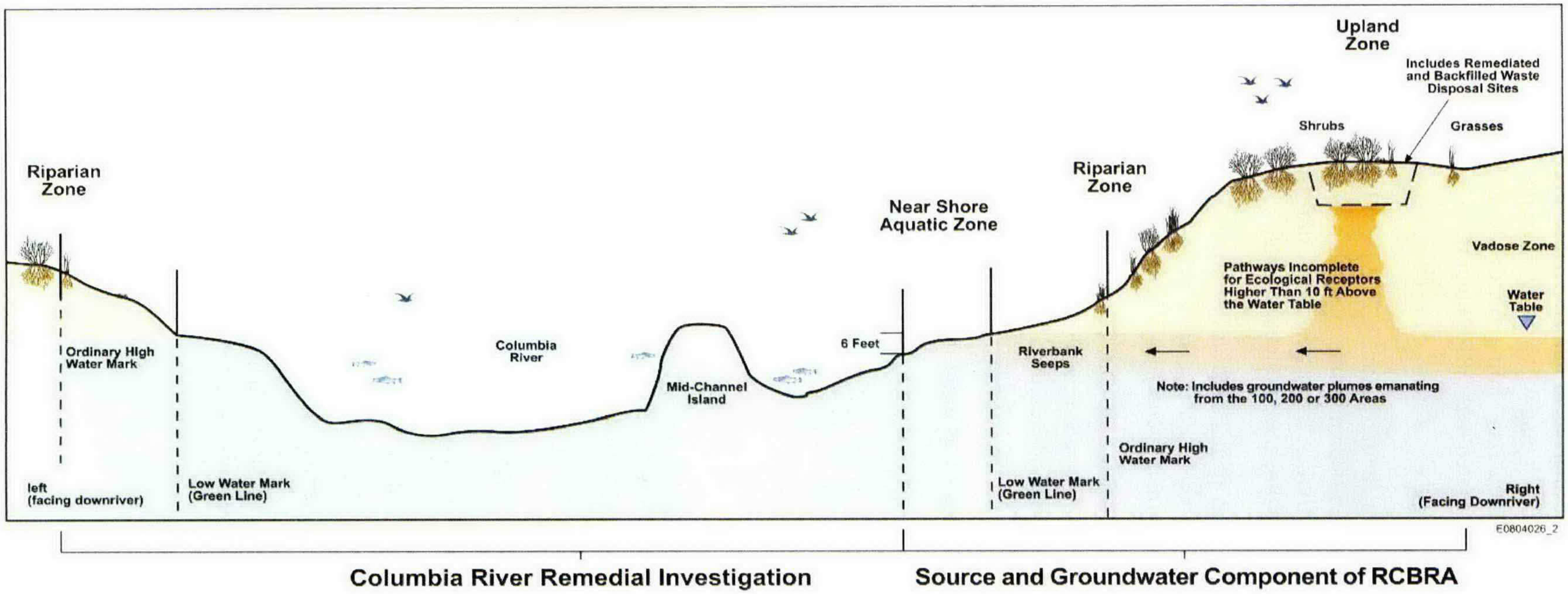

Figure 3-20. River Corridor Baseline Risk Assessment Conceptual Site Model and Study Zones where Animals and People might be Exposed to Contaminants

When complete, the RCBRA will provide a comprehensive analysis of human health and ecological risks in the river corridor. Activities completed pursuant to this work plan will provide an opportunity to refine the conceptual exposure models and verify that potential risks from groundwater are adequately characterized. Results from the risk assessment will be presented in the RI/FS report.

3.6.3 RCBRA Source and Groundwater Component

The RCBRA source and groundwater component addresses about 570 km^2 (220 mi^2) of land and involves analyzing over 440,000 analytical results from more than 35,000 environmental samples. Figures 3-21, 3-22, and 3-23 show several RCBRA sample collection activities. The assessment addresses human health and ecological risks with groundwater and the following environmental zones:

- **Near-shore aquatic zone:** The near-shore aquatic zone includes the surface water of the Columbia River from the area that is permanently inundated by river water (i.e., the low water mark, commonly referred to as the "green line," where the periphyton remain green year-round) up to the riparian zone.
- **Riparian zone:** The riparian zone is a transition area between the aquatic environment in the near-shore zone and the upland zone. The riparian zone extends from the shoreline of the Columbia River to the point on the riverbank where upland vegetation becomes dominant. The riparian zone typically is narrow and varies in width depending on the slope of the riverbank.
- **Upland zone:** The upland zone consists of land that extends inland from the riparian zone and is situated approximately 3 m (10 ft) above the river high water mark. It includes mix waste sites within the 100-B/C, 100-D, 100-F, 100-H, 100-K, and 100-N Areas; the White Bluffs and Hanford townsites; and the 300 Area. The upland zone generally is dry and not readily influenced by river flow. Recharge to groundwater in this zone occurs largely from precipitation.

The environmental zones are shown in Figure 3-24.

3.6.3.1 Human Health Risk Assessment

Human health risks are being assessed for a number of exposure scenarios that varied from low- to high-intensity exposure conditions to provide risk managers with information on how potential risks may vary under a variety of land use conditions. Exposure scenarios under evaluation include the following:

- Future recreational use scenarios (recreational): Avid wild game hunter, avid angler, and casual user.
- Future DOE Tribal use scenario: Non-residential Native American user.
- Future industrial worker scenario (industrial/commercial): Long-term industrial worker.
- Future resident national monument worker scenario (resident national monument/refuge): Seasonal Hanford National Monument worker/resident.
- Future rural residential scenario (rural resident): Long-term rural resident.
- Native American exposure scenarios: Residential Native American users as developed and provided by the Confederated Tribes of the Umatilla Indian Reservation and the Yakama Nation.

Figure 3-21. Soil Sample Collection in the Upland Zone

Figure 3-22. Vegetation Sample Collection Targeting Dominant Plant Species

Figure 3-23. Amphibian and Sediment Sample Collection in the Near-Shore Aquatic Zone

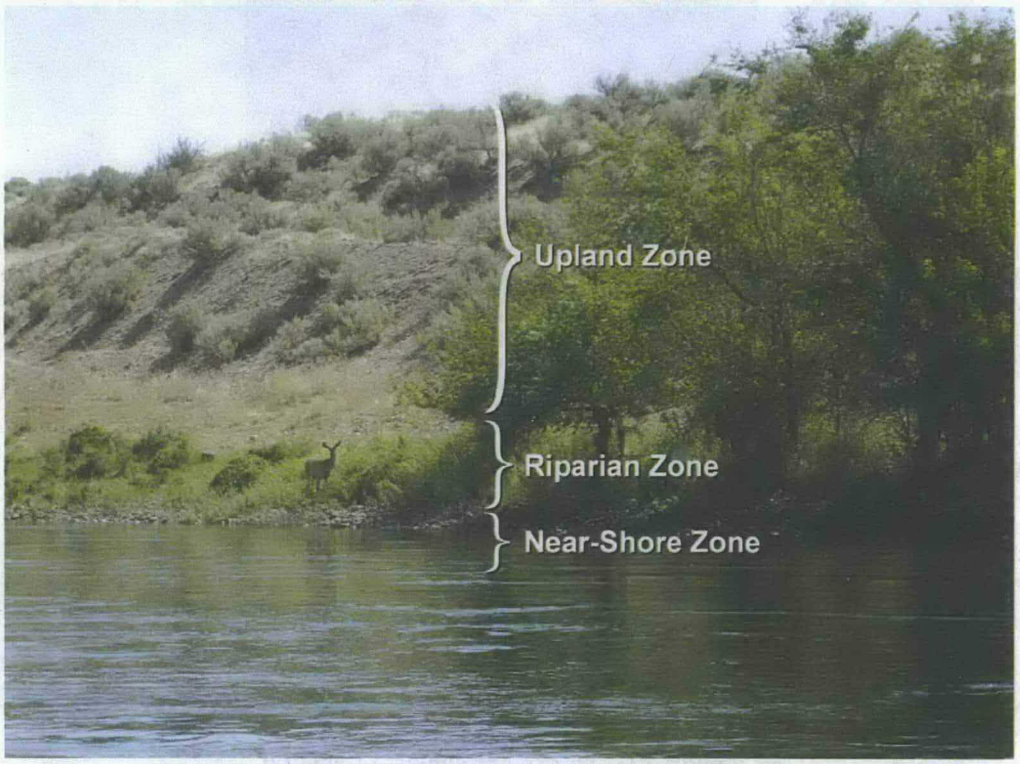

Figure 3-24. Photo Depicting Upland and Shoreline Zones

To support risk management decision making, a range of exposure scenarios is included in the human health risk assessment (HHRA). As previously noted, the interim action RODs prepared for the 100 and 300 Areas relied on qualitative human health and ecological evaluation using only the Great Basin pocket mouse to demonstrate that risks existed and actions were warranted. The RCBRA supports the final action RI/FS and final action RODs by providing the following information:

- The HHRA estimates potential human cancer risks, noncancerous hazards, and dose associated with exposure to residual contamination at 146 remediated 100 Area waste sites under a range of exposure scenarios.
- The HHRA identifies key risk driver chemicals or radionuclides for the various waste sites under a range of human exposure scenarios.
- The HHRA identifies exposure pathways that are key contributors to cumulative risk, hazards, or dose at waste sites for a range of human exposure scenarios.

Risk assessment calculations in the HHRA are being performed independently for the soil source term (includes waste site residual soil and surface soil), the groundwater source term, and fish ingestion. The risk results from exposures to these different media may be summed to estimate the total (additive) risk across each of these media, and can provide some insight into the relative importance of the different sources of risk to a given receptor. It is anticipated that the information to be presented in the HHRA will be sufficient to support risk communication or evaluation of remedial alternatives with regard to all human health scenarios.

3.6.3.2 *Ecological Risk Assessment*

The primary purpose of the ecological risk assessment portion of the RCBRA is to support remedial action decisions that reduce risks to ecological receptors. Through remedial actions, contamination will be reduced to levels that result in the recovery and maintenance of healthy local populations and communities of biota. The ecological risk assessment evaluates contaminants that may pose current risks to receptors associated with residual contamination from waste sites and from associated contaminated soil and groundwater in the River Corridor. The ecological risk assessment addresses residual contaminant concentrations at remediated waste sites in the upland zones and the transport of contaminants from waste sites to the Columbia River riparian and near-shore zones. In addition, ecological management goals for the River Corridor include considering impacts to state or federally listed threatened or endangered species, protecting rare habitats, and minimizing contaminant loading (or bioaccumulation) into biota.

Near-Shore Zone

Media and biota sample data collected from 50 study areas in the near-shore environment of the River Corridor and 10 reference area locations (throughout the Hanford Site) are being evaluated for Hanford Site contaminants of potential ecological concern. These data represent current conditions in study areas where no remedial actions have been conducted; however, the study areas potentially are affected by contaminated groundwater plumes passing through and/or entering the near-shore zone. These results are used to present a baseline ecological risk assessment of the River Corridor near-shore zone.

The near-shore ecological risk assessment evaluates risks to a comprehensive array of assessment endpoints using multiple measures of exposure, effect, and ecosystem/receptor characteristics. The following representative near-shore aquatic receptors are being evaluated in the ecological risk assessment:

- **Lower trophic level:**
  - Plants (algae and vascular plants), aquatic insects, snails, clams, and mussels
- **Middle trophic level:**
  - Herbivores: Mallard duck
  - Omnivores: carp
  - Invertivores: Woodhouse's toad, sculpin, bufflehead duck, and eastern and western kingbirds
- **Upper trophic level:**
  - Carnivores: salmon and mink

There are uncertainties associated with obtaining representative samples of porewater (i.e., a sample that could represent an acute or chronic exposure of concern). Uncertainties were identified with the measurement of exposures for aquatic organisms that inhabit the hyporheic zone. This is relevant because one of the RAOs for groundwater, under the interim action RODs, is protection of aquatic organisms in the Columbia River. The aquatic receptor exposure point is within the river substrate (the salmon redds) at depths of up to 46 cm (18 in), where embryonic salmon and fry could be present during portions of the year. Currently, groundwater sampling from near-river monitoring wells (compliance wells) is being used to evaluate performance of the groundwater remedial system. To account for dilution within the aquifer between the monitoring wells and the exposure point within the river, a two-fold dilution attenuation factor is used in accordance with the interim action RODs (Ecology, et al., 1996).

Flow paths in the groundwater/river zone of interaction vary with daily and seasonal fluctuations in river stage. River water infiltrates the banks during high river stages, moves inland, then downward, and mixes with groundwater discharging through the riverbed. This suggests that the discharge to the river is a mixture of groundwater and river water. Monitoring and modeling studies suggest that dilution of groundwater by river water may range from nearly complete to approximately equal during the daily river stage cycle. Better characterization of dilution is necessary because mixing processes strongly influence the concentrations of contaminants at the location of exposure (i.e., in the riverbed) (PNNL-13674; PNNL-16805, *Investigation of the Hyporheic Zone at the 300 Area, Hanford Site*; PNNL-16894, *Investigation of the Strontium-90 Contaminant Plume Along the Shoreline of the Columbia River at the 100-N Area of the Hanford Site*). Several uncertainties are associated with evaluating compliance with aquatic water quality standards. An additional study will be performed before issuing the final action ROD and will include the following:

- Determine if there is a sampling technique that can accurately represent exposure conditions in the hyporheic zone.
- Determine if near-shore monitoring wells (compliance wells not including aquifer tubes) are adequate for determining protection of aquatic receptors in the absence of sampling within the hyporheic zone.
- Determine if the two-fold dilution attenuation factor is appropriate for the groundwater river interface for purposes of assessing risks from contaminants in groundwater, or developing cleanup levels in groundwater.

Riparian Zone

Media and biota sample data collected from 18 study areas in the riparian environment of the River Corridor and 7 reference area locations (throughout the Hanford Site) were evaluated for Hanford Site contaminants of potential ecological concern. These data represent current conditions in study areas where no remedial actions have been conducted. However, contaminated groundwater plumes passing through and/or entering the riparian environment potentially affect the study areas. These results are used to present a baseline ecological risk assessment of the River Corridor riparian zone.

The riparian ecological risk assessment evaluated risks to a comprehensive array of assessment endpoints using multiple measures of exposure, effect, and ecosystem/receptor characteristics. The following are the representative riparian receptors evaluated in the ecological risk assessment:

- **Lower trophic level:**
  - Plants and soil invertebrates
- **Middle trophic level:**
  - Herbivores: pocket mouse and California quail
  - Omnivores: deer mouse and meadowlark
  - Invertivores: grasshopper mouse and eastern and western kingbird
- **Upper trophic level:**
  - Insectivores: bank swallow and myotis bat
  - Invertivores: great blue heron
  - Carnivores: mink

Current information is considered sufficient and no additional work plan activities are proposed.

Upland Zone

Media and biota sample data collected from study areas associated with 20 remediated waste sites in the upland environment of the River Corridor and 10 reference area locations (throughout the Hanford Site) were evaluated for Hanford Site contaminants of potential ecological concern. These data represent residual conditions for a variety of representative waste sites where remedial actions have been completed. These results are used to present an ecological risk assessment of residual conditions on remediated waste sites in the River Corridor upland zone.

The upland ecological risk assessment evaluated risks to a comprehensive array of assessment endpoints using multiple measures of exposure, effect, and ecosystem/receptor characteristics. The following are the representative terrestrial upland receptors evaluated in the ecological risk assessment:

- **Lower trophic level:**
  - Plants and soil invertebrates
- **Middle trophic level:**
  - Herbivores: pocket mouse and California quail
  - Omnivores: deer mouse and meadowlark
  - Invertivores: grasshopper mouse and killdeer
- **Upper trophic level:**
  - Omnivores: badger and red-tailed hawk

Two general types of remediated waste sites were evaluated in the upland environment; some sites required significant excavation and soil removal, while other sites (referred to as "native soil sites") generally required less physical disturbance of soil and the associated ecological communities. The absence of RAGs for protection of ecological receptors in DOE/RL-96-17 created the need to conduct the ecological risk assessment to support final action remedy decisions. A primary goal of the ecological risk assessment was to determine if the RAGs developed for protection of human health are adequately protective of terrestrial receptors.

3.6.3.3 Groundwater

The Code of Federal Regulations (40 CFR 300.430(a)(I)(iii)(F) expects to return useable groundwaters to their beneficial uses whenever practicable. Washington State regulations indicate that groundwater should be evaluated for the "highest beneficial use (i.e., drinking water, unless the aquifer is non-potable for reasons other than contamination, such as high natural total dissolved solids or a water yield insufficient for pumping) (WAC 173-340). In addition to evaluating the highest beneficial use, groundwater plume movement must be evaluated to assess whether there will be impacts on surface water. If impacts are occurring or may reasonably be expected to occur in the future, then human exposures to surface water and groundwater must be evaluated.

Groundwater beneath portions of the River Corridor currently is contaminated and is not withdrawn for beneficial uses. Under current site use conditions, no complete human exposure pathways to groundwater are assumed to exist. Furthermore, regardless of land use designations for soils, contaminated groundwater beneath waste sites is not anticipated to become a future source of drinking water until cleanup criteria are met. However, to evaluate highest beneficial use, groundwater in the HHRA was evaluated for domestic use and for use in irrigation (i.e., home garden and livestock).

Human health risks associated with each groundwater OU were calculated for the following exposure scenarios:

- Rural resident
- Resident national monument/refuge worker
- Tribal Nation scenarios based on traditional lifestyles

3.6.4 Remedial Investigation for Hanford Site Releases to the Columbia River

Given that a primary objective of the Hanford Site cleanup mission is protection of the Columbia River, a remedial investigation of Hanford Site releases to the Columbia River is being conducted. In support of the RI, an extensive data compilation effort was performed from 2004 to 2006 to identify and organize results from previous investigations and programs. The results from more than 5,900 surface water samples, 1,400 sediment samples, and 7,000 biota (fish, shellfish, waterfowl) samples were evaluated to identify data gaps to be addressed during the RI. A remedial investigation work plan was issued in 2008 (DOE/RL-2008-11) to establish the approach for characterizing the nature and extent of Hanford Site related contaminants that have come to be located within the Columbia River and assessing the current risk to ecological and human receptors posed by Site related contaminants. The risk assessment activities performed as part of this work plan will become a component of the RCBRA.

The geographical study area includes the 193 km (120-mi) stretch of the Columbia River from above Wanapum Dam to McNary Dam (the first dam below the Hanford Site), and a limited investigation just upstream from Bonneville Dam. The field investigation activities were initiated in October 2008 and include collection of more than 1,200 surface water, porewater, sediment, soil, and fish samples from areas not addressed by previous environmental monitoring to support the investigation and assessment activities. The fish to be collected are resident species commonly consumed by humans: whitefish, sucker, walleye, carp, bass, and sturgeon. Salmon were not selected because their migratory nature provides little opportunity for exposure to Hanford Site contaminants. Many of the field investigation activities have been completed through August 2009, with selected sample collection activities shown in Figures 3-25 and 3-26. The remaining field investigation activities are anticipated to be completed in early 2010.

Figure 3-25. River Channel Sediment Sample Collection

Figure 3-26. Fish Collection Using an "Electrofishing" Technique

A key element of the field investigation is a task to identify and characterize sediments from the river bottom in areas where contaminated groundwater is upwelling. The Trident Probe technology (Figure 3-27) is being used to support this task and provides the capability of in-situ conductivity and temperature measurements as well as sample collection for porewater and surface water. The work is being conducted adjacent to each of the reactor sites (100-B/C, 100-K, 100-N, 100-D, 100-H, and 100-F), the Hanford townsite, and the 300 Area using a phased design:

- Phase I was a demonstration of the Trident Probe technology in the Columbia River that was successfully completed in September 2008.
- Phase IIa was completed in August 2009 and consisted of conductivity and temperature mapping surveys at approximately 675 locations.
- Phase IIb consists of porewater collection and screening for key Hanford Site indicator contaminants (e.g., Cr+6, Sr-90, uranium) at approximately 240 locations and is anticipated to be complete in December 2010.

Phase III will be conducted in 2010 to characterize porewater, sediments, and surface water for a suite of analyses at locations selected from the Phase II results.

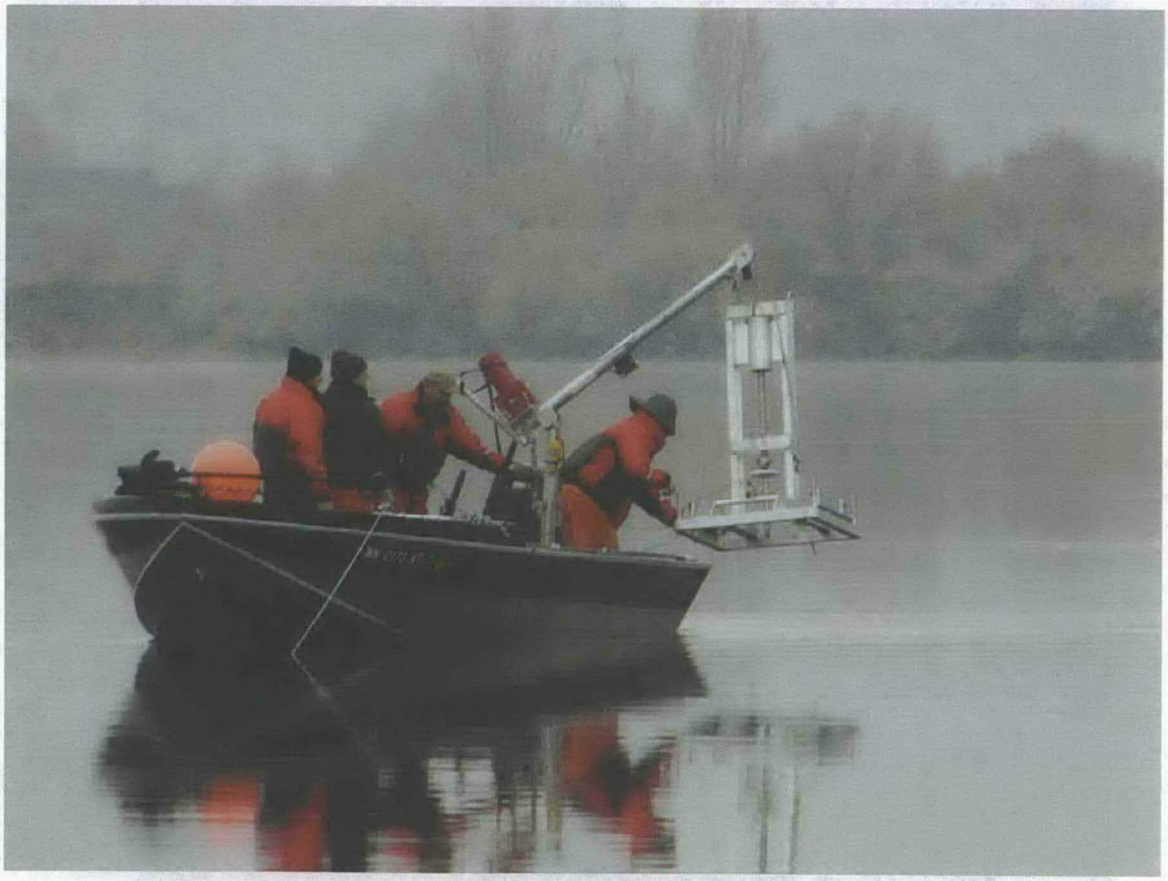

Figure 3-27. Deployment of the Trident Probe

Following completion of the field investigation and receipt of the analytical data, current risk to ecological receptors and humans will be assessed, and a determination will be made regarding the need for additional investigation and data collection. Any human, wildlife, or plant risk uncertainties regarding

Hanford Site contaminant releases to the Columbia River will be addressed through the investigation of Hanford Site releases to the Columbia River. This work will determine what contaminants are present, how concentrated they are, where they are located, and what (if any) undesirable health effects they may have on people, wildlife, and plants that use or live in the river. When completed, results from the remedial investigation of Hanford Site releases to the Columbia River will be used by risk managers to determine whether there is a need to perform remedial action associated with Hanford Site contaminants that have come to be located in the Columbia River.

If Hanford Site contamination that requires remedial action is identified in the river, and it is associated with a current groundwater or soil contamination source, a cleanup decision that offers protection for the river may be included with the final action ROD for one or more of the River Corridor Areas. If Hanford Site contamination that requires remedial action is identified in the river beyond the River Corridor boundary and it is associated with a past release, a separate remedial decision for the river may be developed.

3.6.5 Additional Evaluation and Assessment Activities

A number of uncertainties are associated with the RCBRA. The purpose of this section is to summarize a subset of the uncertainties for which additional activities will be conducted in the RI/FS to support development of final remedial action decisions. If new uncertainties are identified through the RCBRA, they will be addressed as emerging information as described in Section 5.1.

