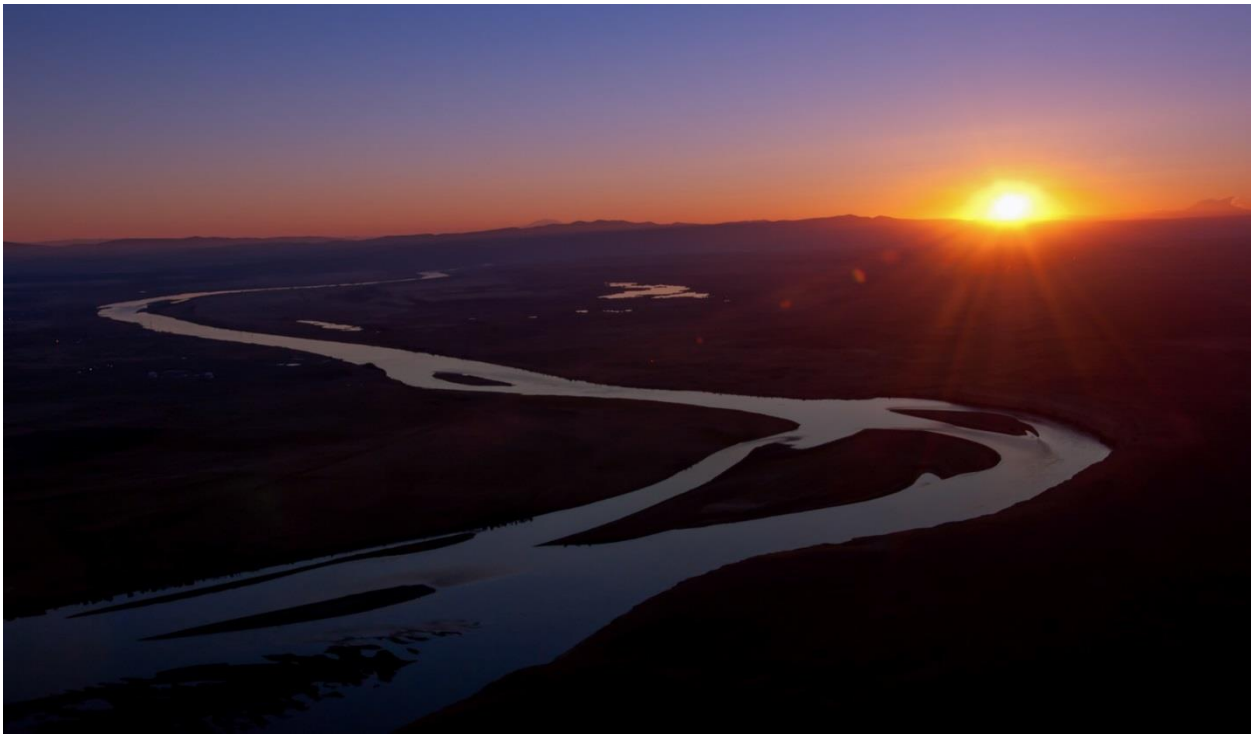
DOE/RL-2016-01
Revision 0

HANFORD SITE

Fourth CERCLA Five-Year Review Report



U.S. DEPARTMENT OF ENERGY

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Hanford Site Fourth CERCLA Five-Year Review Report

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U.S. DEPARTMENT OF ENERGY | Richland Operations Office
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APPROVED
By Janis Aardal at 2:22 pm, Mar 23, 2017

Release Approval Date

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ABSTRACT

This report presents the fourth Sitewide 5-year review of remedial actions at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. Each 5-year review evaluates a remedy's implementation and performance to determine whether the remedy is or will be protective of human health and the environment. This report covers the 5-year period from 2011 through 2015. Thirty operable units (cleanup projects primarily focused on remediating contaminated soil and groundwater) are currently subject to statutory 5-year reviews. Additional Hanford Site operable units will become subject to 5-year reviews once cleanup remedies are selected and documented in formal records of decision. The report's body includes technical assessments of remedy implementation and performance for Hanford Site operable units engaged in cleanup in the River Corridor and on the Central Plateau. Based on the technical assessments, protectiveness statements are presented herein for each of the 30 operable units addressed in this report. Recommendations to address identified issues are also provided. The next 5-year review for the Hanford Site will cover the period from 2016 through 2020.

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Five-Year Review Summary Form

In the order generally discussed within the body of this report, the following four sets of Five-Year Review Summary Forms (FYRSF) (based on EPA templates) are included as tables FYRSF-1 through FYRSF-4:

- Table FYRSF-1. Five-Year Review Summary Form for the Hanford 100 Area
- Table FYRSF-2. Five-Year Review Summary Form for the Hanford 300 Area
- Table FYRSF-3. Five-Year Review Summary Form for the Hanford 1100 Area
- Table FYRSF-4. Five-Year Review Summary Form for the Hanford 200 Area.

Table FYRSF-1. Five-Year Review Summary Form for the Hanford 100 Area.

SITE IDENTIFICATION		
Site Name: Hanford 100 Area (USDOE)		
EPA ID: WA3890090076		
Region: 10	**State:** WA	**City/County:** Richland/Benton
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	**Has the site achieved construction completion?** No	
REVIEW STATUS		
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Department of Energy		
Author name (Federal or State Project Manager): Michael W. Cline		
Author affiliation: U.S. Department of Energy Richland Operations Office		
Review period: 10/1/2010 – 12/30/2015		
Date of site inspection: Various		
Type of review: Statutory		
Review number: 4		
Issues/Recommendations		
Triggering action date: May 4, 2012		
Due date *(five years after triggering action date)*: May 4, 2017		
OU(s) without Issues/Recommendations Identified in the Five-Year Review:		
100-BC-1, 100-BC-2, 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, 100-IU-6, 100-DR-1, 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-NR-1		

Issues and Recommendations Identified in the Five-Year Review:				
OU(s): 100-HR-3	**Issue Category:** Operations and Maintenance			
	Issue: HR3-1 - Hexavalent chromium exceeds the aquatic quality standard at several small areas along the Columbia River Shoreline.			
	Recommendation: HR3-1 – Install additional wells and/or convert existing wells to remove contaminant mass and impose hydraulic containment necessary to protect aquatic receptors in the Columbia River.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	State	9/30/2020
OU(s): 100-KR-2 and 100-KR-4	**Issue Category:** Changed Site Conditions			
	Issue: KR2-1 and KR4-1 -- Several 100-KR-2 waste sites near the 105-KE and 105-KW reactors likely serve as continuing sources of 100-KR-4 OU groundwater contamination.			
	Recommendation: KR2-1 and KR4-1 -- Incorporate supplemental characterization data and risk evaluation in a draft RI/FS report and transmit for regulator review.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Federal Facility	EPA	12/31/2018
OU(s): 100-NR-2	**Issue Category:** Remedy Performance			
	Issue: NR2-1 – Permeable reactive barrier test to reduce the strontium-90 flux to the Columbia River has not yet been expanded from 1,000 ft to 2,500 ft,			
	Recommendation: Complete implementation of the permeable reactive barrier.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
Yes	Yes	Federal Facility	State	12/30/2018

Protectiveness Statement(s)

Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-BC-1	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 100-BC-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-BC-1 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-BC-2	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 100-BC-2 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-BC-2 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-FR-1	Protective	N/A

Protectiveness Statement:
The remedy at the 100-FR-1 source OU is protective of human health and the environment, and exposure pathways that could result in unacceptable risk are being controlled. The RAOs for protecting human and ecological receptors from exposure to contamination, and for controlling the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions, have been met by RTD of waste sites and the imposition of site-specific ICs at waste sites that do not qualify for unlimited use or unrestricted exposure. The RTD scope has been completed and ICs have been implemented.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-FR-2	Protective	N/A

Protectiveness Statement:
The remedy at the 100-FR-2 source OU is protective of human health and the environment, and exposure pathways that could result in unacceptable risk are being controlled. The RAOs for protecting human and ecological receptors from exposure to contamination, and for controlling the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions, have been met by RTD of waste sites and the imposition of site-specific ICs at waste sites that do not qualify for unlimited use or unrestricted exposure. The RTD scope has been completed and ICs have been implemented.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-FR-3	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 100-FR-3 groundwater OU is expected to be protective upon completion of construction. ICs are in place and are protecting human exposure to contaminated groundwater. Construction of additional wells to enhance the remedy component involving monitored natural attenuation began in early 2016 and is expected to be completed by 2019. In the interim, the remedial activities completed to date have addressed the exposure pathways that could result in unacceptable risks in these areas.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-IU-2	Protective	N/A

Protectiveness Statement:
The remedy at the 100-IU-2 source OU is protective of human health and the environment and exposure pathways that could result in unacceptable risk are being controlled. The RAOs for protecting human and ecological receptors from exposure to contamination, and for controlling the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions, have been met by RTD of waste sites. The RTD scope has been completed and ICs have been implemented.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-IU-6	Protective	N/A

Protectiveness Statement:
The remedy at the 100-IU-6 source OU is protective of human health and the environment and exposure pathways that could result in unacceptable risk are being controlled. The RAOs for protecting human and ecological receptors from exposure to contamination, and for controlling the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions, have been met by RTD of waste sites. The RTD scope has been completed and ICs have been implemented.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-DR-1	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 100-DR-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100 DR 1 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates issuance of a final ROD for the 100-D and 100-H areas during the next (2016 – 2020) 5-year review period.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-DR-2	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 100-DR-2 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100 DR-2 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates issuance of a final ROD for the 100-D and 100-H areas during the next (2016 – 2020) 5-year review period.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-HR-1	Will be Protective	N/A

Protectiveness Statement: The remedy at the 100-HR-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-HR-1 source OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates issuance of a final ROD for the 100-D and 100-H areas during the next (2016 – 2020) 5-year review period.		
Operable Unit: 100-HR-2	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: The remedy at the 100-HR-2 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-HR-2 source OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates the issuance of a final ROD for the 100-D and 100-H areas during the next (2016 – 2020) 5-year review period.		
Operable Unit: 100-HR-3	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: The remedy at the 100 HR-3 groundwater OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy at 100-HR-3 (primarily involving groundwater P&T system operations focused on hexavalent chromium contamination, flow-path control, and ICs) has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates issuance of a final ROD for the 100-D and 100 H Areas during the next (2016 –2020) 5-year review period.		
Operable Unit: 100-KR-1	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: The remedy at the 100-KR-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, and revegetation, and ICs) at the 100 KR-1 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.		
Operable Unit: 100-KR-2	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: The remedy at the 100-KR-2 OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring and revegetation, ICs, and deactivation of the SNF basins) at the 100-KR-2 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled		
Operable Unit: 100-KR-4	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A

Protectiveness Statement:
The remedy at the 100-KR-4 groundwater OU will be protective upon completion of the final remedy. The interim remedy for the 100-KR-4 groundwater OU focuses on hexavalent chromium contamination. The KR-4, KW, and KX groundwater treatment systems' operations and the flow-path-control components of the interim remedy are ongoing, and demonstrating effective progress in reducing contaminant plume sizes and concentrations. ICs have been implemented and continue to ensure that unacceptable risks to human health are being controlled. A revised RI/FS report that includes 100 KR-4 is in development, pending the results of supplemental field characterization.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-NR-1	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 100-NR-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the100 NR-1 source OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
100-NR-2	Not Protective	N/A

Protectiveness Statement:
The interim remedy at the 100-NR-2 OU source is not protective because expansion of the permeable reactive barrier remedy-component for addressing strontium-90-contaminated groundwater has not been completed. Approximately 1,000 ft of the 2,500-ft-long barrier have been installed at the time of this report. The action necessary to address protectiveness (per the interim ROD) is to complete the apatite-forming chemical injections at 1,500 ft of the 2,500-ft-long permeable reactive barrier. To address TPH-diesel contamination, in situ bioventing system operations and the free-product removal operations are under way to reduce contaminant mass in the lower vadose zone and groundwater, respectively. Additionally, ICs are in place and are preventing human exposure to the groundwater. Groundwater monitoring and MNA also are under way and will continue to help determine a comprehensive final remedy for 100-NR-2 groundwater.

Sitewide Protectiveness Statement (if applicable)

For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.

Protectiveness Determination:	*Addendum Due Date (if applicable):*
N/A	N/A

Protectiveness Statement:
N/A – Hanford 100 Area NPL Site remedy construction is still under way among multiple OUs.

Table FYRSF-2. Five-Year Review Summary Form for the Hanford 300 Area.

SITE IDENTIFICATION		
Site Name: Hanford 300 Area (USDOE)		
EPA ID: WA3890090077		
Region: 10	**State:** WA	**City/County:** Richland/Benton

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** No

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Department of Energy
Author name (Federal or State Project Manager): Michael W. Cline
Author affiliation: U.S. Department of Energy Richland Operations Office
Review period: 10/1/2010 – 12/30/2015
Date of site inspection: Various
Type of review: Statutory
Review number: 4
Triggering action date: May 4, 2012
Due date *(five years after triggering action date)*: May 4, 2017

Issues/Recommendations				
OU(s) without Issues/Recommendations Identified in the Five-Year Review:				
300-FF-1, 300-FF-2 and 300-FF-5				
Issues and Recommendations Identified in the Five-Year Review:				
OU(s): None	**Issue Category:** No Issue			
	Issue: N/A.			
	Recommendation: N/A.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	N/A

Protectiveness Statement(s)		
Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.		
Operable Unit: 300-FF-1	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: The final remedy at the 300-FF-1 source OU waste sites is expected to be protective of human health and the environment upon completion of the final remedy actions. The final remedy actions (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) ensure that exposure pathways that could result in unacceptable risks are being controlled.		
Operable Unit: 300-FF-2	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: The final remedy at the 300-FF-2 source OU waste sites is expected to be protective of human health and the environment upon completion of the final remedy actions. The final remedy actions (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) ensure that exposure pathways that could result in unacceptable risks are being controlled.		
Operable Unit: 300-FF-5	*Protectiveness Determination:* Will be Protective	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: The remedy at the 300-FF-5 groundwater OU is expected to be protective upon completion. Groundwater monitoring is ongoing, and ICs are in place and are protecting human exposure to the contaminated groundwater. Construction of the remedy component involving enhanced attenuation of uranium is expected to be completed in 2017 and documented in 2018; this is expected to reduce the timeframe for achieving uranium cleanup levels. In the interim, the remedial activities completed to date adequately address the exposure pathways that could result in unacceptable risks in these areas.		

Sitewide Protectiveness Statement (if applicable)	
For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.	
Protectiveness Determination: N/A	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: N/A – Hanford 300 Area (USDOE) NPL Site remedy construction is still under way among multiple OUs.	

Table FYRSF-3. Five-Year Review Summary Form for the Hanford 1100 Area.

SITE IDENTIFICATION		
Site Name: Hanford 1100 Area (USDOE)		
EPA ID: WA3890090077		
Region: 10	**State:** WA	**City/County:** Richland/Benton
SITE STATUS		
NPL Status: Deleted		
Multiple OUs? No	**Has the site achieved construction completion?** Yes	
REVIEW STATUS		
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Department of Energy		
Author name (Federal or State Project Manager): Michael W. Cline		
Author affiliation: U.S. Department of Energy Richland Operations Office		
Review period: 10/1/2010 – 12/30/2015		
Date of site inspection: Various		
Type of review: Statutory		
Review number: 4		
Triggering action date: May 4, 2012		
Due date *(five years after triggering action date)*: May 4, 2017		

Issues/Recommendations				
OU(s) without Issues/Recommendations Identified in the Five-Year Review:				
1100-EM-1				
Issues and Recommendations Identified in the Five-Year Review:				
OU(s): None	**Issue Category:** No Issue			
	Issue: N/A.			
	Recommendation: N/A.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	N/A

Protectiveness Statement(s)		
Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.		
Operable Unit: 1100-EM-1	*Protectiveness Determination:* Protective	*Addendum Due Date (if applicable):* N/A
The remedy at the 1100-EM-1 OU is protective of human health and the environment. Elements of the remedy that protect human health and the environment involve continuing ICs due to the buried asbestos at the Horn Rapids Landfill (the only 1100-EM-1 site that is not closed out). The remedial action objectives were met at the landfill by offsite disposal of PCB contaminated soils, capping of the landfill in accordance the Asbestos NESHAP (40 CFR 61.151) and providing adequate ICs to prevent future receptor exposure to contamination. The continuing ICs include entry restrictions, notice in deed, land use management, and miscellaneous provisions. Fencing, signage and the existing landfill cap are routinely inspected, maintained and upgraded as needed.		
Sitewide Protectiveness Statement (if applicable)		
For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.		
Protectiveness Determination: Protective		*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: N/A – The Hanford 1100 Area (USDOE) Site remedy was removed from the NPL in 1996.		

Table FYRSF-4. Five-Year Review Summary Form for the Hanford 200 Area.

SITE IDENTIFICATION		
Site Name: Hanford 200 Area (USDOE)		
EPA ID: WA3890090078		
Region: 10	**State:** WA	**City/County:** Richland/Benton

SITE STATUS	
NPL Status: Final	
Multiple OUs? Yes	**Has the site achieved construction completion?** No

REVIEW STATUS
Lead agency: Other Federal Agency **If "Other Federal Agency" was selected above, enter Agency name:** U.S. Department of Energy
Author name (Federal or State Project Manager): Michael W. Cline
Author affiliation: U.S. Department of Energy Richland Operations Office
Review period: 10/1/2010 – 12/30/2015
Date of site inspection: Various
Type of review: Statutory
Review number: 4
Triggering action date: May 4, 2012
Due date *(five years after triggering action date)*: May 4, 2017

Issues/Recommendations				
OU(s) without Issues/Recommendations Identified in the Five-Year Review:				
200-UP-1, 200-ZP-1, 200-CU-1, 200-CW-3, 200-DF-1, 200-CW-5, 200-PW-1, 200-PW-3, 200-PW-6				
Issues and Recommendations Identified in the Five-Year Review:				
OU(s): None	**Issue Category:** No Issue			
	Issue: N/A.			
	Recommendation: N/A.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	No	Federal Facility	EPA/State	N/A

Protectiveness Statement(s)

Include each individual OU protectiveness determination and statement. If you need to add more protectiveness determinations and statements for additional OUs, copy and paste the table below as many times as necessary to complete for each OU evaluated in the FYR report.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-UP-1	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 200-UP-1 groundwater OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of uranium treatment capability in the 200 West P&T was completed during this 5-year review period. Publication of a draft treatment technology evaluation plan for iodine-129 was also accomplished. Characterization of the chromium plume to support remedy design was initiated in late 2015 and will be completed after this 5-year review period. The interim action remedy component of groundwater ICs is fully implemented and ensures that exposure pathways that could result in unacceptable risks to human health are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-ZP-1	Protective	N/A

Protectiveness Statement:
The remedy at the 200-ZP-1 groundwater OU is protective of human health and the environment. The RAOs to return the 200-ZP-1 groundwater to restore groundwater to achieve domestic drinking water levels within 150 years, and to protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by contaminants originating from the 200-ZP-1 OU, are being met by the remedy components involving groundwater extraction and treatment, MNA, and flow path control. The RAO of applying ICs to prevent the use of groundwater until the cleanup levels have been achieved (estimated to be within 150 years) has been met by the implementation and continued management of ICs.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-CU-1	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 200-CU-1 OU (221-U Facility (U Plant) is expected to be protective of human health and the environment upon completion of the final remedy actions. Implementation of the final remedy for the 200-CU-1 OU has been put in hiatus. Once implementation is restarted and the remedy is complete, it is expected to be protective of human health and the environment. The remedial actions completed to date, along with implementation of ICs, ensure that exposure pathways that could result in unacceptable risks are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-CW-3	Will be Protective	N/A

Protectiveness Statement:
The remedy for the 200-CW-3 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at 200-CW-3 OU waste sites has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-DF-1	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 200-DF-1 OU (ERDF landfill) is expected to be protective of human health and the environment upon completion. In the interim, remedial activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas. ERDF is an operating landfill; operation is envisioned to continue for at least another 30 years.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-CW-5	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 200-CW-5 Operable Unit is expected to be protective upon completion of the final remedy. While the remedy component involving RTD (with disposal at ERDF or WIPP, as appropriate) has not started, ICs are in place to ensure that exposure pathways that could result in unacceptable risks are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-PW-1	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 200-PW-1 Operable Unit is expected to be protective upon completion of the final remedy. While the remedy components involving RTD (with disposal at ERDF or WIPP, as appropriate) has not started, the remedy component involving soil vapor extraction has been successfully completed, and ICs are in place to ensure that exposure pathways that could result in unacceptable risks are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-PW-3	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 200 PW-3 Operable Unit is expected to be protective upon completion of the final remedy. While the remedy component involving enhancement of the existing soil cover has not started, ICs are in place to ensure that exposure pathways that could result in unacceptable risks are being controlled.

Operable Unit:	*Protectiveness Determination:*	*Addendum Due Date (if applicable):*
200-PW-6	Will be Protective	N/A

Protectiveness Statement:
The remedy at the 200-PW-6 Operable Unit is expected to be protective upon completion of the final remedy. While the remedy components involving RTD and installation of a soil cover has not started, the remedy component involving soil vapor extraction has been successfully completed and ICs are in place to ensure that exposure pathways that could result in unacceptable risks are being controlled.

Sitewide Protectiveness Statement (if applicable)	
For sites that have achieved construction completion, enter a sitewide protectiveness determination and statement.	
Protectiveness Determination: N/A	*Addendum Due Date (if applicable):* N/A
Protectiveness Statement: N/A – Hanford 200 Area (USDOE) NPL Site remedy construction is still under way among multiple OUs.	

TERMS

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ERDF	Environmental Restoration Disposal Facility
FYR	5-year review
FYRSF	Five-Year Review Summary Statement
IC	institutional control
MNA	monitored natural attenuation
N/A	not applicable
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPL	National Priorities List
OU	operable unit
PCB	polychlorinated biphenyl
RI/FS	remedial investigation/feasibility study
RAO	remedial action objective
RTD	remove, treat, if necessary, and dispose of
SNF	spent nuclear fuel
TPH	total petroleum hydrocarbon
USDOE	U.S. Department of Energy
WIPP	Waste Isolation Pilot Plant

Executive Summary

The Hanford Site was established in 1943 to produce nuclear materials for national defense. Many production activities resulted in the disposal of wastes containing hazardous constituents and/or radioactive materials. As a result, in July 1989, the U.S. Environmental Protection Agency (EPA) placed four areas (100, 200, 300, and 1100 Areas) of the Hanford Site on the National Priorities List (NPL) pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*[a] (CERCLA) (42 USC §9601 et seq.).

In anticipation of the NPL listing, the U.S. Department of Energy (DOE), EPA, and Washington State Department of Ecology (Ecology) entered into the *Hanford Federal Facility Agreement and Consent Order*[b] (Tri-Party Agreement) in May of 1989. This agreement established a procedural framework and schedule for developing, implementing, and monitoring CERCLA response actions on the Hanford Site. The agreement also addresses *Resource Conservation and Recovery Act of 1976*[c] (RCRA) permitting, compliance, closure, post-closure care, and corrective action. The Tri-Party Agreement is a legally binding agreement between the DOE, EPA, and Ecology that establishes the guidelines and framework for cleaning up the Hanford Site. Since the Hanford Site was placed on the NPL, DOE has made considerable cleanup progress.

For waste site remedial action where hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure, CERCLA requires a review every 5 years to evaluate the implementation and performance of a remedy to determine whether the remedy is or will be protective of human health and the environment. The 5-year review requirement applies to all remedial actions selected under CERCLA §121. The methods, findings, and conclusions of the 5-year reviews, including the protectiveness statements, are documented in the 5-year review reports.

The *USDOE Hanford Site First Five-Year Review Report* (EPA 2001[d]) documented the results of the first Hanford Site CERCLA 5-year review, which EPA Region 10 completed in September 2000. This report covered all portions of the Hanford Site with a CERCLA decision document and covered areas that contain hazardous substances, pollutants, or contaminants that are to be remediated under CERCLA.

The Second CERCLA Five-Year Review Report for the Hanford Site (DOE/RL-2006-20[e]) documented the results of the second CERCLA 5-year review, which DOE completed in November 2006. The report evaluated the performance of the CERCLA remedies selected in interim records of decision (ROD), including existing institutional controls in place to prevent exposure to the public and the environment.

The *Hanford Site Third CERCLA Five-Year Review Report* (DOE-RL-2011-56[f]) documented the result of the third CERCLA 5-year review, which DOE completed in November 2011. The report evaluated the

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– [a]*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC §9601 et seq. Available on line at http://www.epw.senate.gov/cercla.pdf.

– [b]Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available on line at http://www.hanford.gov/?page=81.

– [c]*Resource Conservation and Recovery Act of 1976*, 42 USC §6901 et seq. Available on line at https://www.epa.gov/laws-regulations/summary-resource-conservation-and-recovery-act.

– [d]EPA, 2001, *USDOE Hanford Site First Five Year Review Report*, U.S. Environmental Protection Agency, Region 10, Hanford Project Office, Richland, Washington. Available on line at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0088482.

– [e]DOE/RL-2006-20, 2007, *The Second CERCLA Five-Year Review Report for the Hanford Site*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available on line at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=DA04570094.

– [f]DOE/RL-2011-56, 2012, *Hanford Site Third CERCLA Five-Year Review Report*, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available on line at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093142.

performance of the CERCLA remedies selected in RODs, including existing institutional controls in place to prevent exposure to the public and the environment.

This report presents the fourth CERCLA 5-year review for the Hanford Site. The purpose of this review is to evaluate implementation and performance of CERCLA remedies to determine whether they are, or will be, protective of human health and the environment. This report documents the results of the fourth CERCLA 5-year review for the period of 2011 to 2015. This report presents the 5-year review of CERCLA remedial actions initiated, in progress, or completed at the DOE Hanford Site where the action resulted in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure.

Based on EPA's Comprehensive Five-Year Review Guidance[g], and the detailed review presented in this report, protectiveness statement categories determined for Hanford CERCLA operable units (OU) can be summarized as follows:

- **No Protectiveness Statement** (not required nor included in this 5-year review as cleanup remedy has not yet been selected and published in a CERCLA Record of Decision):
  - Source OUs: 100-OL-1, 200-BC-1, 200-CB-1, 200-CP-1, 200-CR-1, 200-CW-1, 200-DV-1, 200-EA-1 200-IS-1, 200-OA-1, 200-SW-1, 200-SW-2, and 200-WA-1
  - Groundwater OUs: 100-BC-5, 200-BP-5, and 200-PO-1.
- **Not Protective:**
  - Source OUs: None
  - Groundwater OUs: 100-NR-2[h] (the permeable reactive barrier remedy component has not been completed)
- **Will Be Protective:**
  - Source OUs**:** 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, 100-KR-1, 100-KR-2[h], 100-NR-1, 300-FF-1, 300-FF-2, 200-CU-1, 200-CU-3, 200-DF-1, 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6
  - Groundwater OUs: 100-FR-3, 100-HR-3[h], 100-KR-4[h], 300-FF-5, 200-UP-1
- **Protective in the Short Term**
  - Source OUs: None
  - Groundwater OUs: None
- **Protective**
  - Source OUs: 100-FR-1, 100-FR-2, 100-IU-2, 100-IU-6, 1100-EM-1 (Horn Rapids Landfill)
  - Groundwater OU: 200-ZP-1.

[g] EPA, 2001a, *Comprehensive Five-Year Review Guidance*, U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C.

[h] Recommendations for identified issues are provided herein.

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APPENDICES

FIGURES

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TERMS

AEA	*Atomic Energy Act of 1954*
AMD	record of decision amendment
AR/PIR	Administrative Record/Public Information Repository
ARAR	applicable or relevant and appropriate requirement
BCM	bank cubic meters
BCY	bank cubic yards
BEHP	Bis (2-ethylhexyl) phthalate
Bgs	below grade surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CHPRC	CH2M HILL Plateau Remediation Company
CLUP	*Comprehensive Land Use Plan*
COC	contaminant of concern
CY	calendar year
DCE	cis-1,2-dichloroethene
D&D	deactivation and decommissioning
DOE	U.S. Department of Energy
DOE-ORP	U.S. Department of Energy, Office of River Protection
DOE-RL	U.S. Department of Energy, Richland Operations Office
DST	double-shell tank
DWS	Drinking Water Standard
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
ERDF	Environmental Restoration Disposal Facility
ESD	explanation of significant difference
FS	feasibility study
FY	fiscal year
HAMMER	Volpentest HAMMER Federal Training Center
HCP-EIS	*Hanford Comprehensive Land Use Plan Environmental Impact Statement (HCP-EIS)*
IC	institutional control
IRA	interim remedial action record of decision
ISRM	in situ [reduction oxidation] REDOX manipulation
ISS	interim safe storage
MSA	Mission Support Alliance, LLC
MCL	maximum contaminant level
MNA	monitored natural attenuation
MTCA	"Model Toxics Control Act"
NCP	"National Oil and Hazardous Substances Pollution Contingency Plan"
NEPA	*National Environmental Policy Act*
NPL	National Priorities List
O&M	operation and maintenance
OU	operable unit
P&T	pump and treat
PCB	polychlorinated biphenyl
PFP	Plutonium Finishing Plant
PRB	permeable reactive barrier
PRG	preliminary remediation goals

PRZ	periodically wetted zone
PUREX	Plutonium/Uranium Extraction (Plant)
RAG	remedial action goal
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RDR/RAWP	remedial design report/remedial action work plan
REDOX	reduction/oxidation (Plant or process)
RI	remedial investigation
RFI/CMS	RCRA facility investigation/corrective measures study
ROD	record of decision
RPO	remedial process optimization
RTD	remove, treat, if necessary, and dispose of
SA	supplemental analysis
SAP	sampling and analysis plan
SNF	spent nuclear fuel
SST	single-shell tank
TBD	to be determined
TCE	trichloroethene
TCLP	Toxicity Characteristic Leachate Procedure
TPH	total petroleum hydrocarbon
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
Tri-Party Agreement Action Plan	*Hanford Federal Facility Agreement and Consent Order Action Plan*
TRIDEC	Try-City Development Council
TRU	transuranic
TSD	treatment, storage, and disposal
WAC	*Washington Administrative Code*
WCH	Washington Closure Hanford
WIDS	Waste Information Data System
WIPP	Waste Isolation Pilot Plant
WMA	waste management area

1 INTRODUCTION

This report presents the fourth CERCLA 5-year review of remedial actions at the U.S. Department of Energy (DOE)-owned and -managed Hanford Site in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (*CERCLA) and *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989). This 5-year review follows the U.S. Environmental Protection Agency's (EPA) *Comprehensive Five-Year Review Guidance* (EPA 2001a).

Purpose. The 5-year review evaluates the implementation and performance of a remedy to determine whether the remedy is or will be protective of human health and the environment. The methods, findings, and conclusions of these reviews are documented in the 5-year review reports. The reports also identify any issues found during the review and provide recommendations to address them.

Cleanup Authority. Through Executive Order 12580, the President has delegated many management responsibilities for federal facilities to Executive Branch agencies, including DOE. Under Executive Order 12580, DOE is designated as the lead agency responsible for conducting response actions (removal and remedial) at facilities under its control, including the Hanford Site. Both CERCLA and Executive Order 12580 mandate that, as the federal lead agency, DOE conduct response actions (removal and remedial) at the Hanford Site.

Requirement. One of a Federal lead agency's responsibilities is to review the status of response actions no less frequently than once every 5 years for sites where remaining contamination precludes unlimited use and unrestricted exposure to determine whether the selected remedies at a site remain protective of human health and the environment. DOE is required to implement 5-year reviews in a manner consistent with CERCLA and the "National Oil and Hazardous Substances Pollution Contingency Plan" (Title 40 *Code of Federal Regulations* [CFR] Part 300) (NCP).

Scope. The EPA's National Priorities List (NPL) lists national priorities among the known or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide EPA in determining which sites warrant further investigation. When the Hanford Site (also referred herein as "the Site") was placed on the NPL on November 3, 1989, it was divided into the 100, 200, 300, and 1100 Areas. These NPL designations are based on the extent of contamination present and do not correlate to the commonly recognized Site area boundaries. Each NPL site was divided into operable units (OU) (a grouping of individual sites based primarily on geographic area or common waste sources) to simplify the response actions.

Source OUs address a variety of contaminated media (e.g., soil, sludge, debris) and waste site types (e.g., ponds, cribs, ditches, landfills, tanks, pipelines, and structures) across the Hanford Site. The OUs were established to address cleanup at the 100 Area, 200 Area, 300 Area, and 1100 Area NPL sites. The 100, 300 and 1100 Areas are in the River Corridor; the 200 Area is on the Central Plateau. The River Corridor and the Central Plateau are shown in Figure 1-1. This 5-year review covers CERCLA cleanup projects comprising 23 source OUs and 7 groundwater OUs. For this document, "source OU" broadly applies to non-groundwater OUs that comprise potential contamination at the surface and infers contamination in the vadose zone.

CERCLA remedial actions are documented in formal records of decision (ROD), in accordance with CERCLA, as amended[a], and, to the extent practicable, the NCP. These remediation decisions can be found in the Administrative Record for the Hanford Site, which can be queried for specific OUs (http://pdw.hanford.gov/arpir/index.cfm/predefinedSearch?canType=OpUnit).

Table 1-1 lists the OUs addressed in this report in a chronology of the primary decision document types that have been published for each OU. The table lists the following types of documents:

– [a]The *Superfund Amendments and Reauthorization Act of 1986* (SARA) amended CERCLA. All SARA amendments, along with all subsequent changes to CERCLA are codified in CERCLA as part of the *United States Code* at 42 USC 9601.

- **Interim Remedial Action Record of Decision (IRA)**. The IRA explains the plan for carrying out any cleanup actions before a final remediation plan is formulated and adopted and EPA issues a ROD.
- **Record of Decision (ROD)**. The ROD explains the agreed-on final remediation plan for cleaning up a site.
- **Record of Decision Amendment (AMD)**. The AMD revises a ROD to incorporate changes to the remedy or the ROD's scope.
- **Explanation of Significant Differences (ESD)**. The explanation of significant differences is a standalone document that describes changes to an IRA or ROD.

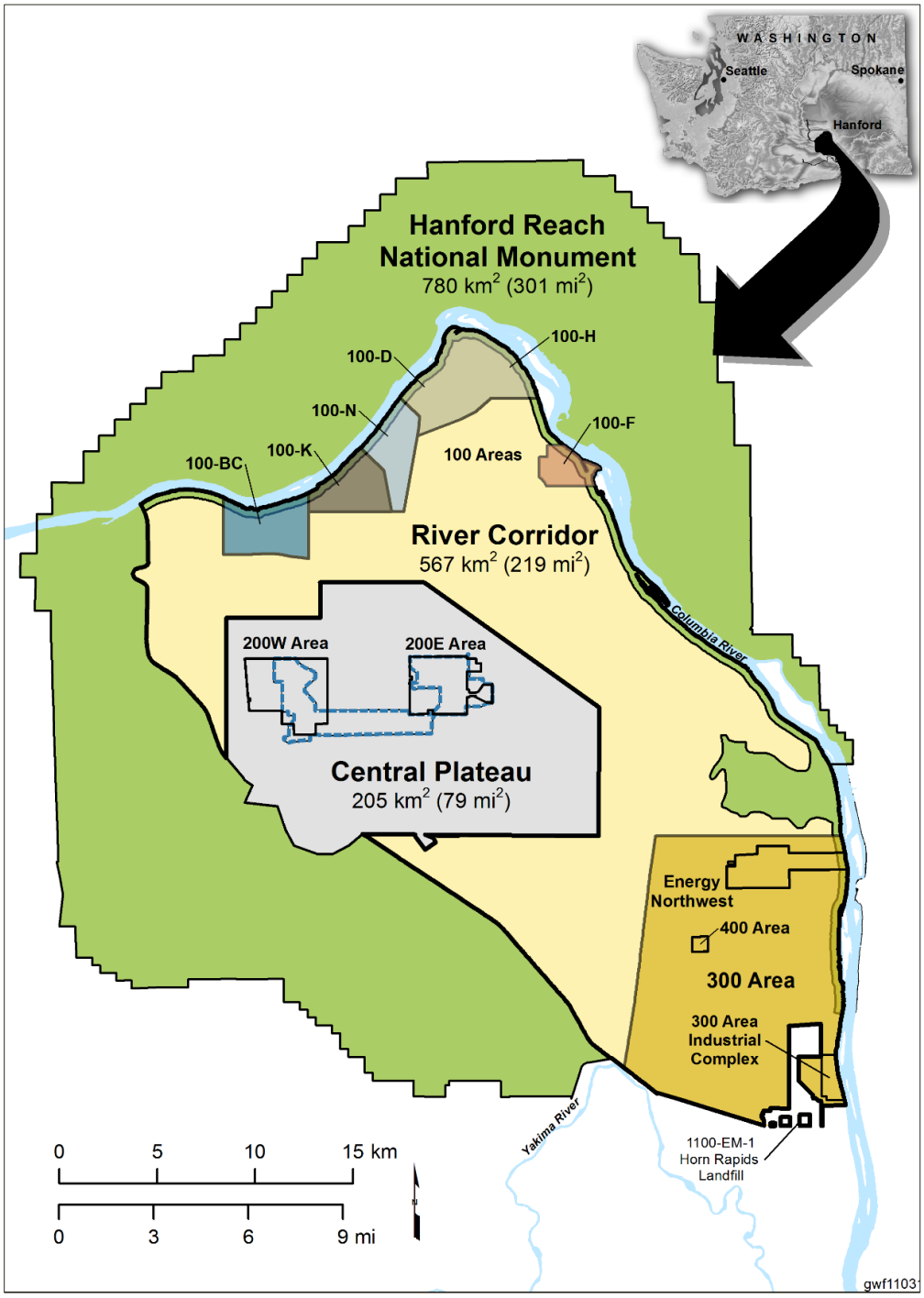


Figure 1-1. Major regions of the Hanford Site: Hanford Reach National Monument, River Corridor, and Central Plateau.

Table 1-1. Operable Units Addressed in this Report.

Operable Unit	CERCLA Decision Document – Type and Year																						
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
River Corridor — 100 Area NPL Site																							
100-BC-1			IRA		AMD		IRA	IRA				ESD					ESD						
100-BC-2							IRA	IRA				ESD			ESD		ESD						
100-FR-1							IRA	IRA				ESD					ESD					**ROD**	
100-FR-2							IRA	IRA				ESD					ESD					**ROD**	
100-FR-3																						**ROD**	
100-IU-2							IRA					ESD					ESD					**ROD**	
100-IU-6							IRA	ESD				ESD					ESD					**ROD**	
100-DR-1			IRA		AMD		IRA	IRA				ESD					ESD						
100-DR-2							IRA	IRA				ESD					ESD						
100-HR-1			IRA		AMD		IRA					ESD					ESD						
100-HR-2							IRA	IRA				ESD					ESD						
100-HR-3				IRA			AMD				ESD						ESD						
100-KR-1							IRA					ESD					ESD						
100-KR-2							IRA, IRA	IRA				ESD	AMD		ESD		ESD						
100-KR-4				IRA													ESD						
100-NR-1							IRA	IRA			ESD							AMD	ESD		ESD		
100-NR-2							IRA				ESD							AMD					
River Corridor — 300 Area NPL Site																							
300-FF-1				**ROD**				ESD													AMD		
300-FF-2									IRA			ESD					ESD		ESD		**ROD**		ESD
300-FF-5				IRA				ESD													**ROD**		
River Corridor — 1100 Area																							
1100-EM-1	**ROD**																	ESD					
Central Plateau — 200 Area NPL Site																							
200-UP-1					IRA												ESD			IRA			
200-ZP-1			IRA													**ROD**							
200-CU-1													ROD										
200-CW-3							IRA				ESD						ESD						
200-DF-1			**ROD**	ESD	AMD		AMD			AMD					AMD		ESD						ESD AMD
200-CW-5																			**ROD**				
200-PW-1																			**ROD**				
200-PW-3																			**ROD**				
200-PW-6																			**ROD**				

Legend: Source OU | Groundwater OU | ROD | IRA

The 100-KR-2 Operable Unit has two separate interim records of decision in 1999

IRA = interim remedial action record of decision

ROD = remedial action record of decision

AMD = record of decision amendment.

ESD = explanation of significant differences.

DOE established December 31, 2015, as the end point for including decision documents issued since the third 5-year report in this fourth 5-year review report. Decision documents issued after December 31, 2015, will be addressed in the next 5-year review.

This 5-year review does not include the 16 OUs that do not have interim or final remedial action RODs at this time; most of these OUs are undergoing the remedial investigation/feasibility study (RI/FS) process or are in the remedy decision process. As cleanup decisions are made for these OUs and documented in a ROD and field construction of the remedy begins, the OUs will be evaluated for protectiveness and included in a future 5-year review report. The Hanford Site OUs currently holding this pre-ROD status are source OUs 100-OL-1, 200-BC-1, 200-CB-1, 200-CP-1, 200-CR-1, 200-CW-1, 200-DV-1, 200-EA-1 200-IS-1, 200-OA-1, 200-SW-1, 200-SW-2, and 200-WA-1 and groundwater OUs 100-BC-5, 200-BP-5, and 200-PO-1.

Public Notification. On November 2, 2014, DOE published a public notice in the local newspaper announcing that the 5-year review would begin in late 2014 and requesting input for topics and questions to consider in this review. DOE received no comments.

Five-Year Review Schedule. The EPA published the first 5-year review report, *USDOE Hanford Site First Five Year Review Report* (EPA 2001b), which covers the period from 1996 through 2000, in 2001. The second and third 5-year review reports for the Hanford Site are DOE/RL-2006-20, *The Second CERCLA Five-Year Review Report for the Hanford Site* (2001 through 2005), and DOE/RL-2011-56, *Hanford Site Third CERCLA Five-Year Review Report* (2006 through 2010), as amended by Errata Sheet "Hanford Site Third Comprehensive Environmental Response, Compensation and Liability Act Five-Year Review Report, April 2012," (12-EMD-0070) for the period of 2006 – 2010. The trigger date for subsequent reviews corresponds to EPA's concurrence signature date for the preceding 5-year review report. DOE will conduct the fifth 5-year review, which will address remedy implementation and performance for the period from 2016 through 2020, in 2021.

Report Structure. This report has been designed to follow EPA guidance, which identifies the required and desired content of CERCLA 5-year review reports, as well as the proper evaluation and determination of protectiveness for CERCLA OUs. To meet these objectives and align with the Hanford Site's cleanup decision framework, this report is organized by source and groundwater OUs, which are segregated by their location either in the River Corridor or on the Central Plateau, as follows:

- Chapter 2, River Corridor National Priorities List Sites, presents the evaluations of remedy implementation and performance for 21 source and groundwater OUs in the 100 and 300 Area NPL sites and the 1100 Area.
- Chapter 3, Central Plateau National Priorities List Sites, presents the evaluations of remedy implementation and performance for nine source and groundwater OUs in the 200 Area NPL Site.

While each OU write-up is tailored to the precise makeup of the subject OU, they all contain the same basic information:

- A brief description of the OU
- An aerial map showing the OU location on the Site
- A chronology table briefly describing the decision documents relevant to the OU
- A list of remedial action objectives (RAOs[a]) taken directly from the ROD
- A description of the remedy components
- A discussion of the progress at that OU since the last CERCLA 5-year review
- A table summarizing the OU cleanup status
- A diagram of the OU showing waste sites and cleanup status
- A technical assessment that answers specific questions posed by the EPA guidance
- A discussion of any new issues and/or corrective actions involving the OU since the last review

[a]An RAO is a general description of what the cleanup will accomplish (e.g., restoration of groundwater to drinking water standards). RAOs serve as the design basis for the remedy and facilitates the 5-year review determination of protectiveness of human health and the environment.

- A protectiveness statement that explains how well the remedy for the OU is working.

In addition, each groundwater OU section contains an overview table summarizing the remedy implementation. The table lists the decision documents, briefly describes the associated RAOs, lists the contaminants of concern (COC), and provides a list of the remedy components and an estimate of each component's construction and implementation progress, along with the estimated operation and maintenance (O&M) time for each component and, based on the O&M duration, an estimated completion year. Remedial process optimization (RPO), such as adding new injection/extraction wells or adjusting injection/extraction rates for a pump-and-treat operation (P&T), is considered part of the O&M phase. The table's construction status chart reflects a snapshot of the remedy component as it was in December 2015; the table does not reflect planned studies or remedy modifications, or speculate on future changes based on current or future studies or findings.

Each groundwater OU section also contains a table providing the contaminant plume concentration and extent from 2011 and 2015, a map showing the OU's well locations, plume maps comparing the contaminant plumes from 2011 and 2015, and a trend plot showing the changes in contaminant concentration since remediation began.

1.1 BACKGROUND

The Hanford Site was established in 1943 to produce nuclear materials for national defense and is managed by the DOE, Richland Operations Office (DOE-RL), and DOE, Office of River Protection (DOE-ORP). The city of Richland, the nearest population center, adjoins the southeastern Hanford Site boundary.

The Hanford Site covers approximately 1500 km^2 (580 mi^2) adjacent to the city of Richland, Washington (Figure 1-1). The original site was 1740 km^2 (670 mi^2) and included buffer areas across the Columbia River in Grant and Franklin counties. Some of this land was returned to private use and now supports orchards and irrigated fields.

When it was established, the Hanford Site was divided into numerically designated areas. These areas served to identify the locations for reactor, chemical separation, and related activities for producing and purifying special nuclear materials and other nuclear activities. Six reactor areas were established along the Columbia River in Hanford's 100 Area. The 200 Areas, include the 200 East and 200 West Areas, and are, respectively, about 7 and 5 miles south and 7 and 12 miles west of the Columbia River where chemical separations of the irradiated fuel took place. Reactor fuel reprocessing took place in the 200 Areas. The 300 Area, located adjacent to the Columbia River and immediately north of the city of Richland, contained the reactor fuel manufacturing plants and the research and development laboratories. The 1100 Area, located southwest of the 300 Area and just north of Richland, served as the central warehousing, vehicle maintenance, and transportation operations center for the Hanford Site. As shown in Figure 1-1, Hanford's 100, Area, 300 Area, and 1100 Area are in an area known as the River Corridor. Hanford's 200 Areas are located on an area known as the Central Plateau.

1.1.1 History and Basis for Taking Action on Cleanup

In early 1943, the U.S. Army Corps of Engineers selected the Hanford Site as the location for plutonium production for national defense. For over 20 years, activities were dedicated primarily to producing plutonium and managing the resulting waste. In later years, activities became increasingly diverse, involving research and development for advanced reactors and renewable energy technologies. The end of the Cold War precipitated the shutdown of the Site's plutonium production and management facilities.

When the cleanup project was initiated in 1989 with the signing of the Tri-Party Agreement (Ecology et al. 1989), efforts to characterize known and suspected areas of contamination began. Early CERCLA remedial investigations/feasibility studies (RI/FS) and RCRA facility investigation/corrective measures study (RFI/CMS) work plans indicated that 7 to 10 years of

characterization would be needed before cleanup alternatives could be evaluated and decisions made, but for many OUs, the characterization process has taken much longer (Table 1-1).

Based on early Hanford Site waste disposal practices and known spills and releases to the environment, the Hanford Site potentially qualified for listing on the CERCLA NPL. The DOE initiated a preliminary assessment/site investigation that included a comprehensive review of historical records including facility operating records; data from groundwater, surface water, soil, and air monitoring and sampling; aerial photographs; interviews with workers; and physically walking the Site to identify potentially disturbed areas. Using the information gathered during these activities, EPA determined that the Site qualified for inclusion on the NPL.

The preliminary assessment/site investigation also revealed that exposure to some contaminants posed a potential threat to human health and the environment. As a result, DOE established a 'bias for action' approach to cleanup. The bias for action allowed DOE, with regulatory agency approval, to conduct removal actions in areas that pose a potential immediate threat to human health and the environment. This resulted in taking interim remedial actions before fully characterizing the type, level, and extent or degree of contamination and before developing final CERCLA remedy selection RODs.

DOE has leased some areas within the Site boundaries to other government organizations; these areas are not included in the CERCLA activities. Leased areas include the Energy Northwest Columbia Generating Station, the US Ecology Commercial Low-Level Radioactive Disposal Site, and the National Science Foundation Laser Interferometer Gravitational-Wave Observatory operated by the California Institute of Technology and the Massachusetts Institute of Technology. Also not included in DOE's CERCLA activities, are the approximately 1,641 acres that DOE recently transferred to the Tri-City Development Council (TRIDEC) Community Reuse Organization by quitclaim deed.

In anticipation of the NPL listing, DOE entered into the Tri-Party Agreement (Ecology et al. 1989) with the Washington State Department of Ecology (Ecology) and the EPA. The legally binding agreement established regulatory guidelines and the framework for achieving the cleanup. For each OU, the Tri-Party Agreement (Ecology et al. 1989) designates either EPA or Ecology as the lead regulatory agency. By Federal law, DOE is the lead agency to implement CERCLA. The official list of waste sites that need CERCLA remedial action is included in the *Hanford Federal Facility Agreement and Consent Order Action Plan* (Tri-Party Agreement Acton Plan) (Ecology et al. 2011), Appendix C. The Waste Information Data System (WIDS) database maintains information for each of these waste sites as required by the Tri-Party Agreement Action Plan. WIDS is managed in accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS).*

The Tri-Party Agreement's (Ecology et al. 1989) scope is broader than this review. It also addresses regulated *Resource Conservation and Recovery Act of 1976* (RCRA) units and the cleanup of past-practice units required under RCRA and/or CERCLA. Active RCRA treatment, storage, and disposal (TSD) units, such as the tank farms, are not part of this review. Although this review does not cover RCRA TSD activities, the Tri-Party Agencies (DOE, EPA, and Ecology) are integrating closure of inactive TSD facilities with CERCLA waste site cleanup, as the Tri-Party Agreement (Ecology et al. 1989) intended. The Tri-Party Agencies also are applying a groundwater cleanup strategy, set forth in *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection* (DOE/RL-2002-68), that integrates the authorities and requirements of the *Atomic Energy Act of 1954* (AEA), CERCLA, and RCRA.

The Tri-Party Agreement also allows the lead regulatory agency an option to perform independent 5-year reviews. EPA exercised this option in calendar year (CY) 2000 and conducted the first CERCLA 5-year review of response actions for the Hanford Site. This first review evaluated the performance of the remedies selected in interim action RODs, including the existing institutional controls (IC) to prevent exposure to the public and the environment. The first review also identified deficiencies and corrective actions to address the deficiencies. The review concluded that the selected remedies were protective or would be protective when the remedial action was completed. In April 2001, EPA released the *USDOE Hanford Site First Five-Year Review Report* (EPA 2001b), which documents those results.

Consistent with CERCLA and Executive Order 12580, DOE conducted the second (2005-2006) and third (2010-2011) 5-year reviews. They used the same approach as EPA in conducting these reviews, following EPA's *Comprehensive Five-Year Review Guidance* (EPA-540-R-01-007), dated June 2001.

Because sufficient information about the level and extent of contamination was not available to support final decisions, interim action decision documents (interim action RODs, expedited response action approvals, and action memorandums) were developed. During interim cleanup actions, samples are collected and analyzed to evaluate the progress of the action and to increase understanding of the types, levels, and extent of the contamination and more complete remedial actions.

These remedial actions addressed the contaminants of greatest concern in the areas where the environmental threat was known to be highest. As a result, cleanup focused for several years in areas that posed the highest risk to the Columbia River (River Corridor, Table 1-1). The focus has been on activities intended to protect the Columbia River primarily by using excavation, treatment and disposal and groundwater P&T systems to remove source contaminants from the soil and groundwater.

1.1.2 Land Use

Cleanup decisions take into consideration the current and reasonably anticipated future land use.

The *Hanford Comprehensive Land Use Plan Environmental Impact Statement (HCP-EIS)* (DOE/EIS-0222-F) addresses land use planning for the Hanford Site. The final selection of land-use designations, map, policies, and procedures, as documented in the HCP-EIS ROD (ROD, 64 FR 61615, November 12, 1999), defines the Site's *Comprehensive Land Use Plan (CLUP)*. The acronym "HCP-EIS" is used when addressing the analysis of the environmental impacts and the *National Environmental Policy Act* (NEPA) process for the EIS. Hanford's land use map, as presented in *Supplement Analysis of the Hanford Comprehensive Land-Use Plan Environmental Impact Statement* (DOE/EIS-0222-SA-02), is shown in Figure 1-2.

As stated in the HCP-EIS, "the CLUP is a living document designed to identify a course over an extended period of development and management of resources, yet the plan is flexible enough to accommodate a wide spectrum of both anticipated and future mission conditions."

The HCP-EIS and ROD will remain in effect as long as DOE retains legal control of some portion of the Hanford Site, which is expected to be longer than 50 years.

1.2 REMEDIAL ACTIONS

Remedial actions under way at the Hanford Site, which vary by OU, are described in detail in Chapters 2 and 3. Common remedy components are as follows:

- **Source OUs**. Decontaminate and demolish buildings; remove, treat if necessary, and dispose of (RTD) contaminated soil, debris, piping, landfills, and engineered structures; treat in situ; backfill, recontour, and revegetate; implement ICs
- **Groundwater OUs**. Extract, treat, and reinject groundwater; treat in situ via chemical additions; use reactive barriers; enhanced attenuation and monitored natural attenuation; groundwater monitoring; and implement ICs.

Because ICs are often a common remedy component for both source and groundwater OUs, they are discussed in more detail in the following subsection.

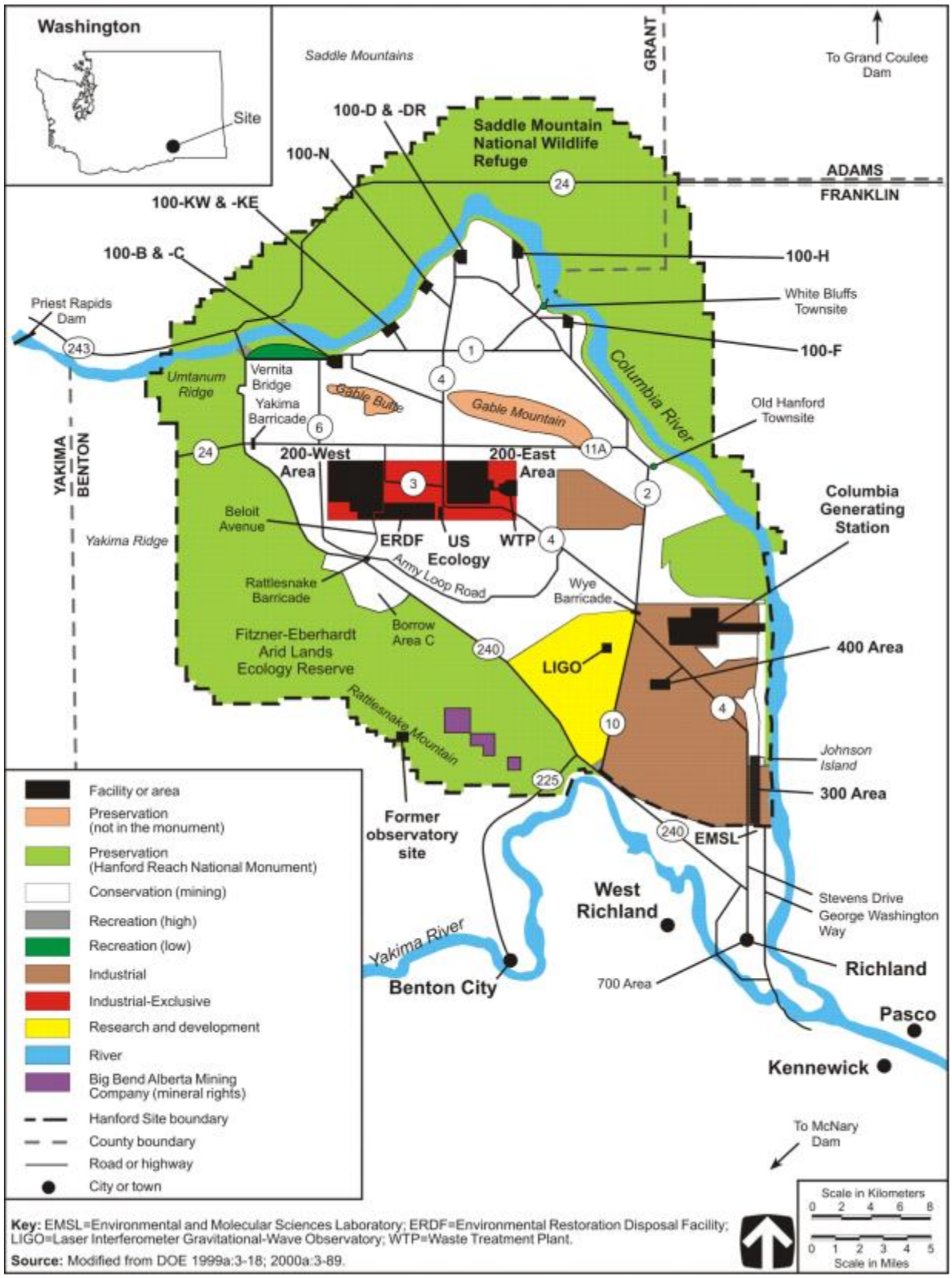


Figure 1-2. Hanford Comprehensive Land-Use Plan Environmental Impact Statement Land-Use Map.

1.2.1 Institutional Controls

ICs have been a critical element of Hanford Site operations since the Site's inception as part of the Manhattan Project. Because of the nature of the Manhattan Project and later nuclear materials production activities, public access to the Site was prohibited; the prohibition was strictly enforced using signs, fences, sophisticated monitoring technology, and armed patrols. With the change in mission to environmental cleanup, the need for some of the more aggressive ICs has been reduced. However, protecting the public and Site workers from inadvertent exposure to potential hazards and protecting physical assets requires that certain ICs remain in place. Table 1-2 summarizes the categories, types and objectives of ICs in use at the Hanford Site as of December 2015, the end of this 5-year review period.

Table 1-2. Categories, Types, and Objectives of Sitewide Controls.

Category	Types	Objectives
Access Controls	Warning Notices	• Provide visual identification and warning of hazardous or sensitive areas
	Entry Restrictions Procedural requirements for access	• Control human access to hazardous or sensitive areas • Ensure adequate training for those entering hazardous or sensitive areas • Avoid disturbance of and exposure to remedies such as engineered barriers or effective vegetative soil layers • Provide a basis for enforcing access restrictions
	Fencing	• Prevent unauthorized human access to hazardous or sensitive areas • Provide protective barriers to standard industrial hazards • Provide visual warnings • Avoid disturbance of and exposure to remedies such as engineered barriers or effective vegetative soil layer
Land-Use Management	Land-use and real property controls	• Ensure land use is compatible with existing hazards • Ensure any land use changes are adequately assessed before being allowed • Ensure the ICs are maintained beyond change of ownership, as appropriate
	Excavation permits Site Evaluation	• Avoid unplanned disturbance or infiltration • Inform and protect workers regarding potential exposure to hazardous waste • Avoid creating potential hazardous waste migration pathways
	Notice in Deed	• Ensure land use is limited to that designated
Groundwater-Use Management	Land-use and real property controls, excavation permits	• Ensure proper use of groundwater
Waste Site Information Management	Administrative	• Maintain and provide access to information on the location and nature of contamination

IC= institutional control.

To ensure the ICs required under CERCLA are implemented effectively, DOE prepared the *Site Wide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Action* (DOE/RL-2001-41). This document provides a consolidated and detailed description of the ICs required by the CERCLA documents (e.g., interim and final RODs, ROD amendments, ESDs, Tri-Party Agreement change notices, cleanup verification packages, and work plans) for each OU. These ICs prevent such remedies as engineered barriers or a vegetated soil layer from being disturbed and help protect DOE employees, contractors, and any or any combination of the following groups:

- **Non-DOE Entities Using DOE Land**. Individuals associated with an organization other than DOE or its contractors who are located on the Hanford Site or are conducting activities on the Hanford Site
- **Hanford Site Visitors**. Individuals who access the Hanford Site for Site-related purposes (e.g., public tours)
- **Inadvertent Intruders**. Individuals who inadvertently access the Site (e.g., stray onto the Site from recreational areas along the Columbia River shoreline).

DOE has the primary responsibility for assessing the performance of the ICs to ensure their effectiveness and identifying any need to adjust the ICs based on performance findings. DOE and its prime contractors (Mission Support Alliance, LLC [MSA], CH2M HILL Plateau Remediation Company [CHPRC], and Washington Closure Hanford [WCH] during this 5-year review period) assess the ICs and annually report on their effectiveness to EPA and Ecology at Hanford's 100/300 Area and 200 Area unit managers meetings. The annual assessment results typically are presented during the September meeting and captured in minutes that are published in the Administrative Record (see example in Attachments 12, 13, and 14 at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). The Sitewide ICs assessment, in conjunction with the CERCLA 5-year review, is a "roll up" of these reviews and is the basis for evaluating the ICs' effectiveness. Five annual IC assessments have been performed since the last 5-year review. Appendix A, Table A-1, summarizes the assessment results for this 5-year period.

1.3 REVIEW PROCESS

The process for reviewing source OUs and groundwater remediation OUs generally included the following activities:

Document Gathering and Data Review. The first step in producing this *Hanford Site Fourth CERCLA Five-Year Review Report* involved gathering data to evaluate the OUs with active remedial actions. Information and data gathered and reviewed included remedy performance and operational requirements, compliance and findings, recommendations, and action items from *The Third CERCLA Five-Year Review Report for the Hanford Site* (DOE/RL-2011-56), as amended by Errata Sheet 12-EMD-0070. Data gathered and reviewed for performance and operational requirements included RODs, ROD amendments, explanations of significant difference (ESD), and remedial design reports/remedial action work plans (RDR/RAWP). Groundwater monitoring data were reviewed and assessed for trends in contaminant plume size, river shoreline impacts, and progress toward full implementation of the remedy components. Waste Information Data System (WIDS) entries were reviewed, along with waste site cleanup documentation such as waste site cleanup verification packages. The results from annual IC assessments, including any breaches/violations ICs, also were gathered and reviewed. Together, this information and data supported the technical basis for performing this 5-year review.

Site Visits and Field Evaluation. DOE representatives and DOE contractor staff regularly perform field evaluations. DOE and regulatory personnel actively oversee the cleanup activities and are frequently in the field inspecting the contractors' work. When necessary, field evaluations are conducted with the DOE contractor performing the work under consideration to review potential issues identified during the data gathering and review portion of the review process. Annual assessments of institutional controls also were performed and presented to Site regulators each fall.

Interviews. Assessment of the more than two dozen OUs addressed in this report required an extensive number of focused personal interviews, team discussions, and information and data exchanges among DOE managers and project leads, Site contractors' OU project managers and lead scientists, as well as with the lead regulatory agency (EPA and Ecology) staff assigned to each OU. While the focused dialogue to support development of this report took place primarily during 2015 and 2016, DOE, EPA, Ecology and other Site stakeholders also actively involved in OU remedy implementation and performance matters interacted via the unit managers meetings (generally held bimonthly) throughout the 5-year review period.

Support for Action Item Discussions. DOE held discussions with the respective lead regulatory agency to address outstanding recommendations or performance issues. Action items resulting from these discussions and draft report reviews are included in this report.

Technical Assessment. The technical assessment evaluates the risk input factors, including the following: future land use and associated exposure pathways; site conditions, such as the degree to which remedy performance is based on the original assumptions; and contaminant toxicity.

Additional considerations included determining whether the remedy is operational and functional through the following methods:

- Evaluating the parameters that the Tri-Party Agencies established as appropriate indicators of performance (i.e., performance assessment of the remedy for completed actions, ongoing long-term remedial actions, and interim remedial actions) via RODs
- Evaluating the assumptions critical to the effectiveness of remedial measures or the protection of human health and the environment for the remedial decisions to determine, given the current information, whether these assumptions are still valid (i.e., whether corrective measures are required to address any identified deficiencies)
- Determining whether opportunities exist to optimize the long-term performance of the remedy or reduce life-cycle costs.

In determining the protectiveness of the remedies, DOE considered the following technical assessment questions:

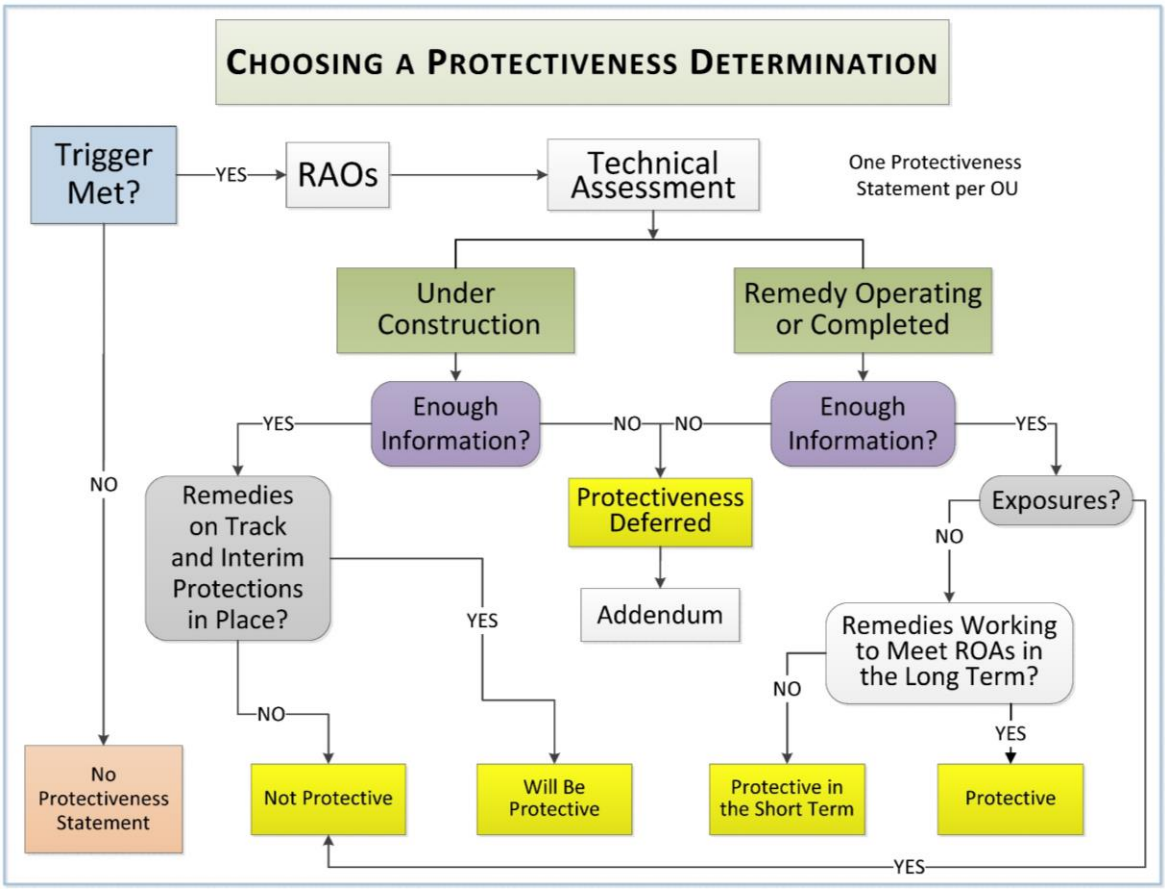
- *Is the remedy functioning as intended by the decision document?*
- *Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?*
- *Has any other information come to light that could call into question the protectiveness of the remedy?*

Protectiveness Statement Development. DOE evaluated the OUs in each Hanford NPL site (100 Area, 200 Area and 300 Area) as well as one waste site located in Hanford's 1100 Area. DOE used the three technical assessment questions provided in the EPA guidance to evaluate the success of implementing the selected remedies against the remedial action objectives and cleanup criteria established in the ROD. Protectiveness statements for each OU were developed in accordance with the process outlined in EPA's *Comprehensive Five-Year Review Guidance* (EPA 2001a), the EPA memo, "Clarifying the Use of Protectiveness Determinations for CERCLA Five Year Reviews" (OSWER 9200.2-111), as well as the general decision logic presented in Figure 1-3.

Report Development. After DOE and their contractors completed the previously noted activities, they assembled a comprehensive report for peer review by the project managers, scientists, and engineers from the Site contractor organizations, DOE, EPA, and Ecology. Other stakeholders provided feedback on the draft 5-year review report as well.

The narratives for the individual OUs or, in some cases, groups of similar source OUs, are presented in a generally common format covering the OU's background, the chronology of the decision documents, the selected remedial action, progress since 2011, a technical assessment, identification of any new issues and corrective actions, and a protectiveness statement for each OU.

Next 5-Year Review. As required under CERCLA, the lead agency must conduct a periodic 5-year review of its remedies as long as contaminants pose a threat to human health and the environment. Because CERCLA remedial actions are expected to continue, the next 5-year review will cover the period from January 2016 through December 2020, with the 5-year review report issued by May 4, 2022.



This figure directly applies for OUs with final action RODs (i.e., 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2 and 100-IU-6; 300-FF-1, 300-FF-2, and 300-FF-5; 200-CW-5, 200-PW-1, 200-PW-3 and 200-PW-6; 200-ZP-1 OUs; and 1100 Area). All other OUs addressed in this report are working under interim action RODs; the figure can apply to these OUs by following the "Under Construction" (left green box) condition.

Figure 1-3. Generalized Decision Logic for Choosing a Protectiveness Determination.

2 RIVER CORRIDOR (100 AREA AND 300 AREA NATIONAL PRIORITIES LIST SITES)

2.1 INTRODUCTION

This chapter presents Hanford's CERCLA 5-year review assessments for OU's that are located in a region of the Site known as the River Corridor. As shown in Figure 1-1, the River Corridor encompasses nearly 220 m^2 directly south and west of the Columbia River, and includes Hanford's 100-BC, 100-K, 100-N, 100-D, 100-H, and 100-F reactor-site areas, the 300 Area, and one isolated waste site in Hanford's 1100 Area. The River Corridor represents almost 40 percent of the Hanford Site's overall footprint.

Two of the three Hanford NPL Sites (i.e., the Hanford 100 Area, and 300 Area NPL Sites) are included in the River Corridor. Table 2-1 provides a list and brief description of the 17 source OUs and the 6 associated groundwater OUs in the 100 and 300 Area NPL sites and the 1100 Area. Collectively, the source OUs contain more than 850[a] waste sites. More than 85 percent of these waste sites had been remediated under a ROD and/or interim remedial-action ROD as of the end of this 5-year review period (December 2015).

The 100 Area NPL site comprises nine retired plutonium production reactors, numerous support facilities, and solid- and liquid-waste disposal sites with contaminated groundwater and soil. The 300 Area NPL site (located immediately north of the city of Richland, Washington) includes an industrial complex that was used for uranium fuel fabrication and research and development activities for the Hanford Site; the 300 Area also includes a number of waste disposal sites and areas of contaminated groundwater. Hanford's 1100 Area was officially removed from the NPL in 1996 (see details in Section 2.4), however, one waste site (the Horn Rapid Landfill, also part of the River Corridor) contains asbestos. As long as asbestos, a hazardous substance, remains at the landfill site and prevents the property from being released for unlimited use and unrestricted exposure, the landfill will be included in Hanford's 5-year review.

Given that land use helps form the basis for exposure assessment assumptions and risk characterization conclusions under CERCLA, the current and reasonably anticipated future uses for OU land in the River Corridor, as well as the current use and future beneficial use of groundwater located beneath these OUs, can be summarized as follows:

- **Current Onsite and Surrounding Land Use.** Land use in the River Corridor is controlled primarily by DOE, with the U.S. Fish and Wildlife Service managing the Hanford Reach National Monument. Together, they manage this federally owned land to protect natural and cultural resources during cleanup activities. The River Corridor area comprises mostly undeveloped land. The 300 Area and the nine reactor areas in the River Corridor are being used for waste management, environmental monitoring, waste site remediation, and conservation (mining). Land use beyond the Hanford Site boundaries includes irrigated agriculture; to the south and east are the cities of Richland, West Richland, Kennewick, and Pasco.
- **Anticipated Future Land Use.** In June 2000, the *Hanford Reach National Monument Proclamation* (Clinton 2000) established the monument within the Hanford Site boundaries. Clinton (2000) mandates preservation of the monument's natural and cultural resources and specifically includes the possibility of adding lands to the monument as they are remediated. DOE's reasonably anticipated future use of the River Corridor land in close proximity to the Columbia River is mostly conservation (mining) and preservation; inland-area land use includes conservation (mining) and industrial use in and near the 300 Area, as well as research and development.

[a]This value represents "Accepted" waste sites in WIDS as of December 2015, per TPA-MP-14.

Table 2-1. Chapter 2 Scope – Hanford NPL Sites and Operable Units Located in the River Corridor.

Hanford Area	CERCLA OU	Brief Description[a]	Report Section
100 Area			**2.3**
100-B/C			2.3.1
	100-BC-1	Waste sites (~29) in the 100-B/C Reactor areas	
	100-BC-2	Waste sites (~88) in the 100-B/C Reactor areas	
	100-BC-5[b]	Contaminated groundwater from 100-BC-1/2 sites	N/A[b]
100-F			2.3.2
	100-FR-1	Waste sites (~72) in the 100-F Reactor area	
	100-FR-2	Waste sites (~18) in the 100-F Reactor area	
	100-IU-2	Waste sites (~49) in the old White Bluffs townsite area, recently expanded to include westward areas	
	100-IU-6	Waste sites (~39) in the old Hanford Townsite area, recently expanded to include southward areas	
	100-FR-3	Contaminated groundwater from 100-FR-1/2 sites	
100-D/H			2.3.3
	100-DR-1	Waste sites (~89) in the 100-D Reactor area	
	100-DR-2	Waste sites (~33) in the 100-DR Reactor area	
	100-HR-1	Waste sites (~49) in the 100-H Reactor area	
	100-HR-2	Waste sites (~17) in the 100-H Reactor area	
	100-HR-3	Contaminated groundwater from 100-DR-1/2 and 100-HR-1/2 sites	
100-K			2.3.4
	100-KR-1	Waste sites (~22) in the 100-K Reactor areas[c]	
	100-KR-2	Waste sites (~107) in the 100-K Reactor areas	
	100-KR-4	Contaminated groundwater from 100-KR-1/2 sites	
100-N			2.3.5
	100-NR-1	Waste sites (~133) in the 100-N Reactor area	
	100-NR-2	Contaminated groundwater from 100-NR-1sites	
100-OL			2.4
	100-OL-1[b]	Former/pre-Hanford orchard land sites in 100 Area	N/A[b]
300 Area			**2.3**
300			2.3.6
	300-FF-1	Waste sites (~39) in the 300 Area[c]	
	300-FF-2	Waste sites (~104) in the 300 Area	
	300-FF-5	Contaminated groundwater from 300-FF-1/2 sites	
1100 Area			**2.4**
1100			
	1100-EM-1	Waste site (1), Horn Rapids Landfill, in the 1100 Area	
Legend	Source OU	Groundwater OU	

[a]Number of waste sites noted in parentheses represents the number of "Accepted" sites noted in WIDS (not including subsites) in accordance with TPA-MP-14[d], *Maintenance of the Waste Information Data System (WIDS)*, as of December 2015. Numbers may change as sites are added or deleted per processes defined in TPA-MP-14.

[b]100-BC-5 and 100-OL-1 are not included in this CERCLA[e] 5-year review because both OUs are in the RI/FS stage and neither interim- nor final-action RODs had been issued as of December 2015.

[c]Waste sites in this OU are principally soils sites contaminated by liquid waste discharges.

[d]TPA-MP-14, 2011, *Maintenance of the Waste Information Data System (WIDS)*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

[e]*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*, 42 USC §9601 et seq.

N/A = not applicable. OU = operable unit. RI/FS = remedial investigation/feasibility study.

- **Current Ground and Surface Water Uses**. Groundwater from all six River Corridor groundwater OUs is contaminated above drinking water standards (DWS), and withdrawal for uses other than research purposes and monitoring is prohibited by DOE's self-imposed site controls. Under current site-use conditions and controls, the only potential complete human exposure pathway to groundwater in these areas is the possibility of limited exposure to groundwater from intermittent seeps along the Columbia River or during remediation, research, and monitoring activities. Groundwater from these OUs is not being used for drinking.

2.2 100 AREA NATIONAL PRIORITIES LIST

2.2.1 Background

The 100 Area NPL Site is located the northern portion of the Hanford Site and encompasses approximately 427 km^2 (165 mi^2) along the Columbia River. The 100 Area includes six reactor areas (100-B/C, 100-K, 100-N, 100-D/DR, 100-H 100-F). There are two reactors each at 100-B/C, 100-D, and 100-K, and one reactor each at 100-F, 100-H, and 100-N.

Eight of the nine 100 Area reactors were constructed between 1944 and 1955 and used Columbia River water for once-through cooling. The water was then discharged back to the river or to liquid waste disposal sites in the soil. The discharged cooling water contained radioactive materials and hazardous waste constituents that resulted in contaminated soil (source sites) and groundwater. The 100-N Reactor, constructed in the early 1960's, differed from the others in that it had a dual purpose of producing electricity as well as tritium and special nuclear material. Using the heat created while producing nuclear material to generate electricity eliminated the need to discharge large volumes of water. Because of this reactor design difference, the 100-N liquid waste disposal sites receive higher concentrations of radionuclides than waste disposal sites at other 100 Area reactor locations.

Collectively, reactor operations in the 100 Area resulted in a large number of contaminated facilities, buried pipelines, buried waste, buried and exposed disposal cribs, disposal trenches, river structures, shoreline sites, and unplanned release sites and regions of contaminated vadose zone and groundwater. Spent nuclear fuel from the reactors in the 100 Area, previously stored in two water-filled basins in the 100-K Area, has been removed. The 100-KE Basin has been decommissioned and demolished; additional remedial actions are ongoing. Cleanup in the 100 Area is being accomplished through the 14 source OUs and 5 groundwater OUs identified in Table 2-1.

Progress since the last (2006 – 2010) CERCLA 5-year review includes more than 425 waste sites that have had remedial actions implemented in the 100 Areas. These sites have been reclassified in WIDS as interim no-action, final no-action, interim closed, or final closed, with completion of the action approved by the lead regulatory agency. Approval is documented through the waste site reclassification forms included with a waste site cleanup verification package or remaining sites verification package. In accordance with the Tri-Party Agreement (Ecology et al. 1989), the status and other descriptive information on each waste site is maintained in the WIDS database. Also since the last 5-year review, continuous groundwater remediation has been under way. Expanded P&T systems have been operating in the 100-D, 100-H, and 100-K Areas, and in situ barrier technology has been deployed in the 100-N Area. The individual OU discussions provide additional information. Annual summary reports for the 100 Area P&T remedy performance and operations can be accessed at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports. In addition, a ROD was issued in 2014 for the 100-FR-1/2 and 100-IU-2/6 source OUs, and the 100-FR-3 groundwater OU.

Progress and assessments of protectiveness at the 100 Area source and groundwater OUs are further described in the following sections.

2.3 100 AREA OPERABLE UNITS

2.3.1 100-B/C Operable Units

The 100-B/C Area is in the northwest portion of the Hanford Site and adjacent to the Columbia River. The 100-B/C Area encompasses the 100-BC-1 and 100-BC-2 source OUs and the 100-BC-5 groundwater OU. Figure 2-1 shows the general locations of the 100-BC-1 and 100-BC-2 source OUs. The 100-BC-5 OU encompasses the area of groundwater contamination originating from these source OUs.

Section 2.3.1.1.7 presents an evaluation of protectiveness for the 100-BC-1 and 100-BC-2 OUs because they have been undergoing waste site remediation in accordance with interim action RODs. However, the 100-BC-5 groundwater OU does not have a ROD and will, therefore, be evaluated for protectiveness in a future CERCLA 5-year review report.

2.3.1.1 100-BC-1 and 100-BC-2 Source Operable Units

This section describes the background and interim remedial actions conducted in the 100-B/C source OUs.

2.3.1.1.1 Background

The 100-BC-1 OU comprises the north portion of the 100-BC area and is immediately adjacent to the Columbia River. The 105-B Reactor was constructed in 1943 and operated from 1944 through 1968, when it was retired from service. In 2008, the 105-B Reactor was designated as a National Historic Landmark by the National Park Service; public tours have been offered since 2009. The 100-BC-1 OU contains waste units associated with the original facilities constructed to support 105-B Reactor operations, as well as the cooling water retention facilities that supported both the 105-B and 105-C Reactors. Waste sites in this OU include solid waste burial grounds, effluent pipelines, dry wells, tanks, outfall structures, retention basins, and liquid waste receiving sites (i.e., unlined trenches, cribs, and French drains).

The 100-BC-2 OU contains waste sites associated with the facilities that supported 105-C Reactor operations and other waste sites at 100-BC, including most of the solid waste burial grounds. The 105-C Reactor, similar to the 105-DR Reactor but completed 2 years earlier, was started up in September 1952. It used as many of the existing 105-B Reactor facilities as possible by expanding these facilities and/or cross-tying pipelines between facilities. The most significant shared facilities were the river pump house, reservoir, and inert gas system. The reactor was permanently shut down in April 1969 and in situ stabilized in 1998.

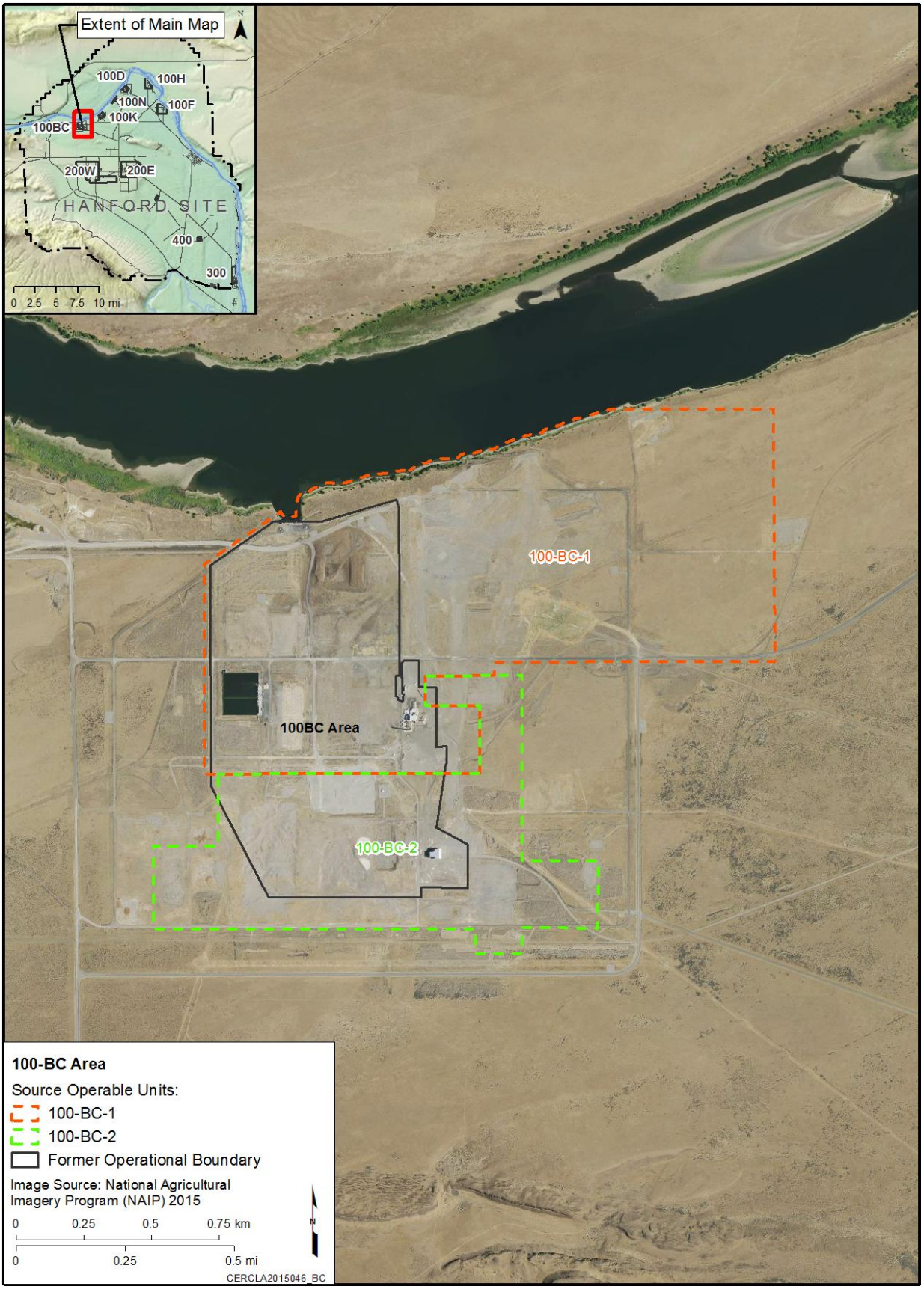


Figure 2-1. Location of 100-BC-1 and 100-BC-2 Source Operable Units.

2.3.1.1.2 Chronology

Table 2-1 lists the remedial action decision documents relevant to source operable unit response actions in the 100-B/C Area.

Table 2-1. Decision Documents for the 100-BC-1 and 100-BC-2 Source Operable Units.

Date	Location	Title
9/1995	EPA/ROD/R10-95/126	***Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This interim action ROD requires removal of contaminated soil, structures, and debris using the observational approach, treatment by thermal desorption to remove organics and/or soil washing for volume reduction or as needed to meet waste disposal criteria, disposal of contaminated materials at ERDF, backfill of excavated areas followed by revegetation.
4/1997	EPA/AMD/R10-97/044	***Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This amendment to the interim action ROD incorporates 34 additional waste sites into the ROD; refines remedial cost estimates for the original 37 sites and additional 34 sites based on actual data, streamlining, and lessons learned; and eliminates the soil washing treatment option before disposal.
7/1999	EPA/ROD/R10-99/039	***Interim Action Record of Decision for the 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 Operable Units Remaining Sites.*** This interim action ROD requires RTD for 46 sites, adds a plug-in approach for the RTD remedy for both remaining 100 Area and 200 North sites and for newly identified 100 Area sites added by ESD, disposal of debris from B, D, H, and K reactors to ERDF, and provides decision framework for leaving waste in place, generally below 15-ft depth.
9/2000	EPA/ROD/R10-00/121	***Interim Action Record of Decision. 100-BC-I, 100-BC-2, 100-DR-I, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2 Operable Units (100 Area Burial Grounds).*** This interim action ROD requires removal of contaminated soil, structures, and debris; treatment as needed; disposal of waste at ERDF; backfilling; and revegetation. It applies to 45 burial grounds in the 100 Area.
2/2004	EPA 2004	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** The ESD adds 28 sites to the ROD; adds 10 CFR 1022 and 40 CFR 6, Appendix A, as ARARs to the ROD; and revises annual ICs report date to coincide with the due date for the Sitewide ICs plan for Hanford CERCLA response actions.
11/2007	08-AMRC-0033	***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).*** This ESD establishes the limit of RTD excavation at the 118-B-1 burial ground considering the balancing factors in the ROD and requires additional ICs to protect groundwater and the Columbia River.
8/2009	EPA et al. 2009	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** This ESD authorizes adding 200-CW-3 OU wastes sites, 99 newly discovered waste sites, and 87 candidate sites using the plug-in approach in the ROD and any newly discovered waste sites documented in the Administrative Record and an annual fact sheet.
3/2011	DOE et al. 2011	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2010 , Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

Table 2-1. Decision Documents for the 100-BC-1 and 100-BC-2 Source Operable Units.

Date	Location	Title
1/2013	DOE et al. 2013	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2012 , Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.
CFR = *Code of Federal Regulations*.
ERDF = Environmental Restoration Disposal Facility.
ESD = explanation of significant difference.
IC = institutional control.
OU = operable unit.
ROD = record of decision.
RTD = removal, treatment, and disposal.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.1.1.3 Remedial Action

Goals and Objectives. The RAO for the 100-BC-1 and 100-BC-2 waste sites, as stated in the 1995 ROD (EPA/ROD/R10-95/126), are as follows:

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.***
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.***
- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.***

Principal requirements for achieving the RAOs are described in each of the respective interim action RODs, as amended.

Remedy Components. The 1995 ROD (EPA/ROD/R10-95/126), as amended; the 1999 ROD (EPA/ROD/R10-99/039), as amended, and the 2000 ROD (EPA/ROD/R10-00/121), as amended; share the same basic remedy components, which generally include the following steps:

- Remove contaminated soil, structures, and debris from 100 Area source waste sites using the observational approach, which uses field data and analytical screening during remediation to guide the extent of excavation. Remediation proceeds until field screening and verification sampling demonstrate that cleanup goals have been achieved.
- Treat the waste, as required, to meet applicable waste disposal criteria.
- Dispose of contaminated materials at the Environmental Restoration Disposal Facility (ERDF).
- Backfill excavated areas and revegetate.
- Implement ICs.

Detailed descriptions of the remedy components are provided in the "Selected Remedy" section of each respective ROD, as amended.

Remedy Implementation Progress Prior to this Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work on the interim remedy, as outlined in the previous section, has been ongoing since 1995. Before 2011, interim remedial actions for a majority (84 of 88) of the waste sites had been completed.

Issues/Corrective Actions from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** No issues or actions were noted for the 100-BC-1 OU and/or 100-BC-2 OU in the previous (2006-2010) CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006-2010) 5-year review report for the 100-BC-1 and 100-BC-2 OUs was as follows:

> *"The final remedy at 100-BC-1 OU[b] is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled."*

Accomplishments. Collectively, the interim action ROD RAOs for 100-BC-1 and 100-BC-2 source OUs were achieved in 2015. The remaining waste sites are associated with either the 105-B or 105-C Reactor, are active facilities, or are river pipeline sites where final remedial action decisions will be identified as part of a future final-action ROD.

Since the 2011 5-year review, interim remedies were implemented at the following waste sites and subsites:

- 100-BC-1 Operable Unit: None
- 100-BC-2 Operable Unit
  - 100-B-35, Electrical Substations
  - 100-C-7, Building and Demolition Waste
  - 100-C-7:1, Stained Soil.

The results are documented in waste site cleanup verification packages or remaining sites verification packages.

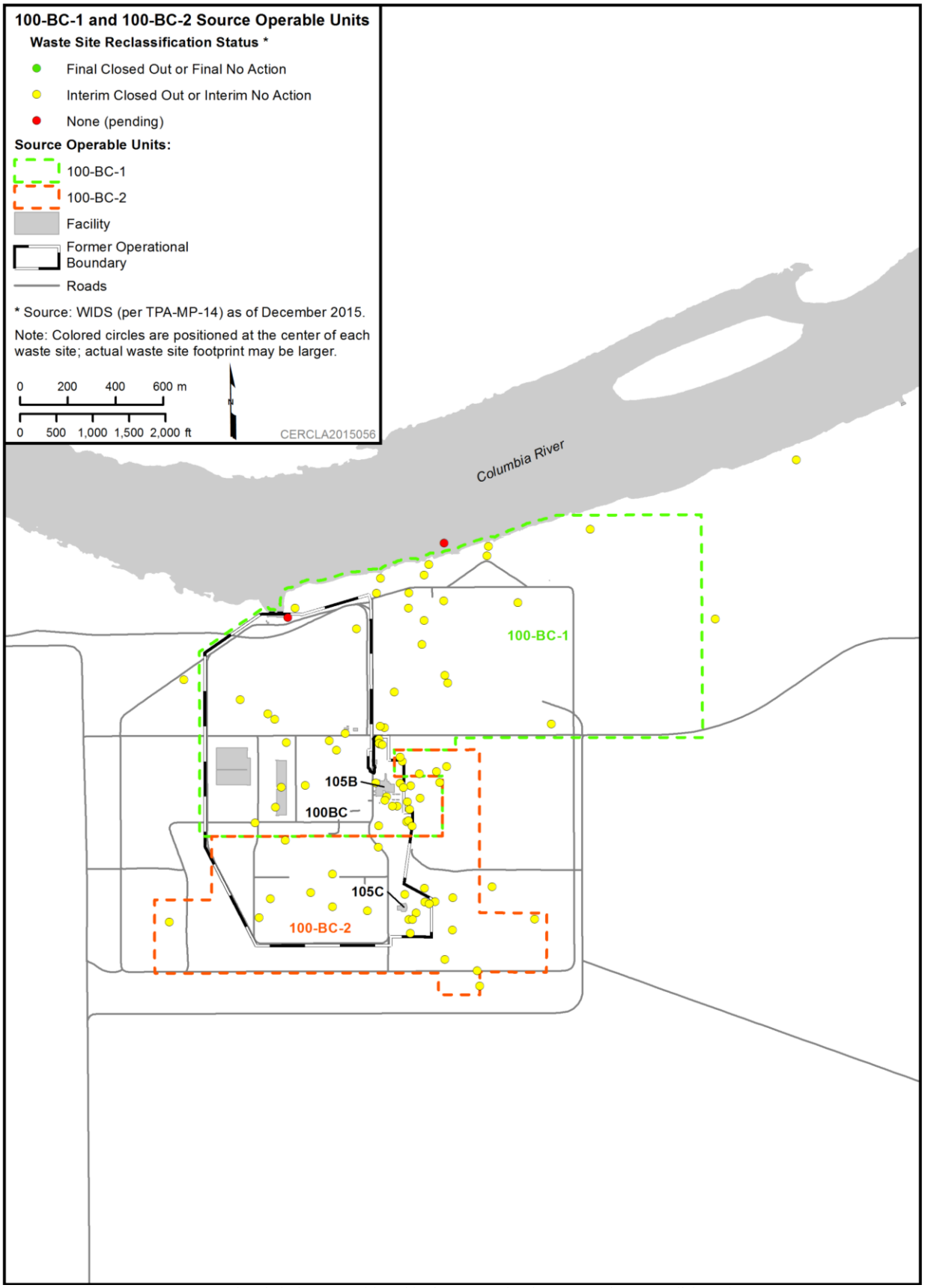
Table 2-2 summarizes the waste site cleanup status for the 100-BC-1 and 100-BC-2 waste sites, including metrics on work accomplished during this past 5-year period (2011 – 2015). Figure 2-2 shows the relative distribution (noted by geographic centers of waste site footprints) and closure status (per WIDS) as of December 2015 for the waste sites in the 100-BC-1 and 100-BC-2 source OUs.

Remedy Implementation. The primary remedial activities in the 100-B/C Area since 2011 have been the remediation of the 100-C-7 and 100-C-7:1 waste sites. These sites consisted of residual sodium dichromate contamination associated with concrete that was left in place after the 1997 decommissioning of the 183-C filter building/pumproom. This work was conducted under the *Remedial Design Report, Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17), as amended.[c] The 100-C-7:1 subsite is the stained surface soil that was observed in 2002 just north of the 183-C head house and adjacent to the northwest corner of the 183-C sedimentation basins.

Remedial action at the 100-C-7 waste site began in 2004. Excavation was completed to a depth of 4.6 m (15 ft), where in-process sampling indicated residual chromium contamination. Following initial remediation of the 100-C-7 waste site, total chromium and hexavalent chromium were found to be present at concentrations exceeding the remedial action objectives and goals established by the 100 Area remedial design report/remedial action work plan (RDR/RAWP) in the subsurface soil beyond the boundaries of the remediation excavations at both the 100-C-7:1 and 100-C-7 monolith waste sites and further remediation was necessary to protect groundwater in the 100-B/C Area.

[b]The 100-BC-2 OU probably should have been include in this or an identential statement given that the OU was discussed with 100-BC-1 in the previous report.

[c]Numerous changes have been made to DOE/RL-96-17 since its initial publication in 1996. The hyperlink included in citations for the RDR/RAWP is to the latest full revision (Rev. 6, published in 2009). Tri-Party Agreement change notices are among the mechanisms used to change the RDR/RAWP. These are listed, along with hyperlinks to their location in the Administrative Record, in the reference section of this CERCLA 5-year review immediately following the entry for DOE/RL-96-17. Historical changes to this RDR/RAWP can be viewed in the Administrative Record by querying DOE/RL-96-17.



Note: Colored circles are positioned in the center of a given waste site's overall footprint.

Figure 2-2. Geographic Distribution and WIDS Reclassification Status of the 100-BC-1 and 100-BC-2 Source Operable Unit Waste Sites as of December 2015.

Additional remedial action below 4.6 m (15 ft) began on June 8, 2010. Remedial actions were completed in December 2011 at the 100-C-7 waste site and approximately 66,387 bank cubic meters (BCM) (86,831 bank cubic yards [BCY]) of contaminated soil were excavated for disposal to ERDF. Remedial actions were completed in January 2013 at the 100-C-7:1 waste site and approximately 293,844 BCM (661,150 BCY) of contaminated soil were excavated for disposal at ERDF. The final excavation depth was approximately 27 m (89 ft) below grade surface (bgs), to the water table.

ICs have been implemented and maintained during this 5-year review period to control access to residual soil and groundwater contamination above standards for unlimited use and unrestricted exposure.

2.3.1.1.4 Technical Assessments

Is the remedy functioning as intended by the decision documents?

The interim remedy (primarily involving RTD, backfilling, revegetation, and ICs) is functioning as intended by the interim action ROD (as amended). As of December 2015, 86 of the 88 100-BC-1 and 100-BC-2 waste sites had been remediated. The two 100-BC-1 OU waste sites that had not yet been remediated as of December 2015 were 100-B-15, 100-BC River Effluent Pipelines, and 1607-B5, Septic Tank System; these two waste sites will be addressed in the future final ROD. A final ROD for the entire 100-B/C Area (including source and groundwater OUs) is anticipated by DOE during the upcoming (2016 – 2020) 5-year review period.

In accordance with TPA-MP-14, the 100-BC-1 and 100-BC-2 remediated waste sites have been documented in WIDS as either interim closed or interim no-action. Cleanup verification packages (including sampling data and other technical information) to support the reclassification to interim closed or no-action are included in the Hanford Site Administrative Record for the 100-BC-1 and 100-BC-2 OUs. The remedial action goals (RAG) (contaminant-specific soil cleanup criteria developed to ensure that remedial actions to be implemented will meet the RAOs) are described in Chapter 2 of the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17, Rev. 6). Additionally, in accordance with EPA guidance in *Close Out Procedures for National Priorities List Sites* (EPA 540-R-98-016), remedial actions are documented in *100-BC-1 Operable Unit Interim Remedial Action Report* (DOE/RL-2011-49), and *100-BC-2 Operable Unit Interim Remedial Action Report* (DOE/RL-2015-47).

The RAOs for the 100-BC-1 and 100-BC-2 remediated waste sites, and the methods used for achieving the RAOs through the interim remedial actions are summarized as follows:

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.***
  - Achieved through excavation to *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act – Cleanup," (MTCA) levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) use
  - Achieved human health total radiological dose standards of less than 15 mrem/yr above background for radionuclides
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.***
  - Achieved through protection such that contaminant levels in soil after remediation do not result in an adverse impact to groundwater that exceeded any nonzero maximum contaminant level goals under the *Safe Drinking Water Act of 1974* or Method B cleanup levels under WAC 173-340**,** "Model Toxics Control Act – Cleanup"
  - Levels of contaminants in the soil after remediation do not result in an impact to groundwater and the Columbia River that could exceed the ambient water quality criteria under the *Clean Water Act of 1977* for protection of fish or Method B cleanup levels under WAC 173-340-730. Because no ambient water quality criteria have been established

for radionuclides, maximum contaminant levels from national primary drinking water standards were used.

– The protection of receptors (aquatic species, with emphasis on salmon) in surface waters was achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River are not subject to any additional adverse risks.

- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.***

  Achieved by removing waste sites to the bottom of the engineered structure, as well as implementing and maintaining ICs, as required.

ICs for the 100-BC-1 and 100-BC-2 source OUs, as required by the interim action RODs (as amended), are further described in the latest version of *Remedial Design Report, Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17) and are actively managed. Specific details associated with each IC also have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs for the 100-BC-1 and 100-BC-2 OUs include waste-site-specific ICs (e.g., drilling and excavation restrictions for waste sites where residual contamination remains at depth) and general-areas ICs, including access control (warning notices and entry restrictions), land-use management (land use and excavation permits), groundwater-use management, and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the *100/300 Area Unit Managers Meeting* meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 100-BC-1 and 100-BC-2 source OUs.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid. These criteria will be reviewed and updated as needed to support final remedy selection.

Has any other information come to light that could call into question the protectiveness of the remedy?

The RI/FS evaluation has indicated some continuing source contamination to groundwater and this information has been incorporated into the evaluation of remedial alternatives that will lead to the final ROD.

Table 2-2. 100-BC-1 and 100-BC-2 Source Operable Unit Cleanup Status.

Source OU	Number of Waste Sites[a]	Sites Dispositioned [b]			
		Pre-2011	2011 – 2015	Total	Percent Complete
100-BC-1	59	57	0	57	97
100-BC-2	29	27	2	29	100

Table 2-2. 100-BC-1 and 100-BC-2 Source Operable Unit Cleanup Status.

Source OU	Number of Waste Sites[a]	Sites Dispositioned [b]			
		Pre-2011	2011 – 2015	Total	Percent Complete
Total	**88**	**84**	**2**	**86**	**98%**

[a] Approximate number of waste sites in the OU, according to WIDS, as of December 2015. Actual numbers change if sites are added to and/or removed from an OU in accordance with DOE and regulatory agency approvals.

[b] Approximate number of sites dispositioned as of December 2015; includes the number of sites that have been reclassified in WIDS, as of December 2015, as either interim closed, final closed, interim no-action, or final no-action in accordance with the guideline TPA-MP-14[c], *Maintenance of Waste Information Data System (WIDS)*. Slight discrepancies may exist between WIDs data and the specific waste sites listed in the table because of the time required to process and approve change requests that add or delete sites before changes are made in the WIDS.

[c] TPA-MP-14, 2011, *Maintenance of the Waste Information Data System (WIDS)*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE = U.S. Department of Energy.
OU = operable unit.
ROD = record of decision.
WIDS = Waste Information Data System.

2.3.1.1.5 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 100-BC-1 and 100-BC-2 OUs were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.3.1.1.6 Protectiveness Statements

100-BC-1 Source OU – Will Be Protective. The remedy at the 100-BC-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-BC-1 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

100-BC-2 Source OU – Will Be Protective. The remedy at the 100-BC-2 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-BC-2 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

2.3.2 100-FR Area and 600 Area Operable Units

This section describes three OUs in the 100-F Area and two adjacent OUs that include waste sites within a large portion of the Hanford Site's 600 Area. The 100-F Area contains the following two source OUs and one groundwater OU that are associated primarily with 100-F Reactor operations:

- 100-FR-1 OU, principally 100-F Area liquid waste disposal sites
- 100-FR-2 OU, principally soil and solid waste disposal sites
- 100-FR-3 OU, groundwater contamination originating from the 100-F Area source OUs.

Adjacent to the 100-F Area OUs and within the 600 Area are the following two source OUs:

- 100-IU-2 OU originally contained waste sites from the old White Bluffs townsite, but was expanded in 2014 to include a vast region to the west
- 100-IU-6 OU originally contained waste sites from the old Hanford Townsite, but was expanded in 2014 to include a vast region to the south.

Figure 2-3 shows the relative locations of the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 OUs.

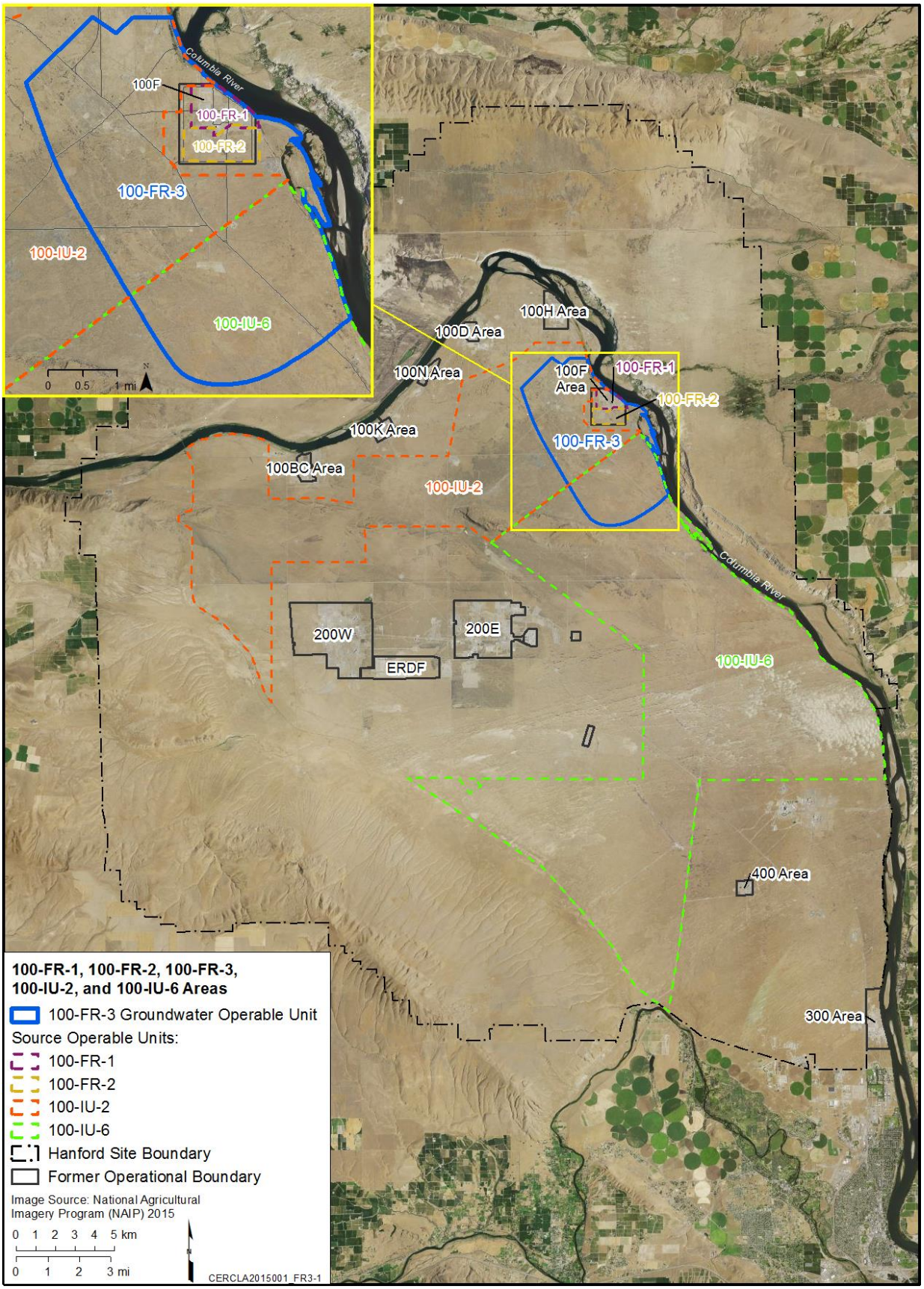


Figure 2-3. Location of 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units.

2.3.2.1 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Source Operable Units

2.3.2.1.1 Background

The 105-F Reactor was constructed from 1943 to 1945 and operated from 1945 to 1965. Most of the facilities associated with the F Reactor also were retired in 1965. The 100-FR-1 and 100-FR-2 source OUs include contaminant sources that are generally related to the operational and waste management process for the former 100-F Reactor and neighboring biological research facilities, while the 100-FR-3 groundwater OU contains the contamination in the underlying groundwater.

The 600 Area contains construction support facilities that were used during the Hanford Works Project, as well as sites associated with the pre-Hanford-Works agricultural community. To address the remediation efforts effectively, the 600 Area was originally divided into 13 OUs. Six of the OUs have since been designated as 200 Area waste groupings; waste sites in the 1100-IU-1, 100-IU-1, and 100-IU-3 OUs were deleted from the NPL; the 100-IU-4 and 100-IU-5 OUs were closed out via a "no action ROD;" and the 100-IU-2 and I00-IU-6 OUs were undergoing cleanup during this review period.

2.3.2.1.2 Chronology

Table 2-3 lists remedial action decision documents relevant to the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs.

Table 2-3. Decision Documents for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Source Operable Units.

Date	Location	Title
4/1997	EPA/AMD/R10-97/044	***Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This amendment adds 34 waste sites to the ROD; refines remedial cost estimate for all 71 sites based on actual data, streamlining, and lessons learned; and eliminates the soil washing treatment option before disposal. It also expands the ROD's scope to include radioactive liquid waste sites in the 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-1, 100-FR-2, 100-HR-1, 100-KR-1, and 100-KR-2 OUs.
7/1999	EPA/ROD/R10-99/039	***Interim Action Record of Decision for the 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 Operable Units Remaining Sites.*** This interim action ROD requires RTD for 46 sites, adds a plug-in approach for the RTD remedy for both remaining 100 Area and 200 North sites and for newly identified 100 Area sites added by ESD, disposal of debris from the B, D, H, and K Reactors to ERDF, and provides a decision framework for leaving waste in place, generally below the 15-ft depth.
6/2000	EPA/ESD/R10-00/045	***Explanation of Significant Differences for the 100-Area Remaining Sites Record of Decision USDOE Hanford 100 Area 100-IU-6 Operable Unit.*** This ESD plugs the 600-23 and JA Jones #1 waste sites into the Remaining Sites ROD.
9/2000	EPA/ROD/R10-00/121	***Interim Action ROD: 100-BC-I, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2 Operable Units (100 Area Burial Grounds).*** This ROD requires removal of contaminated soil, structures, and debris; treatment as needed; disposal at ERDF; backfill; and revegetation. It applies to 45 burial grounds in the 100 Area.
2/2004	EPA 2004	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** This ESD adds 28 waste sites to the ROD; adds 10 CFR 1022 and 40 CFR 6, Appendix A, as ARARs to the ROD; and revises annual ICs report date to coincide with the *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions* due date.

Table 2-3. Decision Documents for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Source Operable Units.

Date	Location	Title
8/2009	DOE et al. 2009	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** Authorizes adding 200-CW-3 OU waste sites, 99 newly discovered waste sites, and 87 candidate sites using the plug-in approach in the ROD and any newly discovered waste sites that will be documented in the Administrative Record and in an annual fact sheet.
3/2011	DOE et al. 2011	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Fiscal Year 2010, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.
2/2012	DOE et al. 2012	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2011, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.
1/2013	DOE et al. 2013	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2012, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.
9/2014	EPA 2014	***100-F/IU-2/IU-6 Area, Record of Decision, Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units.*** This final action ROD requires RTD at 91 waste sites; ICs at 15 waste sites; no additional action because interim remedial actions have been completed at 198 waste sites; monitored natural attenuation to address nitrate, hexavalent chromium, trichloroethene, and strontium-90 in 100-FR-3 groundwater; and ICs.

ESD = explanation of significant differences.
IC = institutional control.
OU = operable unit.
ROD = record of decision.
RTD = removal, treatment, and disposal.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.2.1.3 Remedial Action

Goals and Objectives. The final remedial action objectives for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Source OUs, as specified in the 2014 ROD (EPA 2014), are RAOs 3 through 6:

- ***RAO 3. Prevent unacceptable risk from contaminants migrating and/or leaching through soil that will result in groundwater concentrations that exceed standards and risk-based thresholds for protection of surface water and groundwater.***
- ***RAO 4. Prevent unacceptable risk to human health and ecological receptors from exposure to the upper 4.6 m (15 ft) of soil, structures, and debris contaminated with nonradiological constituents at concentrations above the unrestricted land-use standards for human health (provided in MTCA Method B) or soil contaminant levels protective of ecological receptors.***
- ***RAO 5. Prevent unacceptable risk to human health and ecological receptors from exposure to the upper 4.6 m (15 ft) of soil, structures, and debris contaminated with radiological constituents.*** *For human health and ecological receptors:*

  - *Prevent exposure to radiological constituents at concentrations at or above a dose rate limit that causes an ELCR threshold of 1×10^{-6} to 1×10^{-4} above background for the residential exposure scenario.*
  - *Protect ecological receptors based on a dose rate limit of 0.1 rad/day for terrestrial wildlife populations.*

- ***RAO 6. Manage direct exposure to contaminated soils deeper than 4.6 m (15 ft) to prevent an unacceptable risk to human health and the environment.***

Remedy Components. The final action ROD (EPA 2014), as signed in 2014, provided the following summary-level descriptions of the major components of the selected remedy for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs (i.e., RTD); the italicized text in the following box is a direct quote from the ROD (EPA 2014). As noted in the ROD, the remedies selected may change somewhat as a result of the remedial design and construction process. Any changes to the remedies described in the ROD will be documented using a technical memorandum in the administrative record, an explanation of significant differences, or a ROD amendment, as appropriate.

Excerpt from ROD (EPA 2014):

RTD at Waste Sites for 100-IU-2 and 100-IU-6 – RTD of 91 waste sites identified in Table 1 to achieve RAOs and cleanup levels as follows: (a) RTD the soil and debris with COCs exceeding cleanup levels identified in Table 5 above as deep as 4.6 m (15 ft) bgs to protect human health and ecological receptors from direct exposure to contaminants, (b) RTD the soil and debris below 4.6 m (15 ft) bgs with COCs exceeding cleanup levels in Table 6 [referring to tables in the ROD] *for groundwater and river protection and (c) the excavated waste sites will be backfilled and recontoured, after which native vegetation will be planted, and established. Contaminated soil and debris with concentrations above the cleanup levels will be excavated from the waste sites using shallow and deep excavation technology, treated as necessary to meet applicable land disposal restriction and disposal facility requirements and sent to ERDF, which is considered onsite, or another facility approved by EPA.*

Institutional Controls Component Common to All OUs. ICs are required before, during and after the active phase of remedial action implementation where ICs are needed to protect human health and the environment. ICs are used to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure. DOE shall be responsible for implementing, maintaining, reporting on and enforcing ICs. Although the DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement or through other means, the DOE shall retain ultimate responsibility for remedy integrity and ICs. In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.

The current implementation, maintenance and periodic inspection requirements for ICs at the Hanford Site are described in approved work plans, including the Sitewide Institutional Controls Plan (DOE/RL-2001-41) that was prepared by DOE and approved by EPA and the Washington State Department of Ecology (Ecology) in 2002. No later than 180 days after the ROD is signed, DOE shall update the Sitewide Institutional Controls Plan to include the ICs required by this ROD and specify the implementation and maintenance actions that will be taken, including periodic inspections. The revised Sitewide Institutional Controls Plan shall be submitted to EPA and Ecology for review and approval as a Tri-Party Agreement primary document. The DOE shall comply with the Sitewide Institutional Controls Plan as updated and approved by EPA and Ecology.

The following institutional control performance objectives are required to be met as part of this remedial action. Land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

- *In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.*
- *In the event of any unauthorized access (e.g. trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and evaluation of possible prosecution.*
- *Activities that would disrupt or lessen the performance of any component of the remedies are prohibited.*
- *Signage and access control to waste sites with contamination above cleanup levels will be provided.*

- *Maintain the integrity of any current or future remedial or monitoring system such as monitoring wells.*
- *Prohibit the development and use of property for residential housing, elementary and secondary schools, child care facilities and playgrounds until cleanup levels are met.*
- *DOE shall employ and maintain an excavation permit program for protection of human health against unacceptable exposure, and protection of environmental and cultural resources.*
- *The DOE shall report on the effectiveness of ICs for all OUs that are the subject of this ROD in an annual report, or on an alternative reporting frequency specified by the lead regulatory agency. Such reporting may be for OUs individually or may be part of the Hanford Sitewide ICs report.*

Measures that are necessary to ensure continuation of ICs shall be taken before any lease or transfer of any land subject to ICs. DOE will provide notice to Ecology and EPA at least 6 months before any transfer or sale of land subject to ICs so that the lead regulatory agency can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs. If it is not possible for DOE to notify Ecology and EPA at least 6 months before any transfer or sale, DOE will notify Ecology and EPA as soon as possible, but no later than 60 days before the transfer or sale of any property subject to ICs. In addition to the land transfer notice and discussion provisions, DOE further agrees to provide Ecology and EPA with similar notice, within the same time frames, as to federal-to-federal transfer of property. DOE shall provide a copy of the executed deed or transfer assembly to Ecology and EPA. DOE shall notify EPA and Ecology immediately upon discovery of any activity inconsistent with the specific ICs.

Institutional Controls Component Unique to 100-FR-1 and 100-FR-2 – The following institutional control performance objectives are required to be met as part of this remedial action for 100-FR-1 and 100-FR-2 OUs. Land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

- *Exposure to contamination deeper than 4.6 m (15 ft) bgs is not anticipated. Where contamination at depth exceeds the residential use cleanup levels, ICs are required to ensure future activities do not bring this contamination to the surface or otherwise result in exposure to contaminant concentrations that exceed the cleanup levels.*
- *Prohibit irrigation over or near waste site 116-F-14 that represents an unacceptable surface water protection risk.*

Transition from Interim to Final Action for 100-FR-1, 100-FR-2, 100-IU-2 and 100-IU-6 – In-progress interim action shall use the cleanup levels in this ROD immediately upon issuance of this ROD. All other aspects of the interim actions shall continue to be performed in accord with the existing RD/RAWP. DOE shall develop, and submit for EPA approval, a new RD/RAWP prepared in accordance with the Tri-Party Agreement. When the new RD/RAWP is approved, that document will direct future remedial actions and will replace all interim action ROD work plan requirements.

Remedy Implementation Progress Prior to this Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work on the interim remedy, involving RTD, backfilling, recontouring, revegetation, and implementing ICs had been ongoing since 1999. Before 2011, interim remedial actions for 102 of approximately 180 waste sites at the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs had been completed.

Issues/Corrective Actions from the Previous (2006 – 2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** No issues or actions were noted for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs in the previous (2006 – 2010) CERCLA 5-year review.

Protectiveness Statement from the Previous (2006 – 2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006 – 2010) 5-year review report for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs was as follows:

> *The final remedy at 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs is expected to be protective of human health and the environment upon completion of the final remedy.*

Further information will be obtained by completing the River Corridor Baseline Risk Assessment. It is expected that these actions will be completed by 2016, at which time a protectiveness determination will be made.

2.3.2.1.4 Progress Since 2011 Review

Accomplishments. Accomplishments for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs during the past 5 years can be summarized as follows:

- Completed remediation of more than 80 waste sites
- Published the final action ROD for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs and the 100-FR-3 groundwater OU in 2014 (EPA 2014)
- Published *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU* (DOE/RL-2014-44) in 2015.

Remedy Implementation. The primary cleanup activities since 2011 include the remediation of the remaining pipelines, contaminated soils, and stained soils in the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 areas. Cleanup of surface debris, burn areas, and stained soil sites also was performed in the 100-IU-2 and 100-IU-6 OUs.

Since the 2011 review, more than 70 waste sites have been remediated and are documented in waste site cleanup verification packages or remaining sites verification packages. The waste sites that were actively remediated during this 5-year review period are as follows:

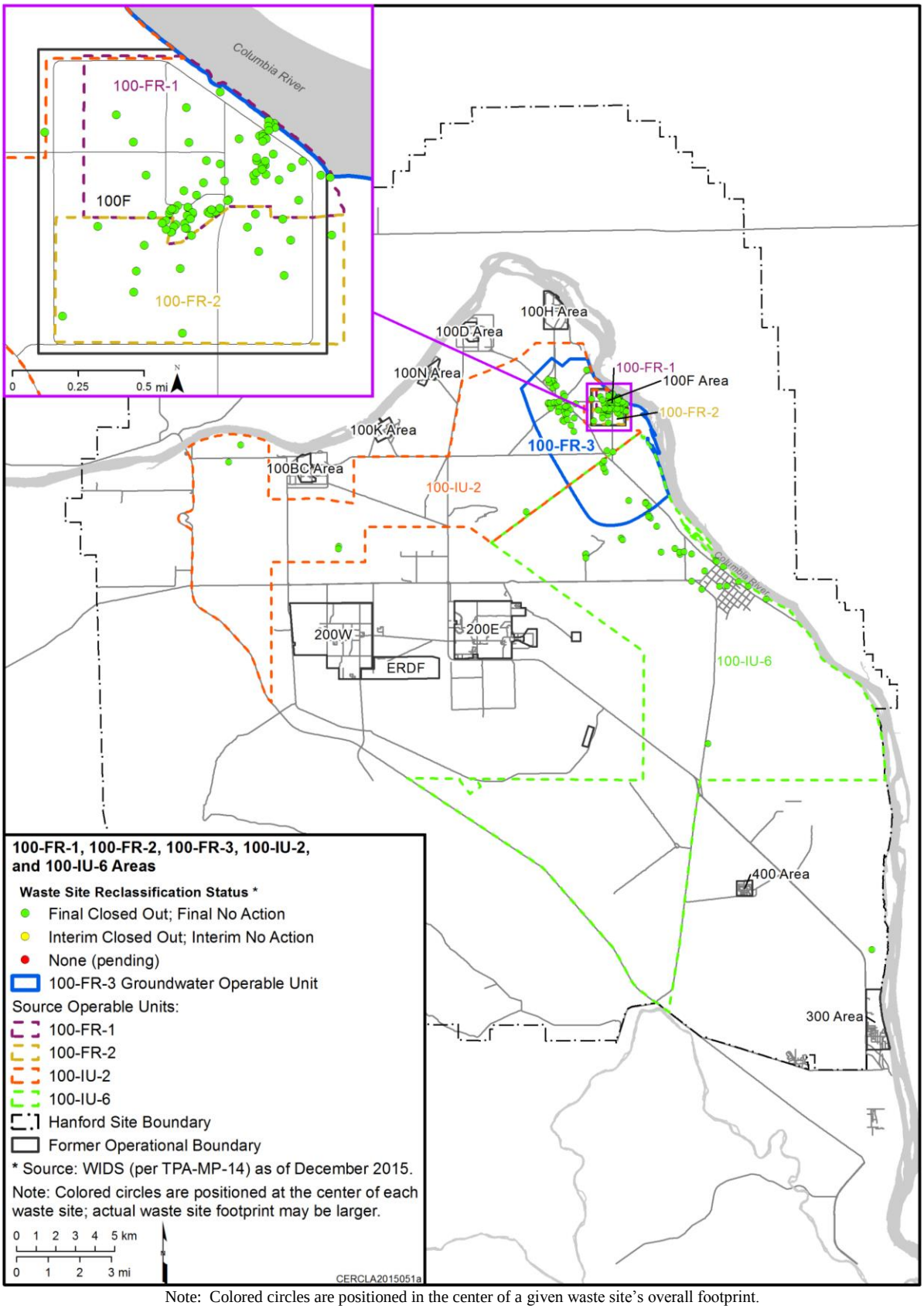
- 100-FR-1 Operable Unit
  - 100-F-26:4, Process Sewer Pipeline
  - 100-F-26:7, Product Pipeline
  - 100-F-48:8, Fuel Supply Pipeline
  - 100-F-48:9, Process Sewer Pipeline
  - 100-F-45, Effluent Pipeline
  - 100-F-48, Debris Pit
  - 100-F-47, Elec. Substation
  - 100-F-49, Lubrication Pit
  - 100-F-51, Contaminated Soils
  - 100-F-55, Contaminated Ash
  - 100-F-56, Surface Debris
  - 100-F-57, Pumphouse Debris
  - 100-F-58, Surface Debris
  - 100-F-61, Stained Soils
  - 100-F-62, Septic Pipelines
  - 100-F-63, Effluent Pipelines
  - 100-F-64, Stained Soils
  - 100-F-65, Stained Soils
- 100-FR-2 Operable Unit
  - 600-344, Stained Soils
  - 600-345, Stained Soils
  - 600-351, Stained Soils
- 100-IU-2 Operable Unit
  - 600-5, Waste Oil Dump
  - 600-100, Sanitary Landfill
  - 600-120, Burn Pit
  - 600-124, Burn Pit
  - 600-125, Disposal Trench
  - 600-127, Fuel Storage Area
  - 600-176, Disposal Area
  - 600-182, Dumping Area
  - 600-188, Disposal Trench
  - 600-279, Dumping Area
  - 600-293, Service Station
  - 600-294, Service Station
  - 600-295, Paint Shop
  - 600-297, Settling Tanks
  - 600-298, Stained Soils
  - 600-299, Surface Debris
  - 600-300, Surface Debris
  - 600-301, Sewer Pipeline
  - 600-303, Vertical Pipes
  - 600-305, Surface Debris
  - 600-306, Burn Pit
  - 600-307, Burn Area
  - 600-308, Garnet Sand
  - 600-309, Burn Area
  - 600-310, Burn Area
  - 600-311, Burn Area
  - 600-312, Burn Area
  - 600-370, Dumping Area
  - 600-371, Dumping Area
  - 600-372, Stained soils
  - 600-373, Dumping Area
  - 600-374, Dumping Area
  - 600-375, Dumping Area
  - 600-376, Stained Soils
- 100-IU-6 Operable Unit
  - 600-3, Dumping Area
  - 600-20, Dumping Area
  - 600-108, Storage Facility
  - 600-314, Surface Debris
  - 600-316, Surface Debris
  - 600-317, Burn Area
  - 600-331, Stained Soils
  - 600-332, Sanitary Sewer
  - 600-334:2, Burn Area

- 600-109, Sanitary Landfill
- 600-146, Dumping Area
- 600-149:1, Pistol Range
- 600-178, Toilet Pit
- 600-202, Burn Pit
- 600-205, Landfill
- 600-257, Storage Facility
- 600-280, Dumping Area
- 600-313, Stained Soils
- 600-318, Surface Debris
- 600-319, Surface Debris
- 600-320, Stained Soils
- 600-321, Surface Debris
- 600-324, Burn Area
- 600-325, Burn Area
- 600-326, Stained Soils
- 600-328, Surface Debris
- 600-350, Experimental Site
- 600-356, Dumping Area
- 600-358, Dumping Area
- 600-368, Stained Soils
- 600-369, Stained Soils
- 600-377, Stained Soils
- 600-378, Fuel Tank
- 600-379, Burn Area

The RAOs for 100-FR-1, 100-FR-2, 100-IU-2 and 100-IU-6 waste sites remediated under the interim ROD, and the methods used for achieving the RAOs through interim remedial actions are summarized below, per interim remedial action reports for the 100-F Area (e.g., *100-FR-1 Interim Remedial Action Report* (DOE/RL-2013-08),*100-FR-2 Operable Unit Interim Remedial Action Report* (DOE/RL-2009-63), *100-F/IU-2/IU-6 Area Segment 1 Interim Remedial Action Report*, (DOE/RL-2011-48), *100-F/IU-2/IU-6 Area Segment 3 Interim Remedial Action Report* (DOE/RL-2012-14), *Segment 5 and 400 Area Interim Remedial Action Report* (DOE/RL-2013-34):

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.***
  - Achieved through excavation to "Model Toxics Control Act – Cleanup," (WAC 173-340) levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) use.
  - Achieve human health standards of less than 15 mrem/yr above background for radionuclides in soil.
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.***
  - Achieved through protection such that contaminant levels in soil after remediation do not result in an adverse impact to groundwater that exceeded any nonzero maximum contaminant level goals under the *Safe Drinking Water Act of 1974* or Method B cleanup levels under WAC 173-340.
  - Levels of contaminants in the soil after remediation do not result in an impact to groundwater and the Columbia River that could exceed the ambient water quality criteria under the Clean Water Act of 1977 for protection of fish or Method B cleanup levels under WAC 173-340. Because no ambient water quality criteria have been established for radionuclides, maximum contaminant levels from national primary drinking water standards were used.
  - The protection of receptors (aquatic species, with emphasis on salmon) in surface waters was achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River are not subject to any additional adverse risks.

Figure 2-4 shows general locations and closure status as of December 2015 for waste sites in the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs. Table 2-4, which summarizes waste site remediation for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs, includes metrics on work accomplished during the 2011 through 2015 5-year period.



Note: Colored circles are positioned in the center of a given waste site's overall footprint.

Figure 2-4. Geographic Distribution and WIDS Reclassification Status of the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Source Operable Unit Waste Sites as of December 2015.

Table 2-4. Waste Site Remediation Summary for 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 Source Operable Units.

Source OU	Number of Waste Sites[a]	Sites Dispositioned[b]			
		Pre-2011	2011 – 2015	Total	Percent Complete
100-FR-1	74	57	17	74	100
100-FR-2	18	18	0	18	100
100-IU-2	49	16	33	49	100
100-IU-6	39	11	27	39	100
Total	**180**	**102**	**77**	**180**	**100%**

[a]Approximate number of waste sites within the OU, according to WIDS, as of December 2015. Actual numbers can and do change if sites are added to or moved from a given OU in accordance with DOE and regulatory agency approvals.

[b]Approximate number of sites dispositioned as of December 2015; includes the number of sites that have been reclassified in WIDS, as of December 2015, as either interim closed, final closed, interim no-action, or final no-action in accordance with the guideline TPA-MP-14[c], *Maintenance of Waste Information Data System (WIDS)*. Slight discrepancies may exist between WIDs data and the specific waste sites listed in the table because of the time required to process and approve change requests that add or delete sites before changes are made in the WIDS.

[c] TPA-MP-14, 2011, *Maintenance of the Waste Information Data System (WIDS)*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE = U.S. Department of Energy. OU = operable unit.

Upon issuance of the final action ROD (EPA 2014) in November 2014, all cleanup levels established in the ROD were applicable for all in-progress cleanup actions. All other aspects of the interim action continued in accordance with the existing RDR/RAWPs.

[Note: Appendix C of this 5-year review report identifies the soil cleanup levels for protection of human health, groundwater, and surface water as presented in Tables 5 and 6 of the 2014 ROD (EPA 2014)].

An integrated RDR/RAWP, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU*, Draft A (DOE/RL-2014-44), was submitted for review in March 2015 and subsequently issued in August 2015. Waste sites previously dispositioned under interim RODs in the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 were evaluated and the evaluation determined that they met the final ROD remedial action objectives.

ICs have been implemented and maintained during this 5-year review period to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure.

2.3.2.1.5 Technical Assessments

The 5-year review determines whether the remedy at a site is or, upon completion, will be protective of human health and the environment. The following is the technical assessment response for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs interim remedy to the technical assessment questions provided in the EPA guidance. The following response also establishes a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision documents?

The remedy for the 100-FR-1,100-FR-2, 100-IU-2 and 100-IU-6 source OUs has been implemented and is working within the specified remedial action objectives, per the ROD (EPA 2014). As of December 2015, remediation of all 180 100-FR-1, 100-FR-2, 100-IU-2 and 100-IU-6 source OU waste sites had been completed and the waste sites reclassified in the WIDS as either final closed-out or final no-action. With the completion of source OU remediation, continued decline of groundwater contaminants in the 100-FR-3 OU is anticipated.

An evaluation of the final ROD remedial action objectives for sites closed under interim action RODs was completed. In accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS)*, remediated waste sites have been and documented in the WIDS as either final closed or final no-action. Cleanup verification packages (including sampling data and other technical information) to

support the reclassification to final closed or final no-action are included in the Hanford Site Administrative Record for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs. Cleanup levels for these source OUs are published in Tables 5 and 6 in the ROD (EPA 2014). The tables are reproduced in Appendix C of this report because the 100-F area is the first 100 Area OU to attain a final remedy ROD (EPA 2014).

ICs for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs, as required by the ROD (EPA 2014), are described in the latest version of *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU* (DOE/RL-2014-44). Specific details associated with each applicable IC have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs include waste-site-specific ICs (e.g., drilling and excavation restrictions for 100-FR-1 and 100-FR-2 because of deep contamination and an irrigation restriction for one 100-FR-1 OU site that presents a surface water protection risk). They also include general-areas ICs including access control (warning notices and entry restrictions), land-use management (land use and excavation permits), groundwater-use management, and miscellaneous provisions. Figure 7 of the ROD (EPA 2014) is a map of the 100-FR-1 and 100-FR-2 OU IC boundary; it also depicts the location of the waste sites associated with ICs for deep contamination and the one site with the IC to prevent irrigation. These ICs are assessed annually and DOE presents a summary, including any noted issues or actions, to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, one deficiency was specifically noted for the 100-FR-1 and 100-FR-3 OU area: one Spanish-language warning sign along the Columbia River was found to be down in 2014 and was reinstalled.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection are still valid.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy for these OUs.

2.3.2.1.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.3.2.1.7 Protectiveness Statements

100-FR-1 Source OU – Protective. The remedy at the 100-FR-1 source OU is protective of human health and the environment, and exposure pathways that could result in unacceptable risk are being controlled.

The RAOs for protecting human and ecological receptors from exposure to contamination, and for controlling the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions, have been met by RTD of waste sites and the imposition of site-specific ICs at waste sites that do not qualify for unlimited use or unrestricted exposure. The RTD scope has been completed and ICs have been implemented.

100-FR-2 Source OU – Protective. The remedy at the 100-FR-2 source OU is protective of human health and the environment and exposure pathways that could result in unacceptable risk are being controlled.

The RAOs for protecting human and ecological receptors from exposure to contamination, and for controlling the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions, have been met by RTD of waste sites and the imposition of site-specific ICs at waste sites that do not qualify for unlimited use or unrestricted exposure. The RTD scope has been completed and ICs have been implemented.

100-IU-2 Source OU – Protective. The remedy at the 100-IU-2 source OU is protective of human health and the environment and exposure pathways that could result in unacceptable risk are being controlled.

The RAOs for protecting human and ecological receptors from exposure to contamination, and for controlling the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions, have been met by RTD of waste sites. The RTD scope has been completed and ICs have been implemented.

100-IU-6 Source OU – Protective. The remedy at the 100-IU-6 source OU is protective of human health and the environment and exposure pathways that could result in unacceptable risk are being controlled.

The RAOs for protecting human and ecological receptors from exposure to contamination, and for controlling the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions, have been met by RTD of waste sites. The RTD scope has been completed and ICs have been implemented.

2.3.2.2 100-FR-3 Groundwater Operable Unit.

2.3.2.2.1 Background

The 100-FR-3 Groundwater OU (shown in Figure 2-3) is 1 of 10 groundwater OUs on the Hanford Site, and 1 of 6 groundwater OUs located in the River Corridor. The 100-FR-3 OU encompasses groundwater contaminated by releases from the 100-FR-1 and 100-FR-2 source OU waste sites.

Waste sites associated with these OUs are associated with the 105-F Reactor, which operated in this area between 1945 and 1965. Most of the facilities associated with the 105-F Reactor were retired in 1965. Biological research facilities also operated in this area from 1945 until 1976. All cleanup work associated with the 100-FR-1 and 100-FR-2 source OU waste sites was complete as of 2014.

Contaminants of concern for the 100-FR-3 groundwater OU are nitrate, hexavalent chromium, strontium-90, and trichloroethene (TCE).

In the northern portion of the 100-F area, groundwater flows to the northeast, toward the Columbia River. In the southern portion of the 100-F area, groundwater flows primarily to the east then curves southeast. During seasonal periods of high river stage, the hydraulic gradient reverses near the river and surface water can flow into the aquifer.

Current land uses in the 100-F Area include interim safe storage (ISS) of the 105-F Reactor and public access to this area is restricted.

Groundwater from the 100-FR-3 groundwater OU is contaminated at levels above DWSs and withdrawal for purposes other than research and monitoring is prohibited. Under current site-use conditions and controls, the only complete human exposure pathway to groundwater is the potential for limited exposure from intermittent seeps along the Columbia River or during remediation, research, and monitoring activities. The 100-FR-3 groundwater is not being used for drinking water.

A summary of 100-FR-3 groundwater condition is included in the *Hanford Site Groundwater Monitoring Report* (published annually to address the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

Additional CERCLA documentation associated with the 100-FR-3 groundwater OU, as well as other OUs, can be accessed directly or queried in the Administrative Record for the Hanford Site's OUs and TSD units, at the following address: http://pdw.hanford.gov/arpir/index.cfm/predefinedSearch?canType=OpUnit.

2.3.2.2.2 Chronology

Table 2-5 lists the remedial action decision document associated with the 100-FR-3 groundwater OU.

Table 2-5. Decision Document for the 100-FR-3 Groundwater Operable Unit.

Date	Location	Title
09/2014	EPA 2014	***Record of Decision, Hanford 100 Area Superfund Site, 100-FR-1, 100-FR-3, 100-IU-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units.*** This final-action ROD presents the selected remedies involving RTD at 91 waste sites, ICs at 15 waste sites, no additional action at 198 waste sites as a result of interim remedial actions completed, monitored natural attenuation to address nitrate, hexavalent chromium, trichloroethene, and strontium-90 in 100-FR-3 OU groundwater, and ICs.

IC = institutional control.
OU = operable unit.
RTD = removal, treatment, and disposal.
ROD = record of decision.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.2.2.3 Remedial Actions

Goals and Objectives. In accordance with the NCP, "EPA expects to return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (40 CFR 300.430[a][1][iii][F]). EPA generally defers to state definitions of groundwater classification provided under EPA-endorsed Comprehensive State Groundwater Protection Programs (EPA/540/G-88/003).

Groundwater from the 100-FR-3 OU is contaminated and is not currently withdrawn from the aquifer for beneficial use; however, the potential beneficial use of the groundwater is as a drinking water source. Consistent with the beneficial-use classifications of Washington State and the EPA, the goal for remediating 100-FR-3 OU groundwater is to reduce contamination to levels that will allow its use as a future drinking water source.

Accordingly, the RAOs applicable to 100-FR-3, as stated in the ROD (EPA 2014), are as follows:

RAO 1. Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds.

RAO 2. Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds.

RAO 7. Restore groundwater impacted from 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 releases to cleanup levels, which include DWSs, within a time frame that is reasonable given the particular circumstances of the site.

Remedy Components. The final action ROD (EPA 2014), as signed in 2014, provided the following summary-level descriptions of the major components of the selected remedy (i.e., monitored natural attenuation and ICs); the italicized text in the following box is a direct quote from the ROD (EPA 2014). As noted in the ROD, the remedies selected may change somewhat as a result of the remedial design and construction process. Any changes to the remedies described in the ROD will be documented using a

technical memorandum in the administrative record, an explanation of significant differences, or a ROD amendment, as appropriate.

Excerpt from ROD (EPA 2014):

Monitored Natural Attenuation (MNA) of Groundwater. MNA will be used for all COCs in 100-FR-3 to reduce groundwater concentrations to concentrations less than the cleanup levels shown in Table 7 [referring to Table 7 within the ROD]. Overall plume behavior is controlled by a combination of the source strength (flux of contaminants into the groundwater) and the rate and capacity of attenuation in the groundwater. Without a continuing source, the net plume response will be to diminish over time. The primary natural attenuation processes for COCs present in 100-FR-3 include biodegradation and abiotic degradation, radioactive decay, dispersion, volatilization, and sorption. The required performance monitoring component includes installation of new wells, periodic sampling, laboratory analysis, and data evaluation needed to assess and confirm the natural attenuation processes, rates of attenuation, and overall protectiveness. The monitoring will continue until cleanup levels are achieved.

Institutional Controls Component Common to All OUs. ICs are required before, during and after the active phase of remedial action implementation where ICs are needed to protect human health and the environment. ICs are used to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure. DOE shall be responsible for implementing, maintaining, reporting on and enforcing ICs. Although the DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement or through other means, the DOE shall retain ultimate responsibility for remedy integrity and ICs. In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.

The current implementation, maintenance and periodic inspection requirements for ICs at the Hanford Site are described in approved work plans, including the Sitewide Institutional Controls Plan (DOE/RL-2001-41) that was prepared by DOE and approved by EPA and the Washington State Department of Ecology (Ecology) in 2002. No later than 180 days after the ROD is signed, DOE shall update the Sitewide Institutional Controls Plan to include the ICs required by this ROD and specify the implementation and maintenance actions that will be taken, including periodic inspections. The revised Sitewide Institutional Controls Plan shall be submitted to EPA and Ecology for review and approval as a Tri-Party Agreement primary document. The DOE shall comply with the Sitewide Institutional Controls Plan as updated and approved by EPA and Ecology.

The following institutional control performance objectives are required to be met as part of this remedial action. Land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.

In the event of any unauthorized access (e.g. trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and evaluation of possible prosecution.

Activities that would disrupt or lessen the performance of any component of the remedies are prohibited.

Signage and access control to waste sites with contamination above cleanup levels will be provided.

Maintain the integrity of any current or future remedial or monitoring system such as monitoring wells.

Prohibit the development and use of property for residential housing, elementary and secondary schools, child care facilities and playgrounds until cleanup levels are met.

DOE shall employ and maintain an excavation permit program for protection of human health against unacceptable exposure, and protection of environmental and cultural resources.

The DOE shall report on the effectiveness of ICs for all OUs that are the subject of this ROD in an annual report, or on an alternative reporting frequency specified by the lead regulatory agency. Such reporting may be for OUs individually or may be part of the Hanford Sitewide ICs report.

Measures that are necessary to ensure continuation of ICs shall be taken before any lease or transfer of any land subject to ICs. DOE will provide notice to Ecology and EPA at least 6 months before any transfer or sale of land subject to ICs so that the lead regulatory agency can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs. If it is not possible for DOE to notify Ecology and EPA at least 6 months before any transfer or sale, DOE will notify Ecology and EPA as soon as possible, but no later than 60 days before the transfer or sale of any property subject to ICs. In addition to the land transfer notice and discussion provisions, DOE further agrees to provide Ecology and EPA with similar notice, within the same time frames, as to federal-to-federal transfer of property. DOE shall provide a copy of the executed deed or transfer assembly to Ecology and EPA. DOE shall notify EPA and Ecology immediately upon discovery of any activity inconsistent with the specific ICs.

Institutional Controls Component Unique to 100-FR-3: The following institutional control performance objectives are required to be met as part of this remedial action for 100-FR-3. Land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

DOE shall employ and maintain an excavation permit program limiting 100-FR-3 groundwater access and use to research purposes and for monitoring and treatment in areas where groundwater is above cleanup levels (see Figure 8 [from the 2014 ROD; the figure shows the 2012 locations of contaminant plumes for nitrate, tritium and uranium within the 100-FR-3 OU.]).

Prevent access or use of the groundwater for drinking water purposes until cleanup levels are met.

Remedy Implementation Progress Prior to this Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** A ROD had not been established for the 100-FR-3 groundwater OU in the years leading up to 2010. Therefore, no remedial actions occurred before this review period.

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for the 100-FR-3 groundwater OU in the 2011 CERCLA 5-year review (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070).

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006-2010) 5-year review report for the 100-FR-3 groundwater OUs was as follows:

> *The final remedy at 100-FR-3 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled. Further information will be obtained by completing installation of the three new wells proposed as part of CERCLA investigations (Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan: 100-F/IU-6 Decision Unit, (DOE/RL-2008-46, Addendum 4), and the River Corridor Baseline Risk Assessment. It is expected that these actions will be completed by 2016. The RI/FS work plan addendum was implemented in 2010 and the necessary data was gathered. Groundwater beneath the 100-F Area is contaminated with chromium, nitrate, strontium-90, and trichloroethene at levels above the DWSs or aquatic standards. The contaminant plumes are present at the top of the aquifer. Their vertical extent is unknown because no wells are monitoring at depth in the unconfined aquifer. Two of the three wells will be drilled to the bottom of the unconfined aquifer and screened at the depth with the highest levels of contamination in water samples (or at the top of the aquifer if no significant contamination is found).*

2.3.2.2.4 Progress Since 2011 Review

Accomplishments. The primary remedial action accomplishments for the 100-FR-3 groundwater OU during the past 5 years can be summarized as follows:

- Completed and issued the *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-1 and 100-IU-2 Operable Units* (DOE/RL-2010-98) in June 2014
- Completed and issued the *Proposed Plan for Remediation of the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-1 and 100-IU-2 Operable Units* (DOE/RL-2012-41) in June 2014
- Issued *Record of Decision, Hanford Site 100 Area Superfund Site, 100-FR-1, 100-FR-3, 100-IU-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (EPA 2014) in September 2014
- Implemented and continued management of ICs as final action remedy components
- Issued *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU* (DOE/RL-2014-44), Rev. 0, in August 2015. This integrated work plan contains two addenda:

Addendum 1 provides information unique to waste site- and/or soil-specific remedies for the 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 source OUs and Addendum 2 provides information specific to planned remedies for the 100-FR-3 groundwater OU. Addendum 2 addresses the work elements, performance measurements, construction management and oversight, and schedule specific to monitored natural attenuation (MNA) at the 100-FR-3 OU.]

- Began performance monitoring for groundwater MNA in fall 2015.

Remedy Implementation. Implementation of the 100-FR-3 remedy, as outlined in the final-action ROD (EPA 2014), is being performed in phases in accordance with the RDR/RAWP (DOE/RL-2014-44). Both MNA and ICs for groundwater are expected to continue for approximately 150 years.

Upon issuance of the ROD in 2014, the IC component of the 100-FR-3 groundwater OU remedy was incorporated into DOE/RL-2001-41.

The MNA component of the remedy is in the early implementation stage. Implementation of the 100-FR-3 groundwater OU performance monitoring began after the August 2015 publication of the integrated RDR/RAWP (DOE/RL-2014-44). Installation of the new Phase 1 monitoring wells was completed in 2016. Data from the new and existing wells will be obtained in the first monitoring year; however, completion of quarterly sampling for all Phase 1 wells will extend into the next monitoring year. A report detailing the initial evaluation of the Phase 1 monitoring program and recommendations for Phase 2 monitoring wells are projected to be completed 6 months after the first year's monitoring data are obtained for all Phase 1 wells.

If required, additional Phase 2 monitoring wells will be completed within approximately 1 year after the recommendations are made. Approval of cultural resource reviews for Phase 2 wells is estimated to take 6 months. Results from the monitoring network will be evaluated for changes to the sampling plan, including additional wells or aquifer tubes, after the first 5 years of monitoring. The first comprehensive 5-year performance monitoring report is anticipated to be prepared in 2020 to support the 2021 Sitewide CERCLA 5-year review.

The duration of MNA performance monitoring is based on a 2011-model-estimated time frame for each COC to achieve its cleanup level, as described in *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (DOE/RL-2010-98). The following estimated time frames are rounded up to account for model uncertainties:

- Hexavalent chromium = 35 years (based on 10 µg/L cleanup level)
- Trichloroethene (TCE) = 50 years
- Nitrate = 80 years
- Strontium-90 = 150 years.

Estimated timeframes for natural attenuation will be refined and updated based on the performance monitoring reports. Once the cleanup level for each COC is achieved, 5 years of attainment monitoring will be performed at each well. The 5-year attainment monitoring period is not included in the time-frame estimates for cleanup level attainment.

Table 2-6 is an overview of primary components of the 100-FR-3 remedy and implementation status.

Table 2-6. Overview of 100-FR-3 Remedy Implementation.

Document Type	Date	Title
Final Action ROD	09/2014	*Record of Decision, Hanford 100 Area Superfund Site, 100-FR-1, 100-FR-3, 100-IU-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (EPA 2014)
RDR/RAWP	08/2015	*Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU*, DOE/RL-2014-44, Rev. 0

Table 2-6. Overview of 100-FR-3 Remedy Implementation.

RAO (brief description)	**1.** Prevent unacceptable risk to human health from ingestion of and incidental exposure to groundwater containing contaminant concentrations above federal and state standards and risk-based thresholds of human exposure to groundwater containing COC concentrations above cleanup levels **2.** Prevent unacceptable risk to human health and ecological receptors from groundwater discharges to surface water containing contaminant concentrations above federal and state standards and risk-based thresholds **7.** Restore groundwater impacted from 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 releases to cleanup levels, which include DWSs, within a time frame that is reasonable, given the particular circumstances of the site.
COCs	Nitrate, hexavalent chromium, strontium-90, and trichloroethene (TCE)

Remedy Component	**Construction Status** (approximate percentage complete for constructing/implementing the remedy component as of December 2015)[a]						**Duration of O&M** (~years)[b]	**Finish**[c] (Est'd year)
	0	**1-25**	**26-50**	**51-75**	**76-99**	**100%**		
Monitored Natural Attenuation	→	→	→				155	2169
Institutional Controls	→	→	→	→	→	→	155	2169

[a] Percentages reflect construction status of the remedy component; post-startup remedial process optimization is considered part of O&M. 100% = fully implemented and now in O&M mode.
[b] Approximate number of years to operate remedy component as estimated in ROD (shorter durations for certain COCs, and longest for attenuation of strontium-90); duration estimate is based on 150 years for attenuation of strontium-90 and 5 years for post-attainment monitoring.
[c] Estimated year when remedy component will be completed.

COC = contaminant of concern.
DWS = Drinking Water Standard.
O&M = operation and maintenance.
RAWP = remedial action work plan.
RAO = remedial action objectives.
RDR = remedial design report.
ROD = record of decision.

2.3.2.2.5 Technical Assessments

Is the remedy functioning as intended by the decision documents?

Per the ROD (EPA 2014), the MNA remedy component (supporting achievement of RAO 2 and RAO 7, is currently under construction, and ICs have been implemented (supporting RAO 1 and RAO 2). Field construction of the Phase 1 performance monitoring wells was completed in 2016; a second set of wells is planned for installation in 2019, if needed. Performance monitoring began at existing wells and aquifer tubes in fall 2015 and at Phase 1 wells in fall 2016. A report detailing an initial evaluation of the monitoring program and recommendations of Phase 2 monitoring wells is projected to be completed 6 months after the first year of monitoring data are obtained for all Phase 1 wells. The first comprehensive 5-year performance monitoring report is anticipated to be prepared in 2020 to support the next Hanford Site CERCLA 5-year review.

As an indicator of recent trends, Table 2-7 provides an overview of 100-FR-3 groundwater OU contaminant plume areas and associated changes to the areas during this past 5-year review period. Wells monitored during 2015 are shown in Figure 2-5. Plume maps in Figure 2-6 depict the changes in plume shapes and areas during this 5-year review period. Figure 2-7 depicts the estimated annual changes in contaminant plume areas over the past decade. Now that source OU remediation is complete, continued declines in groundwater contaminants are anticipated.

Table 2-7. Overview of 100-FR-3 Groundwater Contaminant Plumes.[a]

Groundwater Contaminant	Cleanup Level[b]	Maximum Concentration (2015)	Plume Area[c] (km^2)			Shoreline Intersection[d] (m)		
			2011	2015	Change	2011	2015	Change
Nitrate	45 mg/L[e]	120 mg/L	10.6	9.7	-0.9	0	0	0
Hexavalent Chromium	48 µg/L	51.2 µg/L	N/C	0.01	N/A	0	0	0
	10 µg/L	noted in previous row	0.17[f]	0.21[f]	0.4	100	0	-100
Strontium-90	8 pCi/L	176 pCi/L	0.07	0.13	0.06	0	0	0
Trichloroethene	4 µg/L	18.3 µg/L	0.70	1.4	0.70	0	0	0

[a]Source: Hanford Annual Groundwater Monitoring Reports for 2011 and 2015: http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.
[b]Source: *Record of Decision, Hanford 100 Area, Superfund Site, 100-FR-1, 100-FR-2, 100-FR-3, 100-IU2 and 100-IU-6 Operable Units* (EPA 2014). The groundwater cleanup levels, as presented in the ROD, are included in Appendix C of this report.
[c]Estimated area at a concentration greater than the listed cleanup level.
[d]Length of Columbia River shoreline intersected by contaminant plume.
[e]45 mg/L as NO3 is equivalent to the drinking water standard of 10 mg/L as N
[f]Plume area >10 µg/L in 100-F Area was 0.17 km^2 in 2011 and 0.21 km^2 in 2015. Wells in the western part of the interest area are not included because the aquatic standard does not apply to inland areas.
N/A = not applicable. N/C = not calculated.

For more detailed information on the 100-FR-3 groundwater OU well locations, distribution of contaminant concentrations within each plume, and historic trends associated with each 100-FR-3 COC, see the *Hanford Site Groundwater Monitoring Report* (published each summer for the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

ICs for the 100-FR-3 groundwater OU, as required by the ROD (EPA 2014), are described in the latest version of *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU* (DOE/RL-2014-44), and are actively managed. Specific details associated with each applicable IC have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs for the 100-FR-3 groundwater OU include access control (entry restrictions), land-use management (land use, and excavation permits), groundwater-use management, and miscellaneous provisions. The land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances are at levels that allow for unlimited use and unrestricted exposure and EPA authorizes removal of the restrictions. The ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, one deficiency was specifically noted for the 100-FR-1 and 100-FR-3 area: one Spanish-language warning sign along the Columbia River was found to be down in 2014 and was reinstalled.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

Yes, the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection (2014) are still valid for the OU.

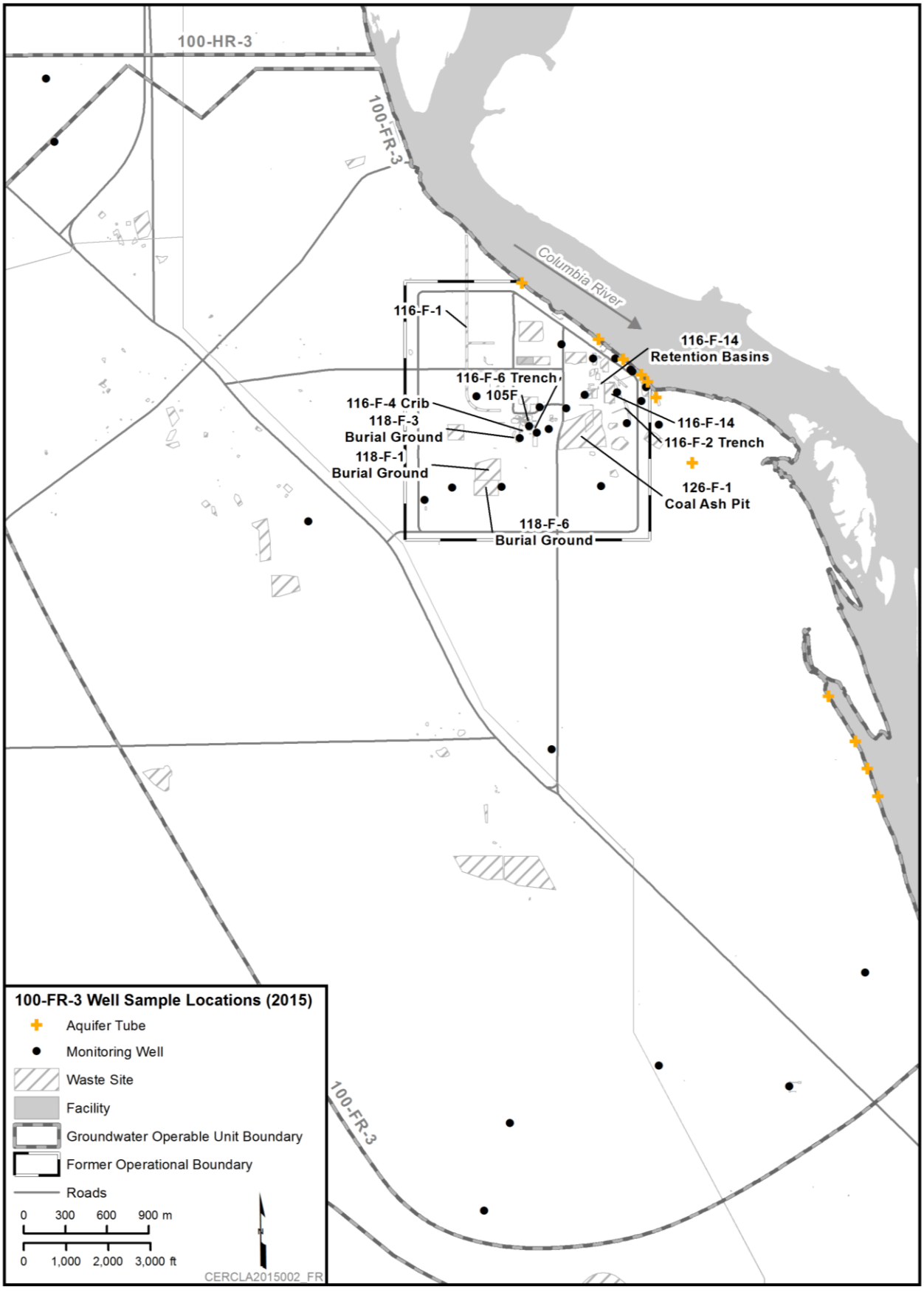


Figure 2-5. 100-FR-3 Well and Aquifer Tube Locations (2015).

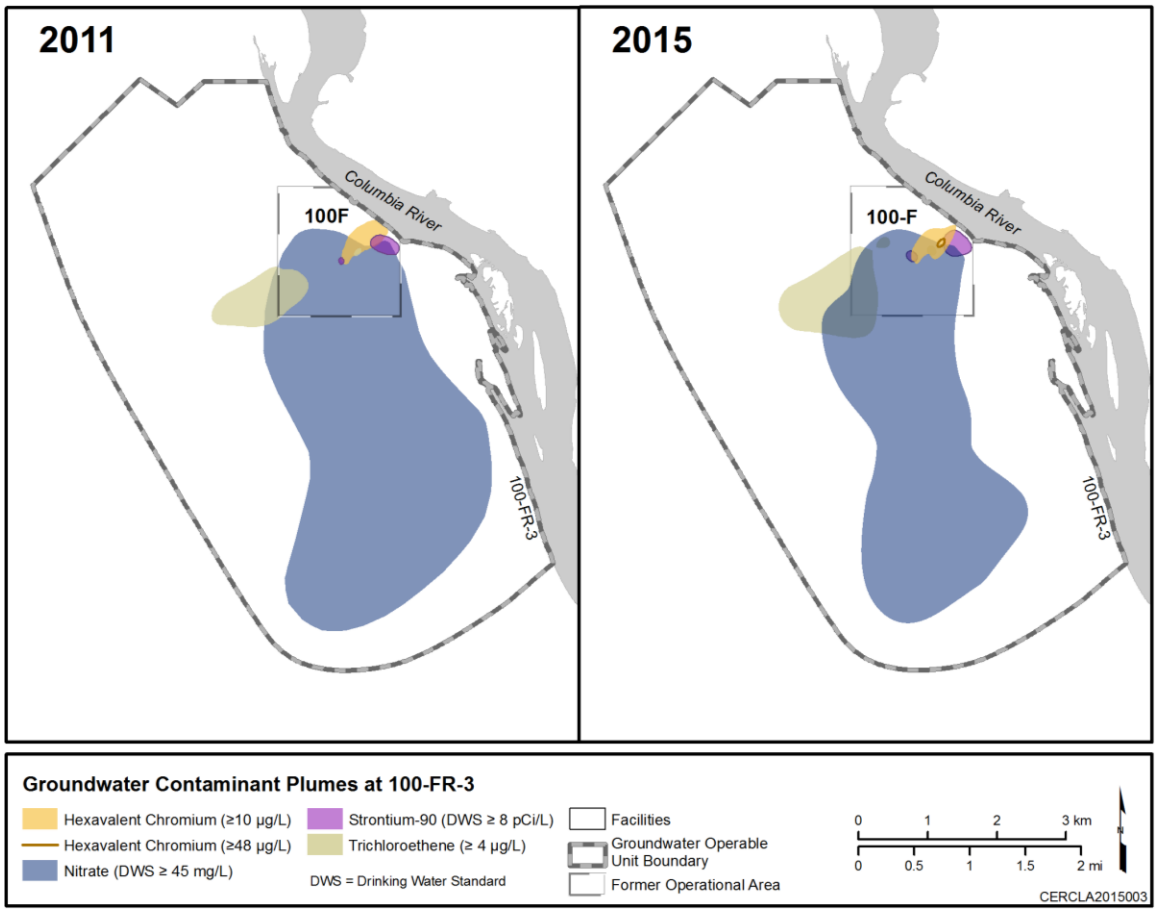
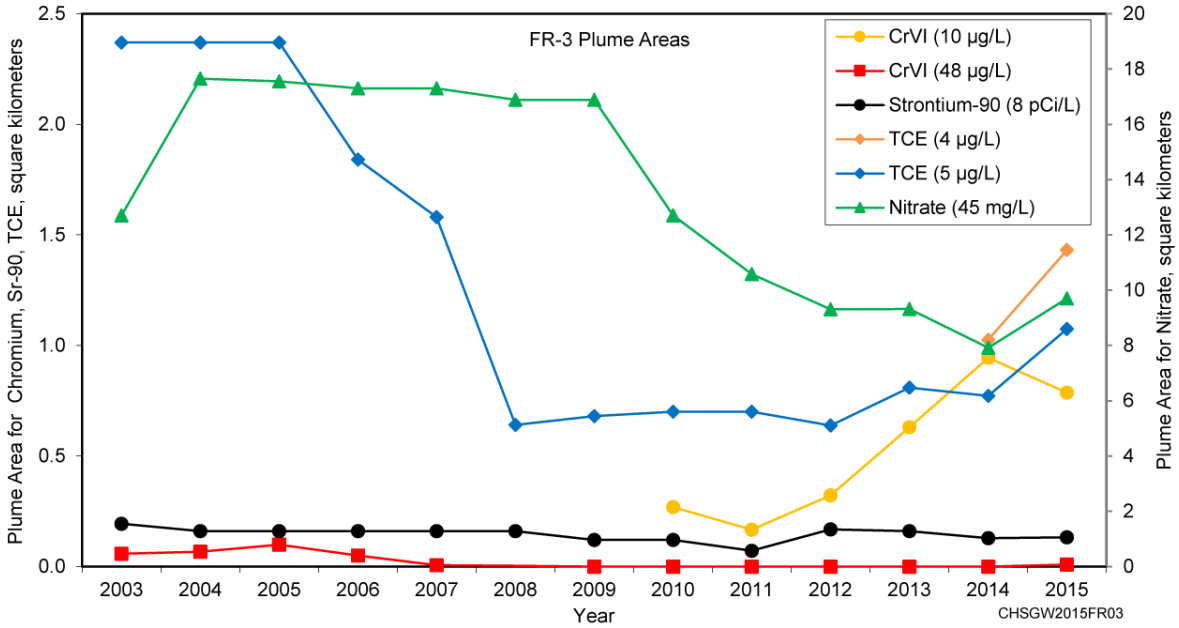


Figure 2-6. 100-FR-3 Groundwater OU Plumes in 2011 (left) and 2015 (right).



This figure shows the plume area for pre-record of decision target cleanup level for trichloroethene at the Drinking Water Standard of 5 µg/L, as well as the 2014 and 2015 plume areas for the post-record of decision (EPA 2014, Table 7) risk-based target cleanup level of 4 µg/L from WAC-173-340, "Model Toxics Control Act – Cleanup."

Figure 2-7. 100-FR-3 Trend Plots of Contaminant Plume Areas (2003 – 2015).

Has any other information come to light that could call into question the protectiveness of the remedy?

No information has come to light that would call into question the protectiveness of the remedy.

2.3.2.2.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 100-FR-3 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.3.2.2.7 Protectiveness Statement

100-FR-3 Groundwater OU – Will Be Protective. The remedy at the 100-FR-3 groundwater OU is expected to be protective upon completion of construction. ICs are in place and are protecting human exposure to contaminated groundwater. Construction of additional wells to enhance the remedy component involving monitored natural attenuation began in early 2016 and is expected to be completed by 2019. In the interim, the remedial activities completed to date have addressed the exposure pathways that could result in unacceptable risks in these areas.