3.6.5.1 Uncertainties Associated with the Human Health Risk Assessment

Early cleanup decisions were intended to be protective of a potential rural residential exposure and DOE will continue to evaluate the potential risks for this type of exposure. The rural residential scenario evaluated in the HHRA is considered more conservative than the scenario used to develop interim action ROD cleanup levels because it uses a set of exposure assumptions based on current guidance and includes additional exposure pathways when compared with the exposure assumptions and exposure pathways used to develop interim RAGs in DOE/RL-96-17. The following activities address uncertainties for the RI/FS associated with evaluating rural residential exposures.

- Define the appropriate exposure pathways and exposure assumptions for assessing risk from a rural residential use.
- Determine the role of the rural residential exposure scenario in remedy evaluation. DOE is committed to establishing final action cleanup levels at least as protective as those levels identified in interim actions. The current HHRA rural residential exposure scenario and other exposure scenarios will be considered during development of cleanup levels for the final action RODs in the 100 Area. Ecology has stated it will evaluate unrestricted land use in accordance with WAC-173-340.
- Perform a systematic comparison of the exposure assumptions and exposure pathways used in the HHRA and DOE/RL-96-17 to determine the significance of differences between the two scenarios.

Uncertainties associated with the groundwater risk assessment in the HHRA are related to the ability of the existing data set to represent current baseline conditions. Analytical data used for the HHRA are obtained from several groundwater-monitoring programs, including the AEA surveillance program, the RCRA compliance program, and the CERCLA program. Sampling and analysis data from these programs comprehensively define the suite of contaminants associated with existing and potential groundwater contamination sources. However, differences in sampling frequencies (monthly, annually, or tri-annually), differences in analytes analyzed at each monitoring well (radiological and chemical), and differences in method detection limits create uncertainties associated with the spatial, chemical, and temporal representative qualities of the data set used for the risk assessment.

Activities that would help reduce uncertainties, verify conclusions of the HHRA, and ensure that no contaminants were inadvertently overlooked based on use of the existing data set include the following:

- Identify existing and/or install new monitoring wells that are spatially representative of the groundwater. This set of monitoring wells will represent locations where a receptor potentially could contact groundwater.
- Conduct multiple rounds of sampling to obtain temporal representation of the unconfined aquifer from influence of river stage. Additional rounds of sampling at spatially representative monitoring wells will represent current groundwater conditions and capture the influence of river fluctuations on COPC concentrations.
- Analyze all spatially representative monitoring wells for a focused list of groundwater COPCs identified for each round of sampling. Analyzing each of the monitoring wells for COPCs will provide a data set that is representative of potential releases to the groundwater.
- Evaluate sample results from characterization activities to support final remedial action decisions for groundwater.

3.6.5.2 Uncertainties Associated with the Ecological Risk Assessment

The following RCBRA uncertainties associated with the protection of ecological receptors will be addressed through the RI/FS process.

- Are soil samples collected from the top 15.2 cm (6 in) of the waste site perimeter adequately representative of ecological exposure conditions from residual contamination at remediated waste sites?
- Would additional waste site soil samples collected to conduct supplementary bluegrass bioassays help reduce uncertainties associated with soil contaminants?

4 Approach

This chapter presents preliminary information related to RAOs, remediation goals, assessment of ARARs, and remedial actions that will be fully developed in the course of completing the RI/FS process.

4.1 Preliminary Remedial Action Objectives

As stated in 40 CFR 300, RAOs must be developed to address contaminants of concern, media of concern, potential receptors, and exposure pathways. The RAOs are narrative statements that define the extent to which waste sites require cleanup to protect human health and the environment.

The RAOs are based on the results of the HHRAs, ecological risk assessments, and the RI. Several expedited response and interim remedial actions already have been implemented (including characterization), thereby providing considerable information concerning contamination and risk. Interim action RODs, RODs, and action memoranda were issued for the 100 Area that addressed contaminated waste removal or facility demolition actions. Expedited response measures for contaminated groundwater also were implemented as remedial actions under interim action RODs to keep principal threat contaminants from reaching the Columbia River. Action memoranda directed efforts to remove various facilities and structures and to place reactors in ISS before final disposition. Appendix A provides a summary of the implementation of the CERCLA process to date for the 100 Area, including facility demolition and removal.

A preliminary list of RAOs has been prepared for the 100 Area (Table 4-1). Media specific RAOs for groundwater, surface water, soil, and land use were developed and combined into one list. The RAOs were based on existing River Corridor regulatory documents (e.g., interim action RODs) and were expanded to cover gaps when integrating all media and resources for an area. The RAOs are refined through the RI/FS process during the RI, baseline risk assessment (RCBRA), and the detailed analyses of alternatives conducted in the FS. The final RAOs are determined when the remedy is selected in the ROD.

Table 4-1. Preliminary Remedial Action Objectives for the 100 Area Operable Units

RAO No.	Goal
	Groundwater
1	Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing nonradiological contaminant concentrations above federal and state standards.
2	Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing radiological contaminant concentrations above federal standards.
	Surface Water
3	Prevent unacceptable risk to human health and ecological exposure to surface water containing nonradiological contaminant concentrations above federal and state standards.
4	Prevent unacceptable risk to human health and ecological exposure to surface water containing radiological contaminant concentrations above federal standards.
	Soil
5	Prevent hazardous chemical contaminants from migrating and/or leaching through soil that will result in groundwater concentrations that exceed standards for protection of surface and groundwater.
6	Prevent migration and/or leaching of radioactive contaminants through soil to groundwater in excess of federal standards.

Table 4-1. Preliminary Remedial Action Objectives for the 100 Area Operable Units

RAO No.	Goal
7	Prevent unacceptable risk to human health and ecological receptors from exposure to the upper 4.6 m (15 ft) of soil contaminated with nonradiological constituents at concentrations above the unrestricted land use criteria for human health or soil contaminant levels for ecological receptors.
8	Prevent unacceptable risk to human health and ecological receptors from exposure to upper 4.6 m (15 ft) of soils and to structures and debris contaminated with radiological constituents.
	Prevent exposure to radiological constituents at concentrations at or above a dose rate limit that causes an excess cancer lifetime risk threshold of 10^{-6} to 10^{-4} above background for the rural residential exposure scenario. An annual dose rate limit of 15 mrem/yr above background achieves EPA excess lifetime cancer risk threshold.
	Protect ecological receptors based on a dose rate limit of 0.1 rad/day for terrestrial wildlife populations, which is a to-be-considered criterion.
	Land Use and Resource
9	Prevent adverse impacts to cultural resources, threatened or endangered wildlife, and ecological receptors using the Columbia River and prevent destruction of sensitive wildlife habitat.
10	Where it is not practicable to remediate levels that will allow for unrestricted use, ensure that appropriate institutional controls and monitoring requirements are established and maintained to protect future users of the remediated waste sites.

EPA = U.S. Environmental Protection Agency

4.2 Preliminary Remediation Goals

The PRGs provide target cleanup levels for use in evaluating how RAOs will be achieved, and they provide preliminary risk reduction targets that a remedial alternative must meet to achieve the criteria set forth in 40 CFR 300.430(e)(9)(iii). The PRGs are refined based on technical feasibility, community acceptance, baseline risk assessment, and other risk management considerations. Office of Solid Waste and Emergency Response (OSWER) Directive 9355.0-30 states that, "These preliminary goals may be modified based on results of the baseline risk assessment, which clarifies exposure pathways and may identify situations where cumulative risk of multiple contaminants or multiple exposure pathways at the site indicate the need for more or less stringent cleanup levels than those initially developed as preliminary remediation goals. In addition to being modified based on the baseline risk assessment, preliminary remediation goals and the corresponding cleanup levels may be modified based on the given waste management strategy selected at the time of remedy selection that is based on the balancing of the nine criteria used for remedy selection (55 FR 8717-8718, 'National Oil and Hazardous Substances Pollution Contingency Plan')." This refinement process ultimately results in establishment of final action cleanup levels, which are documented in the ROD.

For the 100 Area, PRGs will be developed for the protection of human health, ecological receptors, and groundwater. The PRGs will be based on regulatory requirements for exposure pathways, the baseline risk assessment, and future land use considerations. They are identified for individual hazardous substances identified as contaminants of concern or COPCs. If multiple contaminants are present at a waste site, the suitability of using individual PRGs as final action cleanup values protective of human health and the environment will be evaluated based on site-specific information and the potential for contaminant interaction.

The PRGs also are compared to each other to determine which offers the most restrictive value that is protective of all pathways, if it is greater than background concentrations and the practical quantitation limit. If the lowest of the PRGs is lower than background concentrations or the practical quantitation limit, then background concentrations or the practical quantitation limit (whichever is higher) become the PRG. The purpose of this process is to identify those constituents that may pose an unacceptable risk or exceed cleanup standards established by ARARs. Meeting PRGs and the potential ARARs and, by extension, achieving RAOs, can be accomplished by reducing concentrations (or activities) of contaminants to PRG levels or by eliminating potential exposure pathways/routes.

Final RAGs developed from the PRGs will be specified in a final action ROD that identifies the selected remedial alternative for 100 Area operable unit waste sites. For the purpose of this analysis, DOE, in collaboration with EPA and Ecology, has determined that the following principles will apply.

- Cleanup levels for contaminated soil and groundwater that were established in interim action RODs and action memoranda will continue to guide ongoing cleanup actions.
- Cleanup levels promulgated after the interim action ROD (e.g., WAC 173-340) will be used to evaluate ongoing cleanup actions. The evaluation will be done for informational purposes, and the later cleanup levels are not legally enforceable requirements for the ongoing cleanup actions.

Therefore, although alternative PRGs may be discussed in this analysis, it is for determining whether the existing cleanup requirements will be protective of human health and the environment. Residual risks following completed remediation of the 100 Area operable units must meet the RAOs. Documentation of actual media contaminant concentrations achieving cleanup objectives will be presented in a CVP for waste sites within the 100 Area. These packages will describe the remediation activities completed, identify any significant contamination remaining, summarize the sampling and data analysis approach, and demonstrate attainment of cleanup levels.

At the time of this writing, the PRGs have not been finalized for this final action RI/FS work plan. The RCBRA, which presents the results of the ecological risk assessment and HHRA, currently is undergoing revision. Following regulatory review, development of the PRGs will be completed during the RI/FS to address protection of human health and ecological receptors. The results provided in the RCBRA will be used to help validate cleanup levels for the final action RODs.

The PRGs for protection of ecological receptors, including aquatic receptors, are expected to consider state and federal screening values, and site-specific cleanup levels. Decisions regarding the application for direct contact exposure and derivation of dilution/attenuation factors also must be completed.

As additional information becomes available from site-specific risk information, RI site characterization, and chemical specific ARARs, the PRGs will be developed for each area. Some of the standards, procedures, and methodologies that will be used to develop PRGs for the 100 Area are discussed below.

4.3 Potential Applicable or Relevant and Appropriate Requirements

Laws and regulations pertaining to the response actions are identified through the ARAR identification process. The ARARs identification process is based on CERCLA guidance (EPA/540/G-89/004; EPA/540/G-89/006, *CERCLA Compliance with Other Laws Manual: Interim Final*; EPA/540/G-89/009, *CERCLA Compliance with Other Laws Manual – Part II, Clean Air Act and Other Environmental Statutes and State Requirements*). CERCLA Section 121 requires, in part, that any applicable or relevant and appropriate standard, requirement, criterion, or limitation under any federal environmental law, or any more stringent state requirement pursuant to a state environmental statute, be met (or a waiver justified) for any hazardous substance, pollutant, or contaminant that will remain on site after completion of remedial action.

When compiling the requirements presented in this section, the ARARs presented in previous decision documents were reviewed, as well as current requirements that may apply to the investigation and remediation of contaminated waste sites within the 100 Area. In many cases, the ARARs form the basis for the PRGs to which contaminants must be remediated to protect human health and the environment. In other cases, the ARARs define or restrict how specific remedial measures can be implemented. The ARARs identified for the 100 Area operable units are preliminary because the results of the RI have not been documented and the FS remedial alternatives have not been not identified or evaluated. The final ARARs for remediation will be established in the ROD.

Under CERCLA, ARARs consist of two sets of requirements: (1) those requirements that are applicable requirements, and (2) those requirements that are relevant and appropriate requirements of promulgated, environmental laws. CERCLA also provides for the identification of to-be-considered, nonpromulgated advisories, criteria, guidance, or proposed standards, which often are identified with ARARs because they are helpful in selecting or implementing remedies that address, for example, federal and state environmental and public health agencies' advisories, guidance, and proposed standards. However, to-be-considereds are not legally enforceable and are not ARARs. Applicable requirements are those substantive standards that specifically address the situation at a CERCLA site. All jurisdictional prerequisites of the requirement must be met for the requirement to be applicable.

Relevant and appropriate requirements are determined by a two-step process. First, to assign relevance, it must be determined whether the requirement addresses problems or situations sufficiently similar to the circumstances of the proposed response action. Second, for appropriateness, the determination must be made as to whether the requirement also would be well suited to the conditions of the site. A requirement that is relevant and appropriate may not meet one or more jurisdictional prerequisites for applicability, but still may make sense at the site, given the circumstances of the site and the release. In evaluating the relevance and appropriateness of a requirement, the following eight comparison factors in 40 CFR 300.400, "Identification of Applicable or Relevant and Appropriate Requirements," are considered:

- The purpose of the requirement and the purpose of the CERCLA action.
- The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site.
- The substances regulated by the requirement and the substances found at the CERCLA site.
- The actions or activities regulated by the requirement and the remedial action contemplated at the CERCLA site.
- Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site.
- The type of place regulated and the type of place affected by the release or CERCLA action.
- The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or contemplated by the CERCLA action.
- (viii) Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resource at the CERCLA site.

The ARARs are evaluated to determine if they apply to chemical-, location-, or action-specific circumstances related to CERCLA response actions. These categories are defined as follows:

- Chemical-specific requirements usually are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of site cleanup levels that are protective of human health and ecological receptors.
- Location-specific requirements are restrictions placed on the concentration of dangerous substances or the conduct of activities solely because they occur in special geographic areas.
- Action-specific requirements usually are technology- or activity-based requirements or limitations triggered by the remedial actions performed at the site.

Only the substantive requirements (e.g., use of control/containment equipment or compliance with numerical standards) associated with ARARs apply to CERCLA onsite activities. According to CERCLA Section 121(c)(1), ARARs associated with administrative requirements, such as permitting, are not applicable to CERCLA onsite activities. In general, the CERCLA permitting exemption will be extended to all remedial activities conducted at the 100 Area operable units.

To-be-considered materials and information are nonpromulgated advisories or guidance issued by federal or state governments that are not legally enforceable but may contain information that would be helpful in implementing selected remedies.

The requirements of DOE orders must be met but are not identified as ARARs. Similarly, requirements pursuant to the Occupational Safety and Health Administration and other federal and state worker safety requirements are not identified as ARARs because they are employee protection laws and not environmental laws. Workers at CERCLA sites must comply with applicable safety requirements both substantively and administratively.

4.3.1 Waivers from Applicable or Relevant and Appropriate Requirements

EPA may waive ARARs and select a remedial action that does not attain the same level of site cleanup as that identified by the ARARs. The *Superfund Amendments and Reauthorization Act of 1986,* Section 121, identifies circumstances in which EPA may waive ARARs for onsite remedial actions. The circumstances that are pertinent to the Hanford Site remedial actions are as follows.

- The remedial action selected is only a part of a total remedial action (e.g., an interim action), and the final action remedy will attain the ARAR upon its completion.
- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.
- Compliance with the ARAR is technically impracticable from an engineering perspective.
- An alternative remedial action will attain an equivalent standard of performance by using another method or approach.
- The ARAR is a state requirement that the state has not applied consistently (or demonstrated the intent to apply consistently) in similar circumstances.

4.3.2 Potential Applicable or Relevant and Appropriate Requirements for the 100 Area Operable Units

DOE is proposing preliminary ARARs in Appendix B of this work plan in accordance with the Hanford Federal Facility Agreement and Consent Order, Section 7.5. Detailed documentation and further evaluation of the potential ARARs will be provided as an appendix to the individual feasibility studies. ARARs will be finalized though issuing of the RODs.

Groundwater, surface water, and soil cleanup regulations and terrestrial ecological evaluation procedures establish media cleanup standards for nonradioactive and radioactive contaminants. Federal and state air emission standards identify air emission limits and control requirements for any remedial actions that produce toxic air emissions. The RCRA land disposal restrictions will be important standards during the management of wastes generated during remedial actions. The RCRA Corrective Action (as implemented through the Tri-Party Agreement [Ecology et al., 1989a]), as well as treatment, storage, and disposal closure performance standards, are used (when applicable) for cleanup criteria and compliance monitoring requirements that apply to solid waste management units (including RCRA treatment, storage, and disposal units that are regulated units) that are located within the 100 Area.

Potential location-specific ARARs that have been identified for the 100 Area include those that protect cultural, historic, and Native American sites and artifacts, and those that protect critical habitats of federal endangered and threatened species that may occur within the 100 Area.

Action-specific ARARs that could be pertinent to the investigation and remediation include state solid and dangerous waste regulations (for management of characterization and remediation wastes and performance standards for waste left in place), and AEA regulations (e.g., performance standards for high-level radioactive waste sites).

Regarding waste management activities performed during remediation, a variety of waste streams may be generated under an equally wide range of potential remedial actions. It is anticipated that most of the remediation waste will be designated as low-level waste. However, quantities of dangerous or mixed waste, hazardous debris, polychlorinated biphenyl (PCB)-contaminated waste, and asbestos and asbestos-containing material also could be generated. The identification, storage, treatment, and disposal of hazardous waste and the hazardous component of mixed waste are governed by RCRA. The State of Washington implements RCRA requirements under WAC 173-303, "Dangerous Waste Regulations," and has been authorized to implement elements of the RCRA program. Substantive requirements of the state's dangerous waste standards for generation and storage would apply to the management of any dangerous or mixed waste generated during this remedial action. Treatment standards for dangerous or mixed waste subject to RCRA land disposal restrictions are specified in WAC 173-303-140, "Land Disposal Restrictions" (which incorporates 40 CFR 268, "Land Disposal Restrictions," by reference), and also would apply. Substantive portions of RCRA corrective action, as implemented by WAC 173-303-64620, will apply to remedial actions at any solid waste management unit or spill site that presents a threat to human health and the environment including surface impoundments, landfills, waste piles, and land treatment units.

The *Toxic Substances Control Act of 1976* (TSCA) and regulations in 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions," govern the management and disposal of PCB wastes. The TSCA regulations contain specific provisions for PCB waste, including PCB waste that contains a radioactive component. The PCBs also are considered underlying hazardous constituents under RCRA and, thus, could be subject to WAC 173-303 and 40 CFR 268 requirements.

Removal and disposal of asbestos and asbestos-containing material are regulated under the *Clean Air Act of 1990* and amendments and 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," Subpart M, "National Emission Standards for Asbestos." This regulation provides for special precautions to prevent environmental releases or exposure to airborne emissions of asbestos fibers during remedial actions. The regulation found in 40 CFR 61.52, "Emission Standard," identifies packaging requirements. If encountered during the RI/FS, asbestos and asbestos-containing material may be removed, packaged as appropriate, and disposed at the ERDF.

Waste that is designated as low-level waste and that meets ERDF acceptance criteria is assumed to be disposed at the ERDF. The ERDF is engineered to meet appropriate performance standards under 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste," and meet minimum technical requirements for landfills under WAC 173-303-665, "Landfills." Waste designated as dangerous or mixed waste would be treated as appropriate to meet land disposal restrictions (and ERDF waste acceptance criteria) and can be disposed at the ERDF. Applicable packaging and pre-transportation requirements for dangerous or mixed waste generated at the 100 Area operable units would be identified and implemented before disposal. Alternative disposal locations also may be considered when the remedial action occurs, if a suitable and cost-effective location is identified. Potential alternative disposal locations would be evaluated for appropriate performance standards to ensure that they are sufficiently protective of human health and the environment.

If encountered, waste designated as PCB remediation waste likely would be disposed at the ERDF, depending on whether it is low-level waste and meets the waste acceptance criteria. The PCB waste that does not meet ERDF waste acceptance criteria would be retained at a PCB storage area meeting the requirements for TSCA storage and would be transported for future treatment and disposal at an appropriate disposal facility. The TSCA anti-dilution provisions are only applicable to CERCLA response actions that occur once a remedial action is initiated; thus, remediation is based on the "as-found" PCB concentration at a CERCLA site.

CERCLA Section 104(d)(4) states that where two of more noncontiguous facilities are reasonably related on the basis of geography, or on the basis of the threat or potential threat to the public health or welfare or the environment, the facilities can be treated as one for purposes of CERCLA response actions. Consistent with this, the 100 Area operable units and the ERDF would be considered "onsite" for purposes of CERCLA Section 104, and waste may be transferred between the facilities without requiring a permit.

Remedial actions will be performed in compliance with federal and state waste management requirements, such as the identification and designation of waste streams. Before disposal, waste will be managed in a protective manner to prevent releases to the environment.

It is anticipated that selected remedial action alternatives will have the potential to generate airborne emissions of both radioactive and criteria/toxic pollutants and will need to comply with applicable provisions of the federal *Clean Air Act of 1990* and Amendments and RCW 70.94, "Washington Clean Air Act." Under federal implementing regulations, 40 CFR 61, Subpart H, "Department of Energy Facilities," radionuclide airborne emissions from the facility shall be controlled so as not to exceed amounts that would cause an exposure to any member of the public greater than10 mrem/yr effective dose equivalent. The same regulation addresses point sources (i.e., stacks or vents) emitting radioactive airborne emissions, requiring monitoring of such sources with a major potential for radioactive airborne emissions, and requiring periodic confirmatory measurement sufficient to verify low emissions from such sources with a minor potential for emissions. Under portions of the state implementing regulations, the federal regulations are paralleled by adoption, and in addition more specifically address control of radioactive airborne emissions where economically and technologically feasible (WAC 246-247-040[3] and -040[4], "Radiation Protection – Air Emissions," "General Standards," and associated definitions). To address the substantive aspect of these requirements, best or reasonably achieved control technology will be addressed by ensuring that applicable emission control technologies (i.e., those successfully operated in similar applications) will be used when economically and technologically feasible based on cost/benefit. If it is determined that there are substantive aspects of the requirement for monitoring of fugitive or nonpoint sources emitting radioactive airborne emissions (WAC 246-247-075[8], "Monitoring, Testing and Quality Assurance"), then these will be addressed by sampling the effluent streams and/or ambient air as appropriate using reasonable and effective methods.

4.4 Development of Vadose Zone Soil Target Analyte Lists and Groundwater Contaminants of Potential Concern

A process has been developed to identify vadose zone soil target analytes for addressing uncertainties associated with the nature and extent of contamination in the vadose zone. Similarly, a process has been developed to identify groundwater COPCs for addressing uncertainties associated with the spatial and temporal distribution of groundwater contamination. The processes (Table 4-2) described in the following sections provide the approach that will be used to select vadose zone soil and target analytes and groundwater COPCs area. The outcome of these processes will be documented in the SAPs prepared for each area.

Table 4-2. Vadose Zone Soil Target Analyte and Groundwater COPC Identification Process

Methodology Step	Vadose Zone Soil Target Analyte Identification	Groundwater COPC Identification
1	Prepare Initial Target Analyte List	Prepare Groundwater Data Set
2	Develop Master Target Analyte List	Identify Groundwater COPCs
3	Develop Location-Specific Target Analyte List	Compare Groundwater COPCs to Master Target Analyte List
4	Agency Review of Locations and Location-Specific Target Analyte List	Agency Review of Monitoring Wells and Groundwater COPCs

COPC = contaminant of potential concern

4.4.1 Methodology for Development of the Vadose Zone Soil Target Analyte List

The approach for development of vadose zone soil target analytes is a multi-step process. The first two steps develop a master list of target analytes for each area. The third step is to develop location-specific (e.g., waste site) target analyte lists where additional characterization is proposed. Finally, the analyte list will receive regulatory review. During this step, concerns regarding the selection process may result in the addition of analytes by the Tri-Parties.

4.4.1.1 Step 1 – Prepare Initial Target Analyte List

Characterization data for vadose zone soils are not available for addressing uncertainties associated with the nature and extent of contamination in the vadose zone. Therefore, remediation and characterization information (historical and current) are identified and reviewed to develop an initial list of target analytes to represent potential contamination in the vadose zone. The following types of reference documents and information sources are evaluated:

- Focused FSs, limited field investigation (LFI) reports
- Interim action RODs
- CVPs, remaining sites verification process (RSVPs)
- Technical baseline reports
- Dangerous waste permit applications
- Databases containing analytical data resulting from these activities (i.e., characterization, remediation, waste management information)
- Other pertinent documents

4.4.1.2 Step 2 – Prepare Master Target Analyte List

After the initial target analyte list is compiled, the information will undergo additional review steps to remove analytes using generally accepted exclusion criteria; a comparison of the soil target analyte list to the groundwater COPC list will be conducted, and the appropriate analytical methods and detection limits for the master target analyte list will be identified.