2.3.3 100-D/H Area Source Operable Units

The 100-D/H area is located in the north-central region of the Hanford Site, adjacent to the Columbia River. The 100-D/H area contains the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 source OUs and the 100-HR-3 groundwater OU. Figure 2-8 shows all five 100-D/H area OUs.

2.3.3.1 100-DR-1 and 100-DR-2 Source Operable Units

2.3.3.1.1 Background

The 105-D Reactor operated from 1944 to 1967 and the 105-DR Reactor operated from 1950 to 1964.

Past operations associated with the two plutonium production reactors in the 100-D Area (105-D and 105-DR) contributed to soil and groundwater contamination at the Hanford Site. Cleanup decisions for this region were initiated in the 1990s.

To effectively address waste site remediation efforts, the 100-D Area was divided into the 100-DR-1 source OU, associated with the 105-D Reactor, and the 100-DR-2 source OU, associated with the 105-DR Reactor.

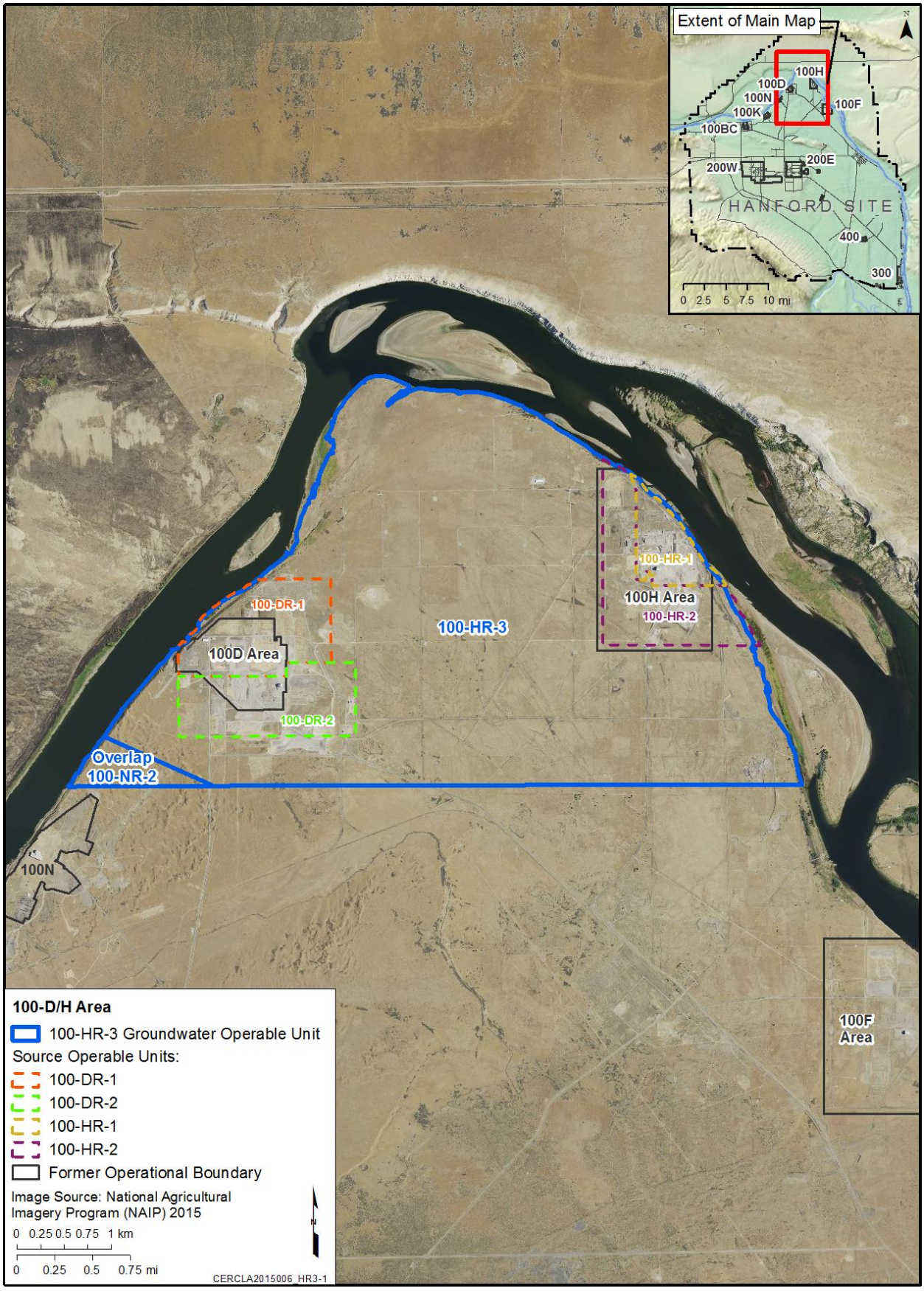


Figure 2-8. Location of D/H Area Operable Units.

2.3.3.1.2 Chronology

Table 2-8 lists remedial action decision documents relevant to source OU response actions in the 100-D area.

Table 2-8. Decision Documents for the 100-DR-1 and 100-DR-2 Source Operable Units.

Date	Location	Title
9/1995	EPA/ROD/R10-95/126	***Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This interim action ROD requires removal of contaminated soil, structures, and debris using the Observational Approach; treatment by thermal desorption to remove organics and/or soil washing for volume reduction or as needed to meet waste disposal criteria; disposal of contaminated materials at ERDF; and backfill of excavated areas followed by revegetation.
4/1997	EPA/AMD/R10-97/044	***Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This amendment to the interim action ROD incorporates 34 additional waste sites into the ROD; refines remedial cost estimate for the original 37 sites and additional 34 sites based on actual data, streamlining, and lessons learned; and eliminates the soil washing treatment option before disposal.
7/1999	EPA/ROD/R10-99/039	***Interim Action Record of Decision for the 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 Operable Units Remaining Sites.*** This interim action ROD requires RTD for 46 sites; adds the plug-in approach for the RTD remedy for both remaining 100 Area and 200 North sites and for newly identified 100 Area sites added by ESD; disposal of debris from B, D, H, and K reactors to ERDF; and provides decision framework for leaving waste in place, generally below 15-ft depth.
9/2000	EPA/ROD/R10-00/121	***Interim Action Record of Decision: 100-BC-I, 100-BC-2, 100-DR-I, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2 Operable Units (100 Area Burial Grounds).*** This interim action ROD requires removal of contaminated soil, structures, and debris; treatment as needed; disposal of waste at ERDF; backfilling; and revegetation. It applies to 45 burial grounds in the 100 Area.
2/2004	EPA 2004	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** The ESD adds 28 sites to the ROD; adds 10 CFR 1022 and 40 CFR 6, Appendix A, as ARARs to the ROD; and revises annual ICs report date to coincide with the due date for the Sitewide ICs plan for Hanford CERCLA response actions.
8/2009	EPA et al. 2009	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision:*** This ESD authorizes adding 200-CW-3 OU waste sites, 99 newly discovered waste sites, and 87 candidate sites using the plug-in approach in the ROD and any newly discovered waste sites documented in the Administrative Record and an annual fact sheet.
3/2011	DOE et al. 2011	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2010, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.
2/2012	DOE et al. 2012	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2011, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

Table 2-8. Decision Documents for the 100-DR-1 and 100-DR-2 Source Operable Units.

Date	Location	Title
1/2013	DOE et al. 2013	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2012, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites*****.** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.
1/2014	DOE et al. 2015	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2014, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites*****.** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
CFR = *Code of Federal Regulations*.
ERDF = Environmental Restoration Disposal Facility.
ESD = explanation of significant difference.
OU = operable unit.
ROD = record of decision.
RTD = remove, treat, if necessary, and dispose of.
TBD = to be determined.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.3.1.3 Remedial Action

Goals and Objectives. The RAOs set forth in the 1995 (EPA/ROD/R10-95/126), 1999 (EPA/ROD/R10-99/039), and 2000 (EPA/ROD/R10-00/121) interim action RODs listed in Table 2-8 are narrative statements that define the extent to which the waste sites require cleanup to protect human health and the environment. The RAOs identified in these interim action RODs (see following list) apply to contaminants in soils, structures, and debris. RAOs 1 and 2 are common to all three interim action RODs. RAOs 3 and 4 are not stated in all RODs, but are associated with future land use.

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics*** (EPA/ROD/R10-95/126, page 25; EPA/ROD/R10-99/039, page 26; and EPA/ROD/R10-00/121, page 19).
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions*** (EPA/ROD/R10-95/126, page 25; EPA/ROD/R10-99/039, page 26 :and EPA/ROD/R10-00/121, page 22).
- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure.*** *Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required* (EPA/ROD/R10-95/126, page 26).
- ***RAO 4. Provide conditions suitable for future land use of the 100 Area*** (EPA/ROD/R10-00/121, page 22).

Remedy Components. The 1995 ROD (EPA/ROD/R10-95/126), as amended; the 1999 ROD (EPA/ROD/R10-99/039) as amended; and the 2000 ROD (EPA/ROD/R10-00/121), as amended, share the same basic interim action remedy components for the 100-DR-1 and 100-DR-2 waste sites. These components generally include the following steps:

- Remove contaminated soil, structures, and debris from 100 Area source waste sites using the observational approach, which uses field data and analytical screening during remediation to guide the extent of excavation. Remediation proceeds until it can be demonstrated through a combination of field screening and verification sampling that cleanup goals have been achieved.
- Treat the waste, as required, to meet applicable waste disposal criteria.

- Dispose of contaminated materials at ERDF.
- Backfill excavated areas and revegetate.
- Implement ICs if unrestricted future use is planned and exposure is not practicable.

Detailed descriptions of the remedy components are provided in the "Selected Remedy" section of each ROD, as amended.

Remedy Implementation Progress Prior to this Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work on the interim remedy, as outlined in the previous section, has been ongoing since 1995. Prior to 2011, interim remedial actions had been completed at 56 of approximately 122 waste sites in the 100-DR-1 and 100-DR-2 OUs.

Issues/Corrective Actions from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** In the previous CERCLA 5-Year Review report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070) for the period of 2006 – 2010, the following single issue and its associated action were noted in the 100-DR-1 and 100-DR-2 source OUs assessment:

> ***Issue 1****: Recent data indicates a low spot in the surface of the Ringold Upper mud in the 100-HR-3 OU that may trap hexavalent chromium in the aquifer, which in combination with a likely continuing vadose source of hexavalent chromium at the adjacent 100-D-100 waste site results in persistent hexavalent chromium concentrations in groundwater southeast of the 182-D reservoir.*
>
> ***Action 1.1****: Remove, treat, and dispose of the chromium discovered in the deep vadose zone at 100-D-100. (Corrective Action Due Date: 4/30/2014).*
>
> *Does this issue/action currently affect the protectiveness of the remedy? – YES*
>
> *Will this issue/action affect the protectiveness of the remedy in the future? – YES*

This corrective action was complete during this 5-year review period; see additional details regarding the 100-D-100 waste site remediation and other major efforts in the Remedy Implementation subsection.

Protectiveness Statement from the Previous (2006 – 2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006 – 2010) 5-year review report for the 100-DR-1 and 100-DR-2 OUs was as follows:

> *The final remedy at 100-DR-1 and 100-DR-2 OUs is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.*

2.3.3.1.4 Progress Since 2011 Review

Accomplishments. Since the 2011 review, interim remedial actions were completed at more than 60 waste sites and documented in waste site cleanup verification packages or remaining sites verification packages. The following waste sites that were actively remediated during this 5-year review period:

- 100-DR-1 Operable Unit
  - 100-D-7, Dumping Area
  - 100-D-8, Sewer Outfall
  - 100-D-30, Contaminated Soils
  - 100-D-31:1, Process Sewer Pipeline
  - 100-D-31:2, Process Sewer Pipeline
  - 100-D-31:3, Process Sewer Pipeline
  - 100-D-31:4, Process Sewer Pipeline
  - 100-D-31:7, Process Sewer Pipeline
  - 100-D-31:8, Process Sewer Pipeline
  - 100-D-76, Crib
  - 100-D-78, Stained Soils
  - 100-D-80:2, Surface Debris
  - 100-D-81, Burn/Stained Soils
  - 100-D-83:1, Acid Pipeline
  - 100-D-83:2, Backwash Pipeline
  - 100-D-83:3, Acid Pipeline
  - 100-D-83:5, Neutralizing Pipeline
  - 100-D-84:2, Sanitary Sewer Pipeline

  - 100-D-31:9, Process Sewer Pipeline
  - 100-D-31:10, Septic Sewer Pipeline
  - 100-D-31:11, 182-D and 1830D Sewer Pipelines
  - 100-D-31:12, 183-D West Process Sewer Pipelines
  - 100-D-50:1, Discharge Pipeline
  - 100-D-50:4, Recirculation Pipeline
  - 100-D-50:6, Drain Pipeline
  - 100-D-50:7, Floor Drain Pipeline
  - 100-D-50:8, Condensate Drain Pipeline
  - 100-D-50:9, Sanitary Sewer Pipeline
  - 100-D-56:1, Product Piping
  - 100-D-56:2, Product Piping
  - 100-D-65,Spillway
  - 100-D-66, Spillway
  - 100-D-69, Stained Concrete and Soil
  - 100-D-71, Safety Rod Tower
  - 100-D-72, Acid Facility Trench
  - 100-D-73, Chemical Pumphouse
  - 100-D-75:1, Electrical Substation
  - 100-D-85:2, Process Sewer Pipelines
  - 100-D-86:1, Process Sewer Pipelines
  - 100-D-86:3, Process Sewer Pipelines
  - 100-D-96:2, French Drains
  - 100-D-98:3, Electrical Substation
  - 100-D-99, Septic Tank
  - 100-D-104, Stained Soils
  - 116-D-5, Outfall Structure
  - 116-D-10, Discharge Pond
  - 116-DR-5, Outfall Structure
  - 118-D-6:4, Contaminated Soils
  - 126-D-2, Coal Pit
  - 128-D-2, Burn Pit
  - 130-D-1, Gasoline Tank
  - 132-D-1, Recirculation Facility
  - 1607-D2:5, Tile Field
  - 1607-D5, Septic Tank
  - 628-3, Burn Pit

- 100-DR-2 Operable Unit
  - 100-D-13, Septic System
  - 100-D-14, Septic Tank
  - 100-D-28:1, Septic System
  - 100-D-58, Sewage System
  - 100-D-62, Septic Tank
  - 100-D-77, Facility
  - 100-D-100, Stained Soil
  - 100-D-106, Sewer Pipeline
  - 116-D-8, Storage Pad
  - 116-DR-8, Crib
  - 118-D-1, Burial Ground
  - 118-D-2:1, Burial Ground
  - 118-D-2:2, Burial Ground
  - 118-D-3:1, Burial Ground
  - 118-D-3:2, Burial Ground
  - 118-D-4, Burial Ground
  - 1607-D1, Septic Tank
  - 600-30, Dumping Area

Table 2-9 summarizes the waste site cleanup status for the 100-DR-1 and 100-DR-2 source OU waste sites, including metrics on work accomplished during this past 5-year period (2011 – 2015). Figure 2-9 shows the general locations and closure status as of December 2015 of waste sites in the 100-DR-1 and 100-DR-2 source OUs.

Table 2-9. 100-DR-1 and 100-DR-2 Source Operable Units Cleanup Status.

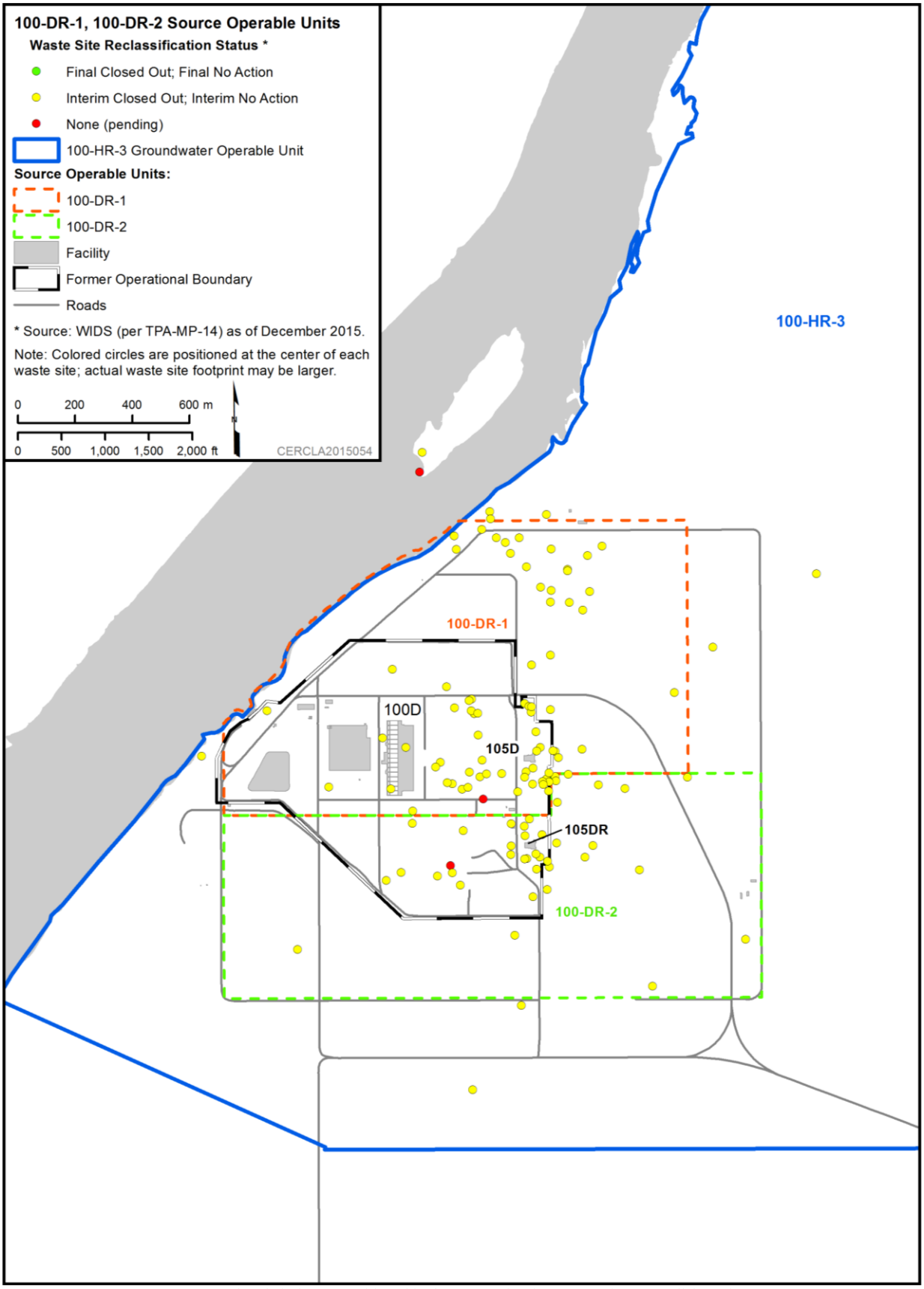
Source OU	Number of Waste Sites[a]	Sites Dispositioned [b]			
		Pre-2011	2011 – 2015	Total	Percent Complete
100-DR-1	89	39	47	86	96
100-DR-2	33	17	16	33	100
Total	**122**	**56**	**63**	**119**	**97%**

[a]Approximate number of waste sites within the OU, according to WIDS, as of December 2015. Actual numbers can and do change if sites are added to or moved from a given OU in accordance with DOE and regulatory agency approvals.

[b]Approximate number of sites dispositioned as of December 2015; includes the number of sites that have been reclassified in WIDS, as of December 2015, as either interim closed, final closed, interim no-action, or final no-action in accordance with the guideline TPA-MP-14[c], *Maintenance of Waste Information Data System (WIDS)*. Slight discrepancies may exist between WIDs data and the specific waste sites listed in the table because of the time required to process and approve change requests that add or delete sites before changes are made in WIDS.

[c] TPA-MP-14, 2011, *Maintenance of the Waste Information Data System (WIDS)*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE = U.S. Department of Energy. OU = operable unit.



Note: Colored circles are positioned in the center of a given waste site's overall footprint.

Figure 2-9. Geographic Distribution and WIDS Reclassification Status of the 100-DR-1 and 100-DR-2 Source Operable Unit Waste Sites as of December 2015.

Remedy Implementation. Since the 2011 review, the primary remedial activities in the 100-D Area include the remediation of the chromium-contaminated waste sites, underground pipeline waste sites, and the remaining waste sites identified through the orphan site process. This work was conducted under the 100 Area RDR/RAWP (DOE/RL-96-17), as amended. The following paragraphs describe several of the major efforts.

- **100-D-100.** The 100-D-100 waste site was discovered when stained surface soil was identified on April 6, 2008; the site was found to contain elevated chromium and hexavalent chromium concentrations resulting from historical spills of sodium dichromate. Remediation of the 100-D-100 waste site was initiated in August 2011 and was initially completed in January 2014 with the depth of the excavation at 26 m (85.3 ft) bgs, which is groundwater elevation. Approximately 196,000 BCM (156,360 BCY) of contaminated soil were excavated and disposed of at ERDF. Approximately 29,000 BCM (37,900 BCY) of this material were treated at ERDF to meet ERDF's waste acceptance criteria for chromium.

  Additional remedial activities to remove saturated soils to a depth of 10 ft below groundwater was initiated in December 2014 and completed in February 2015. Approximately 20,390 BCY (15,589 BCM) of aquifer sediment were removed, dewatered, and disposed of to ERDF.

- **100-D-30 and 100-D-104.** The 100-D-30 and 100-D-104 waste sites were releases associated with the historical use of sodium dichromate at the 190-D complex. Initial remediation of the 100-D-30 waste site to remove hexavalent chromium contamination was performed from June 2006 through May 2007 to a depth of 4.6 m (15 ft) bgs. The 100-D-104 waste site was discovered near the 100-D-30 waste site and additional remediation was performed from October 2011 to March 2012 to a depth of 15.2 m (50 ft) bgs. Removal of hexavalent chromium contaminated soil continued from February 2013 to March 2014 to a final depth of 24 m (78.7 ft) bgs, groundwater elevation. An additional 722 BCM (922 BCY) were removed from the lower sidewalls at two locations in October 2014.

- **100-D-31 and 100-D-50.** Work continued remediating the remaining subsites associated with the 100-D-31 and 100-D-50 waste sites. These two waste sites consist of underground pipelines throughout the 100-D Area that transported treated cooling water, some septic sewer lines, and process sewer wastes, including all nonradioactive waste streams from water treatment, reactor, and laboratory facilities.

ICs have been implemented and maintained during this 5-year review period to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure.

2.3.3.1.5 Technical Assessments

Is the remedy functioning as intended by the decision documents?

The interim remedy (primarily involving RTD, backfilling, revegetation, and ICs) is functioning as intended by the interim action ROD (as amended). As of December 2015, 119 of the 122 100-DR-1 and 100-DR-2 source OU waste sites had been remediated. DOE anticipates a final ROD for the entire 100-D/H area (including source and groundwater OUs) during the upcoming (2016 – 2020) 5-year review period.

In accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS)*, the 100-DR-1 and 100-DR-2 remediated waste sites have been documented in WIDS as either interim closed or interim no-action. Cleanup verification packages (including sampling data and other technical information) to support the reclassification to interim closed and/or no-action are included in the Hanford Site Administrative Record for the 100-DR-1 and 100-DR-2 source OUs. The RAGs are described in Chapter 2 of the *Remedial Design Report/Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17, Rev. 6).

The RAOs for 100-DR-1 and 100-DR-2 source OU remediated waste sites, and the methods used for achieving the RAOs through the interim remedial actions are summarized in the following list:

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.***
  - Achieved through excavation to WAC 173-340, "Model Toxics Control Act – Cleanup," levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) use.
  - Achieved human health total radiological dose standards of less than 15 mrem/yr above background for radionuclides.
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.***
  - Achieved through protection such that contaminant levels in soil after remediation do not result in an adverse impact to groundwater that exceeded any nonzero maximum contaminant level goals under the *Safe Drinking Water Act of 1974* or Method B cleanup levels under WAC 173-340.
  - Levels of contaminants in the soil after remediation do not result in an impact to groundwater and the Columbia River that could exceed the ambient water quality criteria under the Clean Water Act of 1977 for protection of fish or Method B cleanup levels under the WAC 173-340-730, "Surface water cleanup standards." Because no ambient water quality criteria have been established for radionuclides, maximum contaminant levels from national primary drinking water standards were used.
  - The protection of receptors (aquatic species, with emphasis on salmon) in surface waters was achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River are not subject to any additional adverse risks.
- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.***

  Achieved by removing waste sites to the bottom of the engineered structure, as well as implementing and maintaining ICs, as required.

ICs for the 100-DR-1 and 100-DR-2 source OUs, as required by the interim action RODs (as amended), are further described in the latest version of the 100 Area RDR/RAWP (DOE/RL-96-17) and are actively managed. Specific details associated with each IC have also been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 100-DR-1 and 100-DR-2 source OUs include waste-site-specific ICs (e.g., drilling and excavation restrictions for waste sites where residual contamination remains at depth) and general-areas ICs including access control (warning notices and entry restrictions), land-use management (land use, excavation permits, and notice in deed), groundwater-use management, and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 100-DR-1 and 100-DR-2 source OUs.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid. These criteria will be reviewed and updated as needed to support final remedy selection.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the interim remedy for these OUs.

2.3.3.1.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the100-DR-1 and 100-DR-2 source OUs were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.3.3.1.7 Protectiveness Statements

100-DR-1 Source OU – Will Be Protective. The remedy at the 100-DR-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-DR-1 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates issuance of a final ROD for the 100-D and 100-H areas during the next (2016 – 2020) 5-year review period.

100-DR-2 Source OU – Will Be Protective. The remedy at the 100-DR-2 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-DR-2 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates issuance of a final ROD for the 100-D and 100-H areas during the next (2016 – 2020) 5-year review period.

2.3.3.2 100-HR-1 and 100-HR-2 Source Operable Units

2.3.3.2.1 Background

Past operations associated with the 100-H area contributed to soil and groundwater contamination at the Hanford Site. The 105-H Reactor operated from 1949 to 1965. Cleanup decisions for this region were initiated in the 1990s. The 100-HR-3 groundwater OU, which addresses the groundwater beneath both the 100-D and 100-H areas, is addressed in Section 2.1.3.3. Currently, the 100-H Area contains no active facilities, operations, or liquid discharges except for groundwater P&T facilities.

The 100-HR-1 source OU is located in the eastern portion of the 100-H area, and includes liquid and sludge disposal sites associated with the operations of the reactor and related facilities, trenches, cribs, and septic tanks.

The 100-HR-2 source OU is located in the western and southern portions of the 100-H area and primarily includes solid waste burial grounds associated with the operation of the reactor, pits, trench, and septic tanks.

2.3.3.2.2 Chronology

Table 2-10 lists the remedial action decision documents relevant to source OU response actions in the 100-H area.

Table 2-10. Decision Documents for the 100-HR-1 and 100-HR-2 Source Operable Units.

Date	Location	Title
9/1995	EPA/ROD/R10-95/126	***Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This interim action ROD requires removal of contaminated soil, structures, and debris using the observational approach; treatment by thermal desorption to remove organics and/or soil washing for volume reduction or as needed to meet waste disposal criteria, disposal of contaminated materials at ERDF and backfill of excavated areas followed by revegetation.
4/1997	EPA/AMD/R10-97/044	***Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This amendment to the interim action ROD incorporates 34 additional waste sites into the ROD; refines the remedial cost estimate for the original 37 sites and additional 34 sites based on actual data, streamlining, and lessons learned; and eliminates the soil washing treatment option before disposal.
7/1999	EPA/ROD/R10-99/039	***Interim Action Record of Decision for the 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 Operable Units Remaining Sites.*** This interim action ROD requires RTD for 46 sites; adds the plug-in approach for the RTD remedy for both remaining 100 Area and 200 North sites; the plug-in approach for newly identified 100 Area sites added by ESD; disposal of debris from the B, D, H, and K Reactors to ERDF; and provides the decision framework for leaving waste in place, generally below 15-ft depth.
9/2000	EPA/ROD/R10-00/121	***Interim Action Record of Decision: 100-BC-I, 100-BC-2, 100-DR-I, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2 Operable Units (100 Area Burial Grounds).*** This interim action ROD requires removal of contaminated soil, structures, and debris; treatment as needed; disposal of waste at ERDF; backfilling; and revegetation. It applies to 45 burial grounds in the 100 Area.
2/2004	EPA et al 2004	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** The ESD adds 28 sites to the ROD; adds 10 CFR 1022 and 40 CFR 6, Appendix A, as ARARs to the ROD and revises the annual ICs report date to coincide with the due date for the Sitewide ICs plan for Hanford CERCLA response actions.
8/2009	EPA et al. 2009	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** This ESD authorizes adding 200-CW-3 OU wastes sites, 99 newly discovered waste sites, and 87 candidate sites using the plug-in approach in the ROD and any newly discovered waste sites documented in the Administrative Record and an annual fact sheet.
3/2011	DOE et al. 2011	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2010, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.
2/2012	DOE et al. 2012	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2011, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

Table 2-10. Decision Documents for the 100-HR-1 and 100-HR-2 Source Operable Units.

Date	Location	Title
1/2013	DOE et al. 2013	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2012, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.
ERDF = Environmental Restoration Disposal Facility.
ESD = explanation of significant differences.
IC = institutional control.
ROD = record of decision.
RTD = removal, treatment, and disposal.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.3.2.3 Remedial Actions

Goals and Objectives. The RAOs set forth in the 1995 (EPA/ROD/R10-95/126), 1999 (EPA/ROD/R10-99/039), and 2000 (EPA/ROD/R10-00/121) interim action RODs listed in Table 2-10 are narrative statements that define the extent to which the waste sites require cleanup to protect human health and the environment. The RAOs identified in these interim action RODs (see following list) apply to contaminants in soils, structures, and debris. RAOs 1 and 2 are common to all three interim action RODs. RAOs 3 and 4 are not stated in all RODs, as amended, but are associated with future land use.

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics*** (EPA/ROD/R10-95/126, page 25; EPA/ROD/R10-99/039, page 26; and EPA/ROD/R10-00/121, page 19).
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions*** (EPA/ROD/R10-95/126, page 25; EPA/ROD/R10-99/039, page 26 :and EPA/ROD/R10-00/121 , page 22).
- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure.*** *Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.* (EPA/ROD/R10-95/126, page 26).
- ***RAO 4. Provide conditions suitable for future land use of the 100 Area*** (EPA/ROD/R10-00/121, page 22).

Principal requirements for achievement of the RAOs are described in each of the respective interim action RODs, as amended.

Remedy Components. The 1995 ROD (EPA/ROD/R10-95/126), as amended; the 1999 ROD (EPA/ROD/R10-99/039), as amended; and the 2000 ROD (EPA/ROD/R10-00/121), as amended, share the same basic interim action remedy components for the 100-HR-1 and 100-HR-2 waste sites. These components generally include the following steps:

- Remove contaminated soil, structures, and debris from 100 Area source waste sites using the observational approach, which uses field data and analytical screening during remediation to guide the extent of excavation. Remediation proceeds until it can be demonstrated, through a combination of field screening and verification sampling, that cleanup goals have been achieved.
- Treat the waste as required to meet applicable waste disposal criteria
- Dispose of contaminated materials at ERDF
- Backfill excavated areas and revegetate

- Implement ICs if unrestricted future use and exposure are not practicable.

Detailed descriptions of the remedy components are provided in the "Selected Remedy" section of each ROD, as amended.

Remedy Implementation Progress Prior to this Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** As outlined in the previous section, work on the interim remedy has been ongoing since 1995. Before 2011, interim remedial actions had been completed at 32 of approximately 66 waste sites in the 100-HR-1 and 100-HR-2 source OUs.

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for the 100-HR-1 OU or 100-HR-2 OU in the previous (2006 – 2010) CERCLA 5-year review.

Protectiveness Statement from the Previous (2006 – 2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006 – 2010) 5-year review report for the 100-HR-1 and 100-HR-2 source OUs was as follows:

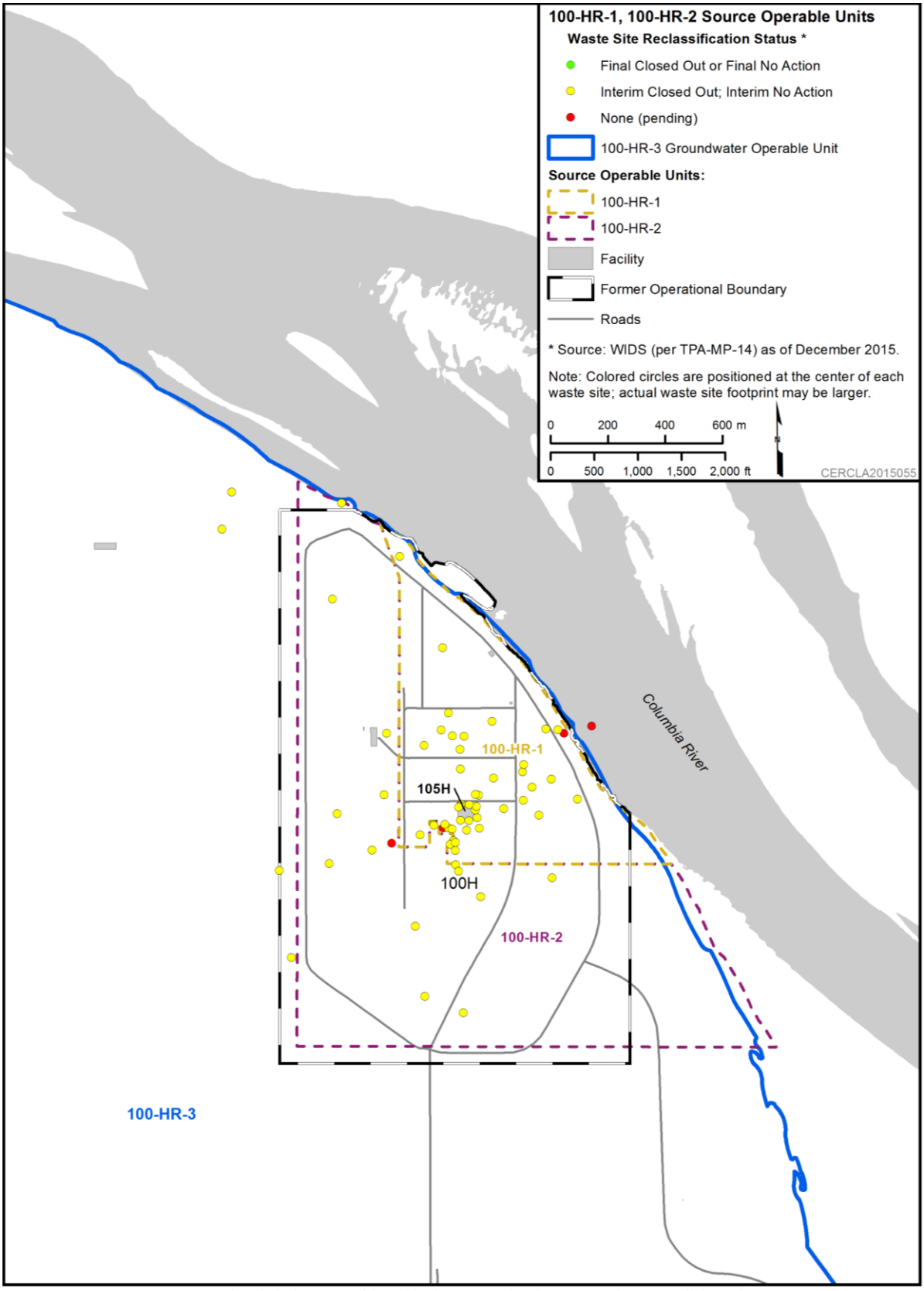
> *The final remedy at 100-HR-1 and 100-HR-2 OUs is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.*

2.3.3.2.4 Progress Since 2011 Review

Accomplishments. Since the 2011 5-year review, interim remedial actions were completed at more than 25 waste sites and documented in waste site cleanup verification packages or remaining sites verification packages. The following waste sites were actively remediated during this 5-year review period:

- 100-HR-1 Operable Unit
  - 100-H-3, Fuel Tanks
  - 100-H-4, French Drain
  - 100-H-28:2, Process Sewer
  - 100-H-28:3, Process Sewer
  - 100-H-28:4, Sanitary Sewer Pipeline
  - 100-H-28:5, 1607-H2 Sanitary Sewer Pipelines
  - 100-H-41, Contaminated Soils
  - 100-H-42, Pump Lift Station
  - 100-H-43, Maintenance Shop
  - 100-H-44, Neutralization Pit, H-016
  - 100-H-46, Contaminated Soils
  - 100-H-48, Underground Tanks
  - 100-H-49:1 French Drains
  - 100-H-51:1,Process Sewer Pipeline
  - 100-H-51:2, Process Sewer Pipeline
  - 100-H-51:3, Process Sewer Pipeline
  - 100-H-51:6,Process Sewer Pipeline
  - 100-H-52, Drain Field
  - 100-H-59:1, Contaminated Soils
  - 100-H-59:2, Debris Piles
  - 116-H-5, Outfall Structure
  - 116-H-9, Crib
  - 118-H-6:4, Contaminated Soils
  - 118-H-6:5, Decontamination Pads
  - 126-H-2, Disposal Pit
  - 132-H-3, Pump Station
  - 1607-H3, Septic Tank
- 100-HR-2 Operable Unit
  - 118-H-1:1, Burial Ground
  - 118-H-1:2, Burial Ground
  - 118-H-2, Burial Grounds
  - 118-H-3, Burial Ground
  - 118-H-4, Burial Ground
  - 128-H-1, Burn Pit
  - 1607-H1, Septic Tank
  - 600-151, Dumping Area
  - 600-380, Dumping Area
  - 600-382:1 through :5, Soil Staining
  - 600-383:1 through :10, Surface Debris
  - 600-384:1 through :5, Soil Staining

Figure 2-10 shows the general locations and closure status as of December 2015 of waste sites in the 100-HR-1 and 100-HR-2 source OUs. Table 2-11 summarizes the waste site cleanup status for the 100-HR-1 and 100-HR-1 source OU waste sites, including metrics on work accomplished during this past 5-year period (2011 – 2015).



Note: Colored circles are positioned in the center of a given waste site's overall footprint.

Figure 2-10. Geographic Distribution and WIDS Reclassification Status of the 100-HR-1 and 100-HR-2 Operable Unit Waste Sites as of December 2015.

Table 2-11. 100-HR-1 and 100-HR-2 Source Operable Units Cleanup Status.

Source OU	Number of Waste Sites[a]	Sites Dispositioned[b]			
		Pre-2011	2011 – 2015	Total	Percent Complete
100-HR-1	49	24	22	46	93
100-HR-2	17	8	8	16	94
Total	**66**	**32**	**30**	**62**	**93%**

[a]Approximate number of waste sites within the OU, according to WIDS, as of December 2015. Actual numbers can and do change if sites are added to or moved from a given OU in accordance with DOE and regulatory agency approvals.

[b]Approximate number of sites dispositioned as of December 2015; includes the number of sites that have been reclassified in WIDS, as of December 2015, as either interim closed, final closed, interim no-action or final no-action in accordance with the guideline TPA-MP-14[c], *Maintenance of Waste Information Data System (WIDS)*. Slight discrepancies may exist between WIDs data and the specific waste sites listed in the table because of the time required to process and approve change requests that add or delete sites before changes are made in WIDS.

[c]TPA-MP-14, 2011, *Maintenance of the Waste Information Data System (WIDS)*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE = U.S. Department of Energy. OU = operable unit.

Remedy Implementation

The primary remedial activities in the 100-H area since 2011 were the remediation of the remaining burial grounds, septic tanks, soil stained areas, and contaminated soils, along with several waste sites located between the 100-D and 100-H areas that were identified through the orphan sites evaluation process. As of December 2015, all interim actions were performed for all 100-HR-1 and 100-HR-2 waste sites except for one located in the horn between 100-H and 100-D; this site was delayed to complete cultural clearance.

ICs have been implemented and maintained during this 5-year review period to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure.

The interim remedial actions are conducted under the 100 Area RDR/RAWP (DOE/RL-96-17), as amended.

2.3.3.2.5 Technical Assessments

Is the remedy functioning as intended by the decision documents?

The interim remedy (primarily involving RTD, backfilling, revegetation, and ICs) is functioning as intended by the interim action ROD (as amended). As of December 2015, 62 of the 66 100-HR-1 and 100-HR-2 source OU waste sites had been remediated. DOE anticipates a final ROD for the entire 100-D/H area (including source and groundwater OUs) during the upcoming (2016 – 2020) 5-year review period.

In accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS)*, the 100-DR-1 and 100-DR-2 remediated waste sites have been documented in WIDS as either interim closed or interim no-action. Cleanup verification packages (including sampling data and other technical information) to support the reclassification to interim closed and/or no-action are included in the Hanford Site Administrative Record for the 100-HR-1 and 100-HR-2 source OUs. The RAGs are described in Chapter 2 of the 100 Area RDR/RAWP (DOE/RL-96-17, Rev. 6).

The RAOs for 100-HR-1 and 100-HR-2 remediated waste sites, and the methods used for achieving the RAOs through the interim remedial actions are summarized in the following list:

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.***
  - Achieved through excavation to WAC 173-340, "Model Toxics Control Act – Cleanup," levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) use.
  - Achieved human health total radiological dose standards of less than 15 mrem/yr above background for radionuclides.
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.***
  - Achieved through protection such that contaminant levels in soil after remediation do not result in an adverse impact to groundwater that exceeded any nonzero maximum contaminant level goals under the *Safe Drinking Water Act of 1974* or Method B cleanup levels under WAC 173-340, "Model Toxics Control Act – Cleanup."
  - Levels of contaminants in the soil after remediation do not result in an impact to groundwater and the Columbia River that could exceed the ambient water quality criteria under the *Clean Water Act of 1977* for protection of fish or Method B cleanup levels under the WAC 173-340-730, "Surface water cleanup standards." Because no ambient water quality criteria have been established for radionuclides, maximum contaminant levels from national primary drinking water standards were used.
  - The protection of receptors (aquatic species, with emphasis on salmon) in surface waters was achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River are not subject to any additional adverse risks.
- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.***

  Achieved by removing waste sites to the bottom of the engineered structure and providing ICs, as required. ICs (via use of excavation permits) prevent uncontrolled drilling or excavation into the deep vadose zone (i.e., greater than 4.6 m [15 ft] below the surface). Applied general area ICs include warning notices, entry restrictions, site evaluation, and monitoring. ICs for the 100-HR-1 and 100-HR-2 source OUs, as required by the interim action RODs (as amended), are further described in the latest version of the 100 Area RDR/RAWP (DOE/RL-96-17) and are actively managed. Specific details associated with each IC also have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 100-HR-1 and 100-HR-2 source OUs include waste-site-specific ICs (e.g., drilling and excavation restrictions for waste sites where residual contamination remains at depth) and general-areas ICs including access control (warning notices and entry restrictions), land-use management (land use and excavation permits), groundwater-use management, and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 100-HR-1 and 100-HR-2 source OUs.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid. These criteria will be reviewed and updated as needed to support final remedy selection.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the interim remedy for these OUs.

2.3.3.2.6 Issues/Corrective Actions

Issues. No issues specific to the100-HR-1 and 100-HR-2 OUs were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.3.3.2.7 Protectiveness Statement

100-HR-1 Source OU – Will Be Protective. The remedy at the 100-HR-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-HR-1 source OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates issuance of a final ROD for the 100-D and 100-H areas during the next (2016 – 2020) 5-year review period.

100-HR-2 Source OU – Will Be Protective. The remedy at the 100-HR-2 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the 100-HR-2 source OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates the issuance of a final ROD for the 100-D and 100-H areas during the next (2016 – 2020) 5-year review period.

2.3.3.3 100-HR-3 Groundwater Operable Unit

2.3.3.3.1 Background

The 100-HR-3 groundwater OU (shown in Figure 2-8) is 1 of 10 groundwater OUs on the Hanford Site, and 1 of 6 located in the River Corridor. The 100-HR-3 groundwater OU consists of the groundwater affected by contaminated releases from the 100-D and 100-H reactor facilities and the associated waste sites in the 100-DR-1, 100-DR-2, 100-HR-1, and 100-HR-2 source OUs.

The 100-D Area is the site of two deactivated reactors: the 100-D Reactor (operated from 1944 to 1967) and the 100-DR Reactor (operated from 1950 to 1964). The 100-H Area is the site of one deactivated reactor: the 100-H Reactor (operated from 1949 to 1965). During the years of reactor operations, large volumes of reactor coolant water were discharged to retention basins for ultimate disposal in the Columbia River through outfall pipelines. Liquid wastes containing significant quantities of chromium from reactor operations also were discharged to the soil column at cribs, trenches, and French drains. Contaminant plumes in groundwater resulted from these obsolete waste disposal practices.

COCs for the 100-HR-3 groundwater OU include hexavalent chromium, total chromium, strontium-90, and nitrate. Other contaminants of interest include tritium, uranium, and technetium-99.

Groundwater in the 100-HR-3 OU flows generally to the northeast from the 100-D area, across the Horn to the 100-H area. Groundwater flow in the 100-H area is to the east and southeast, generally toward the Columbia River. Groundwater flow in the southern and central portions of the 100-D area is northwest toward the Columbia River. Operation of P&T systems at the 100-HR-3 OU changes groundwater flow direction and velocity throughout 100-HR-3, primarily in the reactor areas. These changes are expressed

as depressions and mounds in the water table, which are often localized, and influence local flow and gradient. Daily and seasonal fluctuations in the river stage also affect groundwater levels, gradients, and flow directions.

Current land use is industrial and primarily involves remediation activities. The principal structures in the area are the 105-D, 105-DR, and 105-H reactor buildings. These reactors were placed in ISS between 2002 and 2005. ISS will allow for radionuclide activity levels to decrease for up to 75 years before the final remediation decision is implemented. Public access to the area is restricted.

The Columbia River and north shoreline (across the river from the 100-HR-3 groundwater OU) are used for recreational activities such as hunting, fishing, and boating. They also support a large variety of aquatic and riparian animals and plants. The 100-HR-3 OU footprint contains a large amount of undeveloped land.

A summary of the 100-HR-3 groundwater is included in each of the following reports:

- *Hanford Site Groundwater Monitoring Report* (published annually to address the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- *Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations and 100-NR-2 Groundwater Remediation* for each prior year can be accessed through the same link.

Additional CERCLA documentation associated with the 100-HR-3 groundwater OU, as well as other OUs, can be accessed directly or queried in the Administrative Record for the Hanford Site's OUs and TSD units, at the following address:
http://pdw.hanford.gov/arpir/index.cfm/predefinedSearch?canType=OpUnit.

2.3.3.3.2 Chronology

Table 2-12 lists the remedial action decision documents associated with the 100-HR-3 groundwater OU.

Table 2-12. Decision Documents for the 100-HR-3 Groundwater Operable Unit.

Date	Location	Title
3/1996	EPA/ROD/R10-96/134	***Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Hanford Site, Benton County, Washington.*** This interim action ROD requires P&T removal of hexavalent chromium from groundwater extraction wells, ion exchange treatment, reinjection of treated effluent, monitoring, and institutional controls.
10/1999	EPA/AMD/R10-00/122	***U.S. Department of Energy Hanford Site – 100 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary.*** This amendment to the interim action ROD implements the In Situ Redox Manipulation barrier for the second chromium plume in the 100-HR-3 OU and incorporates Ecology's 1997 change in chronic ambient water quality standard from 11 µg/L to 10 µg/L; existing P&Ts remain in operation.
4/2003	EPA/ESD/R10-03/606	***Explanation of Significant Difference for the 100-HR-3 Operable Unit Record of Decision.*** This ESD provides notice of revisions to the project schedule and cost estimate associated with the ISRM groundwater remedial action at 100-HR-3 and explains that the addition of an evaporation pond invokes an additional ARAR.

Table 2-12. Decision Documents for the 100-HR-3 Groundwater Operable Unit.

Date	Location	Title
8/2009	EPA 2009	***Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Benton County, Washington.*** *This* ESD provides notice of an increase in projected costs for P&T operations for both OUs, changes reinjection location requirements for treated water to other than upgradient locations to help contain the hexavalent chromium plumes and prevent the plume from expanding, and changes the treatment and discharge standards for wells not upgradient of extraction wells to meet the aquatic river protection criterion of 10 µg/L for hexavalent chromium.
10/2010	11-AMCP-0002	***Non-Significant Change for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision.*** This notice of non-significant change indicates that the ISRM barrier would no longer be actively maintained; this shifted the groundwater remedy at the ISRM barrier to the P&T system.

ARAR = applicable or relevant and appropriate requirement.
Ecology = Washington State Department of Ecology.
ESD = explanation of significant difference.
ISRM = in situ REDOX manipulation
OU = operable unit.
P&T = pump and treat.
ROD = record of decision.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.3.3.3 Remedial Actions

Goals and Objectives. In accordance with the NCP, "EPA expects to return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (40 CFR 300.430[a][1][iii][F]). EPA generally defers to state definitions of groundwater classification provided under EPA-endorsed Comprehensive State Groundwater Protection Programs (*Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites* EPA/540/G-88/003).

Groundwater from the 100-HR-3 OU is contaminated and is not currently withdrawn from the aquifer for beneficial use; however, the highest potential beneficial use of groundwater is as a drinking water source. Consistent with the beneficial-use classifications of Washington State and the EPA, the goal for remediating 100-HR-3 OU groundwater is to reduce contaminants to levels that will allow its use as a future drinking water source.

Based on the expectations for 100-HR-3 groundwater restoration, the interim RAOs, as stated in the 1996 interim action ROD (EPA/ROD/R10-96/134), are as follows:

- ***RAO 1. Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.*** *The first remedial action objective for the 100-HR-3 and 100-KR-4 Operable Units is to prevent the discharge of hexavalent chromium to the Columbia River substrate at concentrations exceeding those that are considered protective of aquatic life in the River and riverbed sediments.*
- ***RAO 2. Protection of human health by preventing exposure to contaminants in the groundwater.*** *A second remedial action objective for these operable units is to continue to protect the public such that there is no exposure to contaminants above health based levels.*
- ***RAO 3. Provide information that will lead to the final remedy.***

Additional information will be obtained during the interim action before developing and implementing a final action. [Note: The current RAG is 10 µg/L for hexavalent chromium in the surface water at the point of groundwater discharge. The groundwater remediation is implemented to ensure that this requirement is met.]

Remedy Components. The 1996 interim remedial action ROD provided the following summary-level descriptions of the primary components of the interim remedy for the 100-HR-3 and 100-KR-4 groundwater OUs (i.e., groundwater extraction and treatment, MNA, flow path control, and ICs). The italicized text in the following box is narrative from the original interim remedial action ROD and is provided to give an historical perspective. Some quantities have been modified through subsequent amendments to the interim remedial action ROD (as noted in Table 2-12) and incorporated in the OU's RDR/RAWP documentation. The RDR/RAWP documentation is discussed in the upcoming Remedy Implementation section.

Excerpt from ROD (EPA/ROD/R10-96/134):

Groundwater Extraction. Groundwater will be extracted from wells primarily located along the river in each of the three reactor areas. Extraction wells should be located at a sufficient distance inland from the river to minimize withdrawal of river water. Extraction wells shall be located such that the plume is captured to meet the remedial action objectives. Based on preliminary modeling accomplished for the operable unit focused feasibility studies, the following extraction well design was estimated as sufficient to capture the chromium plume to meet the chromium remedial action objectives:

- *100-K Area: Eleven extraction wells spaced approximately 240 m (786 ft) apart with a composite withdrawal rate of 20 gpm.*
- *100-H Area: Nine extraction wells spaced approximately 160 m (515 ft) apart with a composite withdrawal rate of 225 gpm.*
- *100-D Area: Ten extraction wells spaced approximately 160 m (515 ft) apart with a composite withdrawal rate of 100 gpm.*

During remedial design, estimates will be improved based on the incorporation of the results of ongoing river pore water sampling and shoreline drive point sampling, recent groundwater sampling data, and other pertinent data collected since the completion of the focused feasibility study. The groundwater extraction system shall be designed in accordance with the Remedial Design Report/Remedial Action Work Plan (RDR/RAWP) as approved by EPA and Ecology.

Groundwater Treatment and Discharge Standards – Hexavalent Chromium. 100-D, 100-H, and 100-K Areas. The groundwater treatment systems will reduce the effluent chromium concentrations to the maximum extent practicable. However, groundwater above 50 µg/L chromium will not be discharged to injection wells that are not located upgradient of the extraction wells. The average chromium concentrations in the treated effluent are expected to be at or below 20 µg/L. Treatment will be performed using ion exchange resins.

Groundwater Treatment – Other Contaminants. Because this interim action is designed to reduce levels of hexavalent chromium in the groundwater and the river substrate, there is a potential for other groundwater co-contaminants to be present in the reinjected effluent at concentrations above the drinking water standards set for those contaminants. Potential co-contaminants include nitrate, strontium-90, tritium, uranium, and technitium-99. The ion exchange system required to remove chromium will also reduce concentrations of other anionic contaminants such a nitrate, technitium-99, and uranium-238. Strontium-90 exists in groundwater as a cation and is not expected to be removed in the ion exchange system.

Tritium is also not expected to be removed by the treatment system. In addition to chromium at both operable units; other potential co-contaminants include:

- *100-HR-3: nitrate, strontium-90, tritium, uranium, and technetium-99,*
- *100-KR-4: tritium and strontium-90.*

These other co-contaminants do not exceed the ecological risk criteria, and institutional controls (detailed elsewhere) limit human exposure.

Groundwater Reinjection. After treatment, water will be reinjected into the upper aquifer that will help contain the hexavalent chromium plumes and prevent the plumes from expanding in the 100-HR-3 and 100-KR-4 Operable Units respectively. Based on preliminary modeling accomplished for the operable unit Focused Feasibility Studies, the number of wells needed to accomplish this was estimated to be:

- *100-D Area: Five injection wells.*
- *100-H Area: Three injection wells.*
- *100-K Area: Two injection wells.*

During the remedial design process, more precise estimates are expected to be developed based on the collection and incorporation of well and site-specific data. The groundwater treatment and reinjection system shall be designed in accordance with the RDR/RAWP as approved by EPA and Ecology.

Compliance Monitoring – River Protection. The data analysis and evaluation procedures used to evaluate compliance with cleanup levels shall be defined in a compliance monitoring plan as part of the RDR/RAWP and prepared in accordance with WAC 173-340-720(8) and/or as approved by EPA and Ecology.

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 could be present during parts of the year. Since it is impractical to routinely monitor the river substrate, groundwater will be monitored at near-river on-shore locations above the common high river mark. Monitoring shall be conducted at sufficient locations to evaluate the performance of the remedial action. The siting and design of the compliance monitoring system shall be in accordance with the RDR/RAWP as approved by EPA and Ecology. 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 has been selected based on the available data (i.e., 22 µg/L hexavalent chromium in on-shore near-river well points is considered equivalent to 11 µg/L hexavalent chromium in the river substrate). It will take a period of time for the extraction system to have an effect on groundwater quality adjacent to the Columbia River. Concentrations in excess of 22 µg/L may be observed in the compliance wells during the early stages of operation. [See upcoming Remedy Implementation section: the current remedial action goal is 10 µg/L for hexavalent chromium in surface water (WAC 173-201A, "Water Quality Standards for Surface Waters in the State of Washington") at the point of groundwater discharge.]

Groundwater sampling will be conducted when dilution by river water at the compliance monitoring points is minimal. The details of the groundwater quality monitoring program will be described in the RDR/RAWP. Chromium compliance monitoring will be conducted at multiple depth intervals. Baseline sampling will be conducted prior to the start of the interim action.

Sampling will be conducted monthly for at least three months following start-up of the extraction system. Subsequently, there may be substantial reductions in frequency, number of stations, and depths sampled, if demonstrated to be appropriate, and approved by EPA and Ecology. A network of piezometers (or comparable technique) will be installed and monitored such that the capture zone around the extraction wells can be estimated.

In the event of special conditions such as an unusual flood event or prolonged down-time of the pump-and-treat system, extra monitoring, at the direction of EPA or Ecology shall be conducted.

The analyte list will be defined during remedial design; it shall include:

- *Hexavalent chromium (or total chromium assumed to be hexavalent). The method detection limit and quantitation limit of the selected test method shall be sufficiently low to allow comparison with the remedial action goals.*
- *Conductivity or comparable measurements adequate to indicate ratio of river-derived versus groundwater-derived water.*
- *On an infrequent basis, likely co-contaminants will be monitored as part of on-going Tri-Party Agreement activities to assess protectiveness of human health and the environment.*

Compliance monitoring will include analysis of results in a timely manner to support modifications to the treatment system in order to meet the remedial action objectives. Significant system modifications as identified in the RDR/RAWP are subject to EPA and Ecology approval.

Compliance Monitoring – Effluent for Reinjection. The data analysis and evaluation procedures used to evaluate compliance with cleanup levels shall be defined in the RDR/RAWP and prepared using WAC 173-340-720(8) and approved by EPA and Ecology.

Construction Requirements. Construction requirements shall be scoped as part of the RDR/RAWP with guidance provided by and as approved by EPA and Ecology. This Work Plan shall include at least the following elements:

- *Construction is expected to comply with appropriate worker safety requirements.*
- *In coordination with wildlife and other resource management agencies, activities should avoid or minimize disruption to local wildlife and other natural resources to the extent practicable.*
- *Design should provide for flexibility following startup to accommodate changes in plume characteristics, or different understandings of actual or perceived responses of the aquifer/plume to the pump-and-treat system. When the actual response of the aquifer is known, the pump and treat systems may be altered as needed, and approved by EPA and Ecology to meet the remedial action objectives.*

- *For areas that are disturbed during construction and operation, it is expected that the land will be revegetated following construction in those areas that are not needed for operation and maintenance of the treatment system and where the land is also not expected to be re-disturbed within the next few years by other site activities. Following completion of the interim action, it is expected that rectification of the habitat affected by this activity will be conducted and coordinated with activities in the source operable units (100-DR-l, 100-DR-2, 100-HR-1, 100-HR-2, 100-KR-1, and 100-KR-2).*
- *To the extent practicable, facilities are expected to be designed and located in a manner that minimizes interference with and interference by remedial actions for the source waste sites.*
- *Sites with cultural resource significance should be avoided during remedial activities if avoidance is possible. Where avoidance is not possible, a data recovery/mitigation plan must be prepared in consultation with the affected resource trustee and carried out for each site impacted by remedial activities.*

Schedule. Draft A of the RDR/RAWP is due to EPA and Ecology 120 calendar days after the ROD is signed.

- *Phase 1: Two pump and-treat systems designed in accordance with this ROD in two of the three reactor areas are to be operating as per the RDR/RAWP within 15 months of this ROD. Operating is defined as continuous removal and treatment of water at rates defined in the RDR/RAWP. Some limited testing needed to optimize the system is expected.*
- *Phase 2: The third pump-and-treat system in the third reactor area shall be operating as per the RDR/RAWP. Within 18 months of this ROD.*

The RDR/RAWP will establish a schedule including Tri-Party Agreement milestones for this interim remedial action. This Work Plan including the schedule is subject to EPA and Ecology approval.

Resin Disposal. Waste generated during the remedial action, principally exhausted resins, will be disposed of at the Environmental Restoration Disposal Facility (ERDF) or at other on-site facilities as appropriate. Resins will be stabilized prior to disposal such that:

- *The chromium concentration in leachate generated using the Toxicity Characteristic Leachate Procedure (TCLP) is less than 5.0 mg/L.*
- *ERDF waste acceptance criteria are met for disposal at ERDF.*

In the event that some materials cannot be disposed to ERDF or other on-site facilities, and require disposal at an off-site facility, such a facility must be in compliance with EPA's Offsite Rule (40 CFR 300.440) concerning off-site disposal of wastes. If during the design or conduct of the remedial action it is determined that regeneration of resins is appropriate, that option may be implemented with any waste disposed as described for resins in this paragraph.

Human Access Institutional Controls. Institutional controls are required to prevent human exposure to groundwater. The DOE is responsible for establishing and maintaining land use and access restrictions until MCLs and risk-based criteria are met or the final remedy is selected. Institutional controls include placing written notification of the remedial action in the facility land use master plan. The DOE will prohibit any activities that would interfere with the remedial activity without EPA and Ecology concurrence. In addition, measures necessary to ensure the continuation of these restrictions will be taken in the event of any transfer or lease of the property before a final remedy is selected. A copy of the notification will be given to any prospective purchaser/transferee before any transfer or lease. The DOE will provide EPA and Ecology with written verification that these restrictions have been put in place.

Investigation-Derived Waste. Remedial investigation at 100-HR-3 and 100-KR-4 generated investigation-derived waste consisting of soil and slurries from monitoring well installation, and purge water generated during development and monitoring of the wells. This waste is stored in the respective reactor areas in drums. Soil will be disposed to ERDF, as will slurries following dewatering in accordance with ERDF waste acceptance criteria. Water may be processed via the ion exchange treatment system installed for groundwater under this ROD.

Impacts to RCRA Monitoring. Two RCRA treatment, storage, and disposal (TSD) units, 100-D Pond and the 183-H, Solar Evaporation Basins, are located within the boundaries of the 100 HR-3 Operable Unit.
The 183-H basins are anticipated to be remediated and closed under RCRA, and the 100-D Pond is currently an inactive unit. The implementation of the remedial actions under this Interim Action ROD are believed likely to impact the current RCRA groundwater sampling program around both of these facilities. For any RCRA unit whose monitoring compliance program is impacted, Ecology may approve modifications to the monitoring program as appropriate. Potential alternative compliance actions include monitoring other existing wells (including remediation wells) for appropriate RCRA constituents during the period when the groundwater is affected by the remedial action.

Operational Requirements. The pump and treat portion of the interim remedial action will continue until the selection of a final action or it is demonstrated to EPA's and Ecology's satisfaction that termination (or intermittent operation) is appropriate because: (A) sampling indicates that hexavalent chromium is below the compliance value, and site data indicate it will remain below the compliance value; or (B) based on an evaluation of the following criteria:

- *The effectiveness of the treatment technology does not justify further operation.*
- *An alternate treatment technique, such as in situ chemical reduction or other improved treatment technique is evaluated and proves to be more effective, and/or less costly, and is consistent with the remedial action objectives.*

Wetlands and Flood Plains. The interim action will be implemented such that to the extent practicable disturbance to wetlands will be avoided and system components except monitoring points will be located away from wetlands. System components will be located such that they will not increase deleterious effects of flooding.

Protectiveness. The interim action is expected to provide adequate protection of human health and ecological receptors in the Columbia River until implementation of the final remedy for the 100-HR-3 and 100-KR-4 groundwater operable units, or until such time that the DOE demonstrates to Ecology and the EPA that no further interim action is required. Contaminated soil overlying these operable units are or will be addressed in separate remedial actions.

Disposal to ERDF and Lead Regulatory Agency. The 100-HR-3 Operable Unit was initially designated as a Resource Conservation and Recovery Act (RCRA) Past Practice unit. The Tri-Parties have decided to redesignate this operable unit as a CERCLA Past Practice unit in order to facilitate the disposal of contaminated materials at the CERCLA Environmental Restoration Disposal Facility (ERDF). Section 5.4 of the Hanford Federal Facility, Agreement and Consent Order signed by the DOE, EPA, and Ecology (and hence termed the Tri-Party Agreement) describes the process that was followed to initially designate operable units as RCRA Past Practice or CERCLA Past Practice, and indicates that the remedial actions selected for operable units under either designation would be comprehensive to satisfy the technical requirements of both statutory authorities. Ecology will remain the lead regulatory agency for 100-HR-3 following redesignation.

Based on treatability study demonstrations, in situ treatment of hexavalent chromium was another remedy component added to the 100-HR-3 groundwater OU by the October 1999 ROD amendment (see Table 2-12). This additional remedy component involved installing an in situ [reduction-oxidation] REDOX manipulation (ISRM) barrier to reduce the mobility and toxicity of chromium in groundwater. This component was deemed necessary because sampling from additional wells installed determined that the hexavalent chromium part of a plume was not being captured by the P&T systems. Details on the elements of the ISRM barrier are provided in *EPA Superfund Record of Decision Amendment: Hanford 100-Area (USDOE), EPA ID: WA3890090076, OU 02, Benton County WA, 10/24/1999* (EPA/AMD/R10-00/122) to *EPA Superfund Record of Decision: Hanford 100-Area (USDOE), EPA ID: WA3890090076, OU 02, Benton County, WA, 03/26/1996* (EPA/ROD/R10-96/134). The ISRM barrier, which operated from 1997 to 2012, is described in more detail in the upcoming Remedy Implementation section.

With respect to RCRA monitoring, the former 183-H solar evaporation basin is now in post-closure status (with the CERCLA remedial action being used as a cleanup mechanism), and D pond is a closed site and no longer in the "Hanford Site-Wide RCRA Permit" (WA7890008967). The 183-H basins were demolished in the mid-1990s; the unit was closed in place under the modified closure provisions of the Hanford Permit, with respect to specified measures for post-closure care. DOE submits semiannual reports to Ecology, as required under RCRA corrective action monitoring for the 183-H solar evaporation basins. SGW-59251 *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins and the 300 Area Process Trenches: January – June 201*5 (SGW-59251) covers the monitoring period from January through June 2015. *Post-Closure Corrective Action Groundwater Monitoring Report for the 183-H Solar Evaporation Basins: July – December 201*5 (SGW-59648) covers the rest of 2015. RCRA post-closure corrective action groundwater monitoring for the 183-H solar evaporation basins will continue until the groundwater contamination is remediated under CERCLA as part of the 100-HR-3 groundwater OU.

Remedy Implementation Progress Prior to this Review Period. Before this review period (i.e., before 2011), three CERCLA interim action remedies were operating in the 100−HR−3 groundwater OU. These remedies included the original 100−HR−3 P&T system, which treated groundwater from both the 100-D and 100-H areas, the 100-DR-5 P&T system, and the ISRM barrier in the 100-D Area. These original P&T systems were being enhanced with two new systems; the DX and HX P&T systems. As documented in *Hanford Site Groundwater Monitoring Report for 2010* (DOE/RL-2011-01, Rev.0), as of 2010, more than 719 kg of chromium had been removed by the systems. Further details are described in the previous 5-year review report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070).

Issues/Corrective Actions from the Previous 5-Year Review. In the previous CERCLA 5-Year Review report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070) for the period of 2006 through 2010, the following single issue and its associated action were noted in the 100-HR-3 groundwater OU assessment:

> ***Issue 2****: Leakage and spills from the 182-D Reservoir and export water system may contribute to movement of contaminants into the vadose zone.*
>
> ***Action 2.1****: Complete the engineering export water scoping study to evaluate whether the 182-D Reservoir and export water system is necessary to support the Hanford Cleanup Mission. (Action Due Date: 3/31/2012)*
>
> *Does this issue/action currently affect the protectiveness of the remedy? – YES*
>
> *Will this issue/action affect the protectiveness of the remedy in the future? – YES*

This issue was subsequently documented in Chapters 1 through 3 of *Remedial Investigation/Feasibility Study for the 100-DR-1, 100-DR-2, 100-HR-1, 100-HR-2, and 100-HR-3 Operable Units,* (DOE/RL-2010-95). This RI/FS report, published in 2014, explains that DOE evaluated various options for the Export Water System, including whether the 182-D reservoir was necessary to support the continued Hanford Site cleanup mission. The *Hanford Site Water System Master Plan* (HNF-5828) identified the preferred infrastructure solution for the Export Water System and included monitoring requirements for the 182-D reservoir and export water lines. HNF-5828 calls for maintaining the Export Water System for 10 years beyond November 12, 2012, the approval date of HNF-5828, while a new export water system is designed, permitted, and constructed in the 100-K area. Ultimately, all export water system-related facilities in 100-D will be demolished. The 182-D reservoir and pump station will be removed and the area brought to grade with clean fill. In the meantime, monitoring of the 182-D reservoir will continue using nearby groundwater monitoring wells, as specified in HNF-5828. Monitoring for contaminant levels and water levels is included in the vicinity of the reservoir.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006 – 2010) 5-year review report for the 100-HR-3 groundwater OU was as follows:

> *The remedy at 100-HR-3 Groundwater OU is not protective because the existing interim remedies are not meeting the remedial action objectives. Since the 2006 five-year review, for the 100-HR-3 Groundwater OU, chromium has migrated to the groundwater from soil site sources, resulting in soil and groundwater contamination. Test pits, boreholes, and aquifer response to the rising water table associated with high river stage in the 100 Area have documented that chromium is present in the deep vadose zone. While the majority of source remediation has been completed in the 100-D Area, all of the sources of contamination in the vadose zone are yet to be identified and delineated. It is typical in the 100 and 300 Areas to observe increased contamination levels in the groundwater following sustained high Columbia River water levels. The high river water levels raise the groundwater table and wet portions of the deep vadose zone. These temporary wettings of the contamination in the deep vadose zone may result in pulses of contamination in the groundwater. This potential pulsing may suggest that these deep vadose zone chromium residues continue to act as a reserve for future contamination of the groundwater. Further information will be obtained by completing the RI/FS process*

and selecting a final remedy, at which time a protectiveness determination will be made. Expanded pump-and-treat systems are being implemented in both the 100-H and 100-D areas.

2.3.3.3.4 Progress Since the 2011 Review

Accomplishments. The primary remedial action accomplishments for the 100-HR-3 groundwater OU during the past 5 years can be summarized as follows:

- Continued CERCLA groundwater sampling and analysis at monitoring well locations
- Continued operation of groundwater P&T systems HR-3, DR-5, DX, and HX and removed over 2,200 kg of hexavalent chromium:
  - HR-3 P&T: Operated from 1997 to 2011 and removed 406 kg of hexavalent chromium
  - DR-5 P&T: Operated from 2007 to 2011 and removed 338 kg of hexavalent chromium
  - DX P&T: Operating since 2010 and removed 1,488 kg of hexavalent chromium as of 2015
  - HX P&T: Operating since 2011and removed 118 kg of hexavalent chromium as of 2015
- Completed the RI/FS report (DOE/RL-2010-95); DOE and Ecology worked through the comment resolution process in 2013 and 2014 and Ecology accepted the document in 2014; the proposed plan is expected to be available for public comment in 2016.

Additional narrative on 100-HR-3 groundwater OU accomplishments relative to each ROA (as of 2015) can be viewed in DOE/RL-2016-19, *Calendar Year 2015 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*.

Remedy Implementation. Primary documents that have influenced field implementation of the interim action ROD for 100-HR-3, (EPA/ROD/R10-96/134, as amended) include *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Unit's Interim Action*, Rev. 0 (DOE/RL-96-84) and Rev. 0A. The work plan includes the design and operational requirements for the original 100-HR-3 P&T system.

Associated with each P&T system are additional supporting documents that address such topics as operations, performance monitoring, and sampling requirements.

The interim action ROD for the 100-HR-3 and 100-KR-4 OUs (EPA/ROD/R10-96/134), as modified, define the hexavalent chromium cleanup goal in groundwater discharging to the Columbia River as the current ambient water quality criterion of 10 µg/L. The interim action ROD (EPA/ROD/R10-96/134) hexavalent chromium concentration was identified to achieve the surface water quality standard at the river using the preliminary dilution factor of 1:1. The interim-action ROD identified a RAG of 22 µg/L for hexavalent chromium. The RAG was revised to 20 µg/L in the interim-action ROD amendment (EPA/AMD/R10-00/122) because the chronic ambient water quality standard for hexavalent chromium was revised from 11 to 10 µg/L in November 1997. The 2009 ESD (EPA 2009) stipulated that injection wells not located upgradient of the extraction wells reduce the effluent chromium concentrations to the maximum extent practicable and not exceed 20 µg/L. The current RAG is 10 µg/L for hexavalent chromium in surface water WAC 173-201A, "Water Quality Standards for Surface Waters in the State of Washington") at the point of groundwater discharge. The groundwater remediation is implemented to ensure that this requirement is met. The DWS for total chromium in drinking water remains at 100 µg/L. Ecology has established a Method B groundwater cleanup level of 48 µg/L for hexavalent chromium under WAC 173-340, "Model Toxics Control Act – Cleanup."

To mitigate risks associated with hexavalent chromium contamination in groundwater discharging to the river, multiple CERCLA interim action ion exchange P&T systems have been installed in the 100-HR-3 OU since 1997. The original P&T system (HR-3) operated from 1997 to 2011 and the DR-5 P&T system operated from 2007 to 2011. Two replacement P&T systems, DX and HX, were installed and have been operating since 2010 and 2011, respectively. In 2012, several areas along the river were identified in *Calendar Year 2012 Annual Summary Report for the 100-HR-3 and 100-KR-4*

Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation (DOE/RL-2013-13) as having the potential to be affected by hexavalent chromium. As a result, refinement of the P&T systems was targeted and, in 2013, initiated in those areas. In the 100-D area, additional wells were drilled to increase capture and mass removal of the northern plume; these wells were connected to the P&T system in 2015. Wells also were installed in 100-D south to improve contaminant mass recovery near the 100-D-100 waste site. Realignment in 100-D also included connecting existing wells along the ISRM barrier as extraction wells.

In 2000, an in situ chemical treatment technology was added to the existing P&T remedy in the form of an ISRM to reduce hexavalent chromium to trivalent chromium. Use of this new technology was approved by the 1999 interim ROD amendment (EPA/AMD/R10-00/122). Contaminant breakthrough at the ISRM barrier triggered issuance of a notice of nonsignificant change to the ROD in 2010, which indicated that the barrier would no longer be actively maintained (11-AMCP-0002). The notice of nonsignificant change shifted the groundwater remedy at the ISRM barrier to the P&T system. However, groundwater at the ISRM site is still monitored for hexavalent chromium as part of CERCLA interim action monitoring.

Other interim remedy activities performed during this 5-year review period included groundwater monitoring to track plumes, plume areas, and concentration trends; operation and optimization of interim remediation P&T systems for hexavalent chromium (including adding new wells and realigning existing wells); and finalizing the RI/FS document. ICs to prevent human exposure to contaminated groundwater also were managed throughout the review period.

Table 2-13 presents an overview of primary components of the remedy and implementation status for the 100-HR-3 interim action ROD.

Table 2-13. Overview of 100-HR-3 Groundwater Operable Unit Interim Action Remedy Implementation.

Document Type	**Date**	**Title**
Interim Action ROD, as amended	03/1996, 08/1999	EPA/ROD/R10-96/134, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Hanford Site, Benton County, Washington*
RDR/RAWP	08/2003	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
RAO (abbreviated description)	**1.** Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River **2.** Protect human health by preventing exposure to contaminants in the groundwater **3.** Provide information that will lead to the final remedy	
COCs	Hexavalent chromium, strontium-90, technetium-99, tritium, uranium, fluoride, and nitrate	

Remedy Component (primary)	**Construction Status** (approximate percentage complete for constructing/implementing the remedy component as of December 2015)[a]						**Duration of O&M** (~years)[b]	**Finish**[c] (Est'd year)
	0	**1-25**	**26-50**	**51-75**	**76-99**	**100%**		
P&T with ion exchange resins							TBD	TBD
Reinjection/Flow path control							TBD	TBD
Institutional controls							TBD	TBD

Table 2-13. Overview of 100-HR-3 Groundwater Operable Unit Interim Action Remedy Implementation.

Compliance monitoring for river protection/reinjection							TBD	TBD

[a]Percentages reflect construction status of the remedy component; post-startup remedial process optimization is considered part of O&M. 100% = fully implemented and now in O&M mode.
[b]O&M and duration and completion timeframes are TBD as the interim ROD indicates that the remedy will continue until a final ROD is issued. A final ROD will not be issued until after this 5-year review period (i.e., post-2015).
[c]Estimated year when remedy component will be completed.

COC = contaminant of concern.
O&M = operation and maintenance.
P&T = pump and treat.
RAO = remedial action objectives.
RDR/RAWP = remedial design report/remedial action work plan.
ROD = record of decision.
TBD = to be determined.

2.3.3.3.5 Technical Assessment

Is the remedy functioning as intended by the decision documents?

Yes, the interim remedy identified in the interim action ROD (EPA 2008a) involving extraction and treatment of hexavalent chromium-contaminated groundwater from the 100-HR-3 area, reinjection of treated water, and ICs is functioning as intended.

Operation of the DX and HX P&T systems is demonstrating progress toward interim RAOs 1 and 3 as defined by the interim ROD (see Table 2-14). From 1997 through 2015, P&T systems (HR-3, DR-5, DX and HX), collectively, have removed 2,350 kg of hexavalent chromium. Table 2-14 summarizes the 100-HR-3 groundwater OU contaminants removed by the P&T systems during this 5-year review period and cumulatively since system startup. Concentrations and distribution of strontium-90 have shown consistent, gradual declines in both the 100-D and 100-H areas. In 2015, for the first time, strontium-90 was not detected above the drinking water standard in any aquifer tube in the 100-HR-3 OU.

Table 2-14. Contaminant Mass Removed from 100-HR-3 Groundwater Extraction Systems.

System (Startup)	Constituent	Mass Removed (kg)					
		2011	2012	2013	2014	2015	Since Startup
DX (Dec 2010)	Hexavalent chromium	443	469	294	179	85	1,488
HX (Sept 2011)	Hexavalent chromium	11	32	27	23	25	118

Source: Annual P&T reports: DOE/RL-2013-13, *Calendar Year 2012 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 199-NR-2 Groundwater Remediation*; DOE/RL-2014-25, *Calendar Year 2013 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 199-NR-2 Groundwater Remediation*; DOE/RL-2015-05, *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations, and 100-NR-2 Groundwater Remediation*; and DOE/RL-2016-19, *Calendar Year 2015 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*.

Groundwater waste extraction, reinjection, monitoring, and optimization are conducted through a series of wells, as shown for 2015 in Figures 2-11 and 2-12 for the DX and HX systems, respectively. Specific details on the performance and optimization of each P&T system in the River Corridor are updated and published each year in the *Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations and 100-NR-2 Groundwater Remediation*, which is available at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports. Recommendations for future optimization are described in *FY2017 Plume Containment and Remediation Utilization Plan* (SGW-59936).

Hexavalent chromium is the primary contaminant in 100-HR-3 groundwater; however, smaller plumes of strontium-90 and nitrate also are present. Cleanup decisions for these other contaminants will be defined in an upcoming ROD. While the length of shoreline that the hexavalent chromium plume area above 10 µg/L is interpreted to intersect has increased from 190 m in 2011 to 990 m in 2015, the collective

plume area above 10 µg/L is interpreted to have decreased nearly 40 percent since 2011, and the plume area above 48 µg/L decreased by over 60 percent since 2011. The maximum concentration of hexavalent chromium sampled in 2011 was 3,340 µg/L, and 614 µg/L in 2015.

Table 2-15 provides an overview of 100-HR-3 contaminant plume areas and associated changes to the areas during this 5-year review period. The plume maps in Figure 2-13 show the changes in plume shapes and areas during this 5-year review period. The Figure 2-14 trend plots depict the estimated annual changes in contaminant plume areas over the past several 5-year periods.

Table 2-15. Overview of 100-HR-3 Groundwater Contaminant Plumes. [a]

100-HR-3 Groundwater Plume Summary								
Groundwater Contaminant	**Water Quality Standard[b]**	**Maximum Concentration (2015)**	**Plume Area[c] (km^2)**			**Shoreline Intersection (m)[d]**		
			2011	**2015**	**Change**	**2011**	**2015**	**Change**
Hexavalent Chromium	10 µg/L[e]	614 µg/L	7.73	4.8	-2.93	190	990	800
Hexavalent Chromium	48 µg/L	614 µg/L	1.78	0.66	-1.12	0	0	0
Nitrate	45 mg/L[f]	45.2 mg/L	1.44	0	-1.44	0	0	0
Strontium-90	8 pCi/L	32.7 pCi/L	0.12	0.02	-0.10	190	0	-190
Tritium[g]	20,000 pCi/L	14,400 pCi/L	0	NC	N/A	0	N/A	N/A

[a]Source: Hanford Annual Groundwater Monitoring Reports for 2011 and 2015 http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.
[b]Drinking water standard for all but hexavalent chromium
[c]Estimated area at a concentration greater than the listed cleanup level.
[d]Length of Columbia River shoreline intersected by contaminant plumes.
[e]The applicable standard is the 10 µg/L surface water quality criterion per *Washington Administrative Code* [WAC] 173-201A, "Water Quality Standards for Surface Waters in the State of Washington."
[f]45 mg/L as NO_3 is equivalent to the drinking water standard of 10 mg/L as N.
[g]Tritium was not detected in 2015 above the DWS of 20,000 pCi/L. No Plume area was calculated.
N/A = not applicable. NC = not calculated.

For more detailed information on the 100-HR-3 groundwater OU well locations, distribution of contaminant concentrations within each plume, and historic trends associated with each 100-HR-3 COC plume area, as well as for performance metrics associated with 100-HR-3 OU groundwater treatment, visit the following links:

- *Hanford Site Groundwater Monitoring Report* (published each summer for the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- *Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations and 100-NR-2 Groundwater Remediation* (published for each prior calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- ICs for the 100-HR-3 groundwater OU, as required by the interim action ROD (EPA/ROD/R10-96/134), as amended, are described in *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Unit's Interim Action*, Rev. 0 (DOE/RL-96-84) and Rev. 0-A, and are actively managed in support of RAO 2. Specific details associated with each IC also have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 100-HR-3 OU are required to prevent human exposure to contaminated groundwater and include warning notices, entry restrictions, land-use management (land use), groundwater-use management (excavation permits), and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site

Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 100-HR-3 groundwater OU.