At the conclusion of this step, the master target analyte list is established. The comprehensive master target analyte list includes all the analytes that could potentially be present in the vadose zone and are important for waste site remediation within the area. The following steps are taken to prepare the master target analyte list:

- Apply the following generally accepted exclusion criteria to the initial set of target analytes. Analytes that meet the exclusion criteria will be eliminated as a COPC. Analytes that do not meet the exclusion criteria will be carried to the next step. The exclusion criteria are as follows:
  - Naturally occurring radionuclides associated with background radiation (including potassium-40, radium-226, radium-228, thorium-228, and thorium-232) will be eliminated as COPCs.
  - Radionuclides with a half-life of 3 years (and no significant daughters) will be eliminated as COPCs. Radionuclides with short half-lives can include antimony-125, beryllium-7, cesium-134, curium-242, radium-224, ruthenium-106, and thorium-228.
  - Essential nutrients are those chemicals considered essential for human nutrition. Recommended daily allowances are developed for essential nutrients to estimate safe and adequate daily dietary intakes (NRC, 1989, *Recommended Daily Allowances*). The following metals are considered essential nutrients: calcium, magnesium, potassium, and sodium.
  - Analytes that have no toxicity values (based on the hierarchy of toxicity values recommended by EPA in OSWER Directive 9285.7-53, *Human Health Toxicity Values for Superfund Risk Assessments*).

- Compare the master target analyte list for vadose zone soil with the groundwater COPC list developed for the area. Groundwater COPCs not found on the master target analyte list for soils are added to the list.
- Identify appropriate analytical methods for each analyte on the master target analyte list. Determine if the detection limits for each target analyte can achieve the RAGs for direct exposure, groundwater protection, and Columbia River protection.

4.4.1.3 Step 3 – Develop Location-Specific Target Analyte List

The master target analyte list represents all potential target analytes that could be present in the vadose zone for an area. Location-specific target analytes will be identified from the master list using the following approach:

- Identify the contaminants of concern for the specific waste sites where characterization is proposed from the applicable interim action ROD (which reflects information from LFIs and technical baseline reports). If the characterization location is not at a waste site, evaluate information from waste sites in the vicinity (where available). Include these analytes on the location-specific target analyte list.
- Identify the contaminants of concern for the specific waste site locations from the verification documentation (CVPs or RSVPs). If the characterization location is not at a waste site, evaluate information from waste sites in the vicinity (where available). Include these analytes on the location-specific target analyte list.
- Evaluate local groundwater monitoring well data (wells located within waste site "zones of influence"). Determine if these local wells have been analyzed for groundwater COPCs.
  - If the groundwater COPCs have been analyzed for but not detected, these analytes will not be included on the location-specific target analyte list.
  - If the groundwater COPCs have been analyzed for and have been detected, these analytes will be included on the location-specific target analyte list.
  - If the groundwater COPCs have not been analyzed for, an additional evaluation will be performed to determine if there is a data need. If there is a data need, these COPCs will be included on the waste site-specific target analyte list.

4.4.1.4 Step 4 – Agency Review of Locations and Location-Specific Target Analyte Lists

In the development of the work plan, Ecology raised concerns about the previous steps in the target analyte selection process. This additional step has been created to allow for the adjustment/addition of sample locations and target analytes on a site-specific basis. This adjustment has been agreed upon to ensure that regulator concerns regarding data gaps and uncertainties are addressed. This review is intended to provide an opportunity to address any information requirements not identified in steps 1 through 3. When additional information needs are identified, the agencies will modify the locations for additional characterization or the location-specific target analyte lists to reflect the additions or modifications determined to be needed on an area basis.

4.4.2 Methodology for Identifying Groundwater Contaminants of Potential Concern

The following process will be used to select COPCs for each of the areas. This process will identify groundwater COPCs that will be carried forward and evaluated for nature and extent of characterization and future risk assessment activities. The following paragraphs describe the steps used in the groundwater COPC selection process. A COPC is a constituent identified as a potential threat to human health or the environment with data of sufficient quality for use in a baseline QRA. The COPC list will receive regulatory review. During this step, concerns regarding the selection process may result in the addition of analytes by the Tri-Parties.

4.4.2.1 Step 1 – Prepare Groundwater Data Set

A groundwater data set will be prepared for each area to identify groundwater COPCs. Analytical data will be obtained from the Hanford Environmental Information System (HEIS) database for all monitoring and compliance wells identified within the area. The analytical data set will represent groundwater samples collected from these wells between 1992 and the present (approximately 18 years). This timeframe was selected because it captures analytical data collected during the LFI, which were used to prepare the QRA for each groundwater operable unit. The analytical data from each area will be processed using the steps described below prior to COPC selection to identify one set of results per sampling location and time of collection.

- Select only unfiltered analytical results as these data represent total concentrations of the analyte. Use of filtered sampling results may underestimate chemical and radiological concentrations in water from an unfiltered tap. Filtered samples are not used for the COPC selection process.
- Eliminate analytical results that are rejected and flagged with an "R" qualifier.
- Identify the method that provides the most reliable results when an analyte is reported by more than one analytical method.
- Resolve parent, field duplicate, and field split samples into one set of results per location and collection time.

4.4.2.2 Step 2 – Identify Groundwater COPCs

After the groundwater data set has been prepared, the following steps are taken to identify area groundwater COPCs. A flowchart presenting the COPC selection process is shown in Figure 4-1.

Identify Action Levels. Action levels are derived from readily available sources of chemical-specific ARARs or risk-based PRGs using EPA health criteria and default exposure assumptions. The most protective of chemical-specific ARARs for groundwater are identified as the "action level" for each groundwater COPC. A summary of the sources of available chemical-specific ARARs and PRGs is provided below:

- ARAR-based remediation goals: potential chemical-specific ARARs include concentration limits set by the following.
  - Federal environmental regulations such MCLs, secondary MCLs, and non-zero MCL goals established under the *Safe Drinking Water Act of 1974*.
  - Ambient water quality criteria established under the *Clean Water Act of 1977*.
  - Washington State regulations (WAC 173-340-720; WAC 173-340-730 "Surface Water Cleanup Standards"; WAC 246-290-310, "Group A Public Water Supply", "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs), and WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington").
- Risk-based PRGs: the risk-based concentration table for residential tap waters is used as the source of PRGs. These values are obtained from "Regional Screening Levels for Chemical Contaminants at Superfund Sites." (EPA, 2009). The PRGs for chemicals with carcinogenic effects correspond to a

10^{-6} incremental risk of an individual developing cancer over a lifetime because of exposure to the potential carcinogen from all significant exposure pathways for a given medium. The PRGs for chemicals with noncancerous effects correspond to a hazard index of 1, which is the level of exposure to a chemical from all significant exposure pathways in a given medium below which it is unlikely for even sensitive populations to experience adverse health effects. The direct contact exposure pathway for groundwater considers exposure from ingestion, inhalation of vapors, and dermal contact.

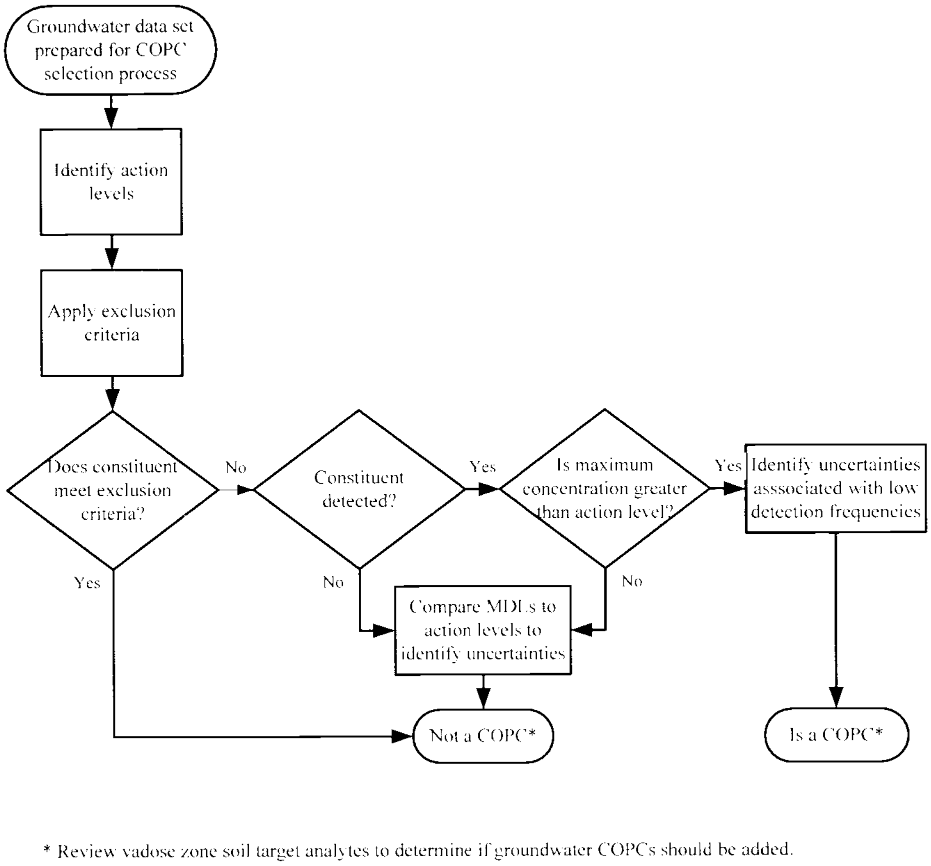

Figure 4-1. Contaminant of Potential Concern Selection – A Multi-Step Process

Apply Exclusion Criteria. Analytes that meet the exclusion criteria will be eliminated as a COPC. Analytes that do not meet the exclusion criteria will be carried to the next step. The exclusion criteria are as follows:

- Naturally occurring radionuclides associated with background radiation (including potassium-40, radium-226, radium-228, thorium-228, and thorium-232) will be eliminated as COPCs.
- Radionuclides with a half-life of 3 years (and no significant daughters) will be eliminated as COPCs. Radionuclides with short half-lives can include antimony-125, beryllium-7, cesium-134, curium-242, radium-224, ruthenium-106, and thorium-228.
- Essential nutrients are those chemicals considered essential for human nutrition. Recommended daily allowances are developed for essential nutrients to estimate safe and adequate daily dietary intakes (NRC, 1989). The following metals are considered essential nutrients: calcium, magnesium, potassium, and sodium.

- Water quality parameters that do not have available toxicological information will be eliminated as COPCs. Groundwater samples are frequently analyzed for water quality parameters and used for purposes other than risk assessment.
- Analytes without an action level will be eliminated as a COPC.

The potential impacts to understating overall cumulative effects by eliminating analytes without an action level will be evaluated as an uncertainty. Activities will be conducted to understand potential uncertainties, including determining if the analyte has been associated with a historical operation process release or if a structurally similar analyte can be identified to evaluate its relative toxicity.

Identify Nondetected Analytes. Analytes that are not detected in any of the samples will be eliminated as groundwater COPCs. All constituents that are detected at least once will be carried to the next step. The reporting limits and detection limits for all analytical constituents (whether detected or not) in groundwater will be compared to the action levels. The potential impacts to the risk estimates of eliminating nondetected constituents as COPCs that have detection limits that exceed action levels will be discussed in an uncertainty assessment of this groundwater COPC selection process. Activities that will be conducted to define the uncertainties include: 1) determining if the analyte has been associated with any historical operation processes, with a potential release, or as a potential degradation product and 2) determining if method detection limits can be achieved at concentrations less than or equal to the action level.

Identify Analytes with Maximum Detected Concentrations Less than Action Levels. Maximum concentrations of analytes that are less than their action level are not identified as COPCs. An uncertainty analysis will be conducted for analytes with maximum concentrations slightly less than their action level (i.e., less than 10 times the action level or one order of magnitude). The purpose of this evaluation is to determine if there is the potential for underestimating cumulative effects when concentrations of analytes are near but do not exceed the action level. Additionally, method detection limits for these analytes to determine if they are adequate for confirming their presence or absence at the action level.

Identify Analytes with Maximum Detected Concentrations Greater than Action Levels. Maximum concentrations of analytes detected in groundwater are compared to action levels to identify analytes that are likely to contribute to overall risk. Steps are taken to identify when an analyte is infrequently detected to determine if the results are reproducible or associated with localized contamination. Additionally, method detection limits will be evaluated to determine if they are adequate for determining their presence or absence at the action level. If the results of this comparison show that the presence of an analyte is reproducible, then the analyte is identified as a groundwater COPC.

4.4.2.3 Step 3 – Compare Groundwater COPCs to Master Target Analyte List

This step of the process is used to confirm that the target analytes identified for vadose zone soils are appropriately considered for groundwater. The target analytes identified for vadose zone soil within the area are developed based on the review of available remediation and characterization reference documents. Based on the transport mechanism associated with the target analyte, it is a reasonable assumption that not all target analytes identified for vadose zone soil will be COPCs for groundwater. If a COPC is identified in groundwater that has not been identified on the master target analyte list for soil, it will be added to this list.

4.4.2.4 Step 4 – Agency Review of Monitoring Well Locations and Groundwater COPCs

In the development of the work plan, Ecology raised concerns about the previous steps in the target analyte selection process. This additional step has been created to allow for the adjustment/addition of sample locations and target analytes on a site-specific basis. This adjustment has been agreed upon to ensure that regulator concerns regarding data gaps and uncertainties are addressed. This review is intended to provide an opportunity to address any information requirements not identified in steps 1 through 3. When additional information needs are identified, the agencies will modify the locations for additional characterization or the groundwater COPC list to reflect the additions/modifications determined to be needed on an area basis.

4.5 Preliminary Remedial Actions

A preliminary compilation of potential remedial actions for vadose zone and groundwater are listed in Tables 4-3 and 4-4, respectively. These potential remedial actions will be evaluated further as the RI/FS process proceeds. Supplemental data are needed to determine the vertical and lateral extent of contamination in the soil and the groundwater so a range of remedial alternatives (including ex situ treatment, in situ treatment, or other alternatives) can be evaluated as appropriate.

4.5.1 Vadose Zone

In accordance with applicable CERCLA guidance (EPA/540/G-89/004), a comparative analysis of the alternatives will be conducted. The comparative analysis will facilitate the relative performance of each alternative in terms of the CERCLA evaluation criteria.

4.5.1.1 Alternative 1 – No Action

Evaluation of a no action alternative establishes a baseline for comparison with other remedial alternatives. The no action alternative represents no corrective or remediation activity and unrestricted access. Selecting the no action alternative would require that a waste site or contamination area not pose an unacceptable threat to human health or the environment.

The waste sites addressed in this work plan are expected to require remediation; thus, the no action alternative is not considered viable.

4.5.1.2 Alternative 2 – Institutional Controls

The waste sites addressed in this work plan generally have significant contamination and are not expected to be remediated by institutional controls as a standalone alternative. Institutional controls alone will not protect environmental receptors and have an uncertain capability of protecting long-term human health.

4.5.1.3 Alternative 3 – Containment and Isolation

This alternative implements control of moisture flowing through the contaminated area though an engineered horizontal barrier. Many design options are available that make use of the dry climate and expected limited infiltration quantities of the area. For evaluation of this alternative, the vertical and lateral extent of the contamination is needed to define contaminated volumes and support modeling of protection of groundwater.

Table 4-3. Preliminary Remedial Actions – Vadose Zone

Remedial Technology	Process Option	Descriptions
No action	**No action**	**Source areas and residual contamination in vadose zone are left untreated.**
Access controls; land use restrictions; water- use restrictions		Physical barriers, deed restrictions, emplaced warning indicators, etc.
Excavation	Standard excavation (approx. 6.1 m [20 ft] below ground surface)	Soil in identified source areas is removed using conventional construction equipment.
	Engineered/benched excavation (greater than 6.1 m [20 ft] below ground surface)	Soil in identified source areas is removed using conventional construction equipment with benching below 6.1 m (20 ft).
	Shored excavation (e.g., caisson excavation greater than 6.1 m [20 ft] below ground surface)	Soil in identified source areas is removed to deeper depths (18.3 to 24.4 m [60 to 80 ft]) using shoring.
Physical/chemical treatment	Chemical infiltration	Liquid with chemical reductant (calcium polysulfide) is applied to ground surface at an application rate substantially below what would create saturation, to treat contamination within vadose zone before reaching groundwater.
	Deep soil mixing	Large mixing augers (1.5 to 3 m [5 to 10 ft] diameter) or horizontally rotating heads are used to blend and homogenize chemical reductants with soil.
	Jet grouting with reactive materials	High-pressure injection of reactive slurry into soil is used to hydraulically mix the in situ material with the slurry.
	Foam injection	Injection of a foam-generating chemical reductant (calcium polysulfide)-surfactant solution into vadose zone.
	In situ gaseous reduction with chemical substrate	A gaseous mixture of chemical reductants (hydrogen sulfide) is injected into and drawn through the vadose zone to reduce and immobilize contamination.
	Water flushing	Clean/treated water (applied to the ground surface or in infiltration trenches) is used to flush contamination out of the vadose zone to the water table, where it would be captured and treated.
Chemical/biological treatment	Combined chemical/biological infiltration	Liquid with chemical reductant (calcium polysulfide) and biological carbon source is applied in combination to ground surface at an application rate substantially below what would create saturation, to treat contamination within vadose zone before reaching groundwater.

Table 4-3. Preliminary Remedial Actions – Vadose Zone

Remedial Technology	Process Option	Descriptions
Biological treatment	Biological infiltration	Liquid with biological carbon source is applied to ground surface at an application rate substantially below what would create saturation, to treat contamination within vadose zone before reaching groundwater.
	In situ gaseous reduction with biological substrate	A gaseous mixture of electron donor gases (propane, butane, ethene, and/or methane) is injected into and drawn through the vadose zone to biologically reduce and immobilize contamination.
Containment and isolation	Surface barrier	An impermeable cover (asphalt) is placed over ground surface to prevent surface water infiltration through the vadose zone and limit contamination leaching to groundwater.
	Vegetative cap (evapotranspiration cap)	A native grass cover is placed over ground surface to increase evapotranspiration rates, decrease the amount of surface water infiltration through the vadose zone, and limit contamination leaching to groundwater.

Table 4-4. Preliminary Remedial Actions – Groundwater

Remedial Technology	Process Option	Descriptions
No action	No action (monitored natural attenuation)	Relies on natural attenuation processes to remediate site.
Access controls; land-use restrictions; water- use restrictions		Physical barriers, deed restrictions, emplaced warning indicators, etc.
Extraction	Expand extraction systems	Install additional extraction wells to existing extraction network to control plume migration and remove dissolved contamination mass.
	Current extraction system	Continued operation of existing groundwater extraction wells.
Chemical treatment	Ion exchange	Ions from the aqueous phase are removed by exchange with innocuous ions on the exchange medium.
	Ferrous reduction	Dissolved contaminants are transformed into an insoluble solid, facilitating the contaminant's subsequent removal from the liquid phase by sedimentation or filtration. Usually uses pH adjustment, addition of a chemical precipitant, and flocculation.
Biological treatment	Wetlands	Groundwater is discharged to a constructed wetland where contamination sorbs to soil, is biologically reduced, or is taken up by plants and algae.
	Sub-grade bioreactors	Groundwater is amended with electron donor (optional) and injected upgradient of the extraction wells into a shallow infiltration trench backfilled with organic media (wood chips or mulch). Contamination is biologically reduced as it percolates through the trench and before infiltrating back to groundwater where additional treatment will occur.
	Ex situ bioreactors	Groundwater is amended with electron donor (carbon source) and passes through a matrix (fixed bed, fluidized bed, or membranes) with microbial films, where contamination is biologically reduced. Effluent is oxygenated, filtered, and amended before recharge back into the ground.
	Phytoremediation	Use of plants and their associated rhizospheric microorganisms to remove, degrade, or contain chemical contaminants in groundwater.
Physical treatment	Reverse osmosis	Water pressure is used to force water molecules through a very fine membrane, leaving the contaminants behind. Purified water is collected from the clean or "permeate" side of the membrane, and water containing the concentrated contaminants is disposed.
Onsite discharge	Groundwater injection	Treated groundwater is injected into onsite wells.

Table 4-4. Preliminary Remedial Actions – Groundwater

Remedial Technology	Process Option	Descriptions
	Injection of water at the river (mounding)	Treated groundwater or surface water is injected into injection wells, horizontal wells, or infiltration trenches along river.
	Reinfiltration with chemical amendments	Groundwater is amended with chemical reductant (calcium polysulfide) and then applied to ground surface at an application rate substantially below what would create saturation.
	Reinfiltration with biological amendments	Groundwater is amended with biological carbon source and then applied to ground surface at an application rate substantially below what would create saturation, to treat contamination within vadose zone and underlying groundwater.
Chemical treatment	In situ chemical treatment	Subsurface delivery and recirculation of chemical reductants within plume to stimulate reduction of contamination.
	ISRM maintenance/amendment	Inject additional sodium dithionite or non-zero valent iron to in-fill treatment zone gaps in the existing ISRM.
	Reactive chemical barrier	Subsurface delivery and recirculation of chemical reductants along cross-gradient rows transecting plume. Contamination is passively removed as groundwater moves through the treatment zone barriers.
Biological treatment	Reactive biological barrier	Subsurface delivery and recirculation of electron donors along cross-gradient rows transecting plume. Contamination is passively removed as groundwater moves through the treatment zone barriers.
	In situ biological treatment	Subsurface delivery and recirculation of electron donors within plume to stimulate anaerobic biodegradation of contamination.
Chemical/biological treatment	In situ treatment using combined bio and chemical substrate	Subsurface delivery and recirculation of both chemical reductants and electron donors within plume to stimulate chemical and anaerobic biological reduction of contamination.
Physical treatment	Water flushing	Clean/treated water (applied to the ground surface or in infiltration trenches) to flush out contamination in vadose zone and groundwater hot spots to expedite remediation of plumes.
Containment	Containing wall (e.g., slurry wall)	Slurry wall barriers consist of a vertical trench excavated perpendicular to the groundwater flow direction, filled with bentonite slurry to support the trench, and subsequently backfilled with a mixture of low-permeability material.
	Hydraulic containment	Install extraction wells along downgradient edge of plumes to control migration of contamination into the river.

NOTE: The information in this table is partially taken from EPA/540/G-89/004

ISRM = in situ redox manipulation

4.5.1.4 Alternative 4 – Source Removal, Treatment, and Disposal

Under this alternative, soil with contaminant concentrations above the future remediation goals would be removed, treated as appropriate, and disposed at the ERDF or other approved disposal facilities. This alternative would prevent contamination from reaching groundwater in the future.

For evaluation of this alternative, the vertical and lateral extents are needed to define contaminated volumes and support modeling of protection of groundwater. As a removal action progresses, an observational approach would be used to further define the extent of contamination. As previously unidentified contamination sources are located, a "plug-in" approach could be invoked to apply this alternative. The removed contamination would be treated for disposal in an onsite or offsite facility.

4.5.1.5 Alternative 5 – In Situ Treatment

In situ soil treatment involves injecting chemical or biological agents to react with the contaminant. This alternative would render the contaminant nonhazardous or immobilize it to prevent its movement to a receptor. This alternative would deliver the reactant to the entire contamination plume though physical mixing of the soil or infiltration techniques.

For in situ treatment applications, physical and chemical heterogeneity of the aquifer materials in the 100 Area must be considered in the design of the treatment system. The same data are required as with the ex situ and barrier alternatives.

4.5.2 Groundwater

In accordance with applicable CERCLA guidance (EPA/540/G-89/004), a comparative analysis of the alternatives will be conducted. The comparative analysis will facilitate the relative performance of each alternative in terms of the CERCLA evaluation criteria.

4.5.2.1 Alternative 1 – No Action

Evaluation of a no action alternative establishes a baseline for comparison with other remedial alternatives. The no action alternative represents no corrective or remediation activity and unrestricted access. Selecting the no action alternative would require that the area of contaminated groundwater not pose unacceptable threat to human health or the environment.

4.5.2.2 Alternative 2 – Institutional Controls

The areas of contaminated groundwater addressed in this work plan generally have significant contamination and are not expected to be remediated by institutional controls as a standalone alternative. Institutional controls alone will not protect environmental receptors and have an uncertain capability of protecting long-term human health.