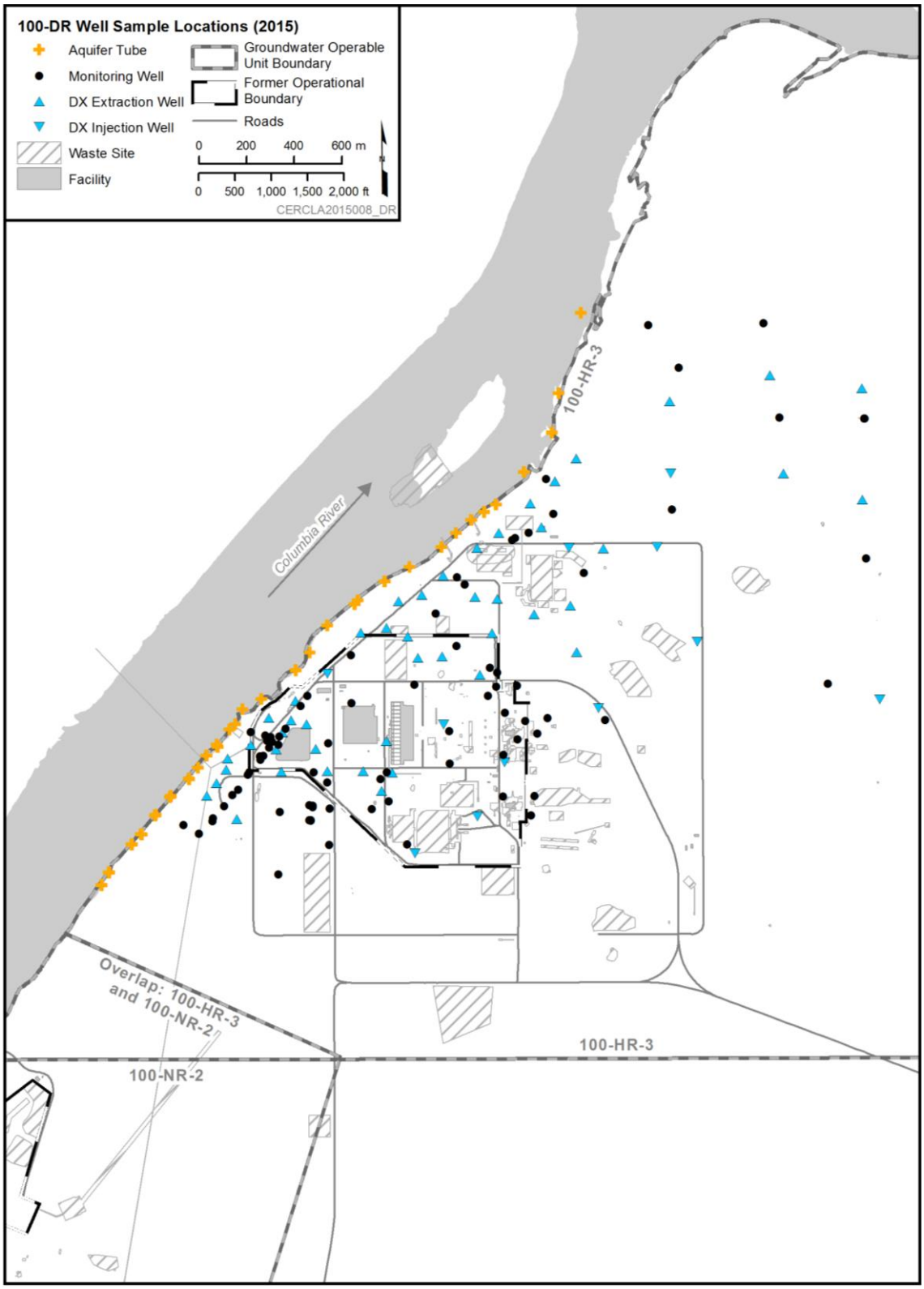


Figure 2-11. Locations 100-DR Wells and Aquifer Tubes Sampled in 2015.

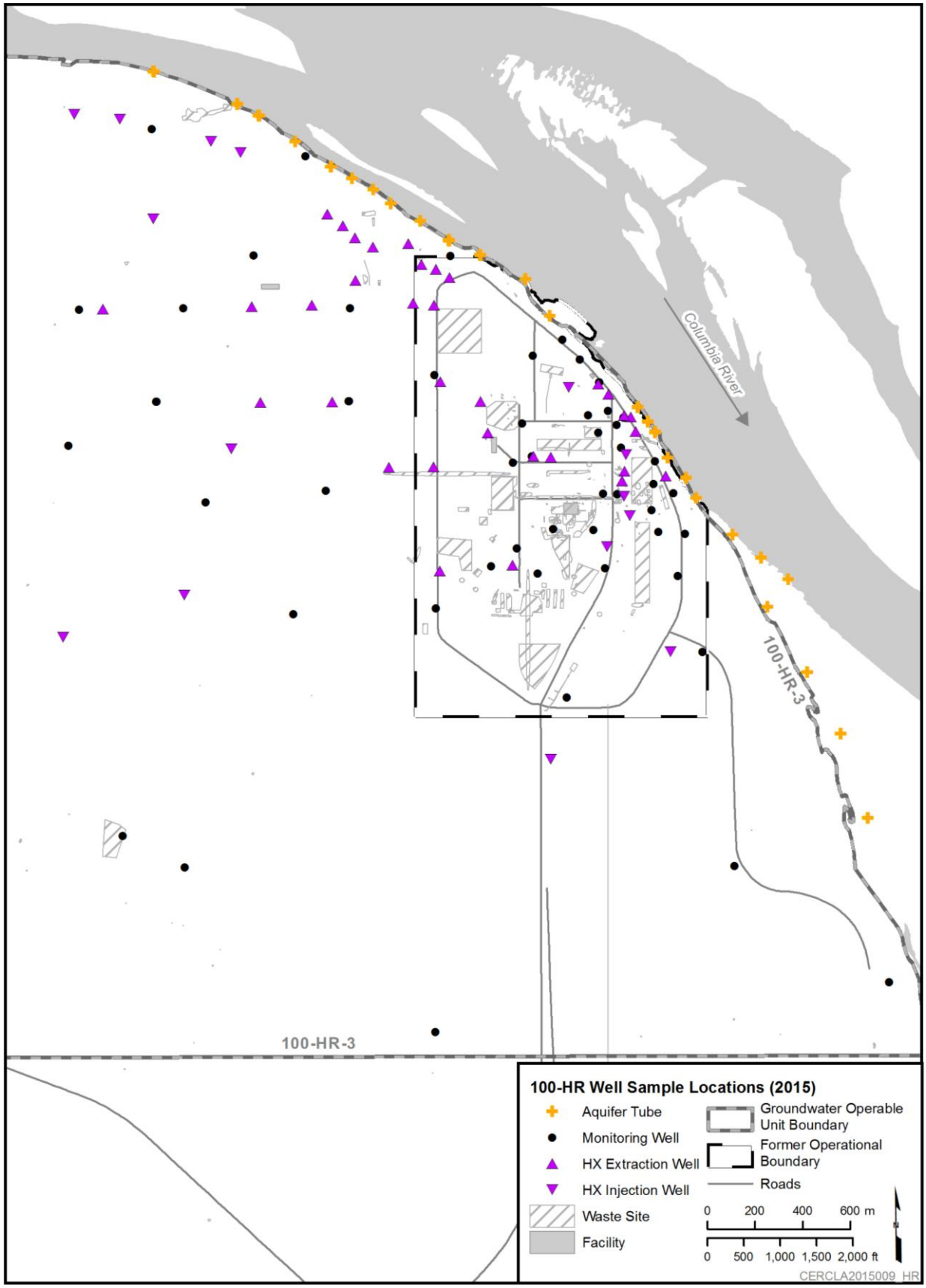


Figure 2-12. Locations of 100-HR Wells and Aquifer Tubes Sampled in 2015.

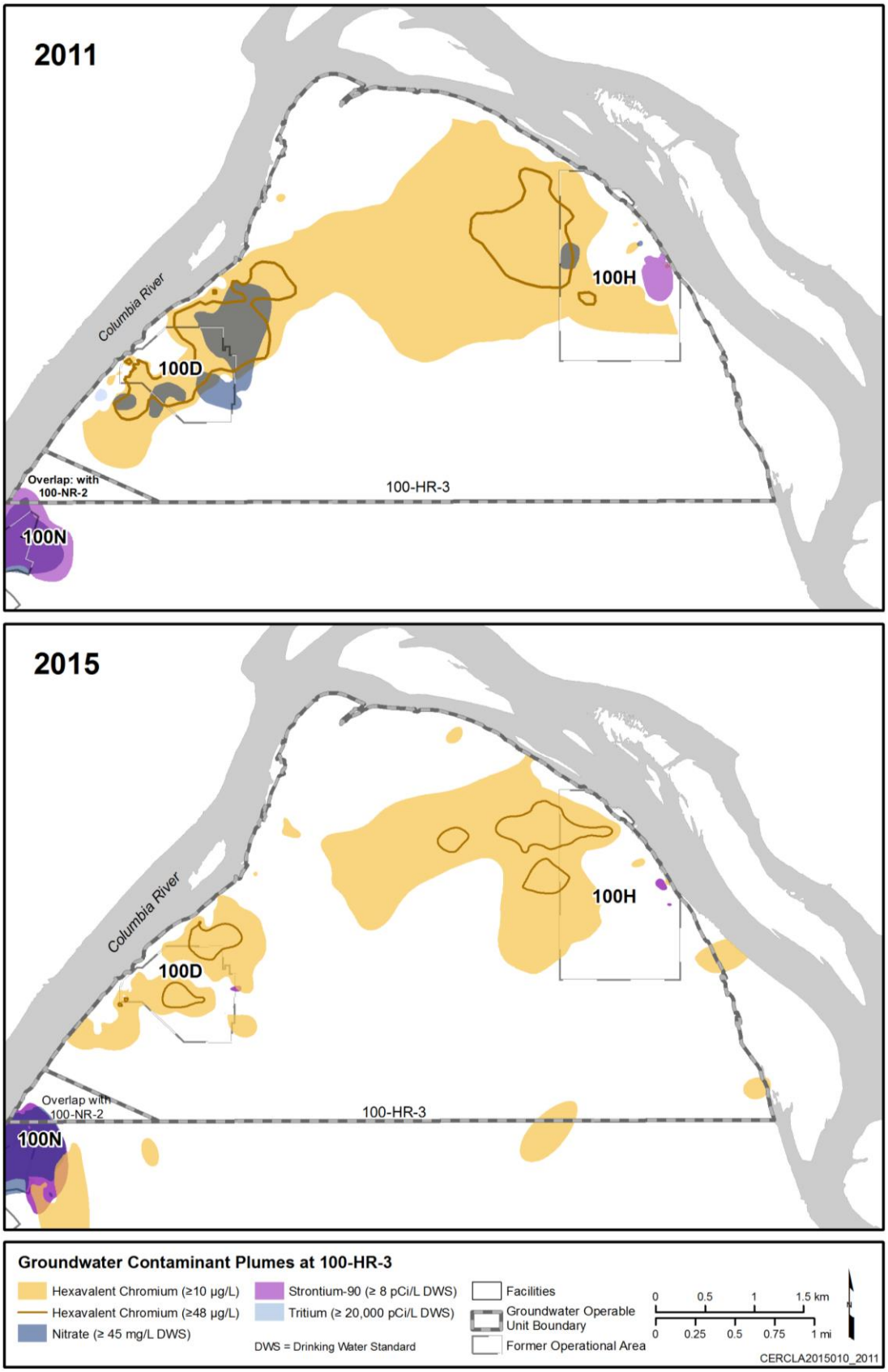


Figure 2-13. 100-HR-3 Groundwater Operable Unit Plumes in 2011 (top) and 2015 (bottom).

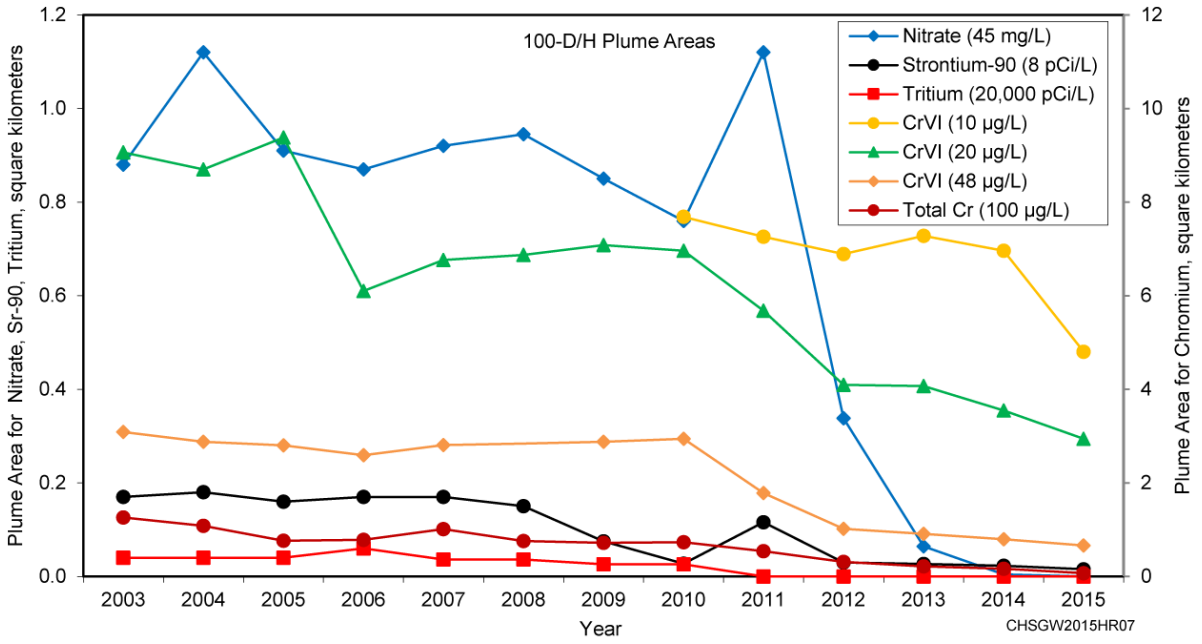


Figure 2-14. 100-HR-3 Trend Plots of Contaminant Plume Areas (2003 – 2015).

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

As explained earlier and captured in the ESD (EPA 2009), hexavalent chromium cleanup levels established for protection of aquatic life were modified from 11 to 10 µg/L in 1997 (WAC 173-201A). Otherwise, exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of original remedy selection are still valid. These criteria will be reviewed and updated as needed to support final remedy selection.

Has any other information come to light that could call into question the protectiveness of the remedy?

No information has come to light that would call into question the protectiveness of the interim remedy.

2.3.3.3.6 Issues/Corrective Actions

While the 100-HR-3 P&T systems have removed substantial amounts of hexavalent chromium from the groundwater (over 1,600 kg since startup), at several areas along the 100-HR-3 shoreline, the RAO for protection of aquatic receptors is not fully attained and additional system realignments are needed. Localized areas where contaminants still reach the river include a small area downgradient of the 100-D northern plume, south of the ISRM barrier, a small area along the northern portion of the Horn, and in the 100-H Reactor area.

Issue HR3-1. Hexavalent chromium exceeds the aquatic water quality standard at several small areas along the Columbia River shoreline.

Corrective Action HR3-1. Install additional wells and/or convert existing wells to remove contaminant mass and impose hydraulic containment necessary to protect aquatic receptors in the Columbia River. (Action Due Date: September 30, 2020).

Does this issue/action currently affect the protectiveness of the remedy? – NO

Will this issue/action affect the protectiveness of the remedy in the future? – YES

2.3.3.3.7 Protectiveness Statement

100-HR-3 Groundwater OU – Will Be Protective. The remedy at the 100-HR-3 groundwater OU is expected to be protective of human health and the environment upon completion of the final remedy.

Implementation of the interim remedy at 100-HR-3 (primarily involving groundwater P&T system operations focused on hexavalent chromium contamination, flow-path control, and ICs) has demonstrated that exposure pathways that could result in unacceptable risks are being controlled. DOE anticipates issuance of a final ROD for the 100-D and 100-H Areas during the next (2016 – 2020) 5-year review period.

2.3.4 100-K Area Operable Units

The 100-K area is located in the north-northwest region of the Hanford Site, adjacent to the Columbia River. The 100-K area contains the 100-KR-1 and 100-KR-2 source OUs, and the 100-KR-4 groundwater OU. Figure 2-15 shows all three 100-K area OUs.

To effectively address waste site remediation efforts, the 100-K Area was divided into two source OUs: the 100-KR-1 OU principally contains soil sites contaminated by liquid discharges; the 100-KR-2 OU principally contains soil, structures, and landfills.

2.3.4.1 100-KR-1 Source Operable Unit

2.3.4.1.1 Background

Past operations associated with the two plutonium production reactors (105-KE and 105-KW) in the 100-K area contributed to soil and groundwater contamination at the Hanford Site. The 105-KE Reactor operated from 1955 to 1971 and the 105-KW Reactor operated from 1955 to 1970. Cleanup decisions for this region were initiated in the 1990s.

This section focuses on the 100-KR-1 source OU which contains soil sites contaminated by liquid discharges.

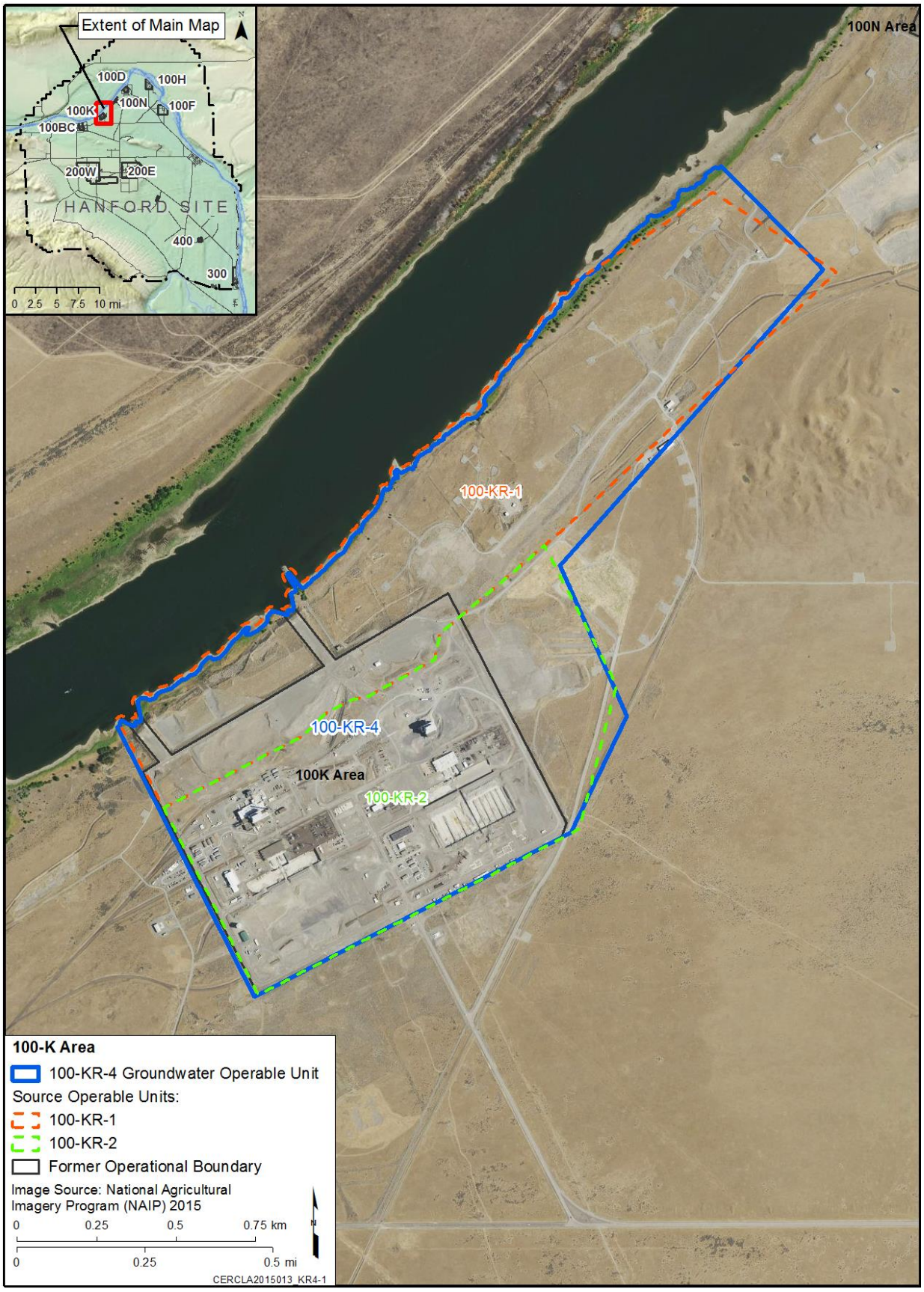


Figure 2-15. Location of 100-K Area Operable Units.

2.3.4.1.2 Chronology

Table 2-16 lists the remedial action decision documents relevant to the 100-KR-1 source OU.

Table 2-16. Decision Documents for the 100-KR-1 Source Operable Unit.

Date	Location	Title
4/1997	EPA/AMD/R10-97/044	***Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This amendment to the 1995 interim action ROD (EPA/ROD/R10-95/126) incorporates 34 additional waste sites (including 100-KR-1 and 100-KR-2 sites); refines the remedial cost estimate for the original 37 sites and additional 34 sites based on actual data, streamlining, and lessons learned; and eliminates the soil washing treatment option before disposal. [Note: The 1995 interim action ROD did not originally include 100-K Area waste sites. The 1995 ROD requires removal of contaminated soil, structures, and debris using the observational approach treatment by thermal desorption to remove organics and/or soil washing for volume reduction or as needed to meet waste disposal criteria, disposal of materials at ERDF, backfill of excavated areas followed by revegetation.]
7/1999	EPA/ROD/R10-99/039	***Interim Action Record of Decision for the 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 Operable Units Remaining Sites.*** This interim action ROD requires RTD for 46 sites; adds a plug-in approach for the RTD remedy of both remaining 100 and 200 North Area sites and newly identified 100 Area sites added by ESD; and disposal of debris from B, D, H, and K Reactors to ERDF. It also provides a decision framework for leaving waste in place, generally below 15-ft depth.
2/2004	EPA 2004	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** The ESD adds 28 sites to the ROD; adds 10 CFR 1022 and 40 CFR 6, Appendix A, as ARARs to the ROD; and revises the annual ICs report date to coincide with the due date for the Sitewide ICs plan for Hanford CERCLA response actions.
8/2009	EPA et al. 2009	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** This ESD authorizes adding 200-CW-3 OU wastes sites, 99 newly discovered waste sites, and 87 candidate sites using the plug-in approach in the ROD and any newly discovered waste sites documented in the Administrative Record and an annual fact sheet.
3/2011	DOE et al. 2011	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2010 Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
ESD = explanation of significant difference. ROD = record of decision.
OU = operable unit. RTD = removal, treatment, or disposal.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.4.1.3 Remedial Action

Goals and Objectives. The RAOs set forth in the interim action RODs listed in Table 2-16 are narrative statements that define the extent to which the waste sites require cleanup to protect human health and the environment. The following RAOs identified in these interim action RODs apply to contaminants in soils, structures, and debris.

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics*** (EPA/ROD/R10-95/126, page 25, and EPA/ROD/R10-99/039, page 26).
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions*** (EPA/ROD/R10-95/126, page 25; and EPA/ROD/R10-99/039, page 26).
- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure.*** *Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.* (EPA/ROD/R10-95/126, page 26).

Remedy Components. The 1995 ROD (EPA/ROD/R10-95/126), as amended, and the 1999 ROD (EPA/ROD/R10-99/039), as amended, share the same basic interim action remedy components for the 100-KR-1 source OU waste sites. These components generally include the following steps:

- Remove contaminated soil, structures, and debris from 100 Area source waste sites using the observational approach, which uses field data and analytical screening during remediation to guide the extent of excavation. Remediation proceeds until it can be demonstrated through a combination of field screening and verification sampling that cleanup goals have been achieved.
- Treat the waste as required to meet applicable waste disposal criteria
- Dispose of contaminated materials at ERDF
- Backfill excavated areas and revegetate
- Implement ICs if unrestricted future use and exposure is not practicable.

Detailed descriptions of the remedy components are provided in the "Selected Remedy" section of each ROD, as amended.

Remedy Implementation Progress Prior to this Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work on the interim remedy began after issuance of the ROD amendment in 1997, with the first cleanup verification package approved in 2004. Before 2011, interim remedial actions had been completed at 4 of approximately 22 waste sites in the 100-KR-1 source OU.

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for 100-KR-1 OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006 – 2010) 5-year review report for the 100-HR-1 and 100-HR-2 source OUs was as follows:

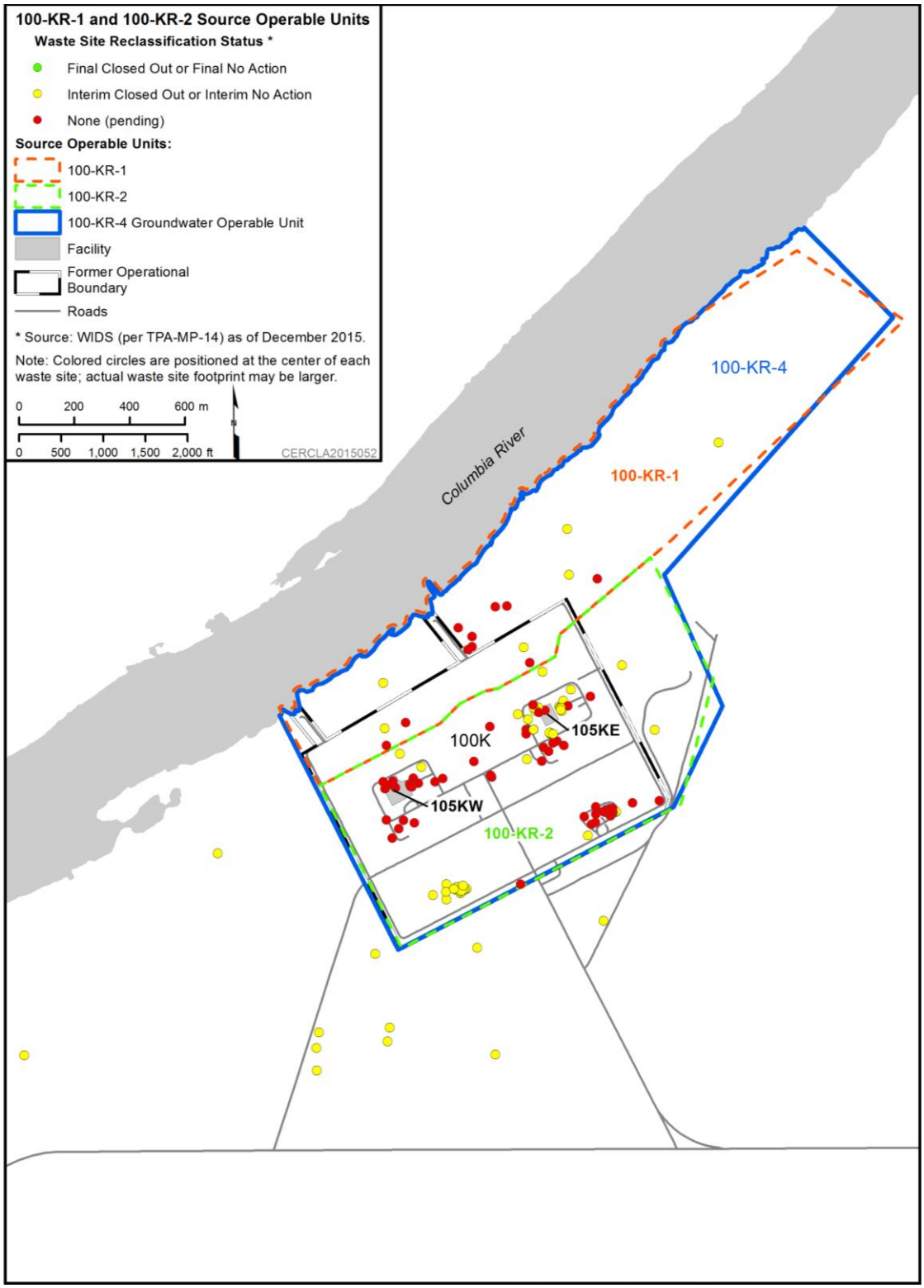
> *The final remedy at 100-KR-1 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.*

2.3.4.1.4 Progress Since 2011 Review

Accomplishments. Since the 2011 5-year review, interim remedial actions were completed at nine waste sites and documented in waste site cleanup verification packages or remaining sites verification packages. The following waste sites were actively remediated during this 5-year review period:

- 100-KR-1 Operable Unit
  - 100-K-63, Unplanned Release
  - 100-K-78, Fenced Contamination Area
  - 100-K-86, Unplanned Release
  - 100-K-87, Unplanned Release
  - 100-K-88, Unplanned Release
  - 100-K-90, White Granular Material
  - 100-K-91, Unplanned Release
  - 110-K-92, Unplanned Release
  - 100-K-95, Unplanned Release

Figure 2-16 shows the relative distribution (noted by geographic centers of waste site footprints) and reclassification/closure status (per WIDS) as of December 2015 for the waste sites in the 100-KR-1 and 100-KR-2 OUs. Table 2-17 summarizes the waste site cleanup status for the 100-KR-1 and 100-KR-2 waste sites, including metrics on work accomplished during this past 5-year period (2011 – 2015).



Note: Colored circles are positioned in the center of a given waste site's overall footprint.

Figure 2-16. Geographic Distribution and WIDS Reclassification Status of the 100-KR-1 and 100-KR-2 Source Operable Unit Waste Sites as of December 2015.

Table 2-17. 100-KR-1 and 100-KR-2 Source Operable Units Cleanup Status.

Source OU	Number of Waste Sites[a]	Sites Dispositioned[b]			
		Pre-2011	2011 – 2015	Total	Percent Complete
100-KR-1	22	4	9	13	59
100-KR-2	107	15	34	49	45
Total	**129**	**18**	**43**	**62**	**48%**

[a]Number of waste sites within the OU, according to the Tri-Party Agreement[c], Appendix C, as of December 2015.
[b]Sites with an interim closed out, final closed out, interim no action or final no action reclassification status reflected in the WIDS as of December 2015. Additional sites may have been dispositioned but not been assigned to the Operable Unit in Appendix C of the Tri-Party Agreement as of December 2015.
[c] Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

DOE = U.S. Department of Energy. Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order*.
OU = operable unit.

DOE submitted *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft A (DOE/RL-2010-97), and *Proposed Plan for Remediation of 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft A (DOE/RL-2011-82), to EPA in 2011. EPA reviewed the documents in 2012. Additional characterization needs were identified (i.e., a subsurface soil contamination assessment in the vicinity of the 105-KE fuel storage basin); the results of supplemental source characterization activities will be incorporated into the RI/FS on completion. The RI/FS report presents results of RI studies and evaluates alternatives for cleaning up the vadose zone and groundwater.

Remedy Implementation. The primary remedial activities in the 100-KR-1 OU involved completing the interim remedial action at the nine sites listed in the previous section. This work was conducted under the 100 Area RDR/RAWP (DOE/RL-96-17), as amended.

ICs, as required by the interim action RODs (as amended) have been implemented and maintained during this 5-year review period to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure.

2.3.4.1.5 Technical Assessments

Is the remedy functioning as intended by the decision documents?

The interim remedy (primarily involving RTD, backfilling, revegetation, and ICs) is functioning as intended by the interim action ROD (as amended). As of December 2015, 13 of the 22 100-KR-1 OU waste sites had been remediated.

In accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS)*, the 100-KR-1 remediated waste sites have been documented in WIDS as either interim closed or interim no-action. Cleanup verification packages (including sampling data and other technical information) to support the reclassification to interim closed and/or no-action are included in the Hanford Site Administrative Record for the 100-KR-1 source OU. The RAGs are described in Chapter 2 of the 100 Area RDR/RAWP (DOE/RL-96-17, Rev. 6). Additionally, in accordance with EPA guidance in *Close Out Procedures for National Priorities List Sites* (EPA 540-R-98-016), remedial actions completed for a number of the 100-KR-1 and 100-KR-2 OU wastes sites are documented in are documented in *100-K Area Interim Remedial Action Report* (DOE/RL-2014-15).

The RAOs for the 100-KR-1 remediated waste sites, and the methods used for achieving the RAOs through the interim remedial actions are summarized in the following list:

- ***RAO 1. Protect human and ecological receptors from exposure to* contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.**
  - Achieved through excavation to WAC 173-340, "Model Toxics Control Act – Cleanup," levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) use.
  - Achieved human health total radiological dose standards of less than 15 mrem/yr above background for radionuclides.
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.***
  - Achieved through protection such that contaminant levels in soil after remediation do not result in an adverse impact to groundwater that exceeded any nonzero maximum contaminant level goals under the *Safe Drinking Water Act of 1974* or Method B cleanup levels under WAC 173-340, "Model Toxics Control Act – Cleanup."
  - Levels of contaminants in the soil after remediation do not result in an impact to groundwater and the Columbia River that could exceed the ambient water quality criteria under the Clean Water Act of 1977 for protection of fish or Method B cleanup levels under the WAC 173-340-730, " Surface water cleanup standards." Because no ambient water quality criteria have been established for radionuclides, maximum contaminant levels from national primary drinking water standards were used.
  - The protection of receptors (aquatic species, with emphasis on salmon) in surface waters was achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River are not subject to any additional adverse risks.
- ***RAO* 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.**

  Achieved by removing waste sites to the bottom of the engineered structure and providing ICs, as required. ICs (via use of excavation permits) prevent uncontrolled drilling or excavation into the deep vadose zone (i.e., greater than 15 ft [4.6 m] below the surface).

ICs for the 100-KR-1 source OU, as required by the interim action RODs (as amended), are further described in the latest version of *Remedial Design Report, Remedial Action Work Plan for the 100 Area* (DOE/RL-96-17) and are actively managed. Specific details associated with each IC have also been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs for the 100-KR-1 source OU include waste-site-specific ICs (e.g., drilling and excavation restrictions for waste sites where residual contamination remains at depth) and general-areas ICs including access control (warning notices and entry restrictions), land-use management (land use, and excavation permits), and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, one deficiency was noted for the 100-KR-1 source OU; warning notice signs along the river shoreline were noted as missing during the 2011 annual IC inspection and subsequently replaced.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid for most waste sites. These criteria will be reviewed and updated as needed to support final remedy selection. However, cleanup levels for some contaminants (e.g., hexavalent chromium) that were developed for shallow soil remediation may not be adequately applicable for deep vadose and periodically rewetted-zone contamination conditions.

Has any other information come to light that could call into question the protectiveness of the remedy?

The presence of full-thickness vadose zone contamination challenges the implementability of the RTD remedy, but not the protectiveness (if indeed RTD is implemented over the full contaminated thickness). In the 100-KR-1 and KR-2 source OUs, the interim remedial actions involving RTD remedies have thus far been limited to partial-thickness of the contaminated vadose zone at a few deeply contaminated sites.

2.3.4.1.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 100-KR-1 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.3.4.1.7 Protectiveness Statement

100-KR-1 Source OU – Will Be Protective. The remedy at the 100-KR-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, and revegetation, and ICs) at the 100-KR-1 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

2.3.4.2 100-KR-2 Source Operable Unit

2.3.4.2.1 Background

Past operations associated with the105-KE and 105-KW Reactors in the 100-K area contributed to soil and groundwater contamination at the Hanford Site. The 105-KE Reactor operated from 1955 to 1971 and the 105-KW Reactor operated from 1955 to 1970. Cleanup decisions for this region were initiated in the 1990s.

This section focuses on the 100-KR-2 source OU, and is followed by the 100-KR-4 groundwater OU.

Hanford's K Basins Closure Project has been focused on removing the spent fuel that has been stored in the fuel storage basins in the 100-K area for over 20 years. The project includes removing all the fuel, the baskets, the racks in which the fuel was stored, the sludge accumulated in the basins, and the water in the basins; it culminates with demolition and disposal of the basin structures; the 105-KE fuel storage basin has been demolished. The other work in the 100-K area involves the demolition and disposal of the ancillary buildings, placing the reactors in ISS, remediating soil waste sites, and remediating the groundwater (performed under the 100-KR-4 OU).

2.3.4.2.2 Chronology

Table 2-18 lists the remedial action decision documents relevant to the 100-KR-2 source OU.

Table 2-18. Decision Documents for the 100-KR-2 Source Operable Unit.

Date	Location	Title
4/1997	EPA/AMD/R10-97/044	***Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units.*** This amendment to the 1995 interim action ROD (EPA/ROD/R10-95/126) incorporates 34 additional waste sites including the 100-KR-1 and 100-KR-2 sites; refines the remedial cost estimate for all 71 sites based on actual data; streamlining, and lessons learned; and eliminates the soil washing option treatment prior to disposal. [Note: The 1995 interim action ROD did not originally include 100-K Area waste sites. The 1995 ROD requires removal of contaminated soil, structures, and debris using the observational approach treatment by thermal desorption to remove organics and/or soil washing for volume reduction or as needed to meet waste disposal criteria, disposal of materials at ERDF, backfill of excavated areas followed by revegetation.]
7/1999	EPA/ROD/R10-99/039	***Interim Action Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 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 Operable Units Remaining Sites.*** This interim action ROD requires RTD for 46 sites; adds the plug-in approach for the RTD remedy of both remaining 100 Area and 200 North sites and for newly identified 100 Area sites added by ESD; and disposal of debris from the B, D, H, and K Reactors to ERDF. It also provides a decision framework for leaving waste in place, generally below the 15-ft depth.
9/1999	EPA/ROD/R10-99/059	***Declaration of the Record of Decision for the 100-KR-2 Operable Unit, Hanford Site, Benton County, Washington.*** This interim action ROD requires removing spent nuclear fuel from basins, removing sludge from basins, treating and removing water from the basins, removing debris from the basins, deactivating the basins, and instituting ICs.
9/2000	EPA/ROD/R10-00/121	***Interim Action Record of Decision: 100-BC-I, 100-BC-2, 100-DR-I, 100-DR-2, 100-FR-2, 100-HR·2, 100-KR-2 Operable Units (100 Area Burial Grounds).*** This interim action ROD requires removing contaminated soil, structures, and debris; treatment as needed; disposing of waste at ERDF; backfilling; and revegetation. It applies to 45 burial grounds in the 100 Area.
2/2004	EPA et al. 2004	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** This ESD adds 28 sites to the ROD; adds 10 CFR 1022 and 40 CFR 6, Appendix A, as ARARs to the ROD; and revises the annual ICs report date to coincide with the due date for the Sitewide ICs plan for Hanford CERCLA response actions.
6/2005	EPA 2005a	***Interim Remedial Action Record of Decision Amendment, U.S. Department of Energy; 100 K Area K Basins, Hanford Site – 100 Area, Benton County, Washington.*** The amendment to the interim action ROD (EPA/ROD/R10-99/059) modifies the remedy for sludge by including sludge treatment prior to interim storage and shipment to a national repository and modifies the remedy for debris by including grouting in place for some of the basin debris, followed by removal along with the basin removal.
11/2007	08-AMRC-0033	***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).*** This ESD established the limit of RTD excavation at the 118-B-1 burial ground considering the balancing factors in the ROD and required additional ICs to protect groundwater and the Columbia River.
8/2009	EPA et al. 2009	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision.*** This ESD authorizes adding 200-CW-3 OU wastes sites, 99 newly discovered waste sites, and 87 candidate sites using the plug-in approach in the ROD and any newly discovered waste sites documented in the Administrative Record and an annual fact sheet.

Table 2-18. Decision Documents for the 100-KR-2 Source Operable Unit.

Date	Location	Title
2/2012	DOE et al. 2012	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2011, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites.*** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.
CFR = *Code of Federal Regulations*.
ERDF = Environmental Restoration Disposal Facility.
ESD = explanation of significant difference.
IC = institutional control.
OU = operable unit.
ROD = record of decision.
RTD = remove, treat, if necessary, and dispose of.
TBD = to be determined.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.4.2.3 Remedial Action

Goals and Objectives. Two sets of RAOs apply to the 100-KR-2 OU; one set applies to the 100-K Basins and the other applies to other waste sites. The RAOs set forth in the interim action RODs for waste sites, as listed, generally apply to 100-KR-2 contaminants in soils, structures, and debris. RAOs 1 and 2 are common to all three interim action RODs. RAOs 3 and 4 are not stated in all RODs, as amended, but are associated with future land use.

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics*** (EPA/ROD/R10-95/126, page 25; EPA/ROD/R10-99/039, page 26; and EPA/ROD/R10-00/121, page 19).
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions*** (EPA/ROD/R10-95/126, page 25; EPA/ROD/R10-99/039, page 26 :and EPA/ROD/R10-00/121, page 22).
- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure.*** *Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.* (EPA/ROD/R10-95/126, page 26)
- ***RAO 4. Provide conditions suitable for future land use of the 100 Area*** (EPA/ROD/R10-00/121, page 22).

The set of RAOs unique to the K Basins, in accordance with the September 1999 interim action ROD for the 100-KR-2 source OU, EPA/ROD/R10-99/059, as amended, includes the following.

- ***RAO 1. Reduce the potential for future releases of hazardous substances from the K Basins to the environment.***
  - *Remove hazardous substances from the K Basins near the Columbia River in a safe and timely manner.*
  - *Provide for safe treatment, storage, and final disposal of the spent nuclear fuel, sludge, water, and debris removed from the K Basins.*
  - *Prevent further deterioration of the spent nuclear fuel*
- ***RAO 2. Reduce occupational radiation exposure to workers at the basins.***
- ***RAO 3. Address the sludge management concerns.***
- ***RAO 4. Develop the most cost effective site-wide approach, consistent with the CERCLA nine criteria, for treatment, storage, and disposal of sludge.***

- ***RAO 5. Treat, store, and/or dispose of sludge soon after removal.***

Remedy Components. The 1995 ROD (EPA/ROD/R10-95/126), as amended, the 1999 ROD (EPA/ROD/R10-99/039) as amended, and the 2000 ROD (EPA/ROD/R10-00/121) as amended, share the same basic interim action remedy components for the 100-KR-2 OU waste sites. These components generally include the following steps:

- Remove contaminated soil, structures, and debris from 100 Area source waste sites using the observational approach, which uses field data and analytical screening during remediation to guide the extent of excavation. Remediation proceeds until it can be demonstrated through a combination of field screening and verification sampling that cleanup goals have been achieved.
- Treat the waste, as required, to meet applicable waste disposal criteria
- Dispose of contaminated materials at ERDF
- Backfill excavated areas and revegetate
- Implement ICs if unrestricted future use and exposure is not practicable.

Detailed descriptions of the remedy components are provided in the "Selected Remedy" section of each ROD, as amended.

Major components of the remedy for the two 100-K area spent nuclear fuel (SNF) storage basins, 100-K-42 (K-east basin) and 100-K-43 (K-west basin), are specified in the September 1999 interim remedial action ROD, EPA/ROD/R10-99/059, as amended, include the following:

- Remove the SNF from the K basins
- Remove sludge from the K basins
- Treat and remove water from the K basins
- Remove debris from the K basins
- Deactivate the basins
- Institute ICs.

Here again, further description of the remedy components is provided in the "Selected Remedy" section of the 1999 ROD (EPA/ROD/R10-99/059), as amended.

Remedy Implementation Progress Prior to this Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work on the interim remedy began after issuance of the ROD amendment in 1997, with the first cleanup verification package approved in 2004. Before 2011, interim remedial actions had been completed at 15 of approximately 49 waste sites in the 100-KR-2 OU.

Issues/Corrective Actions from the Previous (2006-2010) 5-Year Review. No previous issues or actions were noted for the 100-KR-2 OU during the previous (2006-2010) CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006-2010) 5-year review report for the 100-KR-2 OU was as follows:

> *The final remedy at 100-KR-2 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.*

2.3.4.2.4 Progress Since 2011 Review

Accomplishments. Since the 2011 5-year review, interim remedial actions were completed at more than 30 waste sites and documented in waste site cleanup verification packages or remaining sites verification packages. The following waste sites were actively remediated during this 5-year review period:

- **100-KR-2 Operable Unit**
  - 100-K-3, Pump Pit
  - 100-K-89, Burn Site
  - 120-KW-1, Dry Well

- 100-K-6, Vacuum Pit
- 100-K-18, Caustic Pit
- 100-K-19, Tank Site
- 100-K-34, Acid Neutralization Pit
- 100-K-36, Dry Well
- 100-K-46, Dry Well
- 100-K-53, Pipeline
- 100-K-62, Filter Building
- 100-K-68, Tank and Sump
- 100-K-69, Sump
- 100-K-70, Tank
- 100-K-71, Collection Box
- 100-K-77, Buried Rail Ties
- 100-K-84, Stained Soils
- 100-K-97, French drain
- 100-K-102, French Drains
- 100-K-106, Fuel Oil Crib
- 100-K-109, Stained Soil
- 118-K-1, Burial Ground
- 118-KE-2, Rod Cave
- 118-KW-2, French drain
- 120-KW-2, Rod Cave
- 120-KW-3,
- 120-KW-4, Tank
- 120-KW-5, Tank
- 120-KW-7, Pump Pit
- 128-K-2, Dump
- 130-KE-1, Tank
- 132-KE-1, Stack
- 600-29, Construction Laydown
- 1607-K-3, Sanitary Sewer

Table 2-17 and Figure 2-16, shown in Section 2.2.4.1.4, summarize the waste site cleanup status for both the 100-KR-1 and 100-KR-2 waste sites, including metrics on work accomplished during this past 5-year period (2011 – 2015).

The 105-KW fuel storage basin has had continuous activity since the 2011 5-year review. Fuel was removed from the 105-KE Basin and 105-KW Basin and sent to a facility in the 200 East Area for storage. Water and sludge were transferred from the 105-KE Basin to the 105-KW Basin and the 105-KE Basin was decommissioned and demolished. Procurement of process equipment and construction of the building that will house sludge-loading equipment are progressing, so the sludge remaining in 105-KW Basin can be placed in a storage facility in the 200 West Area before deactivation and decommissioning (D&D).

Remediation of the 118-K-1 burial ground also was completed during this period, requiring excavation and disposal of more than 125,000 BCM of material. The excavation found tritium in soil beneath the burial ground that exceeded the groundwater protection target. This contamination will be addressed by the final RI/FS report and proposed plan.

DOE submitted *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft A (DOE/RL-2010-97), and *Proposed Plan for Remediation of 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft A (DOE/RL-2011-82), to EPA in 2011. EPA reviewed the documents in 2012, and recommended additional field characterization. DOE will incorporate the results of the supplemental source characterization activities on completion of additional investigation activities. The RI/FS report revision present results of RI studies and evaluate alternatives for cleaning up the vadose zone and groundwater.

Remedy Implementation. Remedial activities in the 100-KR-2 source OU involved completing the interim remedial action at the more than 35 waste sites listed in the accomplishments discussion. This work was conducted under the 100 Area RDR/RAWP (DOE/RL-96-17), as amended. Cleanup of the 100-KR-2 waste site will continue into the next 5-year review period.

Remediation at the 105-KW Basin is ongoing and will continue into the next 5-year review period. This work is conducted under *Remedial Design/Remedial Action Work Plan for the 100 Area Remaining Sites Interim Remedial Action: 105-K West Basin Demolition and Removal* (DOE/RL-2010-53). A series of other work plans applicable to various elements of K Basin D&D scope are included in the Hanford Site Administrative Record (http://pdw.hanford.gov/arpir/) for the 100-KR-2 OU.

Removing SNF from both K Basins satisfied one of the remedial action objectives. The 105-KE Basin has been decommissioned and demolished. Design, construction, and procurement work to allow sludge removal from 105-KW Basin is under way; once the sludge is gone, water removal will begin. This work is conducted under DOE/RL-2010-53.

ICs, as required by the interim action RODs (as amended) have been implemented and maintained during this 5-year review period in order to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure.

2.3.4.2.5 Technical Assessments

Is the remedy functioning as intended by the decision documents?

The interim remedy (primarily involving RTD, backfilling, revegetation, and ICs) is functioning as intended by the interim action ROD (as amended). As of December 2015, nearly all (49 of 107) 100-KR-2 waste sites had been remediated.

In accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS)*, the 100-KR-2 remediated waste sites have been documented in WIDS as either interim closed or interim no-action. Cleanup verification packages (including sampling data and other technical information) to support the reclassification to interim closed and/or no-action are included in the Hanford Site Administrative Record for the 100-KR-2 OU. The remedial action goals (contaminant-specific soil cleanup criteria developed to ensure that remedial actions to be implemented will meet the RAOs) are described in Chapter 2 of the 100 Area RDR/RAWP (DOE/RL-96-17, Rev. 6). Additionally, in accordance with EPA guidance in *Close Out Procedures for National Priorities List Sites* (EPA 540-R-98-016), remedial actions completed for a number of the 100-KR-1 and 100-KR-2 source OU wastes sites are documented in *100-K Area Interim Remedial Action Report* (DOE/RL-2014-15).

The RAOs for 100-KR-2 remediated waste sites, and the methods used for achieving the RAOs through the interim remedial actions are summarized in the following list:

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.***
  - Achieved through excavation to WAC 173-340, "Model Toxics Control Act – Cleanup," levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) use.
  - Achieved human health total radiological dose standards of less than 15 mrem/yr above background for radionuclides.
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.***
  - Achieved through protection such that contaminant levels in soil after remediation do not result in an adverse impact to groundwater that exceeded any nonzero maximum contaminant level goals under the *Safe Drinking Water Act of 1974* or Method B cleanup levels under WAC 173-340**,** "Model Toxics Control Act – Cleanup."
  - Levels of contaminants in the soil after remediation do not result in an impact to groundwater and the Columbia River that could exceed the ambient water quality criteria under the *Clean Water Act of 1977* for protection of fish or Method B cleanup levels under the WAC 173-340-730, "Surface water cleanup standards." Because no ambient water quality criteria have been established for radionuclides, maximum contaminant levels from national primary drinking water standards were used.
  - The protection of receptors (aquatic species, with emphasis on salmon) in surface waters was achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River are not subject to any additional adverse risks.

- ***RAO 3. To the extent practicable, return soil concentrations to levels that allow for unlimited future use and exposure. Where it is not practicable to remediate to levels that will allow for unrestricted use in all areas, institutional controls and long-term monitoring will be required.***

  Achieved by removing waste sites to the bottom of the engineered structure and providing ICs, as required. ICs (via use of excavation permits) prevent uncontrolled drilling or excavation into the deep vadose zone (i.e., greater than 15 ft [4.6 m] below the surface).

ICs for the 100-KR-2 source OU, as required by the interim action RODs (as amended), are described in the latest version of 100 Area RDR/RAWP (DOE/RL-96-17) and are actively managed. Specific details associated with each IC have also been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 100-KR-2 OU include waste-site-specific ICs (e.g., drilling and excavation restrictions for waste sites where residual contamination remains at depth) and general-areas ICs including access control (warning notices, entry restrictions, and fencing), land-use management (land use, and excavation permits), groundwater use management, and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 100-KR-2 source OU.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of original remedy selection are still valid. This information will be reviewed and updated as needed to support final remedy selection.

Has any other information come to light that could call into question the protectiveness of the remedy?

The potential for continuing sources from mobile contaminates in the deep vadose zone may require additional protectiveness remedies. Suspect continuing source contribution effects noted in 100-KR-2 OU include the following:

- Data collected from well borings near the 105-KE Reactor fuel storage basin (UPR-100-K-1) and the 116-KE-3 crib in late 2015 indicate elevated concentrations of cesium-137, strontium-90, and transuranic (TRU) elements across the vadose zone thickness. Groundwater is observed to exhibit persistent contamination by strontium-90 beneath the fuel storage basin site and at downgradient well locations. These characterization borings were completed as monitoring wells; 100-KR-4 will continue groundwater monitoring at these locations. These supplemental characterization data will be further evaluated and incorporated in a revised draft RI/FS report during the next 5-year review period (2016 – 2020).
- Tritium at a monitoring well near the former 118-K-1 burial ground exceeds drinking water standards.
- Persistent areas of elevated hexavalent chromium in groundwater (e.g., near the 183-KE and 183-KW head houses) suggest the likelihood of continuing contaminant contributions from deep vadose soil contamination at these locations.
- Persistent plumes of elevated carbon-14, tritium, and nitrate are observed downgradient of the 116-KE-1 and 116-KW-1 gas condensate cribs. These conditions suggest that deep vadose zone contamination is a continuing source of groundwater contamination at these locations.

2.3.4.2.6 Issues/Corrective Actions During this Review Period

Issue KR-2-1. Several 100-KR-2 OU waste sites near the 105-KE and 105-KW Reactors likely serve as continuing sources of 100-KR-4 OU groundwater contamination.

Corrective Actions KR-2-1. Incorporate supplemental characterization data and risk evaluation information in a revised draft RI/FS report and transmit for regulator review. (Corrective Action Due Date: December 31, 2018).

Does this issue/action currently affect the protectiveness of the remedy? – NO

Will this issue/action affect the protectiveness of the remedy in the future? – YES

Note: This issue/corrective-action set also is included in the 100-KR-4 Groundwater OU section of this report.

2.3.4.2.7 Protectiveness Statements

100-KR-2 Source OU – Will Be Protective. The remedy at the 100-KR-2 OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring and revegetation, ICs, and deactivation of the SNF basins) at the 100-KR-2 OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

2.3.4.3 100-KR-4 Groundwater Operable Unit

2.3.4.3.1 Background

The 100-KR-4 groundwater OU (shown in Figure 2-15) is 1 of 10 groundwater OUs on the Hanford Site, and 1 of 6 located in the River Corridor. The 100-KR-4 OU consists of the groundwater affected by contaminated releases from facilities and waste sites in the 100-KR-1 and 100-KR-2 source OUs. The 100-K area is the site of two deactivated reactors: the 105-KE Reactor (operated from 1955 to 1971) and the 105-KW Reactor (operated from 1955 to 1970).

The 105-KE and 105-KW reactors were the largest single-pass cooling water reactors built on the Hanford Site, with 60 percent more fuel rods than earlier reactor designs, higher initial and final power ratings, and higher numbers of fuel elements. The reactors also used a larger amount of cooling water and inert cover gases (source of carbon-14) to dissipate reactor heat. Over 568,000 L/min (150,000 gal/min) of cooling water were used to cool each reactor. This flow rate increased to more than 757,000 L/min (200,000 gal/min) as the reactor power ratings increased. More than 80 percent of the cooling water used was discharged to the retention basins and then to the Columbia River via underwater pipelines. The remainder was discharged to the soil column at liquid effluent waste sites; in some cases, valves and conveyance pipelines leaked effluent to the vadose zone. The 105-KW and 105-KE Reactors were shut down in 1970 and 1971, respectively. A subset of the liquid- and solid-waste disposal sites in the 100-KR-1 and 100-KR-2 source OU are known or suspected to have contributed to the 100-KR-4 groundwater contamination.

Contaminants of concern for the 100-KR-4 OU include hexavalent chromium, total chromium, tritium, nitrate, strontium-90, carbon-14, and trichloroethene (TCE).

Groundwater in the 100-KR-4 OU flows generally to the northwest toward the Columbia River, which forms a discharge boundary for the unconfined aquifer. Operation of P&T systems at the 100-KR-4 OU creates changes in groundwater flow direction and velocity. These changes are expressed as depressions and mounds in the water table that affect the flow direction. Daily and seasonal fluctuations in the river stage also affect groundwater flow in the 100-KR-4 OU. As would be expected, longer term changes in the river stage produce more extensive and longer lived changes in the water levels, hydraulic gradient, and flow directions in the unconfined aquifer. Intrusion of river water into the aquifer during high river stage can lower contaminant concentrations in aquifer tubes and in some near-river wells.

Current land use consists of facilities support and remediation activities. Facilities support includes maintaining existing structures, roads, and grounds. The principal structures include the two reactors, a new potable water treatment plant, parts of the water treatment infrastructure, groundwater treatment systems, and multiple support buildings. While most of these structures are planned to be removed, the two reactor buildings, 105-KE and 105-KW, will be placed in ISS for up to 75 years before the final remediation decision is implemented, allowing radionuclide activity levels to decrease through radioactive decay to levels suitable for final decommissioning. The Columbia River and north shoreline are used for recreational activities such as hunting, fishing, and boating, and support a large variety of aquatic and riparian animals and plants. The 100-KR-4 OU also contains a large amount of undeveloped land.

A summary of the 100-KR-4 groundwater is included in each of the following reports:

- *Hanford Site Groundwater Monitoring Report* (published annually to address the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- *Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations and 100-NR-2 Groundwater Remediation* for each prior year can be accessed through the same link at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

Additional CERCLA documentation associated with the 100-KR-4 groundwater OU, as well as other OUs, can be accessed directly or queried in the Administrative Record for the Hanford Site's OUs and TSD units, at the following address:
http://pdw.hanford.gov/arpir/index.cfm/predefinedSearch?canType=OpUnit

2.3.4.3.2 Chronology

Table 2-19 lists the remedial action decision documents associated with the 100-KR-4 groundwater OU.

Table 2-19. Decision Documents for the 100-KR-4 Groundwater Operable Unit.

Date	Location	Title
3/1996	EPA/ROD/R10-96/134	***Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Hanford Site, Benton County, Washington*.** This interim action ROD requires P&T removal of hexavalent chromium from groundwater extraction wells, ion exchange treatment, reinjection of treated effluent, monitoring, and institutional controls.
8/2009	EPA 2009	***Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Benton County, Washington*:** This ESD provides notice of an increase in projected costs for P&T operations for both OUs, changes reinjection location requirements for treated water to other than upgradient locations to help contain the hexavalent chromium plumes and prevent the plume from expanding, and changes the treatment and discharge standards for wells not upgradient of extraction wells to meet the aquatic river protection criterion of 10 µg/L for hexavalent chromium.

ESD = explanation of significant difference.
OU = operable unit.
P&T = pump and treat.
ROD = record of decision.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.4.3.3 Remedial Actions

Goals and Objectives. In accordance with the NCP, "EPA expects to return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (40 CFR 300.430[a][1][iii][F]). EPA generally defers to state definitions of

groundwater classification provided under EPA-endorsed Comprehensive State Groundwater Protection Programs (EPA/540/G-88/003).

Groundwater within the 100-KR-4 OU is contaminated and is not currently withdrawn from the aquifer for beneficial use; however, the potential beneficial use of the groundwater is as a drinking water source. Consistent with the beneficial-use classifications of Washington State and the EPA, the goal for remediating 100-KR-4 groundwater is to reduce contaminants to levels that will allow its use as a future drinking water source.

Based on the expectations for 100-KR-4 groundwater restoration, the interim RAOs, as stated in the 1996 interim action ROD (EPA/ROD/R10-96/134), are as follows:

- ***RAO 1. Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.*** The first remedial action objective for the 100-HR-3 and 100-KR-4 Operable Units is to prevent the discharge of hexavalent chromium to the Columbia River substrate at concentrations exceeding those that are considered protective of aquatic life in the River and riverbed sediments.

  Additional information will be obtained during the interim action before the development and implementation of a final action. [Note: The current RAG is 10 µg/L for hexavalent chromium in the surface water at the point of groundwater discharge. The groundwater remediation is implemented to ensure that this requirement is met.]

- ***RAO 2. Protection of human health by preventing exposure to contaminants in the groundwater.*** A second remedial action objective for these operable units is to continue to protect the public such that there is no exposure to contaminants above health-based levels.

- ***RAO 3. Provide information that will lead to the final remedy.***

Remedy Components. The 1996 interim remedial action ROD provided the following summary-level descriptions of the primary components of the interim remedy for the 100-HR-3 and 100-KR-4 groundwater OUs (i.e., groundwater extraction and treatment, MNA, flow path control, and ICs). The original ROD narrative (in italicized text in the following box) is provided to give an historical perspective; some quantities and components have been modified through subsequent amendments to the interim remedial action ROD (as noted in Table 2-12) and incorporated in the OU's RDR/RAWP documentation. The RDR/RAWP documentation is discussed in the upcoming Remedy Implementation section.

Excerpt from ROD (EPA/ROD/R10-96/134):

Groundwater Extraction. Groundwater will be extracted from wells primarily located along the river in each of the three reactor areas. Extraction wells should be located at a sufficient distance inland from the river to minimize withdrawal of river water. Extraction wells shall be located such that the plume is captured to meet the remedial action objectives. Based on preliminary modeling accomplished for the operable unit focused feasibility studies, the following extraction well design was estimated as sufficient to capture the chromium plume to meet the chromium remedial action objectives:

- *100-K Area: Eleven extraction wells spaced approximately 240 m (786 ft) apart with a composite withdrawal rate of 20 gpm.*
- *100-H Area: Nine extraction wells spaced approximately 160 m (515 ft) apart with a composite withdrawal rate of 225 gpm.*
- *100-D Area: Ten extraction wells spaced approximately 160 m (515 ft) apart with a composite withdrawal rate of 100 gpm.*

During remedial design, estimates will be improved based on the incorporation of the results of ongoing river pore water sampling and shoreline drive point sampling, recent groundwater sampling data, and other pertinent data collected since the completion of the focused feasibility study. The groundwater extraction system shall be designed in accordance with the Remedial Design Report/Remedial Action Work Plan (RDR/RAWP) as approved by EPA and Ecology.

Groundwater Treatment and Discharge Standards – Hexavalent Chromium. 100-D, 100-H, and 100-K Areas. The groundwater treatment systems will reduce the effluent chromium concentrations to the maximum extent

practicable. However, groundwater above 50 µg/L chromium will not be discharged to injection wells that are not located upgradient of the extraction wells. The average chromium concentrations in the treated effluent are expected to be at or below 20 µg/L. Treatment will be performed using ion exchange resins.

Groundwater Treatment – Other Contaminants. Because this interim action is designed to reduce levels of hexavalent chromium in the groundwater and the river substrate, there is a potential for other groundwater co-contaminants to be present in the reinjected effluent at concentrations above the drinking water standards set for those contaminants. Potential co-contaminants include nitrate, strontium-90, tritium, uranium, and 2-81anford2-81it-99. The ion exchange system required to remove chromium will also reduce concentrations of other anionic contaminants such a nitrate, 2-81anford2-81it-99, and uranium-238. Strontium-90 exists in groundwater as a cation and is not expected to be removed in the ion exchange system.

Tritium is also not expected to be removed by the treatment system. In addition to chromium at both operable units; other potential co-contaminants include:

- *100-HR-3: nitrate, strontium-90, tritium, uranium, and technetium-99,*
- *100-KR-4: tritium and strontium-90.*

These other co-contaminants do not exceed the ecological risk criteria, and institutional controls (detailed elsewhere) limit human exposure.

Groundwater Reinjection. After treatment, water will be reinjected into the upper aquifer that will help contain the hexavalent chromium plumes and prevent the plumes from expanding in the 100-HR-3 and 100-KR-4 Operable Units respectively. Based on preliminary modeling accomplished for the operable unit Focused Feasibility Studies, the number of wells needed to accomplish this was estimated to be:

- *100-D Area: Five injection wells.*
- *100-H Area: Three injection wells.*
- *100-K Area: Two injection wells.*

During the remedial design process, more precise estimates are expected to be developed based on the collection and incorporation of well and site-specific data. The groundwater treatment and reinjection system shall be designed in accordance with the RDR/RAWP as approved by EPA and Ecology.

Compliance Monitoring – River Protection. The data analysis and evaluation procedures used to evaluate compliance with cleanup levels shall be defined in a compliance monitoring plan as part of the RDR/RAWP and prepared in accordance with WAC 173-340-720(8) and/or as approved by EPA and Ecology.

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 could be present during parts of the year. Since it is impractical to routinely monitor the river substrate, groundwater will be monitored at near-river on-shore locations above the common high river mark. Monitoring shall be conducted at sufficient locations to evaluate the performance of the remedial action. The siting and design of the compliance monitoring system shall be in accordance with the RDR/RAWP as approved by EPA and Ecology. 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 has been selected based on the available data (i.e., 22 µg/L hexavalent chromium in on-shore near-river well points is considered equivalent to 11 µg/L hexavalent chromium in the river substrate). It will take a period of time for the extraction system to have an effect on groundwater quality adjacent to the Columbia River. Concentrations in excess of 22 µg/L may be observed in the compliance wells during the early stages of operation.

Groundwater sampling will be conducted when dilution by river water at the compliance monitoring points is minimal. The details of the groundwater quality monitoring program will be described in the RDR/RAWP. Chromium compliance monitoring will be conducted at multiple depth intervals. Baseline sampling will be conducted prior to the start of the interim action.

Sampling will be conducted monthly for at least three months following start-up of the extraction system. Subsequently, there may be substantial reductions in frequency, number of stations, and depths sampled, if demonstrated to be appropriate, and approved by EPA and Ecology. A network of piezometers (or comparable technique) will be installed and monitored such that the capture zone around the extraction wells can be estimated.

In the event of special conditions such as an unusual flood event or prolonged down time of the pump-and-treat system, extra monitoring, at the direction of EPA or Ecology shall be conducted.

The analyte list will be defined during remedial design; it shall include:

- *Hexavalent chromium (or total chromium assumed to be hexavalent). The method detection limit and quantitation limit of the selected test method shall be sufficiently low to allow comparison with the remedial action goals.*
- *Conductivity or comparable measurements adequate to indicate ratio of river-derived versus groundwater-derived water.*
- *On an infrequent basis, likely co-contaminants will be monitored as part of on-going Tri-Party Agreement activities to assess protectiveness of human health and the environment.*

Compliance monitoring will include analysis of results in a timely manner to support modifications to the treatment system in order to meet the remedial action objectives. Significant system modifications as identified in the RDR/RAWP are subject to EPA and Ecology approval.

Compliance Monitoring – Effluent for Reinjection. The data analysis and evaluation procedures used to evaluate compliance with cleanup levels shall be defined in the RDR/RAWP and prepared using WAC 173-340-720(8) and approved by EPA and Ecology.

Construction Requirements. Construction requirements shall be scoped as part of the RDR/RAWP with guidance provided by and as approved by EPA and Ecology. This Work Plan shall include at least the following elements:

- *Construction is expected to comply with appropriate worker safety requirements.*
- *In coordination with wildlife and other resource management agencies, activities should avoid or minimize disruption to local wildlife and other natural resources to the extent practicable.*
- *Design should provide for flexibility following startup to accommodate changes in plume characteristics, or different understandings of actual or perceived responses of the aquifer/plume to the pump-and-treat system. When the actual response of the aquifer is known, the pump and treat systems may be altered as needed, and approved by EPA and Ecology to meet the remedial action objectives.*
- *For areas that are disturbed during construction and operation, it is expected that the land will be revegetated following construction in those areas that are not needed for operation and maintenance of the treatment system and where the land is also not expected to be re-disturbed within the next few years by other site activities. Following completion of the interim action, it is expected that rectification of the habitat affected by this activity will be conducted and coordinated with activities in the source operable units (100-DR-l, 100-DR-2, 100-HR-1, 100-HR-2, 100-KR-1, and 100-KR-2).*
- *To the extent practicable, facilities are expected to be designed and located in a manner that minimizes interference with and interference by remedial actions for the source waste sites.*
- *Sites with cultural resource significance should be avoided during remedial activities if avoidance is possible. Where avoidance is not possible, a data recovery/mitigation plan must be prepared in consultation with the affected resource trustee and carried out for each site impacted by remedial activities.*

Schedule. Draft A of the RDR/RAWP is due to EPA and Ecology 120 calendar days after the ROD is signed.

- *Phase 1: Two pump and-treat systems designed in accordance with this ROD in two of the three reactor areas are to be operating as per the RDR/RAWP within 15 months of this ROD. Operating is defined as continuous removal and treatment of water at rates defined in the RDR/RAWP. Some limited testing needed to optimize the system is expected.*
- *Phase 2: The third pump-and-treat system in the third reactor area shall be operating as per the RDR/RAWP. Within 18 months of this ROD.*

The RDR/RAWP will establish a schedule including Tri-Party Agreement milestones for this interim remedial action. This Work Plan including the schedule is subject to EPA and Ecology approval.

Resin Disposal. Waste generated during the remedial action, principally exhausted resins, will be disposed of at the Environmental Restoration Disposal Facility (ERDF) or at other on-site facilities as appropriate. Resins will be stabilized prior to disposal such that:

- *The chromium concentration in leachate generated using the Toxicity Characteristic Leachate Procedure (TCLP) is less than 5.0 mg/L.*
- *ERDF waste acceptance criteria are met for disposal at ERDF.*

In the event that some materials cannot be disposed to ERDF or other on-site facilities, and require disposal at an off-site facility, such a facility must be in compliance with EPA's Offsite Rule (40 CFR 300.440) concerning

off-site disposal of wastes. If during the design or conduct of the remedial action it is determined that regeneration of resins is appropriate, that option may be implemented with any waste disposed as described for resins in this paragraph.

Human Access Institutional Controls. Institutional controls are required to prevent human exposure to groundwater. The DOE is responsible for establishing and maintaining land use and access restrictions until MCLs and risk-based criteria are met or the final remedy is selected. Institutional controls include placing written notification of the remedial action in the facility land use master plan. The DOE will prohibit any activities that would interfere with the remedial activity without EPA and Ecology concurrence. In addition, measures necessary to ensure the continuation of these restrictions will be taken in the event of any transfer or lease of the property before a final remedy is selected. A copy of the notification will be given to any prospective purchaser/transferee before any transfer or lease. The DOE will provide EPA and Ecology with written verification that these restrictions have been put in place.

Investigation-Derived Waste. Remedial investigation at 100-HR-3 and 100-KR-4 generated investigation-derived waste consisting of soil and slurries from monitoring well installation, and purge water generated during development and monitoring of the wells. This waste is stored in the respective reactor areas in drums. Soil will be disposed to ERDF, as will slurries following dewatering in accordance with ERDF waste acceptance criteria. Water may be processed via the ion exchange treatment system installed for groundwater under this ROD.

Impacts to RCRA Monitoring. Two RCRA treatment, storage, and disposal (TSD) units, 100-D Pond and the 183-H, Solar Evaporation Basins, are located within the boundaries of the 100 HR-3 Operable, Unit. The 183-H basins are anticipated to be remediated and closed under RCRA, and the 100-D Pond is currently an inactive unit. The implementation of the remedial actions under this Interim Action ROD are believed likely to impact the current RCRA groundwater sampling program around both of these facilities. For any RCRA unit whose monitoring compliance program is impacted, Ecology may approve modifications to the monitoring program as appropriate. Potential alternative compliance actions include monitoring other existing wells (including remediation wells) for appropriate RCRA constituents during the period when the groundwater is affected by the remedial action.

Operational Requirements. The pump and treat portion of the interim remedial action will continue until the selection of a final action or it is demonstrated to EPA's and Ecology's satisfaction that termination (or intermittent operation) is appropriate because: (A) sampling indicates that hexavalent chromium is below the compliance value, and site data indicate it will remain below the compliance value; or (B) based on an evaluation of the following criteria:

- *The effectiveness of the treatment technology does not justify further operation.*
- *An alternate treatment technique, such as in situ chemical reduction or other improved treatment technique is evaluated and proves to be more effective, and/or less costly, and is consistent with the remedial action objectives.*

Wetlands and Flood Plains. The interim action will be implemented such that to the extent practicable disturbance to wetlands will be avoided and system components except monitoring points will be located away from wetlands. System components will be located such that they will not increase deleterious effects of flooding.

Protectiveness. The interim action is expected to provide adequate protection of human health and ecological receptors in the Columbia River until implementation of the final remedy for the 100-HR-3 and 100-KR-4 groundwater operable units, or until such time that the DOE demonstrates to Ecology and the EPA that no further interim action is required. Contaminated soil overlying these operable units are or will be addressed in separate remedial actions.

Remedy Implementation Progress Prior to this Review Period. Before this review period (i.e., before 2011), three P&T systems were operating in 100−KR-4 OU. These primarily included the original KR4 P&T system (beginning operation 1997), the KW P&T system (beginning in 2007), and the KX P&T system (beginning operations in 2009). As of 2010, more than 575 kg of chromium had been removed by these systems (DOE/RL-2011-01, Rev. 0). All three system continued to operate through the previous reporting period and beyond. Further details can be found in the 2011 5-year review report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for the 100-KR-4 OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report. The 100-KR-4 groundwater OU protectiveness statement from the previous (2006-2010) 5-year-review report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070) was as follows:

> *The final remedy at 100-KR-4 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.*

2.3.4.3.4 Progress Since the 2011 Review

Accomplishments. The primary remedial action accomplishments for the 100-KR-4 groundwater OU during the past 5 years can be summarized as follows:

- Continued CERCLA groundwater sampling and analysis at monitoring well locations and operation of three interim groundwater remediation systems focusing on removal of hexavalent chromium have achieved the following reductions in hexavalent chromium:
  - KR4 P&T: Operating since 1997 and removed 375 kg of hexavalent chromium as of 2015
  - KW P&T: Operating since 2007 and removed 238 kg of hexavalent chromium as of 2015
  - KX P&T: Operating since 2009 and removed 222 kg of hexavalent chromium as of 2015
- Optimization of the remedial processes at 100-KR-4 OU, particularly through changes in the ion exchange resin used to remove hexavalent chromium and modification of pumping rates at extraction wells, have nearly doubled the overall throughput capacity of the OU's groundwater treatment systems to 1,200 gpm over the past 5 years.
- DOE submitted *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft A (DOE/RL-2010-97), and *Proposed Plan for Remediation of 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*, Draft A (DOE/RL-2011-82), to EPA in 2011.
- EPA reviewed the documents in 2012, and DOE will incorporate the results of supplemental source characterization activities upon completion of additional investigation activities. The RI/FS report presents results of RI studies and evaluates alternatives for cleaning up the vadose zone and groundwater. Based on the observed efficacy of P&T systems at the 100-KR-4 OU, the proposed plan for this OU will likely include P&T as a major element of a preferred alternative for hexavalent chromium.

Additional narrative on 100-KR-4-3 OU accomplishments relative to each ROA (as of 2015) can be viewed in DOE/RL-2016-19, *Calendar Year 2015 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*.

Remedy Implementation. The interim action ROD for the 100-HR-3 and 100-KR-4 OUs (EPA/ROD/R10-96/134), as modified, defined the hexavalent chromium cleanup goal in groundwater discharging to the Columbia River as the current ambient water quality criterion of 10 µg/L.

To mitigate risks associated with hexavalent chromium contamination in groundwater discharging to the river, three CERCLA interim action ion exchange P&T systems have been installed in the 100-KR-4 OU. All three systems were operational throughout this 5-year review period. The KR-4 system, the first system installed, began operation in 1997; it was designed to remediate groundwater around the 116-K-2 trench. The KW P&T system, the second system installed, began remediating hexavalent chromium in the KW Reactor area in January 2007. The newest P&T system, KX, began operating in February 2009. The KX system is used primarily to treat hexavalent chromium in groundwater that migrated from the 116-K-2 trench area toward N Reactor and near the proximal end of the trench near the KE Reactor area.

A number of RDR/RAWP documents have influenced field implementation of the interim action ROD for 100-KR-4 (EPA/ROD/R10-96/134), as amended, for the three P&T systems. Higher level documents include the following:

- DOE/RL-96-84, Rev. 0, and Rev. 0A, *Remedial Design and Remedial action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*. The work plan describes the design and operational requirements for the original 100-KR-4 P&T system.
- DOE/RL-2006-52, Rev. 1, *The KW Pump-and-Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 OU Interim Action*. This document established the initial operational, monitoring, and sampling requirement for the 100-KW P&T system.
- DOE/RL-2006-52, Rev. 2, *The KW Pump-and-Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 OU Interim Action*. This document describes modifications to the KW P&T system, including additions to increase treatment capacity and the addition of new extraction and injection wells.
- DOE/RL-2006-75, Rev. 1, *Reissue, Supplement to the 100-HR-3 and 100-KR-4 Remedial Design and Remedial Action Workplan for the Expansion of the 100-K Area Technical Assessment*. This supplement established the basis for expanding the remedial action to include construction of the 100-KX treatment plant and increasing the number of extraction and injection wells. The 100-K Area P&T system was intended to contain the groundwater chromium plume while the waste sites were remediated. The primary remedial action objective is to prevent the discharge of hexavalent chromium to the Columbia River substrate at concentrations exceeding those considered protective of aquatic life in the river and riverbed sediments.
- TPA-CN-273, "TPA Change Notice Supplement to the 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" (DOE/RL-2006-75), addressed a number of required changes to improve operations at the 100-KR-4 and KX P&T systems. The most significant changes are as follows:
  - Realign wells between the two systems to contain impacts of a tritium plume potentially affecting groundwater quality at KX injection wells
  - Standardize sampling of extraction, compliance, and injection wells at the 100-KR-4 and KX systems
  - Identify five new wells with locations for 100-KR-4 and KX systems, plus the sampling requirements, proposed uses, and general well design
  - Delete requirement to prepare a semiannual report to status the P&T systems.

Associated with each P&T systems are additional supporting documents that address such topics as operations, performance monitoring, and sampling requirements.

Table 2-20 presents an overview of primary components of the remedy and implementation status.

Table 2-20. Overview of 100-KR-4 Interim Action Remedy Implementation.

Document Type	Date	Title
Interim Action ROD, as amended	03/1996, 08/1999	EPA/ROD/R10-96/134, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Hanford Site, Benton County, Washington*

Table 2-20. Overview of 100-KR-4 Interim Action Remedy Implementation.

Document Type	Date	Title
RDR/RAWPs	Multiple.	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. 0A. DOE/RL-2006-52, *The KW Pump-and-Treat System Remedial Design and Remedial Action Work Plan, Supplement to the 100-KR-4 OU Interim Action*, Rev. 2. DOE/RL-2006-75, *Reissue, Supplement to the 100-HR-3 and 100-KR-4 Remedial Design and Remedial Action Work Plan for the Expansion of the 100-K Area Technical Assessment*, Rev. 1. TPA-CN-273, TPA Change Notice "Supplement to the 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" (DOE/RL-2006-75)
RAO (abbreviated description)	**1.** Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River **2.** Protect human health by preventing exposure to contaminants in the groundwater **3.** Provide information that will lead to the final remedy	
COCs	Hexavalent chromium, total chromium, tritium, nitrate, strontium-90, carbon-14 and trichloroethene (TCE)	

Remedy Component (primary)	**Construction Status** (approximate percentage complete for constructing/implementing the remedy component as of December 2015)[a]						**Duration of O&M** (~years)[b]	**Finish**[c] (Est'd year)
	0	**1-25**	**26-50**	**51-75**	**76-99**	**100%**		
P&T with ion exchange resins							TBD	TBD
Reinjection/Flow path control							TBD	TBD
Institutional controls							TBD	TBD
Compliance monitoring for river protection							TBD	TBD

[a]Percentages reflect construction status of the remedy component; post-startup remedial process optimization is considered part of O&M. 100% = fully implemented and now in O&M mode.
[b]O&M and duration and completion timeframes are TBD as the interim ROD indicates that the remedy will continue until a final ROD is issue. A final ROD will not be issued until after this 5-year review period (i.e., post-2015).
[c]Estimated year when remedy component will be completed.

COC = contaminant of concern.
FY = fiscal year.
O&M = operation and maintenance.
OU = operable unit.
P&T = pump and treat.
RAO = remedial action objectives.
RDR/RAWP = remedial design report/remedial action work plan
ROD = record of decision.
TBD = to be determined.

2.3.4.3.5 Technical Assessment

Is the remedy functioning as intended by the decision documents?

Yes, the interim remedy identified in the interim action ROD as amended (EPA 2009) involving extraction and treatment of hexavalent chromium-contaminated groundwater from the 100-KR-4 OU area, reinjection of treated water, and ICs is functioning as intended.

Operation of the three P&T systems is demonstrating progress toward meeting interim RAOs 1 and 3 as defined by the ROD (see Table 2-20). Table 2-21 summarizes 100-KR-4 groundwater OU contaminants removed from the groundwater extraction systems during this 5-year review period and cumulatively since system startup. It is notable that the mass of hexavalent chromium removed annually by the three systems has decreased over the past few years; this is the expected result of increased throughput of the systems and increased extraction of groundwater from areas of highest concentration, resulting in overall reduction of the maximum observed hexavalent chromium concentration in groundwater at 100-KR-4 OU.

Table 2-21. Contaminant Mass Removed from 100-KR-4 Groundwater Operable Unit Extraction Systems.

System (Startup)	Constituent	Mass Removed (kg)					
		2011	2012	2013	2014	2015	Since Startup
KW (Jan 2007)	Hexavalent chromium	25.9	22.6	15.6	19.4	17.4	238.2
KR4 (Sept 1997)	Hexavalent chromium	5.42	5.36	6.1	5.0	3.9	375.3
KX (Nov 2008)	Hexavalent chromium	30.1	27.5	27.0	25.8	28.6	222.9

Source: Annual P&T reports: DOE/RL-2013-13, *Calendar Year 2012 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation*; DOE/RL-2014-25, *Calendar Year 2013 Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*; DOE/RL-2015-05, *Calendar Year 2014 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*; and DOE/RL-2016-19, *Calendar Year 2015 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*.