4.5.2.3 Alternative 3 – Containment and Isolation

Physical barriers to contain the groundwater are likely not viable. Permeable reactive barriers to treat contaminants as they pass through the barrier or to capture contaminants in a stabilized form continue to be tested in the 100 Area. An ISRM barrier has been installed in the 100-D Area to reduce CrVI to trivalent chromium as the groundwater flows through the barrier. In the 100-N Area, injections of apatite are underway to form a barrier to Sr-90 movement. The strontium is integrated into the apatite crystal structure and immobilized as it undergoes radioactive decay. One concern expressed with these types of barriers is that the groundwater must flow to the barriers for treatment and, with low groundwater flow rates, many years are required to treat the entire contaminated volume.

Hydraulic barriers may be created by injecting clean water or by removing water to alter the local groundwater flow. Such barriers may be applicable for protecting localized or sensitive receptors from contamination.

To evaluate these alternatives, data are needed to understand the groundwater flow patterns and the aquifer permeability for introducing the chemical or other materials to form the barrier.

4.5.2.4 Alternative 4 – In Situ Treatment

In situ groundwater treatment involves injecting chemical or biological agents to react with the contaminant. This alternative would render the contaminant nonhazardous or immobilize it to prevent its movement to a receptor. The actions in this alternative are similar to creating a permeable reactive barrier, but this alternative would deliver the reactant to the entire contamination plume instead of allowing the normal groundwater flow to carry the contaminant to the reactant. The treatment agents could be introduced through injection wells or by infiltration through the unsaturated soil to the groundwater.

For in situ treatment applications, physical and chemical heterogeneity of the aquifer materials in the 100 Area must be considered in the design of the treatment system. The same data are required as needed for the ex situ and barrier alternatives.

4.5.2.5 Alternative 5 – Ex Situ Groundwater Treatment

With this alternative, contaminated groundwater is extracted, treated to remove contaminants, and reinjected into the aquifer. Several processes have been identified and demonstrated to remove the contamination, and the most commonly used are ion exchange, chemical or biological reaction to precipitate the contaminant for removal, chemical or biological treatment to convert the contaminant to a nonhazardous form, and electrochemical treatment.

For evaluation of this alternative, the vertical and lateral extent of contamination must be determined. The identification of other chemical species in the groundwater is necessary in order to select the appropriate chemical or biological process and to identify any potential adverse reactions. The treatment to remove the contaminant also may convert a nonhazardous component to a hazardous component. Groundwater flows must be understood so the network of extraction and reinjection wells can be properly designed.

4.5.3 Combined Alternatives

For the 100 Area, the best alternatives likely will involve a combination of in situ, ex situ, and source removal actions. Various actions may be applied in different areal locations of a plume, such as the source area versus the distal portions of the plume, and in the vadose zone versus the saturated zone.

When considering design of any remedial system for the 100 Area, the following should be considered:

- Target contaminants for remediation
- Chemistry of the groundwater
- Geochemistry and mineralogy of the aquifer materials
- Geochemical interactions of the added chemicals or biological agents, water, and aquifer materials, including any potential byproducts
- Impact on adjacent remedial systems

- Physical heterogeneity of the aquifer
- Hydrogeological conditions
- Risk to receptors

The preferred approach involves analysis of all evaluation criteria for each of the alternatives under consideration.

4.6 NEPA Values

Under DOE Order 451.1B, *National Environmental Policy Act Compliance Program*, Section 5.a.(13), DOE will "...incorporate NEPA values, such as analysis of cumulative, offsite, ecological, and socioeconomic impacts, to the extent practicable, in DOE documents prepared under the Comprehensive Environmental Response, Compensation, and Liability Act." These NEPA values include, but are not limited to, cumulative, ecological, cultural, historical, and socioeconomic impacts, and irreversible and irretrievable commitments of resources.

For the 100 Area operable units, the NEPA value analyses will be documented in conjunction with the CERCLA criteria in (a) each FS specific to an area and (b) in the resulting CERCLA ROD. The aforementioned NEPA values will be based on consideration of detailed information presented in the 100 Area CERCLA Evaluation Criteria, specific site characteristics, contaminants of potential concern, and the evaluation of the remedial action alternatives. A "sliding scale" of analysis of the NEPA values for the 100 Area (using DOE's "Green Book" [DOE, 2004, "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements"]) will be applied, in conjunction with consideration of the CERCLA applicable or relevant and appropriate requirements (to be detailed in 100 Area feasibility studies). The principal impacts and resource areas of concern associated with the NEPA values are expected to include (but not be limited to) solid and liquid radioactive and hazardous waste management, air emissions, potential adverse effects to historical and cultural resources, ecological resources, socioeconomics (including environmental justice concerns), and transportation. The following is a general discussion of NEPA values anticipated to be addressed for the 100 Area, with the analysis to be provided in each FS.

In general, when soils at a site are found to be contaminated with hazardous substances in concentrations presenting a material threat to human health and the environment, it would be expected that the threat would be mitigated by meeting the applicable ARAR standards as well as following current DOE policy and guidance. The net anticipated effect could be a positive contribution to cumulative environmental effects at the Hanford Site through removal, treatment, and disposal of such hazardous substances and contaminants of concern into a facility that has been designed and legally authorized to safely contain such contaminants. DOE expects that the primary facility to receive contaminated soils will be the Hanford ERDF.[9]

Any airborne releases of radiological contaminants that could occur during these removal actions would be controlled in accordance with DOE radiation control and DOH air pollution control standards to minimize emissions of air pollutants at the Hanford Site, and protect all communities residing outside the Site boundaries. As part of the development of the CERCLA remedial investigation and feasibility study,

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9 Note that NEPA values in the planning for the ERDF operation were explained in detail in the original ERDF NEPA Roadmap, DOE/RL-94-41, *NEPA Roadmap for ERDF Regulatory Package*, for the ERDF Remedial Investigation/Feasibility Study (RI/FS, DOE/RL-93-99, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility*) as described in the most recent ERDF ROD Amendment (May 2007).

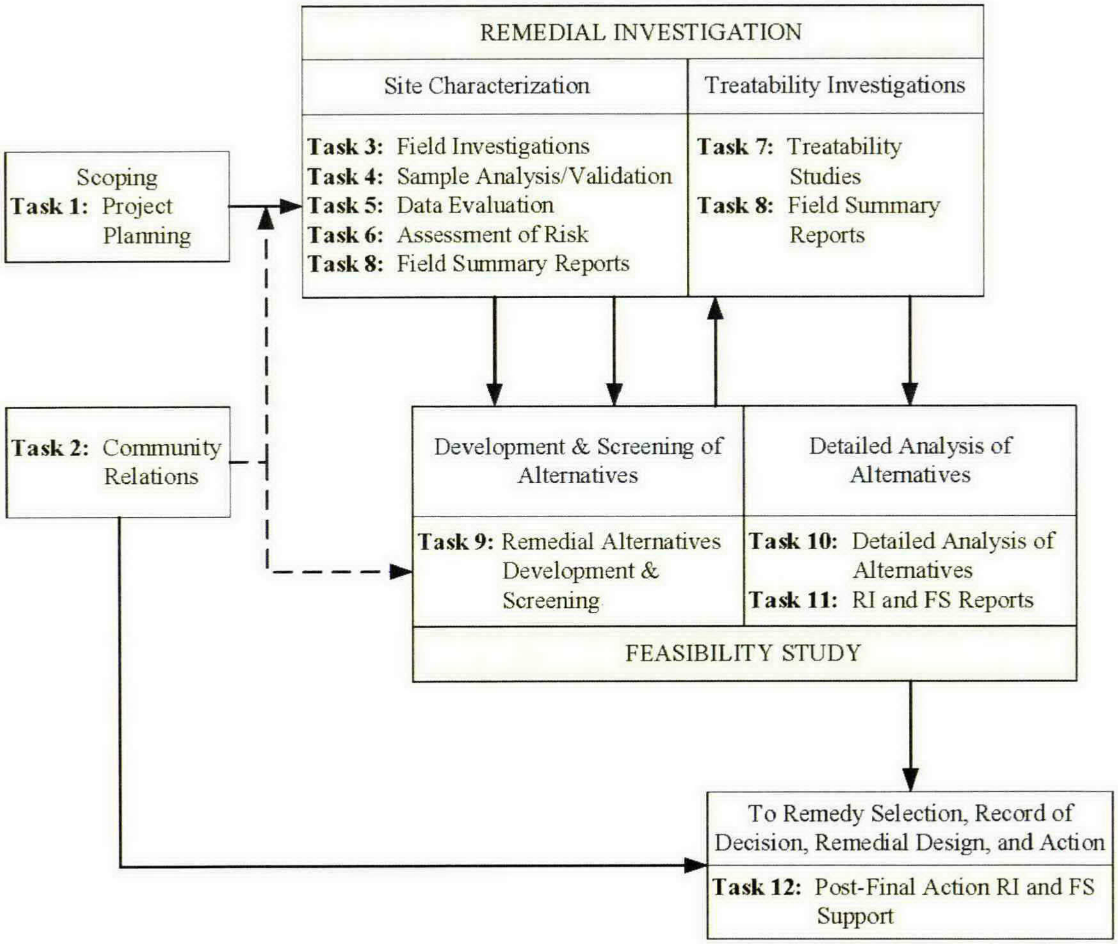
investigations and site-specific surveys are performed to assess the presence of historical, cultural, and ecological resources on the sites planned for remediation. Impacts on ecological resources near the removal actions would be mitigated in accordance with DOE/RL-96-32, *Hanford Site Biological Resources Management Plan* and DOE/RL-96-88, *Hanford Site Biological Resources Mitigation Strategy* and with the applicable standards of all relevant biological species protection regulations. Although these sites previously have been disturbed, only isolated cultural resource artifacts would be potentially encountered during project activities. Impacts to other cultural values including the viewshed from nearby traditional cultural properties could be minimized through implementation of DOE/RL-98-10, DOE/RL-2005-27, *Revised Mitigation Action Plan for Environmental Restoration Disposal Facility*, and consultation with area Tribal Nations throughout the design and project implementation. This could help ensure appropriate mitigation to avoid or minimize any adverse effects to natural and cultural resources and address any other relevant concerns.

Per Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, DOE seeks to ensure that no group of people bears a disproportionate share of negative environmental consequences resulting from proposed federal actions. Because access to the Hanford Site is restricted to the public, the majority of potential environmental impacts from the proposed action would be associated with onsite activities and would not affect populations residing offsite; thus, the potential for environmental justice concerns is small.

In addition, DOE is including the combined effects anticipated from ongoing CERCLA/Tri-Party Agreement (Ecology et al., 1989a) response actions as part of the cumulative impact analysis in the forthcoming draft Tank Closure and Waste Management EIS. Cumulative groundwater impacts from the proposed actions evaluated in the EIS as well as from other ongoing Hanford Site activities, including Tri-Party Agreement (Ecology et al., 1989a) cleanup actions, are included in this site-wide cumulative impact analysis. The cumulative impact analysis will present the public with an additional, separate opportunity for comment as part of the Tank Closure and Waste Management EIS NEPA process, and will be used to inform the public concerning the effects of ongoing cleanup actions on the Hanford Site in combination with other planned site activities.

5 Remedial Investigation/Feasibility Study Tasks

This chapter describes the tasks and processes that will be used during the final RI/FS. These descriptions incorporate RI site characterization tasks, data evaluation methods, analysis of remedial alternatives and reporting, and the preliminary determination of tasks to be conducted after site characterization. Figure 5-1 illustrates the relationships among these CERCLA RI/FS tasks. As part of the RI process, continued implementation of interim cleanup actions during the RI/FS process has been ongoing at the Hanford Site for the past 15 years.



CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
RI/FS = remedial investigation/feasibility study

Figure 5-1. CERCLA Remedial Investigation/Feasibility Study Process

An integrated cleanup program has been implemented in the River Corridor with a primary objective of protecting the Columbia River. Elements of the integrated cleanup program include D4 of contaminated and excess facilities, placing shutdown reactors in ISS, removing of contaminated soil and debris from waste sites, and cleaning up or immobilizing of contaminants in groundwater. Implementation of these cleanup actions in the River Corridor has reduced risk and produced large quantities of information and data that are valuable to guide development of the RI/FS work plan. Continued implementation of these cleanup actions throughout the RI/FS process will produce additional information to address many of the current data gaps and provide opportunities for refinement of site knowledge. These activities continue to be efficient and cost-effective approaches for addressing the additional information needed to complete the RI/FS process.

Elements of the integrated cleanup program that will continue to be implemented through the RI/FS process and their associated relevance toward the objective of protecting the Columbia River are summarized below.

- Facilities – Eliminate potential for future environmental releases and provide access to underlying soil. Contaminated and excess facilities will be removed and disposed at the ERDF or other offsite facility (as appropriate) through the D4 process. Implementation of these actions removes contamination and waste inventories that might otherwise present a potential for future releases to the environment if left in place. Completing the D4 process provides access to underlying waste sites that are present in many of the facilities in the River Corridor. It also provides opportunities for discovery of new waste sites that will be added to the existing remedies for cleanup.

- Reactors – Contain reactor cores in a safe configuration (ISS) while decay occurs before final disposition. ISS protects the reactor from environmental degradation and prevents the spread of contamination by "cocooning," or providing an upgraded, weather resistant shell to isolate the reactor core until final action remedial activities are conducted. This action also minimizes the facility footprint by removing all peripheral reactor buildings and equipment and properly disposing the debris.

- Waste sites – Remove contaminated soil and debris to reduce potential exposure and prevent future degradation of groundwater. Remediation of waste sites in the River Corridor will continue to be implemented with a bias for action approach. Cleanup will primarily consist of implementation of the RTD remedy, which will generate additional characterization data to address many of the current data gaps and help refine overall site knowledge. Contaminated soil and debris will be removed and disposed at the ERDF or other offsite facility (as appropriate) until the cleanup levels are met. Risk associated with remaining sites will be addressed as data gaps in each addenda.

  As part of the remedy, borehole drilling and/or additional test pitting in conjunction with sampling and analysis may be performed to better define the nature and extent of the contamination and identify sources within the vadose zone. Activities are guided during excavation using data obtained through field measurements or in process sampling using quick turnaround laboratory analyses working concurrently with excavation and used to update the site characteristics databases continually. The observational-approach based cleanup also provides opportunities for discovery of new waste sites that will be added to the existing remedies for cleanup. Sequencing of waste site cleanup is based on the Tri-Party Agreement (Ecology et al., 1989a) milestone framework. Within this framework, knowledge of operational process (e.g., sodium dichromate use) and past releases may be used to target and prioritize specific waste sites or areas with contaminants that presently exist in or potentially impact groundwater.

  Effective implementation of waste site cleanup prevents further degradation of groundwater, thereby increasing the likelihood for success of cleanup actions (e.g., pump-and-treat) directed specifically at contaminated groundwater.

- Groundwater – Restore groundwater to its beneficial use (40 CFR 300.430(a)(I)(iii)(F)/highest beneficial use (WAC 173-340-730(1)(a))) to protect human health, the environment, and the Columbia River. Groundwater remedial actions are expected to restore groundwater to drinking water standards, or the most stringent ARAR. In those cases where groundwater discharges are impacting the Columbia River "surface water," ensure that the water quality criteria for aquatic life are achieved. The cleanup levels will be established in the final ROD. It is intended that these objectives be achieved, unless technically impractical, within a reasonable time. The primary cleanup approach is to pump-and-treat contaminated groundwater. This is supplemented with other technologies (e.g., chemical treatment) to remediate specific contaminants or to address select areas of high concentration within contaminant plumes.

Community involvement during the RI activities will be consistent with Ecology et al., 2002, *Hanford Site Tri-Party Agreement Public Involvement Community Relations Plan.*

5.1 Task 1 – Project Planning

Project planning includes the previously approved interim action RI/FS work plans for the individual OUs (summarized in Appendix A), the systematic planning workshops (including the CSM plates) for each area, uncertainty team meetings, development of the CSM, and development of data needs and SAPs for each plan.

Existing LFI work plans describe the approach and rationale for initial characterization activities. The approach and rationale to support the final action RODs are supplemental to previously approved interim action RI/FS work plans and incorporate the additional data needs to support the final action decisions for the 100 Area. Project planning is complete when the work plan is approved. The FSs generated in support of remediation process optimization are a significant element of the ongoing remediation activities and will be incorporated into the 100 Area FSs, which lead to a final action ROD. Appendix C provides a list of proposed Tri-Party Agreement (Ecology et al., 1989a) milestones associated with the final action ROD activities for the 100 Area operable units.

5.1.1 Remedial Investigation/Feasibility Study Change Control

Extensive fieldwork is planned for each area. Normal reporting processes will continue to provide progress reporting and preliminary findings during and after the implementation of the RI/FS work plan. Emerging information during investigations can be classified into the following three categories, each requiring a different response.

- The first category of new information is not relevant to the RI/FS report. Information that might be classified as not relevant might include new information on the details associated with historical operation and general weather conditions.
- The second category of new information is relevant to the RI/FS report, but generally within expected ranges or bounds for the type of data. This information will be considered in the development of the RI report, but would not likely lead to changes in the RI/FS work plan.
- The third category is information or results from field activities that might call the CSM into question (e.g., waste sites extending and/or below the ordinary high-water mark, waterfront structures, and pipelines extending into the Columbia River). Unexpected results of sample analysis or field observations could fit into this category. This category could lead to changes in the RI/FS work plan activities.

Significant changes to the work plan, including changes in the schedule by two months or more to complete sampling and analysis for an area or decreasing the number of sampling locations or contaminants of concern, would occur formally and with regulatory approval. At a minimum, the disposition of emerging information will be reported at regular 100 Area Tri-Party Agreement (Ecology et al., 1989a) project manager meetings.

Minor changes, including changes in sample locations by a few meters (e.g., less than 3 m [10 ft]) because of physical obstructions, changes in location to better meet the DQO/SAP, or additions of sample depth(s), can be made and documented in the field log in accordance with Section 12.4 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

More significant changes in sample locations that do not affect the DQO/SAP will require notification and approval of the waste site remediation task lead as detailed in the SAP. Changes to sample locations that could result in impacts to meeting the DQO/SAP will require RL and regulatory approval. Significant differences in geophysical or hydrological conditions encountered require regulatory notification. If such differences are determined to result in an impact to meeting the objectives of the DQO/SAP, RL and regulatory approval is then required.

Revisions to the SAP will be evaluated and processed in accordance with Section 9.3 of the Tri-Party Agreement Action Plan (Ecology et al., 1989b).

5.2 Task 2 – Community Relations

The Community Relations Plan (Ecology et al., 2002) outlines stakeholder and public involvement processes and opportunities. Public involvement during the RI activities will be consistent with the Community Relations Plan. The project will use existing tribal, stakeholder, and public forums to ensure input to the work plan. The Hanford Site is located on lands ceded by Tribal Nations according to the following treaties.

- Confederated Tribes of the Umatilla Indian Reservation through the *Treaty with the Walla Walla, Cayuse, and Umatilla, 1855*
- Yakama through the *Treaty with the Yakima, 1855*
- Nez Perce through the *Treaty with the Nez Perce Indians, 1855*

Although not a signatory to a treaty, the Wanapum territory traditionally included the Hanford Site.

Involvement efforts fall into three categories: tribal, stakeholder, and public. All interactions with the HAB and public are done through and coordinated with the RL public involvement manager.

5.2.1 Tribal Nations Involvement

All interactions with Tribal Nations are done through the RL tribal liaison. RL has biweekly conference calls with the tribes to brief them on upcoming issues of interest. As Tribal Nations are not stakeholders, their involvement is on a government-to-government basis. Where possible, briefings to Tribal Nations will be done through existing forums. RL will work with Tribal Nations to ensure ongoing communication and involvement in the River Corridor decision-making process.

Relationship with the Tribal Nations is based on treaties, statutes, executive orders, and DOE policy statements. The treaties secured to the Tribal Nations certain rights and privileges to continue traditional activities outside the reservations, and established a trust relationship between the federal government and the Tribal Nations. To meet this responsibility, and to facilitate consultations, Executive Order 13175, *Consultation and Coordination with Indian Tribal Governments*, states that each federal agency "shall have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications." More specifically, under DOE O 144.1, *Department of Energy American Indian Tribal Government Interactions and Policy*, Attachment 2, *Memorandum for Heads of Department Elements*, DOE "will implement a proactive outreach effort of notice and consultation regarding current and proposed actions affecting tribes… This effort will include timely notice to all potentially impacted Indian nations in the early planning stages of the decision-making process…" Further, under this order, "consultation will include the prompt exchange of information regarding identification, evaluation, and protection of cultural resources. To the extent allowed by law, consultation will defer to tribal policies on confidentiality and management of cultural resources."

5.2.2 Stakeholder Involvement

The Community Relations Plan identifies processes governing public information and involvement processes. Stakeholders are individuals who see themselves affected by and/or have an interest in Hanford Site issues. They commit time and energy to participate in decisions. Hanford Site stakeholders include local governments, local and regional businesses; Hanford Site workforce; local, regional, and national environmental interest groups; and local and regional public health organizations. Another group of stakeholders with whom the Tri-Parties work is the Hanford National Resources Trustees and the State of Oregon. The HAB is a *Federal Advisory Committee Act 1972* Board consisting of 31 individuals representing a balanced mix of the diverse interests affected by Hanford Site cleanup issues. The HAB advises the Tri-Parties on cleanup issues. The body of HAB advice was reviewed for this work plan to ensure responsiveness to HAB values, principles, and issues. The HAB's River and Plateau Committee addresses River Corridor and Central Plateau issues. The cleanup program will work with DOE to identify opportunities to inform and involve this committee on significant work plan issues and progress. The River and Plateau Committee meets approximately 10 times per year. Based on the timing of the development of significant work plan components (e.g., the CSM and data needs), periodic updates will be provided to the River and Plateau Committee.

The River and Plateau Committee provides an ongoing opportunity for informal stakeholder feedback on work plan components and evolving project activities. The committee discusses issues and decides whether an issue should be brought to the HAB.

5.2.3 Public Involvement

In addition, public involvement is governed by Tri-Party Agreement (Ecology et al., 1989a) activities. The public consists of those individuals who are aware of but may choose not to be involved in decisions. At this time, public meetings or comment periods are not conducted on the initial draft work plan. As subsequent addenda to the work plan are developed, consultation with the Tri-Parties, River and Plateau, and Public Involvement and Communication Committees would determine the need for public involvement.

5.3 Task 3 – Field Investigations

Field investigations will be conducted in the 100 Area to supplement information received from the LFIs and in response to results from ongoing remedial actions under interim action RODs (e.g., CERCLA 5-year reviews). The field investigation and data collection activities will address additional data needs developed through the systematic planning process (Section 1.5) and refined using EPA's DQO process documented in the addenda. The specific data needs for each area are defined in each addendum.

The scope of the field investigation will be described in a SAP. The primary objective of the SAP is to provide sampling strategies to obtain the supplemental data required to satisfy specific data needs identified during the systematic planning workshops. An RI –area specific SAP will be prepared for each 100 Area and will be included in the respective addendum.

It is anticipated that the RI field investigations will use similar approaches to those in the LFIs and remedial actions under interim action RODs for characterizing site conditions; delineating waste disposal; defining the nature and extent of contamination; and characterizing human health, ecological, and environmental impacts. Future field investigation approaches will include the following:

- Field screening (e.g., radionuclides and volatile organic compounds)
- Soil gas surveys
- Wipe sampling
- Boreholes and test pits
- Surface and subsurface soil sampling
- Surface and borehole geophysics
- Sludge sampling
- Sediment sampling
- Groundwater sampling
- Porewater sampling
- Aquifer testing
- River gauging
- Ecological surveys and sampling

Selection of sites or locations where additional vadose zone soil characterization is planned as part of the RI/FS field investigation is based on the consideration of the following criteria:

- Existing plans/commitments for remedial action per interim action per interim action RODs
- Historical demolition activities and associated end-state
- Proximity to high concentration groundwater plumes
- Volume and concentration of liquid disposal activities
- Historical impacts to groundwater quality
- Extent of excavation relative to the bottom of the engineered structure(s)
- Contaminants sampled to support site reclassification relative to contaminants identified in historical investigations (e.g., decontamination and repair, LFIs)
- Concentration of residual soil contamination relative to screening levels for groundwater protection
- Concentration of residual soil contamination relative to WAC 173-340 2007 values
- Characterization information beneath extent of excavation
- Evidence of deep soil contamination
- Contaminant mobility properties in soil (i.e. distribution coefficient)
- Potential data needs identified in the systematic planning workshops
- Anticipated applicability of RI/FS characterization results to other sites

Consideration and relative weighting of the criteria at specific sites or locations may vary based on process history and present conditions at the site or locations being evaluated. Selection of sites or locations where additional vadose zone soil characterization is planned as part of the RI/FS field investigation will be based on discussion with and concurrence by the Tri-Parties and is presented in the addenda. The Tri-Party Agreement (Ecology et al., 1989a) allows for the initiation of site survey and screening activities before submittal of the RI/FS work plan. These nonintrusive activities include the following:

- Surveillance for location of sites
- Surface radiation surveys
- Surface geophysical surveys
- Air sampling
- Soil gas surveys
- Biotic surveillance

These surveys allow for a quicker start of characterization activities upon approval of the RI/FS work plan, and results may be factored into the work plan as appropriate. To further expedite the process, near surface vadose zone sampling may commence two weeks after receipt of lead regulatory agency comments on the initial draft of the RI/FS work plan, if the comments regarding vadose zone sampling have been resolved.