Groundwater extraction, reinjection, and monitoring are conducted through a series of wells, as shown for 2015 in Figure 2-17. Specific details on the performance of each P&T system are updated and published each year in the *Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations and 100-NR-2 Groundwater Remediation*, which is available at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

Hexavalent chromium plume areas above 10 µg/L have collectively decreased by approximately 40 percent since 2011. In addition, the length of shoreline that the plume areas above 10 µg/L is interpreted to intersect has decreased about 80 percent since 2011 (i.e., from 1,300 m to 271 m). While the collective plume area for hexavalent chromium at concentrations above 48 µg/L has remained relative constant during this past five year period, the maximum sample concentrations have declined. Hexavalent chromium is the primary contaminant in the 100-KR-4 groundwater interim action ROD. Smaller plumes of tritium, nitrate, strontium-90, carbon-14, and trichloroethene (TCE) also are present. The plume areas for these other contaminants have been declining gradually and are not reaching the Columbia River at levels above the water quality standards. Cleanup actions for these other contaminants will be defined in an upcoming ROD.

Table 2-22 provides an overview of 100-KR-4 contaminant plume areas and associated changes to the areas during this 5-year review period. Plume maps in Figure 2-18 show the changes in plume shapes and areas during this 5-year review period. The Figure 2-19 trend plots depict the estimated annual changes in contaminant plume areas over the past several 5-year periods.

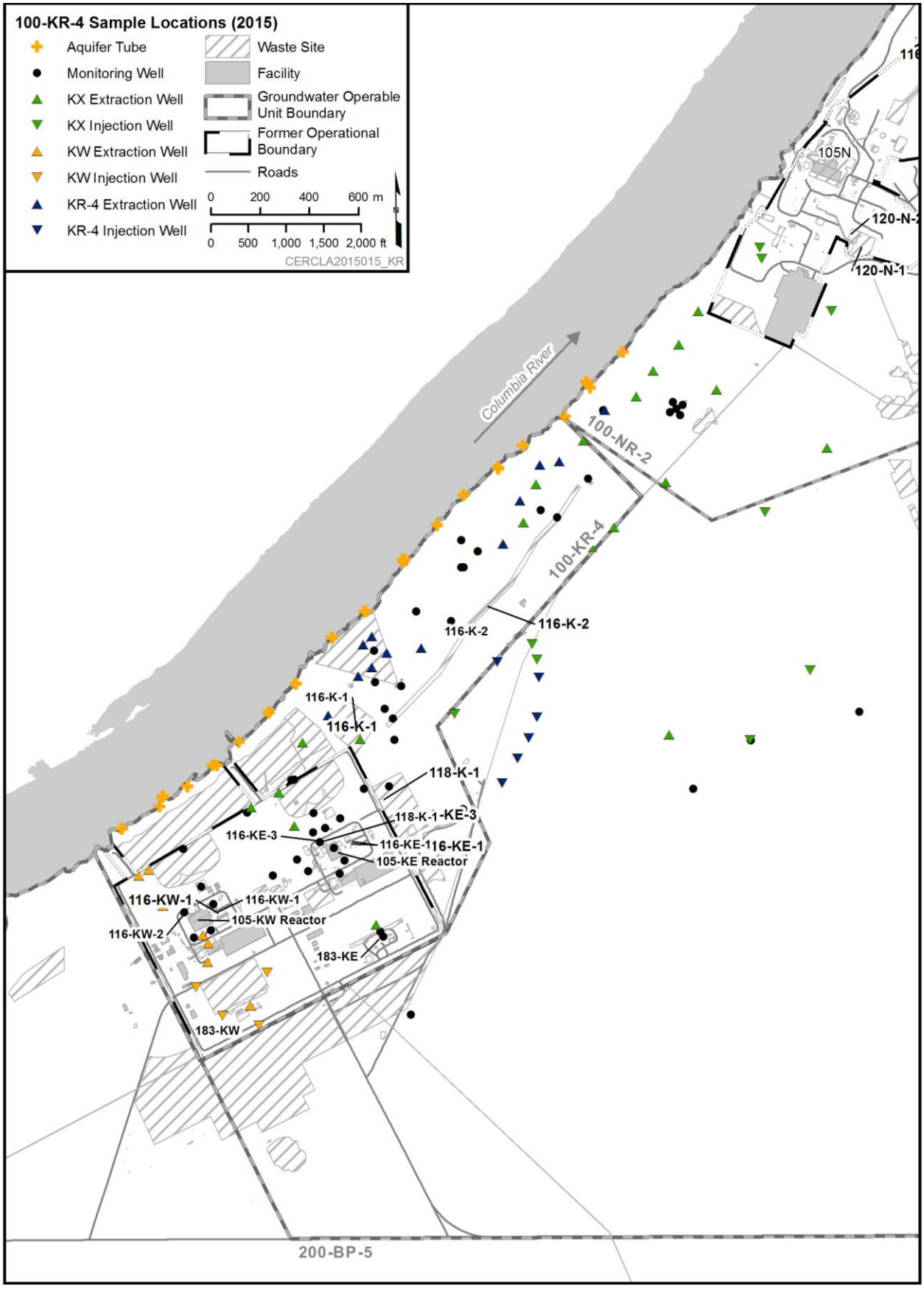


Figure 2-17. Locations of 100-KR-4 Wells and Aquifer Tubes Sampled in 2015.

Table 2-22. Overview of 100-KR-4 Groundwater Contaminant Plumes.[a]

Groundwater Contaminant	Water Quality Standard[b]	Maximum Concentration (2015)	Plume Area[c] (km^2)			Shoreline Intersection (m)[d]		
			2011	2015	Change	2011	2015	Change
Hexavalent Chromium	10 µg/L[e]	see entry below	2.5	1.5[f]	-1.0	1,300	271	-1,029
Hexavalent Chromium	48 µg/L	348 µg/L	0.06	0.07	0.01	0	0	0
Tritium	20,000 pCi/L	935,000 pCi/L	0.24	0.11	-0.13	0	0	0
Nitrate	45 mg/L[g]	75 mg/L	0.041	<0.01	-0.040	0	0	0
Strontium-90	8 pCi/L	4,000 pCi/L	0.063	0.03	-0.03	0	0	0
Carbon-14	2,000 pCi/L	14,200 pCi/L	0.051	0.04	-0.01	0	0	0
TCE	5 µg/L	8.7 µg/L	0.007	0.01	0.003	0	0	0

[a]Source: Hanford Annual Groundwater Monitoring Reports for 2011 and 2015, DOE/RL-2011-118, *Hanford Site Groundwater Monitoring for 2011*, and DOE/RL2016-09, *Hanford Site Groundwater Monitoring for 2015*, respectively.
[b]Drinking water standard for all but hexavalent chromium
[c]Estimated area at a concentration greater than the listed cleanup level.
[d]Length of Columbia River shoreline at 100-KR that is not considered to be "protected" against potential for continuing release of hexavalent chromium to the river. Other contaminant plumes do not intersect the river at concentrations above standards, based on data from wells and aquifer tubes.
[e]The applicable standard is the 10 µg/L surface water quality criterion. The interim remedial action objective remains to protect the Columbia River against releases that would cause exceedance of the 10 µg/L surface water quality criterion.
[f]Based on a concentration greater than the 10 µg/L surface water quality criterion. This area includes the plume within the 100-KR interest area plus approximately 0.2 km^2 of additional chromium within the 100-NR and 100-FR interest areas that is apparently attributable to 100-KR historical operations located within 100-NR interest area.
[g]45 mg/L as NO_3 is equivalent to the drinking water standard of 10 mg/L as N.
N/A = not applicable. TBD = to be determined. TCE = trichloroethene.

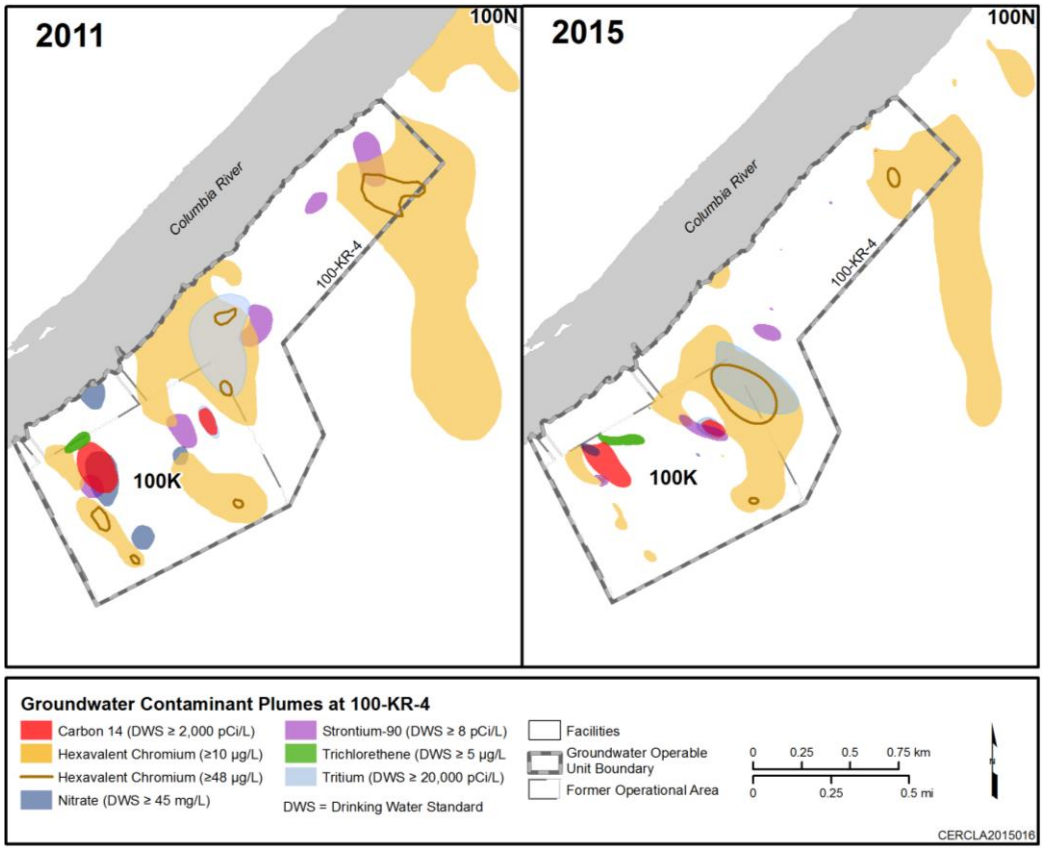


Figure 2-18. 100-KR-4 Groundwater OU Plumes in 2011 (left) and 2015 (right).

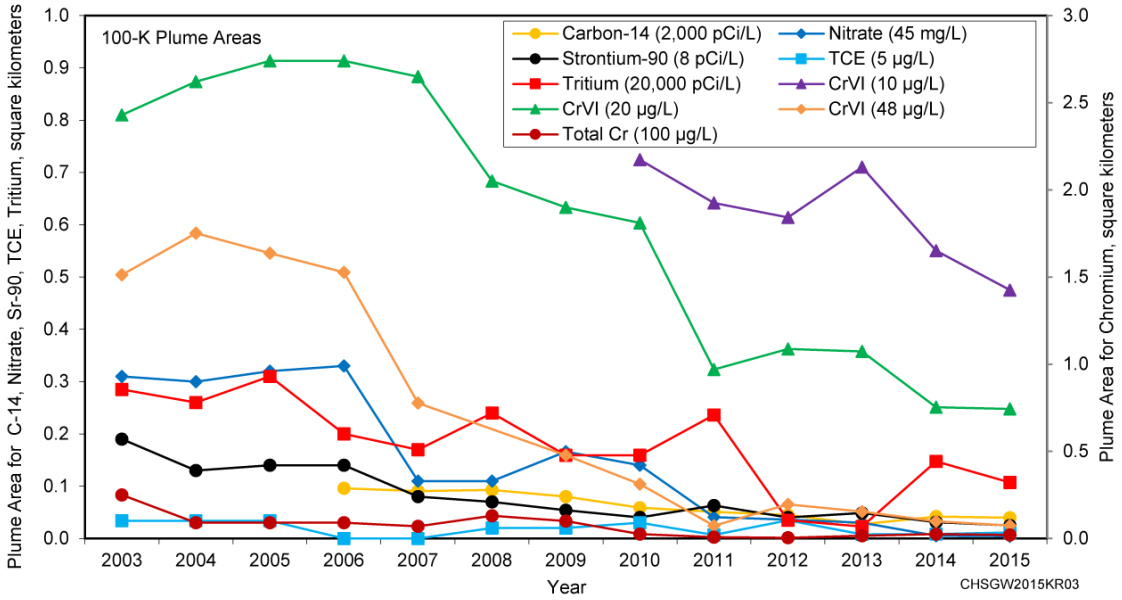


Figure 2-19. 100-KR-4 Trend Plots of Contaminant Plume Areas (2003 – 2015).

In support of ongoing remedial process optimization, four high-capacity groundwater extraction wells and one additional injection well were installed between 2011 and 2015 to increase plume containment and mass removal. Seven additional groundwater monitoring wells were installed at strategic locations to support plume definition and remedy monitoring. For more detailed information on the 100-KR-4 groundwater OU well locations, distribution of contaminant concentrations within each plume, and historic trends associated with each 100-KR-4 COC plume area, as well as for performance metrics associated with 100-KR-4 OU groundwater treatment, visit the following links:

- *Hanford Site Groundwater Monitoring Report* (published each summer for the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- *Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations and 100-NR-2 Groundwater Remediation* (published for each prior calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports

ICs for the 100-KR-4 groundwater OU, as required by the interim action ROD (EPA/ROD/R10-96/134), as amended, are described in the latest version of *Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Unit's Interim Action*, Rev. 0 (DOE/RL-96-84) and Rev. 0A, and are actively managed. Specific details associated with each IC have also been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 100-KR-4 OU are required to prevent human exposure to contaminated groundwater and include warning notices, entry restrictions, land-use management (land use), groundwater-use management (excavation permits), and miscellaneous provisions. These ICs (supporting achievement of RAO 2) are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, one deficiency was noted for the 100-KR-4 groundwater OU; warning notice signs along the river shoreline were noted as missing during the 2011 annual IC inspection and subsequently replaced.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

As described earlier and captured in the ESD (EPA 2009), hexavalent chromium cleanup levels for protection of aquatic life were modified from 11 to 10 µg/L in 1997. Otherwise, exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of original remedy selection are still valid. These criteria will be reviewed and updated as needed to support final remedy selection.

Has any other information come to light that could call into question the protectiveness of the remedy?

Data collected during this period indicate that the interim groundwater remedial action implemented for control of hexavalent chromium has been effective at reducing the discharge of contaminated groundwater to the Columbia River, controlling plume migration toward exposure points, and reducing the concentration of hexavalent chromium observed in groundwater at 100-KR-4 OU.

2.3.4.3.6 Issues/Corrective Actions During this Review Period

Issue KR4-1. Several 100-KR-2 OU waste sites likely serve as continuing sources of 100-KR-4 OU groundwater contamination by hexavalent chromium as well as other COCs.

Corrective Action KR4-1. Incorporate supplemental characterization data and risk evaluation information in a revised draft RI/FS report and transmit for regulator review. (Corrective Action Due Date: December 31, 2018).

Does this issue/action currently affect the protectiveness of the remedy? – NO

Will this issue/action affect the protectiveness of the remedy in the future? – YES

Note: This issue/corrective action set also was included in the 100-KR-2 source OU section of this report.

2.3.4.3.7 Protectiveness Statement

100-KR-4 Groundwater OU – Will Be Protective. The remedy at the 100-KR-4 groundwater OU will be protective upon completion of the final remedy. The interim remedy for the 100-KR-4 groundwater OU focuses on hexavalent chromium contamination. The KR-4, KW, and KX groundwater treatment systems' operations and the flow-path-control components of the interim remedy are ongoing, and demonstrating effective progress in reducing contaminant plume sizes and concentrations. ICs have been implemented and continue to ensure that unacceptable risks to human health are being controlled. A revised RI/FS report that includes 100-KR-4 is in development, pending the results of supplemental field characterization.

2.3.5 100-N Area Operable Units

The 100-N Area is located in the north-central region of the Hanford Site, adjacent to the Columbia River. The 100-N Area contains the 100-NR-1 source OU and the 100-NR-2 groundwater OU. Figure 2-20 shows the current boundaries for the 100-N Area OUs.

2.3.5.1 100-NR-1 Source Operable Unit

2.3.5.1.1 Background

The 105-N Reactor operated from 1963 until 1987. It was a dual-purpose reactor that produced plutonium for DOE and steam for the Hanford Generating Plant, located adjacent to the 105-N Reactor, to produce electrical power. The Bonneville Power Administration switching station also is located in the 100-N Area. In 1991, DOE issued the final decision to permanently retire the 105-N Reactor from service.

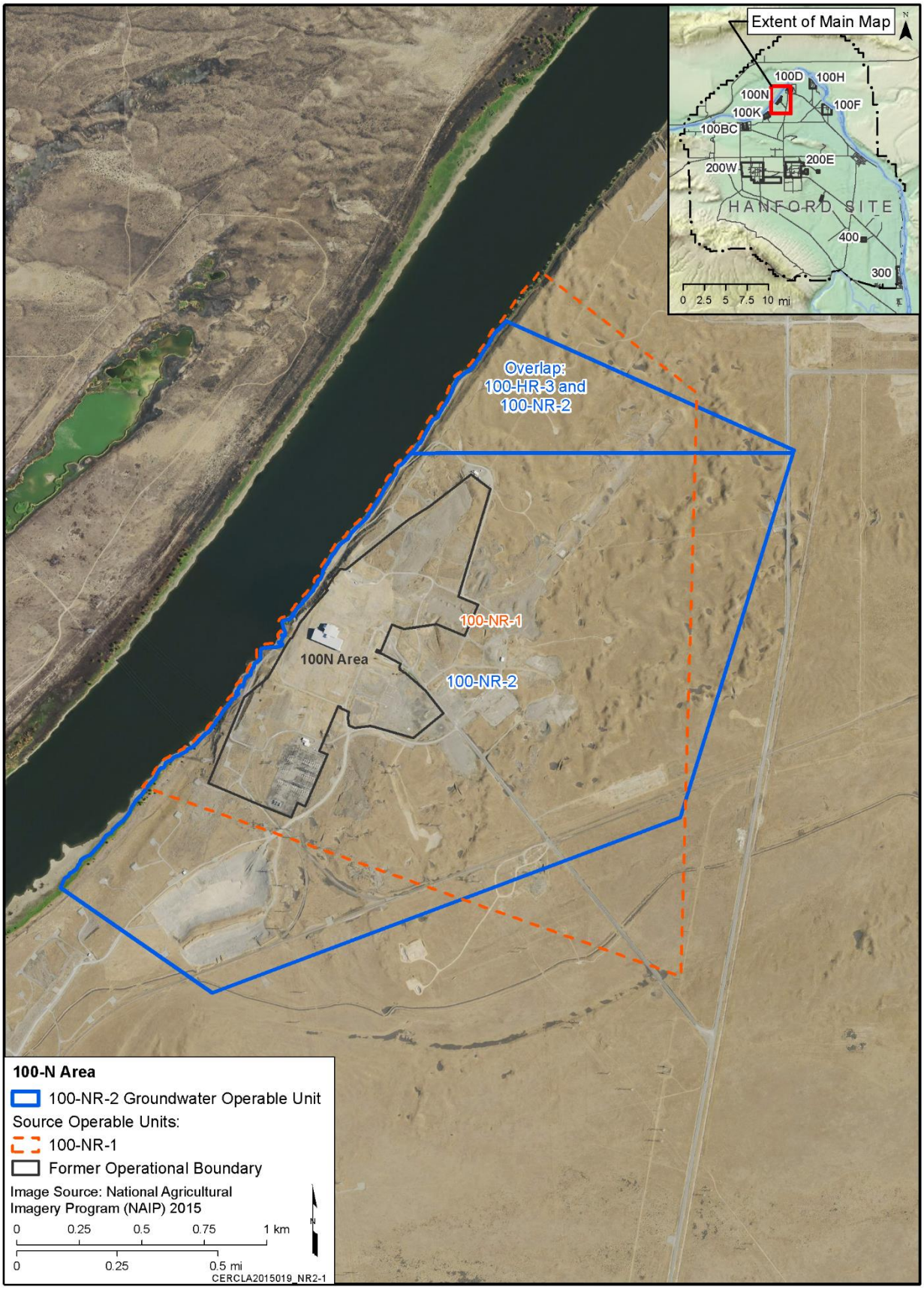


Figure 2-20. Location of 100-N Area Operable Units.

Past operations associated with the 105-N Reactor contributed to soil and groundwater contamination in the 100-N area. The 100-NR-1 source OU includes liquid and solid waste disposal sites and unplanned releases in the vicinity of or related to the 105-N Reactor. These waste sites include cribs, trenches, pits, French drains, solid waste burial grounds, septic tanks, and drain fields. Cleanup decisions for this region were initiated in the 1990s.

2.3.5.1.2 Chronology

Table 2-23 lists remedial action decision documents relevant to the 100-NR-1 source OU.

Table 2-23. Decision Documents for the 100-NR-1 Source Operable Unit.

Date	Location	Title
9/1999	EPA/ROD/R10-99/112	***Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington.*** This interim action ROD requires the OUs to continue removing strontium-90 through P&T with ion exchange and discharge treated groundwater upgradient into the aquifer, maintain groundwater monitoring networks to monitor P&T operations and impacts to groundwater, evaluate technologies for strontium-90 removal and aquatic and riparian receptor impacts from contaminated groundwater, remove petroleum hydrocarbons (free-floating product) from any monitoring well and dispose of it at an approved facility, remove petroleum-contaminated solid waste, and dispose of non-hazardous wash/rinse waters to Ecology-approved facilities.
1/2000	EPA/ROD/R10-00/120	***Interim Remedial Action Record of Decision for the 100-NR-1 Operable Unit of the Hanford 100-N Area.*** This interim action ROD requires RTD of the 116-N-1 and 116-N-3 cribs with disposal at ERDF, backfilling, and revegetation; any pipelines will be sampled and removed or left in place based on sample results.
5/2003	EPA/ESD/R10-03/605	***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.*** This ESD removes the July 31 annual ICs requirement and consolidates reporting with the Sitewide IC annual report, eliminates the requirement to evaluate applying 30 in. of irrigation water to determine whether remaining contaminants will impact groundwater for 116-N-1, and identifies the need for additional ICs to preclude access to contaminated groundwater; any additional ICs will be incorporated into the Sitewide IC document.
3/2011	EPA 2011b	***Explanation of Significant Differences for the 100-NR-1 and 100-NR-2 Operable Units Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington.*** This ESD adds 45 waste sites in the 100-NR-1 OU for remediation by RTD (characterized per the 100-N Area sampling and analysis plan) and increases the total cost 38% to $67,510,386.
8/2013	Ecology et al. 2013	***Explanation of Significant Difference for the 100-NR-1 and 100-NR-2 Operable Units Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington.*** This ESD adds two waste sites in the 100-NR-1 OU for remediation by RTD and increases the total cost by $401,500.

Ecology = Washington State Department of Ecology.
ERDF = Environmental Restoration Disposal Facility.
ESD = explanation of significant difference.
IC = institutional control.
OU = operable unit.
P&T = pump and treat.
ROD = record of decision.
RTD = removal, treatment, and disposal.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.5.1.3 Remedial Action

Goals and Objectives. The following RAOs set forth in the interim action RODs listed in the chronology are narrative statements that define the extent to which the waste sites require cleanup to protect human health and the environment.

- ***RAO 1. Protect human and ecological receptors from exposure to radioactive contaminants in surface and subsurface soils, structures, and debris.***
- ***RAO 2. Protect potential human and ecological receptors from exposure to nonradioactive contaminants present in the upper 15 feet (4.6 meters) of soil and debris.***
- ***RAO 3. Protect the unconfined groundwater system from adverse impacts by reducing concentrations of radioactive and nonradioactive chemical contaminants present in the soil column that could migrate to the groundwater.***
- ***RAO 4. Protection of the Columbia River from adverse impacts so that designated beneficial uses are maintained.***
- ***RAO 5. Prevent destruction of significant cultural resources and sensitive wildlife habitat.***

Remedy Components. Remedy components for the 100-NR-1 source OU waste sites generally include the following steps:

- Remove contaminated soil, structures, and debris from 100 Area source waste sites using the observational approach, which uses field data and analytical screening during remediation to guide the extent of excavation. Remediation proceeds until it can be demonstrated through a combination of field screening and verification sampling that cleanup goals have been achieved.
- Treat the waste as required to meet applicable waste disposal criteria; for petroleum contaminated waste sites, this includes in situ and ex situ bioremediation
- Dispose of contaminated materials, preferably at ERDF or another location approved by the regulators
- Backfill excavated areas and revegetate
- Implement ICs where wastes are left in place and preclude unrestricted land use.

Detailed descriptions of the remedy components are provided in the "Selected Remedy" section of each interim action ROD, as amended.

Remedy Implementation Progress Prior to this Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work on the interim remedy began after issuance of the ROD in 1999, with the initial cleanup verification package approved in 2004. Before 2011, interim remedial actions had been completed at 16 of approximately 133 waste sites in the 100-NR-1 OU.

Issues/Corrective Actions from the Previous (2006 – 2010) 5-Year Review. No previous issues or actions were noted for the 100-NR-1 OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006 – 2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006-2010) FYR report for the 100-NR-1 OU was as follows:

> *The final remedy at 100-NR-1 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.*

2.3.5.1.4 Progress Since 2011 Review

Accomplishments. Since the 2011 5-year review, primary accomplishments for the 100-NR-1 source OU include the following:

- Submitted DOE/RL-2012-15, *Remedial Investigation Feasibility Study for 100-NR-1 and 100-NR-2 Operable Units*, Draft A, to Ecology for review in 2013, and submitted a revised document in 2014 based on comments

- Issued DOE/RL-2005-93, *Remedial Design Report/Remedial Action Work Plan for the 100-N Area*, Rev. 1, in 2013

- Completed interim remedial actions at more than 100 waste sites.

Interim remedial actions were completed at more than 100 waste sites and documented in waste site cleanup verification packages or remaining sites verification packages. The waste sites that were actively remediated during this 5-year review period are as follows:

- 100-NR-1 Operable Unit
  - 100-N-6, Burn Pit
  - 100-N-13, Contaminated Soils
  - 100-N-14, Contaminated Soils
  - 100-N-16, Burn Pit
  - 100-N-17, Burn Pit
  - 100-N-18, Burn Pit
  - 100-N-22, Septic Tank
  - 100-N-23, Process Pit
  - 100-N-24, French Drain
  - 100-N-25, French Drain
  - 100-N-26, French Drain
  - 100-N-28, Process Pit
  - 100-N-29, Unplanned Release
  - 100-N-30, Unplanned Release
  - 100-N-31, Unplanned Release
  - 100-N-32, Unplanned Release
  - 100-N-33, Coal Ash Pit
  - 100-N-34, Dumping Area
  - 100-N-36, Stained Pad
  - 100-N-37, Surface Debris
  - 100-N-38, Unplanned Release
  - 100-N-47, Solid Waste
  - 100-N-53, Oil Tank
  - 100-N-54, French Drain
  - 100-N-55, French Drain
  - 100-N-57, Catch Tank
  - 100-N-59, Unplanned Release
  - 100-N-60, French Drain
  - 100-N-61, Water Treatment Pipelines
  - 100-N-62, Process Sewer Pipeline
  - 100-N-63:2, Process Sewer Pipeline
  - 100-N-64, Cooling Water Pipelines
  - 100-N-68, Unplanned Release
  - 100-N-79, Outfall
  - 100-N-81, Garnet Sand
  - 100-N-82, Decontamination Pad
  - 100-N-84:2, Fuel Pipeline
  - 100-N-84:4, Condensate Pipeline
  - 100-N-84:5, Sanitary Pipelines
  - 100-N-84:6, Process Sewer Pipeline
  - 100-N-85, Fuel Tanks
  - 100-N-86, Electrical Substation
  - 100-N-87, French Drain
  - 100-N-88, French Drain
  - 100-N-100, Stained Soils
  - 100-N-101, Stained Soils
  - 100-N-102:1, French Drains
  - 100-N-104, Spillway
  - 116-N-2, Storage Tanks
  - 116-N-4, Retention Basin
  - 118-N-1, Burial Silo
  - 120-N-3, French Drain
  - 120-N-4, Storage Pad
  - 120-N-7, French Drain
  - 124-N-1, Septic Tank
  - 124-N-2, Septic Tank
  - 124-N-3, Septic Tank
  - 124-N-4, Septic Tank
  - 124-N-9, Septic Tank
  - 124-N-10, Sewage Lagoon
  - 128-N-1, Burn Pit
  - 130-N-1:1, Discharge Pond
  - 600-35, Dumping Area
  - 600-340, Stained Soils
  - 628-2, Burn Pit
  - 1908-N, Outfall
  - 1908-NE, Outfall
  - UPR-100-N-1, Unplanned Release
  - UPR-100-N-2, Unplanned Release
  - UPR-100-N-3, Unplanned Release
  - UPR-100-N-4, Unplanned Release
  - UPR-100-N-5, Unplanned Release
  - UPR-100-N-6, Unplanned Release
  - UPR-100-N-7, Unplanned Release
  - UPR-100-N-8, Unplanned Release
  - UPR-100-N-9, Unplanned Release
  - UPR-100-N-10, Unplanned Release
  - UPR-100-N-11, Unplanned Release
  - UPR-100-N-12, Unplanned Release
  - UPR-100-N-13, Unplanned Release
  - UPR-100-N-14, Unplanned Release
  - UPR-100-N-18, Unplanned Release
  - UPR-100-N-19, Unplanned Release
  - UPR-100-N-20, Unplanned Release
  - UPR-100-N-21, Unplanned Release
  - UPR-100-N-22, Unplanned Release
  - UPR-100-N-23, Unplanned Release
  - UPR-100-N-24, Unplanned Release

- 100-N-89, French Drain
- 100-N-90, Rod Storage Cave
- 100-N-91, Surface Debris
- 100-N-93, Stained Soils
- 100-N-94, Stained Soils
- 100-N-95, Septic Tank
- 100-N-96, Dumping Area
- 100-N-97, Stained Soils
- 100-N-98, Stained Soils
- 100-N-99, Stained Soils
- UPR-100-N-25, Unplanned Release
- UPR-100-N-26, Unplanned Release
- UPR-100-N-29, Unplanned Release
- UPR-100-N-30, Unplanned Release
- UPR-100-N-31, Unplanned Release
- UPR-100-N-32, Unplanned Release
- UPR-100-N-36, Unplanned Release
- UPR-100-N-39, Unplanned Release
- UPR-100-N-42, Unplanned Release
- UPR-100-N-43, Unplanned Release

Table 2-24 summarizes the waste site cleanup status for the 100-NR-1 source OU waste sites, including metrics on work accomplished during this past 5-year period (2011 – 2015). Figure 2-21 shows the general locations and closure status as of December 2015 for waste sites in the 100-NR-1 source OU.

Remedy Implementation. The *Remedial Design Report/Remedial Action Work Plan for the 100-N Area* (DOE/RL-2005-93, Rev. 1) describes the design and implementation of remedial action processes for the for the 100-NR-1 OU, excluding the 100N TSD units.

The majority of the remedial activities in the 100-N area since 2011 have been completed. As of December 2015, only 100-N-83 remains, where RTD remediation activities are ongoing or are planned in the near term. The following remaining accepted waste sites in the 100-N area have not been reclassified:

- Subsurface soil contamination associated with the 105-N/109-N facility
- Subsurface soil associated with subsurface petroleum releases that are actively being treated
- Sites associated with active facilities (e.g., 100 Area fire station)
- Sites where cleanup decisions have been deferred to the final ROD.

Table 2-24. 100-NR-1 Operable Unit Cleanup Status.

Source OU	Number of Waste Sites[a]	Sites Dispositioned[b]			
		Pre-2011	2011 – 2015	Total	Percent Complete
100-NR-1	133	16	106	123	92
Total	**133**	**16**	**106**	**123**	**92%**

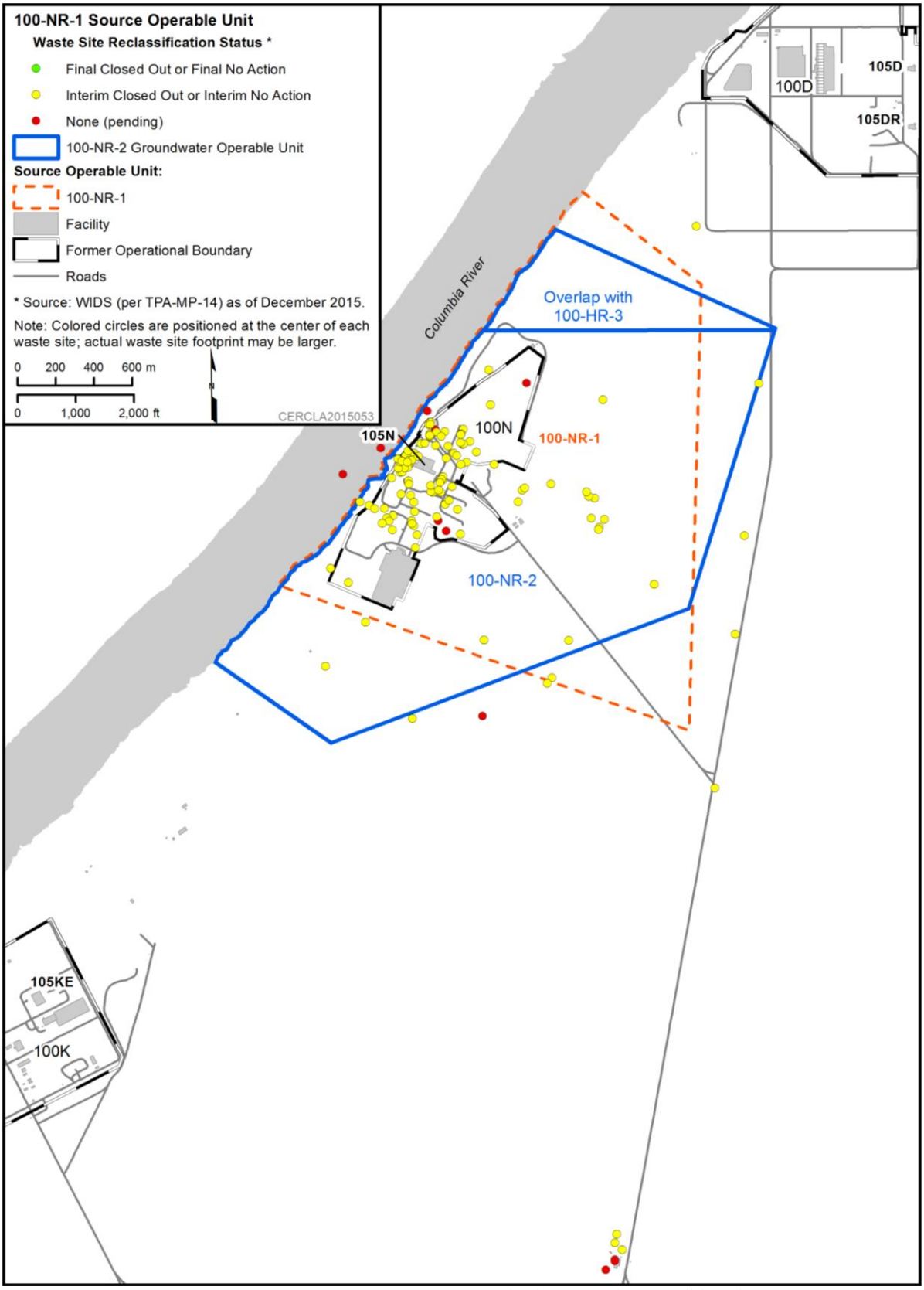
[a]Approximate number of waste sites within the OU, according to WIDS, as of December 2015. Actual numbers can and do change if sites are added to or moved from a given OU in accordance with DOE and regulatory agency approvals.

[b]Approximate number of sites dispositioned as of December 2015; includes the number of sites that have been reclassified in WIDS, as of December 2015, as either interim closed, final closed, interim no-action or final no-action in accordance with the guideline TPA-MP-14[c], *Maintenance of Waste Information Data System (WIDS)*. Slight discrepancies may exist between WIDs data and the specific waste sites listed in the table because of the time required to process and approve change requests that add or delete sites before changes are made in the WIDS.

[c]TPA-MP-14, 2011, *Maintenance of the Waste Information Data System (WIDS)*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE = U.S. Department of Energy. OU = operable unit.

ICs have been implemented and maintained during this 5-year review period to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure.



Note: Colored circles are positioned in the center of a given waste site's overall footprint.

Figure 2-21. Geographic Distribution and WIDS Reclassification Status of 100-NR-1 Source Operable Unit Waste Sites as of December 2015.

2.3.5.1.5 Technical Assessments

Is the remedy functioning as intended by the decision documents?

The interim remedy (primarily involving RTD, backfilling, revegetation, and ICs) is functioning as intended by the interim action RODs (as amended). As of December 2015, 123 of the 133 100-NR-1 source OU waste sites had been remediated. Full-scale in situ bioventing remediation operations began in 2012 and continued through this review period.

In accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS)*, the 100-NR-1 remediated waste sites have been documented in the WIDS as either interim closed or interim no-action. Cleanup verification packages (including sampling data and other technical information) to support the reclassification to interim closed and/or no-action are included in the Hanford Site Administrative Record for the 100-NR-1 source OU. The remedial action goals (contaminant-specific soil cleanup criteria developed to ensure that remedial actions to be implemented will meet the RAOs) are described in Chapter 2 of the *Remedial Design Report/Remedial Action Work Plan for the 100-N Area* (DOE/RL-2005-93, Rev. 1).

The RAOs for 100-NR-1 remediated waste sites, and the methods used for achieving the RAOs through the interim remedial actions are summarized in the following list:

- ***RAO 1. Protect human and ecological receptors from exposure to radioactive contaminants in surface and subsurface soils, structures, and debris.***

  Achieved by reducing concentrations of contaminants in the upper 4.6 m (15 ft) of soil. Soils well be removed to a depth of 1.5 m (5 ft) below the engineered structures of the 116-N-1 and 116-N-3 cribs and trenches that contain plutonium-239/240. The levels of reduction are such that the total dose does not exceed 15 millirem (mrem)/year above Hanford Site background for 1,000 years following remediation. The 1,000-year requirement ensures that the proposed standard accounts for decay of radionuclides to daughter products that are more highly radioactive.

- ***RAO 2. Protect potential human and ecological receptors from exposure to nonradioactive contaminants present in the upper 15 feet (4.6 meters) of soil and debris.***

  Achieved by reducing concentrations of contaminants in the upper 4.6 m (15 ft) of soil to the Washington State MTCA Method B levels or alternatives as allowed by MTCA.

- ***RAO 3. Protect the unconfined groundwater system from adverse impacts by reducing concentrations of radioactive and nonradioactive chemical contaminants present in the soil column that could migrate to the groundwater.***

  Achieved by reducing contaminant levels such that concentrations reaching the groundwater do not exceed the Washington State MTCA Method B levels or [maximum concentration level] MCLs.

- ***RAO 4. Protection of the Columbia River from adverse impacts so that designated beneficial uses are maintained.***

  Achieved by reducing concentrations of, or limiting exposure pathways to, contaminants present in the soil column that could migrate to the groundwater and eventually to the river. Contaminant levels were reduced so that concentrations reaching the river do not exceed MTCA Method B values, MCLs promulgated under the federal *Safe Drinking Water Act*, Washington State's DWS, ambient water quality criteria, or Washington State's Surface Water Quality Standards (including hexavalent chromium standard of 10 µg/L) (WAC 173-201A), whichever is most stringent.

- ***RAO*** 5. Prevent destruction of significant cultural resources and sensitive wildlife habitat.

  Achieved by performance of cultural and ecological reviews before the start of remedial action activities, and by restricting access to areas not directly required to complete remedial action activities.

ICs for the 100-NR-1 source OU, as required by the interim action RODs (as amended), are described in DOE/RL-2005-93, *Remedial Design Report/Remedial Action Work Plan for the 100-N Area*, Rev. 1, and are actively managed. Specific details associated with each IC have also been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 100-NR-1 OU include waste-site-specific ICs (e.g., drilling and excavation restrictions for waste sites where residual contamination remains at depth, and an irrigation restriction) and general-areas ICs including access control (warning notices, entry restrictions), land-use management (land use, drilling and excavation restrictions), and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 100-NR-1 source OU.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and the interim remedial action objectives used at the time of remedy selection are still valid. These criteria will be reviewed and updated as needed to support final remedy selection.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy for the 100-NR-1 OU.

2.3.5.1.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 100-NR-1 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.3.5.1.7 Protectiveness Statements

100-NR-1 Source OU – Will Be Protective. The remedy at the 100-NR-1 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) at the100-NR-1 source OU has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

2.3.5.2 100-NR-2 Groundwater Operable Unit

2.3.5.2.1 Background

The 100-NR-2 groundwater OU (previously shown in Figure 2-20) is 1 of 10 groundwater OUs on the Hanford Site, and 1 of 6 located in the River Corridor. Groundwater contamination in 100-NR-2 is primarily associated with waste effluents produced by the 100-N Reactor and associated waste effluents disposed of in the 100-NR-1 OU waste sites.

The N Reactor operated from 1963 to 1987 and was unique among Hanford's plutonium production reactors in that it was a dual-purpose reactor that produced plutonium for defense purposes and steam for

generating electrical power. Groundwater contamination in the 100-NR-2 OU primarily consists of strontium-90, nitrate, hexavalent chromium, and tritium produced by the reactor and associated processes. This OU also addresses a petroleum hydrocarbon (TPH) plume present in the groundwater as result of a release from a fuel storage tank in the 1960s.

Contaminants of concern for the 100-NR-2 OU include strontium-90, nitrate, TPH-diesel, hexavalent chromium, sulfate, tritium, and manganese.

Groundwater in the 100-NR-2 OU generally flows northwest toward the Columbia River. In recent years, groundwater flow was influenced by groundwater extraction and injection for the KX P&T remediation system located in the southwest portion of the 100-NR-2 OU. A groundwater mound approximately 1 m high surrounding the KX injection wells creates local radial flow.

Current activities in the 100-NR-2 OU area are industrial in nature and primarily focused on remediation. Access to the waste site areas and contaminated groundwater is restricted. The Columbia River (adjacent to 100-NR-2 OU) is used for recreational activities such as fishing, and boating, and supports a large variety of aquatic and riparian animals and plants.

A summary of the 100-NR-2 groundwater is included in each of the following reports:

- *Hanford Site Groundwater Monitoring Report* published annually to address the previous calendar year and available on line at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.
- *Annual Summary Report for the 100-HR-3 and 100-KR-4 P&T Operations and 100-NR-2 Groundwater Remediation* for each prior year can be accessed through the same link at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

Additional CERCLA documentation associated with the 100-NR-2 groundwater OU, as well as other OUs, can be accessed directly or queried in the Administrative Record for the Hanford Site's OUs and TSD units, at the following address:
http://pdw.hanford.gov/arpir/index.cfm/predefinedSearch?canType=OpUnit.

2.3.5.2.2 Chronology

Table 2-25 lists the remedial action decision documents associated with the 100-NR-2 groundwater OU.

Table 2-25. Decision Documents for the 100-NR-2 Groundwater Operable Unit.

Date	Location	Title
9/1994	Ecology and EPA 1994	***Action Memorandum: N Springs Expedited Response Action Cleanup Plan.*** This ERA identifies a P&T system combined with a vertical barrier for implementation at N Springs. These systems are a component of overall N Springs cleanup, but also were intended to provide additional information to the ongoing CERCLA and RCRA processes. This ERA is not a final decision.
9/1999	EPA/ROD/R10-99/112	***Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington.*** Continue removing strontium-90 through P&T with ion exchange and discharge treated groundwater upgradient into the aquifer, maintain groundwater monitoring networks to monitor P&T operations and impacts to groundwater, evaluate technologies for strontium-90 removal and aquatic and riparian receptor impacts from contaminated groundwater, remove petroleum hydrocarbons (free-floating product) from any monitoring well and dispose of at an approved facility, remove petroleum-contaminated solid waste, and dispose of non-hazardous wash/rinse waters to Ecology-approved facilities.

Table 2-25. Decision Documents for the 100-NR-2 Groundwater Operable Unit.

Date	Location	Title
5/2003	EPA/ESD/R10-03/605	***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.*** This ESD removes the IC annual reporting requirements and consolidates reporting with the Sitewide IC annual report, eliminates requirement to evaluate applying 30 in. of irrigation water to determine whether remaining contaminants will impact groundwater, and identifies a need for additional ICs to preclude access to contaminated groundwater; these will be incorporated into the Sitewide IC document.
9/2010	EPA 2010	***U.S. Department of Energy, 100-NR-1 and NR-2 Operable Units, Hanford Site – 100 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary.*** This amended ROD summary deploys an apatite sequestration technology for remediating strontium-90 in the 100-NR-2 OU by extending the existing apatite permeable reactive barrier to approximately 2,500 ft, allows for deployment of the apatite sequestration technology elsewhere in the 100-NR-2 OU in accordance with an Ecology-approved work plan, and includes decommissioning the treatment components of the existing 100-NR-2 P&T system.

CERCLA = *Comprehensive Environmental Response, Compensation and Liability Act of 1980*.
Ecology = Washington State Department of Ecology.
ERA = expedited response action.
ESD = explanation of significant difference.
IC = institutional control.
O&M = operation and maintenance.
OU = operable unit.
P&T = pump and treat.
RAO = remedial action objective.
RCRA = *Resource Conservation and Recovery Act of 1976.*
ROD = record of decision.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

2.3.5.2.3 Remedial Actions

Goals and Objectives. In accordance with the NCP, "EPA expects to return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site" (40 CFR 300.430[a][1][iii][F]). EPA generally defers to state definitions of groundwater classification provided under EPA-endorsed Comprehensive State Groundwater Protection Programs (EPA/540/G-88/003).

Groundwater from the 100-NR-2 OU is contaminated and is not currently withdrawn from the aquifer for beneficial use; however, the highest potential beneficial use of the groundwater is as a drinking water source. Consistent with the beneficial-use classifications of Washington State and the EPA, the goal for remediating 100-NR-2 OU groundwater is to reduce contaminants to levels that will allow its use as a future drinking water source.

Based on the expectations for 100-NR-2 groundwater restoration, the interim RAOs, as stated in the interim remedial action ROD (EPA 1999 as amended), are as follows:

- ***RAO 1. Protect the Columbia River from adverse impacts from the 100-NR-2 groundwater so that designated beneficial uses of the Columbia River are maintained.*** *Protect associated potential human and ecological receptors using the river from exposure to radioactive and nonradioactive contaminants present in the unconfined aquifer. Protection will be achieved by limiting exposure pathways, reducing or removing contaminant sources, controlling groundwater movement, or reducing concentrations of contaminants in the unconfined aquifer.*

- ***RAO 2. Protect the unconfined aquifer by implementing remedial actions that reduce concentrations of radioactive and nonradioactive contaminants present in the unconfined aquifer.***
- ***RAO 3. Obtain information to evaluate technologies for Sr-90 removal and evaluate ecological receptor impacts from contaminated groundwater (by October 2004).*** [*NOTE: In accordance with DOE/RL-2001-27, Rev. 1, this RAO was achieved with the issuance of FH-0403540, "Transmittal of the Draft Letter Report, Evaluation of Strontium-90 Treatment Technologies for the 100-NR-2 Groundwater Operable Unit," and DOE/RL-2006-26, *Aquatic and Riparian Receptor Impact Information for the 100-NR-2 Groundwater Operable Unit*. In 2006, Ecology, EPA, and DOE approved placing the P&T system in cold-standby status and constructing a permeable reactive barrier. A 90 m-long apatite permeable reactive barrier (PRB) was completed as a treatability test in accordance with DOE/RL-2005-96, *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater Operable Unit*. Based on the treatability test results (PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*; PNNL-SA-70033, *100-NR-2 Apatite Treatability Test FY09 Status: High-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*), the apatite technology showed promise as a remediation option. As a result, the interim action ROD was amended in 2010 to allow for expansion of the apatite barrier and permanent decommissioning of the 100-NR-2 P&T system.]
- ***RAO 4. Prevent destruction of sensitive wildlife habitat.*** *Minimize the disruption of cultural resources and wildlife habitat in general and prevent adverse impacts to cultural resources and threatened or endangered species.*

Remedy Components. The current interim action is a blend of remedy components that were first identified in the initial interim action ROD (EPA/ROD/R10-99/112), then amended by *U.S. Department of Energy 100-NR-1 and NR-2 Operable Units, Hanford Site – 100 Area, Benton County, Washington* (EPA 2010) to include new activities while retaining some of the original remedy components. A consolidated description of the remedy components can be found in the *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, latest version as of publication date of this 5-year review (DOE/RL-2001-27). This RD/RAWP was approved by both DOE and Ecology (the Tri-Party Agreement lead regulating agency for the 100-NR-2 OU) in September 2014. For purposes of this 5-year review, selected and, for some remedy components, abbreviated narrative from the RD/RAWP were used as the primary source for the following remedy components descriptions.

Extend Apatite Permeable Reactive Barrier (PRB). Extend the length of the existing apatite PRB from 990 m (300 ft) to approximately 760 m (2,500 ft). Perform additional apatite injections at a subset of injection well locations within 5 years of completing all first round apatite injections, as determined through performance monitoring of the PRB in both the saturated and vadose zones.

Decommission the P&T System. Concurrent with or following extension of the apatite PRB, DOE will decommission the treatment components of the existing 100-NR-2 OU groundwater P&T system. The decommissioning work will include removing any residual ion exchange media and disposing of it at ERDF, dismantling all noncontact treatment system hardware and salvaging reusable components, and cutting the high-density polyethylene conveyance piping into short lengths for transport to and disposal at ERDF. Wells will remain in place and be reconfigured as monitoring wells. The status of the decommissioning work will be provided at unit managers' meetings and summarized in a future Hanford Site groundwater monitoring and performance report or an interim action status report.

Perform Groundwater Monitoring. Long-term and routine monitoring for the 100-NR-2 OU under CERCLA are ongoing, conducted in accordance with approved sampling and analysis plans (SAP), and further described in DOE/RL-2001-27, latest version as of publication date.

Allow MNA for Strontium-90 in Groundwater Up-gradient of the PRB. MNA is the reliance on natural processes, within the context of a carefully controlled and monitored cleanup, to reduce the mass, toxicity, mobility, volume, and/or concentration of contaminants in affected media. MNA will play an important role in upland groundwater remediation of strontium-90 (radioactive decay and sorption to aquifer materials). Because strontium-90 is strongly retarded and has a relatively short half-life, the majority of the strontium-90 present in the aquifer and associated sediments upgradient of the apatite PRB will attenuate in place through radioactive decay. MNA will be used to monitor this plume and confirm

that strontium-90 concentrations decline as expected; it also will be used to monitor and confirm the rate of natural degradation. Monitoring of the MNA will be conducted in accordance with the well network and schedule outlined in EPA/ROD/R10-99/112. Long-term monitoring results will be presented in future Hanford Site groundwater monitoring and performance reports.

Remove Free-Phase Petroleum Hydrocarbon. EPA/ROD/R10-99/112 requires the remediation of free-phase hydrocarbon product (i.e., diesel) observed in any 100-N Area monitoring well. Normally, petroleum product cleanup is regulated under RCRA corrective action, not CERCLA remedial action. However, as discussed in the Tri-Party Agreement (Ecology et al. 1989), the CERCLA remedial actions will meet the technical requirements of RCRA corrective actions. This remedy element currently consists of removing TPH-diesel from well 199-N-18. If TPH-diesel is observed in other wells, this remedy would apply in those cases. The passive remediation approach involves the use of a polymer (Smart Sponge[d]) that selectively absorbs petroleum product from the surface of water. Every 2 months, 2 sponges are lowered to the surface of the water table in well 199-N-18. The sponges are weighed both before insertion and after removal from the well; the difference in weight represents the amount of diesel fuel contamination removed from the well.

Institutional Controls. The remedy selected in EPA/ROD/R10-99/112 requires the maintenance of ICs. The following ICs are required as part of the interim action ROD, as amended):

- DOE will continue to use a badging program and control access to the sites associated with the interim action ROD for the duration of the interim action. Visitors entering any of the sites associated with the interim action ROD must be escorted at all times.
- DOE will use the onsite excavation permit process to control land use, well drilling, and soil excavation within the 100 Area OUs to prohibit any drilling or excavation except as approved by Ecology.
- DOE will maintain existing signs prohibiting public access.
- Trespass incidents will be reported to the Benton County Sheriff's Office for investigation and evaluation for possible prosecution.
- DOE will notify Ecology on discovery of any trespass incidents.
- DOE will take the necessary precautions to add access-restriction language to any land transfer, sale, or lease of property that the U.S. Government considers appropriate while ICs are compulsory and Ecology will have to approve any access restrictions before transfer, sale, or lease.
- Until final remedy selection, DOE shall not delete or terminate any IC requirement established in the interim action ROD unless Ecology has provided written concurrence on the deletion or termination and appropriate documentation has been placed in the Administrative Record.

DOE shall evaluate the implementation and effectiveness of ICs for the 100-NR-1 source OU on an annual basis. DOE shall submit a report to EPA and Ecology, as required by DOE/RL-2001-41, summarizing the results of the evaluation for the preceding calendar year. At a minimum, the report shall contain an evaluation of whether the IC requirements continue to be met and describe any deficiencies discovered and corrective measures taken.

Maintain Riprap Cover. DOE will maintain the existing riprap cover placed over the historical groundwater seeps and springs along the shoreline. Maintenance will consist of periodic visual monitoring of the riprap cover along the shoreline and replacing any eroded cover material. Any maintenance performed will be described in future annual Hanford Site groundwater monitoring and performance reports.

Remedy Implementation Progress Prior to this Review Period. The 100-NR-2 remediation scope began with a P&T system to remove strontium-90 from groundwater. The P&T system operated from 1995 to 2006, when the system was placed into cold-standby status to facilitate a treatability test for

[d]Smart Sponge is a trademark of AbTech Industries, Scottsdale, Arizona.

construction of an apatite PRB along the 100-N Area shoreline. Based on the treatability test results, the apatite technology showed promise as a remediation option. The initial apatite PRB was constructed from 2006 through 2008 for the treatability test, which placed a 91 m (300-ft)-long apatite PRB along the 100-N area shoreline. The Tri-Party Agencies amended the interim action ROD in 2010 to allow for permanent decommissioning of the 100-NR-2 OU P&T system and expansion of the existing PRB from approximately 91 m (300 ft) long to 760 m (2,500 ft) long. Additional detail on this earlier period of remediation can be found in the previous 5-year review report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070).

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for the 100-NR-2 OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous (2006-2010) 5-year review report for the 100-NR-2 groundwater OU was as follows:

> *A protectiveness determination of the remedy at 100-NR-2 Groundwater OU cannot be made at this time until further information is obtained. Further information will be obtained by completing the Jet Injection Design Optimization Study for 100-NR-2 Groundwater Operable Unit (DOE/RL-2010-68). With the completion of the optimization study and selection of the final remedy, a protectiveness determination will be made for 100-NR-2 Groundwater OU. It is expected that completion of the design optimization will take approximately two years to complete. Institutional controls required by the ROD for interim action prevent human exposure to contaminants.*

2.3.5.2.4 Progress Since the 2011 Review

Accomplishments. The primary remedial action accomplishments for the 100-NR-2 groundwater OU during the past 5 years can be summarized as follows:

- Continued groundwater monitoring and management of ICs as interim remedy components under the interim action ROD
- Apatite-forming chemical injections were conducted in September 2011 to treat an additional 107 m (350 ft) upriver and downriver of the existing apatite PRB, expanding the treated length of the PRB from 91 m (300 ft) to 305 m (1,000 ft)
- Continued performance of interim actions for cleanup of strontium-90 and TPH-diesel in 100-NR-2 groundwater. Additionally, the following document-related accomplishments during this five-year review period are worth noting:
  - Submitted DOE/RL-2012-15, *Remedial Investigation Feasibility Study for 100-NR-1 and 100-NR-2 Operable Units*, Draft A, to Ecology for review in 2013, and submitted revised sections in 2014 based on comments
  - Issued DOE/RL-2001-27, *Remedial Design Report/Remedial Action Work Plan for the 100--NR-2 Operable Unit*, Rev. 1, in 2014 to include chemical injection treatment and performance monitoring for buildout of the full 760 m (2,500 ft) PRB.

Submitted DOE/RL-2001-27, *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, Rev. 2, Draft A, in 2015 to update the sampling and analysis plan in Appendix A. Revision 2 of the RD/RAWP, DOE/RL-2001-27 was approved and issued in July 2016. Additional narrative on 100-NR-3 OU accomplishments relative to each ROA (as of 2015) can be viewed in DOE/RL-2016-19, *Calendar Year 2015 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*.

Remedy Implementation. Implementation of the interim remedy components was conducted under the RDR/RAWP for the 100-NR-2 OU (DOE/RL-2001-27). While detailed status about the implementation of the 100-NR-2 OU remedy components is routinely provided in the Hanford Site's annual groundwater monitoring report (e.g., DOE/RL-2015-07) and DOE/RL-2014-25, *Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump-and-Treat Operations, and 100-NR-2 Groundwater Remediation*, the following is a summary-level overview.

Extend Apatite Permeable Reactive Barrier. When the expedited response action for N Springs was issued in 1994, the approved cleanup alternative for strontium-90 in groundwater involved applying P&T and a vertical barrier. The 100-NR-2 groundwater P&T system was constructed in 1995 and operated from 1995 until 2006. The system removed approximately 1.8 Ci of strontium-90 from the aquifer, which was less than the amount removed by radioactive decay during the same period. Because strontium-90 binds strongly to the sediment, the P&T system was not effective in removing strontium-90 from the aquifer. One of the requirements of the interim action ROD was to evaluate alternative technologies for groundwater cleanup. Therefore, in 2006, Ecology, EPA, and DOE approved placing the P&T system in cold standby status and constructing a PRB. A 90 m (300-ft)-long apatite PRB was completed as a treatability test in accordance with DOE/RL-2005-96, *Strontium-90 Treatability Test Plan for 100-NR-2 Groundwater Operable Unit*.

Based on the treatability test results (PNNL-17429, *Interim Report: 100-NR-2 Apatite Treatability Test: Low-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization*; PNNL-SA-70033, *100-NR-2 Apatite Treatability Test FY02 Status: High-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization, Interim Report*), the apatite technology showed promise as a remediation option. As a result, the interim action ROD was amended in 2010 to allow for expansion of the apatite barrier and permanent decommissioning of the 100-NR-2 P&T system.

The original, 90 m (300-ft)-long apatite PRB was created by injecting apatite-forming solutions into 16 wells from 2006 through 2008 (PNNL-19572, *100-NR-2 Apatite Treatability Test: High-Concentration Calcium-Citrate-Phosphate Solution Injection for In Situ Strontium-90 Immobilization, Final Report*). The expanded apatite PRB well network was installed between late 2009 and early 2010, extending the original barrier well network both upriver and downriver for a total length of 760 m (2,500 ft). No apatite solutions were injected into these wells during the expansion of the barrier well network.

In September 2011, apatite solutions were injected into 24 wells upriver and 24 wells downriver of the original barrier in accordance with DOE/RL-2010-29, *Design Optimization Study for Apatite Permeable Reactive Barrier Extension for the 100-NR-2 Operable Unit*, extending the length of the apatite PRB to approximately 300 m (1,000 ft). These injections extended the apatite PRB along the 100-N shoreline to intercept the strontium-90 groundwater plume before it reaches the river. During 2015, performance of all three barrier segments (upriver, central [original], and downriver) was monitored.

In 2009, a field demonstration was completed to evaluate potential strategies for jet injection of three different media:

- A phosphate-only solution
- Preformed apatite
- Phosphate combined with preformed apatite (SGW-47062, *Treatability Test Report for Field-Scale* A*patite Jet Injection Demonstration for the 100-NR-2 Operable Unit*).

The injections were conducted upgradient of the existing apatite PRB within a moderate-concentration region of the strontium-90 plume. The solutions were injected into the vadose zone and the upper portion of the unconfined aquifer. Sediment cores were collected from four boreholes located within the test plot footprints. Results from collected sediment cores indicated that jet injection is a viable method for emplacing phosphate and preformed apatite in the vadose zone. The details of the core analyses are provided in PNNL-19524, *Hanford 100-N Area In Situ Apatite and Phosphate Emplacement by Groundwater and Jet Injection: Geochemical and Physical Core Analysis*.

Based on the results from the treatability tests documented in SGW-47062, DOE/RL-2010-68, *Jet Injection Design Optimization Study for 100-NR-2 Groundwater Operable Unit*, was developed. DOE/RL-2010-68 includes a detailed design for the vertical extension of the PRB into the unsaturated vadose zone.

Apatite solutions have not been jet-injected in the vadose zone. Plans for further expansion of the apatite barrier via saturated zone and vadose zone injections and associated PRB performance monitoring are outlined in DOE/RL-2001-27, latest version. The barrier was expanded in accordance with a design optimization study (DOE/RL-2010-29), which had seven objectives for evaluating barrier implementation and effectiveness. Data from the injections and subsequent performance monitoring are used to evaluate these objectives.

Decommission the Pump and Treat System. The in-well P&T equipment (e.g., pumps) has been removed. The P&T system buildings and components have not yet been decommissioned. In accordance with DOE/RL-2001-27, decommissioning planning was initiated in 2014 and demolition was completed in 2016.

Perform Groundwater Monitoring. Groundwater is monitored at four waste sites to meet requirements of RCRA and WAC 173-303, "Dangerous Waste Regulations." RCRA monitoring continues under final status detection programs at the 1301-N, 1324-N/NA, and 1325-N facilities (waste sites 116-N-1, 120-N-1, 120-N-2, and 116-N-3). Results continued to indicate no releases of dangerous waste constituents from the RCRA units during this review period (DOE/RL-2016-09, *Hanford Site Groundwater Monitoring Report for 2015*). Performance monitoring of the PRB continued during high-river and low-river stages with details provided in the annual groundwater monitoring reports.

Allow MNA for Strontium-90 in Groundwater Upgradient of the PRB. Strontium-90 in the aquifer is naturally attenuating through radioactive decay. Groundwater monitoring wells are periodically sampled to assess the ongoing decline in contaminant concentrations within the groundwater OU.

Remove Free-Phase Petroleum Hydrocarbon. TPH-diesel groundwater contamination is the result of a 1966 diesel fuel spill at unplanned release site UPR-100-N-17. Removal of petroleum hydrocarbon light, nonaqueous-phase liquid from well 199-N-18 continued. In 2015, 1,050 g of diesel were removed from well 199-N-18. Total product removal since this activity began in October 2003 through the end of 2015 is 14 kg).

Institutional Controls. Implemented ICs include entry restrictions (security), escorts, and badging of site visitors, drilling and excavation restrictions, surveillance, posted signs, and deed notifications to restrict land and groundwater use (DOE/RL-2001-27).

Maintain Riprap Cover. The riprap cover was placed over the groundwater seeps and springs to prevent erosion of the river shoreline. Maintenance, which could include moving or adding riprap, will be conducted if needed to prevent erosion of the river shoreline (DOE/RL-2001-27). The existing riprap cover is being maintained and no issues have been noted during this review period (DOE/RL-2016-19).

Table 2-26 presents an overview of the primary components of the 100-NR-2 remedy and their implementation status.

Table 2-26. Overview of 100-NR-2 Operable Unit Interim Action Remedy Implementation.

Document Type	Date	Title
Interim Action ROD	9/1999, amended 9/2010	(EPA 2010), *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington*
RD/RAWP	07/2016	(DOE/RL-2001-27), *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit, latest version as of publication.*

Table 2-26. Overview of 100-NR-2 Operable Unit Interim Action Remedy Implementation.

Document Type	Date	Title
Applicable RAOs (brief description)	**1.** Protect the Columbia River from adverse impacts from the 100-NR-2 groundwater OU so designated beneficial uses of the Columbia River are maintained. Protect associated potential human and ecological receptors using the river from exposure to radioactive and nonradioactive contaminants present in the unconfined aquifer. Protection will be achieved by limiting exposure pathways, reducing or removing contaminant sources, controlling groundwater movement, or reducing concentrations of contaminants in the unconfined aquifer. **2.** Protect the unconfined aquifer by implementing remedial actions that reduce concentrations of radioactive and nonradioactive contaminants present in the unconfined aquifer. **4.** Restore groundwater impacted by Hanford Site releases to cleanup levels that include DWSs, within a reasonable timeframe given the particular circumstances of the site.	
COCs	Strontium-90, nitrate, TPH-diesel, hexavalent chromium, and tritium	

Remedy Component	**Construction Status** (approximate percentage complete for constructing/implementing the remedy component as of December 2015)[a]						**Duration of O&M** (~years)[b]	**Finish** (Est'd year)[c]
	0	**1-25**	**26-50**	**51-75**	**76-99**	**100%**		
Extend Apatite Barrier to 2,500 ft							N/A	2018
Decommission Pump & Treat System							N/A	2016
Groundwater Monitoring							115	2125
MNA for Sr-90 (upgradient)							300	2310
Remove Total Petroleum Hydrocarbons							TBD	TBD
Institutional Controls							300	2310
Maintain Riprap Cover							300	2310

[a]Percentages reflect construction status of the remedy component; post-startup upgrades and system performance optimization is considered part of O&M. 100% = fully implemented and now in O&M mode.
[b]Approximate number of years to operate remedy component as estimated in ROD (shorter durations for certain COCs) or RD/RAWP.
[c]Estimated year when remedy component will be completed.

COC = contaminant of concern.
DWS = drinking water standards.
MNA = monitored natural attenuation.
N/A = not applicable.
O&M = operation and maintenance.
OU = operable unit.
RAO = remedial action objectives.
RDR/RAWP = remedial design report/remedial action work plan.
ROD = record of decision.
TBD = to be determined.
TPH = total petroleum hydrocarbon.

2.3.5.2.5 Technical Assessment

Is the remedy functioning as intended by the decision documents?

No, the interim remedy is not completely functioning as intended because it is still in the process of being implemented. The P&T remedy selected in the 1999 ROD did not function within the specified remedial action objectives; as a result, the 1999 ROD was amended. The 2010 amended-ROD revised the selected interim remedial action for the strontium‑90 groundwater contamination in the 100-NR-2 OU. The amended-ROD selected the permeable reactive barrier technology to sequester strontium-90 (supporting achievement of RAO 1). The monitoring results for the current 1,000-ft-long PRB remedy indicate that the barrier shows promise in meeting the remedial action objectives. Field construction of the current remedy components to extend the apatite barrier and decommission and demolish the P&T facility will continue beyond this 5-year review period. Remedy components involving groundwater monitoring, MNA for strontium-90, removal of TPHs, ICs, and maintenance of the N Springs riprap cover have been implemented.

Table 2-27 provides an overview of 100-NR-2 contaminant plume areas and associated changes to the areas during this 5-year review period. The network of wells sampled in 2015 is shown in Figure 2-22.

Plume maps in Figure 2-23 show the changes in plume shapes and areas during this 5-year review period. The plots in Figure 2-24 depict the estimated annual changes in contaminant plume areas over the past several 5-year periods. The strontium-90 plume area has been relatively constant since 2003. The nitrate plume area has decreased slightly during the past 5 years. The TPH-diesel shoreline impact of 60 m reflects a change in assumptions made while preparing plume maps (starting in 2013); the shoreline impact was noted in 2012 as 0, in 2013 as 55 m, and in both 2014 and 2015 as 60 m; yet, overall concentrations have decreased as a result of full-scale bioventing that began in 2012. Hexavalent chromium continued to be detected below the 48 µg/L MTCA standard in wells approximately 750 m (2,500 ft) inland from the N Reactor and northeast around the upgradient portion of the 116-N-3 waste site. This chromium is not believed to be associated 100-NR waste sites. This chromium contamination migrated inland while the 116-K-2 trench was in use and a groundwater mound was present. A portion of this 100-KR chromium plume has migrated northward into the 100-NR area. Only one well in the 100-N Area, well 199-N-80, had dissolved chromium above the federal DWS (100 µg/L) in 2015; this water-bearing zone has not been identified in surrounding wells and boreholes and is not believed to be laterally continuous. Sulfate has been detected in wells at concentrations slightly above the secondary drinking water standard of 250 mg/L. The maximum concentration in 2015 was 290 mg/L. The source may be associated with an earlier unplanned release of diesel and may be an oxidation byproduct of the diesel from bioremediation (i.e., bioventing with oxygen) being used at the waste site. While the tritium plume area was not calculated because tritium is infrequently detected at concentrations greater than 20,000 pCi/L, one aquifer tube cluster has shown elevated concentrations since 2013. This suggests that an isolated slug of tritium is moving through the area as a result of a recent deep excavation and the addition of dust-suppression water at waste sites between the reactor and the river (DOE/RL-2015-07).

Table 2-27. Overview of 100-NR-2 Groundwater Contaminant Plumes.[a]

Groundwater Contaminant	Water Quality Standard	Maximum Concentration (2015)	Plume Area[b] (km^2)			Shoreline Intersection[c] (m)		
			2011	2015	Change	2011	2015	Change
Strontium-90	8 pCi/L[d]	13,600 pCi/L	0.57	0.64	0.07	620	670	50
Nitrate	45 mg/L[e]	308 mg/L	0.57	0.55	-0.02	150	80	-70
Diesel (as total petroleum hydrocarbons)	0.5 mg/L[f]	6.40 mg/L	N/A	0.02	N/C	0	60	60
Hexavalent Chromium	48 µg/L/ 10 µg/L[g]	149/120 µg/L[h]	U/0.17	0.0/0.49[i]	U/0.32	None	0	N/A
Sulfate	250 mg/L[d]	290 mg/L	N/C	N/C	N/A	0	0	N/A
Tritium	20,000 pCi/L[d]	876,000 pCi/L	0	N/C[j]	N/A	0	N/C[j]	N/C

[a]Source: Hanford annual groundwater monitoring reports for 2011 and 2015, available at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.
[b]Estimated area at a concentration greater than the listed cleanup level.
[c]Length of Columbia River shoreline at 100-NR that is intersected by contaminant plumes.
[d]Drinking water standard; secondary drinking water standard for sulfate
[e]45 mg/L (expressed as the NO_3 ion) is an equivalent concentration to the federal drinking water standard for nitrate of 10 mg/L (expressed as NO_3-N). To convert nitrate as the NO_3 ion, the NO_3-N drinking water standard value is multiplied by 4.43.
[f]MTCA Method A for TPH-diesel range organics.
[g]48 µg/L MTCA standard, 10 µg/L surface water standard per *Washington Administrative Code* [WAC] 173 201A, "Water Quality Standards for Surface Waters in the State of Washington."
[h]Total chromium (filtered) and hexavalent chromium values are listed.
[i]Includes one hexavalent chromium plume completely within 100-NR area. Excludes plume partially within 100-KR area as it is believed to have origins in 100-KR area.
[j]Plume area not calculated due to infrequent detection of tritium greater than 20,000 pCi/L. Shoreline impact not calculated because tritium was detected above 20,000 pCi/L in only one aquifer tube cluster.

DWS = drinking water standards.
MTCA = "Model Toxics Control Act."
N/A = not applicable.
N/C = not calculated.
TPH = total petroleum hydrocarbon.
U = undefined.

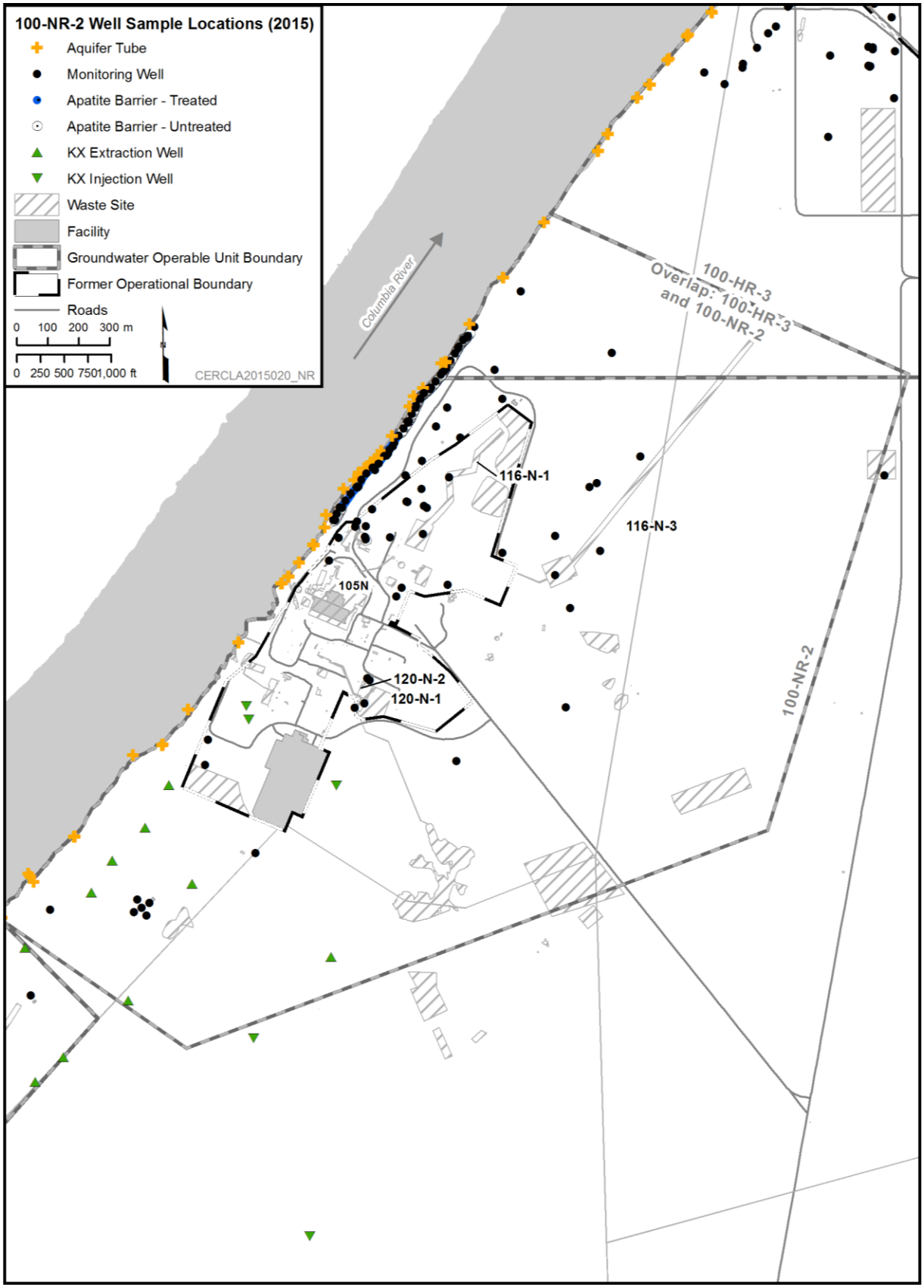
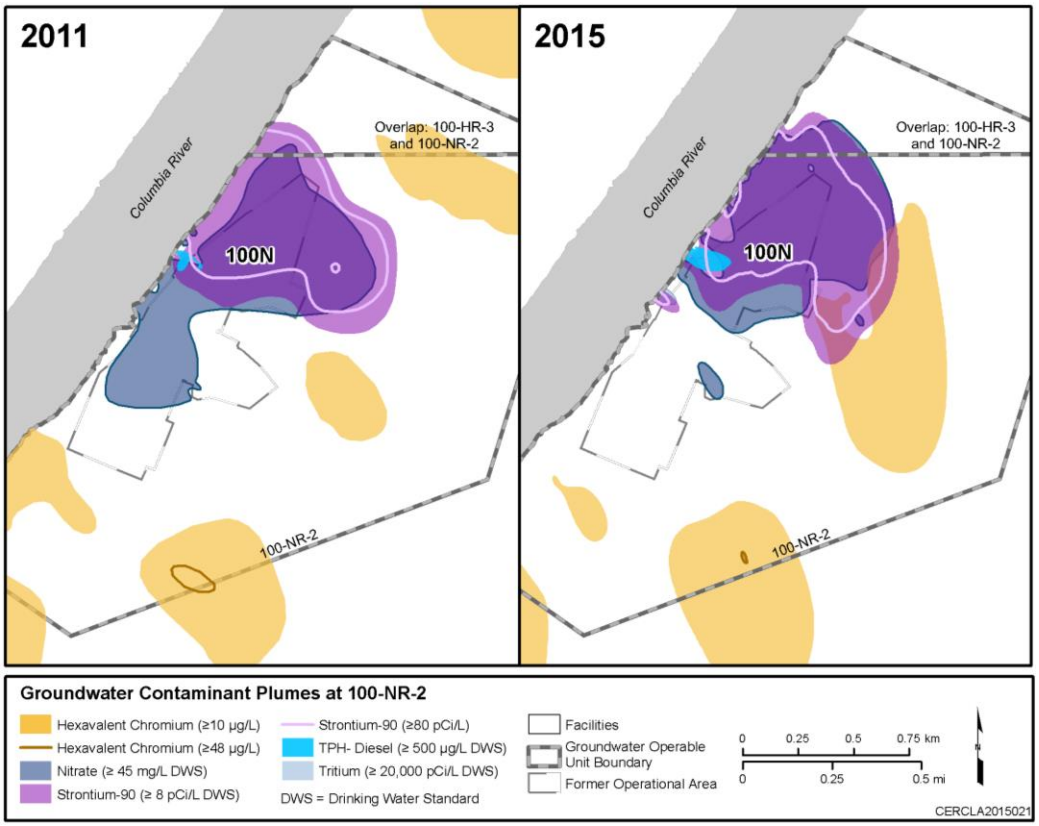


Figure 2-22. Locations of 100-NR-2 Wells and Aquifer Tubes Sampled in 2015.



2011 TPH Diesel plume is shown at ≥ 200 µg/L.

Figure 2-23. 100-NR-2 Groundwater OU Plumes in 2011 (left) and 2015 (right).

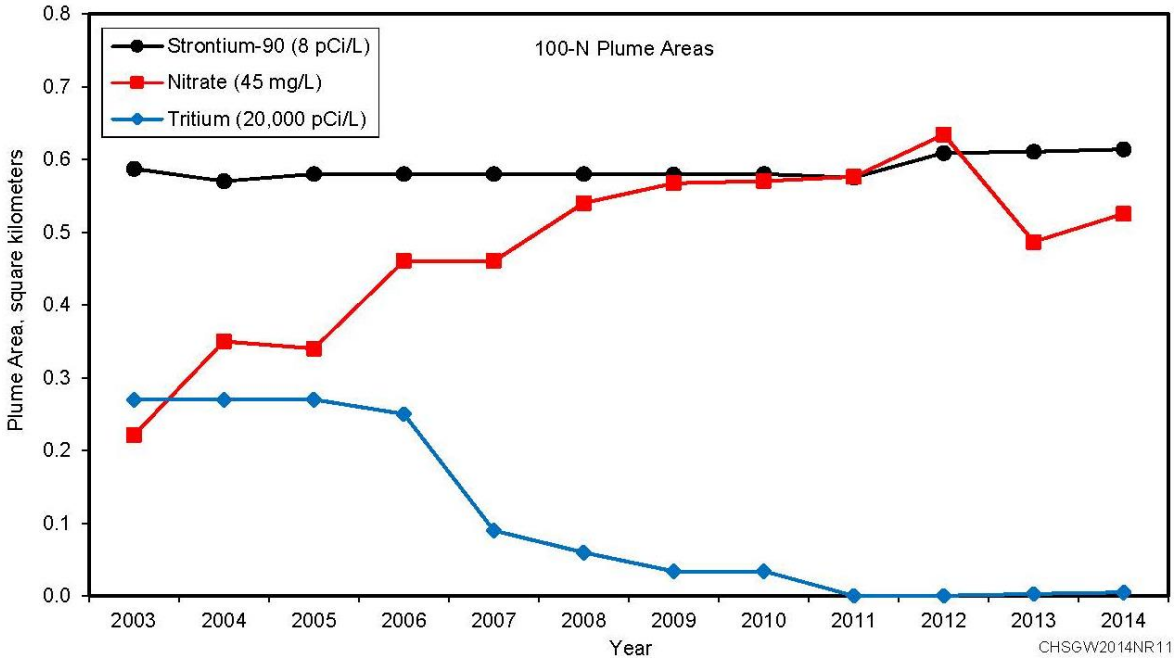


Figure 2-24. 100-NR-2 Trend Plots of Contaminant Plume Areas (2003 – 2015).

More detailed information on the 100-NR-2 groundwater OU well locations, distribution of contaminant concentrations within each plume, and historic trends associated with each 100-NR-2 OU COCs, as well as for performance metrics associated with 100-NR-2 OU groundwater treatment, is available in *Hanford*

Site Groundwater Monitoring Report (published each summer for the previous calendar year). The reports are available at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

Approximately 330 m (1,000 ft) of the apatite PRB has been treated since 2011. As of 2015, the strontium-90 concentrations were still considerably lower in the wells monitored along the central segment of the barrier than before the injections started in 2008. The treatability test plan objective for the PRB was a 90-percent reduction in strontium-90 concentrations in the performance monitoring wells; this objective has not yet been fully met. The 2015 data indicate that the strontium-90 concentrations in 2 of the 4 wells monitored along the central section of the barrier have been reduced by approximately 90 percent. Depending on the time of year, the percent reduction in strontium-90 in all 4 wells ranged from 76 percent to 95 percent. In 2015, the percent reduction in strontium-90 concentration in wells along the upriver barrier extension ranged from 26 percent to 97 percent. The downriver barrier segment wells indicated strontium-90 reductions from 65 percent to 96 percent from preinjection concentrations in 2 of the 4 monitoring wells; the other 2 monitoring wells showed increasing trends in 2015 and rebounded to preinjection concentrations in the fall of 2015. Ongoing monitoring will allow the determination of the continued effectiveness of the apatite barrier and support decisions regarding additional future apatite treatments and need for reinjection.