5.3.1 Supplemental Investigations

The following supplemental activities have been identified to prove input to the CERCLA cleanup process. These five items below support information needs for the entire River Corridor and will be addressed separately from other field investigation activities described in the specific SAPs. As specific schedules and details associated with these activities are developed, communication and input from the regulators will be obtained:

- Evaluating and developing approaches to obtain data that will demonstrate compliance with ambient water quality standards in the river for final ROD decisions. In April 2008, a technical review panel was convened to evaluate groundwater interactions with the Columbia River (SGW-39305). The panel suggested that the current mixing/dilution conceptual model should be re-evaluated. In addition, data may be needed to show representativeness of contaminant concentrations for compliance. Therefore, evaluation will include determination of whether 1:1 dilution assumption for groundwater entering the river is valid, and may include evaluation of whether data from aquifer tube samples are representative. Data collected as part of the remedial investigation for Hanford Site releases to the Columbia River may be useful in this evaluation.

- Collecting data and developing River Corridor background values for antimony, boron, molybdenum, and selenium. Site-specific background values for these constituents may be needed to determine final soil RAG values where calculated risk-based concentrations and/or ecological protection concentrations are less than background. Interim remedial actions have used Washington State background values for antimony and selenium; interim soil RAGs for boron and molybdenum are above expected site-specific background values.

- Re-evaluate soil cleanup level for CrVI to support the final ROD. The lowest soil RAG for CrVI under the interim RODs is 2.0 mg/kg. However, the calculated WAC-173-340-747(3)(a) (2007) soil RAG value may be below the current limits of analytical quantitation in environmental samples, depending on the soil-partitioning value and groundwater-to-river dilution attenuation factor used, and final soil cleanup values may default to the limits of quantitation. Because there is uncertainty in analytical detection and quantitation of CrVI near the limits of detection, it may be necessary to consider the realistic capabilities of analytical performance in determination of a final soil cleanup value.

- Determining a site-specific soil-partitioning value for antimony. This value is necessary for calculation of WAC-173-340-747(3)(a) (2007) soil RAG values for antimony. Antimony is not a significant contaminant in the River Corridor, and determination will include review of scientific literature, which suggests antimony soil-partitioning values in the range of 1.4 to 45 ml/g.
- Re-evaluate soil cleanup levels for arsenic to support the final ROD. The soil RAG for arsenic under the interim RODs is 20 mg/kg, based upon Tri-Party Agreement (Ecology et al., 1989a) to use the WAC 173-340-740(2) (1996) Method A value (DOE/RL-96-17, Rev. 5). The WAC 173-340-740(2) (2007) Method A value is also 20 mg/kg. The WAC 173-340-740(3) (2007) Method B and WAC 173-340-747(3)(a) (2007) soil values for arsenic are below the Hanford Site arsenic background of 6.5 mg/kg. Selection of a final soil cleanup level for arsenic in the River Corridor will be accomplished through development of final RODs.

5.4 Task 4 – Sample Analysis/Validation

Each work plan addendum will identify areaspecific target analytes, analytical methods, and quantification levels for analysis of media samples collected. The data obtained will be reviewed, verified, and validated. Data verification will be performed to ensure and document that the reported results reflect those activities that were actually performed.

The data verification checks include review for completeness, use of the correct analytical methods/procedures, review for transcription errors, correct application of dilution factors, appropriate reporting of dry weight versus wet weight, and the correct application of conversion factors. Laboratory personnel may perform data verification.

Data validation will be performed to ensure that the data quality goals established during the RI/FS planning phase have been achieved. Validation activities will be based on EPA functional guidelines (EPA, 1988a. *Laboratory Data Validation: Functional Guidelines for Evaluating Inorganics Analysis;* EPA, 1988b, *Laboratory Data Validation: Functional Guidelines for Evaluating Organics Analysis*). Data validation may be performed by the analytical laboratory, the Sample and Data Management organization, and/or by a party independent of both the data collector and the data user.

5.5 Task 5 – Data Evaluation

Following verification and validation, data will be evaluated to assess whether the original questions were answered (e.g., project DQOs). The data quality assessment process compares completed field sampling activities to those proposed in corresponding sampling documents, and provides an evaluation of the resulting data. The data quality assessment process (EPA/240/B-06/003, *Data Quality Assessment: Statistical Methods for Practitioners*) is discussed in further detail in each SAP.

The RI data will be managed through a data management system to provide accurate, appropriate, consistent, traceable, and defensible data to all users throughout the project. The data management process will provide project teams with electronic data access to control revisions and additions to the data set. The types of data expected to be managed during the RI include the following:

- Analytical laboratory data
- Physical data
- Borehole logs
- Well construction reports
- Geographical information systems data

- Modeling data inputs and outputs
- Drawings
- Historical narrative/reports
- Process engineering data
- Environmental surveillance data
- Geophysical or geochemical data

In order to meet modeling input and output data needs, DOE will conduct a verification and validation of residual radioactivity for chemicals. Further details of the data management process are provided in each SAP.

5.6 Task 6 – Assessment of Risk

Section 3.6 discusses the process and activities for evaluating baseline and residual risks for the 100 Area. The sample collection tasks under the RI/FS do not include additional risk assessment. RI/FS information and data will be compared to the assumptions and conclusions of the RCBRA (and other pertinent assessments) to determine if there is any impact on risk conclusions that would affect final action decision making. Methods that can be used for comparison are discussed below. Results of this evaluation will be in the RI/FS report.

The data generated from the sampling plan will be combined with existing data in the HEIS database for use in evaluating the nature and extent of area contamination. This section briefly summarizes methods that may be employed to compare the RI data with RCBRA data. Results from this comparison will be used by the Tri Parties to determine if RI data might affect the risk analyses in the RCBRA.

5.6.1 Graphical Data Displays

As part of data interpretation, graphical representation of analytical results will be generated for use in evaluation of contaminant trends. Exploratory data analysis plots allow for visual inspection and summary of the data. Each plot described below provides a different visual presentation of the distributions of contaminants.

The choice of plotting procedures depends on the hypothesis being tested and may include and/or depend on the following:

- The type of difference that is to be displayed, such as an overall shift in concentration.
- When the centers are nearly equal, a difference between the upper tails of the two distributions (elevated concentrations in a small fraction of one distribution).

A number of established methods for graphically displaying data that could be used for the RI/FS:

- **Histograms.** Histograms split the full range of results into equal-width data classes (intervals).
- **Estimated (Probability) Density Functions.** In density functions, the horizontal axis indicates the analyte results in the appropriate units. The curve, or density estimate, is a smoothed histogram.
- **Box Plots**. Box plots summarize information about the shape and spread of the distribution of data. Box plots consist of a box, a (median) line across the box, whiskers (lines extended beyond the box and terminated with a perpendicular line segment), and points outside the whiskers.

- **Bivariate Plots.** Scatter plots are an example of a bivariate display used to look for a mutual relationship or correlation between two variables of interest in the same sample. Data relating to one variable (y-axis) are plotted against data from a second variable (x-axis).
- **Spatial Plots.** Spatial plots present data across a given area using a variety of techniques. One simple plot used to provide information on spatial trends for two-dimensional data is a circle plot. Circle plots provide simple graphical representations of the magnitude of results at each sample location.

In addition to test results described in this section, the data will be plotted spatially and evaluated relative to the conceptual site model. Spatial plots of the data are used to verify or better define the site conceptual model.

5.6.2 Statistical Methods

To determine whether the RI data set may affect the risk analysis in the RCBRA, the data sets will be compared, and uncertainties for chemical, spatial, and temporal similarities or differences will be evaluated. Results of these data collection efforts will be statistically evaluated by one or more of the following statistical methods. Resulting data gaps from these data collection efforts will be filled appropriately.

- **Student's t-test.** This is a parametric, two-sample test that determines whether the mean concentration of site data is statistically greater than the mean concentration of background or reference site data.
- **Welch's t-test.** Welch's t-test is an adaption of the Student's t-test, described above, for use in circumstances where the variances of the site and background data are unequal.
- **Wilcoxon rank sum test (or Mann-Whitney U-test.** This test is the nonparametric equivalent to the t-test. The Wilcoxon test pools site and background or reference site data into one aggregate set and determines whether the average rank of the site data is greater than that of the background data.
- **Bartlett's test.** This test is used to determine the homogeneity of variance between samples from two populations.
- **Gehen test.** When, as is frequently the case for environmental data, some of the data area "censored" or reported as below a detection limit, and especially when not all the detection limits are identical, the Gehan modification to the Wilcoxon test is useful. The Gehan test uses a modified ranking of sample results to accommodate nondetected values together with detected values, and then applies the Wilcoxon rank sum test.
- **Quantile test.** The quantile test determines whether more of the observations in the top 20 percent (chosen percentile) of the combined data set come from the site data set than would be expected by chance, given the relative sizes of the site and background data sets.
- **Statistical Quantities.** Percentiles or quantiles are measures of relative standing that are useful for summarizing data. A percentile is the data value that is greater than or equal to a given percentage of the data values. Stated in mathematical terms, the p^{th} percentiles is data value that is greater than or equal to p% of the data values and is less than or equal to (1-p%) of the data values.
- **Slippage test.** This test is based on the maximum observed concentration in the background or reference site data set and the number of potentially affected site concentrations that exceed the maximum concentration in the background or reference data set.

5.6.3 Assessment of Risk for Arsenic and Lead

Soils in the large parts of Washington State contain levels of arsenic and lead caused by past releases from metal smelters and historical application of agricultural pesticides. This low to moderate-level soil contamination, dispersed over large geographic areas, is referred to as area-wide soil contamination. Some areas of the Hanford Site (including the 100-D and 100-H Areas) are affected by application of lead-arsenate pesticides prior to 1943. The residual contamination at the Hanford Site created a problem for the Tri-Parties during implementation of interim remedial actions: residual arsenic made it difficult to close out interim clean up of sites contaminated by the Hanford Site production processes. The Tri-Parties dealt with this problem by establishing an interim remedial action goal of 10 mg/kg arsenic. DOE in coordination with EPA and Ecology will conduct the necessary work to determine a final cleanup level of residual arsenic. This may include site-specific terrestrial ecological evaluations consistent with the elements of WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures." During its state fiscal year (SFY) 2009-2010, Ecology Environmental Assessment Program and Toxics Cleanup Program has initiated work on site-specific cleanup levels for smelter-and orchard-affected lands elsewhere in the state. Ecology's Nuclear Waste Program participated in scoping those SFY 2009-2010 studies.

5.7 Task 7 – Treatability Studies

Treatability studies may be conducted to provide additional area-specific data to reduce cost and performance uncertainties, to allow a treatment alternative to be fully developed and evaluated during the RI/FS detailed analysis, and to support the remedial design of a selected alternative. The process for incorporating the treatability study into the RI/FS process includes the following steps:

1. Determine data needs.
2. Review the existing site data and available information on technologies to determine if existing data are sufficient to evaluate alternatives.
3. Perform treatability studies, as appropriate, to determine performance, operating parameters, and relative costs of potential remedial technologies.
4. Evaluate the data to ensure that DQOs are met.

The *Technology Readiness Assessment (TRA)/Technology Maturation Plan (TMP) Process Guide* (DOE, 2008) also has been used at the Hanford Site to assess whether the maturity of critical technology elements is sufficient for incorporation into final designs. The technology readiness assessment process consists of the following three parts:

1. Identify the critical technology elements.
2. Assess the technology readiness level of each critical technology element using the technical readiness scale used by the U.S. Department of Defense and the National Aeronautics and Space Administration, and adapted by the assessment team for use by DOE.
3. Evaluate technology testing or engineering work necessary to bring immature technologies to appropriate maturity levels.

Treatability studies and remedial actions under interim action RODs conducted to date in the 100 Area include groundwater pumping with treatment by ion exchange ISRM using a reactive treatment zone injected with sodium dithionite, biostimulation, electrocoagulation, calcium polysulfide, and apatite barrier.

Several projects are currently underway, or were previously completed, as technology demonstrations to evaluate other innovative in situ treatment technologies, including in situ bioremediation and calcium polysulfide injection, and an ex situ pilot test of electrocoagulation for CrVI removal. Possible future treatability studies to help bring these technologies to full-scale implementation include studies of ion exchange regeneration, in situ carbon polysulfide treatment, and bioreduction approaches. More detail on treatability studies for each 100 Area is discussed in their respective addendum.

5.8 Task 8 – Field Summary Reports

As the field investigations and treatability studies are completed, field summary reports are prepared to document the data collection and to provide updates to the CSM. The field summary reports, which are used during preparation of the RI/FS reports, discuss the investigative approach used, the results, and conclusions.

5.9 Task 9 – Remedial Alternatives Development and Screening

The development and screening of remedial alternatives begins once sufficient data are available. This task may occur concurrently with the preparation of field summary reports. The primary objective of this task is to develop an appropriate range of remedial options that will be analyzed more fully in Task 10. Appropriate remedial options may include the complete elimination of hazardous substances, the reduction of concentrations of hazardous substances to acceptable health based levels, and the prevention of exposure to hazardous substances via engineering or institutional controls.

Remedial alternatives are developed by assembling combinations of technologies for affected media into alternatives that address the contamination for each area. This process consists of the following six general steps (EPA/540/G-89/004):

1. Develop RAOs specifying the contaminants and media of interest, exposure pathways, and PRGs that permit a range of treatment and containment alternatives to be developed. The PRGs are developed based on chemical specific ARARs (when available), other available information (e.g., reference doses), and areaspecific risk related factors.

2. Develop general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, which may be taken to satisfy the RAOs for the area.

3. Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the RAOs and the chemical and physical characterization of the area.

4. Identify and screen the technologies applicable to each general response action to eliminate those technologies that cannot be technically implemented at the area. The general response actions are further defined to specify remedial technology types (e.g., the general response action of treatment can be further defined to include chemical or biological technology types).

5. Identify and evaluate technology process options to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.
6. Assemble the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate.

The screening should be used to identify and distinguish any differences among the various alternatives and to evaluate each alternative for effectiveness, implementability, and cost. The result of this task is a refined list of remedial alternatives for a specific area that is judged as the best or most promising based on these evaluation factors and should be retained for more detailed analysis.

The remedial action alternatives developed through this process are screened and FS-level designs and costs are developed for the preferred alternative.

5.10 Task 10 – Detailed Analysis of Alternatives

During the detailed analysis, the alternatives that passed screening are further refined and analyzed. A number of alternatives should be developed that provide a range of options and sufficient information to compare alternatives against one another. For source control options, the following type of alternatives should be developed to the extent practicable (EPA/540/G-89/004).

- A number of treatment alternatives, ranging from an alternative that would eliminate or minimize to the extent feasible the need for long-term management (including monitoring) at a site, to an alternative that would use treatment as a primary component of an alternative to address the principal threats at the site. Alternatives within this range typically will differ in the type and extent of treatment used and the management requirements of treatment residuals or untreated wastes.
- One or more alternatives that involve containment of waste, with little or no treatment, but protect human health and the environment by preventing potential exposure and/or reducing the mobility of contaminants.
- A no action alternative.

For groundwater response actions, the range of alternatives may use different technologies to achieve cleanup levels within varying timeframes.

The selection of the preferred alternative is determined through the application of nine evaluation criteria identified in the detailed analysis of alternatives. These criteria are grouped by their importance. Each alternative must meet the following threshold criteria:

- Overall protection of human health and the environment
- Compliance with ARARs

The analysis of alternatives is based on the following primary balancing criteria:

- Long-term effectiveness and permanence
- Reductions in toxicity, mobility, and volume through treatment

- Short-term effectiveness
- Implementability
- Cost

Modifying criteria evaluated following comment on the proposed plan and addressed in the ROD are as follows:

- State acceptance
- Community acceptance

5.11 Task 11 –Remedial Investigation/Feasibility Study Report(s)

The previous tasks lead to preparation of the RI/FS reports. As an outcome of the systematic planning process, the results of the source and groundwater investigations and the RCBRA will be presented together in the RI/FS reports.

The RI report presents the collection of data and evaluations to characterize site conditions, determine the nature and extent of contamination, and assess risk to human health and the environment. The field summary reports prepared under Task 8 address these RI elements for individual field investigation activities and are discussed overall within the RI report. The FS report presents the RAOs; development, screening, and detailed evaluation of remedial alternatives; and selection of the preferred remedy. The results of treatability studies also are presented, if available.

5.12 Task 12 – Post-Remedial Investigation/Feasibility Study Support

Upon agency acceptance of the 100 Area RI/FS reports, a proposed plan and ROD will be prepared that address all media for each area. These documents will incorporate all existing completed remedial actions under interim action RODs, validate their completion, and identify any remaining actions to support completion, including presumptive remedies, plug-in approaches, and contingent remedies, as appropriate. No further action will be required for sites that already have been through the CVP process.

5.12.1 Proposed Plan

The proposed plan is the mechanism by which the lead agency presents the preferred alternative to the public. The plan should briefly describe the remedial alternatives analyzed, propose a preferred alternative, and summarize the information used to select the preferred alternative. The purpose of the proposed plan is to summarize the RI/FS information and provide the public with a reasonable opportunity to comment on the preferred alternative (as well as alternative plans under consideration) and to participate in the selection of remedial alternatives for the OUs. Following public review and comment on the proposed plan, a responsiveness summary will be prepared that summarizes significant comments, criticisms, and new relevant information received during the comment process. The responsiveness summary will be incorporated into the final action ROD.

5.12.2 Record of Decision

Following receipt of public comments and any final comments from supporting agencies, a remedy is selected and documented in a final ROD. The ROD documents the remedial action plan for a site or OU and serves four basic functions (EPA/540/R-98/031, *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*). The ROD serves as:

- A legal document in that it certifies that the remedy selection process was carried out in accordance with CERCLA and, to the extent practicable, in accordance with the NCP.
- A substantive summary of the technical rationale and background information contained in the Administrative Record file (e.g., RI/FS including the baseline risk assessment).
- A technical document that provides information necessary for determining the conceptual engineering components, and that outlines the remedial action objectives and cleanup levels for the selected remedy.
- A key communication tool for the public that explains the contamination problems the remedy seeks to address and the rationale for its selection.

5.12.3 Post-Record of Decision Activities

The selected remedial alternative is implemented when the final action ROD is approved. This stage may involve remedial design and design verification studies, construction, remediation process optimization, and operation and maintenance of the implemented processes. Performance is evaluated during 5-year reviews. Actions identified in the first two 5-year reviews associated with the groundwater interim action RODs have been completed or are in progress. The next 5-year review will occur in 2011.

If new information is generated that could affect the implementation of the selected remedy, the information can be addressed through one of the following means:

- A memorandum to the post-ROD file for an insignificant or minor change.
- An ESD for a significant change.
- A ROD amendment for a fundamental change.

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6 Project Management Considerations

This chapter discusses project organization, project coordination, change control, and the dispute resolution processes. Change control processes increase in definition as needed, to document and achieve approval for changes that arise during the RI/FS. Problems are resolved at the lowest possible level, with higher levels of project oversight engaged to resolve the issues.

6.1 Project Organization

RL is responsible for the Hanford Site cleanup of the River Corridor. The RL contractors implement cleanup for RL and are responsible for planning, coordinating, and executing the RI/FS activities. The lead regulatory agency authorizes the work scope in accordance with the Tri-Party Agreement (Ecology et al., 1989a) and oversees the work for regulatory compliance. Figure 6-1 illustrates the project organization structure for cleanup of the 100 Area.

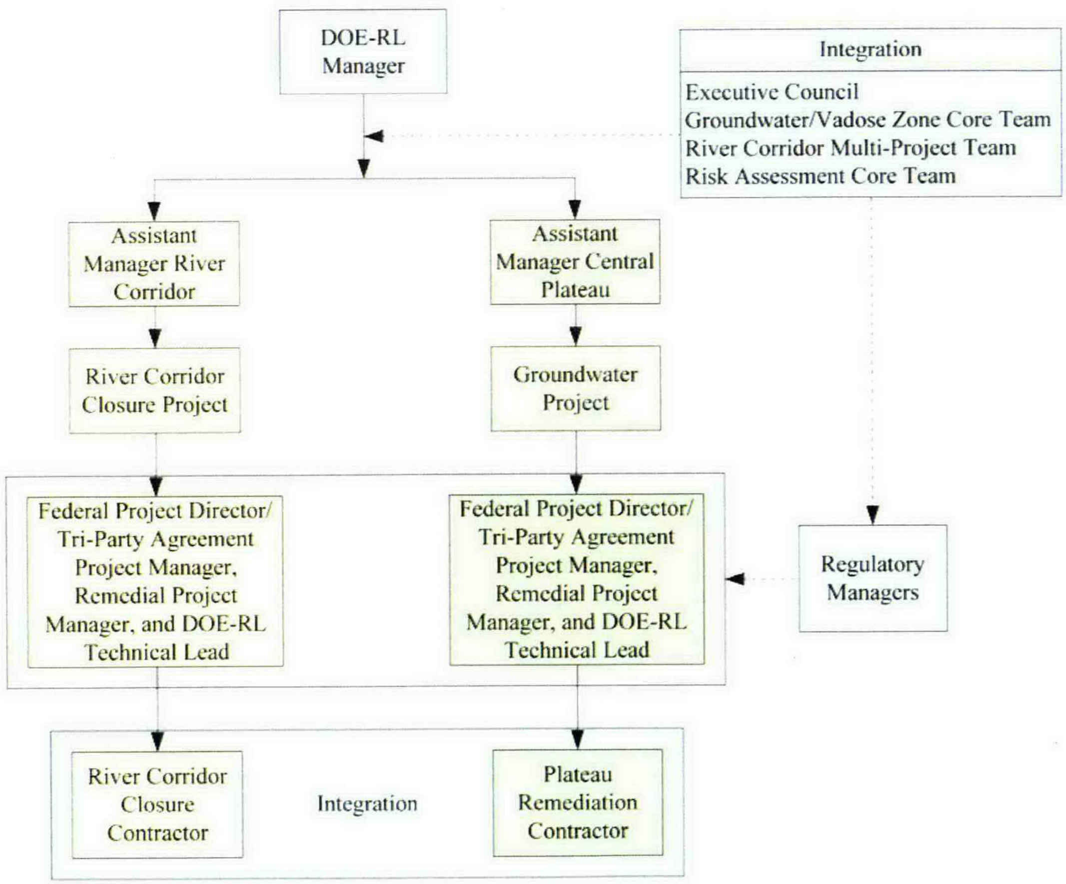

Figure 6-1. Project Organization

6.1.1 U.S. Department of Energy, Richland Operations Office Project Organization

Cleanup actions for source and groundwater OUs in the River Corridor are programmatically separated between RL projects and associated Hanford Site contractors. RL has established an interface control agreement (08-AMRC-0116, "Contract No. DE-AC06-05RL14655 – Interface Agreement for Coordinating Groundwater and Vadose Zone Cleanup Programs") between programs to ensure integration and coordination between source and groundwater actions and to identify responsibilities for its associated contractors. As cleanup progresses and the Tri-Parties work toward establishing final action RODs for the River Corridor, effective integration between RL programs and responsible contractors will continue to be a focus and an expectation of the Tri-Parties and Hanford Site stakeholders.

The RL River Corridor Closure Project is responsible for cleanup of source OUs in the River Corridor. The federal project director for the River Corridor Closure Project reports to the assistant manager for River Corridor. RL's responsibility for groundwater cleanup lies with the Groundwater Project. The Groundwater Project federal project director reports to the assistant manager for the Central Plateau. The assistant manager for the River Corridor and the assistant manager for the Central Plateau report to the RL office manager.

The RL federal project directors are responsible for authorizing the respective contractors to perform the RI/FS activities for the 100 Area. The federal project director also is responsible for obtaining lead regulator approval of the work plan and SAP, which authorize the RI/FS activities under the Tri-Party Agreement (Ecology et al., 1989a). The RL technical leads are responsible for day-to-day oversight of contractors performing the RI/FS activities, for working with the contractors and the regulatory agencies to identify and work through issues, and to provide technical input to the RL federal project directors.