Per DOE/RL-2016-19, the following status applies to 100-NR-2 as of December 2015, relative to each RAO.

- ***RAO 1. Protect the Columbia River from adverse impacts from the 100-NR-2 OU groundwater so designated beneficial uses of the Columbia River are maintained.***
  - The PRB captures strontium-90 contamination moving in groundwater along the section of the 100-N area shoreline with the highest historical groundwater contamination. Apatite solutions were injected in wells of the central (original) barrier segment from 2006 to 2008 and in wells of the upriver and downriver segments in 2011. Strontium-90 concentrations in some monitoring wells near the apatite PRB temporarily increased in response to the apatite injections. The concentrations in the majority of the monitoring wells in 2015 were lower than preinjection levels by at least 90 percent. However, in 2015 concentrations of strontium-90 have increased in some of the monitoring wells, and are close to preinjection levels in two monitoring wells. DOE plans to expand the PRB in the future.
  - The TPH-diesel plume bioremediation and free-product removal continues to reduce the contaminant mass in groundwater and the lower vadose zone that could eventually affect the river.
- ***RAO 2. Protect the unconfined aquifer by implementing remedial actions that reduce concentrations of radioactive and nonradioactive contaminants in the unconfined aquifer***.
  - The P&T system was not effective at removing strontium-90 from the groundwater because strontium-90 strongly adsorbs to sediment grains; therefore, the P&T system was placed in cold-standby status on March 9, 2006.
  - The apatite PRB was installed along the section of the 100-N area shoreline with the highest historical groundwater contamination. The injection design provides emplacement of sufficient apatite in the PRB to sequester the strontium-90 flux to the river long enough for the upland strontium-90 groundwater contamination to decay naturally.
  - Smart Sponges have been deployed in well 199-N-18 to remove TPH-diesel free product; 14 kg has been removed since 2003. A full-scale bioventing system for remediation of TPH-diesel in the deep vadose zone was implemented in December 2012 and continued to operate in 2015.

- ***RAO 3. Obtain information to evaluate technologies for strontium-90 removal and evaluate ecological receptor impacts from contaminated groundwater.***
  - A 311 m (1,020-ft)-long apatite PRB is installed near the Columbia River shoreline. The remainder of the planned PRB extension to approximately 760 m (2,500 ft) will be performed in the future.
  - In addition to the apatite PRB, three other types of strontium-90 remediation technologies were tested for potential use in the 100-NR-2 OU. Passive infiltration did not prove to be a viable method for emplacement of apatite-forming chemicals along the 100-N area shoreline. Jet injection tests showed that the technology could effectively place apatite or apatite-forming chemicals into the upper vadose zone with good coverage. Phytoextraction has the potential to remove strontium-90 from the shoreline area, as demonstrated by greenhouse and laboratory (growth chamber) studies of strontium-90 uptake, and field studies in a contaminant-free location at the 100-K area. No additional work on these technologies occurred in 2015.
  - Technologies for remediation of strontium-90 are being evaluated in the RI/FS report for the 100-NR- 1 and 100-NR-2 OUs (DOE/RL-2012-15, *Remedial Investigation/Feasibility Study for the 100-NR-1 and 100-NR-2 Operable Units).*
- ***RAO 4. Prevent destruction of sensitive wildlife habitat. Minimize disruption of cultural resources and wildlife habitat, in general, and prevent adverse impacts to cultural resources and threatened or endangered species.***

  The interim remedial action ROD (EPA/ROD/R10-99/112 and EPA 2010) established the following ICs that were implemented and maintained throughout this review period. These provisions include access control and visitor escorting requirements; maintaining signs prohibiting public access (new signs were placed along the river and at major road entrances at each reactor area); an excavation permit process to control all intrusive work (e.g., well drilling and soil excavation); and regulatory agency notification of any trespassing incidents.

ICs for the 100-NR-2 groundwater OU, as required by the interim action ROD (as amended), are described in the latest version of *Remedial Design Report/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, (DOE/RL-2001-27), and are actively managed. Specific details associated with each applicable IC have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. As indicated earlier, the ICs for the 100-NR-2 OU include the following categories/type: access control (warning notices and entry restrictions), land-use management (land use, and excavation and drilling restrictions), and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see examples in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 100-NR-2 groundwater OU.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid for this OU for purposes of implementing the interim action ROD. However, since the issuance of the interim action ROD (as amended in 2010), cleanup levels, toxicity data, and risk assessment guidance have been revised. The revised information will be considered during development of the final ROD.

Has any other information come to light that could call into question the protectiveness of the remedy?

No information has come to light that would call into question the protectiveness of the remedy. Performance monitoring has indicated that the permeable reactive barrier technology can be effective, however, some sections of the barrier expansion have experienced contaminant rebound since the initial injections suggesting the potential need for reinjection and/or refinement of the barrier injection methodology.

2.3.5.2.6 Issues/Corrective Actions During this Review Period

Delays in expanding the treated zone of the permeable reactive barrier from 1,000 ft to 2,500 ft are associated with traditional cultural property issues. DOE/RL-2001-27, Rev. 1, of the RD/RAWP, was approved and issued in September 2014 to implement the recommendations from the *Design Optimization Study for Apatite Permeable Reactive Barrier Extension for the 100-NR-2 Operable Unit* (DOE/RL-2010-68). However, effective January 2014, a revised traditional cultural property boundary encompasses the permeable reactive barrier project area; cultural review of the project activities, addressing the requirements of the *National Historic Preservation Act of 1966* (NHPA), Section 106, process (specifically 36 CFR 800.3 through 800.5), deemed the project to have an "adverse effect" on the traditional cultural property, as defined in 36 CFR 800.5(b). Therefore, the work involved in expanding the barrier is dependent on completion of the NHPA, Section 106, reviews and is subject to schedule delays pending establishment of a memorandum of agreement to conduct the project activities deemed to have an adverse effect on the traditional cultural property. Collectively, this is viewed as potentially challenging the achievement of RAO 4, which includes preventing adverse impacts to cultural resources. RD/RAWP (DOE/RL-2001-27, Rev. 2) was published in July 2016 which updates the anticipated period of performance for expansion of the barrier in fiscal years 2017 and 2018 (following completion of NHPA, Section 106, process (including the memorandum of agreement), and confirmation of PRB placement based on finalization of modeling/analysis to be presented in the 100-N Area RI/FS report [DOE/RL-2012-15, Rev. 0, pending]). Therefore, the following issue is noted for future action:

Issue NR2-1. Permeable reactive barrier test has not been expanded from 1,000 ft to 2,500 ft.

Corrective Action NR2-1. Complete full implementation of the permeable reactive barrier (Action Due Date: September 30, 2018)

Does this issue/action currently affect the protectiveness of the remedy? – YES

Will this issue/action affect the protectiveness of the remedy in the future? – YES

2.3.5.2.7 Protectiveness Statement

100-NR-2 Groundwater OU -- Not Protective. The interim remedy at the 100-NR-2 OU source is not protective because expansion of the permeable reactive barrier remedy-component for addressing strontium-90-contaminated groundwater has not been completed. Approximately 1,000 ft of the 2,500-ft-long barrier have been installed at the time of this report. The action necessary to address protectiveness (per the interim ROD) is to complete the apatite-forming chemical injections at 1,500 ft of the 2,500-ft-long permeable reactive barrier. To address TPH-diesel contamination, in situ bioventing system operations and the free-product removal operations are under way to reduce contaminant mass in the lower vadose zone and groundwater, respectively. Additionally, ICs are in place and are preventing human exposure to the groundwater. Groundwater monitoring and MNA also are under way and will continue to help determine a comprehensive final remedy for 100-NR-2 groundwater.

2.4 300 AREA NATIONAL PRIORITIES LIST SITE

The 300 Area is located in the southeastern portion of the Hanford Site along the Columbia River and adjacent to the northern city limits of Richland, Washington. The 300 Area, as currently described for remediation purposes, encompasses approximately 40 mi^2 (105 km^2) and comprises the 300 Area industrial complex including major liquid waste disposal sites and solid waste burial grounds, waste sites

associated with the Fast Flux Test Facility (FFTF) in the 400 Area, the 618-10 and 618-11 burial grounds, and waste sites near and east of the 300 Area Industrial Complex.

The 1.35 km^2 (0.52-mi^2) 300 Area Industrial Complex, which was used for uranium fuel fabrication and research and development activities for the Hanford Site, began operations in 1943. During the 300 Area Industrial Complex's operating period (most operations ended before or during the 1990's), fuel fabrication and laboratory facilities' disposal practices and spills and other unplanned releases resulted in contamination of the facilities, surface, underlying soil column, and groundwater.

Waste from 300 Area operations was purposefully disposed of in unlined landfills and burial grounds and discharged to unlined surface ponds and trenches. Solid waste was disposed of in burial grounds and shallow landfills from 1943 through the 1950s. In later years, highly radioactive waste, including waste with TRU contaminants, was disposed of in the 600 Area burial grounds.

Industrial activities associated with operations in the 400 Area also resulted in soil contamination and are addressed by the 300 Area NPL Site cleanup.

While facility deactivation, decommissioning, and demolition has been ongoing in the 300 Area industrial complex for more than a decade, a few buildings primarily dedicated to research and development will be in use through at least 2045.

Land adjacent to the 300 Area industrial complex and associated outlying waste sites is shrub steppe habitat with the following exceptions:

- Adjacent to the 618-11 burial ground is an operating commercial nuclear power plant
- Adjacent and east of the 300 Area Industrial Complex is the Columbia River.
- The southern part of the 300 Area wraps around DOE's Hanford Patrol Academy and the Volpentest HAMMER Federal Training Center (HAMMER).
- The northwest quadrant of the 300 Area include the deactivated FFTF in a small region known as the 400 Area.

The 300 Area NPL site is being addressed by two source OUs (300-FF-1 and 300-FF-2) and one groundwater OU (300-FF-5). The 300-FF-1 OU contains principally liquid waste disposal sites in the northeast quadrant of the 300 Area Industrial Complex. The 300-FF-2 OU contains principally solid waste disposal sites in the 300 Area. The 300-FF-5 OU addresses groundwater contamination from past disposal to 300-FF-1 and 300-FF-2 waste sites. Locations of the 300-FF-1 and 300-FF-2 source OUs and the 300-FF-5 groundwater OU are shown in Figure 2-25.

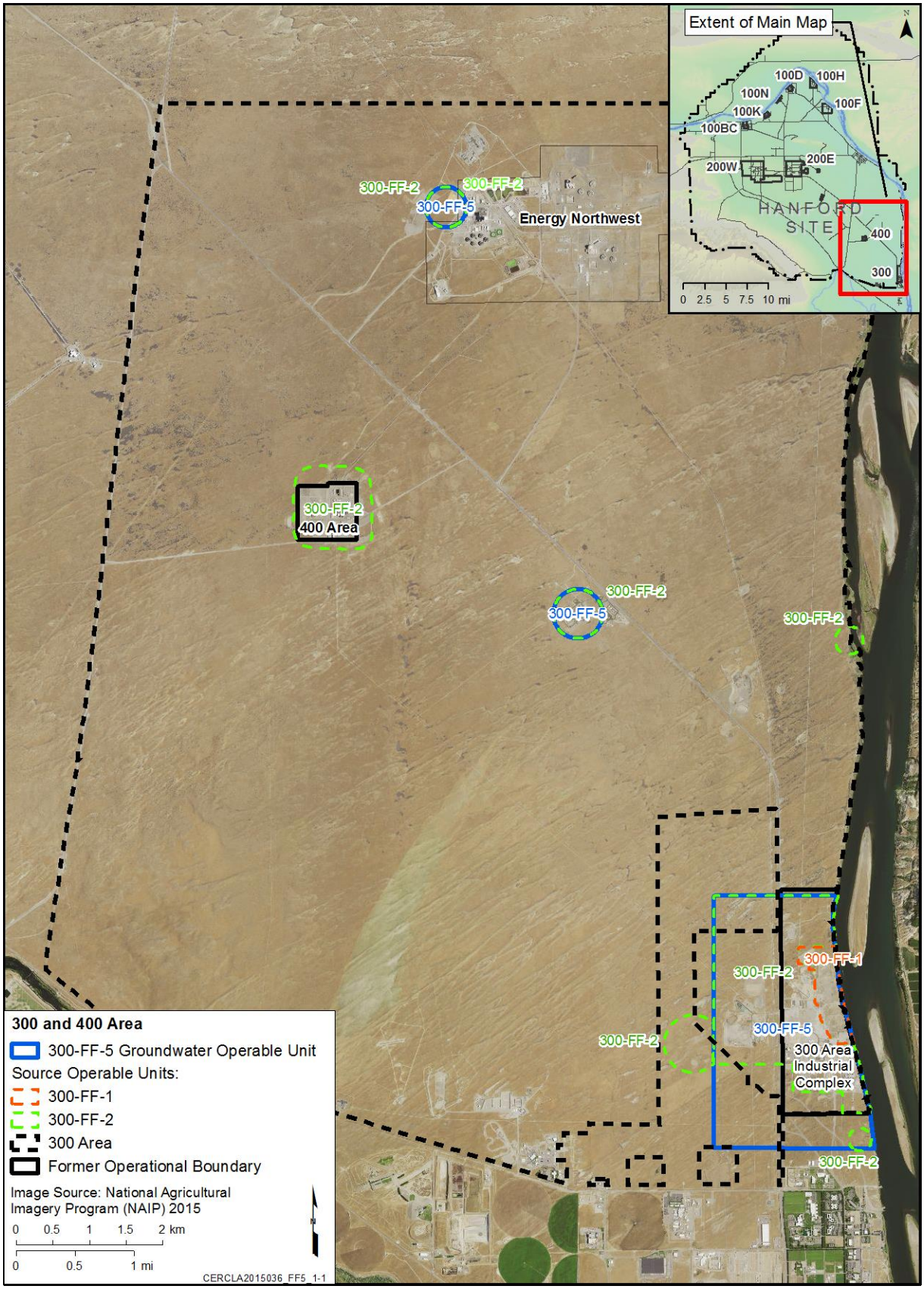
2.4.1 300 Area Operable Units

2.4.1.1 300-FF-1 and 300-FF-2 Source Operable Units

2.4.1.1.1 Background

The 300-FF-1 OU is bounded on the east by the Columbia River and on the north, south, and west by the 300-FF-2 OU. The 300-FF-1 OU includes the major 300 Area liquid and process waste disposal sites, the 618-4 burial ground, and three small landfills. The liquid and process waste disposal sites were unlined trenches and ponds that received discharges of millions of gallons of contaminated wastewater. These liquid and process waste disposal sites are suspected to be the primary source of uranium contamination in the groundwater beneath the 300 Area.

The 300-FF-2 OU contains primarily solid waste disposal sites located beneath facilities and/or covered areas inside the 300 Area Industrial Complex fences. This OU also contains several waste sites that were identified outside the industrial complex fences, including general-content burial grounds located near the 300 Area (one was beneath a building in the complex area), and two burial grounds containing TRU-contaminated material located north of the 300 Area fenced complex.



300-FF-5 is defined by groundwater contaminated by Hanford 300 Area releases (EPA and DOE 2013).

Figure 2-25. 300 Area Operable Units.

2.4.1.1.2 Chronology

Table 2-28 lists the remedial action decision documents associated with the 300-FF-1 and 300-FF-2 source OUs.

Table 2-28. Decision Documents for the 300 Area Source Operable Unit (300-FF-1 and 300-FF-2).

Date	Location	Document Title
1996	EPA/ROD/R10-96/143	***Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units.*** This document contains a final action ROD for the 300-FF-1 OU to remove contaminated soil and debris, dispose of it at ERDF, backfill and recontour the site, and implement ICs. It also contains an interim action ROD for the 300-FF-5 OU that implements monitoring and ICs.
2000	EPA, et al. 2000	***Explanation of Significant Differences for 300-FF-1 Operable Unit Site-Specific Variance from Land Disposal Restrictions Treatment Standard for Lead.*** This ESD is a site-specific land disposal restriction treatability variance for lead contamination found in the 628-4 waste site, also known as Landfill 1D.
2001	EPA 2001c	***Record of Decision for the 300-FF-2 Operable Unit Interim Actions.*** This document is an interim action ROD to remove contaminated soil, structures, and debris from the 300-FF-2 OU; treat as needed; dispose of at ERDF, WIPP, or another repository; backfill and revegetate the site; establish ICs; continue monitoring groundwater under the 300-FF-5 OU; and define a plug-in approach for accelerating future decisions.
2004	DOE 2004	***Explanation of Significant Differences for the 300-FF-2 Operable Unit Record of Decision.*** This ESD modifies the uranium soil cleanup level from 350 to 267 pCi/g, based on an engineering study, to ensure protectiveness of the groundwater and river; modifies the land-use assumption for 8 outlying waste sites from industrial to unrestricted; and changes cleanup levels for these sites to be consistent with 100 Area cleanup.
2009	EPA et al. 2009	***Explanation of Significant Differences for the 300-FF-2 Operable Unit Interim Action Record of Decision.*** This ESD incorporates 14 plug-in sites into the ROD and subsequent ESDs, incorporates 2 newly discovered sites into the ROD and subsequent ESDs, and allows future newly discovered sites to be incorporated into the ROD and ESDs, as long as cost impacts remain within specified limits.
10/2010	E1009034	***TPA Fact Sheet: "300-FF-2 "Plug-In" Waste Sites for Fiscal 2010."*** This is the 2010 list of waste sites plugged into the RTD remedy in the 2001 interim action ROD for the 300-FF-2 OU.
2011	EPA 2011c	***TPA Explanation of Significant Differences, Hanford 300 Area, 300-FF-2 Operable Unit, 618-10 Burial Ground.*** This ESD modifies the remedy to allow necessary treatment of liquid waste in bottles, up to 1 gal/bottle, to occur in trays within the excavation area in accordance with an approved work plan.
8/2011	DOE et al. 2011	***TPA Fact Sheet: 300-FF-2 "Plug-In" Waste Sites for Fiscal 2011.*** This is the 2011 list of waste sites plugged into the RTD remedy in the 2001 interim action ROD for the 300-FF-2 OU.
9/2012	DOE et al. 2012	***TPA Fact Sheet: 300-FF-2 "Plug-In" Waste Sites for Fiscal 2012.*** This is the 2012 list of waste sites plugged into the RTD remedy in the 2001 interim action ROD for the 300-FF-2 OU.

Table 2-28. Decision Documents for the 300 Area Source Operable Unit (300-FF-1 and 300-FF-2).

Date	Location	Document Title
11/2013	EPA and DOE 2013	***Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1 Hanford Site, Benton County, Washington*.** This ROD selects a final remedy for the waste sites in the 300-FF-2 OU, a final remedy for the groundwater in the 300-FF-5 OU, and amends the remedy for three 300-FF-1 OU waste sites. This final-action remedy replaces the interim-action remedies for the 300-FF-5 and 300-FF-2 OUs selected in 1996 and 2000, respectively. The 1996 remedy for 300-FF-1 is amended for additional remedial action of uranium from three sites. Contaminated buildings are being removed in accordance with CERCLA action memoranda and are not part of the OUs addressed by this ROD. The major components of the selected remedy for the 300-FF-2 OU are as follows: • Remove, treat, and dispose of at waste sites • Emplace temporary surface barriers and fill pipeline voids • Perform enhanced attenuation of uranium using sequestration in the vadose zone, periodically rewetted zone, and top of the aquifer • Institute ICs, including the requirement that DOE prevent the development and use of 300 Area Industrial Complex and 618-11 property that does not meet residential cleanup levels for other than industrial uses, including use for residential housing, elementary and secondary schools, childcare facilities, and playgrounds. The major components of the selected remedy for the 300-FF-5 OU are as follows: • Monitored natural attenuation • Groundwater monitoring • Enhanced attenuation of uranium at the top of aquifer • ICs. The major component of the amended remedy for the 300-FF-1 OU is enhanced attenuation of uranium using sequestration in the vadose zone, periodically rewetted zone, and top of the aquifer.
6/2015	DOE/RL-2014-13, DOE/RL-2014-13-ADD1, DOE/RL-2014-13-ADD2	***Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units*, DOE-2014-13, Rev. 0; *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils*, DOE/RL-2014-13-ADD1, Rev. 0; *Remedial Design report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, DOE/RL-2014-13-ADD2, Rev. 0.** These documents support remedy implementation for the 2013 300 Area ROD/ROD amendment. The first document is an integrated RDR/RAWP containing common information to support remedy implementation, the second is an addendum containing information specific to the waste site and/or soil-specific remedies for the 300-FF-2 OU, and the third is an addendum containing information specific to groundwater remedies for the 300-FF-5 OU and uranium sequestration elements implemented at the 300-FF-1 and 300-FF-2 OUs.
9/2015	DOE and EPA 2015	***Explanation of Significant Differences for the Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*.** This ESD adds two waste sites to the 300 Area ROD, Table 1. Waste site 600-386 requires no additional action to meet the selected remedy requirement of the 300-FF-2 OU and waste site 600-393 was added for RTD to residential cleanup levels.

CERCLA = *Comprehensive Environmental Response, Compensation and Liability Act of 1980*.
ERDF = Environmental Restoration Disposal Facility.
ESD = explanation of significant difference.
IC = institutional control.
OU = operable unit.
ROD = record of decision.
RTD = remove, treat, if necessary, and dispose of.
WIPP = Waste Isolation Pilot Plant.

See Appendix B for a consolidated listing of decision documents for Hanford Site OUs.

2.4.1.1.3 Remedial Action

Goals and Objectives. The RAOs for the 300-FF-1 and 300-FF-2 waste sites, as stated in the 2013 ROD (EPA and DOE 2013), are as follows. RAOs 2 through 6 apply to 300-FF-2 and RAOs 2 and 7 apply to the 300-FF-1 ROD amendment because remediation of the 300-FF-1 waste sites had been completed under the original ROD. RAO 1, not listed, applies to the 300-FF-5 groundwater OU.

- ***RAO 2. Prevent COCs migrating and/or leaching through soil that will result in groundwater concentrations above CULs for protection of groundwater, and of surface water concentrations above CULs for the protection of surface water at locations where groundwater discharges to surface water.***
- ***RAO 3. Prevent human exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above residential scenario-based CULs in areas outside both the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).***
- ***RAO 4. Prevent human exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above CULs for industrial use in the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).***
- ***RAO 5. Manage direct exposure to contaminated soils deeper than 4.6 m (15 ft) to prevent an unacceptable risk to human health and the environment.***
- ***RAO 6. Prevent ecological receptors from direct exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above CULs.***

Remedy Components. The final action ROD for the 300-FF-2 source OU and the ROD amendment for the 300-FF-1 source OU, as published in 2013 (EPA and DOE 2013), provided the following summary-level descriptions (see italicized text in the following box) of the major components of the selected remedy (i.e., RTD, temporary surface barriers and pipeline-void filling, ICs and enhanced attenuation of uranium).

Excerpt from ROD (EPA and DOE 2013):

RTD at Waste Sites for 300-FF-2 -- RTD of waste sites to achieve RAOs and CULs through (a) RTD the soil with COCs exceeding CULs identified in table 4 above as deep as 4.6 m (15 ft) bgs to protect human health and ecological receptors from direct exposure to contaminants, (b) remove the engineered structures which includes pipelines with contamination exceeding CULs (e.g., burial ground trenches, drums, caissons and vertical pipe units), (c) RTD the soil and engineered structures below 4.6 m (15 ft) bgs with COCs other than uranium that exceeds CULs in table 4 for groundwater and river protection and (d) backfill and revegetate the excavated waste sites. Except as specified in section 12.2.6 and 12.2.7 below, uranium that is identified during remedial activities to exceed CULs below 4.6m will be addressed either by RTD and/or sequestration with phosphate as approved by EPA.

Contaminated soil, structures and debris with concentrations above the CULs will be removed from the waste sites, treated as necessary to meet disposal facility requirements and sent to ERDF, which is considered onsite, or another facility approved by EPA. CULs apply to soil, structures which includes pipelines and debris. CULs do not apply to chemicals that are an integral part of manufactured structures (for example zinc in galvanized metal). The chemicals that are an integral part of manufactured structures are not considered contamination. The need for remedial action is based on contamination. In addition, treatment will be conducted as necessary in advance of removal to control worker exposure and minimize airborne releases (e.g., for highly radioactive materials, including principal threat waste).

Soil from waste site 300-296 below the 324 Building B Cell is part of 300-FF-2 and is addressed in the selected remedy. The highly contaminated soil that requires remote excavation methods will be retrieved and placed into other non-leaking 324 Building hot cells. These cells provide additional shielding to workers from radioactive contaminants. Removal of the 324 Building, and the hot cells that would contain this 300-296 waste, will be performed under the CERCLA Action Memorandum #2 for the 300 Area Facilities. In addition, closure of the TSD units in the 324 Building Radiochemical Engineering Cells will be performed under the RCRA Closure Plan.

Principal threat waste from the 300-296 waste site, vertical pipe units at 618-10 and 618-11 and caissons at 618-11 will be treated to the maximum extent practicable to reduce the toxicity, mobility, contamination or

radiation exposure. Treatment may be in-situ or during excavation as needed to control worker exposure. Treatment will be with grout or an alternative method approved by EPA during remedial design.

Temporary Surface Barriers and Pipeline Void Filling for 300-FF-2 -- For waste sites that exceed CULs in table 4 [referring to table 4 in the ROD] that are adjacent to the 300 Area facilities and utilities that will remain in operation through at least 2027 (long-term facilities), temporary surface barriers will be installed and maintained in areas specified in the RD/RAWP to reduce infiltration and contaminant flux to groundwater. The design of the barriers will be described in the RD/RAWP. Surface barriers will be constructed of asphalt or alternative materials approved by EPA in the RD/RAWP to decrease permeability. In addition, pipelines with uranium and/or mercury contamination that exceed CULs in table 4 for groundwater and river protection that are inaccessible for the RTD remedy because of their close proximity to long-term facilities will be void filled to the maximum extent practicable as defined in the RD/RAWP to immobilize radionuclides (and elemental mercury in waste site 300 RRLWS) in the pipelines for groundwater protection. When the long-term facilities are no longer in use and are removed, the waste sites and pipelines will be remediated as described above in the RTD discussion. The long-term retained facilities are shown on figure 3.

Institutional Controls Common Elements for 300-FF-2 and 300-FF-5 -- ICs are required before, during and after the active phase of remedial action implementation where ICs are needed to protect human health and the environment. ICs are used to control access to residual contamination in soil and groundwater above standards for unlimited use and unrestricted exposure. DOE shall be responsible for implementing, maintaining, reporting on and enforcing ICs. Although the DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement or through other means, the DOE shall retain ultimate responsibility for remedy integrity and ICs. In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.

The current implementation, maintenance and periodic inspection requirements for ICs at the Hanford Site are described in approved work plans and in the Sitewide Institutional Controls Plan (DOE/RL-2001-41) that was prepared by DOE and approved by EPA and the State in 2002. No later than 180 days after the ROD is signed, DOE shall update the Sitewide Institutional Controls Plan to include the ICs required by this ROD and specify the implementation and maintenance actions that will be taken, including periodic inspections. The revised Sitewide Institutional Controls Plan shall be submitted to EPA and the Washington State Department of Ecology (Ecology) for review and approval as a Tri-Party Agreement primary document. The DOE shall comply with the Sitewide Institutional Controls Plan as updated and approved by EPA and Ecology.

The following institutional control performance objectives are required to be met as part of this remedial action. Land-use controls will be maintained until CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

- *In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.*
- *In the event of any unauthorized access (e.g. trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and evaluation of possible prosecution.*
- *Activities that would disrupt or lessen the performance of any component of the remedies are prohibited.*
- *The DOE shall report on the effectiveness of ICs for 300-FF-2 and 300-FF-5 in an annual report, or on an alternative reporting frequency specified by the lead regulatory agency. Such reporting may be for 300-FF-2 and 300-FF-5 alone or may be part of the Hanford Sitewide ICs report.*

Measures that are necessary to ensure continuation of ICs shall be taken before any lease or transfer of any land subject to ICs. DOE will provide notice to Ecology and EPA at least 6 months before any transfer or sale of land subject to ICs so that the lead regulatory agency can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs. If it is not possible for DOE to notify Ecology and EPA at least 6 months before any transfer or sale, DOE will notify Ecology and EPA as soon as possible, but no later than 60 days before the transfer or sale of any property subject to ICs. In addition to the land transfer notice and discussion provisions, DOE further agrees to provide Ecology and EPA with similar notice, within the same time frames, as to federal-to-federal transfer of property. DOE shall provide a copy of the executed deed or transfer assembly to Ecology and EPA. DOE shall notify EPA and Ecology immediately upon discovery of any activity inconsistent with the specific ICs.

Institutional Controls Unique Elements for 300-FF-2 -- The following institutional control performance objectives are required to be met as part of this remedial action for 300-FF-2. Land-use controls will be maintained until

CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

- *Exposure to contamination deeper than 4.6 m (15 ft) bgs is not anticipated. Where contamination at depth exceeds the residential or industrial use CULs, ICs are required to ensure future activities do not bring this contamination to the surface or otherwise result in exposure to contaminant concentrations that exceed the CULs.*
- *The DOE will prevent the development and use of property that does not meet residential CULs at the 300 Area Industrial Complex and 618-11 (figure 10* [from the ROD]*) for other than industrial uses, including use of property for residential housing, elementary and secondary schools, childcare facilities and playgrounds.*
- *Signage and access control to waste sites with contamination above CULs will be provided.*
- *DOE shall employ and maintain an excavation permit program for protection of human health against unacceptable exposure, and protection of environmental and cultural resources.*
- *Prevent enhanced recharge in the 300 Area Industrial Complex and 618-11over or near waste sites with soil concentration at any depth that exceed residential (irrigation-based) groundwater and surface water protection CULs until the CULs are achieved. Enhanced recharge controls are no irrigation or landscape watering, control drainage from low permeability areas including paved parking lots or buildings, and prevent bare gravel or bare sand covers.*

Enhanced Attenuation of Uranium Common Elements for 300-FF-1 and 300-FF-2 -- Enhanced attenuation of uranium is to be achieved via sequestration treatment with phosphate. Phosphate will be applied near the ground surface; within the lower vadose zone, [periodically wetted zone] *PRZ and top of the aquifer via injection wells; and within the top of the aquifer toward the east and south of the vadose treatment area.*

Uranium sequestration by phosphate application will be implemented to enhance the natural attenuation of the uranium source mass in the vadose zone, PRZ and top of the aquifer in the area of highest uranium contamination (figure 9). The groundwater plume in this area results from three 300-FF-1 sites (316-1, 316-2 and 316-5) and four 300-FF-2 waste sites (316-3, 618-1, 618-2 and 618-3.) The treatment area is approximately 1 hectare (3 acres) and includes injection of phosphate at the top of the aquifer to address uranium that may be mobilized during the treatment process. The specific target area will be identified in the RD/RAWP. Uranium concentration and leachability characterization will be conducted on vadose zone and PRZ core samples collected before and after phosphate treatment to quantify the vadose zone and PRZ treatment effectiveness, and to refine the groundwater model. Groundwater monitoring will be conducted to assess changes in uranium concentrations and the lateral spread of phosphate.

Wells will be used for injection of phosphate to a zone that is located just above and/or within the aquifer to mitigate potential impacts to the aquifer from uranium that may be carried downward by the water used to inject the phosphate. This treatment zone will be in place during water and reagent application in the vadose zone and maintained for a short period afterwards to react with any uranium that leaches into groundwater as a result of the phosphate solution applied to the vadose zone and PRZ. Phosphate injections will be performed when groundwater conditions are favorable (e.g., when groundwater flows in from the river during rising and high river stages).

The specific reagent blends of phosphate will be designed to optimize desired treatment characteristics, depending on the delivery method and target media. For instance, a slower release formulation that contains polyphosphate is desirable for infiltration and PRZ injection applications, where the slower delivery rate and less certain reagent distribution pattern would benefit from a slower reaction time to allow the reagent to migrate further into the unsaturated soil. In contrast, a faster-reacting formulation containing 100 percent orthophosphate is beneficial when targeting groundwater at the top of the aquifer during transient high-water stages. The feasibility study was based a reagent blend of 20 percent polyphosphate and 80 percent orthophosphate for infiltration and PRZ injections, and a 100 percent orthophosphate reagent was assumed for aquifer injections. The reagent blend will be determined during remedial design.

Near surface treatment will use the following general approach, with details to be developed in remedial design and established in the RD/RAWP:

- *Surface infiltration with phosphate reagent-amended water*
- *Reagent mixing facility, pipelines, injection wells, pumps, valves*
- *Reagent delivery system for surface application*

- *Monitoring and verification sampling, including soil borings and monitoring wells to monitor effectiveness and potential impacts to groundwater*
- *Estimated system flow rate ranging from 190 to 1,135 L/min (50 to 300 gal/min) per acre*

Phosphate reagent will be injected into the lower vadose zone and PRZ through wells selectively screened or packed to apply reagent into a focused treatment interval. Treatment will use the following general approach, with details to be developed in remedial design and established in the RD/RAWP:

- *Well injection with phosphate reagent-amended water*
- *Reagent mixing facility, pipelines, injection wells, pumps, valves*
- *Phosphate reagent injection wells will be spaced approximately 15 m (50 ft) apart. Wells will be screened across the lower vadose zone and PRZ within the footprint of and adjacent to (along the river side) of the 1 hectare (3 acre) target area. Preliminary design includes 47 injection wells.*
- *Monitoring and verification sampling including soil borings and monitoring wells to monitor effectiveness and potential impacts to groundwater*
- *Injection rates ranging from approximately 380 to 760 L/min (100 to 200 gal/min) for each well.*

The timing of the application in the PRZ would be scheduled to maximize contact with the smear zone during the seasonal high groundwater elevation. Properly deployed, lateral reagent injection will be capable of contacting lower vadose zone and PRZ sediment at distances approximately 15 m (50 ft) from each injection well.

Transition from Interim Remedy to Final Action Remedy for 300-FF-2 and 300-FF-5 -- In-progress interim action shall use the CULs in this ROD immediately upon issuance of this ROD. All other aspects of the interim actions shall continue to be performed in accord with the existing RD/RAWP. DOE shall develop, and submit for EPA approval, a new RD/RAWP prepared in accordance with the Tri Party Agreement. When the new RD/RAWP is approved, that document will direct future remedial actions and will replace all interim action ROD work plan requirements.

Description of Amended Remedy for 300-FF-1 -- The ROD for 300-FF-1 is amended to require enhanced attenuation with sequestration for uranium using phosphate at 300-FF-1 waste sites as described above in section 12.2.6.[in the ROD) *Phosphate will be applied to the vadose zone and PRZ using a combination of surface infiltration and injection into the deep vadose zone and PRZ near the southern portion of waste site 316-5 as described above. Uranium sequestration will be conducted at the top of the aquifer below the vadose treatment zone to limit the mobility of any uranium mobilized from the vadose zone during surface infiltration and injection into the vadose zone and PRZ.*

The remedies selected may change somewhat as a result of the remedial design and construction process. Any changes to the remedies described in the ROD are typically documented using a technical memorandum in the Administrative Record, an ESD, ROD amendment, or via version-control of the RDR/RAWP, as appropriate.

COCs for the 300-FF-1 and 300-FF-2 OUs collectively include a variety of radionuclides, nonvolatile organics, volatile organics, metals, inorganic ions, and asbestos. Detailed listings are provided in the respective RODs.

Remedy Implementation Progress Prior to this (2011-2015) Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work on the 300-FF-1 OU remedy began after issuance of the ROD in 1996, with the initial cleanup verification package approved in 1997. Before 2011, remedial actions had been completed at all 39 300-FF-1 OU waste sites, as documented in *300-FF-1 Operable Unit Remedial Action Repor*t, (DOE/RL-2004-74) Work on the 300-FF-2 interim remedy began after issuance of the interim action ROD in 2001. Before 2011, interim remedial actions had been completed at 36 of approximately 104 waste sites in the 300-FF-2 OU.

Issues/Actions from the Previous 5-Year Review. No issues or actions were noted for the 300-FF-1 source OU and/or the 300-FF-2 source OU in the 2011 CERCLA 5-year review.

Protectiveness Statements from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statements from the previous (2006 – 2010) 5-year review report for the 300-FF-1 and 300-FF-2 source OUs were as follows:

- 300-FF-1 OU: "*The remedy at 300-FF-1 OU was selected under a ROD, and is protective of human health and the environment, because cleanup standards were met and are within the acceptable risk range. However, the River Corridor Baseline Risk Assessment will re-evaluate this OU again, and final decisions will be for the source sites adjacent to the 300-FF-1 OU (i.e., waste sites in the 300-FF-2 OU) to ensure long term protectiveness."*
- 300-FF-2 OU: "*The final remedy at 300-FF-2 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled.*"

2.4.1.1.4 Progress Since 2011 Review

Accomplishments. Primary remedial action accomplishments for the 300-FF-1 and 300-FF-2 source OUs during the past 5 years can be summarized as follows:

- Completed remediation of more than 40 waste sites in the 300-FF-2 OU
- Published the final action ROD for the 300-FF-2 source OU and 300-FF-5 groundwater OU, as well as a ROD amendment for the 300-FF-1 Source OU in November 2013 (EPA and DOE 2013)
- Published an integrated RDR/RAWP for the 300, Area *Integrated Remedial Design Report/ Remedial Action Work Plan or the 300 Area (300-FF-1, 300-FF-2 and 300-FF-5 Operable Units)* (DOE/RL-2014-13); an RDR/RAWP addendum for 300-FF-2 soils, *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils* (DOE/RL-2014-13-ADD1), and an RDR/RAWP addendum for the 300 Area Groundwater, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater* (DOE/RL-2014-13-ADD2); in June 2015. A Tri-Party Agreement change to DOE/RL-2014-13-ADD1 (TPA-CN-705, "Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils") was issued in December 2015 to clarify that ICs do not apply to use of the Columbia River or access to the shoreline near the 300 Area.
- Initiated implementation of final ROD remediation for 300-FF-2 and amended ROD remedial actions for 300-FF-1 OU sites.

While the 39 300-FF-1 source OU waste sites were cleaned up in the period from 1997 to 2004, the remedial actions in the 300-FF-2 source OU began in 2009 and are ongoing. The primary cleanup actions for the 300-FF-2 OU involve removing contaminated soil and debris; treating the material, as appropriate, to reduce waste toxicity, mobility, or volume; disposing of the material in an appropriate long-term waste management facility; backfilling and revegetating the area, and, where appropriate, implementing ICs. By 2012, all 300-FF-2 waste sites located in the northern portion of the 300 Area Industrial Complex (i.e., North of Apple Street) were completed. Remedial actions in the southern portion of the 300 Area continued through 2015. The majority of the waste from the 300 Area cleanup has been disposed of at ERDF. Approximately 1.29 million metric tons (1.42 million tons) of CERCLA remediation waste have been removed from 300 Area waste sites since 2011. Remediation of the 618-10 burial ground trenches began in 2011 and continued through 2015.

More than 40 300-FF-2 source OU waste sites have been remediated and documented in waste site cleanup verification packages or remaining sites verification packages in the period from 2011 to 2015. The waste sites that were actively remediated during this 5-year review period are as follows:

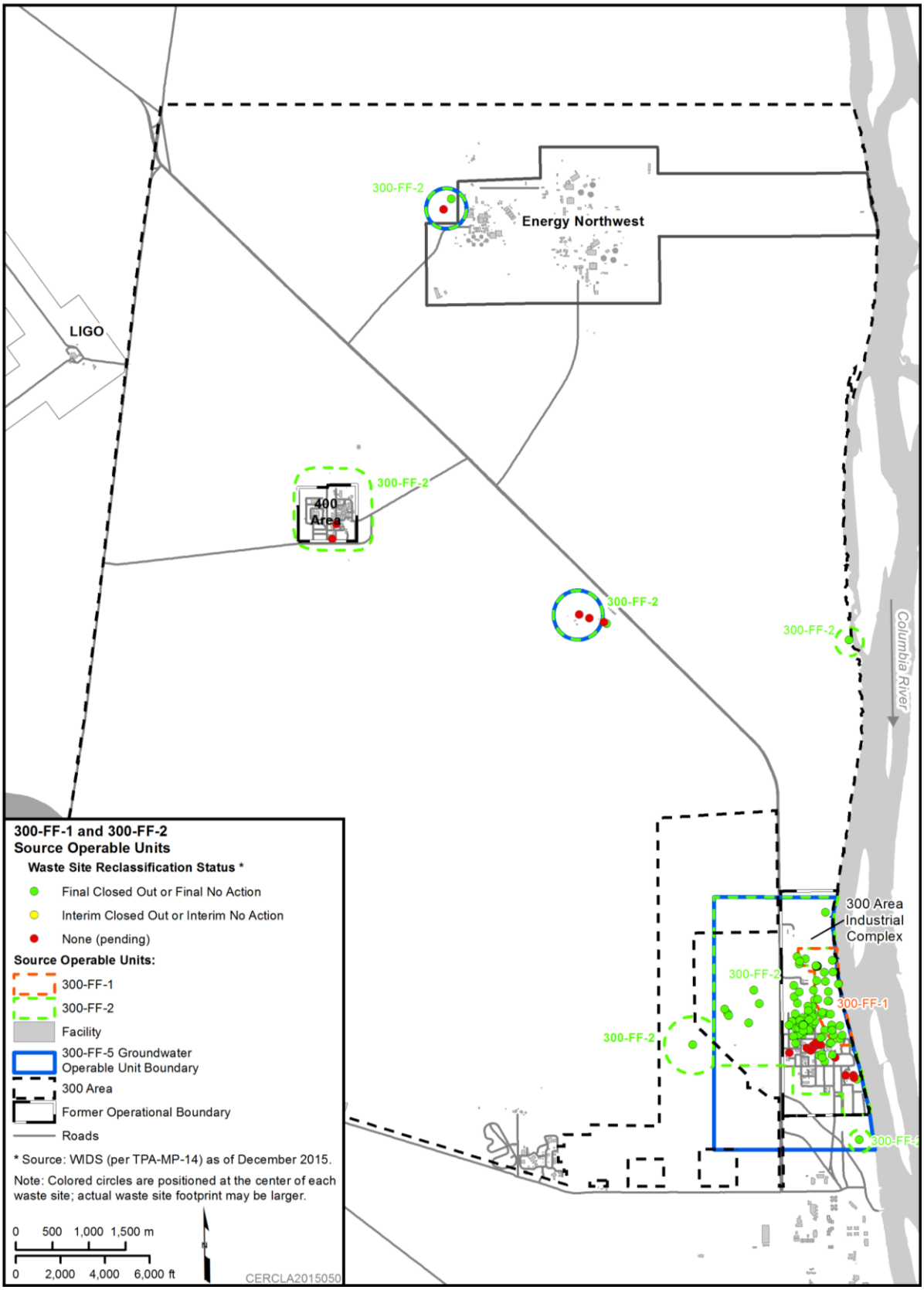
- 300-4, Soil Contamination
- 300-6, Storage Tank
- 300-7, Burial Ground
- 300-9, Burial
- 300-15:2:3, :6, Process Sewer
- 300-273, Fuel Oil Pipeline
- 300-274, Surface Debris
- 300-276, Sanitary Sewer
- 300-277, Unplanned Release
- 300-278, Storage Unit

- 300-16:1, :2, and :3, Soil Contamination
- 300-22, Unplanned Release
- 300-24, Soil Contamination
- 300-28, Soil Contamination
- 300-32, Foundation and Soil Contamination
- 300-33, Unplanned Release
- 300-34, Unplanned Release
- 300-43, Unplanned Release
- 300-46, Soil Contamination
- 300-48, Soil Contamination
- 300-40, Unplanned Release
- 300-41, Neutralization Tank
- 300-80, French Drain
- 300-123, French Drain
- 300-214:1 Process Sewer Pipelines
- 300-218, Laboratory
- 300-219, Acid Transfer Line
- 300-224, Pipe Trench
- 300-249, Soil Contamination
- 300-251, Unplanned Release
- 300-255, 309 Tank Farm Contaminated Soil
- 300-256, Unplanned Release
- 300-257, Process Sewer
- 300-258, Pipe Trench
- 300-263, Diversion Tank
- 300-268, Building Foundation
- 300-270, Unplanned Release
- 300-256, Unplanned Release
- 300-289, Stained Soils
- 300-280, Dumping Area
- 300-284, Unplanned Release
- 300-286, French Drains
- 300-287, Dumping Area
- 300 RLWS:1 and :2,Radioactive Process Sewer Pipelines
- 300 RRLWS:1 Radioactive Process Sewer
- 333 WSTF, Waste Tank
- 313 ESSP, Storage Pad
- 316-3, Process Water Trenches
- 600-386, Dumping Area
- 340 COMPLEX, Radioactive Liquid Vault
- 3712, Uranium Scrap Storage Area
- UPR-300-40, Unplanned Release
- UPR-600-22, Unplanned Release
- UPR-300-40, Unplanned Release
- UPR-600-22, Unplanned Release
- UPR-300-40, Unplanned Release
- UPR-600-22, Unplanned Release
- UPR-300-40, Unplanned Release
- UPR-600-22, Unplanned Release
- UPR-300-40, Unplanned Release
- UPR-600-22, Unplanned Release
- UPR-300-38, Unplanned Release
- UPR-300-39, Unplanned Release
- UPR-300-40, Unplanned Release
- UPR-300-42, Unplanned Release.

Figure 2-26 shows the general locations and closure status as of December 2015 for waste sites in the 300-FF-1 and 300-FF-2 source OUs. Table 2-29 summarizes the waste site cleanup status for the 300-FF-1 and 300-FF-2 waste sites, including metrics on work accomplished during this past 5-year period (2011 – 2015).

Remedy Implementation. The 2011 through 2015 5-year review period involved recent transitions in ROD status for the 300-FF-1 and 300-FF-2 source OUs. The 2013 ROD for the 300 Area (EPA and DOE 2013) includes an amendment to the original 300-FF-1 final action ROD from 1996 (EPA/ROD/R10-96/143, as amended), and a final-action ROD for the 300-FF-2 OU. The 300-FF-2 OU has transitioned from the 2001 interim action ROD (EPA 2001c, as amended) to the 2013 final action ROD. Some remedy components (e.g., RTD and ICs) have continued in the field during this transition period, while others (e.g., enhanced attenuation of uranium) were being prepared for field implementation in late 2015.

To support implementation of the new remediation requirements, the following RDR/RAWPs, as previously noted in the Accomplishments section, were published in the second half of 2015: DOE/RL-2014-13; DOE/RL-2014-13-ADD1, and DOE/RL-2014-13-ADD2. Because of these recent decisions and remedy implementation documents and the upcoming remediation activity, more comprehensive updates on remedy implementation and assessment of protectiveness will be included in future 5-year review reports.



Note: Colored circles are positioned in the center of a given waste site's overall footprint.

Figure 2-26. Geographic Distribution and WIDS Reclassification Status of the 300-FF-1 and 300-FF-2 Source Operable Unit Waste Sites as of December 2015.

Table 2-29. 300-FF-1 and 300-FF-2 Cleanup Status.

Source OU Cleanup Status - 300 Area					
Source OU	**Number of Waste Sites[a]**	**Sites Dispositioned[b]**			
		Pre-2011	**2011 - 2015**	**Total**	**Percent Complete**
300-FF-1 [c]	39	39		39	100
300-FF-2	104	36	45	81	77
Total	**143**	**76**	**45**	**120**	**83%**

[a]Approximate number of waste sites in the OU, according to WIDS, as of December 2015. Actual numbers change if sites are occasionally added to or moved from an OU in accordance with DOE and regulatory agency approvals.
[b]Approximate number of sites dispositioned as of December 2015; includes the number of sites that have been reclassified in WIDS, as of December 2015, as either interim closed, final closed, interim no-action or final no-action in accordance with the guideline TPA-MP-14[d], *Maintenance of Waste Information Data System* (WIDS). Slight discrepancies may exist between WIDs data and the specific waste sites listed in the table because of the time required to process and approve change requests that add or delete sites before changes are made in the WIDS.
[c]Three 300-FF-1 sites that required phosphate injections for sequestration of uranium (per the 2013 ROD amendment for 300-FF-1, are being addressed in DOE/RL-2014-13-ADD2[e], the 300-FF-5 OU's Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater.
[d] TPA-MP-14, 2011, *Maintenance of the Waste Information Data System (WIDS)*, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Richland Operations Office, Richland, Washington.
[e]DOE/RL-2014-13-ADD2, 2015, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE = U.S. Department of Energy.
OU = operable unit.
ROD = record of decision.
WIDS = Waste Information Data System.

RTD of 300-FF-2 waste sites has continued during the past 5 years and will continue in the future. Remedial action completion for a majority of the 300-FF-2 waste sites is summarized in *300-FF-2 Operable Unit Remedial Action Report* (DOE/RL-2016-45, Rev. 0). While most of the 300 Area Industrial Complex facilities have been demolished, some facilities and utilities supporting the continuing mission of the Pacific Northwest National Laboratory are expected to be retained through at least 2045. Some waste sites adjacent to these active facilities and utilities will receive interim remediation (i.e., temporary surface barriers and pipeline void-fill grouting) until final remedial actions can take place after 2045.

ICs, as required by the ROD for 300-FF-1 and 300-FF-2, have been incorporated into (DOE/RL-2001-41) and implemented.

2.4.1.1.5 Technical Assessments

The 5-year review determines whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the technical assessment response to the technical assessment questions provided in the EPA guidance for the 300 Area source OU remedy. These questions also establish a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the protectiveness of the remedy.

Is the remedy functioning as intended by the decision document?

The remedies for the 300-FF-1 and 300-FF-2 wastes sites are functioning as intended by the decision document to the extent the actions have been completed. Remediation of all 39 waste sites in the 300-FF-1 OU were completed before this review period. As of December 2015, 81 of 104 waste sites in the 300-FF-2 OU had been remediated.

An evaluation of the final ROD remedial action objectives for 300-FF-2 sites closed under an interim action ROD was completed. In accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS)*, the remediated waste sites have been documented in the WIDS as either final closed or final no-action. Cleanup verification packages (including sampling data and other technical information) to support the reclassification to final closed or final no-action are included in the Hanford Site Administrative Record for the 300-FF-1 and 300-FF-2 OUs.

The RAOs for 300 Area remediated waste sites, and the methods used for achieving the RAOs through the remedial actions are summarized in the following list (DOE/RL-2016-45, Rev. 0):

- ***RAO 2. Prevent COCs migrating and/or leaching through soil that will result in groundwater concentrations above CULs for protection of groundwater, and of surface water concentrations above CULs for the protection of surface water at locations where groundwater discharges to surface water.***
  - Protection such that contaminant levels in soil after remediation did not result in an adverse impact to groundwater that exceeded any nonzero maximum contaminant level goals under the *Safe Drinking Water Act of 1974* or Method B cleanup levels under WAC 173-340, "Model Toxics Control Act – Cleanup."
  - Protection such that contaminant levels in the soil after remediation did not result in an impact to groundwater and the Columbia River that exceeded the ambient water quality criteria under the *Clean Water Act of 1977* for protection of fish or Method B cleanup levels under WAC 173-340, "Model Toxics Control Act – Cleanup." Because no ambient water quality criteria have been established for radionuclides, maximum contaminant levels from national primary drinking water standards were used.
  - The protection of receptors (aquatic species, with emphasis on salmon) in surface waters was achieved by reducing or eliminating further contaminant loadings to groundwater such that receptors at the groundwater discharge in the Columbia River were not subjected to any additional adverse risks.
- ***RAO 3. Prevent human exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above residential scenario-based CULs in areas outside both the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).***

  Cleanup levels for nonradionuclides in the 300 Area industrial land use scenario are based on WAC 173-340-745(5), which assumed that the exposure pathway for residual contamination will be from ingestion of contaminated soil. Soil cleanup levels were calculated using the equations provided by WAC 173-340-745(5), Method C, for carcinogens and noncarcinogens.
  For carcinogens, a lifetime cancer risk goal of 1x10-5 was achieved. For noncarcinogens, a hazard quotient of 1 was achieved.
- ***RAO 4. Prevent human exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above CULs for industrial use in the 300 Area Industrial Complex and waste site 618-11 (adjacent to Energy Northwest).***

  The same method was used as is noted for RAO 3.
- ***RAO 5. Manage direct exposure to contaminated soils deeper than 4.6 m (15 ft) to prevent an unacceptable risk to human health and the environment.***

  Attain individual COC cleanup levels. Direct contact cleanup levels for nonradionuclides are based on risk calculations provided in the WAC 173-340, "Model Toxics Control Act – Cleanup," procedures. Direct contact cleanup levels for radionuclides are calculated based on an excess lifetime cancer risk of 1x10-4 or a radiological dose of 15 mrem/yr. For each radionuclide, the lower of risk- or dose-based calculations was used as the cleanup level.
- ***RAO 6. Prevent ecological receptors from direct exposure to the upper 4.6 m (15 ft) of soil, structures and debris contaminated with COCs at concentrations above CULs.***

  Achieved through excavation to WAC 173-340, "Model Toxics Control Act – Cleanup," levels for organic and inorganic chemical constituents in soil to support unrestricted (residential) and/or industrial use. Achieved human health total radiological dose standards of less than 15 mrem/yr above background for radionuclides.

ICs applicable within the entire 300 Area IC boundary area include the application of deed restrictions in the event that land is transferred out of federal ownership, reporting of unauthorized access to the Benton County's Sheriff's Office, prohibiting any activities that would disrupt or lessen the performance of any

component of the remedy, and notifying EPA and Ecology on discovery of any activity inconsistent with the specific ICs. As further described in DOE/RL-2001-41, DOE also has other administrative ICs (e.g., a site excavation permitting program) to limit the access and use of groundwater in a manner that is protective of human health where groundwater contamination is above the cleanup levels, protect environmental and cultural resources, prevent enhanced recharge (e.g., no irrigation or landscape watering, controlling drainage, and prevention of bare gravel or bare sand covers). DOE also is required to prevent the development and use of property that does not meet the residential cleanup levels at the 300 Area Industrial Complex and the 618-11 waste site. These and other ICs applicable to the 300-FF-1 and 300-FF-2 source OUs are assessed annually and DOE presents any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes, which are archived in the Hanford Site Administrative Record (see example in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During this 5-year review period, no deficiencies were noted for the 300-FF-1 and 300-FF-2 source OUs.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

Yes. The exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection in the 2013 ROD are still valid.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information is known that could call into question the protectiveness of the remedy.

2.4.1.1.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 300-FF-1 and 300-FF-2 OUs were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.4.1.1.7 Protectiveness Statements

300-FF-1 Source OU – Will Be Protective. The final remedy at the 300-FF-1 source OU waste sites is expected to be protective of human health and the environment upon completion of the final remedy actions. The final remedy actions (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) ensure that exposure pathways that could result in unacceptable risks are being controlled.

300-FF-2 Source OU – Will Be Protective. The final remedy at the 300-FF-2 source OU waste sites is expected to be protective of human health and the environment upon completion of the final remedy actions. The final remedy actions (primarily involving RTD, backfilling, recontouring, revegetation, and ICs) ensure that exposure pathways that could result in unacceptable risks are being controlled.

2.4.1.2 300-FF-5 Groundwater Operable Unit

2.4.1.2.1 Background

The 300-FF-5 groundwater OU (previously shown in Figure 2-25) is 1 of 10 groundwater OUs on the Hanford Site, and 1 of 6 located in the River Corridor. The 300-FF-5 OU is defined by the groundwater contaminated by releases from the 300-FF-1 OU and 300-FF-2 OU waste sites.

A subset of the waste sites in the 300-FF-1 and 300-FF-2 source OUs has contributed to the contamination plumes being addressed by the 300-FF-5 groundwater OU. These waste sites and associated groundwater plumes are located in three regions: the 300 Area Industrial Complex, the 618-11 burial ground located west of Energy Northwest, and a region that includes the 618-10 burial ground and 316-4 cribs located southeast of the 400 Area; see Figure 2-25.

The 300-FF-5 OU groundwater contamination originated primarily from past disposal of liquid effluent associated with fabrication of nuclear fuel assemblies and research involving irradiated fuel processing. Because the principal liquid waste disposal facilities in the 300 Area have been out of service for decades and most have been remediated by removing contaminated soil, the contamination remaining in the underlying vadose zone and aquifer is residual.

COCs for the 300-FF-5 OU are cis-1,2-dichloroethene (DCE), gross alpha, nitrate, trichloroethene (TCE), tritium, and uranium (as metal).

The groundwater in the unconfined aquifer beneath the southeastern portion of the Hanford Site flows primarily to the east or southeast toward the Columbia River. This flow direction is induced by regional groundwater flow that converges from the northwest, west, and southwest. Flow patterns throughout the region are complicated by the variable permeability of sediment in the upper portion of the unconfined aquifer. Near the river, groundwater flow also is influenced by river-stage fluctuations. Groundwater underlying the 300 Area Industrial Complex flows south-southeast during low river stage and south-southwest during high river stage (typically March through June).

Current onsite land use in and around the 300-FF-1, 300-FF-2, and 300-FF-5 OUs is industrial and access to the waste site areas and contaminated groundwater is restricted. Ongoing research and development activities within the 300 Area Industrial Complex are projected to continue in designated facilities through at least 2045. The DOE, Pacific Northwest Site Office (PNSO), documents this need to maintain a presence in the 300 Area in memo 16-PNSO-0057, "Need for the Pacific Northwest National Laboratory (PNNL) Occupied/Operated 300 Area Environmental Management (EM) Facilities Anticipated to Extend Through 2045."

A summary of the 300-FF-5 groundwater is included in the *Hanford Site Groundwater Monitoring Report* (published annually to address the previous calendar year, and available on line at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports).

Additional CERCLA documentation associated with the 300-FF-5 groundwater OU, as well as other OUs, can be accessed directly or queried in the Administrative Record for the Hanford Site's OUs and TSD units, at the following address:
http://pdw.hanford.gov/arpir/index.cfm/predefinedSearch?canType=OpUnit

2.4.1.2.2 Chronology

Table 2-30 lists the remedial action decision documents associated with the 300-FF-5 groundwater OU.

Table 2-30. Decision Documents for the 300-FF-5 Groundwater Operable Unit.

Date	Location	Title
7/1996	EPA/ROD/R10-96/143	***Declaration of the Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington*.** This is the initial final-action ROD for the 300-FF-1 OU and an interim action ROD for the 300-FF-5 OU. The 300-FF-1 OU actions required removal of contaminated soil and debris with disposal at ERDF, backfilling, recontouring, and implementing ICs. The 300-FF-5 OU actions included monitoring and maintaining ICs for groundwater.
6/2000	EPA/ESD/R10-00/524	***Explanation of Significant Difference for the 300-FF-5 Record of Decision*.** This document expands the scope of the 300-FF-5 OU ROD to include groundwater in the 300 Area, including 300-FF-2 OU sites and any sites plugged into the 300-FF-1 OU ROD.

Table 2-30. Decision Documents for the 300-FF-5 Groundwater Operable Unit.

Date	Location	Title
11/2013	EPA and DOE 2013	***Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1 Hanford Site, Benton County, Washington*.** This ROD selects final remedies for the waste sites in the 300-FF-2 OU and the groundwater in the 300-FF-5 OU and amends the remedy for three 300-FF-1 OU waste sites. This final action remedy replaces the interim action remedies for the 300-FF-5 and 300-FF-2 OUs selected in 1996 and 2000, respectively. It amends the 1996 remedy for the 300-FF-1 OU to add remedial action for uranium from three sites. Contaminated buildings are being removed in accordance with CERCLA action memoranda and are not part of the OUs addressed by this ROD. The major components of the selected remedy for the 300-FF-2 OU are as follows: • RTD at waste sites • Emplace temporary surface barriers and fill pipeline voids • Perform enhanced attenuation of uranium using sequestration in the vadose zone, periodically wetted zone, and top of the aquifer • Implement ICs, including the requirement that DOE prevent the development and use of property at the 300 Area Industrial Complex and 618-11 that does not meet residential cleanup levels for other than industrial uses, including use for residential housing, elementary and secondary schools, childcare facilities, and playgrounds.
		The major components of the selected remedy for the 300-FF-5 OU are as follows: • Monitored natural attenuation • Groundwater monitoring • Enhanced attenuation of uranium at the top of aquifer • ICs. The major component of the amended remedy for 300-FF-1 OU is enhanced attenuation of uranium using sequestration in the vadose zone, periodically wetted zone, and top of the aquifer.
9/2015	16-AMRP-0259	***Explanation of Significant Differences for the Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*.** This ESD adds two waste sites to the 300 Area ROD, Table 1; waste site 600-386 requires no additional action to meet the selected remedy requirement of the 300-FF-2 OU; and waste site 600-393 was added for RTD to residential cleanup levels.

ARAR = applicable or relevant and appropriate requirement.
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.
ERDF = Environmental Restoration Disposal Facility.
ESD = explanation of significant difference.
IC = institutional control.
MCL = maximum contamination level.
O&M = operation and maintenance.
P&T = pump and treat.
ROD = record of decision.
RTD = remove, treat, and dispose of.

See Appendix B for a consolidated list of decision documents for Hanford site OUs.

2.4.1.2.3 Remedial Action

Goals and Objectives. In accordance with the NCP, "*EPA expects to return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site*" (40 CFR 300.430[a][1][iii][F]). EPA generally defers to state definitions of groundwater classification provided under EPA-endorsed Comprehensive State Groundwater Protection Programs (EPA/540/G-88/003).

Groundwater from the 300-FF-5 OU is contaminated and is not currently withdrawn from the aquifer for beneficial use; however, the potential beneficial use of the groundwater is as a drinking water source. Consistent with the beneficial-use classifications of Washington State and the EPA, the goal for remediating 300-FF-5 OU groundwater is to reduce contamination to levels that will allow its use as a future drinking water source.

Accordingly, the RAOs for the 300-FF-5 OU, as stated in the ROD (EPA and DOE 2013), are as follows:

- ***RAO 1. Prevent human exposure to groundwater containing COC concentrations above CULs.***
- ***RAO 2. Prevent COCs migrating and/or leaching through soil that will result in groundwater concentrations above CULs for protection of groundwater, and of surface water concentrations above CULs for the protection of surface water at locations where groundwater discharges to surface water.***
- ***RAO 7. Restore groundwater impacted by Hanford Site releases to CULs which include DWSs, within a timeframe that is reasonable given the particular circumstances of the site.***

Remedy Components. The ROD, as signed in 2013, provided the following summary-level descriptions of the major components of the selected remedy (i.e., monitored natural attenuation, groundwater monitoring, enhanced attenuation of uranium at the top of the aquifer, and ICs); the italicized text in the following box is a direct quote from the original ROD (EPA and DOE 2013). As noted in the ROD, the remedies selected may change somewhat through the remedy design and construction process. Any changes to the remedies and ROD amendment described in the ROD will be documented using a technical memorandum in the administrative record, an ESD, or a ROD amendment, as appropriate.

Excerpt from ROD (EPA and DOE 2013):

Monitored Natural Attenuation (MNA) of Groundwater. Monitored natural attenuation is a remedial strategy that monitors natural attenuation processes until CULs are met, provided they are met within a reasonable timeframe. Natural attenuation relies on natural processes within the aquifer to achieve reductions in the toxicity, mobility, volume, concentration and/or bioavailability of contaminants. These natural processes include physical, chemical and biological transformations that occur without human intervention. Contaminants in groundwater in 300-FF-5 that will be managed through MNA are nitrate and tritium down gradient from the 618-11 Burial Ground and TCE and DCE at the 300 Area Industrial Complex.

Natural attenuation of nitrate and tritium from the 618-11 Burial Ground will occur through a combination of dispersion during transport and natural radiological decay for tritium. Computer modeling predicts that the tritium concentrations will decrease to below the CUL by 2031. The waste within the 618-11 Burial Ground that released the nitrate and tritium will be removed by RTD.

MNA is used for the TCE and DCE in groundwater from the 300 Area Industrial Complex. Natural attenuation will occur primarily through physical attenuation (diffusion and dispersion) and biodegradation.

MNA includes monitoring to ensure the effectiveness of natural attenuation to meet CULs. Monitoring as a component of MNA as well as the remaining monitoring requirements for 300-FF-5 will be integrated into the sampling and analysis portion of the RD/RAWP. This integrated sampling is described in section 12.2.9 below (i.e., Section 12.2.9 in the ROD).

Groundwater Monitoring. Groundwater monitoring, including monitoring as required as a component of MNA, will be integrated into the sampling and analysis portion of the RD/RAWP. Sampling will be sufficient to document changes in contaminant plumes for all groundwater COCs. As part of monitoring the lateral extent of plumes, groundwater will be monitored in the near vicinity of the Columbia River throughout the 300 Area Industrial Complex and both north and south of that area to ensure lateral extent of the plumes are defined. Because several of the 300-FF-5 groundwater COCs are also contaminants in 200-PO-1 that move through the 300 Area, monitoring of 300-FF-5 COC plumes will include lateral extent sufficient to distinguish contamination that is part of 300-FF-5 versus 200-PO-1. Monitoring will continue until COCs have attained the CULs and are expected to continue to meet CULs and EPA approves termination of the monitoring. Considered in the evaluation will be processes that can affect concentrations such as river fluctuations, waste site activities and land use activities. Groundwater monitoring will be performed to evaluate the effectiveness of the selected 300-FF-5 remedy to achieve CULs. The monitoring will be for groundwater COCs (uranium, gross alpha, nitrate, TCE and DCE at the 300 Area Industrial Complex; uranium and gross alpha down gradient from the 618-7 Burial Ground; and tritium and nitrate down gradient from the 618-11 Burial Ground). [Note: monitoring is also conducted for gross alpha downgradient of the 618-10 burial ground and 316-4 crib in accordance with 300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan (DOE/RL-2014-42, Rev. 0).]

Enhanced Attenuation of Uranium at the Top of the Aquifer. Uranium sequestration phosphate solutions will be delivered to the top of the aquifer through injection wells to limit the lateral mobility of untreated uranium that may be mobilized from the vadose zone during surface infiltration and injection into the PRZ. Treatment will use the following general approach, with details to be developed in remedial design and established in the RD/RAWP:

- *Well injection of phosphate reagent-amended water*
- *Reagent mixing facility, pipelines, injection wells, pumps, valves*
- *Phosphate reagent injection wells spaced approximately 60 to 120 m (200 to 400 ft) apart adjacent to (along the river side) the approximately 1 hectare (3 acre) target area. Preliminary design includes six injection wells*
- *Injection rates ranging from approximately 380 to 760 L/min (100 to 200 gal/min) for each well.*

Institutional Controls (Common Elements for 300-FF-2 and 300-FF-5). "…Land-use controls will be maintained until CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs include the following:

- *In the event that land is transferred out of federal ownership, deed restrictions (proprietary controls such as easements and covenants) are required that are legally enforceable against subsequent property owners.*
- *In the event of any unauthorized access (e.g. trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and evaluation of possible prosecution.*
- *Activities that would disrupt or lessen the performance of any component of the remedies are prohibited.*
- *The DOE shall report on the effectiveness of ICs for 300-FF-2 and 300-FF-5 in an annual report, or on an alternative reporting frequency specified by the lead regulatory agency. Such reporting may be for 300-FF-2 and 300-FF-5 alone or may be part of the Hanford Sitewide ICs report.*

Measures that are necessary to ensure continuation of ICs shall be taken before any lease or transfer of any land subject to ICs. DOE will provide notice to Ecology and EPA at least 6 months before any transfer or sale of land subject to ICs so that the lead regulatory agency can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective ICs. If it is not possible for DOE to notify Ecology and EPA at least 6 months before any transfer or sale, DOE will notify Ecology and EPA as soon as possible, but no later than 60 days before the transfer or sale of any property subject to ICs. In addition to the land transfer notice and discussion provisions, DOE further agrees to provide Ecology and EPA with similar notice, within the same time frames, as to federal-to-federal transfer of property. DOE shall provide a copy of the executed deed or transfer assembly to Ecology and EPA. DOE shall notify EPA and Ecology immediately upon discovery of any activity inconsistent with the specific ICs."

Institutional Controls (Unique Elements for 300-FF-5): Land-use controls will be maintained until CULs are achieved and the concentrations of hazardous substances are at such levels to allow for unlimited use and unrestricted exposure and EPA authorizes the removal of restrictions. ICs to be implemented by DOE to support achievement of the RAOs are the following:

- *Administrative controls limiting 300-FF-5 groundwater access and use in a manner that is protective of human health where groundwater is above CULs (see figure 2* [of the 2013 ROD; the figure shows the 2012 locations of contaminant plumes for nitrate, tritium, and uranium within the 300-FF-5 OU]*).*

Remedy Implementation Progress Prior to this Review Period.

Both remedy components (i.e., continued monitoring of groundwater contaminated above health-based levels to ensure that concentrations continue to decrease, and ICs to ensure that groundwater use is restricted to prevent unacceptable exposures to groundwater), as specified in the 1996 interim action ROD (EPA/ROD/R10-96/143, as amended), were implemented and continued up to and beyond the previous (2006-2010) review period. Further details on this earlier period of monitoring and ICs are included in the previous 5-year review report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070).

Issues/Corrective Actions from the Previous 5-Year Review. In the previous CERCLA 5-Year Review Report (DOE/RL-2011-56, as amended by Errata Sheet 12-EMD-0070), the following issue and action were noted (with EPA identified as the Tri-Party Agreement lead regulator):

- ***Issue 4****: Remediation approach in interim action ROD (EPA/ESD/R10-00/524) for natural attenuation is not effective in meeting groundwater remediation goals in the 300 Area.*
- ***Action 4****.1: Submit proposed plan for a ROD to support meeting groundwater remediation goals (Action Due Date: 12/31/2011)*
  - *Does this issue/action currently affect the protectiveness of the remedy?* – YES
  - *Will this issue/action affect the protectiveness of the remedy in the future?* – YES

In support of this issue and action, *Proposed Plan for Remediation of the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* (DOE/RL-2011-47), was prepared and finalized in 2013. As noted in an upcoming section, subsequent action resulted in issuance of the ROD for the 300-FF-5 OU in 2013.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The 300-FF-5 OU protectiveness statement from the previous (2006 – 2010) 5-year review report was noted as follows:

> *The remedy at 300-FF-5 Groundwater OU is not protective because the interim remedy selected of monitoring the expected attenuation of the uranium are not predicted to meet the groundwater cleanup standards. As a result, the remedial actions and remedial action objectives for the final remedy are being evaluated. Further information will be obtained by completing the River Corridor Baseline Risk Assessment. It is expected that these actions will be completed by 2016, at which time a protectiveness determination will be made. In April 2010, the 300 Area Remedial Investigation/Feasibility Study Sampling and Analysis Plan for the 300-FF-1, 300-FF-2 and 300-FF-3 Operable Units, DOE/RL-2009-45 was issued.*

2.4.1.2.4 Progress Since 2011 Review

Accomplishments. The primary remedial action accomplishments for the 300-FF-5 groundwater OU during the past 5 years can be summarized as follows:

- Continued groundwater monitoring and management of ICs as interim remedy components under the interim-action ROD
- Submitted a draft proposed plan for remediation of the 300-FF-1, 300-FF-2, and 300-FF-5 OUs (December 2011)
- Issued the RI/FSs, *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* (DOE/RL-2010-99) and *Remedial Investigation/Feasibility Study for the 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units, Addendum* (DOE/RL-2010-99-ADD1) and the proposed plan (DOE/RL-2011-47) for the 300-FF-5 OU in July 2013
- Issued a 300-Area ROD for the 300-FF-2 and 300-FF-5 OUs and a ROD amendment for the 300-FF-1 OU (November 2013)
- Continued to perform MNA and manage ICs as final-action remedy components
- Issued the RDR/RAWP addendum for groundwater in June 2015
- Completed enhanced attenuation of uranium on Stage A (0.75 acre) in November 2015
- Issued DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, the remedy implementation sampling and analysis plan, in September 2015
- EPA and DOE agreed that TCE had achieved the cleanup level in all but one well in the TCE monitoring network; therefore, TCE will be monitored only at one well in accordance with DOE/RL-2014-42.

Remedy Implementation. Remedy implementation during this 5-year review period transitioned from interim to final actions.

Implementation of *Declaration of the Record of Decision for the 300-FF-1 and 300-FF-5 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-96/143) and as amended via an ESD in 2000 (EPA/ESD/R10-00/524) continued through the first portion of this 5-year review period. The interim action remedy components included MNA, groundwater monitoring, and ICs.

The ROD (EPA and DOE 2013) was issued in 2013. In accordance with the 2013 ROD, the remedy for the 300-FF-5 OU consists of the following components:

- MNA for nitrate, tritium, TCE, and DCE
- Groundwater monitoring for uranium, gross alpha, nitrate, tritium, TCE, and DCE
- Enhanced attenuation of uranium using sequestration by phosphate application at the top of the aquifer
- ICs.

In accordance with the 2013 ROD, the in-progress interim actions were to use the cleanup levels in the 2013 ROD immediately upon its issuance. Performance of all other aspects of the interim action was to continue in accordance with the existing documents for the interim action until the new RDR/RAWP that implements the 2013 ROD was issued. The ROD also specifies that once the new RDR/RAWP is approved, it will direct future remedial actions and replace all interim-action ROD and earlier work plan requirements.

In 2015, DOE issued the following suite of RDR/RAWP documents:

- *Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units)*, Rev. 0 (DOE/RL-2014-13);
- *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils*, Rev. 0 (DOE/RL-2014-13-ADD1)
- *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, Rev. 0 (DOE/RL-2014-13-ADD2).

DOE/RL-2014-13-ADD2, the RDR/RAWP for the 300-FF-5 OU, which implements the groundwater portion of the 2013 ROD, was issued in June 2015 and amended to accommodate schedule changes via TPA-CN-700, "DOE/RL-2014-13-ADD2 Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater," in November 2015.

In accordance with the plan and schedule included in the RDR/RAWP (DOE/RL-2014-13-ADD2), construction/implementation of all remedy components is expected to take several years and will be followed by several decades of O&M. Implementation plans, which are documented in DOE/RL-2014-42, *300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, include sequentially performing two phases (Stages A and B) of well/piezometer installations and phosphate injections for enhanced uranium sequestration in FYs 2015, 2016, and 2017 and issuing a uranium sequestration completion report in fiscal year (FY) 2018. The performance monitoring plan contained in the remedy implementation SAP (DOE/RL-2014-42) outlines the well locations, sampling frequency, and analytes to be addressed by the groundwater monitoring and MNA remedy components.

The IC component of the 300-FF-5 OU remedy has been incorporated into and is being managed under the *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE-RL-2001-41).

Table 2-31 presents an overview of the primary components of the 300-FF-5 remedy and their implementation status.

Table 2-31. Overview of 300-FF-5 Groundwater OU Remedy Implementation.

Document Type	Date	Title
ROD	11/2013	*Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1 Hanford Site, Benton County, Washington* (EPA and DOE 2013)
RDR/RAWP	06/2015	*Integrated Remedial Design Report/Remedial Action Work Plan for the 300 Area (300-FF-1, 300-FF-2 & 300-FF-5 Operable Units*, DOE-2014-13, Rev. 0, *Remedial Design Report/Remedial Action Work Plan for 300-FF-2 Soils*, DOE/RL-2014-13-ADD1, Rev. 0, *Remedial Design Report/Remedial Action Work Plan Addendum for the 300 Area Groundwater*, DOE/RL-2014-13-ADD2, Rev. 0
Remedy Implementation SAP	09/2015	*300-FF-5 Operable Unit Remedy Implementation Sampling and Analysis Plan*, DOE/RL-2014-42, Rev. 0
Applicable RAOs (brief description)	1. Prevent human exposure to groundwater containing COC concentrations above cleanup levels. 2. Prevent COCs migrating and/or leaching through soil that will result in groundwater concentrations above cleanup levels for protection of groundwater and of surface water concentrations above cleanup levels for the protection of surface water at locations where groundwater discharges to surface water. 7. Restore groundwater impacted by Hanford Site releases to cleanup levels that include DWSs, within a timeframe that is reasonable given the particular circumstances of the site.	
COCs	Cis-1,2-dichloroethene (DCE), gross alpha, nitrate, trichloroethene (TCE), tritium, and uranium (as metal)	

Remedy Component	**Construction Status** (approximate percentage complete for constructing/implementing the remedy component as of December 2015)[a]						**Duration of O&M** (~years)[b]	**Finish**[c] (Est'd year)
	0	**1-25**	**26-50**	**51-75**	**76-99**	**100%**		
Monitored Natural Attenuation							28	2041
Groundwater Monitoring							28	2041
Enhanced Attenuation of Uranium (Stage A [began in 2015])							N/A	2015
Enhanced Attenuation of Uranium (Stage B [begins in 2017])							N/A	2018
Institutional Controls							28	2041

[a]Percentages reflect construction status of the remedy component; post-startup upgrades and system performance optimization is considered part of O&M. 100% = fully implemented and now in O&M mode.
[b]Approximate number of years to operate remedy component as estimated in ROD (shorter durations for certain COCs)
[c]Estimated year when remedy component will be completed.
COC = contaminant of concern.
O&M = operation and maintenance.
N/A = not applicable.
OU = operable unit.
RAO = remedial action objectives.
ROD = record of decision.
SAP = sampling and analysis plan.

2.4.1.2.5 Technical Assessments

Is the remedy functioning as intended by the decision documents?

Yes, the 300-FF-5 remedy is mostly functioning as intended by the ROD (EPA and DOE 2013); remedy components including MNA, groundwater monitoring, enhanced attenuation of uranium – Stage A, and ICs. However, construction/conduct of Stage B is a future task. Field construction of the remedy component involving "enhanced attenuation of uranium" (supporting achievement of RAO 2 and RAO 3) began and was completed in 2015 for Stage A. Stage B will begin in 2017 and be completed in 2018 and will be addressed in the next 5-year review (2021). ICs (supporting achievement RAO 1) are continuing to function as planned to prevent human exposure to the groundwater.

Table 2-32 provides an overview of 300-FF-5 OU contaminant plume areas and associated changes to the areas during this 5-year review period. The network of wells and aquifer tubes sampled in 2015 is shown in Figure 2-27. Plume maps in Figure 2-28 show the changes in plume shapes and areas during this 5-year review period. The plots in Figure 2-29 depict the estimated annual changes in contaminant plume areas over the past several 5-year periods with a generally decreasing trend for the period.

For more detailed information on the 300-FF-5 groundwater OU well locations (supporting the MNA remedy component, and achievement of RAO 3), distribution of contaminant concentrations within each plume, and historic trends associated with each 300-FF-5 contaminant of concern, as well as for performance metrics associated with 300-FF-5 OU groundwater treatment, see the *Hanford Site Groundwater Monitoring Report* (published each summer for the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

Table 2-32. Overview of 300-FF-5 Groundwater Contaminant Plumes.[a]

Groundwater Contaminant	Cleanup Level[b]	Maximum Concentration (2015)	Plume Area[c] (km^2)			Intersection[d] (m)		
			2011	2015	Change	2011	2015	Change
Uranium (300 Area Industrial Complex)	30 µg/L	165 µg/L	0.49	0.34	-0.15	1,160	1,480	320
Gross Alpha (300 Area)	15 pCi/L	107 pCi/L	N/C[e]	N/C[e]	N/A	N/C[e]	N/C[e]	N/A
cis-1,2-Dichloroethene (DCE) (300 Area Industrial Complex)	16 µg/L	211 µg/L	U[f]	U[f]	U[f]	U[f]	U[f]	N/A
Trichloroethene (TCE) (300 Area Industrial Complex)	4 µg/L	1.4 J µg/L	U[f]	U[f]	U[f]	U[f]	U[f]	N/A
Tritium (618-11)	20,000 pCi/L	877,000 pCi/L	0.33[g]	0.12[g]	-0.21	None	None	N/A
Nitrate (618-11)	45 mg/L[h]	57.5 mg/L	0.24[g]	0.18[g]	-0.06	N/C	None	N/A

[a]Source: Hanford Annual Groundwater Monitoring Reports for 2011 and 2014. Available online at http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

[b]Source: *Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1, Hanford Site 300 Area* (EPA and DOE et al. [2013]).

[c]Estimated area at a concentration greater than the cleanup level. Plume areas for uranium, tritium and nitrate for 2011 and 2015 are based on Drinking Water Standards.

[d]Length of Columbia River shoreline intersected by contaminant plumes.

[e]Because gross alpha activity is associated with uranium, it will be addressed with the remediation of uranium.

[f]Organics are locally present in deeper sediments. Plumes cannot be defined by current data.

[g]Excludes tritium and nitrate in plume associated with 200-PO-1 and nitrate from off Site.

[h]45 mg/L (expressed as the NO_3 ion) is an equivalent concentration to the federal drinking water standard for nitrate of 10 mg/L (expressed as NO_3-N). To convert nitrate as the NO_3 ion, the NO_3-N drinking water standard value is multiplied by 4.43.

J = laboratory estimated value.
N/A = not applicable.
N/C = not calculated.
U = undefined.

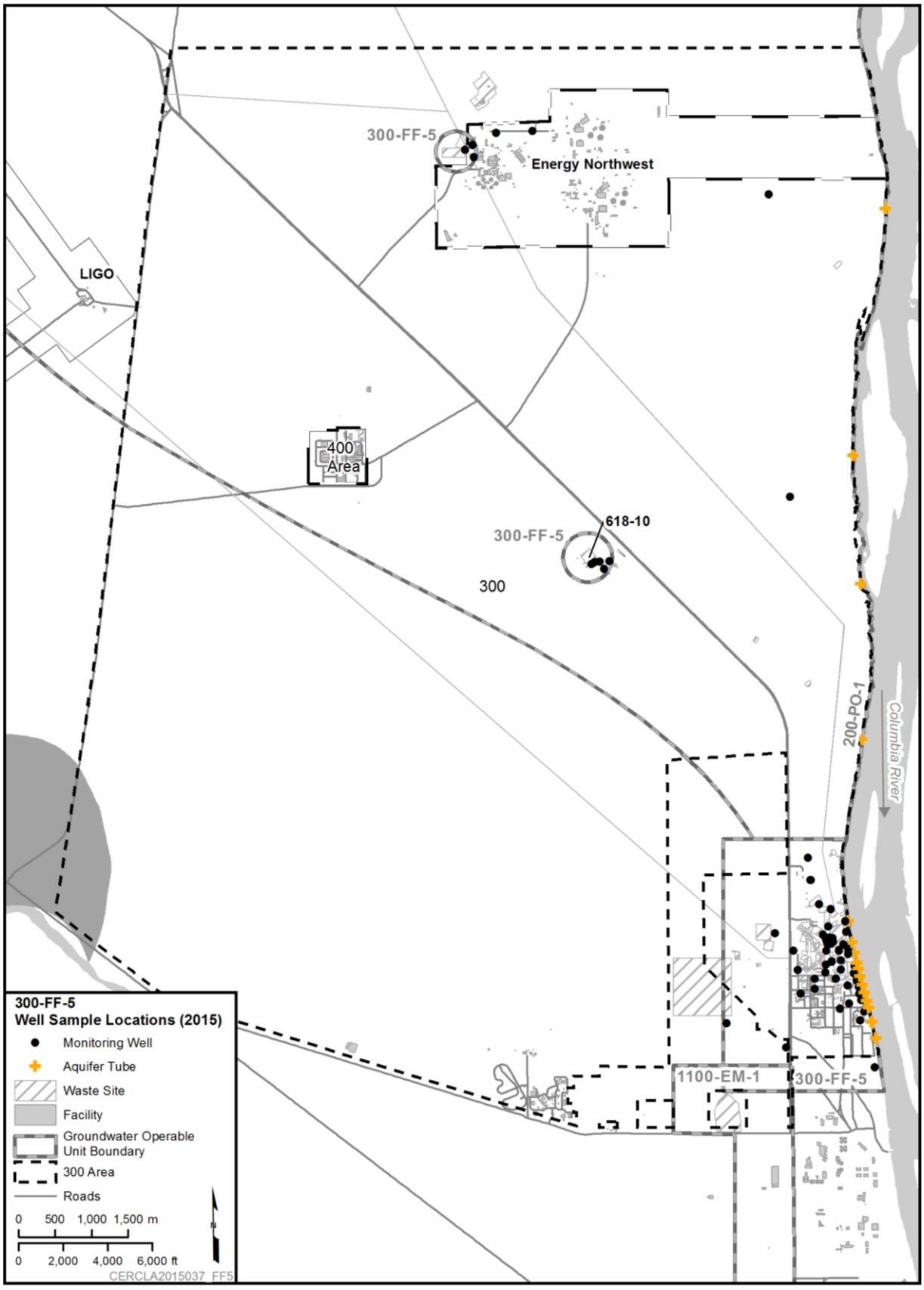


Figure 2-27. Locations of 300-FF-5 Groundwater OU Wells and Aquifer Tubes Sampled in 2015.

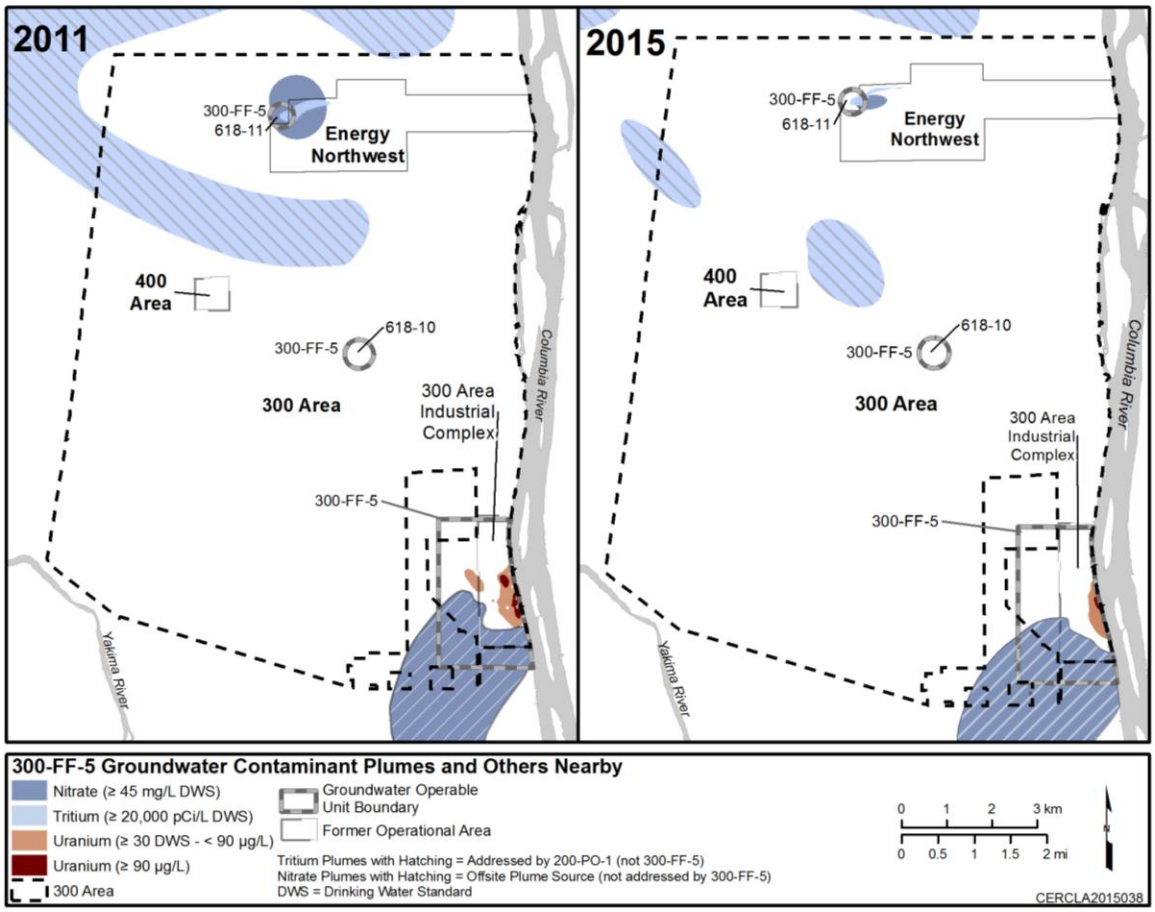


Figure 2-28. 300-FF-5 Groundwater OU and Nearby Plumes in 2011 (left) and 2015 (right).

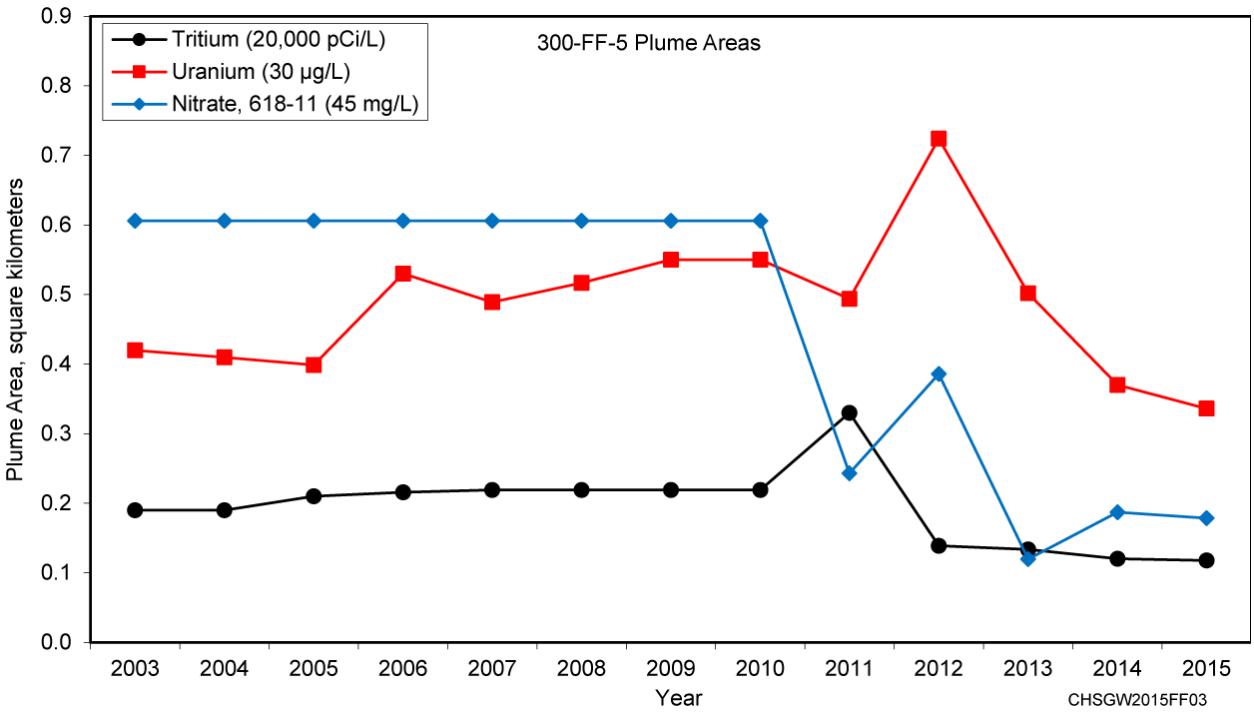


Figure 2-29. 300-FF-5 Trend Plots of Contaminant Plume Areas (2003 – 2015).

ICs, as required by the 2013 ROD (EPA and DOE 2013), are captured in DOE/RL-2001-41 and are actively managed. ICs applicable within the entire 300 Area IC boundary area include applying deed restrictions in the event that land is transferred out of federal ownership, reporting of unauthorized access to the Benton County's Sheriff's Office, prohibiting any activities that would disrupt or lessen the performance of any component of the remedy, and notifying EPA and Ecology on discovery of any activity inconsistent with the specific ICs. As further described in DOE/RL-2001-41, DOE also has other administrative ICs (e.g., requirement for a site excavation permitting program) to limit the access and use of groundwater in a manner that is protective of human health where groundwater contamination is above the cleanup levels, protect environmental and cultural resources, and prevent enhanced recharge (e.g., no irrigation or landscape watering, controlling drainage from low permeability areas, and preventing bare gravel or bare sand covers). Assessments on these and other ICs applicable to the 300-FF-5 OU are performed annually and any noted issues or actions are presented by DOE to the Site regulators each fall and documented in meeting minutes, which are archived in the Hanford Site Administrative Record (see example in Attachments 12, 13, and 14 at the following link: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=1511240005). During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 300-FF-5 Groundwater OU ICs.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection (2013) are still valid for the OU.

Has any other information come to light that could call into question the protectiveness of the remedy?

No information has come to light that would call into question the protectiveness of the remedy.

2.4.1.2.1 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 300-FF-5 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

2.4.1.2.2 Protectiveness Statements

300-FF-5 Groundwater OU – Will Be Protective. The remedy at the 300-FF-5 groundwater OU is expected to be protective upon completion. Groundwater monitoring is ongoing, and ICs are in place and are protecting human exposure to contaminated groundwater. Construction of the remedy component involving enhanced attenuation of uranium is expected to be completed in 2017 and documented in 2018; this is expected to reduce the timeframe for achieving uranium cleanup levels. In the interim, the remedial activities completed to date adequately address the exposure pathways that could result in unacceptable risks in these areas.

2.5 1100 AREA – 1100-EM-1 OPERABLE UNIT

The 1100 Area was officially removed from the NPL in 1996, as documented in "National Oil and Hazardous Substances Pollution Contingency Plan; National Priorities List Update" (61 FR 51019). The 1100 Area contained four OUs: 1100-EM-1, 1100-EM-2, 1100-EM-3, and 1100-IU-1. Construction of the remedies selected for the 1100 area OUs in its final ROD, *EPA Superfund Record of Decision: USDOE Hanford 1100-AREA* (EPA/ROD/R10-93/063), as amended, was completed in 1995.

The remedy components included offsite incineration of Bis (2-ethylhexyl) phthalate (BEHP)-contaminated soils, offsite disposal of polychlorinated biphenyl (PCB)-contaminated soils, installation of a landfill cap in accordance with the asbestos "National Emission Standards for Hazardous Air Pollutants" (NESHAP) (40 CFR 61.151), offsite disposal of contaminated soil and debris, natural attenuation and groundwater monitoring, and ICs.

Even though the RAOs were met years ago and the 1100 Area has been removed from the NPL, one 1100-EM-1 OU waste site, the Horn Rapids Landfill, contains asbestos. As long as asbestos (a hazardous substance) remains at the landfill site and prevents the property from being released for unlimited use or unrestricted exposure, the landfill will be included in CERCLA 5-year reviews.

The Horn Rapids Landfill (1100-EM-1) was used for asbestos disposal and was closed in accordance with the asbestos regulations. Asbestos waste disposed of in the Horn Rapids Landfill is in place and remains secure. In September 2010, Ecology issued *Explanation of Significant Differences for the Record of Decision for the USDOE Hanford 1100 Area in Benton County, Washington*, (Ecology 2010) for the 1100 Area ROD to modify the IC requirements to be consistent with the current EPA guidance. A fence, signage, and the existing cap are maintained and upgraded as needed. The IC component for the Horn Rapids Landfill remedy was incorporated into DOE/RL-2001-41. During this 5-year review period, no issues were noted with the fencing, and one sign was changed-out. The landfill cover remains protective of human health and the environment. Inspection and maintenance of the Horn Rapids Landfill cover is the only remaining remedy component and will continue to be addressed in future CERCLA 5-year reviews unless a decision is made to clean-close the property.

Groundwater monitoring near the 1100-EM-1 OU continued during most of the this 5-year review period, even though groundwater monitoring since 2001 has repeatedly demonstrated that trichloroethene (TCE) levels in compliance wells have remained below the 5 mg/L cleanup level. On August 13, 2015, DOE and the lead regulatory agency (EPA) agreed, per Tri-Party Agreement Change Notice TPA-CN-679, "PNNL–220 -- Sampling and Analysis Plan for Groundwater Monitoring 1100-EM-1 Operable Unit," that annual groundwater monitoring for 1100-EM-1 groundwater is no longer required and may be discontinued.

Protectiveness Statement

1100-EM-1 Source OU – Protective. The remedy at the 1100-EM-1 OU is protective of human health and the environment.

Elements of the remedy that protect human health and the environment involve continuing ICs to address to the buried asbestos at the Horn Rapids Landfill (the only 1100-EM-1 site that is not closed out). The remedial action objectives were met at the landfill by offsite disposal of PCB-contaminated soils, capping of the landfill in accordance the Asbestos NESHAP (40 CFR 61.151) and providing adequate ICs to prevent future receptor exposure to contamination. The continuing ICs include entry restrictions, notice in deed, land use management, and miscellaneous provisions. Fencing, signage and the existing landfill cap are routinely inspected, maintained and upgraded as needed. No further review for the 1100 Area is included in this report.

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3 CENTRAL PLATEAU (200 AREA NATIONAL PRIORITIES LIST SITE)

3.1 BACKGROUND

The 200 Area NPL Site comprises the 200 East and West Areas and a smaller 200 North Area, all located on the Central Plateau, which covers approximately 205 km^2 (79 mi^2). The 200 East Area is located 27 km (17 mi) north-northwest of the city of Richland. The 200 West Area is located 9.6 km (6 mi) farther west. The 200 Area was added to the NPL on October 4, 1989, and remedial investigations began in 1992.

Historical Perspective. The Central Plateau's 200 Areas were used primarily for waste management activities and reprocessing SNF to recover special nuclear materials for use in national defense. Approximately 1,000 facilities, structures, and buildings, including the Plutonium Finishing Plant (PFP) and five large chemical processing or 'canyon' facilities (T Plant, B Plant, U Plant, REDOX Plant, and the Plutonium/Uranium Extraction (PUREX) Plant) were built to support processing irradiated fuel from the plutonium production reactors and for waste TSD. These processing activities generated large volumes of radioactive, hazardous, and mixed waste that either were disposed of to the soil column as liquid effluent via engineered structures such as cribs and trenches, or went into the soil column as spills and leaks. The liquid effluents were transported to the disposal waste sites or tank farms via single- and double-wall pipelines. The processing activities also generated solid waste that was disposed of in landfills. The intentional disposal and inadvertent release of this waste created more than 800 waste sites in the Central Plateau.

Chemical processing of nuclear materials was terminated in the early 1990s, but ongoing waste management activities are expected to continue into the future. Radioactive- and mixed-waste treatment and disposal are anticipated to continue until at least 2035. The underground tank farms, buried solid waste, and contaminated inactive soil areas and groundwater are the legacy of the production mission and the primary focus of today's cleanup mission.

High-radioactivity liquid effluents generated during reprocessing operations at the canyons were sent to 177 single- and double-shell underground tanks in tank farms on the Central Plateau. These single-shell tanks (SST) and double-shell tanks (DST) range in size from 208,198 L (55,000 gal) to approximately 3.8 million L (1 million gal). The tanks received liquid waste from all the processing facilities.

DSTs are active RCRA-permitted TSD units, while SSTs are RCRA TSD units in varying stages of waste retrieval and closure planning. In some cases, leaks from SSTs are either known or suspected to commingle with soil contamination from liquid effluent disposal sites (e.g., cribs). The Tri-Party Agencies are beginning to characterize the commingled contamination in an integrated manner (e.g., at the B, BX, and BY tank farms and adjacent waste disposal sites).

Another key component of the 200 Areas is ERDF, which was built to provide a safe disposal site for waste generated by the ongoing cleanup activities across the Site. ERDF is discussed in Section 3.4.2.3.

Cleanup Approach. As described in Revision 1 of *Hanford Site Cleanup Completion Framework*, (DOE/RL-2009-10), cleanup of the Central Plateau is a highly complex activity because of the large number of waste sites, surplus facilities, active treatment and disposal facilities, and areas of deep soil contamination. Past discharges of more than 450 billion gal of liquid waste and cooling water to the soil have resulted in about 155 km^2 (60 mi^2) of contaminated groundwater, with some plumes extending far beyond the plateau. Containing and remediating these plumes remains a high priority.

For areas of groundwater contamination in the Central Plateau, the goal is to restore the aquifer to achieve drinking water standards whenever practical. In instances where remediation goals are not achievable in a reasonable time frame, programs will be implemented to contain the plumes and prevent exposure to contaminated groundwater. Near-term actions are being taken to control plume migration.

DOE's goal is to minimize the area used for long-term waste management activities that require ICs to ensure protection of human health and the environment. At the completion of cleanup efforts, some residual hazardous and radioactive contamination will remain, both in surface disposal facilities and in subsurface media. To meet DOE's goal, the residual contamination will be confined within a portion of the Central Plateau called the "Inner Area."

DOE's Central Plateau cleanup strategy 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 alternatives, including active treatment, to restore the groundwater
- Make and implement cleanup decisions in a geographic approach analogous to the geographic approach applied to the River Corridor
- Develop and apply deep vadose zone treatment technologies to protect the groundwater
- Make and implement cleanup decisions that are protective of human health and the environment and that support anticipated future land use
- Address residual contamination in 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 make the area used for long-term waste management activities as small as practical.

3.1.1 Central Plateau Land Areas

The Central Plateau's Inner Area is currently defined by DOE (DOE/RL-2009-10) as the final footprint of the Hanford Site that will be dedicated to waste management and containment of residual contamination; the Inner Area will remain under federal ownership and control for the future. The Inner Area boundary is defined by waste disposal decisions already in place and anticipated future decisions that will result in the requirement for continued waste management and containment of residual contamination.

The "Outer Area" is defined as all areas of the Central Plateau beyond the Inner Area boundary. The Tri-Party Agencies are planning to clean up this portion of the Site to a level comparable to the level agreed on for the River Corridor. Contaminated soil and debris from the Outer Area will be removed to ERDF for final disposal. Completion of the Outer Area cleanup will shrink the active cleanup footprint to the approximately 16 km^2 (10-mi^2) final Inner Area.

3.1.2 Land Use

The HCP-EIS (DOE/EIS-0222) addressed land use for the Hanford Site. The Central Plateau is designated "Industrial-Exclusive" land use. This allows for continued waste management operations consistent with the NEPA, CERCLA, and RCRA commitments that have established numerous waste management TSD facilities. This designation allows for expansion of existing facilities or development of new compatible facilities. CERCLA documents for the Central Plateau have so far used an "Industrial" land-use designation to set exposure scenarios and establish cleanup levels. As described in DOE/EIS-0222, an Industrial land-use designation represents an area suitable and desirable for activities such as reactor operations, rail and barge transport facilities, mining, manufacturing, food processing, assembly, warehouse, distribution operations, and related activities consistent with industrial uses.

3.1.3 Groundwater Use

Groundwater in the Central Plateau is currently contaminated and not withdrawn from the aquifer for beneficial use (drinking water or industrial use). An alternative source of water derived from the Columbia River is provided to current industrial workers conducting activities on the Central Plateau. For the foreseeable future, as long as the anticipated land use remains industrial, it is unlikely that the groundwater will be used as a drinking water source because drinking water is provided from a central water treatment facility.

3.2 200 AREA SCOPE FOR THIS REVIEW

To support waste site remediation in the 200 Area, more than 15 source OUs have been established. These OUs comprise more than 800 waste sites in a wide range of types (e.g., ponds, cribs, ditches, trenches, pipelines, tanks, landfills, canyon buildings, and unplanned releases to soil). The general locations of the Central Plateau's source OUs are shown in Figure 3-1. While the source OUs in the Central Plateau are in various stages of the CERCLA process, RODs have been published for interim or final remedial action at the 200-CU-1 (U Plant); 200-CW-3; 200-DF-1 (ERDF); 200-PW-1/3/6, and 200-CW-5 (a grouping of primarily plutonium- and cesium-contaminated waste sites) OUs. These OUs are addressed in this 5-year review document. As remedial action decisions are made for the other source OUs in the Central Plateau, the OUs will be added to future 5-year reviews.

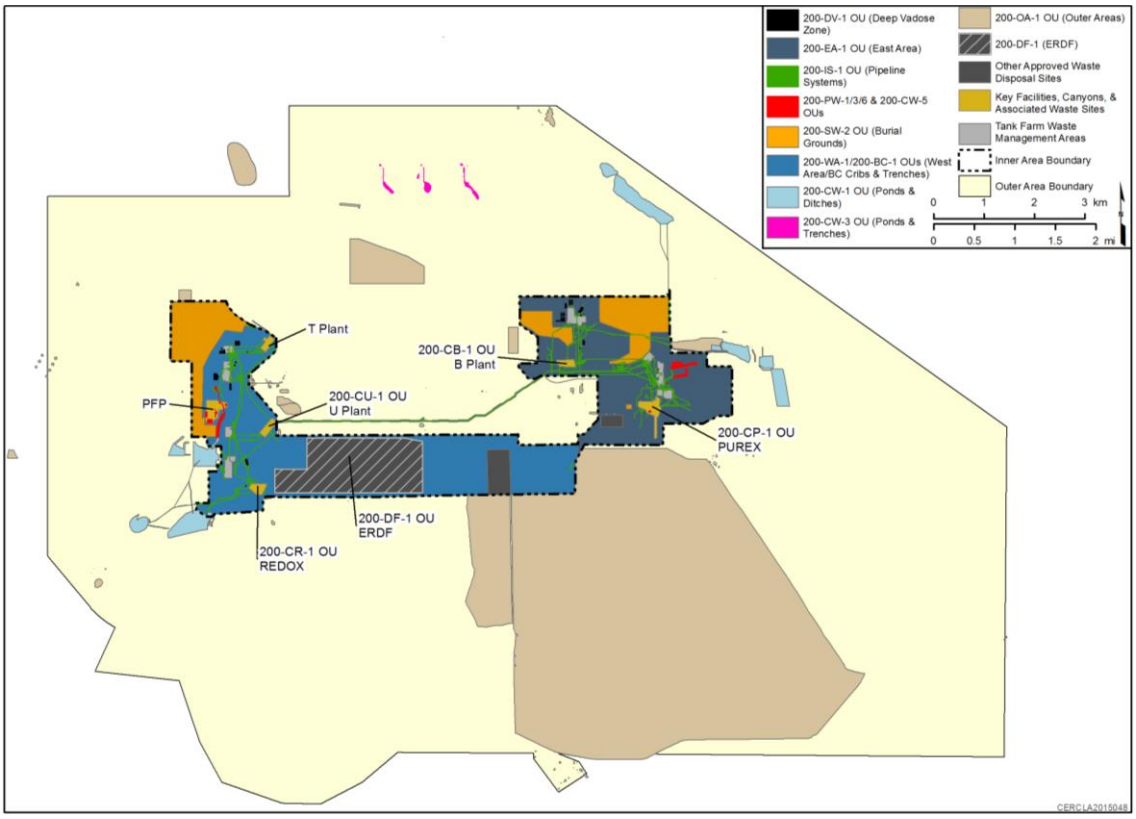


Figure 3-1. Source Operable Units in the Central Plateau

To support groundwater remediation in the 200 Area, four source OUs have been established: 200-BP-5, 200-PO-1, 200-UP-1, and 200-ZP-1). The 200 Area groundwater OUs are shown in Figure 3-2. This 5-year review covers two 200 Area groundwater OUs (200-UP-1 and 200-ZP-1, both in the 200 West Area) where remedial actions published in RODs are being implemented. As remedial action decisions are made for the other two groundwater OUs based in the Central Plateau, they will be included in future 5-year reviews.

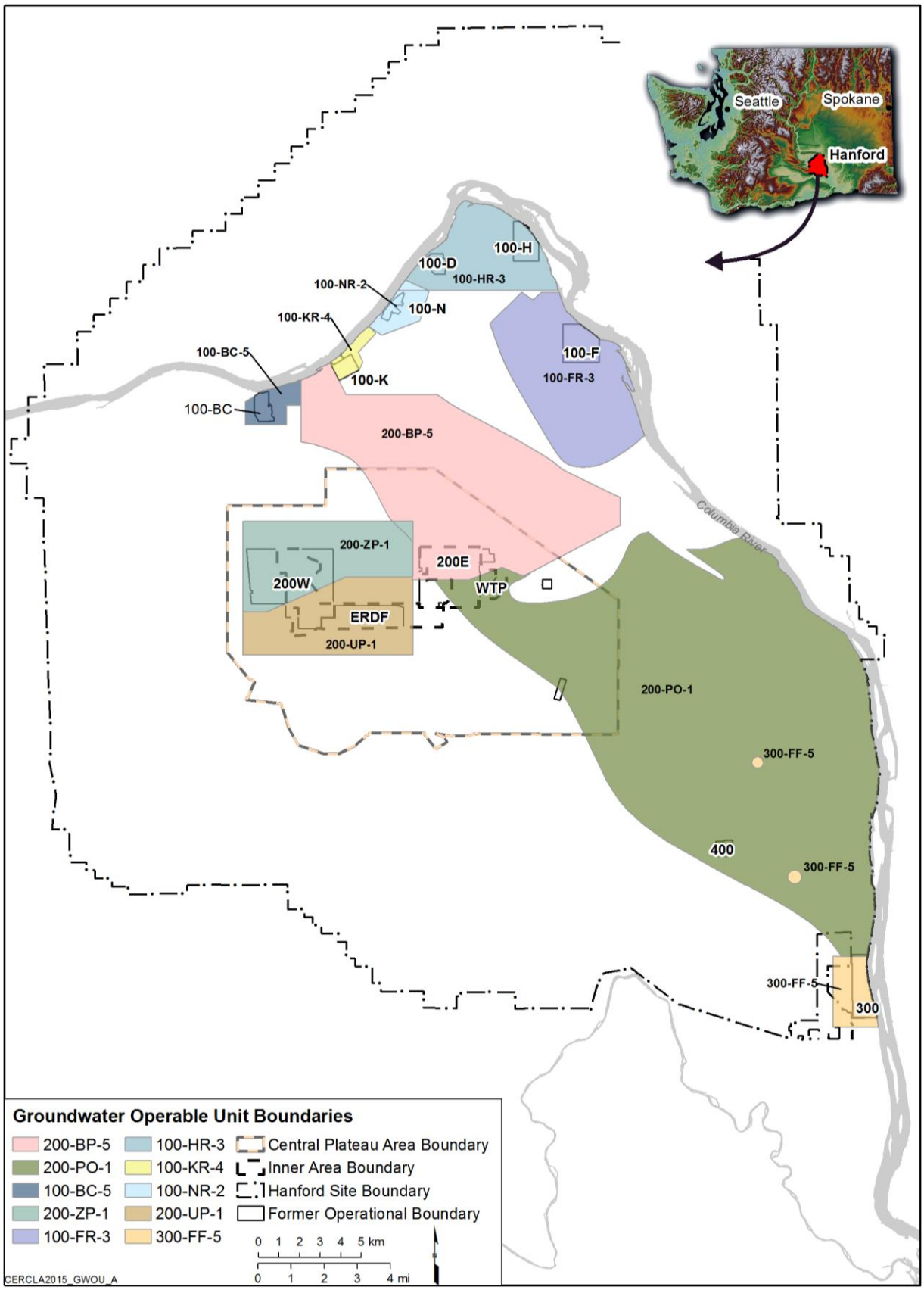


Figure 3-2. Hanford Groundwater Operable Units.

The following 12 source OUs and 2 groundwater OUs, which are based in the Central Plateau, are undergoing the RI/FS process and are out of scope for this 5-year review report, but will be included in future 5-year reviews once remedial action decisions are published in RODs and implementation of the remedy has been initiated.

- Source OUs not included in this 5-year review:
  - 200-BC-1, cribs, trenches, and tank associated with uranium recovery and tank-waste-scavenging operations in the 200 East Inner Area
  - 200-CB-2, B Plant canyon and service facility
  - 200-CP-1, PUREX canyon and service facility
  - 200-CR-1, REDOX canyon and service facility
  - 200-CW-1, cooling water ponds and ditches in 200 Areas
  - 200-DV-1, cribs and trenches in the 200 Area that contributed to deep vadose-zone contamination
  - 200-EA-1, 200 East Inner Area waste sites
  - 200-IS-1, pipelines and associated structures in Central Plateau
  - 200-OA-1, trenches, cribs, pits, ditches, dumping areas in Central Plateau Outer Area
  - 200-SW-1, nonradioactive solid waste landfills
  - 200-SW-2, radioactive solid-radioactive-waste landfills
  - 200-WA-1, 200 West Inner Area waste sites
- Groundwater OUs not included in this 5-year review:
  - 200-BP-5, groundwater in northern portion of 200 East Area and adjacent northwest regions
  - 200-PO-1, groundwater in southern portion of 200 East Area and eastward regions.

3.3 200 AREA OPERABLE UNITS INCLUDED IN THIS REVIEW

3.3.1 200 Area Groundwater Operable Units Included in this Review

The source OUs, which include the waste sites and contaminated soil/vadose zone above the 200 Area groundwater OUs, are shown in Figure 3-1. These OUs are the sources of the groundwater contamination in the OU. These contamination sources are or will be addressed as part of the cleanup of other source OUs through separate CERCLA or RCRA actions.

3.3.1.1 200-UP-1 Groundwater Operable Unit

3.3.1.1.1 Background

The 200-UP-1 Groundwater OU is 1 of 10 groundwater OUs on the Hanford Site, and 1 of 4 groundwater OUs located on the Central Plateau (Figure 3-2). The 200-UP-1 OU consists of the groundwater beneath the southern portion of the 200 West Area (Figure 3-3).

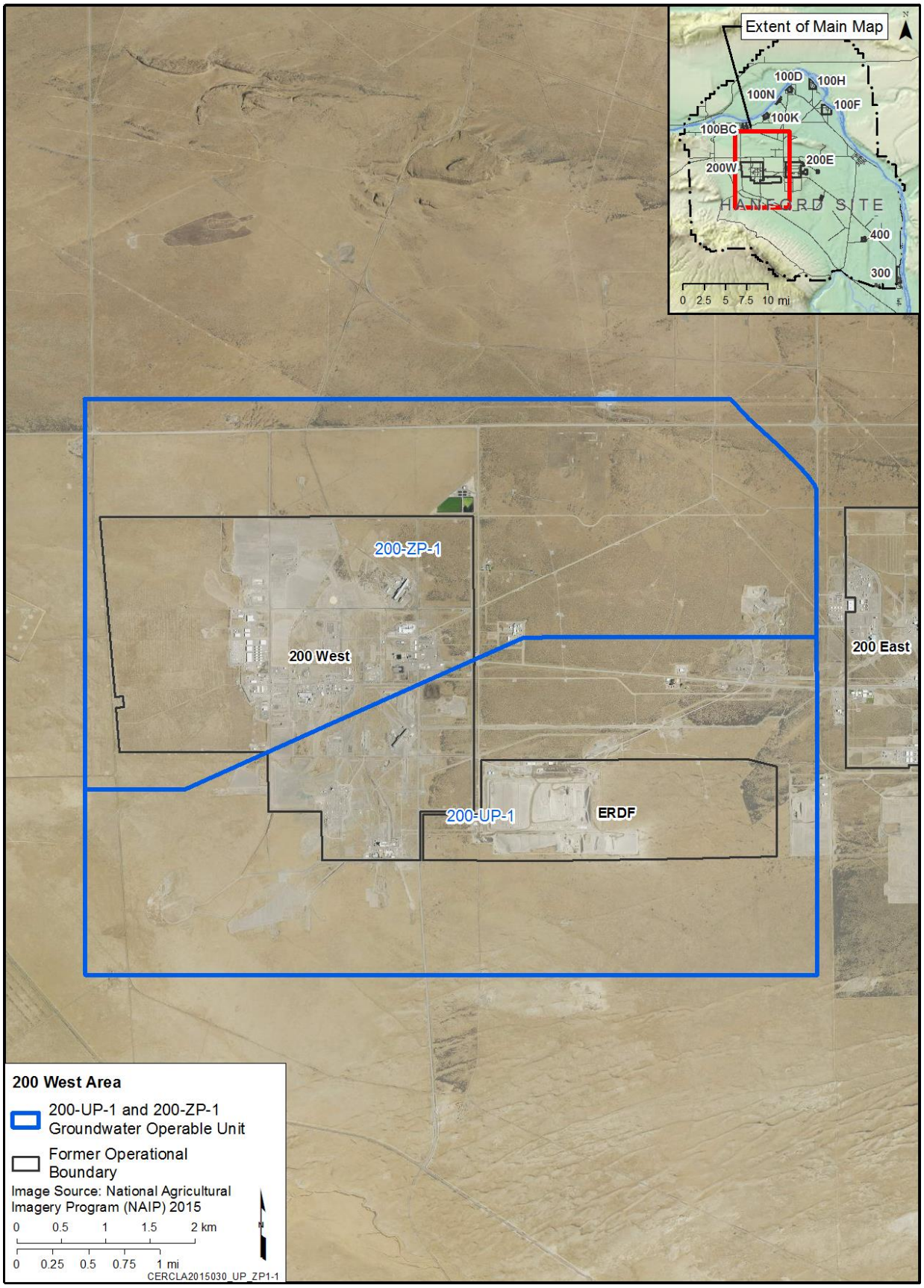


Figure 3-3. Location of 200-UP-1 and 200-ZP-1 Groundwater Operable Units.

The 200 West Area contains waste management facilities and former irradiated fuel reprocessing facilities that have been grouped into four process areas: U Plant, Z Plant, REDOX Plant, and T Plant. The major waste streams that contributed to 200-UP-1 OU groundwater contamination were associated with the plutonium-separation and uranium recovery operations at the REDOX Plant and U Plant facilities, where liquid wastes were disposed of to the ground via ponds, cribs, ditches, and trenches. The REDOX Plant operated from 1952 to 1967 and U Plant operated from 1952 to 1957. As effluent was discharged to these waste sites in the past, the more mobile contaminants migrated through the vadose zone to groundwater. Some groundwater contamination also resulted from SST leaks or unplanned releases, particularly associated with Waste Management Area (WMA) S-SX. In addition, groundwater contamination has migrated from the adjacent 200-ZP-1 OU into the 200-UP-1 OU; this contamination originated from liquid waste disposed of to the ground at Z Plant plutonium concentration and recovery facilities.

The waste sites and soil above the 200-UP-1 OU are the sources of the groundwater contamination in the OU and are or will be addressed as part of the cleanup of other source OUs through separate CERCLA or RCRA actions.

Contaminants of concern for the 200-UP-1 OU include carbon tetrachloride, chromium (total and hexavalent), nitrate, iodine-129, technetium-99, tritium, and uranium.

Current land use on the 200 West Area portion of the Central Plateau where the 200-UP-1 groundwater OU is located is industrial and public access is restricted. Land use is anticipated to remain industrial for the foreseeable future. The land is and, for the foreseeable future, will be used for ongoing waste disposal operations and infrastructure services.

A summary of the 200-UP-1 groundwater is included in each of the following reports:

- *Hanford Site Groundwater Monitoring Report* (published annually to address the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- *Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations* (published annually to address the prior calendar year's performance): http://www.hanford.gov/c.cfm/sgrp/GWRep13/start.htm.

Additional CERCLA documentation associated with the 200-UP-1 groundwater OU, as well as other OUs, can be accessed directly or queried in the Administrative Record for the Hanford Site's OUs, TSD groups, and expedited response actions at the following address: http://pdw.hanford.gov/arpir/index.cfm/predefinedSearch?canType=OpUnit.

3.3.1.1.2 Chronology

Table 3-1 lists the remedial action decision documents associated with the 200-UP-1 groundwater OU.

Table 3-1. Decision Documents for the 200-UP-1 Groundwater Operable Unit.

Date	Location	Title
2/1997	EPA/ROD/R10-97/048	***Declaration of Record of Decision for the U.S. DOE Hanford 200-UP-1 Operable Unit, 200 Area, Hanford Site, Benton County, Washington.*** This document records the initial decision for this interim ROD: Extract groundwater from high-concentration zone of uranium and technetium-99 plumes and treat at 200 Area Effluent Treatment Facility.
2/2009	Ecology, EPA, and DOE 2009	***Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Benton County, Washington.*** This revised decision adds the national MCL of 30 µg/L for uranium as an ARAR for treating extracted water, replaces 190-gal/min pumping with a pumping requirement from existing and new wells consistent with an approved RDR/RAWP until uranium and technetium-99 concentrations are less than 10 times the MCL for 4 consecutive quarters, adds sampling requirements, and updates cost estimates and IC requirements.

Table 3-1. Decision Documents for the 200-UP-1 Groundwater Operable Unit.

Date	Location	Title
9/2012	EPA 2012	***Record of Decision For Interim Remedial Action, Hanford 200 Area Superfund Site, 200-UP-1 Operable Unit.*** This revised decision supersedes the previous interim action ROD (February 1997) and ESD (February 2009). The remedial action includes groundwater extraction and treatment (with flow path control through injection of treated water) in combination with monitored natural attenuation for technetium-99, uranium, chromium (total and hexavalent), nitrate, and carbon tetrachloride; monitored natural attenuation for tritium; hydraulic containment and further treatment technology evaluation for iodine-129; remedy performance monitoring; and ICs.

ARAR = applicable or relevant and appropriate requirement.
ESD = explanation of significant difference.
IC = institutional control.
MCL = maximum contamination level.
O&M = operation and maintenance.
OU = operable unit.
ROD = record of decision.

See Appendix B for a consolidated list of decision documents for Hanford site OUs.

3.3.1.1.3 Remedial Action

Goals and Objectives. In accordance with the NCP, "*EPA expects to return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site*" (40 CFR 300.430[a][1][iii][F]). EPA generally defers to state definitions of groundwater classification provided under EPA-endorsed Comprehensive State Groundwater Protection Programs (EPA/540/G-88/003).

Groundwater from the 200-UP-1 OU is contaminated and is not currently withdrawn from the aquifer for beneficial use; however, the potential beneficial use of the groundwater is as a drinking water source. Consistent with the beneficial-use classifications of Washington State and the EPA, the goal for remediating 200-UP-1 OU groundwater is to reduce contamination to levels that will allow its use as a future drinking water source. Based on the expectations for groundwater restoration, the interim RAOs for the 200-UP-1 OU, as stated in the interim action ROD (EPA 2012) are as follows:

- ***RAO 1. Return the 200-UP-1 OU groundwater to beneficial use as a potential drinking water source.***
- ***RAO 2. Prevent human exposure to contaminated 200-UP-1 OU groundwater that exceeds acceptable risk levels for drinking water.***

Remedy Components. The interim remedial action ROD, *Record of Decision For Interim Remedial Action, Hanford 200 Area Superfund Site 200-UP-1 Operable Unit* (EPA 2012), provided the following summary-level description of the primary components of the selected remedy for the 200-UP-1 groundwater OU (see italicized text in the following box).

Excerpt from ROD (EPA 2012):
Groundwater Extraction and Treatment. The groundwater extraction and treatment component will use a pump-and-treat (P&T) system consisting of a network of groundwater extraction wells, conveyance piping (with transfer pump stations), and use of the existing groundwater treatment facility in the 200 West Area. The system will be modified to meet the 200-UP-1 OU selected remedy treatment requirements. Extraction wells will be designed and installed to remove contaminated groundwater from the aquifer and to reduce or prevent further plume migration.

The P&T system will be designed and implemented in combination with monitored natural attenuation to achieve cleanup levels for all COCs in the 200-UP-1 OU except I-129 within the following time frames: 15 years for Tc-99, 25 years for uranium, 25 years for chromium (total and hexavalent) through P&T, 35 years for nitrate through P&T and monitored natural attenuation (MNA), 125 years for carbon tetrachloride through P&T and

MNA, and 25 years for tritium through MNA. Injection wells will be used to inject treated water back into the aquifer to provide flow path (gradient) control.

Monitored Natural Attenuation. The selected remedy relies on MNA for parts of the nitrate and carbon tetrachloride plumes and for the entire tritium plume. The parts of the nitrate plume that will be addressed through MNA are the diffuse (low-concentration) nitrate plume areas not captured by the P&T system. Carbon tetrachloride will require the longest MNA time frame (estimated to be 125 years), which is consistent with the MNA timeframe for carbon tetrachloride identified in the ROD for the adjacent 200-ZP-1 OU. The tritium plume will be addressed through MNA because of its short radioactive half-life (12.3 years) and lack of effective tritium groundwater treatment technology.

I-129 Hydraulic Containment and Treatment Technology Evaluation. The technology evaluation for I-129 that was completed as part of the feasibility study determined that no current treatment technology can achieve the federal DWS of 1 pCi/L for the I-129 concentrations present in the 200-UP-1 OU. DOE will evaluate potential treatment options for I-129 as part of the selected remedy through further technology evaluation. If one or more viable technologies is identified, treatability tests will be conducted for those technologies. Hydraulic containment of the I-129 plume will be implemented until a subsequent remedial decision for the I-129 plume is made. Hydraulic containment will be performed using injection wells placed at the leading edge of the I-129 plume.

The selected remedy requires an interim waiver of the federal DWS of 1 pCi/L for I-129, which is an ARAR. If a viable treatment technology is not available, the use of a technical impracticability waiver under 40 CFR 300.430(f)(l)(ii)(c) may need to be considered as part of the final remedy.

Remedy Performance Monitoring. Remedy performance monitoring must be conducted over the life of the interim remedial action to evaluate and confirm its performance and optimize its effectiveness. Performance monitoring for the extraction and injection well network will include groundwater sampling and analysis for COCs, extraction well flow rate assessments, and water level measurements. This will allow evaluation of each contaminant's mass removal rate as well as determine the effectiveness of the injection well network to hydraulically contain the I-129 plume. Because cleanup decisions for the soil OUs located above the 200-UP-1 OU have not yet been identified, monitoring will also be conducted for the final contaminants of potential concern (COPC), which include the COCs and the following contaminants: 1,4-dioxane, chloroform, tetrachloroethene, trichloroethene, and strontium-90. Monitoring for the final COPCs will help determine whether they are impacting groundwater at concentrations that may pose an unacceptable risk to human health and the environment.

Performance monitoring of the 200 West Groundwater Treatment Facility includes sampling and analysis to evaluate the effectiveness of the facility to remove or treat COCs in extracted groundwater to meet treatment requirements before returning the water to the aquifer. Performance monitoring will also be used to confirm that the natural attenuation processes for carbon tetrachloride, tritium, and nitrate are performing as planned.

Institutional Controls. Institutional controls will be required for the 200-UP-1 OU as long as groundwater contamination precludes its use as a potential source of drinking water. These institutional controls include the requirement that DOE control access to groundwater to prevent exposure of humans to contaminated groundwater, except as otherwise authorized by EPA, and the requirement that DOE prohibit activities that would damage components of the remedy or disrupt or lessen performance of any component of the remedy, except as otherwise authorized in lead regulatory agency-approved documents. The DOE is responsible for implementing, maintaining, reporting on, and enforcing the institutional controls required under this ROD. Although DOE may later transfer these procedural responsibilities to another party by contract, property conveyance agreement, or other means, DOE shall retain ultimate responsibility for remedy integrity and institutional controls.

Remedy Implementation Progress Prior to this Review Period. Remedy implementation before this this 5-year review period, in accordance with the 1997 interim action ROD as amended, primarily involved pumping the highest concentration zone of the contaminated groundwater plume at the 200-UP-1 groundwater OU followed by treatment using the existing 200 Area Effluent Treatment Facility (a state-permitted dangerous waste management unit). The effluent from the 200 Area Effluent Treatment Facility was then discharged to a state-permitted wastewater discharge facility. This interim remedial action reduced contaminant mass within the plume and minimizes migration of uranium and technetium-99 from the 200 West Area. The 200-UP-1 (U Plant) P&T system, located in the area of U Plant, continued operating during the previous 5-year review period until it was shut down in the spring of 2011, once the remedial action objectives within the capture zone were satisfied. ICs were also in

place to restrict access to groundwater. Additional detail on this earlier period of 200-UP-1 groundwater remediation can be found in the 2010 annual groundwater monitoring report (DOE/RL-2011-01).

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for the 200-UP-1 OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The 200-UP-1 groundwater OU protectiveness statement from the previous (2006 – 2010) 5-year review report was noted as follows:

> *The final remedy at 200-UP-1 OU is expected to be protective of human health and the environment upon completion of the final remedy. The current interim actions ensure that exposure pathways that could result in unacceptable risks are being controlled. The interim remedial action addresses both chemicals and radionuclides.*

3.3.1.1.4 Progress Since 2011 Review

Accomplishments. The primary remedial action accomplishments for the 200-UP-1 groundwater OU during the past 5 years can be summarized as follows:

- Continued operating the U Plant P&T system until 2011 (initial interim action began in 1994)
  - Removed 220.5 kg uranium by 2011
  - Removed 2.17 Ci technetium-99 by 2011
- Began operating the S-SX Tank Farms Groundwater Extraction System (interim action) in July 2012[a]
  - Removed 2.18 Ci technetium-99 since startup
  - Removed 36.1 kg chromium since startup
  - Removed 22,600 kg nitrate since startup
  - Removed 39.5 kg carbon tetrachloride since startup
- Published a new interim remedial action ROD, *Record of Decision for Interim Remedial Action, Hanford 200 Area Superfund Site, 200-UP-1 Operable Unit* (EPA 2012), in September 2012
- Issued *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan* (DOE/RL-2013-07) in September 2013
- Issued *Performance Monitoring Plan for the 200-UP-1 Groundwater Operable Unit Remedial Action* (DOE/RL-2015-14) in August 2015
- Completed construction, installation, and turnover to Operations of extraction wells for the U Plant area plumes of uranium, technetium-99, and nitrate
- Completed uranium treatment expansion at the 200 West P&T and began operations in September 2015
  - Removed 1.8 kg uranium since startup
  - Removed 0.19 Ci technetium-99 since startup
  - Removed 22,300 kg nitrate since startup
  - Removed 5.3 kg carbon tetrachloride since startup
- Completed installation of the injection wells for iodine-129 plume containment
- Issued *UP-1 Evaluation Plan for Iodine – Draft A*, (DOE/RL-2015-69, Draft A) in November 2015.

Remedy Implementation. Details on implementing the interim action ROD are provided in the 200 UP-1 RDR/RAWP (DOE/RL-2013-07). This work plan includes detail on the basis for remedial

[a]Note: values listed were current as of publication of the latest ROD in 2012.

action, remedial design approach, remedial action approach, environmental management and controls, a cost estimate through FY 2017, and the schedule through FY 2018.

While operations at the 200 West P&T are partially under way and currently anticipated to continue for more than 20 years, some components of the remedy are planned for implementation, but have not yet been implemented, and others (e.g., monitored natural attenuation and ICs) are planned to continue for more than 100 years. Table 3-2 presents an overview of the remedy's primary components and implementation status.

Table 3-2. Overview of 200-UP-1 Interim Action Remedy Implementation.

Document Type	**Date**	**Title**
Interim Action ROD	09/2012	EPA 2012, *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit*
RD/RA Work Plan	09/2013	DOE/RL-2013-07, *200-UP-1 Groundwater Operable Unit Remedial Design/Remedial Action Work Plan*
RAO	**1.** Return the 200-UP-1 OU groundwater to beneficial use as a potential drinking water source **2.** Prevent human exposure to contaminated 200-UP-1 OU groundwater that exceeds acceptable risk levels for drinking water.	
Major COCs:	Carbon tetrachloride, chromium, nitrate, iodine-129, technetium-99, tritium, uranium	

Remedy Component	**Construction Status** (approximate percentage complete for constructing/implementing the remedy component as of December 2015)[a]						**Duration of O&M** (~years)[b]	**Finish**[c] (Est'd year)
	0	**1-25**	**26-50**	**51-75**	**76-99**	**100%**		
Groundwater extraction and treatment[d]							25	2037
Monitored natural attenuation							125[e]	2137
I-129 hydraulic containment and treatment technology evaluation							N/A	
Remedy performance monitoring							125	2137
Institutional controls							125	2137

[a] Percentages reflect construction status of the remedy component; post-startup upgrades and system performance optimization is considered part of O&M. 100% = fully implemented and now in O&M mode.
[b]Approximate number of years to operate remedy component as estimated in ROD (shorter durations for certain COCs)
[c]Estimated year when remedy component will be completed.
[d]The S-SX WMA treatment has been operational since 2012; uranium treatment facility construction and start of operation testing begun in late FY 2015 will continue; enhancing chromium plume characterization and treatment design also is a future task.
[e]Long duration is currently driven by MNA for carbon tetrachloride and does not yet consider I-129.

COC = contaminant of concern.
MNA = monitored natural attenuation.
N/A = not applicable.
O&M = operation and maintenance.
OU = operable unit.
RAO = remedial action objectives.
RD/RA = remedial design/remedial action.
ROD = record of decision.
WMA = waste management area.

3.3.1.1.5 Technical Assessment

Is the remedy functioning as intended by the decision documents?

Yes, the interim remedy identified in the initial interim remedial action ROD, *EPA Superfund Record of Decision: Hanford 200 Area (USDOE) EPA ID: WA1890090078, OU 12, Benton County, WA, 02/11/1997* (EPA/ROD/R10-97/048) functioned as intended and continued operations until 2011. The remedy involved extracting groundwater from the U Plant area and treating it at the 200 East Area Effluent Treatment Facility to remove uranium and technetium-99 from the groundwater.

The interim action ROD issued in 2012 (which superseded the 1997 200-UP-1 interim remedy decisions) is proceeding as planned. Remedy components of the new interim action ROD issued in 2012 and associated RDR/RAWP are in the pre-implementation, construction, and operation phases. Design, construction, and operations will continue into the next 5-year review period.

In 2012, treatment for technetium-99, chromium, nitrate, and carbon tetrachloride began at the 200 West P&T, shown in Figure 3-4.

Figure 3-4. 200 West Pump and Treat System.

Included in DOE/RL-2013-07 are tasks for installing treatment capability for uranium in the 200 West P&T. The uranium treatment capability was installed and tested late in 2015. Construction of an iodine plume containment remedy also was completed in 2015. An iodine-129 treatment technology evaluation is ongoing and will continue into the next CERCLA 5-year review period.

Table 3-3 summarizes 200-UP-1 groundwater OU contaminants removed by the WMA S-SX groundwater extraction system during 2015 and cumulatively since startup in 2012. Table 3-4 summarizes 200-UP-1 groundwater OU contaminants removed by the uranium plume groundwater extraction system in 2015.

Table 3-3. Contaminant Mass (or Activity) Removed from Aquifer by the Waste Management Area S-SX Groundwater Extraction System.*

Constituent	Mass (Activity) Removed During 2015	Mass (Activity) Removed Since Startup in 2012
Technetium-99, g (Ci)	30.6 (0.520)	128.6 (2.18)
Chromium, kg	8.0	36.1
Nitrate (as NO_3), kg	6,320	22,600
Carbon tetrachloride, kg	12.4	39.5

*Source: Source: Hanford Annual Groundwater Monitoring Reports for 2015 http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports

Table 3-4. Contaminant Mass (or Activity) Removed from Aquifer by the Uranium Plume Groundwater Extraction System.*

Constituent	Mass (Activity) Removed During 2015
Uranium, kg	1.8

Table 3-4. Contaminant Mass (or Activity) Removed from Aquifer by the Uranium Plume Groundwater Extraction System.*

Constituent	Mass (Activity) Removed During 2015
Technitium-99, g (Ci)	11.0 (0.19)
Nitrate, kg	22,300
Carbon tetrachloride, kg	5.3

*Source: DOE/RL-2016-09, *Hanford Annual Groundwater Monitoring Report for 2015*, available on line at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0075314H.

Remedy performance monitoring will be conducted over the duration of the interim remedial action to evaluate its performance and optimize its effectiveness. Monitoring is under way to evaluate the performance of the P&T systems, hydraulic containment, and MNA components. Future enhancements also are planned, as outlined in the 200-UP-1 RD/RA Work Plan (DOE/RL-2013-07) and the *Sampling and Analysis Plan for Remediation Wells in the 200-UP-1 Operable Unit* (DOE/RL-2014-27). At least 20 additional characterization and monitoring wells are planned to be constructed during the next 5-year review period. Figure 3-5 shows the location of groundwater monitoring, extraction, and injection wells associated for the 200-UP-1 OU in 2015.

Because cleanup decisions for the soil OUs located above the 200-UP-1 OU have not yet been identified, monitoring is being conducted for the 200-UP-1 COCs noted earlier, as well as waste site contaminants of potential concern (COPCs), which include the COCs and the following contaminants: 1,4-dioxane, chloroform, tetrachloroethene, trichloroethene, and strontium-90. Monitoring for these COPCs will help determine whether they are impacting groundwater at concentrations that may pose an unacceptable risk to human health and the environment. Table 3-5 provides an overview of 200-UP-1 contaminant plume areas and associated changes to the areas during this 5-year review period. Plume maps in Figure 3-6 show the changes in plume shapes and areas during this 5-year review period. The Figure 3-7 trend plots depict the estimated annual changes in contaminant plume areas over the past several 5-year periods.

Table 3-5. Overview of 200-UP-1 Groundwater Contaminant Plumes.[a]

Groundwater Contaminant	Cleanup Level[b]	Maximum Concentration (2015)	Plume Area[c] (km^2)			Shoreline Intersection[d] (m)		
			2011	2015	Change	2011	2015	Change
Carbon tetrachloride	3.4 µg/L	612 µg/L	13.3[e]	18.0[e]	4.7	0	0	0
Chromium (hexavalent and total)	48[f]/100[g] µg/L	406 µg/L	NC/0.78[h]	5.7/0.5[h]	NA/-0.3	0	0	0
Nitrate	45 mg/L	3,190 mg/L	8.0	5.7	-2.3	0	0	0
Iodine-129	1 pCi/L	6.07 pCi/L	3.8	3.5	-0.3	0	0	0
Technetium-99	900 pCi/L	51,400 pCi/L	0.2	0.3	0.1	0	0	0
Tritium	20,000 pCi/L	271,000 pCi/L	6.9	5.4	-1.5	0	0	0

Table 3-5. Overview of 200-UP-1 Groundwater Contaminant Plumes.[a]

Groundwater Contaminant	Cleanup Level[b]	Maximum Concentration (2015)	Plume Area[c] (km^2)			Shoreline Intersection[d] (m)		
			2011	2015	Change	2011	2015	Change
Uranium	30 µg/L	1,550 µg/L	0.4	0.3	-0.1	0	0	0

[a]Source: Hanford Annual Groundwater Monitoring Reports for 2011 and 2015 http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports

[b]From Table 14 of *Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit* (EPA 2012).

[c]Estimated area above the cleanup level, unless otherwise noted.

[d]Length of Columbia River shoreline intersected by contaminant plumes.

[e]Represents the entire extent of the plume (including the 200-ZP-1 OU) above 5 µg/L.

[f]WAC 173-340, "Model Toxics Control Act—Cleanup," Method B groundwater cleanup level for hexavalent chromium.

[g]Federal drinking water standard for total chromium.

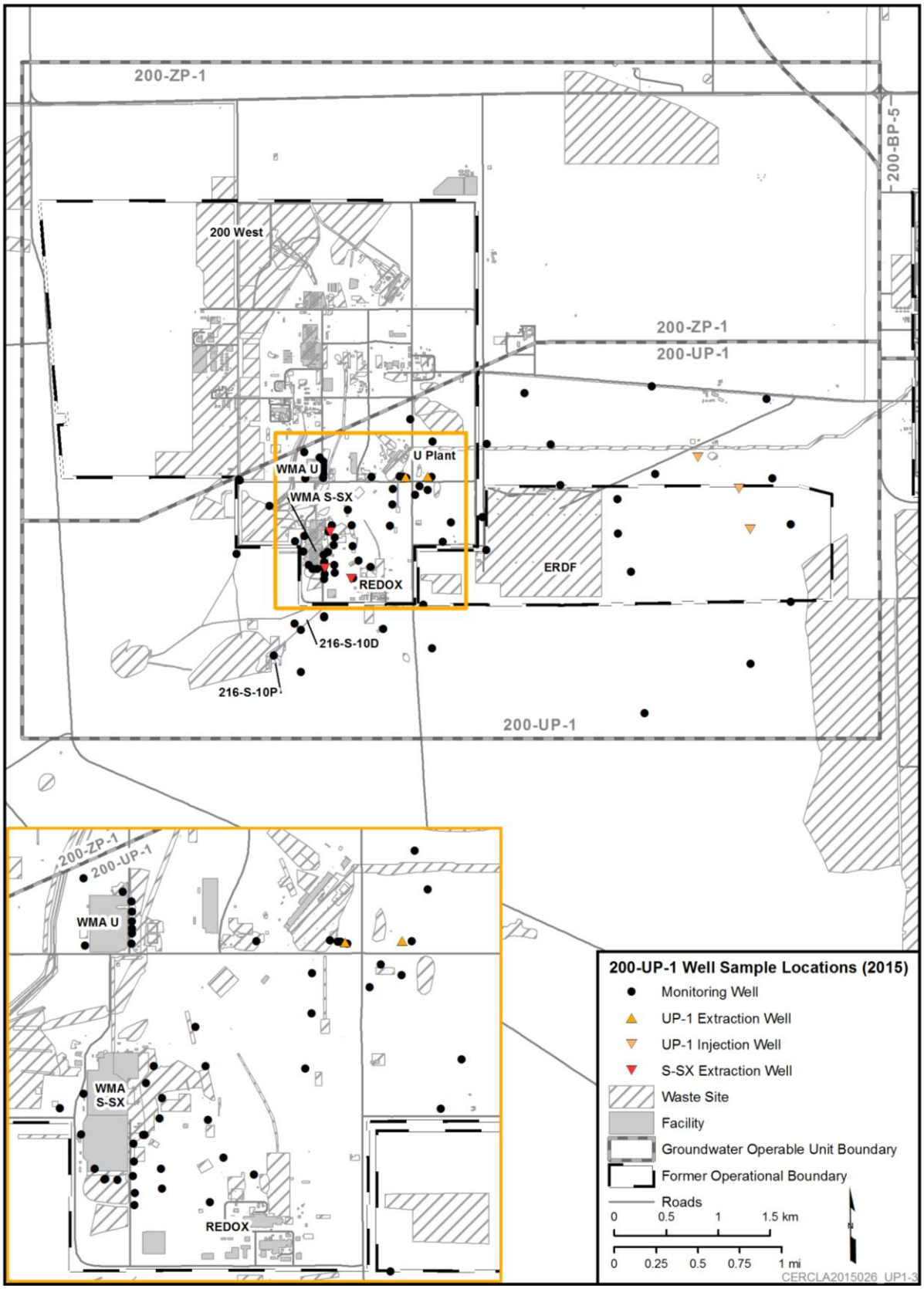
[h]Plume areas (0.78 and 0.5 km^2) above the 100 µg/L federal drinking water standard; 5.7 value represents plume area above 48 µg/L. Plume area for hexavalent chromium at 48 µg/L was not noted in the 2011 Annual Groundwater Monitoring Report for 200-UP-1.

For more detailed information on the 200-UP-1 groundwater OU well locations, distribution of contaminant concentrations within each plume, and historic trends associated with each of the 200-UP-1 contaminants of concern, as well as for performance metrics associated with 200-UP-1 OU groundwater treatment, visit the following links:

- *Hanford Site Groundwater Monitoring Report* (published each summer for the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- *Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations* (published for each calendar year): http://www.hanford.gov/c.cfm/sgrp/GWRep13/start.htm.

The remedy components involving groundwater extraction and treatment, monitored natural attenuation, iodine-129 hydraulic containment and treatment technology evaluation, and remedy performance monitoring are supporting achievement of RAO 1.

ICs for the 200-UP-1 groundwater OU, as required by the interim action ROD (EPA 2012), are described in the latest version of *200-UP-1 Groundwater Operable Unit remedial Design/Remedial Action Work Plan*, (DOE/RL-2013-07), and are actively managed in support of RAO 2. Specific details associated with each IC also have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 200-UP-1 OU are required to prevent human exposure to contaminated groundwater and include warning notices, entry restrictions, land-use management (land use), groundwater-use management (excavation permits), and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes' attachments (e.g., CHPRC-1503264), which are archived in the Hanford Site Administrative Record. During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 200-UP-1 groundwater OU.



(Source: *Calendar Year 2013 Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and Treat Operations* [DOE/RL-2014-26])

Figure 3-5. Locations of 200-UP-1 Wells Sampled in 2015.

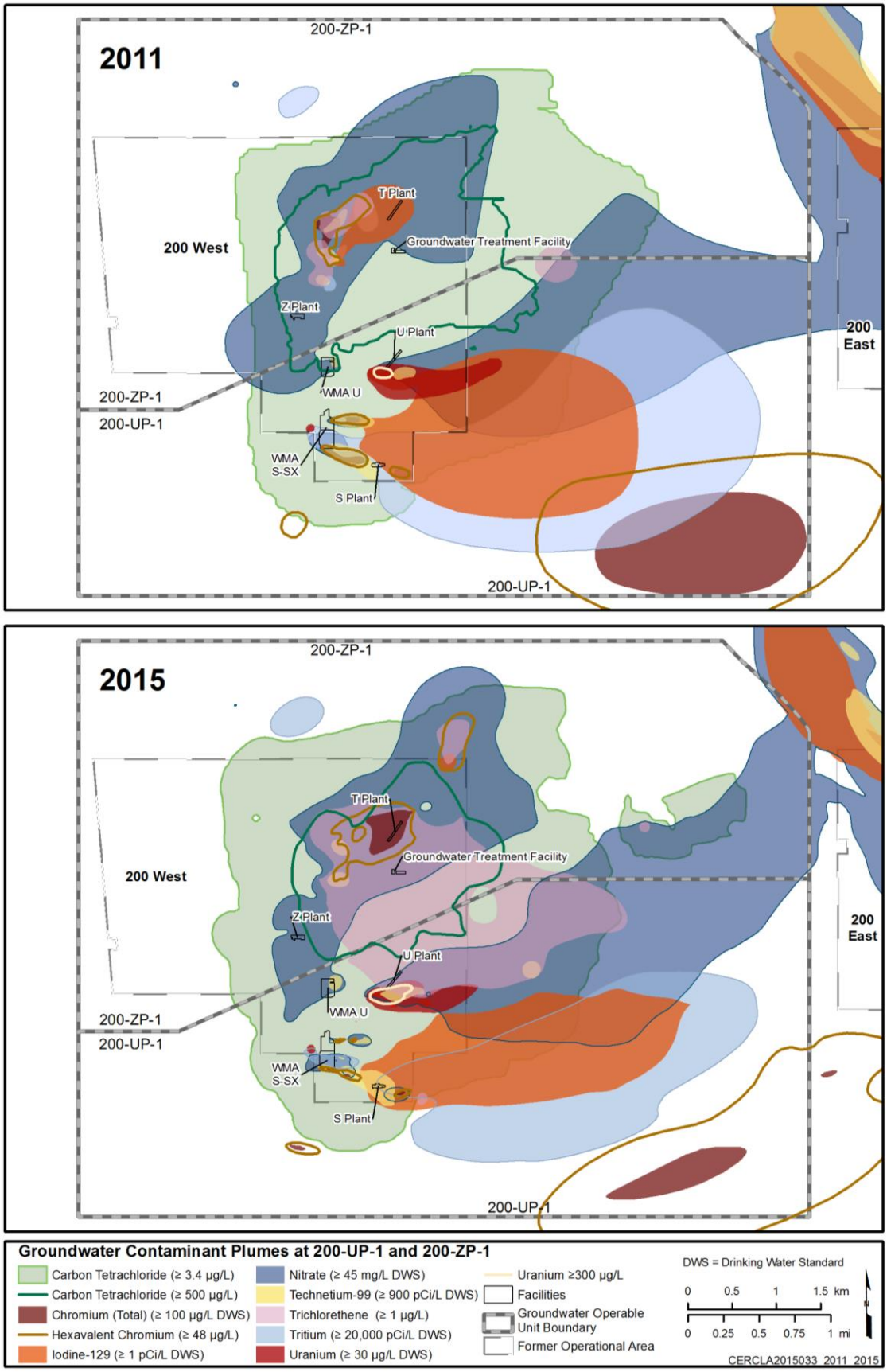


Figure 3-6. 200-UP-1 and 200-ZP-1 Groundwater Operable Unit Plumes in 2011 (top) and 2015 (bottom).

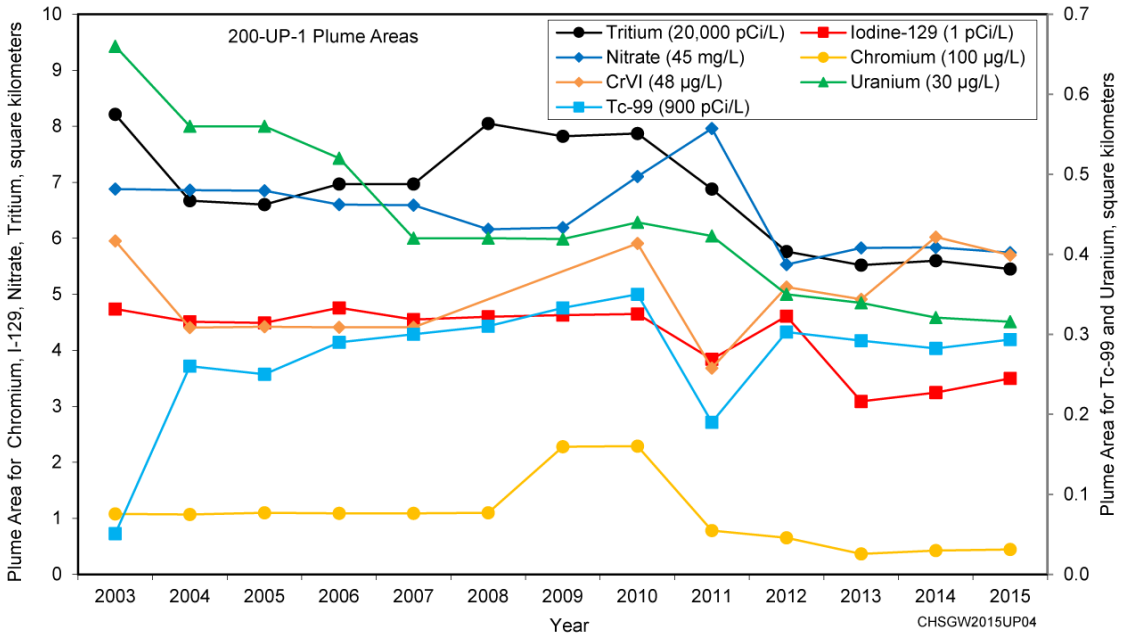


Figure 3-7. 200-UP-1 Trend Plots of Contaminant Plume Areas (2003 – 2015).

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection (2012) are still valid for the OU.

Has any other information come to light that could call into question the protectiveness of the remedy?

No information has come to light that would call into question the protectiveness of the remedy. However, groundwater concentrations of chromium in well 299-W26-13 near the 216-S-10 pond waste site have been increasing during the past 5-year period. At the end of 2015, concentrations were 151 µg/L for total chromium and 150 µg/L for hexavalent chromium, approximately 3 times the 48 µg/L cleanup level. No active groundwater remedy is planned for this area. This situation will continue to be monitored during the next 5-year period.

In accordance with the RD/RAWP (DOE/RL-2013-07), additional characterization of the chromium plume southeast of the 200 West Area (shown in Figure 3-6) is planned in the next 2 years. Characterization wells will be drilled to refine the geometry of the plume to focus and optimize the remedial design for the chromium plume remedy.

3.3.1.1.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 200-UP-1 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

3.3.1.1.7 Protectiveness Statement

200-UP-1 Groundwater OU – Will Be Protective. The remedy at the 200-UP-1 groundwater OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of uranium treatment capability in the 200 West P&T was completed during this 5-year review period. Publication of a draft treatment technology evaluation plan for iodine-129 was also accomplished. Characterization of the chromium plume to support remedy design was initiated in late 2015 and will be completed after this 5-year review period. The interim action remedy component of groundwater ICs is fully implemented and ensures that exposure pathways that could result in unacceptable risks to human health are being controlled.

3.3.1.2 200-ZP-1 Groundwater Operable Unit

3.3.1.2.1 Background

The 200-ZP-1 groundwater OU is 1 of 10 groundwater OUs on the Hanford Site, and 1 of 4 located on the Central Plateau (Figure 3-2). Collectively, these four OUs and their RODs will define the necessary groundwater cleanup actions across the Central Plateau. The 200-ZP-1 OU consists of the groundwater beneath the northern portion of the 200 West Area.

The 200 West Area contains waste management facilities and former irradiated fuel reprocessing facilities that have been grouped into four process areas: U Plant, Z Plant, REDOX Plant, and T Plant. The major waste streams that contributed to groundwater contamination in the 200-ZP-1 OU were associated with plutonium-separation operations at T Plant (1944 – 1956) and plutonium concentration and recovery operations at Z Plant (1949 – 1989) in the 200 West Area. Liquid waste disposal in the cribs and trenches near the T Plant and Z Plant facilities resulted in several groundwater contamination plumes in the 200-ZP-1 OU.

Contaminants of concern for the 200-ZP-1 OU are carbon tetrachloride, chromium (total and hexavalent), nitrate, iodine-129, technetium-99, trichloroethylene (also documented as trichloroethene, and noted herein as TCE), and tritium. Carbon tetrachloride is the main contaminant of concern, forming a plume that covers more than 13 km^2 extending north, south, and east from the source areas. During recent decades, groundwater in the northern 200 West Area flowed east-northeast, but flow is now influenced locally by ongoing remedial action activities.

Current land-use activities on the 200 West Area of the Central Plateau where the 200-ZP-1 groundwater OU is located are industrial, and public access to the site is restricted. Land use is anticipated to remain industrial for the foreseeable future, with the land being used for ongoing waste disposal operations and infrastructure services.

A summary of the 200-ZP-1 groundwater is included in each of the following reports:

- *Hanford Site Groundwater Monitoring Report* (published annually to address the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- *Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations* (published annually to address the prior calendar year's performance): http://www.hanford.gov/c.cfm/sgrp/GWRep13/start.htm.

Additional CERCLA documentation associated with the 200-ZP-1 groundwater OU, as well as other OUs, can be accessed directly or queried in the Administrative Record for the Hanford Site's OUs and TSD units at the following address: http://pdw.hanford.gov/arpir/index.cfm/predefinedSearch?canType=OpUnit.

3.3.1.2.2 Chronology

Table 3-6 lists the remedial action decision documents associated with the 200-ZP-1 groundwater OU.

Table 3-6. Decision Documents for the 200-ZP-1 Groundwater Operable Unit.

Date	Location	Title
5/1995	EPA 1995	***Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit.*** This interim action ROD involves P&T to address carbon tetrachloride, chloroform, and trichloroethylene; treatment with air stripping and vapor-phase activated carbon; and reinjection of treated water. The interim action continued until the final action was instituted in 2012.

Table 3-6. Decision Documents for the 200-ZP-1 Groundwater Operable Unit.

Date	Location	Title
9/2008	EPA 2008b	***Record of Decision, Hanford 200 Area, 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington.*** This is a final action ROD involving P&T to address carbon tetrachloride, nitrate, chromium, trichloroethylene, iodine-129, technetium-99, and natural radioactive decay to address tritium; monitored natural attenuation; flow-path control through injection of treated water; and institutional controls.

O&M = operation and maintenance.
OU = operable unit.
P&T = pump and treat.
ROD = record of decision.

See Appendix B of this document for a consolidated list of decision documents for Hanford Site OUs.

3.3.1.2.3 Remedial Actions

Goals and Objectives. In accordance with the NCP, "*EPA expects to return useable ground waters to their beneficial uses wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site*" (40 CFR 300.430[a][1][iii][F]). EPA generally defers to state definitions of groundwater classification provided under EPA-endorsed Comprehensive State Groundwater Protection Programs (EPA/540/G-88/003).

Groundwater from the 200-ZP-1 OU is contaminated and is not currently withdrawn from the aquifer for beneficial use; however, the potential beneficial use of the groundwater is as a drinking water source. Consistent with the beneficial-use classifications of Washington State and the EPA, the goal for remediating 200-ZP-1 OU groundwater is to reduce contamination to levels that will allow its use as a future drinking water source.

Based on the expectations for groundwater restoration, the RAOs, as stated in the 200-ZP-1 OU ROD (EPA 2008b), are as follows:

- ***RAO 1. Return the 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve domestic drinking water levels) by achieving the cleanup levels (provided later in Table 11 [of the ROD]).*** *This objective is to be achieved within the entire 200-ZP-1 OU groundwater plume. The estimated timeframe to achieve cleanup levels is within 150 years.*
- ***RAO 2. Apply institutional controls to prevent the use of groundwater until the cleanup levels (provided later in Table 11 [of the ROD]) have been achieved.*** *Within the entire OU groundwater plumes, institutional controls must be maintained and enforced until the cleanup levels are achieved, which is estimated to be within 150 years.*
- ***RAO 3. Protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by contaminants originating from the 200-ZP-1 OU.*** *This final objective is applicable to the entire 200-ZP-1 OU groundwater plume. Protection of the Columbia River from impacts caused by 200-ZP-1 OU contaminants must last until the cleanup levels are achieved, which is estimated to be within 150 years.*

Remedy Components. The final action ROD (EPA 2008b) signed in 2008 provided the following summary-level descriptions (see italicized text in the following box) of the primary components of the selected remedy for the 200-ZP-1 Groundwater OU (i.e., groundwater extraction and treatment, monitored natural attenuation, flow path control, and ICs).

Excerpt from ROD (EPA 2008b):
Groundwater Extraction and Treatment. A groundwater pump-and-treat system will be designed, installed and operated in accordance with an approved remedial design/remedial action (RD/RA) work plan. The system will be designed to capture and treat contaminated groundwater to reduce the mass of carbon tetrachloride, total chromium (chromium III and chromium VI), nitrate, trichloroethylene, iodine-129, and technetium-99, throughout the 200-ZP-1 OU by a minimum of 95% in 25 years. The pump-and-treat component will be designed and implemented in combination with monitored natural attenuation to achieve cleanup levels listed in Table 11

for all COCs in 125 years. Carbon tetrachloride concentrations in the groundwater above 100 µg/L correspond to approximately 95% of the mass of carbon tetrachloride currently residing in the aquifer. The estimated pumping rate required to reduce the mass of COCs by 95% in 25 years is 1,600 gpm for this action. The fate and transport evaluation estimated that a system comprised of 27 extraction and 27 injection wells would be needed to achieve the design requirements.

Following extraction, the COCs in groundwater (except tritium) will be treated to achieve the cleanup levels listed in Table 11 of the ROD. The treated groundwater will then be returned to the aquifer through injection wells.

Specific extraction and injection well locations, treatment equipment design, operational requirements, and other system details will be determined during the remedial design phase and will be documented in the RD/RA work plan and its accompanying remedial design (the "RD/RA documents"). The RD/RA documents will be reviewed and approved by EPA.

The remedial design will also consider as necessary the need for treatment of other constituents (such as uranium) that may be captured by the 200-ZP-1 OU extraction wells. While not COCs for the 200-ZP-1 OU, such constituents may be encountered during restoration from sources related to the other adjacent groundwater OUs. There is no viable treatment technology to remove tritium from the groundwater. However, the half-life of tritium is sufficiently short, so the tritium will decay below the cleanup standard before it leaves the industrial land-use zone.

Monitored Natural Attenuation (MNA). In addition to the pump-and-treat system, natural attenuation processes will be used to reduce concentrations to below the cleanup levels.

Natural attenuation processes to be relied on as part of this component include abiotic degradation, dispersion, sorption, and, for tritium, natural radioactive decay. Monitoring will be employed in accordance with the approved RD/RA documents to evaluate the effectiveness of the pump-and-treat system and natural attenuation processes. Fate and transport analyses conducted as part of the FS (DOE/RL-2007-28) indicate that the timeframe necessary to reduce the remaining COC concentrations to acceptable levels through MNA will be approximately 100 years. Modeling also indicates that this portion of the plume area will remain on the Central Plateau geographic area during this timeframe.

Monitoring is required to be conducted over the life of the action to evaluate its performance and optimize its effectiveness and shall be conducted in accordance with the approved RD/RA documents. For the MNA component, monitoring locations, points of compliance and specifications will be developed as part of the RD/RA documents that will provide data on performance, including data indicating whether the key mechanisms of natural attenuation are performing in a manner to satisfy selected remedy requirements and schedule.

The overarching requirement is to meet the groundwater cleanup levels identified in this ROD within 125 years. Monitoring shall be conducted to evaluate the performance of pump-and-treat system, flow path control and MNA and shall be designed and operated to:

1. *Demonstrate whether or not the pump-and-treat system will remove at least 95% of the mass of COCs in 25 years or less and whether the remedial action being taken, including natural attenuation, will achieve cleanup levels for all COCs within 125 years,*
2. *Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of the pump-and-treat system, natural attenuation processes, and the flow path control actions,*
3. *Identify any potentially toxic and/or mobile transformation products,*
4. *Verify that the contamination is not expanding downgradient, laterally or vertically subsequent to the period of time over which the pump-and-treat component has been functional,*
5. *Detect new releases of contaminants of concern to the environment that could impact the effectiveness of the remedy,*
6. *Verify attainment of remediation requirements*

Flow Path Control. Flow-path control is also required and shall be achieved by injecting the treated groundwater into the aquifer to the northeast and east of the groundwater contamination such that the treated injected water in these locations will slow the natural eastward flow of most of the groundwater and, as a result, keep COCs within the capture zone, as well as increase the time available for natural attenuation processes to reduce the contaminant concentrations not captured by the extraction wells.

Flow-path control shall also be used to minimize the potential for groundwater in the northern portion of the aquifer to flow northward through Gable Gap and toward the Columbia River. Injection wells will be located to

re-direct the groundwater flow to the east, which is the longest groundwater flow path to the river (about 26 km [16 mi]).

Groundwater modeling is required to locate injection and extraction wells, to estimate required injection and extraction rates, and to determine the location of injection wells for flow-path control. This modeling and the design, installation and implementation of the flow path controls shall be conducted in accordance with the approved RD/RA documents.

Institutional Controls. *200-ZP-1 OU groundwater use will be restricted through institutional and land use controls for the foreseeable future until cleanup levels are achieved.*

The DOE is responsible for implementing, maintaining, reporting on, and enforcing the institutional and land use controls required under this ROD. Although DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, DOE shall retain ultimate responsibility for remedy integrity and institutional controls. The current implementation, maintenance, and periodic inspection requirements for the institutional controls at the Hanford Site are described in approved work plans and in the Sitewide Institutional Controls Plan (DOE/RL-2001-41) that was prepared by DOE and approved by EPA and Ecology in 2002. One requirement listed in the Sitewide Institutional Controls Plan is the commitment to notify EPA and Ecology immediately upon discovery of any activity that is inconsistent with the land use designation of a site.

No later than 180 days after the ROD is signed, DOE shall update the Sitewide Institutional Controls Plan to include the institutional controls required by this ROD and specify the implementation and maintenance actions that will be taken, including periodic inspections. The revised Sitewide Institutional Controls Plan shall be submitted to EPA and Ecology for review and approval as a Tri Party Agreement primary document. The DOE shall comply with the Sitewide Institutional Controls Plan as updated and approved by EPA and Ecology.