6.1.2 Regulatory Agency Oversight Organization

Both EPA and Ecology have assigned project managers who are responsible for overseeing various RI/FS field activities. The project managers from the regulatory agencies are responsible for working with RL to resolve issues and approve the documents in accordance with Article XVI of the Tri-Party Agreement (Ecology et al., 1989a). The regulatory project managers are responsible for approving work plans and SAPs.

6.1.3 Contractor Organization

Cleanup of the source OUs and development of the RCBRA is conducted by Washington Closure Hanford, LLC (WCH) under DE-AC06-05RL14655, *Washington Closure Hanford, LLC (WCH), River Corridor Closure Contract*. The RL oversight of the work performed by WCH is provided through the River Corridor Closure Project federal project director and the assistant manager for the River Corridor. Groundwater cleanup activities and lead integration responsibilities are conducted by the CH2M HILL Plateau Remediation Company (CHPRC) under DE-AC06-08RL14788, *CH2M HILL Plateau Remediation Company LLC(CPRC) Plateau Remediation Contract*. The RL oversight of the work performed by CHPRC is provided through the Groundwater Project's federal project director and the assistant manager for the Central Plateau. Together, CHPRC and WCH are the contractors responsible for integrating and executing the full scope of RI/FS activities in the River Corridor. General descriptions of the key positions responsible for conducting the RI/FS sampling and characterization activities are provided in each the SAP for each area.

6.1.4 Integration Teams

RL has established multiple teams to facilitate integration of work between RL programs, contractors, and the regulatory agencies. The teams report to the Groundwater/Vadose Zone Executive Council, which oversees the integration of groundwater and vadose zone work scope and provides policy direction. The Executive Council prepares, updates, and assesses the progress of priorities to guide integration activities. The Executive Council is chaired by the Assistant Manager for Central Plateau and members include the Assistant Manager for the River Corridor, and the Assistant Manager for Tank Farms. The RL Groundwater Remediation Project Federal Project Director is an ex-officio member of the Council.

Federal Project Directors for affected projects participate in meetings as needed to support specific agenda topics. The teams that are relevant to the scope of RI/FS activities in the River Corridor are as follows:

- **Groundwater/Vadose Zone Multi-Project Team:** The purpose of the Groundwater/ Vadose Zone Multi-Project Team is to ensure successful implementation of the "Interface Agreement for Coordination of Groundwater and Vadose Zone Cleanup Programs," (08-AMRC-0116). This Multi-Project Team oversees all aspects of groundwater and vadose zone work at the Hanford Site, including integration of fieldwork, decision processes, treatability testing, and remedy implementation. This includes Central Plateau and River Corridor work scope, as well as vadose zone investigations.
- **River Corridor Multi-Project Team:** The River Corridor Multi-Project Team develops and maintains an integrated approach to assessment and decision making for River Corridor Project remediation decisions. The River Corridor Multi-Project Team ensures that all River Corridor source, vadose zone, and groundwater OU cleanup decisions are coordinated between the River Corridor Project and the other Hanford Site CERCLA projects.
- **Risk Integration Core Team:** The Risk Integration Core Team provides a forum for coordinating Hanford Site risk assessments to ensure their applicability to remediation, corrective action, closure, and disposal decisions. This team identifies risk assessment activities that are underway and planned for Hanford Site projects and determines whether those activities require DOE management decisions to improve their coordination, consistency, and effectiveness. The team identifies issues affecting multiple projects that may require resolution by the Groundwater/Vadose Zone Executive Council.

Each of these teams meets on a regular basis to discuss integration items, opportunities, and emerging issues. Team representatives are made up of RL and contractor representatives. In addition, individuals representing the regulatory agencies typically are invited to participate in the team meetings.

6.2 Project Coordination, Decision Making, and Documentation

Coordination among EPA or Ecology, the lead agency (DOE), and the contractors performing the work is essential for successful execution of the RI/FS. The RI/FS work plan will be developed using the systematic planning process (completed for each area, with the approval of each addendum to this work plan). Coordination with other agencies, the Tribal Nations, and local public and private organizations will be handled as described in the Community Relations Plan.

Documented consensus from the regulatory agency project managers is important for dynamic field activities. Before mobilization, the lines of communication and authority will be clearly outlined and the project managers and field team lead will determine how often or when to make and document decisions. These periodic decisions help avoid the need for remobilization after work has been completed at a particular location.

Field decisions will be documented stating consensus decisions. A decision log will be kept to track each decision, and the decision log will refer to attachments as applicable. Larger scale changes may require formal decision memorandums. In either case, the project manager for the Groundwater Project and the regulatory agency project managers will be involved in the decision and documentation.

6.3 Change Control and Dispute Resolution

The SAPs represent the Tri-Parties' assessment of the data needs at the end of the systematic planning process. As new information becomes available, changes to work scope may be required. These changes will be made to the sampling plans for the specific areas and may not require a corresponding change to the work plan.

Changes that affect the Tri-Party Agreement (Ecology et al., 1989a) are documented using change control forms. The class or level of the change (i.e., signatory, executive management, or project management) is noted and the description/justification and impact of the change is documented.

Dispute resolution is handled in accordance with the Tri-Party Agreement (Ecology et al., 1989a), Article XVI. The Tri-Parties are to make reasonable attempts to resolve all disputes informally at the project manager level. Disputes that cannot be resolved informally are submitted in writing to, and resolved by, the Interagency Management Integration Team at the executive manager level. If resolution is not achieved at this level, the dispute is forwarded to higher levels of management. As a last resort, the formal dispute resolution processes outlined in the Tri-Party Agreement (Ecology et al., 1989a), Article VIII or XXVI, is used.

To promote dispute avoidance, potential problems will be identified during field preparation planning, and associated contingency/variance plans will be developed.

7 References

08-AMRC-0116, 2008, "Contract No. DE-AC06-05RL14655 – Interface Agreement for Coordination of Groundwater and Vadose Zone Cleanup Programs" (letter to C.G. Spencer, Washington Closure Hanford, LLC, from Stacie L. Sedgwick), U.S. Department of Energy, Richland Operations Office, Richland, Washington, February 11.

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36 CFR 60, "National Register of Historic Places," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_09/36cfr60_09.html.

40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr61_08.html.

61.52, "Emission Standard."
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Appendix A

Summary of Existing CERCLA Documentation

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A1 Introduction

The tables in this appendix, grouped by area, provide information on an operable unit (OU)-by-OU basis for the investigative phase, including work plan development and remedial investigation/feasibility study process, the decision process including records of decision and action memoranda, and the post-record of decision requirements (e.g., remedial design/remedial action documentation). Tables A-1 through A-7 also provide references for 100 Area common investigations and reports that address conditions across multiple OUs. Table A-6 contains four isolated unit OUs that require no further action, and Table A-7 contains 100 Area common investigations and annual remedy performance reviews relevant to some areas.

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Table A-1. Summary of Existing CERCLA Primary Documents and Decisions for the 100-D/H Area

Operable Unit	Work Plan	Remedial Investigation/ Feasibility Study	Decisions	Post-ROD
100-DR-1 Source OU High-priority/primary liquid site Contains soil, buildings, and burial grounds Lead agency: Ecology	DOE/RL-89-09, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-DR-1 Operable Unit, Hanford Site, Richland, Washington.* WHC-SD-EN-TI-181, *100-D Area Technical Baseline Report.*	DOE/RL-92-11, *100 Area Feasibility Study, Phases 1 and 2.* DOE/RL-93-29, *Limited Field Investigation Report for the 100-DR-1 Operable Unit.*DOE/RL-94-64, *100-DR-1 Operable Unit Focused Feasibility Study Report.*DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA/ROD/R10-95/126, *Declaration of the Record of Decision, 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington.* *EPA, Ecology, and DOE, 1997, Amendment to the Record of Decision for the USDOE Hanford 100-BC-1, 100-DR-1, and 100-HR-1 Operable Unit Interim Remedial Actions.* DOE/RL-98-37, *Removal Action Report for the 105-DR and 105-F Building Interim Safe Storage Projects and Ancillary Buildings.* EPA, Ecology, and DOE, 1998, "Action Memorandum 105-F and 105-DR Reactor Buildings and Ancillary Facilities, Hanford Site, Benton County, Washington. EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-00/121, *Declaration of the Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington.* EPA, Ecology, and DOE, 2000, "Action Memorandum 105-D and 105-H Reactor Facilities and Ancillary Facilities, Hanford Site, Benton County, Washington." EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*	DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-DR-2 Source OU Contains soil, buildings, and burial grounds Lead agency: Ecology In April 1994, 100-DR-3 was consolidated into the 100-DR-2 OU	WHC-SD-EN-TI-181, *100-D Area Technical Baseline Report.* DOE/RL-93-46, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-DR-2 Operable Unit, Hanford Site, Richland, Washington.*	DOE/RL-92-11, *100 Area Feasibility Study, Phases 1 and 2.* .DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.* DOE/RL-93-99, *Remedial Investigation and Feasibility Study Report for the Environmental Restoration Disposal Facility.*	DOE/RL-98-37, *Removal Action Report for the 105-DR and 105-F Building Interim Safe Storage Projects and Ancillary Buildings.* EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-00/121, *Declaration of the Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington.* EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*	DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.

Table A-1. Summary of Existing CERCLA Primary Documents and Decisions for the 100-D/H Area

Operable Unit	Work Plan	Remedial Investigation/ Feasibility Study	Decisions	Post-ROD
100-HR-1 Source OU High-priority/primary liquid site Contains soil, buildings, and burial grounds Lead agency: Ecology	DOE/RL-88-35, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-1 Operable Unit Hanford Site, Richland, Washington.* DOE/RL-88-36, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-3 Operable Unit, Hanford Site, Richland, Washington.* BHI-00127, *100-H Area Technical Baseline Report.* DOE/RL-94-101, *Proposed Plan for Interim Remedial Measures at the 100-HR-1 Operable Unit.*	DOE/RL-92-11, *100 Area Feasibility Study, Phases 1 and 2.* DOE/RL-93-51, *Limited Field Investigation Report for the 100-HR-1 Operable Unit.* DOE/RL-94-63, *100-HR-1 Operable Unit Focused Feasibility Study Report.* DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA/ROD/R10-95/126, *Declaration of the Record of Decision, 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington.* EPA, Ecology, and DOE, 1995, "Action Memorandum.183-H Solar Evaporation Basin Waste Expedited Response Action Cleanup Plan, 1996, U.S. Department of Energy, Hanford Site, Richland, Washington." EPA, Ecology, and DOE,1997, *Amendment to the Record of Decision for the USDOE Hanford 100-BC-1, 100-DR-1, and 100-HR-1 Operable Unit Interim Remedial Actions.* EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA, Ecology, and DOE, 2000, "Facilities and Ancillary Facilities, Hanford Site, Benton County, Washington." EPA, Ecology, and DOE, 2003, "Action Memorandum, 200 West Area, Central Waste Complex, 183-H Solar Evaporation Basin Waste, Hanford Site, Benton County, Washington, 2003." EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*	DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-HR-2 Source OU Contains soil, buildings, and burial grounds Lead agency: Ecology	BHI-00127, *100-H Area Technical Baseline Report.*	DOE/RL-92-11, *100 Area Feasibility Study, Phases 1 and 2.* DOE/RL-94-65, *100-HR-2 Operable Unit Focused Feasibility Study.* DOE/RL-94-53, *Limited Field Investigation Report for the 100-HR-2 Operable Unit.*DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-00/121, *Declaration of the Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington.*	DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area,* Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan,* Rev. 4, September 2004.
100-HR-3 Groundwater OU Contains groundwater under and between the 100-DR and 100-H Reactor areas Lead agency: Ecology	DOE/RL-88-35, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-3 Operable Unit, Hanford Site, Richland, Washington.* DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action.*	DOE/RL-92-11, *100 Area Feasibility Study, Phases 1 and 2.* DOE/RL-93-43, *Limited Field Investigation Report for the 100-HR-3 Operable Unit.* DOE/RL-94-67, *100-HR-3 Operable Unit Focused Feasibility Study.* DOE/RL-95-83, *The Pilot-Scale Treatability Test Summary for the 100-HR-3 Operable Unit.*	EPA/ROD/R10-96/134, *Declaration of the Record of Decision, 100-HR-3 and 100-KR-4 Operable Units, Hanford Site, Benton County, Washington.* EPA/AMD/R10-00/122, *Interim Remedial Action Record of Decision Amendment, 100-HR-3 Operable Unit, Hanford Site, Benton County, Washington.* EPA, Ecology, and DOE, 2003, *Explanation of Significant Difference for the HR-3-Operable Unit Record of Decision.*	DOE/RL-96-90, *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units*, Rev. 0, April 1997, (updated by DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*, Rev. 0-A, April 2003). DOE/RL-99-51, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 Groundwater Operable Unit In Situ Redox Manipulation*, Rev. 1, June 2000. DOE/RL-2006-75, *Supplement to 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump-and-Treat System,* Rev. 1, September 2008.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
Ecology = Washington State Department of Ecology
OU = operable unit
ROD = record of decision

Table A-2. Summary of Existing CERCLA Primary Documents and Decisions for the 100-K Area

Operable Unit	Work Plan	Remedial Investigation/ Feasibility Study	Decisions	Post-ROD
100-KR-1 Source OU Contains soil sites contaminated by liquid discharges Lead agency: EPA	DOE/RL-90-20, *Remedial Investigation/Feasibility Study Work Plan for the 100-KR-1 Operable Unit Hanford Site, Richland, Washington.*	DOE/RL-93-78, *Limited Field Investigation Report for 100-KR-1 Operable Unit*, Rev. 0. DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.* EPA and DOE, 2005, "Action Memorandum for the Non-Time-Critical Removal Action for the 100-K Ancillary Facilities.	DOE/RL-98-71, *Proposed Plan for the K Basins Interim Remedial Action*, Rev. 0, April 1999. DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area,* Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004. DOE/RL-2005-26, *Removal Action Work Plan for 105-KE/105-KW Reactor Facilities and Ancillary Facilities,* Rev. 1, February 2007; includes 27 ancillary facilities.
100-KR-2 Source OU Contains soil, buildings, and burial grounds Lead agency: EPA In October 1994, 100-KR-3 was consolidated into the 100-KR-2 OU		DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.* DOE/RL-98-66, *Focused Feasibility Study for the K Basins Interim Remedial Action.* DOE/RL-99-89, *Remedial Design Report and Remedial Action Work Plan for the K Basins Interim Remedial Action.*	EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-99/059, *Declaration of the Record of Decision, 100-KR-2 Operable Unit, Hanford Site, Benton County, Washington.* EPA/ROD/R10-00/121, *Declaration of the Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington.* EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.* DOE/RL-2004-48, *Proposed Plan for an Amendment to the K Basins Interim Remedial Action Record of Decision, Hanford Site, Richland, Washington*, Rev. 1. EPA, 2005, *Interim Remedial Action Record of Decision Amendment 100 K Area K Basins, Hanford Site – 100 Area, Benton County, Washington,* June. EPA and DOE, 2005, "Action Memorandum for the Non-Time-Critical Removal Action for the 100-K Ancillary Facilities."	DOE/RL-98-71, *Proposed Plan for the K Basins Interim Remedial Action*, Rev. 0, April 1999. DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area,* Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004. DOE/RL-2005-26, *Removal Action Work Plan for 105-KE/105-KW Reactor Facilities and Ancillary Facilities,* Rev. 1, February 2007; includes 27 ancillary facilities.

Table A-1. Summary of Existing CERCLA Primary Documents and Decisions for the 100-D/H Area

Operable Unit	Work Plan	Remedial Investigation/ Feasibility Study	Decisions	Post-ROD
100-KR-4 Groundwater OU Contains groundwater under the 100-K Area Lead agency: EPA	DOE/RL-90-21, *Remedial Investigation/Feasibility Study Work Plan for the 100-KR-4 Operable Unit Hanford Site, Richland, Washington.*	DOE/RL-93-79, *Limited Field Investigation Report for the 100-KR-4 Operable Unit.* DOE/RL-94-48, *100-KR-4 Operable Unit Focused Feasibility Study.* DOE/RL-98-66, *Focused Feasibility Study for the K Basins Interim Remedial Action.* DOE/RL-2005-05, *Treatability Test Plan for Fixation of Chromium in the Groundwater at 100-K.*	EPA/ROD/R10-96/134, *Declaration of the Record of Decision 100-HR-3 and 100-KR-4 Operable Units, Hanford Site, Benton County, Washington.*	DOE/RL-94-113, *Proposed Plan for Interim Remedial Measure at the 100-KR-4 Operable Unit*, Rev. 1, September 1995. DOE/RL-96-84, *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units Interim Action*, Rev. 0-A, April 2003. DOE/RL-96-90, *Interim Action Monitoring Plan for the 100-HR-3 and 100-KR-4 Operable Units*, Rev. 0, April 1997 (updated as DOE/RL-96-84, *Remedial Design and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*, Rev. 0-A, April 2003). DOE/RL-2006-52, *The KW Pump and Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 Groundwater Operable Unit Interim Action*, Rev. 1, December 2006. DOE/RL-2006-75, *Supplement to 100-HR-3 and 100-KR-4 Remedial Design Report and Remedial Action Workplan for the Expansion of the 100-KR-4 Pump-and-Treat System*, Rev. 0, December 2007.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
Ecology = Washington State Department of Ecology
OU = operable unit
ROD = record of decision

Table A-3. Summary of Existing CERCLA Primary Documents and Decisions for the 100-B/C Area

Operable Unit	Work Plan	Remedial Investigation/ Feasibility Study	Decisions	Post-ROD
100-BC-1 Source OU High-priority/primary liquid site Contains soil, building structures and burial grounds Lead agency: EPA	DOE/RL-90-07, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-1 Operable Unit Hanford Site, Richland, Washington.*	DOE/RL-92-11, *100 Area Feasibility Study Phases 1 and 2.* DOE/RL-93-06, *Limited Field Investigation Report for the 100-BC-1 Operable Unit.* DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA, 1995, "Action Memorandum: Expedited Response Action Proposal; 100-BC-1 Demonstration Project; U.S. Department of Energy Hanford Site; Richland, Washington." EPA/ROD/R10-95/126, *Declaration of the Record of Decision, 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington.* EPA, 1997, "Approved Action Memorandum for the 100-B/C Area Ancillary Facilities and the 108-F Building Removal Action, U.S. Department of Energy Hanford Site, Richland, WA." EPA/AMD/R10-97/044, *Amendment to the Record of Decision, 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-00/121, *Declaration of the Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington.* EPA and DOE, 2001, "Action Memorandum 105-B Reactor Facility, Hanford Site, Benton County, Washington. EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*	DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-BC-2 Source OU Contains soil, building structures, and burial grounds Lead agency: EPA In February 1994, 100-BC-3 and 100-BC-4 were consolidated into 100-BC-2	DOE/RL-91-07, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-2 Operable Unit Hanford Site, Richland, Washington.*	DOE/RL-92-11, *100 Area Feasibility Study Phases 1 and 2.* DOE/RL-94-42, *Limited Field Investigation Report for the 100-BC-2 Operable Unit.* DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-00/121, *Declaration of the Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington.* EPA, Ecology, and DOE, 2001, "Action Memorandum for 105-D and 105-H Reactor Buildings and Ancillary Facilities, Hanford Site, Benton County, Washington." EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision,* February.	DOE/RL-97-37, *Sampling and Analysis Plan for Release of the 105-C Below-Grade Structures and Underlying Soils*, Rev. 0, February 1998. DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-BC-5 Groundwater OU Contains groundwater under the 100-B/C Area Lead agency: EPA There is no cleanup ROD or action remedy for the 100-BC-5 OU, only the monitoring of existing conditions	DOE/RL-90-08, *Remedial Investigation/Feasibility Study Work Plan for the 100-BC-5 Operable Unit Hanford Site, Richland, Washington.*	DOE/RL-92-11, *100 Area Feasibility Study Phases 1 and 2.* DOE/RL-93-37, *Limited Field Investigation Report for the 100-BC-5 Operable Unit.* DOE/RL-94-112, *Proposed Plan for Interim Decision at the 100-BC-5 Operable Unit, Hanford Site, Richland, Washington.*		PNNL-13326, *Groundwater Sampling and Analysis Plan for the 100-BC-5 Operable Unit*, September 2000.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
Ecology = Washington State Department of Ecology
OU = operable unit
ROD = record of decision

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Table A-4. Summary of Existing CERCLA Primary Documents and Decisions for 100-F and Isolated Units 100-IU-2 and 100-IU-6

Operable Unit	Work Plan	Remedial Investigation/ Feasibility Study	Decisions	Post-ROD
100-FR-1 Source OU High-priority/primary liquid site Lead agency: EPA	DOE/RL-90-33, *Remedial Investigation/Feasibility Study Work Plan for the 100-FR-1 Operable Unit Hanford Site, Richland, Washington.*	DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.* DOE/RL-93-82, *Limited Field Investigation Report for the 100-FR-1 Operable Unit.*	DOE/RL-98-37, *Removal Action Report for the 105-DR and 105-F Building Interim Safe Storage Projects and Ancillary Buildings.* EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-00/121, *Declaration of the Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington.* EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*	DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-FR-2 Source OU Contains soil, buildings, and burial grounds Lead agency: EPA		DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	DOE/RL-98-37, *Removal Action Report for the 105-DR and 105-F Building Interim Safe Storage Projects and Ancillary Buildings.* EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ROD/R10-00/121, Declaration *of the Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-2, and 100-KR-2 Operable Units, Hanford Site (100 Area Burial Grounds), Benton County, Washington.* EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*	DOE/RL-96-17, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, Rev. 5, September 2004. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-FR-3 Groundwater OU Lead agency: EPA		DOE/RL-93-83, *Limited Field Investigation Report for the 100-FR-3 Operable Unit.*		PNNL-13327, *Groundwater Sampling and Analysis Plan for the 100-FR-3 Operable Unit*, September 2000.
100-IU-2 Source OU White Bluffs Townsite area Lead agency: EPA		DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*	DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-IU-6 Source OU Hanford Townsite area Lead agency: EPA		DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA/ROD/R10-99/039, *Interim Action Record of Decision, 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-HR-2, 10-KR-1, 100-KR-2, I00-IU-2, 100-IU-6, and 200-CW-3 Operable Units, Hanford Site, Benton County, Washington.* EPA/ESD/R10-00/045, *Explanation of Significant Difference for the 100 Area Remaining Sites ROD, USDOE Hanford 100 Area, 100-IU-6 Operable Area.* EPA, Ecology, and DOE, 2004, *Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*	DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
Ecology = Washington State Department of Ecology
OU = operable unit
ROD = record of decision

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Table A-5. Summary of Existing CERCLA Primary Documents and Decisions for the 100-N Area

Operable Unit	Work Plan	Remedial Investigation/ Feasibility Study	Decisions	Post-ROD
100-NR-1 Source Operable Unit Contains soil, buildings, and burial grounds (includes consolidated 100-NR-3 sites) Lead agency: Ecology	DOE/RL-90-23, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-3 Operable Unit, Hanford Site, Richland, Washington.* DOE/RL-90-22, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-1 Operable Unit, Hanford Site, Richland, Washington.*	DOE/RL-92-11, *100 Area Feasibility Study Phases 1 and 2.* DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.* DOE/RL-93-80, *Limited Field Investigation for 100-NR-1 Abatement Assessment.*	EPA, Ecology, and DOE, 1996b, "Action Memorandum N Area Waste Expedited Response Action Cleanup Plan, U.S. Department of Energy, Hanford Site, Richland, WA." EPA, Ecology, and DOE, 1999, "Action Memorandum 100-N Area Ancillary Facilities, Hanford Site, Benton County, Washington." EPA/ROD/R10-99/112, *Interim Remedial Action Record of Decision, U.S. Department of Energy / Hanford 100 Area, 100-NR-1 and 100-NR-2 Operable Units.* EPA/ROD/R10-00/120, *Interim Remedial Action Record of Decision, U.S. Department of Energy 100 Area, 100-NR-1 Operable Unit.* EPA, Ecology, and DOE, 2003,, *Explanation of Significant Difference for the 100-NR-1 Operable Unit Treatment, Storage, and Disposal Interim Action Record of Decision and 100-NR-1/100-NR-2 Operable Unit Interim Action Record of Decision.* Ecology, 2005, "Action Memorandum 105-N Reactor Facility and 100-N Heat Exchanger Building, Hanford Site, Benton County, Washington.	DOE, "Notice of Change to the Waste Volume Estimates in the N Area Waste Expedited Response Action Memorandum," March 1997. DOE, "Inclusion of 105-N Roof Waste in the Future Action Memorandum for the 100-N Area Ancillary Facilities," September 1998. DOE, "Final Waste Volumes for N Area Project and Clarification to the N Area Waste Expedited Response Action Memorandum," December 1998. Ecology, "Replacement Page 30 of Table 3 of Interim Remedial Action Record of Decision for 100-NR-1 and 100-NR-2 OU of Hanford 100-N Area," October 1999. Ecology, "Replacement of Appendix B in Interim Remedial Action Record of Decision for 100-NR-1 and 100-NR-2 OU," November 1999. DOE/RL-2000-16, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-1 Treatment, Storage, and Disposal Units*, Rev. 2, March 2001. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-NR-2 Groundwater Operable Unit Groundwater under the 100-N and Shoreline site N Springs Lead agency: Ecology	DOE/RL-90-22, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-1 Operable Unit, Hanford Site, Richland, Washington.* DOE/RL-91-46, *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-NR-2 Operable Unit, Hanford Site, Richland, Washington.*	DOE/RL-92-11, *100 Area Feasibility Study Phases 1 and 2.* DOE/RL-93-81, *Limited Field Investigation Report for the 100-NR-2 Operable Unit, Hanford Site Richland, Washington.*	DOE/RL-93-231994, *N Springs Expedited Response Action Proposal*, Rev. 0. Ecology, 1997a,"Action Memorandum: N Springs Expedited Response Action Cleanup Plan." DOE,1995, "Request to Change N Springs Action Memorandum." DOE, 1997, "Clarification to Language in Action Memorandum: N Springs Expedited Response Action Cleanup Plan and Modification of Performance Monitoring for N Springs Pump and Treat." EPA/ROD/R10-99/112, *Interim Remedial Action Record of Decision, U.S. Department of Energy / Hanford 100 Area, 100-NR-1 and 100-NR-2 Operable Units.* Ecology, 1999b, "Replacement Page 30 of Table 3 of Interim Remedial Action Record of Decision for 100-NR-1 and 100-NR-2 OU of Hanford 100-N Area1999." EPA/ROD/R10-00/120, *Interim Remedial Action Record of Decision, U.S. Department of Energy 100 Area, 100-NR-1 Operable Unit.* EPA, Ecology, and DOE, 2003, *Explanation of Significant Difference for the 100-NR-1 Operable Unit Treatment, Storage, and Disposal Interim Action Record of Decision and 100-NR-1/100-NR-2 Operable Unit Interim Action Record of Decision.*	DOE/RL-2001-27, *Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, Draft A, November 2001.

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Ecology = Washington State Department of Ecology
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Table A-6. Summary of Existing CERCLA Primary Documents and Decisions for Remaining 100-IU Areas

Operable Unit	Work Plan	Remedial Investigation/Feasibility Study	Decisions	Post-ROD
100-IU-1 Source OU Riverland railroad wash station Lead agency: EPA	DOE/RL-95-60, *Proposed Plan for the 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units.*	DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA, 1993, "Action Memorandum: Expedited Response Action Proposal; Riverland Site, U.S. Department of Energy Hanford Site, Richland, Washington." PA/ROD/R10-96/151, *Declaration of the Record of Decision, USDOE Hanford 100 Area, 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units.*	DOE/RL-94-30, *Riverland Expedited Response Action Assessment*, Rev. 0, June 1995. EPA, "Notice of partial deletion of the Hanford 100-Area (USDOE) Superfund site from the National Priorities List," July 1998. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-IU-3 OU North slope or Wahluke Slope" Lead agency: Ecology	DOE/RL-93-47, *North Slope (Wahluke Slope) Expedited Response Action Cleanup Plan.* DOE/RL-95-60, *Proposed Plan for the 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units.*	DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	Ecology and DOE, 1997, "Action Memorandum 100-IU-3 Operable Unit (Wahluke Slope), Hanford Site, Adams, Grant, and Franklin Counties, Washington." EPA/ROD/R10-96/151, *Declaration of the Record of Decision, 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units, Hanford Site, Benton County, Washington.*	EPA, "Notice of partial deletion of the Hanford 100-Area (USDOE) Superfund site from the National Priorities List," July 1998. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-IU-4 OU Buried sodium dichromate drums Lead agency: Ecology	DOE/RL-95-60, *Proposed Plan for the 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units.*	DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	Ecology, 1993, "Action Memorandum Approval: Sodium Dichromate Barrel Landfill, U.S. Department of Energy Hanford Site, Richland, WA." EPA/ROD/R10-96/151, *Declaration of the Record of Decision, 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units, Hanford Site, Benton County, Washington.*	DOE/RL-93-25, *Sodium Dichromate Barrel Landfill Expedited Response Action Proposal*, September 1993. DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.
100-IU-5 OU Pickling acid cribs Lead agency: EPA	DOE/RL-95-60, *Proposed Plan for the 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units.*	DOE/RL-94-61, *100 Area Source Operable Unit Focused Feasibility Study.*	EPA/ROD/R10-96/151, *Declaration of the Record of Decision, 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units, Hanford Site, Benton County, Washington.*	DOE/RL-96-22, *100 Area Remedial Action Sampling and Analysis Plan*, Rev. 4, September 2004.

Note: These operable units have undergone final CERCLA actions.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

Ecology = Washington State Department of Ecology

EPA = U.S. Environmental Protection Agency

OU = operable unit

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Table A-7. Summary of 100-Area Common Investigations and Reports Mandated by CERCLA

100 Area Risk Assessment Documentation	100 Area Groundwater Reports	100 Area Annual CERCLA Remedy Performance
These documents describe the plan, scope, and results of risk assessment activities to support cleanup decision making for the 100 Area.	These reports provide details of the nature and extent of groundwater contamination for all groundwater operable units in the 100 Area.	These reports provide a summary of the performance of the interim actions selected for the 100 Area. They discuss not just monitoring, but also the characteristics of the plume, analyze requirements of the remedial design/remedial action work plan, remedy performance information. Only for locations with decisions on chromium cleanup groundwater remedies for sites 100-HR-3, 100-KR-4, and 100-NR-2.
DOE/RL-2004-37, *Risk Assessment Work Plan for the 100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment (RCBRA)*, Rev. 2, May 2005. DOE/RL-2005-42, *100 Area and 300 Area Component of RCBRA Sampling and Analysis Plan,* Rev. 1, November 2006. DOE/RL-2007-21, *Risk Assessment Report for the100 Area and 300 Area Component of the River Corridor Baseline Risk Assessment*, Draft A, June 2007.	Groundwater monitoring plans for each area (already listed in Table 2-2 through Table 2-7). PNNL-16346, *Hanford Site Groundwater Monitoring for Fiscal Year 2006,* March 2007. DOE/RL-2008-01, *Hanford Site Groundwater Monitoring for Fiscal Year 2007,* Rev. 0, March 2008.	DOE/RL-2006-08, *Calendar Year 2005 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operations*, Rev. 0, May. *DOE/RL-2006-76,* Calendar Year 2006 Annual Summary Report for 100-HR-3, 100-KR-4 and 100-NR-2 Operable Units Pump-and-Treat Operations, Decisional Draft, May 2007.

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OU = operable unit

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Appendix B

Identification of Potential Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

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B1 Introduction

This appendix also provides U.S. Environmental Protection Agency (EPA) Region 6 screening levels. EPA Region 10 risk evaluation unit calls for the use of these Region 6 screening levels because they are updated regularly.

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173-303-077, "Requirements for Universal Waste."
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246-247-035, "National standards adopted by reference for sources of radionuclide emissions."

246-247-040, "General Standards."

246-247-075, "Monitoring, Testing and Quality Assurance."

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Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
CHEMICAL-SPECIFIC ARARs				
***Safe Drinking Water Act of 1974*; 40 CFR 141, "National Primary Drinking Water Regulations"**				
40 CFR 141.61, "Maximum contaminant levels for organic contaminants" 40 CFR 141.50, "Maximum contaminant level goals for organic contaminants"	Establishes MCLs and MCL goals as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of organic contaminants in the drinking water.	Groundwater in the 100 Area contains contaminants that require remediation; it is not currently used for drinking water but is a potential drinking water source and it discharges into the Columbia River (which is used for drinking water).	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).
40 CFR 141.62, "Maximum contaminant levels for inorganic contaminants" 40 CFR 141.51, "Maximum contaminant level goals for inorganic contaminants"	Establishes MCLs and MCL goals as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of inorganic contaminants in the drinking water.	Groundwater in the 100 Area contains contaminants that require remediation; it is not currently used for drinking water but is a potential drinking water source and it discharges into the Columbia River (which is used for drinking water).	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).
40 CFR 141.66, "Maximum contaminant levels for radionuclides" 40 CFR 141.55, "Maximum contaminant level goals for radionuclides"	Establishes MCLs and MCL goals as criteria for groundwater and surface water that are or may be used for drinking water. The standards/goals are designed to protect human health from adverse effects of inorganic contaminants in the drinking water.	Groundwater in the 100 Area contains contaminants that require remediation; it is not currently used for drinking water but is a potential drinking water source and it discharges into the Columbia River (which is used for drinking water).	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
Clean Water Act of 1977; **40 CFR 131, "Water Quality Standards"**				
40 CFR 131.10, "Designation of uses"	Establishes numeric water quality criteria for the protection of human health and aquatic organisms. Toxic criteria for the protection of aquatic life is provided in the water quality criteria regulations 40 CFR 131.36(b)(1), "EPA's Section 304(a), Criteria for Priority Toxic Pollutants," which supersede criteria adopted by the state, except where the state criteria are more stringent than the federal criteria.	Groundwater in the 100 Area contains contaminants that require remediation; groundwater also discharges into the Columbia River.	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).
Toxic Substances Control Act (TSCA); **40 CFR 761, "Polychlorinated Biphenyls Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions"**				
40 CFR 761.50(b)1, 2, 3, 4 and 7, "Applicability," "PCB Waste" 40 CFR 761.50(c), "Applicability," "Storage for Disposal"	Establishes general PCB disposal requirements for the storage and disposal of PCB wastes including liquid PCB wastes, PCB items, PCB remediation waste, PCB bulk product wastes, and PCB/radioactive wastes at concentrations greater than 50 ppm.	PCB wastes may be encountered and or generated during the RI and subsequent remediation of the 100 Area.	ARAR	Soil excavation and remediation, equipment and debris handling and disposal, and IDW management and disposal.
40 CFR 761.60(a), "Disposal Requirements" "PCB liquids" 40 CFR 761.60(b), "Disposal Requirements" "PCB Articles" 40 CFR 761.60(c), "Disposal Requirements" "PCB Containers"	Establishes requirements applicable to the handling and disposal of PCB liquids, PCB articles, and PCB containers.	PCB liquids, articles, and/or containers may be encountered and or generated during the RI and subsequent remediation of the 100 Area.	ARAR	Equipment and debris handling, storage, and disposal; IDW management and disposal.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
40 CFR 761.61, "PCB remediation waste"	Provides cleanup and disposal options for PCB remediation waste based on the concentration at which the PCBs are found.	PCB remediation wastes may be encountered and or generated during the RI and subsequent remediation of the 100 Area.	ARAR	Soil remediation, RTD, and IDW management and disposal.
***Clean Air Act of 1977;* 40 CFR 60, "Standards of Performance for New Stationary Sources"**				
40 CFR 60, "Standards of Performance for New Stationary Sources"	Applies to specific stationary sources that emit toxic air pollutants where construction or modification of the facility commences after the effective date of any standard promulgated in this regulation.	Target analytes detected in soil and groundwater within the 100 Area include constituents that would constitute hazardous air pollutants if released to the air.	ARAR	Soil and groundwater remediation activities such as treatment systems that have the potential to emit regulated hazardous air pollutants and are considered a new source.
***Clean Air Act of 1977;* 40 CFR 61, "National Emission Standard for Hazardous Air Pollutants"**				
40 CFR 61.01, "Lists of pollutants and applicability of part 61" 40 CFR 61.05, "Prohibited activities" 40 CFR 61.12, "Compliance with standards and maintenance requirements" 40 CFR 61.14, "Monitoring requirements"	Provides general requirements for facility operations that emit regulated hazardous air pollutants. The regulation applies to any stationary source for which a standard has been prescribed.	Target analytes detected in soil and groundwater within the 100 Area include constituents that would constitute hazardous air pollutants if released to the air.	ARAR	Soil and groundwater remediation activities such as treatment systems that have the potential to emit regulated hazardous air pollutants subject to this part.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
40 CFR 61.92, "Standard" (National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities)	Requires that emissions of radionuclides to the ambient air from DOE facilities shall not exceed amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.	Target analytes detected in soil and groundwater in the 100 Area include constituents that would constitute radionuclides regulated as hazardous air pollutants.	ARAR	Soil and groundwater remedial activities (e.g., RTD, soil vapor extraction, decontamination, and demolition) implemented during the RI/FS t.hat have the potential to emit hazardous radionuclides.
***Clean Air Act of 1977;* 40 CFR 61 Subpart M, "National Emission Standard for Asbestos"**				
40 CFR 61.140, "Applicability" 40 CFR 61.145, "Standard for demolition and renovation"	Defines regulated ACM and regulated removal and handling requirements. Specifies sampling, inspection, handling, and disposal requirements for regulated sources having the potential to emit asbestos. Specifically, no visible emissions are allowed during handling, packaging, and transport of ACM.	Encountering ACM on pipelines or buried asbestos within the 100 Area is possible during the RI and/or during remediation activities.	ARAR	Site investigation and remediation activities that include demolition and/or renovation and associated handling, packaging and transportation of ACM, including IDW management and disposal.
40 CFR 61.150, "Standard for waste disposal for manufacturing, fabricating, demolition, renovation, and spraying operations"	Identifies requirements for the removal and disposal of asbestos from demolition and renovation activities.	Encountering ACM on pipelines or buried asbestos within the 100 Area is possible during the RI and/or during remediation activities.	ARAR	Site investigation and remediation activities that include demolition and/or renovation and associated handling, packaging and transportation of ACM including IDW management and disposal.
***Clean Air Act of 1977;* 40 CFR 50, "National Primary and Secondary Ambient Air Quality Standards"**				
40 CFR 50.7, "National primary and secondary ambient air quality standards for ambient air quality standards for $PM_{2.5}$"	Establishes primary and secondary air quality standards for particulate matter, which are 15 $\mu g/m^3$ annually or 65 $\mu g/m^3$ per 24-hour average concentration. This requirement is applicable to airborne releases of radionuclides and criteria pollutants.	Soil and groundwater target analytes detected in the 100 Area include radionuclides that may be generated during characterization or remedial actions. Although national primary and secondary ambient air quality standards for particulate matter is not an ARAR, it should be considered if RIs or treatment operations	TBC	Soil and groundwater remediation (e.g., RTD).

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
		raise emissions above the standard.		
	Radionuclide ARAR Dose Compliance Concentrations for Superfund			
OSWER Directive 9200.4-18, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination* OSWER Directive 9200.4-31P, *Distribution of OSWER Radiation Risk Assessment Q&A's Final Guidance*	This memorandum presents clarification for establishing protective cleanup levels in media for radioactive contamination at CERCLA sites. The EPA has determined that the dose limits established by the NRC in 62 FR 39058, "Radiological Criteria for License Termination Final Rule" (25 mrem/yr which is equivalent to 5×10^{-4} increase lifetime risk) will not provide a protective basis for establishing PRGs under CERCLA. A dose of 15 mrem/yr effective dose (approximately equivalent to 3×10^{-4} increase in lifetime risk) is preferred as the maximum dose limit for humans. In the final guidance, EPA further clarifies that 15 mrem/yr is not a presumptive cleanup level under CERCLA. Rather, site decision makers should continue to use the CERCLA risk range when ARARs are not used to set cleanup levels. This is for several reasons, as using dose based guidance would result in unnecessary inconsistency regarding how radiological and nonradiological (chemical) contaminants are addressed at CERCLA sites.	Target analytes detected in soil and groundwater in the 100 Area include constituents that would constitute radionuclides regulated as NESHAPs.	TBC	Development of media cleanup levels.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
		LOCATION-SPECIFIC ARARs		
		Archaeological and Historic Preservation Act of 1974		
40 CFR 6.301(c), "Applicant Requirements"	Requires that remedial actions do not cause the loss of any archaeological or historic data. This act mandates preservation of the data; it does not require protection of the actual waste site or facility.	Archaeological and historic sites have been identified within the 100 Area.	ARAR	Investigation and remediation activities that occur in areas near archeological or historic sites.
		National Historic Preservation Act of 1966		
36 CFR 800, "Protection of Historic Properties" 40 CFR 6.301(b), "Applicant Requirements" Executive Order 11593, *Protection and Enhancement of the Cultural Environment* 36 CFR 65, "National Historic Landmarks Program" 36 CFR 60, "National Register of Historic Places"	Requires federal agencies to consider the impacts of their undertaking on cultural properties through identification, evaluation, mitigation processes, and consultation with interested parties.	Cultural and historic sites have been identified within the 100 Area.	ARAR	Investigation and remediation activities that occur in areas near cultural or historic sites.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
***Native American Graves Protection and Repatriation Act of 1990;* 43 CFR 10, "Native American Graves Protection and Repatriation Regulations"**				
43 CFR 10, "Native American Graves Protection and Repatriation Regulations"	Establishes federal agency responsibility for discovery of human remains, associated and unassociated funerary objects, sacred objects, and items of cultural patrimony. Requires Native American consultation in the event of discovery.	Native American archaeological, cultural, and historic sites have been identified within the 100 Area; Native American remains and associated objects may be present.	ARAR	Investigation and remediation activities that occur in areas near Native American archaeological, cultural, and historic sites that contain associated remains and objects.
Endangered Species Act of 1973				
50 CFR 402, "Interagency Cooperation—Endangered Species Act of 1971, as amended" 40 CFR 6.302(c), "Responsible Official Requirements"	Prohibits actions by federal agencies that are likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of habitat critical to them. Mitigation measures must be applied to actions that occur within critical habitats or surrounding buffer zones of listed species, in order to protect the resource.	Federal endangered and/or threatened species including fish, plants, and animals are found within the 100 Area.	ARAR	Remediation actions and investigation activities that occur within critical habitats or designated buffer zones of federal listed species.
Floodplain Management, Executive Order 11988				
Executive Order 11988, *Floodplain Management* 10 CFR 1022, "Compliance with Floodplain and Wetland Environmental Review Requirements"	Take action to avoid adverse effects, minimize potential harm, and restore and preserve natural and beneficial values of the floodplain.	Some of the waste sites within the 100 Area subject to remediation are located within the Columbia River floodplain.	ARAR	Remedial actions will occur in the floodplain.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
		ACTION-SPECIFIC ARARs		
		***Safe Drinking Water Act of 1974;* 40 CFR 144, "Underground Injection Control Program"; and 40 CFR 146, "Underground Injection Control Program Criteria and Standards"**		
40 CFR 144, "Underground Injection Control Program" 40 CFR 146, "Underground Injection Control Program: Criteria and Standards"	Establishes criteria and standards for an underground injection control program.	Groundwater in the 100 Area contains contaminants that require remediation; treated groundwater may be discharged through underground injection wells.	ARAR	Groundwater remedial activities may involve underground injection.
		***Clean Air Act of 1977;* 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants"**		
40 CFR 61.05, "Prohibited Activities"	Identifies prohibited activities from stationary sources of air pollutants including operating a stationary source that is in violation of any national emission standard unless specifically exempted; or operating any existing source that is subject to national emission standards, in violation of the standards.	Target analytes detected in soil and groundwater in the 100 Area include constituents that would be subject to NESHAPs requirements.	ARAR	Investigative and remedial actions from stationary sources that have the potential to emit regulated hazardous air pollutants (e.g., vapor extraction systems, decontamination stations, and waste storage structures).
40 CFR 61.12, "Compliance with Standards and Maintenance Requirements"	Requires the owner and operator of each stationary source to maintain and operate the source and associated air pollution control equipment in a manner that minimizes emissions.	Target analytes detected in soil and groundwater in the 100 Area include constituents that would be subject to NESHAPs requirements.	ARAR	Investigative and remedial actions from stationary sources that have the potential to emit regulated air pollutants (e.g., vapor extraction systems, waste decontamination stations, waste storage structures).

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application
40 CFR 61.14, "Monitoring Requirements"	Requires the owner and operator to maintain and operate each monitoring system in a manner consistent with air pollution control practices for minimizing emissions.	Soil, air, and groundwater in the 100 Area contain target analytes that include NESHAPs regulated hazardous air pollutants that will need to be monitored.	ARAR	Investigative and remedial soil, air, groundwater monitoring systems and decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums, that may produce airborne emissions of radioactive particulates to unrestricted areas.
40 CFR 61.92, "Standard" (National Emission Standards for Hazardous Air Pollutants)	Limits exposure of radioactive contamination release to an equivalent of 10 mrem/yr for an offsite receptor.	Soil, air, and groundwater in the 100 Area contain target analytes (radionuclides) that if released into the air, would be subject to radionuclide emission requirements.	ARAR	Remediation activities including decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums, each of which may provide airborne emissions of radioactive particulates to unrestricted areas.
40 CFR 61.93, "Emission monitoring and test procedures"	Specifies that radionuclide emission measurements shall be made at all release points that have the potential to discharge radionuclides to the air in quantities that cause an effective dose equivalent in excess of 1percent of the standard. The regulation also requires that all radionuclides which could contribute greater than 10 percent of the potential dose equivalent for a release point be measured.	Soil, air, and groundwater in the 100 Area contain target analytes (radionuclides) that if released into the air, would be subject to NESHAPs radionuclide emission requirements.	ARAR	Remediation activities including decontamination and stabilization of contaminated structures, treatment of sludge, and operation of exhausters and vacuums, each of which may provide airborne emissions of radioactive particulates to unrestricted areas.

Table B-1. Identification of Potential Federal Applicable or Relevant and Appropriate Requirements and to be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Potential Relevancy	Possible Application

NOTE: The references cited in this table are included in the references section of this appendix.

ACM = asbestos containing material.
ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
CFR = *Code of Federal Regulations.*
DOE = U.S. Department of Energy.
EPA = U.S. Environmental Protection Agency.
IDW = investigation derived waste.
MCL = maximum contaminant level.
MNA = monitored natural attenuation.
NESHAP = National Emissions Standards for Hazardous Air Pollutant.
NRC = U.S. Nuclear Regulatory Commission.
PCB = polychlorinated biphenyl.
PRG = preliminary remediation goal.
RI = remedial investigation.
RI/FS = remedial investigation/feasibility study.
RTD = removal, treatment, and disposal.
TBC = to be considered.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
		CHEMICAL-SPECIFIC ARARs		
		***Model Toxics Control Act;* WAC 173-340, "Model Toxics Control Act – Cleanup"**		
WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards"	Establishes soil cleanup levels where residential land use represents the reasonable maximum exposure under both current and future site use conditions. Cleanup standards require specification of the following: hazardous substance concentrations that protect human health and the environment (clean up levels), the location of the site where clean up levels must be attained ("points of compliance"), and other regulatory requirements that apply to the clean up action because of the type of action or location of the site. These requirements are specified in the applicable state and federal laws and are generally established in conjunction with the selection of a specific cleanup action.	Soil in the 100 Area contains contaminants that require remediation. The human health conceptual exposure model for the 100 Area is considered rural residential land use. This land use assumes the reasonable maximum exposure to soil will be unrestricted by future users and therefore corresponds to Method B soil cleanup levels.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceed Method B cleanup levels at the point of compliance.
WAC 173-340-747, "Deriving Soil Concentrations for Ground Water Protection"	Establishes soil cleanup levels where residential land use represents the reasonable maximum exposure under both current and future site use conditions. Cleanup standards require specification of the following: hazardous substance concentrations that protect human health and the environment (cleanup levels), the location of the site where cleanup levels must be attained ("points of compliance"), and other regulatory requirements that apply to the cleanup action because of the type of action or location of the site. These requirements are specified in the applicable state and federal laws and are generally established in conjuncture with the selection of a specific cleanup action.	Soil in the 100 Area contains contaminants that require remediation. The human health conceptual exposure model for the 100 Area is considered rural residential land use. This land use assumes the reasonable maximum exposure to soil will be unrestricted by future users.	ARAR	Soil cleanup actions where concentration of hazardous substances in the soil exceeds soil concentration for protection of groundwater at the point of compliance.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-340-720, "Ground Water Cleanup Standards" WAC 173-340-720(4), "Method B Cleanup Levels for Potable Ground Water" WAC 173-340-720(7), "Adjustments to Cleanup Levels"	Groundwater cleanup levels are based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions. Groundwater cleanup levels are established at concentrations that do not directly or indirectly cause violations of surface water, sediments, soil, or air cleanup standards.	Groundwater in the 100 Area contains contaminants that require remediation; it is not currently used for drinking water but is a potential drinking water source and it discharges into the Columbia River (which is used for drinking water).	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).
WAC 173-340-730, "Surface Water Cleanup Standards"	Surface water cleanup levels are based on estimates of the highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions.	Groundwater in the 100 Area contains contaminants that require remediation and discharges into the Columbia River. The Columbia River is a current and future source of drinking water.	ARAR	Soil, groundwater, and surface water remediation activities that impact surface water.
WAC 173-340-7490, "Terrestrial Ecological Evaluation Procedures" WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures" WAC 173-340-7494, "Priority Contaminants of Ecological Concern"	Defines goals and procedures for determining whether a release of hazardous substances to soil may pose a threat to the terrestrial environment. Characterizes existing or potential threats to terrestrial plants or animals exposed to hazardous substances in soil; and establishes site-specific cleanup standards for the protection of terrestrial plants and animals.	Soil in the 100 Area contains contaminants that require evaluation to determine if ecological exposures have the potential to cause significant adverse effects.	ARAR	Soil remediation activities including containment, RTD, and MNA.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
***Hazardous Waste Management Act of 1976;* WAC 173-303, "Dangerous Waste Regulations"**				
WAC 173-303-645 (3), "Releases from Regulated Units"	Provides standards for groundwater protection including background, MCLs, and ACLs. The MCLs are established at the same levels as SDWA MCLs, and where SDWA MCLs do not exist, health based ACLs may be established that are protective of human health and environment.	Some 100 Area are regulated under state dangerous waste regulations and require groundwater remediation.	ARAR	Groundwater remediation and management (e.g., discharge of treated groundwater, in situ remediation of groundwater, and MNA).
***Water Pollution Control Act;* WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington"**				
WAC 173-201A-240(3), "Toxic Substances"	Establishes water quality standards for surface waters of the State of Washington consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife.	Groundwater in the 100 Area contains contaminants that require remediation and discharges into the Columbia River. The use designations for the Columbia River include aquatic life use (spawning and rearing), primary contact recreation, water supply (drinking, irrigation, and agriculture), and miscellaneous uses (wildlife habitat, harvesting, commerce, boating, and aesthetics).	ARAR	Soil, groundwater, and surface water remediation activities that impact surface water.
LOCATION-SPECIFIC ARARs				
***Habitat Buffer Zone for Bald Eagle Rules;* WAC 232-12-292, "Bald Eagle Protection Rules"**				
WAC 232-12-292, "Bald Eagle Protection Rules"	Protects eagle habitat to maintain eagle populations so the species is not classified as threatened, endangered, or sensitive in Washington State.	Bald eagles nest, feed, and overwinter along the shores of the Columbia River.	ARAR	Investigative and remediation activities that impact bald eagle habitat.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
ACTION-SPECIFIC ARARs				
***Hazardous Waste Management Act of 1976;* WAC 173-303, "Dangerous Waste Regulations"**				
WAC 173-303-016, "Identifying Solid Waste" WAC 173-303-017, "Recycling Processes Involving Solid Waste"	Establishes criteria for solid and recycled solid wastes.	Solid wastes and/or recycled solid wastes may be generated during the 100-Area RI/FSs.	ARAR	Investigative and remediation activities.
WAC 173-303-070, "Designation of Dangerous Waste"	Establishes the method for determining if a solid waste is a dangerous waste (or an extremely hazardous waste).	Dangerous/hazardous waste may be generated during the 100 Area RI/FSs.	ARAR	Investigative and remediation (including waste treatment) activities that generate wastes (e.g., drums, barrels, tanks, containers, bulk wastes, debris, and contaminated soil).
WAC 173-303-073, "Conditional Exclusion of Special Wastes"	Establishes the conditional exclusion and the management requirements of special wastes, as defined in WAC 173-303-040.	Special wastes may be generated during the 100 Area RI/FSs.	ARAR	FS remediation activities (disposal, storage, recycling, and onsite treatment) that manage special wastes consistent with the requirements of the Washington Administrative Code.
WAC 173-303-077, "Requirements for Universal Waste"	Identifies those wastes exempted from regulation under WAC 173-303-140 and WAC 173-303-170 through 173-303-9907 (excluding WAC 173-303-960). These wastes are subject to regulation under WAC 173-303-573.	Universal wastes may be generated during the 100 Area RI/FSs.	ARAR	FS remediation activities (disposal, storage, recycling, and onsite treatment) that manage universal wastes consistent with the requirements of the Washington Administrative Code.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-303-120, "Recycled, Reclaimed, and Recovered Wastes" WAC 173-303-120(3), "Recycled, Reclaimed, and Recovered Wastes" WAC 173-303-120(5), "Recycling of Used Oil"	These regulations define the requirements for the recycling of materials that are solid and dangerous waste. Specifically, WAC 173-303-120(3) provides for the management of certain recyclable materials, including spent refrigerants, antifreeze, and lead acid batteries. WAC 173-303-120(5) provides for the recycling of used oil.	Recycled, reclaimed, and recovered wastes may be generated during the 100 Area RI/FSs.	ARAR	FS remediation recycling activities consistent with the requirements of the *Washington Administrative Code* and are not otherwise subject to CERCLA as hazardous substances.
WAC 173-303-140, "Land Disposal Restrictions"	This regulation establishes treatment requirements and disposal prohibitions for land disposal of dangerous waste and incorporates by reference (WAC 173-303-140[2)][a], "Land Disposal Restrictions") the federal land disposal restrictions of 40 CFR 268, "Land Disposal Restrictions," that are applicable to solid waste that is designated as dangerous or mixed waste in accordance with WAC 173-303-070(3), "Designation Procedures."	Onsite land disposal may be a selected remedy for 100 Area dangerous waste and debris.	ARAR	Investigative and remediation wastes destined for onsite land disposal.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-303-170, "Requirements for Generators of Dangerous Waste"	Establishes the requirements for dangerous waste generators. WAC 173-303-170(3) includes the substantive provisions of WAC 173-303-200, "Accumulating Dangerous Waste On-Site," by reference. WAC 173-303-200, "Accumulating Dangerous Waste On-Site," further includes certain substantive standards from WAC 173-303-630 and -640 by reference. Specifically, the substantive standards for management of dangerous/mixed waste are relevant and appropriate to the management of dangerous waste that will be generated during the remedial action.	Dangerous wastes may be generated from the RI/FS of the 100 Area.	ARAR	IDW and remediation wastes (contaminated soil and groundwater, personnel protective gear, treatment chemicals, etc.).
WAC 173-303-200, "Accumulating Dangerous Waste On-Site"	Establishes the requirements for accumulating wastes onsite. WAC 173-303-200 further includes certain substantive standards from WAC 173-303-630, "Container Management," and -640 by reference.	Dangerous waste may be generated from the RI/FS of the 100 Area.	ARAR	Management of dangerous waste during remedial and investigative actions.
WAC 173-303-64610, "Purpose and Applicability" WAC 173-303-64620, "Requirements"	Establishes requirements for corrective action for releases of dangerous wastes and dangerous constituents including releases from solid waste management units.	Releases of dangerous wastes and dangerous constituents have occurred within the 100 Area that may present a threat to human health and the environment.	ARAR	Investigative and remediation of dangerous wastes and dangerous constituents from solid waste management units and spill sites. Corrective action can also be applied at TSD units whenever a release occurs.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-303-610(2), "Closure and Post-Closure"	Establishes closure requirements applicable to all dangerous waste facilities and post-closure care requirements applicable to all regulated units (as defined in WAC 173-303-040, "Definitions") at which dangerous wastes will remain after closure (including tank systems, landfills, surface impoundments, waste piles, and miscellaneous units).	Dangerous wastes may remain in the 100 Area after closure.	ARAR	Remedial design and operation of regulated units that contain dangerous wastes and that will remain in the 100 Areas after closure
WAC 173-303-665(6), "Dangerous Waste Regulations," "Landfills," "Closure and postclosure"	Specifies closure and post-closure requirements for landfills.	The FS may propose containment as a preferred remedy.	ARAR	Design and operation of an engineered landfill cover.
***Water Well Construction Act of 1971;* WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells"**				
WAC 173-160-161, "How Shall Each Water Well Be Planned and Constructed?"	Identifies well planning and construction requirements.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-171, "What Are the Requirements for the Location of the Well Site and Access to the Well?"	Identifies the requirements for locating a well.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-181, "What Are the Requirements for Preserving the Natural Barriers to Ground Water Movement Between Aquifers?"	Identifies the requirements for preserving natural barriers to groundwater movement between aquifers.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-160-400, "What Are the Minimum Standards for Resource Protection Wells and Geotechnical Soil Borings?"	Identifies the minimum standards for resource protection wells and geotechnical soil borings.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-420, "What Are the General Construction Requirements for Resource Protection Wells?"	Identifies the general construction requirements for resource protection wells.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-430, "What Are the Minimum Casing Standards?"	Identifies the minimum casing standards.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-440, "What Are the Equipment Cleaning Standards?"	Identifies the equipment cleaning standards.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
WAC 173-160-450, "What are the Well Sealing Requirements?"	Identifies the well sealing requirements.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-160-460, "What is the Decommissioning Process for Resource Protection Wells?"	Identifies the decommissioning process for resource protection wells.	Groundwater monitoring and treatment wells and borings occur in the 100 Area.	ARAR	Investigative and remediation activities that require siting, installation, construction, operation, maintenance, and decommissioning of wells and borings.
Clean Air Act; **WAC 173-400, "General Regulations for Air Pollution Sources"**				
WAC 173-400, "General Regulations for Air Pollution Sources"	Defines methods of control to be employed to minimize the release of air contaminants associated with fugitive emissions resulting from materials handling, construction, demolition, or other operations. Emissions are to be minimized through application of best available control technology.	Soil and groundwater remedial actions implemented in the 100 Area have the potential to emit emission subject to these standards because soil and groundwater target analytes detected in the 100 Area include covered hazardous air pollutants.	ARAR	Actions performed at the 100 Area that could result in the emission of hazardous air pollutants, including decontamination, demolition, and excavation activities implemented during the RI/FS that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
WAC 173-400-040, "General Standards for Maximum Emissions"	All sources and emissions units are required to meet the general emission standards unless a specific source standard is available. General standards apply to visible emissions, particulate fallout, fugitive emissions, odors, emission detrimental to health and property, sulfur dioxide, and fugitive dust.	Soil and groundwater remedial actions implemented in the 100 Area have the potential to emit emission subject to these standards because target analytes detected in the 100 Area include covered regulated hazardous air pollutants.	ARAR	Remedial actions that have the potential to release hazardous air emissions.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-400-075, "Emission Standards for Sources Emitting Hazardous Air Pollutants"	Establishes national emission standards for hazardous air pollutants. Adopts, by reference, 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants," and appendices.	Soil and groundwater target analytes detected in the 100 Area include covered regulated hazardous air pollutants.	ARAR	Actions performed at the 100 Area that could result in the emission of hazardous air pollutants, including decontamination, demolition, and excavation activities implemented during the RI/FS that have the potential to emit visible, particulate, fugitive, and hazardous air emissions and odors.
Water Pollution Control Act; **WAC 173-218, "Underground Injection Control Program"**				
WAC 173-218, "Underground Injection Control Program"	Protects ground water quality by regulating the discharge of fluids into underground injection control wells.	Groundwater in the 100 Area contains contaminants that require remediation. Treated groundwater may be discharged through underground injection wells.	ARAR	Groundwater remedial activities may involve underground injection.
Solid Waste Management – Reduction and Recycling; WAC 173-350, "Solid Waste Handling Standards"				
WAC 173-350-025, "Owner Responsibilities for Solid Waste" WAC 173-350-040, "Performance Standards" WAC 173-350-300, "On Site Storage, Collection and Transportation Standards" WAC 173-350-900, "Remedial Action"	Establishes minimum functional performance standards for the proper handling and disposal of solid waste. Requirements for the proper handling of solid waste materials originating from residences, commercial, agricultural and industrial operations and other sources and identifies those functions necessary to ensure effective solid waste handling programs at both the state and local level.	Solid, nondangerous waste will be generated during the implementation of the 100 Area RI/FSs.	ARAR	Investigative and remedial actions that generate solid, nondangerous waste.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
***Clean Air Act;* WAC 173-460, "Controls for New Sources of Toxic Air Pollutants"**				
WAC 173-460-010, "Purpose" WAC 173-460-030, "Applicability" WAC 173-460-060, "Control technology requirements" WAC 173-460-070, "Ambient impact requirement." WAC 173-460-080, "First tier review" WAC 173-460-150, "Table of ASIL, SQER and de minimis emission values"	Establishes control of new sources emitting toxic air pollutants to prevent air pollution, reduce emissions to the extent reasonably possible, and maintain such levels of air quality as will protect human health and safety. Toxic air pollutants include carcinogens and noncarcinogens listed in WAC 173-460-150. Three major requirements of this regulation include (1) implementation of best available control technology for toxics, (2) quantification of toxic air pollutant emissions, and (3) health and safety protection demonstration.	Target analytes detected in soil and groundwater in the 100 Area include constituents that would constitute toxic air pollutants if released to the air.	ARAR	Groundwater and soil remediation activities such as treatment systems that have the potential to emit hazardous air emissions and would be considered a new source.
***Clean Air Act* ; WAC 173-470, "Ambient Air Quality Standards for Particulate Matter"**				
WAC 173-470-100, "Ambient Air Quality Standards"	Sets maximum acceptable levels for particulate matter in the ambient air at 150 μg/m^3 over a 24-hour period, or 60 μg/m^3 annual geometric mean. It also sets the 24-hour ambient air concentration standards for particles less than 10 μm in diameter (PM_{10}) at 105 μg/m^3 and 50 μg/m^3 geometric mean.	Although ambient air quality standards for particulate matter are not ARARs, they should be considered if RIs or treatment operations raise emissions above the standard.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, containment) that have the potential to emit particulate matter above maximum acceptable levels.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-470-110, "Particle Fallout Standards"	Establishes the standard for particle fallout not to exceed 10 g/m^2 per month in an industrial area or 5 g/m^2 per month in residential or commercial areas. Alternative levels for areas where natural dust levels exceed 3.5 g/m^2 per month are set at 6.5g/m^2 per month, plus background levels for industrial areas and 1.5 g/m^2 per month, plus background in residential and commercial areas.	Particulates and dust can be generated during RI/FS actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, containment) that have the potential to emit particulate matter above maximum acceptable levels.
***Clean Air Act;* WAC 173-480; "Ambient Air Quality Standards and Emission Limits for Radionuclides"**				
WAC 173-480-040, "Ambient Standard"	Defines the maximum allowable level for radionuclides in the ambient air, which shall not cause a maximum accumulated dose equivalent of 25 mrem/yr to the whole body or 75 mrem/yr to any critical organ. However, ambient air standard under 40 CFR, Subparts H and I are not to exceed amounts that result in an effective dose equivalent of 10 mrem/yr to any member of the public.	Target analytes detected in soil and groundwater in the 100 Area include radionuclides that could be emitted to ambient air during RI/FS actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, vacuuming/exhaust) that have the potential to emit radionuclides above maximum acceptable levels.
WAC 173-480-050, "General standards for maximum permissible emissions"	At a minimum, all emission units shall make every reasonable effort to maintain radioactive materials in effluents to unrestricted areas, ALARA. Control equipment of sites operating under ALARA shall be defined as reasonably available control technology and as low as reasonably achievable control technology.	The potential for fugitive and diffuse emissions due to demolition and excavation and related activities will require efforts to minimize those emissions. This requirement is action-specific.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, vacuuming/exhaust) that have the potential to emit radionuclides above maximum acceptable levels.

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 173-480-070, "Emission Monitoring and Compliance Procedures"	Requires that radionuclide emissions shall be determined by calculating the dose to members of the public using Department of Health approved sampling procedures at the point of maximum annual air concentration in an unrestricted area where any member of the public may be.	Target analytes detected in soil and groundwater in the 100 Area include radionuclides that could be emitted to unrestricted areas during RI/FS actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, and vacuuming/exhaust) that have the potential to emit radionuclides to unrestricted areas above maximum acceptable levels.
WAC 173-480-060, "Emission Standards for New and Modified Emission Units"	Requires that construction, installation, or establishment of a new air emission control units utilize BARCT.	Target analytes detected in soil and groundwater in the 100 Area include radionuclides that could be emitted from air emission control units during RI/FS actions.	ARAR	Investigative and remediation activities (e.g., excavation, RTD, demolition, ventilation, and vacuuming/exhaust) that require air pollution control equipment and have the potential to emit radionuclides.
Nuclear Energy and Radiation; **WAC 246-247, "Department of Health," "Radiation Protection -- Air Emissions"**				
WAC 246-247-035 (1)(a)(ii), "National Standards. Adopted by Reference for Sources of Radionuclide Emissions"	Established requirements equivalent to 40 CFR 61, Subpart H, by reference. Radionuclide airborne emissions from the waste site shall be controlled so as not to exceed amounts that would cause an exposure to any member of the public of greater than 10 mrem/yr effective dose equivalent.	Substantive requirements of this standard are applicable because the remedial action may include activities such as excavation, decontamination, and stabilization of contaminated areas that many provide airborne emissions of radioactive particles.	ARAR	Investigative and remedial activities.
WAC 246-247-040(3), "General Standards" WAC 246-247-040(4), "General Standards"	Requires that emissions be controlled to ensure emission standards are not exceeded.	Target analytes detected in soil and groundwater in the 100 Area reactor sites include radionuclides that could be emitted during RI/FS actions.	ARAR	Investigative and remediation activities (e.g., RTD, excavation, demolition, ventilation).

Table B-2. Identification of Potential State of Washington Applicable and Relevant or Appropriate Requirements and to Be Considered for the Remedial Action Sites

Citation	Description of Requirement	Rationale for Use	Relevancy	Possible Action(s)
WAC 246-247-075, "Monitoring, Testing and Quality Assurance"	Establishes the monitoring, testing, and quality assurance requirements for radioactive air emissions. Emissions from non-point and fugitive sources of airborne radioactive material shall be measured. Measurement techniques may include, but are not limited to sampling, calculation, smears, or other reasonable method for identifying emissions as determined by the lead agency.	Target analytes in the 100 Area reactor sites include radionuclides that could be emitted as airborne radioactive material during RI/FS actions.	ARAR	Investigative and remediation activities (e.g., RTD, excavation, demolition, ventilation) that could be emitted from fugitive sources.

NOTE: The references cited in this table are included in the references section of this appendix.

ACL = alternative concentration limit
ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
BARCT = best available radionuclide control technology
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR = *Code of Federal Regulations*
FS = feasibility study
IDW = investigation derived waste
MCL = maximum contaminant level
MNA = monitored natural attenuation
RI = remedial investigation.
RI/FS = remedial investigation/feasibility study
RTD = removal, treatment, and disposal
SDWA = *Safe Drinking Water Act of 1974*
TSD = treatment, storage, and/or disposal (unit)

Appendix C

Proposed Tri-Party Agreement Milestones Associated with the Final Action Record of Decision Activities for the 100 Area Operable Units

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C1 Introduction

Table C-1 provides proposed *Hanford Federal Facility Agreement and Consent Order* (Ecology et al, 1989) milestones associated with the final action ROD activities for the 100 Area operable units.

C2 References

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," *Code of Federal Regulations*. Available at: http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfr300_08.html

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 USC 9601, et seq. Available at: http://uscode.house.gov/download/pls/42C103.txt.

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Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=91&parent=0

PNNL-16424, 2007, *Treatability Test Plan for an In Situ Biostimulation Reducing Barrier*, Rev. 0, Pacific Northwest National Laboratory, Richland, Washington. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-16424.pdf

Table C-1. Proposed Tri-Party Agreement Milestones Associated with the Final Action Record of Decision Activities for the 100 Area Operable Units

Tri-Party Agreement Milestone No.	Milestone	Due Date
M-015-00D	DOE shall complete the RI/FS process through the submittal of a proposed plan for all 100 Area and 300 Area OUs.	12/31/2012
M-016-110-T01	DOE shall take actions necessary to contain or remediate CrVI groundwater plumes in each of the 100 Area NPL OUs such that ambient water quality standards for CrVI are achieved in the hyporheic zone and river water column.	12/31/2012
M-016-110-T02	DOE shall take actions necessary to remediate CrVI groundwater plumes such that CrVI will meet drinking water standards in each of the 100 Area NPL OUs.	12/31/2020
M-016-110-T03	DOE shall take actions necessary to contain the strontium-90 groundwater plume at the 100-NR-2 OU such that the default ambient water quality standard (8 pCi/L) for strontium-90 is achieved in the hyporheic zone and river water column.	12/31/2016

Table C-1. Proposed Tri-Party Agreement Milestones Associated with the Final Action Record of Decision Activities for the 100 Area Operable Units

Tri-Party Agreement Milestone No.	Milestone	Due Date
M-016-110-T04	DOE shall implement remedial actions selected in all 100 Area RODs for groundwater OUs so that no contamination above drinking water standards or ambient water quality standards enters the Columbia River unless otherwise specified in a CERCLA decision.	12/31/2016
M-016-110-T05	DOE will have in place an operational and functional remedial system designed to meet federal drinking water standards for uranium throughout the groundwater plume in the 300-FF-5 OU unless otherwise specified in a CERCLA decision document.	12/31/2018
M-016-111A	Expand current pump-and-treat system at the 100-KR-4 OU to be operational and functional at a total 900-gpm capacity.	05/31/2009
M-016-111B	Expand current pump-and-treat system at the 100-HR-3 OU using ex situ treatment, in situ treatment, or a combination of both, to be operational and functional at a total 500-gpm capacity, or as specified in the work plan.	12/31/2010
M-016-111C	Expand current pump-and-treat system at the 100-HR-3 OU using ex situ treatment, in situ treatment, or a combination of both, to be operational and functional at a total 800-gpm capacity, or as specified in the work plan.	12/31/2011
M-016-112A	DOE shall complete demonstrations for biostimulation and electrocoagulation according to previously approved test plans (DOE/RL-2006-70, *Treatability Test Plan for Removing Chromium from Groundwater at 100-D Area Using Electrocoagulation*; PNNL-16424, *Treatability Test Plan for an In Situ Biostimulation Reducing Barrier*).	12/31/2009
M-015-60	If an amendment to the 100-NR-1/100-NR-2 ROD for interim action is issued, DOE shall submit a remedial design/remedial action work plan.	6 months after the ROD amendment
M-015-61	Submit RI/FS work plan for the 100-NR-1 and 100-NR-2 OUs.	12/31/2009
M-015-62-T01	Submit an FS report and proposed plan for the 100-NR-1 and 100-NR-2 OUs, including groundwater and soil. The FS report and proposed plan will evaluate the permeable reactive barrier technology and other alternatives and will identify a preferred alternative in accordance with CERCLA requirements.	12/31/2011
M-015-63	Submit CERCLA RI/FS work plan for the 100-FR-1/100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 OUs for groundwater and soil.	09/30/2009
M-015-64-T01	Submit CERCLA RI/FS report and proposed plan for the 100-FR-1/100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 OUs for groundwater and soil.	11/30/2011

Table C-1. Proposed Tri-Party Agreement Milestones Associated with the Final Action Record of Decision Activities for the 100 Area Operable Units

Tri-Party Agreement Milestone No.	Milestone	Due Date
M-015-65	Submit CERCLA RI/FS work plan for the 100-KR-1, 100-KR-2, and 100-KR-4 OUs for groundwater and soil.	05/31/2009
M-015-66-T01	Submit CERCLA RI/FS report and proposed plan for the 100-KR-1, 100-KR-2, and 100-KR-4 OUs for groundwater and soil.	07/31/2011
M-015-67	Submit CERCLA RI/FS work plan for the 100-BC-1, 100-BC-2, and 100-BC-5 OUs for groundwater and soil.	09/30/2009
M-015-68-T01	Submit CERCLA RI/FS report and proposed plan for the 100-BC-1, 100-BC-2, and 100-BC-5 OUs for groundwater and soil.	11/30/2011
M-015-69	Submit RI/FS work plan for the 100-HR-1, 100-HR-2, 100-HR-3, 100-DR-1, and 100-DR-2 OUs for groundwater and soil.	05/31/2009
M-015-70-T01	Submit FS report and proposed plan for the 100-HR-1, 100-HR-2, 100-HR-3, 100-DR-1, and 100-DR-2 OUs for groundwater and soil.	07/30/2011

Notes:

DOE = U.S. Department of Energy

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

FS = feasibility study

CrVI = hexavalent chromium

NPL = National Priorities List (40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List")

OU = operable unit

Tri-Party Agreement = Ecology et al., 1989a, *Hanford Federal Facility Agreement and Consent Order*

RI/FS = remedial investigation/feasibility study

ROD = record of decision

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