The following institutional control performance objectives are required to be met as part of this remedial action. Land-use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances in groundwater are at such levels to allow for unrestricted use and EPA authorizes the removal of restrictions.

Institutional controls required through the time of completion of the remedy are:

1. *The DOE shall control access to prevent unacceptable exposure of humans to contaminants in the 200-ZP-1 OU groundwater addressed in the scope of this ROD until the remedy is complete. Visitors entering any site areas of the 200-ZP-1 OU will be required to be badged and escorted at all times.*
2. *No intrusive work shall be allowed in the 200-ZP-1 OU unless EPA has approved the plan for such work and that plan is followed.*
3. *The DOE shall prohibit well drilling in the 200-ZP-1 OU, except for monitoring, characterization or remediation wells authorized in EPA approved documents.*
4. *Groundwater use in the 200-ZP-1 OU is prohibited, except for limited research purposes, monitoring, and treatment authorized in EPA approved documents. The Sitewide Institutional Controls Plan will contain the institutional controls and implementing details prohibiting well drilling and groundwater use in the 200-ZP-1 OU, as defined in the Decision document for the 200-ZP-1 OU.*
5. *The DOE shall post and maintain warning signs along pipelines conveying untreated groundwater that caution site visitors and workers of potential hazards from the 200-ZP-1 OU groundwater.*
6. *In the event of any unauthorized access to the site (e.g., trespassing), DOE shall report such incidents to the Benton County Sheriff's Office for investigation and evaluation of possible prosecution.*
7. *Activities that would disrupt or lessen the performance of the pump-and-treat, MNA, and flow-path control components of the remedy are to be prohibited.*
8. *The DOE shall prohibit activities that would damage the pump-and-treat, MNA, and flow-path control components (e.g., extraction wells, injection wells, piping, treatment plant, or monitoring wells).*
9. *The DOE shall report on the effectiveness of institutional controls for the 200-ZP-1 OU remedy in an annual report, or on an alternative reporting frequency specified by EPA. Such reporting may be for this OU alone or may be part of a Hanford sitewide report.*
10. *The DOE will provide notice to EPA at least six months prior to any transfer or sale of the any land above the 200-ZP-1 OU so EPA can be involved in discussions to ensure that appropriate provisions are included in the transfer terms or conveyance documents to maintain effective institutional controls. If it is not possible for DOE to notify EPA at least six months prior to any transfer or sale, then the DOE will notify EPA as soon as possible but no later than 60 days prior to the transfer or sale of any property*

subject to institutional controls. In addition to the land transfer notice and discussion provisions above, the DOE further agrees to provide EPA with similar notice, within the same time frames, as to federal-to-federal transfer of property. The DOE shall provide a copy of executed deed or transfer assembly to EPA.

11. *The DOE will prevent the development and use of property above the 200-ZP-1 groundwater OU for residential housing, elementary and secondary schools, childcare facilities and playgrounds.*
12. *Land use controls will be maintained until cleanup levels are achieved and the concentrations of hazardous substances in groundwater are at such levels to allow for unrestricted use and exposure and EPA authorizes the removal of restrictions.*

Remedy Implementation Progress Prior to this Review Period. Beginning in 1994, DOE operated the 200-ZP-1 groundwater OU P&T system located near the middle of the 200 West Area, and removed carbon tetrachloride as the primary contaminant of concern, along with chloroform, and trichloroethene, and other contaminants of concern. Through 2010, this system had removed 12,000 kg (400 lb) of carbon tetrachloride from the groundwater. The P&T system limited movement of the shallow, high-concentration portion of the plume; however, it did not address contamination deeper in the aquifer and at the periphery of the plume. In 2009, under a ROD for final remediation (EPA 2008b), DOE began constructing the 200 West Area Groundwater Treatment Facility to address the full plume. Additional detail on this earlier period of 200-ZP-1 groundwater remediation can be found in the 2010 annual groundwater monitoring report (DOE/RL-2011-01).

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for the 200-ZP-1 OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The 200-ZP-1 groundwater OU protectiveness statement from the previous (2006-2010) 5-year review report was noted as follows:

> *A protectiveness determination of the final remedy at 200-ZP-1 Groundwater OU cannot be made at this time until further information is obtained. Further information will be obtained when the final pump-and-treat remedy is constructed and operational. It is expected that the pump-and-treat final remedial action will operate for 25 years with continued monitored natural attenuation taking place over 125 years for all contaminants of concern to meet cleanup levels. The two RODs for interim action that address groundwater contaminants, two interim action pump-and-treat systems, and a vapor extraction system will continue operations until the final remedy has been constructed and is operational.*

3.3.1.2.4 Progress Since 2011 Review

Accomplishments. The primary remedial action accomplishments for the 200-ZP-1 groundwater OU during the past 5 years can be summarized as follows:

- Completed construction of the 200 West P&T and began operations in July 2012 (construction was initiated in late 2009)
- Removed from service the 200-ZP-1 interim P&T system and the WMA T P&T system in 2012
- Continuously operated the 200 West P&T in 2013 through 2015
  - Removed 9,264 kg of carbon tetrachloride since startup
  - Removed 259 kg of chromium (total and hexavalent) since startup
  - Removed 242,000,000 pCi of iodine-129 since startup
  - Removed 844,113 kg of nitrate since startup
  - Removed 4.8 Ci (284 g) of technetium-99 since startup
  - Removed 36.7 kg of TCE since startup
  - Removed 8.25 kg of uranium since startup

- Removed (as of the end of 2015) a combined total of 102,282 kg of carbon tetrachloride from the vadose zone (200-PW-1 soil vapor extraction system [1992 − 2012], and groundwater (200-ZP-1 interim action system [1995 − 2012], and the final action system (i.e., the 200 West P&T) [2012 − 2015]) through source and groundwater actions.

Additional narrative on 200-ZP-1 OU accomplishments (as of 2015) can be viewed in DOE/RL-2016-20, *Calendar Year 2015 Annual Summary Report for the 100-HR-3 and 100-KR-4 Pump and Treat Operations and 100-NR-2 Groundwater Remediation*

Remedy Implementation. At the beginning of this 5-year review period, construction of the 200 West P&T was under way; construction on the balance of the plant began in late 2009; construction of the radiological building and biological process facility began in 2010. Commissioning and startup of the facility took place in 2011 and early 2012; operations began in July 2012.

Details on implementing the final action ROD are provided in *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78). The *200-West Area Groundwater Pump and Treat Remedial Design Report* (DOE/RL-2010-13) outlines the design basis of the 200 West P&T. Two primary documents that support the remedial design report are an O&M plan and a performance monitoring plan. The *200 West Pump and Treat Operations and Maintenance Plan*, (DOE/RL-2009-124) outlines the activities necessary to operate, maintain, and monitor operation of the 200 West P&T, from construction completion through system decommissioning. *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action* (DOE/RL-2009-115) was prepared in a data quality objective-type format and presents recommendations for the types of data that should be collected, the well networks that should be monitored, the frequency for data collection, and analysis of the data to satisfy the requirements of the ROD.

Table 3-7 presents an overview of primary components of the remedy and implementation status.

Table 3-7. Overview of 200-ZP-1 Groundwater Operable Unit Remedy Implementation.

Document Type	**Date**	**Title**
Final Action ROD	09/2008	EPA 2008b, *Record of Decision, Hanford 200 Area, 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington*
RD/RA Work Plan	07/2009	DOE/RL-2008-78, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan*
RAO (brief description)	**1.** Return the 200-ZP-1 OU groundwater to beneficial use (restore groundwater to achieve domestic drinking water levels) within 150 years **2.** Apply institutional controls to prevent the use of groundwater until the cleanup levels have been achieved (estimated to be within 150 years) **3.** Protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by contaminants originating from the 200-ZP-1 OU	
COCs	Carbon tetrachloride, chromium (total and hexavalent), nitrate, iodine-129, technetium-99, TCE, tritium	

Remedy Component	**Construction Status** (approximate percentage complete for constructing/implementing the remedy component as of December 2015)[a]						**Duration of O&M** (~years)[b]	**Finish**[c] (Est'd year)[c]
	0	**1-25**	**26-50**	**51-75**	**76-99**	**100%**		
Groundwater extraction and treatment							25	2037
Monitored natural attenuation (also includes performance monitoring)							125	2137
Flow path control							25	2037
Institutional controls							125	2137

Table 3-7. Overview of 200-ZP-1 Groundwater Operable Unit Remedy Implementation.

[a]Percentages reflect construction status of the remedy component; post-startup upgrades and system performance optimization is considered part of O&M. 100% = fully implemented and now in O&M mode..
[b]Approximate number of years to operate remedy component as estimated in ROD (shorter durations for certain COCs)
[c]Estimated year when remedy component will be completed.

COC = contaminant of concern.
O&M = operation and maintenance.
OU = operable unit.
RAO = remedial action objectives.
RD/RA = remedial design/remedial action.
ROD = record of decision.

3.3.1.2.5 Technical Assessment

Is the remedy functioning as intended by the decision documents?

Yes, the remedy identified in the final action ROD (EPA 2008b) involving extraction of groundwater from the 200-ZP-1 OU area and treatment at the 200 West P&T, monitored natural attenuation, flow-path control via injection of treated groundwater (all supporting achievement of RAO 1 and RAO 3), and ICs has been functioning as intended since 2012. Combined, the final remedial action system, the interim remedial action system, and a soil vapor extraction system have removed over 100,000 kg of carbon tetrachloride from the subsurface since 1996. Since startup of the 200 West P&T system in 2012, over 9,000 kg of carbon tetrachloride has been removed. As further explained in DOE/RL-2016-09, the significant decline in both maximum carbon tetrachloride concentration (from 8,700 µg/L in 1990 to 1,980 µg/L in 2015) and the number of wells exceeding 2,000 µg/L (from 40 wells to zero) demonstrates the effectiveness of the remedial actions in reducing carbon tetrachloride contamination.

Table 3-8 summarizes the mass or activity removed at the 200 West P&T both during 2015 and cumulatively since startup in July 2012.

Table 3-8. 200 West Area Pump and Treat Performance.[a]

Constituent	Mass (Activity) Removed During 2015	Mass (Activity) Removed Since Startup in 2012
Carbon tetrachloride, kg	2,786	9,264
Chromium, (total and hexavalent) kg	83.54	249.91
Iodine-129, pCi	N/A (undetected in 2015)	242
Nitrate (as NO_3), kg	348,431	844,113
Technetium-99, Ci (g)	1.87 Ci (109 g)	4.82 Ci (284 g)
Trichloroethene, kg	11.00	36.73
Tritium	N/A	N/A
Uranium[b] (kg)	6.39	8.25

[a]Source: *Hanford Site Groundwater Monitoring Report for 2015*, Table 12-2 (DOE/RL-2016-09).
[b]Uranium is not a COC in 200-ZP-1; contaminant is background contamination removed from wells in the 200-ZP-1 OU.
COC = contaminant of concern. OU = operable unit. N/A = not applicable.

Remedy performance monitoring will be conducted over the duration of the interim remedial action to evaluate its performance and optimize its effectiveness. Monitoring is under way to evaluate the performance of the P&T systems, hydraulic containment, and MNA components. Two of eight additional wells to enhance monitoring capability, as proposed in the *Performance Monitoring Plan for the 200-ZP-1 Groundwater Operable Unit Remedial Action* (DOE/RL-2009-115), have been installed as of 2015. The network of wells sampled in 2015 is shown in Figure 3-8.

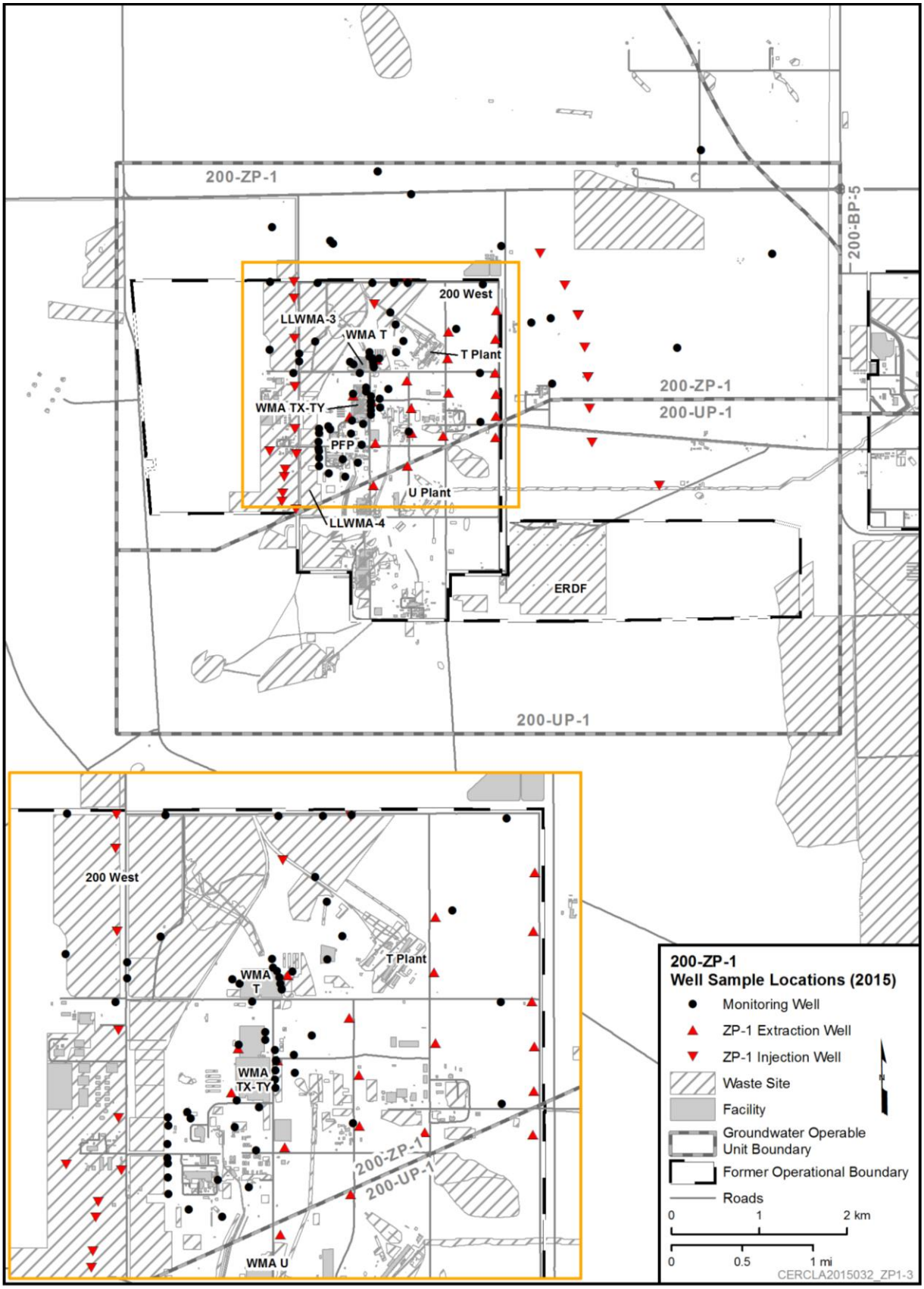


Figure 3-8. Locations of 200-ZP-1 Wells Sampled in 2015.

Table 3-9 provides an overview of the 200-ZP-1 contaminant plume areas and associated changes to the areas during this 5-year review period. Plume maps in Figure 3-9 shows the changes in plume shapes and areas during this 5-year review period. The Figure 3-10 trend plots depict the estimated annual changes in contaminant plume areas over the past several 5-year periods. While concentrations of carbon tetrachloride in most wells continued to decline between 2012 and 2015, plume area increases during in 2015 (as shown in Figure 3-10) are attributed to sample data collected during the drilling of new wells and a model update. The increases shown in Figure 3-10 for carbon tetrachloride, nitrate, and TCE during 2010 through 2012 also are attributed to new wells established before the P&T startup in 2012 and contributed to the improved definition of plume extent for certain COCs shown in Figure 3-9.

Table 3-9. Overview of 200-ZP-1 Groundwater Contaminant Plumes.[a]

Groundwater Contaminant	Cleanup Level[b]	Maximum Concentration (2015)	Plume Area[c] (km^2)			Shoreline Intersection[d] (m)		
			2011	2015	Change	2011	2015	Change
Carbon tetrachloride	3.4 µg/L	1,980 µg/L	13.3[e]	18.0[e]	4.70	0	0	0
Chromium (hexavalent/total)	48[f]/100[g] µg/L	198/278 µg/L[h]	0.20	0.60	0.40	0	0	0
Iodine-129	1 pCi/L	1.38 pCi/L	0.50	0.09	-0.41	0	0	0
Nitrate	45[i] mg/L	810 mg/L	8.30	7.2	-1.10	0	0	0
Technetium-99	900 pCi/L	20,500 pCi/L	0.08	0.06	-0.02	0	0	0
Trichloroethene	1 µg/L	12 µg/L	0.20	2.9	2.70	0	0	0
Tritium	20,000 pCi/L	13,500 pCi/L	0.39	0.20	-0.19	0	0	0

[a]Primary source: Hanford Annual Groundwater Monitoring Reports for 2011 and 2015 available at http://www.hanford.gov/c.cfm/sgrp/GWRep13/start.htm.
[b]From Table 14 of *Record of Decision Hanford 200 Area 200-ZP-1 Superfund Site, Benton County, Washington* (EPA 2008b).
[c]Estimated area above the cleanup level, unless otherwise noted.
[d]Length of Columbia River shoreline intersected by contaminant plumes.
[e]Represents the entire extent of the plume (including the 200-UP-1 OU) above 5 µg/L.
[f]WAC 173-340, "Model Toxics Control Act—Cleanup," Method B groundwater cleanup level for hexavalent chromium.
[g]Federal drinking water standard for total chromium.
[h]2011 area value is for unfiltered total chromium, and 2015 value is for hexavalent chromium.
[i]Nitrate as nitrate; 10 mg/L nitrate as nitrogen.

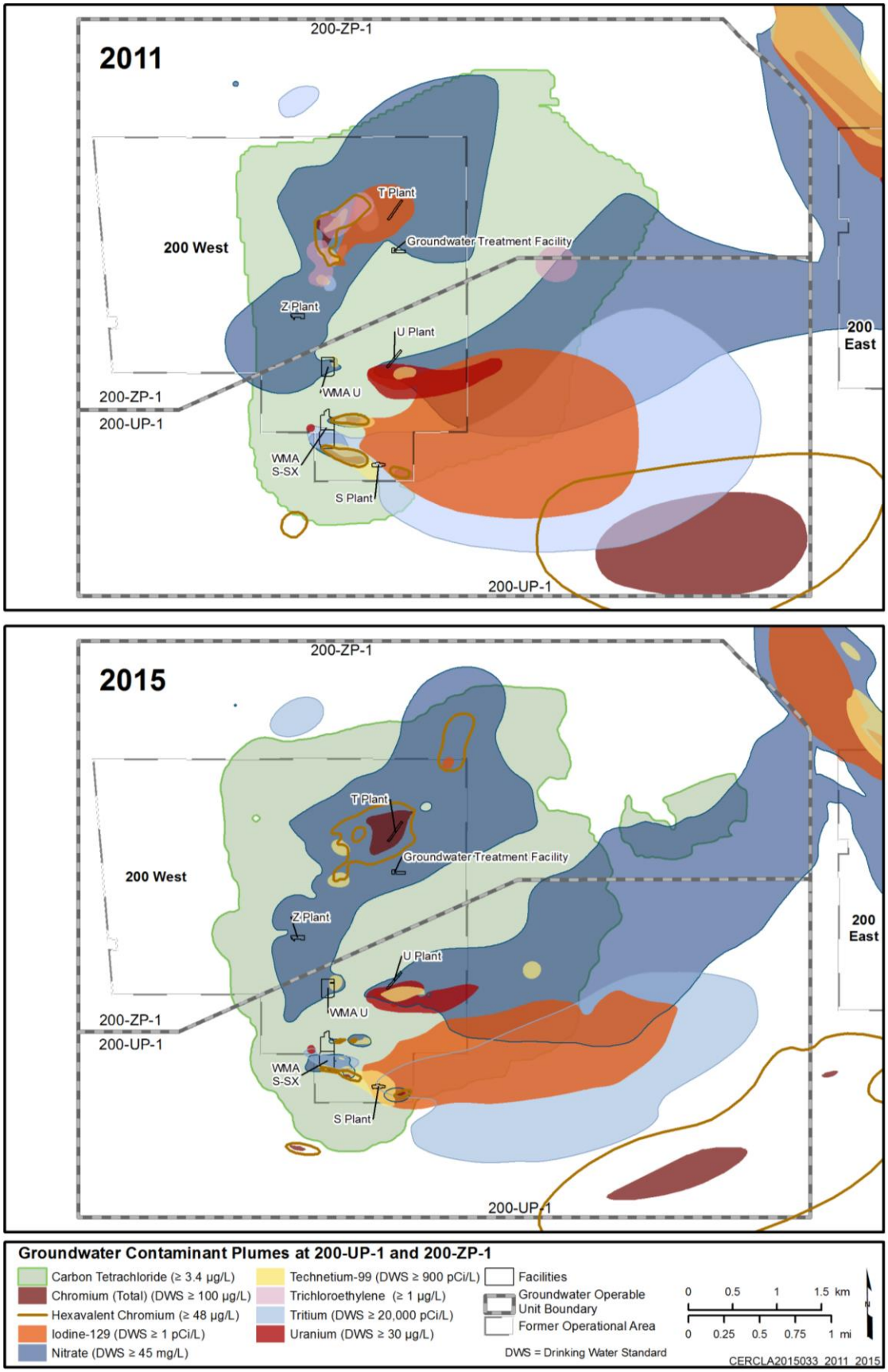
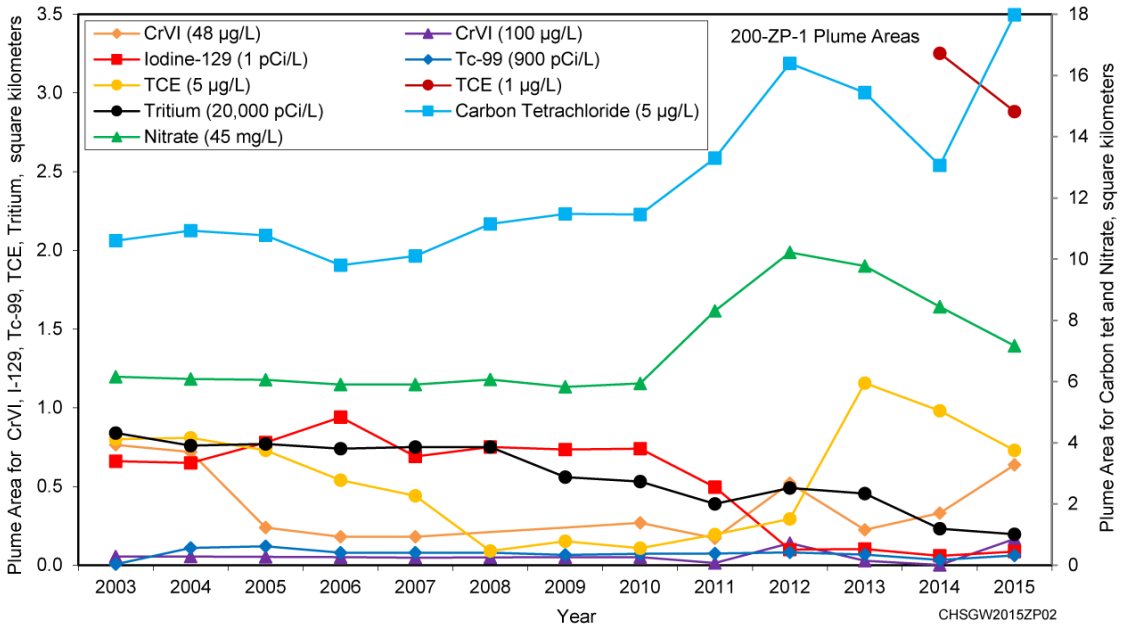


Figure 3-9. 200-UP-1 and 200-ZP-1 Groundwater Operable Unit Plumes in 2011 (top) and 2015 (bottom).



The actual cleanup level for carbon tetrachloride is 3.4 ppb and for TCE is 1 pbb.

Figure 3-10. 200-ZP-1 Trend Plots of Contaminant Plume Areas (2003 – 2015).

For more detailed information on the 200-ZP-1 groundwater OU well locations, distribution of contaminant concentrations within each plume, and historic trends associated with each 200-ZP-1 COC plume area, as well as for performance metrics associated with 200-ZP-1 OU groundwater treatment, visit the following websites:

- *Hanford Site Groundwater Monitoring Report* (published each summer for the previous calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports
- *Annual Summary Report for the 200-ZP-1 and 200-UP-1 Operable Unit Pump-and-Treat Operations* (published for each calendar year): http://www.hanford.gov/page.cfm/SoilGroundwaterAnnualReports.

ICs for the 200-ZP-1 groundwater OU, as required by the ROD (EPA 2008b) are described in the latest version of *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Action Work Plan* (DOE/RL-2008-78) and are actively managed. Specific details associated with each IC also have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 200-ZP-1 OU support achievement of RAO 2 and include warning notices, entry restrictions, land-use management (land use), groundwater-use management (excavation permits), and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes' attachments (e.g., CHPRC-1503264), which are archived in the Hanford Site Administrative Record. During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 200-ZP-1 groundwater OU.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection (2008) are still valid for the OU.

Has any other information come to light that could call into question the protectiveness of the remedy?

No information has come to light that would call into question the protectiveness of the remedy.

3.3.1.2.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 200-ZP-1 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

3.3.1.2.7 Protectiveness Statement

200-ZP-1 Groundwater OU – Protective. The remedy at the 200-ZP-1 groundwater OU is protective of human health and the environment.

The RAOs to restore groundwater in the return the 200-ZP-1 OU to achieve domestic drinking water levels within 150 years, and to protect the Columbia River and its ecological resources from degradation and unacceptable impact caused by contaminants originating from the 200-ZP-1 OU, are being met by the remedy components involving groundwater extraction and treatment, MNA, and flow path control. The RAO of applying ICs to prevent the use of groundwater until the cleanup levels have been achieved (estimated to be within 150 years) has been met by the implementation and continued management of ICs.

3.3.2 200 Area Source Operable Units

This section covers the following four groups of 200 Area source OUs that have published RODs for remedial action:

- 200-CU-1 (U Plant canyon building)
- 200-CW-3
- 200-DF-1 (ERDF)
- 200-PW-1, 200-PW-3, 200-PW-6 and 200-CW-5.

As cleanup decisions are made for the other 200 Area source OUs, the decisions are documented in a ROD and field construction of the remedy is initiated, those OUs will be evaluated for protectiveness and included in a future 5-year review report. Future cleanup decisions are anticipated for the following 200 Area source OUs: 200-BC-1, 200-CP-1, 200-CR-1, 200-CW-1, 200-DV-1, 200-EA-1, 200-IS-1, 200-OA-1, and 200-WA-1.

3.3.2.1 200-CU-1 Source Operable Unit

3.3.2.1.1 Background

Background. The Central Plateau contains five large defense production facilities, referred to as canyons, which were originally designed for fuel reprocessing operations: T Plant, B Plant, U Plant, REDOX Plant, and PUREX Plant. The canyon buildings range from approximately 244 m (800 ft) long to over 305 m (1,000 ft) long and are constructed of thick, reinforced concrete. Approximately half of each structure was constructed below grade level for shielding purposes. The below-grade portion of the structure is divided into cells that contain equipment and piping used for reprocessing operations. Thick concrete cover blocks protect the cells and form the surface of the canyon deck.

Primary waste streams from canyon facilities included process waste, decontamination wastewater, and aqueous process waste that were discharged to tanks, cribs, and trenches. The nonradioactive, low-volume chemical sewer waste was generally sent to ponds and ditches. Very-low-volume radioactive waste streams were sent to French drains.

Only T Plant continues to support Hanford Site waste management. B Plant, U Plant, REDOX Plant, and PUREX Plant are no longer in use and are targeted for remediation within the CERLCA 200-CB-1, 200-CU-1, 200-CR-1 and 200-CP-1 OUs, respectively. The U Plant (221-U Facility) is the first canyon building to get a ROD for final disposition. Implementation of *Record of Decision 221-U Facility Canyon Disposition Initiative) Hanford Site, Washington* (EPA 2005b) is viewed as a pilot project to provide a blueprint for the disposition of the remaining four canyon buildings and lessons learned for

dealing with similar facilities at the Idaho National Laboratory and Savannah River Site. This pilot project also is known as the Canyon Disposition Initiative.

The 221-U Facility is approximately 800 ft long, 70 ft wide, and 80 ft high, and was built to extract plutonium from fuel rods irradiated in Hanford Site production reactors. However, it was never used for this purpose because existing canyon buildings met the Site's production needs. Instead, the facility was used to train operators for B Plant and T Plant until 1952. At that time, it was modified to include a uranium recovery process for waste from other canyon facilities. Process equipment was transferred from other canyon facilities to process remote-handled materials and materials contaminated with TRU isotopes.

3.3.2.1.2 Chronology

Table 3-10 lists the remedial action decision documents associated with the 200-CU-1 source OU.

Table 3-10. Decision Documents for the 200-CU-1 Source Operable Unit.

Date	Location	Document Title
10/2005	EPA 2005b	***Record of Decision 221-U Facility (Canyon Disposition Initiative), Hanford Site, Washington.*** This final action ROD includes removing waste from facility vessels and equipment with levels of transuranic isotopes greater than 100 nCi/g and eventual disposal at WIPP, removing or treating to remove liquids from the facility, and partial removal of contaminated equipment and piping from the gallery side of the facility and disposal at ERDF. It also includes demolition and subsequent stabilization of the railroad tunnel; the 271-U, 276-U, 291-U, and 292-U structures; and the 291-U-1 and 296-U-10 stacks and their disposal at ERDF. Final ROD activities consist of constructing an engineered barrier; planting semiarid-adapted vegetation on the barrier; initiating ICs; providing post-closure care; and ensuring ongoing barrier performance and groundwater monitoring.

ERDF = Environmental Restoration Disposal Facility.
IC = institutional control.
ROD = record of decision.
WIPP = Waste Isolation Pilot Plant.

See Appendix B for a consolidated listing of decision documents for Hanford Site OUs.

3.3.2.1.3 Remedial Actions

Goals and Objectives. The RAOs for the 200-CU-1 OU are as follows:

RAO 1. Prevent unacceptable health and occupational risks to workers from physical, chemical, and radiological hazards posed by the 221-U Facility.

RAO 2. Prevent unacceptable risk to human health, ecological receptors, or natural resources associated with external exposure to, ingestion of, inhalation of, and dermal contact with 221-U Facility contents at levels that exceed ARARs or risk-based criteria.

RAO 3. Prevent migration of contaminants to surface waters and through the soil column to groundwater such that no further degradation of groundwater occurs due to leaching from the 221-U Facility.

RAO 4. Minimize physical, ecological, or cultural impacts caused by remediation of the 221-U Facility or by use of the 221-U Facility as a disposal facility.

Remedy Components. The selected remedy in this final ROD (EPA 2005b) includes the following components.

Excerpt from ROD (EPA 2005b):

- *Removal of waste from vessels and equipment in the facility that, if stabilized in place, would contain levels of transuranic isotopes greater than 100 nCi/g, in accordance with an approved Remedial*

Design/Remedial Action (RD/RA) work plan, and eventual disposal of that waste at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico.

- *Removal of liquids from the facility or treatment to remove liquids.*
- *Partial removal of contaminated equipment and piping from the gallery side of the facility, as needed to facilitate demolition activities, and disposal of this waste at the Environmental Restoration Disposal Facility (ERDF) located on Hanford's Central Plateau between the 200 West and 200 East Areas or other disposal facilities approved in advance by the U.S. Environmental Protection Agency (EPA).*
- *Treatment, as necessary, to meet waste acceptance criteria at an acceptable disposal facility.*
- *Consolidation of contaminated equipment on the deck into the below-grade cells for disposal.*
- *Grouting of internal vessel spaces, as well as cell, gallery, pipe trench, drain header, and other spaces within the facility.*
- *Demolition of the railroad tunnel, 271-U, 276-U, 291-U, and 292-U structures and the 291-U-1 and 296-U-10 stacks, and disposal of the resulting waste at the ERDF or other disposal facilities approved in advance by the EPA, followed by stabilization of the former locations of these structures to support construction of the engineered barrier.*
- *Removal of roof and wall sections of the 221-U Facility down to the deck level and placement on or near the deck.*
- *Construction of an engineered barrier over the remnants of the canyon building (with the possible inclusion of inert rubble from the demolition of ancillary facilities as fill material).*
- *Planting of semiarid-adapted vegetation on the barrier to enhance evapotranspirative design of the barrier.*
- *Institutional controls to ensure that the remedy is protected and changes in land use do not occur that could result in unacceptable exposures to residual contamination.*
- *Post-closure care, including barrier inspection and maintenance.*
- *Ongoing barrier performance and groundwater monitoring to ensure effectiveness of the remedial action and to support five-year remedy reviews.*

Remedy Implementation Progress Prior to this (2011-2015) Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work on the 200-CU-1 OU remedy began after issuance of the ROD in 2005. Before 2011, the following tasks were completed: cell loading and deck cleaning of U Canyon; demolishing the above-ground tanks (211-U/UA) and the 203-UX process facility; debris from both structure was disposed of in ERDF. The 224-U/UA process facilities also were demolished. ICs have been in place since remedial activities commenced in 2008 and have been effective to prevent exposure to contamination by unauthorized personnel or the public.

Issues/Corrective Actions from the Previous 5-Year Review. No issues or actions were noted for the 200-CU-1 source OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006 – 2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). A protectiveness statement was not included in the previous 5-year review report.

3.3.2.1.4 Progress Since 2011 Review

Accomplishments. The tasks associated with the 221-U Facility remedy include the following:

- Equipment size reduction
- Cell 30, Tank-10 contents disposition
- Canyon void space grouting, including equipment in the cells
- Canyon demolition

- Engineered barrier construction.

During this 5-year review period, the first three remedy components were completed.

Remedy Implementation. Implementation of remedial action at the 221-U Facility has been conducted under the *Remedial Design/Remedial Action Work Plan for the 221-U Facility* (DOE/RL-2006-21). The following remedial activities are still to be implemented:

- Demolish the railroad tunnel; 271-U, 276-U, 291-U, and 292-U structures; and the 291-U-1 and 296-U-10 stacks and disposal of the resulting waste at the ERDF or other disposal facilities approved in advance by the EPA; stabilize the sites to support engineered barrier construction
- Remove facility roof and wall sections down to the deck level and place on or near the deck
- Construct an engineered barrier over the remnants of the canyon building, possibly including inert rubble from the demolition of ancillary facilities as fill material
- Plant semiarid-adapted vegetation on the barrier to enhance its evapotranspirative design
- Implement ICs to ensure that the remedy is protected and changes in land use do not occur that could result in unacceptable exposures to residual contamination
- Begin post-closure care, including barrier inspection and maintenance
- Monitor ongoing barrier performance and groundwater to ensure effectiveness of the remedial action and to support 5-year remedy reviews.

Reasonably anticipated future land use for the 200 Area is industrial, and the 221-U Facility remedy will result in protection of human health and the environment based on the exposure assumptions contained in the 200 Area industrial use scenario.

3.3.2.1.5 Technical Assessment

The 5-year review determines whether the remedy at a site is, or upon completion will be, protective of human health and the environment. The following is the response to the technical assessment questions provided in the EPA guidance for the 200-CU-1 OU remedy. These questions also establish a framework for organizing and evaluating data and ensuring that all relevant issues are considered when determining the remedy's protectiveness.

Is the remedy functioning as intended by the decision document?

Construction has not been completed for the entire remedy; therefore, no final decision can be made to determine whether the remedy is functioning as intended. However, as the final remedial designs are completed, approved, and implemented, there is no indication that the remedy will not function within the specified remedial action objectives.

ICs for the 200-CU-1 OU, as required by the ROD (EPA 2005b), are described in the latest version of DOE/RL-2005-93, *Remedial Design Report/Remedial Action Work Plan for the 221-U Facility*. Specific details associated with each IC also have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 200-CU-1 OU include access control (warning notices, entry restrictions), land-use management (land use, and excavation permits), groundwater use management (excavation permits), and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes' attachments (e.g., CHPRC-1503264), which are archived in the Hanford Site Administrative Record. During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 200-CU-1 OU.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

Yes. The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid for this canyon remedy.

Has any other information come to light that could call into question the protectiveness of the remedy?

No additional information has come to light since the 2011 5-year review that calls into question the protectiveness of the final remedy, once constructed.

3.3.2.1.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 200-CU-1 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

3.3.2.1.7 Protectiveness Statement

200-CU-1 Source OU – Will Be Protective. The remedy at the 200-CU-1 OU (221-U Facility (U Plant) is expected to be protective of human health and the environment upon completion of the final remedy actions. Implementation of the final remedy for the 200-CU-1 OU has been put in hiatus. Once implementation is restarted and the remedy is complete, it is expected to be protective of human health and the environment. The remedial actions completed to date, along with implementation of ICs, ensure that exposure pathways that could result in unacceptable risks are being controlled.

3.3.2.2 200-CW-3 Source Operable Unit

3.3.2.2.1 Background

The waste sites in the 200-CW-3 source OU include trenches, ponds, pits, pipelines, and unplanned releases of shallow contamination generally less than 4.6 m (15 ft) deep. They also include unplanned release sites where chemical and radioactive contaminants were released during material transfers. Some sites were produced by airborne dissemination of radioactive particles, or dispersal through plants or animal fecal material. Locations of the 200-CW-3 OU waste sites were shown in Figure 3-1.

3.3.2.2.2 Chronology

Table 3-11 lists the remedial action decision documents relevant to the 200-CW-3 source OU.

Table 3-11. Decision Documents for the 200-CW-3 Source Operable Unit.

Date	Location	Title
7/1999	EPA/ROD/R10-99/039	***Interim Action Record of Decision for the 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 Operable Units Remaining Sites*.** This interim action ROD requires RTD for 46 sites; the plug-in approach for the remaining 100 Area and 200 North sites and the newly identified 100 Area sites; disposal of debris from B, D, H, and K Reactors to ERDF; and provides the decision framework for leaving waste in place, generally below 15-ft depth.
2/2004	EPA 2004	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision*.** The ESD adds 28 sites to the ROD; adds 10 CFR 1022 and 40 CFR 6, Appendix A, as ARARs to the ROD; and revises the annual ICs report date to coincide with the due date for the Sitewide ICs plan for Hanford CERCLA response actions.

Table 3-11. Decision Documents for the 200-CW-3 Source Operable Unit.

Date	Location	Title
8/2009	EPA et al. 2009	***Explanation of Significant Difference for the 100 Area Remaining Sites Interim Remedial Action Record of Decision*.** This ESD authorizes adding 200-CW-3 OU wastes sites, 99 newly discovered waste sites, and 87 candidate sites using the plug-in approach in the ROD and any newly discovered waste sites documented in the Administrative Record and an annual fact sheet.
2/2012	DOE et al. 2012	**Tri-Party Agreement Fact Sheet:** ***100 Area "Plug-In" and Candidate Waste Sites For Calendar Year 2011, Annual listing of waste sites plugged into the remove, treat and dispose remedy in the 1999 interim action Record of Decision for the 100 Area Remaining Sites*.** This is the annual listing of candidate waste sites for confirmatory sampling and waste sites plugged into the RTD remedy in the 1999 interim action ROD for the 100 Area Remaining Sites.

ESD = explanation of significant difference. ROD = record of decision.
OU = operable unit. RTD = removal, treatment, and disposal.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

3.3.2.2.3 Remedial Action

Goals and Objectives. The RAOs set forth in EPA/ROD/R10-99/039 are narrative statements that define the extent to which the waste sites require cleanup to protect human health and the environment. The following RAOs identified in the interim action ROD apply to contaminants in soils, structures, and debris.

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics*.**
- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions*.**

Remedy Components. The 1999 ROD (EPA/ROD/R10-99/039), as amended, includes the following basic interim action remedy components applicable to 200-CW-3 waste sites:

- Remove contaminated soil, structures, and debris using the observational approach, which uses field data and analytical screening during remediation to guide the extent of excavation. Remediation proceeds until it can be demonstrated through a combination of field screening and verification sampling that cleanup goals have been achieved.
- Treat the waste as required to meet applicable waste disposal criteria
- Dispose of contaminated materials at ERDF
- Backfill excavated areas and revegetate.
- Implement ICs.

Remedy Implementation Progress Prior to this (2011-2015) Review Period (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070)**.** Work, on the 200-CW-3 OU remedy began after issuance of the ROD in 1999. Before 2011, interim remedial actions for 10 of the 13 waste sites in the 200-CW-3 OU had been completed.

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for the 200-CW-3 OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). The protectiveness statement from the previous

(2006 – 2010) 5-year review report included 200-CW-3 along with the 200-CW-1 and 200-OA-1 OUs. The statement was worded as follows:

> *A protectiveness determination of the remedy at 200-CW-1, 200-CW-3 and 200-OA-1 Operable Units (Outer Area) cannot be made at this time until further information is obtained. Further information will be obtained by completing a risk assessment.*[b]

3.3.2.2.4 Progress Since 2011 Review

Accomplishments. Since the 2011 5-year review, interim remedial actions were completed at 3 waste sites and documented in waste site cleanup verification packages or remaining sites verification packages. The waste sites are as follows:

- 200-CW-3 Operable Unit
  - 216-N-1, Unplanned Release
  - 216-N-4, Unplanned Release
  - 216-N-6, Unplanned Release

In September of 2011, DOE-RL published DOE/RL-2011-58, *200-CW-3 Operable Unit Interim Remedial Action Report*. The report verifies that the remedial actions at all of the 200-CW-3 waste sites meet the interim action remedial action objectives.

Table 3-12 summarizes the cleanup status for the 200-CW-3 source OU.

Table 3-12. 200-CW-3 Source Operable Unit Cleanup Status.

Source OU	Number of Waste Sites[a]	Sites Dispositioned[b]			
		Pre-2011	2011 - 2015	Total	Percent Complete
200-CW-3	13	10	3	13	100
Total	**13**	**10**	**3**	**13**	**100%**

[a]Approximate number of waste sites within the OU, according to WIDS, as of December 2015. Actual numbers can and do change if sites are added to or moved from a given OU in accordance with DOE and regulatory agency approvals. For example, the guard house sewer lines, 2607-N, -P, and –R are listed in DOE/RL-2011-58, 200-CW-3 *Operable Unit Interim Remedial Action Report*, however, they were rejected as wastes sites.

[b]Approximate number of sites dispositioned as of December 2015; includes the number of sites that have been reclassified in WIDS, as of December 2015, as either interim closed, final closed, or no-action in accordance with the guideline TPA-MP-14, *Maintenance of Waste Information Data System (WIDS)*. Slight discrepancies may exist between WIDs data and the specific waste sites listed in the table because of the time required to process and approve change requests that add or delete sites before changes are made in the WIDS.

DOE = U.S. Department of Energy. OU = operable unit.

Remedy Implementation. All interim remedial actions were conducted under DOE/RL-2007-55, *Remedial Design/Remedial Action Work Plan for 200 North Area Waste Sites Located in the 200-CW-3 Operable Unit*. Current plans are to address the 200-CW-3 waste sites in a future, final ROD along with the 200-OA-1 and 200-CW-1 OUs.

3.3.2.2.5 Technical Assessment

Is the remedy functioning as intended by the decision documents?

The interim remedy (primarily involving RTD, backfilling, revegetation, and ICs) is functioning as intended by the interim action ROD (as amended). As of December 2015, all 13 200-CW-3 OU waste sites had been remediated and ICs are in place. A future final action ROD may address additional exposure scenarios and additional models for evaluating contaminant migration pathways.

[b]Note that since a ROD has not been issued for 200-CW-1 and 200-OA-1 OUs, they are both considered out of scope for this report.

In accordance with TPA-MP-14, *Maintenance of the Waste Information Data System (WIDS)*, the 200-CW-3 remediated waste sites are documented in the WIDS as either interim closed or interim no-action. Cleanup verification packages (including sampling data and other technical information) to support the reclassification to interim closed and/or no-action are included in the Hanford Site Administrative Record for the 200-CW-3 OU. The remedial action goals (contaminant-specific soil cleanup criteria developed to ensure that remedial actions to be implemented will achieve the RAOs) are described in Chapter 2 of the RD/RAWP (DOE/RL-2007-55).

The RAOs for 200-CW-3 remediated waste sites, and the methods used for achieving the RAOs through the interim remedial actions are summarized in the following list:

- ***RAO 1. Protect human and ecological receptors from exposure to contaminants in soil, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics, or organics.***

  Achieved by reducing concentrations of, or limiting exposure pathways to, contaminants in the upper 4.6 m *(*15 ft) of the soil exposure scenario. The levels of reduction will be such that, for radionuclides, the EPA CERCLA risk range of 10^{-4} to 10^{-6} increased excess lifetime cancer risk will be achieved. To address this objective, the total dose for radionuclides shall not exceed 15 mrem/yr above Hanford Site background for 1,000 years following remediation and MTCA Method B levels for inorganics and organics.

- ***RAO 2. Control the sources of groundwater contamination to minimize the impacts to groundwater resources, protect the Columbia River from further adverse impacts, and reduce the degree of groundwater cleanup that may be required under future actions.***

  – Achieved through protection such that contaminant levels in soil after remediation do not result in an adverse impact to groundwater that could exceeded any nonzero MCLs and non-zero MCL goals under the *Safe Drinking Water Act of 1974*.

  – Protection of the Columbia River from adverse impacts of contaminants remaining in the soil after remediation that do not result in an impact to groundwater and, therefore, the Columbia River, that could exceed the ambient water quality criteria under the *Clean Water Act* for protection of fish. Becauseare no ambient water quality criteria have been established for radionuclides, MCLs will be used.

ICs for the 200-CW-3 source OU, as required by the interim action ROD (as amended), are described in the latest version of the *RD/RAWP* (DOE/RL-2007-55). Specific details associated with each IC also have been incorporated into *Sitewide Institutional Controls Plan for the Hanford CERCLA Response Actions and RCRA Corrective Actions* (DOE/RL-2001-41); this report is routinely updated within 180 days after publication of each decision document that addresses ICs. The ICs implemented for the 200-CW-3 source OU include access control (warning notices and entry restrictions), land-use management (excavation permits), and miscellaneous provisions. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes' attachments (e.g., CHPRC-1503264), which are archived in the Hanford Site Administrative Record. During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 200-CW-3 OU.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information has come to light that could call into question the protectiveness of the interim remedy for the 200-CW-3 OU.

3.3.2.2.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 200-CW-3 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

3.3.2.2.7 Protectiveness Statement

200-CW-3 Source OU -- Will Be Protective. The remedy for the 200-CW-3 source OU is expected to be protective of human health and the environment upon completion of the final remedy. Implementation of the interim remedy (primarily involving RTD, backfilling, recontouring, revegetation, and institutional controls) at 200-CW-3 OU waste sites has demonstrated that exposure pathways that could result in unacceptable risks are being controlled.

3.3.2.3 200-DF-1 Source Operable Unit

3.3.2.3.1 Background

The 200-DF-1 OU comprises the ERDF, shown in Figure 3-11. The ERDF is a large CERCLA waste disposal facility located just southeast of the 200 West Area on the Central Plateau (previously noted in Figure 3-1). It was constructed using a double liner and a leachate collection system that meets RCRA, Subtitle C, minimum technological requirements. The ERDF is used to dispose of hazardous and dangerous waste, low-level radioactive waste, and mixed waste that meets, or has been treated to meet, land disposal restrictions and ERDF waste acceptance criteria.

Designed to be expanded as needed, the ERDF consists of 10 disposal areas called cells. Each pair of cells is 21 m (70 ft) deep, 152 m (500 ft) wide, and 305 m (1,000 ft) long at the base. Cells 1 through 8 can hold 2.5 million metric tons (2.8 million tons) of material per pair, Cells 9 and 10 are super cells that can hold 2.7 metric tons (3.0 million tons) each. As each pair of cells is filled to capacity, an interim cover is installed to prevent water infiltration. A permanent cap will be placed over the facility when Hanford Site cleanup is completed.

Figure 3-11. Aerial View of 200-DF-1 OU, Environmental Restoration Disposal Facility.

3.3.2.3.2 Chronology

Table 3-13 lists the remedial action decision documents relevant to the 200-DF-1 source OU.

Table 3-13. Decision Documents for the 200-DF-1 Source Operable Unit.

Date	Location	Title
1/1995	EPA et al. 1995	***Record of Decision for the U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington.*** This ROD authorizes the construction of ERDF to provide waste disposal capacity for cleanup of contaminated areas on the Hanford Site.
7/1995	EPA/ESD/R10-96/145	***USDOE Environmental Restoration Disposal Facility (ERDF), Hanford Site Benton County Washington Explanation of Significant Difference (ESD).*** This ESD allows for disposal of investigation-derived waste, D&D waste, waste from RCRA past-practice OUs and closures, and non-RCRA waste from inactive TSD units. The ESD also authorized the conditional use of ERDF leachate for dust suppression and waste compaction.
9/1997	EPA/AMD/R10-97/101	***Amended Record of Decision for the U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington.*** This first ROD amendment authorizes facility expansion by constructing disposal cells 3 and 4 and allows for limited waste treatment at ERDF.
3/1999	EPA/AMD/R10-99/038	***Amended Record of Decision for the U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington.*** This second ROD amendment authorizes the delisting of ERDF leachate, which allows for implementation of more cost-effective and appropriate leachate handling techniques. The basis for delisting is that leachate analytical results showed contaminants were not present at a significant level.
1/2002	EPA/AMD/R10-02/030	***Amended Record of Decision for the U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington.*** This third ROD amendment authorizes the second ERDF expansion to disposal cells 5 through 8, and allows the staging of remediation waste at ERDF while awaiting treatment.
5/2007	EP`A 2007	***Amended Record of Decision for the U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington.*** This fourth ROD amendment authorizes disposal of certain Hanford Site waste in storage and creates a 'plug-in' approach for accepting Hanford-only generated waste in storage for ERDF disposal.
8/2009	(09-AMRC-0179).	***Amended ROD and Explanation of Significant Differences for the U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site – 200-Area, Benton County, Washington.*** This fifth ROD amendment authorizes construction of super cells 9 and 10, including modification of the cell design to allow a single super cell to be used in place of the double-cell, side-by-side configuration described in the initial ROD. The amendment also authorizes the addition of future ERDF cells upon EPA approval through the issuance of a fact sheet by DOE, rather than using the ROD amendment process required by the original ERDF ROD.
10/2015	EPA 2015	***Explanation of Significant Differences for the U.S. Department of Energy Environmental Restoration Disposal Facility Hanford Site – 200 Area, Benton County, Washington.*** This ESD allows ERDF leachate to be transferred to either the ETF located in the 200 East Area **or** the 200 West Area P&T for treatment. Previously, excess leachate from ERDF operations was collected and transferred by pipeline to the ETF.

Table 3-13. Decision Documents for the 200-DF-1 Source Operable Unit.

Date	Location	Title
12/2015	Ecology 2015	***Amended ROD for the U.S. DOE Hanford Environmental Restoration Disposal Facility, Hanford Site – 200-Area, Benton County, Washington*.** This sixth ROD amendment authorizes placement of certain long, large, and/or heavy hazardous waste items in an ERDF trench prior to completing the required land disposal restriction treatment because treatment prior to placement results in greater risk to human health and the environment.

DOE = U.S. Department of Energy.
ERDF = Environmental Restoration Disposal Facility.
ETF = Effluent Treatment Facility.
P&T = pump and treat.
ROD = record of decision.
RCRA = *Resource Conservation and Recovery Act of 1976.*
TSD = treatment, storage, and disposal.

See Appendix B for a consolidated list of decision documents for Hanford Site OUs.

3.3.2.3.3 Remedial Action

The RAOs set forth in the ERDF ROD are as follows:

RAO 1. Prevent unacceptable direct exposure to waste in accordance with applicable or relevant and appropriate requirements (ARARs) and health-based criteria. *Direct exposure to the types of waste received at the ERDF could result in unacceptable health risks. Direct exposure of workers and biota to waste could occur during operation of the ERDF (i.e., during waste transport and filling operations). Because of access control at the Hanford Site, the direct exposure pathway does-not-apply-to the public during operations. Once the ERDF is closed, direct exposure to waste is only possible if institutional controls fail and the surface cover is breached.*

RAO 2. Prevent unacceptable contaminant releases in accordance with ARARs and health based criteria. *Inhalation exposure to the types of waste received at the ERDF could result in unacceptable health risks. Similar to the direct exposure pathway, inhalation of waste by workers and biota could occur during operation of the ERDF (i.e., during waste transport and filling operations). Airborne transport of waste off the Hanford Site could result in exposures to the public, but these exposures would be negligible compared with worker risks. Once the ERDF is closed, air releases are only possible if institutional controls fail and the surface cover is breached.*

RAO 3. Prevent contaminant releases to groundwater above ARARs and health-based criteria. *Migration of contaminants through the vadose zone to groundwater could result in unacceptable human exposure to contaminants. This RAO has been acknowledged in the fourth amendment to the Tri-Party Agreement, which states: "the point of [risk] assessment will be the intersection of the groundwater and the vertical line drawn from the edge of the disposal facility". The Tentative Agreement on Tri-Party Agreement Negotiations, which was circulated for public comment in 1993, and formed the basis for the Fourth Amendment to the Tri-Party Agreement, further provided the time of assessment (10,000 years) and the compliance standard (10-5 for the first 100 years and 10° thereafter). Since the risk assessment indicates that the risk associated with the groundwater pathway should remain below 10-5 for the first 100 years, the relevant compliance standard is 10.*

RAO 4. Minimize Ecological Impacts. *Construction of the ERDF will result in harmful impacts to the ecology of the ERDF site and possibly to the borrow sites (if needed) that provide materials for ERDF construction. Significant value is attached to the ecology at these sites. Mitigation measures to reduce ecological impacts have been incorporated into the alternatives. Potential options for additional mitigation measures will be evaluated by DOE.*

Mitigation measures included in the alternatives are (i) clearing of the site in preparation for construction prior to nesting season to ensure that wildlife is not destroyed, only displaced;(ii) constructing the landfill in a sequential fashion on an as-needed basis, which may minimize ultimate habitat loss; (iii) use of the deep area-fill trench configuration to minimize the amount of land disturbed at the ERDF; (iv) initiating site clearing activities in the southern corner, progressing to the north, to buffer the shrub-steppe habitat immediately south of the ERDF site from ongoing construction activities; (v) revegetation. Additional mitigation measures to be evaluated include restoration of the site, creation or enhancement of similar habitat, and actions to acquire or provide protection for similar habitat.

Remedy Components. Components of the 200-DF-1 (ERDF) remedy (i.e., disposal cell construction, leachate collection and storage, surface-water runoff control, air monitoring, groundwater monitoring, protection of workers, development of waste acceptance criteria, RCRA-complaint landfill-closure covers, and ICs) are described on pages 38 and 39 of the original ROD (EPA et al. 1995) and subsequently modified as noted in the five ROD amendments: EPA/AMD/R10-97/101, EPA/AMD/R10-99/038, EPA/AMD/R10-02/030, EPA 2007, and 09-AMRC-0179.

Issues/Corrective Actions from the Previous 5-Year Review. No previous issues or actions were noted for the 200-DF-1 OU in the 2011 CERCLA 5-year review.

Protectiveness Statement from the Previous (2006-2010) 5-Year Review Report (DOE/RL-2011-56, Rev. 1, as amended by Errata Sheet 12-EMD-0070). A protectiveness statement for the 200-DF-1 OU was not included in the previous 5-year review.

3.3.2.3.4 Progress Since 2011 Review

Accomplishments. Since beginning operation on July 1, 1996, more than 15.83 million metric tons (17.44 million tons) of remediation waste have been disposed of at ERDF. Approximately 84.8 million L (22.4 million gal) of ERDF leachate have been treated or recycled, and approximately 202,300 metric tons (223,000 tons) of waste have been treated (stabilized or encapsulated) at ERDF before disposal. Cells 1 through 4 are full and have an interim cover installed. Cells 5 and 6 are being filled and are near operational capacity, cells 7 and 8 are over half full, and disposal in super cells 9 and 10 continues.

Remedy Implementation. See status summary under "Accomplishments."

3.3.2.3.5 Technical Assessment

Is the remedy functioning as intended by the decision document?

Yes, the remedy is functioning as intended by the ROD (as amended).

The IC required by the ROD (EPA et al. 1995) is to restrict public access to the landfill. This is accomplished through Hanford Site access controls.

Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of remedy selection still valid?

The exposure assumptions, toxicity data, cleanup levels, and interim remedial action objectives used at the time of remedy selection are still valid.

Has any other information come to light that could call into question the protectiveness of the remedy?

No new information has come to light that could call into question the protectiveness of the interim remedy for the 200-DF-1 OU.

3.3.2.3.6 Issues/Corrective Actions During this Review Period

Issues. No issues specific to the 200-DF-1 OU were identified during this 5-year review.

Corrective Actions. No corrective actions were identified.

3.3.2.3.7 Protectiveness Statement

200-DF-1 Source OU – Will Be Protective. The remedy at the 200-DF-1 OU (ERDF landfill) is expected to be protective of human health and the environment upon completion. In the interim, remedial activities completed to date have adequately addressed all exposure pathways that could result in unacceptable risks in these areas. ERDF is an operating landfill; operation is envisioned to continue for at least another 30 years.

3.3.2.4 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Source Operable Units

In September 2011, EPA published *Record of Decision for USDOE Hanford 200 Area, 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units, Benton County, Washington* (EPA 2011b). *Remedial Design/Remedial Action Work Plan for the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* (DOE/RL-2015-23, Rev. 0) was drafted in 2015 and approved in 2016, subsequent to this 2011 – 2015 5-year review period. Because field implementation of the remedy for this entire group of OUs had not started as of December 2015, this report provides only a brief narrative. ICs (including warning notices, entry restrictions, land use, and groundwater use management) have been implemented and are maintained. These ICs are assessed annually and DOE presents a summary including any noted issues or actions to the Site regulators each fall at the unit managers meeting. The presentation is documented in the meeting minutes attachments (e.g., CHPRC-1503264), which are archived in the Hanford Site Administrative Record. During the 5-year review period of 2011 through 2015, no deficiencies were noted for the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 OUs.

The following information is excerpted primarily from the introductory pages of the ROD (EPA 2011b) and serves as background on the remedial action decision that was made during this 5-year review period.

This ROD*…presents the selected final remedial action for the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 OUs which are part of the overall soil remediation effort in the Central Plateau's Inner Area. The 200-CW-5, 200-PW-1, and 200-PW-6 OUs are located in the 200 West Area and the 200-PW-3 OU is located in the 200 East Area. The locations of waste sites associated with these OUs was shown earlier in Figure 3-1. Groundwater located beneath these OUs in the 200 West Area is being addressed through separate CERCLA processes for the 200-ZP-1 and 200-UP-1 groundwater OUs.*

In these OUs, the soils contaminated with significant concentrations of plutonium or cesium radionuclides are considered principal threat wastes since they are highly toxic contaminants. The NCP Section 300.430(a)(1)(iii)(A) establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable. However, there is no feasible technology to practicably treat radionuclides that will not result in larger volumes, creating greater impracticability for disposal. The amount of waste disposed is a limiting factor since plutonium waste generated at 200-PW-1 and 200-PW-6 waste sites will include transuranic waste, which will be disposed at the Waste Isolation Pilot Plant (WIPP), a half-mile deep repository in southern New Mexico that has limited capacity. The contaminated soils will be packaged appropriately for on-site disposal at the Hanford Site Environmental Restoration Disposal Facility (ERDF) or for off-site disposal at the (WIPP), as appropriate. DOE and EPA have determined that the waste remaining in place will not pose an unacceptable risk to human health or the environment.

The selected remedy for the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 OUs addresses soils and subsurface disposal structures, two settling tanks, and associated pipelines contaminated primarily with plutonium and cesium. Also, structures and other debris that must be removed in order to conduct required remediation will be excavated.

The major components of the selected remedy, as described in the ROD (EPA 2011b), are as follows:

- ***Removal, Treatment, and Disposal of Contaminated Soil and Debris*** *– Removal, Treatment (as needed) and Disposal (RTD) of soil and debris to the specified depths or specified cleanup levels will be used to address plutonium-contaminated soils and subsurface structures and debris. This consists of: (1) removing a portion of contaminated soil, structures, and debris; (2) treating these removed wastes as required to meet disposal requirements at ERDF, which is located on the Hanford Site, or waste acceptance criteria for off-site disposal at WIPP; and (3) disposal at ERDF or WIPP. The selected pipelines associated with these OUs will also be excavated and disposed at ERDF. Cleanup levels have been selected which are protective of groundwater and the current and reasonably expected future industrial land use. The remedy is summarized further in the bullets below.*
  - The 200-CW-5 OU, also known as the Z-ditches, will use the RTD approach to excavate contaminated soils and debris exceeding cleanup levels to a depth of 15 ft bgs)with disposal at ERDF or WIPP, as appropriate.
  - Three of the six 200-PW-1 waste sites, also known as the "High-Salt Waste Group," will use the RTD approach to excavate contaminated soils and debris located to a minimum of 2 ft below the bottom of the disposal structure (20 ft – 23 ft bgs), with disposal at WIPP or

ERDF, as appropriate. After the excavations are filled, an evapotranspiration barrier will be constructed over the remaining waste in these waste sites.

- The 200-PW-6 OU and three of the six 200-PW-1 waste sites, also known as the "Low-Salt Waste Group," will use the RTD approach to excavate contaminated soils and debris to a depth of 22 ft to 3 ft bgs, with disposal at ERDF or WIPP, as appropriate. After the excavations are filled, an evapotranspiration barrier will be constructed over remaining waste in these waste sites.

- ***Soil Vapor–Extraction --*** *A soil vapor extraction (SVE) system was implemented as an expedited response action to remove and treat carbon tetrachloride contamination in the vadose zone at waste sites in the High-Salt Waste Group. The system has been operating since 1992 and has been effective in removing and treating carbon tetrachloride. SVE is being incorporated into the selected remedy. The system will continue to be used until vadose zone cleanup levels are met.* ***Soil Covers****-- Soil covers will be used to provide coverage to a depth of at least 15 feet over cesium-contaminated soils. This consists of enhancing the existing soil cover with additional backfill where necessary to provide a minimum of 15 feet of soil cover at each of the waste sites and then maintaining the soil cover. The 200-PW-3 OU, also known as the Cesium-137 Waste Group, will require that three of the five waste sites receive additional backfill to achieve coverage of at least 15 feet depth. Contamination at the other two waste sites is deeper than 15 feet from the ground surface and will not require additional backfill.*

- ***Institutional Controls --*** *Institutional controls and long-term monitoring will be required for waste sites in the 200-CW-5, 200-PW-1, 200-PW-3, and 200-PW-6 OUs where contamination is left in place and precludes an unrestricted land use. These institutional and land use controls will be required to ensure that activities are consistent with and restricted to the reasonably anticipated future industrial land uses for the Inner Area of the Central Plateau. The Department of Energy (DOE) is responsible for implementing, maintaining, reporting on, and enforcing the institutional and land use controls required under this ROD. Although DOE may later transfer these procedural responsibilities to another party by contract, property transfer agreement, or through other means, DOE shall retain ultimate responsibility for remedy integrity and institutional controls.*

The 2011 ROD (EPA 2011b) selected soil vapor extraction (SVE) as the final remedial action for carbon tetrachloride and methylene chloride in the vadose zone. As indicated the ROD narrative, the SVE system had been operating since 1992 under an expedited response action per "Action Memorandum: Expedited Response Action Proposal for 200 West Area Carbon Tetrachloride Plume" (EPA and Ecology 1992). Over several decades, the SVE system had removed over 90 tons of contamination. Because contaminant concentrations and SVE mass removal rates declined in recent years to minimal levels, *Response Action Report for the 200-PW-1 Operable Unit Soil Vapor Extraction Remediation* (DOE/RL/2014-48) was published in August 2016. Based on this history, DOE and EPA approved closure of the SVE remedy and permanently discontinuing SVE operations and vadose zone monitoring.

While this group of OUs will be further described and assessed in the next 5-year review (covering the period of 2016 – 2020), the following protectiveness statements are provided at this time:

200-CW-5 – Will Be Protective. The remedy at the 200-CW-5 source OU is expected to be protective upon completion of the final remedy. While the remedy component involving RTD (with disposal at ERDF or WIPP, as appropriate) has not started, ICs are in place to ensure that exposure pathways that could result in unacceptable risks are being controlled.

200-PW-1 Source OU – Will Be Protective. The remedy at the 200-PW-1 source OU is expected to be protective upon completion of the final remedy. While the remedy components involving RTD (with disposal at ERDF or WIPP, as appropriate) has not started, the remedy component involving soil vapor extraction has been successfully completed, and ICs are in place to ensure that exposure pathways that could result in unacceptable risks are being controlled.

200-PW-3 Source OU – Will Be Protective. The remedy at the 200-PW-3 source OU is expected to be protective upon completion of the final remedy. While the remedy component involving enhancement of the existing soil cover has not started, ICs are in place to ensure that exposure pathways that could result in unacceptable risks are being controlled.

200-PW-6 Source OU – Will Be Protective. The remedy at the 200-PW-6 source OU is expected to be protective upon completion of the final remedy. While the remedy components involving RTD and installation of a soil cover have not started, the remedy component involving soil vapor extraction has been successfully completed and ICs are in place to ensure that exposure pathways that could result in unacceptable risks are being controlled.

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APPENDIX A
SITEWIDE CONTROLS

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APPENDIX A
INSTITUTIONAL CONTROLS

Table A-1 summarizes the institutional control (IC) assessments for this 5-year review period (2011 to 2015).

Specific details on whether the ICs are to be applied at Site boundaries, OU boundaries, individual waste sites, or individual contaminated groundwater plumes, are provided in the CERCLA decision documents for the individual operable unit (OU). A consolidated presentation of all OU-specific ICs with such detail is consolidated and conveniently presented in the latest version of *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*, DOE/RL-2001-41, 2009 (see hyperlink in the following reference). DOE/RL-2001-41 is updated within 180-days after issuance of each record of decision.

REFERENCE

DOE/RL-2001-41, 2015, *Sitewide Institutional Controls Plan for Hanford CERCLA Response Actions and RCRA Corrective Actions*, Rev. 8, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available on line at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081640H.

Table A-1. Summary of Institutional Control Assessment for 2011 to 2015.

IC	2011	2012	2013	2014	2015
Warning Notice	Signs along the river shoreline in the 100-KE and 100-KW areas were noted as missing during the 2011 RCC annual IC review and subsequently replaced (100-KR-1 and 100-KR-4 Areas). All the other required signs are in place	All the required signs are in place. Installed additional sign at new entrance on west side of 300 Area main complex (300-FF-2 OU Area). Shoreline signs are in place.	All the required signs, including warning signs at roadway entrances and shoreline signs, are in place.	A Spanish-language warning sign along the river shoreline was down (100-FR-1 and 100-FR-3 OU Areas). Reinstalled the sign.	All the required signs, including warning signs at roadway entrances and shoreline signs, are in place.
Entry Restrictions*	No reportable trespassing incidents.	Two trespassing incidents reported to Benton County Sheriff's Office.	Five trespassing incidents were reported to Benton County Sheriff's Office.	No reportable trespassing incidents. A section of fence was down along SR 240; fixed the fence.	Two trespassing incidents reported to Benton County Sheriff's Office.
Land-Use Management	Excavation permits complied with the IC requirement of no excavation below 15 ft.	Excavation permits complied with the IC requirement of no excavation below 15 ft.	Excavation permits complied with the IC requirement of no excavation below 15 ft.	Excavation permits complied with the IC requirement of no excavation below 15 ft.	Excavation permits complied with the IC requirement of no excavation below 15 ft.
Groundwater-Use Management	No unauthorized groundwater use has occurred.	No unauthorized groundwater use has occurred.	No unauthorized groundwater use has occurred.	No unauthorized groundwater use has occurred.	No unauthorized groundwater use has occurred.
Waste Site Information	No deficiencies were noted.	No deficiencies were noted.	No deficiencies were noted.	No deficiencies were noted.	No deficiencies were noted.

* Nine reportable trespassing incidents took place during the period of 2011 to 2015. These incidents involved Sitewide entry restrictions for unauthorized personnel, generally near the Hanford Site boundaries.

IC = institutional control. RCC = River Corridor Closure. SR = state route.

APPENDIX B
HANFORD SITE EXISTING CLEANUP DECISIONS

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APPENDIX B
HANFORD SITE EXISTING CLEANUP DECISIONS

The Table B-1 summary of Hanford cleanup decisions indicates whether the decision is considered to be final by placing the word "Final" after the document title in the first column. In addition to the decisions that have been made, whether final or not, many cleanup decisions are yet to be made. By definition, the absence of a decision means that a final cleanup decision has not been made. Developing an exhaustive list of the decisions that still need to be made to complete Hanford cleanup would be difficult. However, as these decisions are made, this table will be updated.

Table B-1. CERCLA Records of Decision and Associated Changes. (7 pages)

Record of Decision			
Title: *Record of Decision, USDOE Hanford 1100 Area* (EPA/ROD/R10-93/063) **FINAL** **ROD Type:** CERCLA Final ROD **Area:** 1100 **Date Approved:** September 1993 **Initial Decision:** Cap Horn Rapids Landfill; offsite disposal of PCB-contaminated soils; offsite incineration of bis (2-ethylhexyl) phthalate contaminated soils; monitored natural attenuation of groundwater contamination.			
Revision Title	**Type**	**Date**	**Revised Decision**
Explanation of Significant Differences for the Record of Decision for the USDOE Hanford 1100 Area Benton County, Washington (EPA 2010a)	ESD	09/2010	Documents significant differences to selected remedies in the ROD. This ESD clarifies the IC requirements for the Horn Rapids Landfill.
Record of Decision			
Title: *Declaration of the Record of Decision for the Environmental Restoration Disposal Facility* (EPA/ROD/R10-95/100) **FINAL** **ROD Type:** CERCLA Final ROD **Area:** 200 West **Date Approved:** January 1995 **Initial Decision:** Initial construction of two cells; maximum size of 1.6 mi^2; landfill construction in accordance with RCRA; capped at completion.			
Revision Title	**Type**	**Date**	**Revised Decision**
USDOE Environmental Restoration Disposal Facility, Hanford Site, Benton County, Washington, Explanation of Significant Difference (ESD) (EPA/ESD/R10-96/145)	ESD	07/1996	Allow disposal of investigation-derived waste and RCRA past-practice waste to ERDF; allow disposal of nonprocess inactive TSD waste to ERDF; allow use of ERDF leachate for dust suppression/compaction activities at ERDF.
U.S. Department of Energy, Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary, (also see proposed plan for amendment) (EPA/AMD/R10-97/101)	Amended ROD	09/1997	Authorizes two additional disposal cells and the option of treating waste as needed by containerization and encapsulation at ERDF instead of at the OU.
U.S. Department of Energy, Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary, (also see proposed plan for amendment) (EPA/AMD/R10-99/038)	Amended ROD	03/1999	Establishes conditional approval for delisting of the ERDF leachate.
Declaration of the Amendment to Record of Decision for the USDOE Hanford Environmental Restoration Disposal Facility (Ecology 2015)	Amended ROD	12/2015	Waives the 40 CFR 268.45(a) and WAC 173-303-140(2)(a) prohibition on placing hazardous waste in a land disposal unit before completing required land disposal restriction treatment.

Table B-1. CERCLA Records of Decision and Associated Changes. (7 pages)

U.S. Department of Energy, Environmental Restoration Disposal Facility, Hanford Site – 200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary, (also see proposed plan for amendment) (EPA/AMD/R10-02/030)	Amended ROD	01/2002	Authorizes four additional disposal cells and the option of staging waste at ERDF pending treatment and/or disposal.
U.S. Department of Energy, Environmental Restoration Disposal Facility, Hanford Site-200 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary (EPA 2007a)	Amended ROD	05/2007	Allows specific waste (e.g., waste associated with surveillance and maintenance of Hanford facilities, environmental research/development activities, sample analyses, liquid effluent waste treatment, infrastructure support, and environmental monitoring programs) to be disposed of at ERDF; identifies a plug-in approach for ERDF disposal of additional similar Hanford cleanup waste generated in support of RCRA/CERCLA cleanup actions.
Declaration: U.S. Department of Energy, Environmental Restoration Disposal Facility, Hanford Site - 200 Area, Benton County, Washington (EPA 2009a)	Amended ROD and ESD	08/2009	Allows for ERDF expansion of an area equal to 4 cells or 2 super cells; updates cell design to allow super cell concept and allows for ERDF expansion via EPA approval and fact sheets rather than ROD amendments.
Record of Decision			
Title: *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA/ROD/R10-95/114) **ROD Type:** CERCLA Interim Action ROD **Area:** 200 West; 200-ZP-1 OU **Date Approved:** May 1995 **Initial Decision:** P&T to address carbon tetrachloride, chloroform, and trichloroethylene; treatment with air stripping and vapor-phase activated carbon; interim action to continue until final action instituted; reinjection of treated water.			
Record of Decision			
Title: *Declaration of the Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-95/126) **ROD Type:** CERCLA Interim Action ROD **Area:** 100; 100-BC-1, 100-DR-1, and 100-HR-1 OUs **Date Approved:** September 1995 **Initial Decision:** Remove contaminated soil, structures and debris using observational approach; treatment by thermal desorption to remove organics and/or soil washing to reduce volume, or as needed to meet waste disposal criteria; disposal of contaminated materials at ERDF; backfill of excavated areas followed by revegetation.			
Revision Title	**Type**	**Date**	**Revised Decision**
Amendment to the Interim Action Record of Decision for the 100-BC-1, 100-DR-1, and 100-HR-1 Operable Units, Hanford Site, Benton County, Washington (see Draft B ESD and Proposed Amendment documents preceding this ROD amendment) (EPA/AMD/R10-97/044)	Amended ROD	04/1997	Incorporates 34 additional waste sites into the ROD; refines remedial cost estimate for original 37 sites and additional 34 sites based on actual data, streamlining, and lessons learned; and eliminates the soil washing treatment option before disposal.
Record of Decision			
Title: *Declaration of the Record of Decision for the 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-96/151) **FINAL** **ROD Type:** CERCLA Final ROD **Area:** 100; 100-IU-1, 100-IU-3, 100-IU-4, and 100-IU-5 OUs **Date Approved:** February 1996 **Initial Decision:** No action.			

Table B-1. CERCLA Records of Decision and Associated Changes. (7 pages)

Record of Decision			
Title: *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-96/134) **ROD Type:** CERCLA Interim Action ROD **Area:** 100; 100-H, 100-K **Date Approved:** March 1996 **Initial Decision:** Interim action to remove hexavalent chromium from groundwater; 30 extraction wells; ion exchange treatment; reinject treated effluent; monitor; institute ICs.			
Revision Title	**Type**	**Date**	**Revised Decision**
U.S. Department of Energy Hanford Site – 100 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary (EPA/AMD/R10-00/122)	Amended ROD	Oct-99	Implements In Situ Redox Manipulation barrier for second chromium plume in 100-HR-3 OU; existing P&Ts remain in operation.
Explanation of Significant Difference for the 100-HR-3 Operable Unit Record of Decision (EPA/ESD/R10-03/606)	ESD	Mar-03	Provides justification for increased schedule/cost from the 1999 Amendment associated with a greater number of wells and aquifer thickness that affected implementation of the ISRM barrier.
Explanation of Significant Differences for the 100-HR-3 and 100-KR-4 Operable Units Interim Action Record of Decision, Hanford Site, Benton County, Washington (EPA 2009b)	ESD	Aug-09	Provides justification for increased cost and location of reinjection wells from the 1999 Amendment associated with operation beyond initial 5-year estimate and need to control plume migration.
Record of Decision			
Title: *Declaration of the Record of Decision, USDOE Hanford 200 Area, Hanford Site, Benton County, Washington* (EPA/ROD/R10-97/048) **ROD Type:** CERCLA Interim Action ROD **Area:** 200 West; 200-UP-1 OU **Date Approved:** February 1997 **Initial Decision:** Extract groundwater from high concentration zone of uranium and Tc-99 plumes and treat at Effluent Treatment Facility.			
Revision Title	**Type**	**Date**	**Revised Decision**
Explanation of Significant Differences for the Interim Action Record of Decision for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Benton County, Washington (EPA 2009c)	ESD	02/2009	Adds National MCL of 30 µg/L for uranium as ARAR for treating extracted water; replaces 190 gal/min pumping with a pumping requirement from existing and new wells consistent with approved RDR/RAWP until uranium and Tc-99 concentrations are less than 10 times the MCL for 4 consecutive quarters; adds sampling requirements and updates cost estimates and IC requirements.
Record of Decision for Interim Remedial Action Hanford 200 Area Superfund Site 200-UP-1 Operable Unit (EPA 2012)	Interim Action ROD	09/2012	Supersedes previous interim action ROD (Feb-97) and ESD (Feb-09). Includes groundwater extraction/treatment (with flow path control through injection of treated water) in combination with monitored natural attenuation for Tc-99, uranium, chromium (total and hexavalent), nitrate, carbon tetrachloride and tritium; hydraulic containment and further treatment technology evaluation for I-129; remedy performance monitoring and ICs.

Table B-1. CERCLA Records of Decision and Associated Changes. (7 pages)

Record of Decision			
Title: *Interim Action Record of Decision for the 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 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-99/039) **ROD Type:** CERCLA Interim Action ROD **Area:** 100, 200 North **Date Approved:** July 1999 **Initial Decision:** Requires RTD for 46 sites; adds the plug-in approach for the RTD remedy for both remaining 100 Area and 200 North sites and for newly identified 100 Area sites added by ESD; disposal of debris from B, D, H, and K reactors to ERDF; provides decision framework for leaving waste in place, generally below 15-ft depth.			
Revision Title	**Type**	**Date**	**Revised Decision**
Explanation of Significant Difference for the 100 Area Remaining Sites ROD, USDOE Hanford 100 Area, 100-IU-6 Operable Unit, Hanford Site, Benton County, Washington (EPA/ESD/R10-00/045)	ESD	06/2000	Plugs in 600-23 and JA Jones #1 waste sites to the Remaining Sites ROD.
Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision (EPA 2004a)	ESD	02/2004	Adds 28 sites to ROD; adds 10 CFR 1022 and 40 CFR 6, Appendix A as ARARs to ROD; revises annual ICs report date to be coincident with the due date for the Sitewide ICs Plan for Hanford CERCLA Response Actions.
Explanation of Significant Differences for the 100 Area Remaining Sites Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington (EPA 2009d)	ESD	08/2009	Authorizes adding 200-CW-3 OU wastes sites, 99 newly discovered waste sites, and 87 candidate sites using the plug-in approach in the ROD and any newly discovered waste sites that will be documented in the Administrative Record and in an annual fact sheet.
Record of Decision			
Title: *Declaration of the Record of Decision for the 100-KR-2 Operable Unit, Hanford Site, Benton County, Washington* (EPA/ROD/R10-99/059) **ROD Type:** CERCLA Interim Action ROD **Area:** 100-K **Date Approved:** September 1999 **Initial Decision:** Remove spent nuclear fuel from basins; remove sludge from basins; treat and remove water from the basins; remove debris from the basins; deactivate the basins; and institute ICs.			
Revision Title	**Type**	**Date**	**Revised Decision**
Interim Remedial Action Record of Decision Amendment, U.S. Department of Energy; 100 K Area K Basins, Hanford Site - 100 Area, Benton County, Washington (EPA 2005a)	Amended ROD	Jun-05	Modifies remedy for sludge by including sludge treatment prior to interim storage and shipment to a national repository; modifies remedy for debris by including grouting in place some of the basin debris followed by removal along with the removal of the basins.
Record of Decision			
Title: *Interim Remedial Action Record of Decision for the 100-NR-1 and 100-NR-2 Operable Units, Hanford Site, Benton County, Washington* (EPA/ROD/R10-99/112) **ROD Type:** CERCLA Interim Action ROD **Area:** 100-N **Date Approved:** September 1999 **Initial Decision:** ICs for shoreline site; in situ and RTD with ex situ bioremediation for petroleum sites; RTD for remainder of sites in 100-NR-1; maintain ERA P&T for 100-NR-2.			

Table B-1. CERCLA Records of Decision and Associated Changes. (7 pages)

Revision Title	Type	Date	Revised Decision
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 (EPA/ESD/R10-03/605)	ESD	05/2003	Removes July 31 annual ICs reporting requirements, consolidates reporting with the site-wide IC annual report; eliminates requirement to evaluate applying 30 in. of irrigation water to determine if remaining contaminants will impact groundwater; identifies need for additional ICs to preclude access to contaminated groundwater which will be incorporated into site-wide IC document.
U.S. Department of Energy, 100-NR-1 and NR-2 Operable Units, Hanford Site - 100 Area, Benton County, Washington, Amended Record of Decision, Decision Summary and Responsiveness Summary (EPA 2010b)	Amended ROD	09/2010	Deploys the apatite sequestration technology for remediating Sr-90 in the 100-NR-2 OU by extending existing apatite permeable reactive barrier to ~2,500 ft, allows for deployment of the apatite sequestration technology elsewhere in the 100-NR-2 OU in accordance with an Ecology approved work plan, and includes decommissioning the treatment components of the existing P&T system.
Explanation of Significant Differences for the 100-NR-1 and 100-NR-2 Operable Units Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington (EPA 2011a)	ESD	03/2011	Adds 45 additional waste sites in the 100-NR-1 OU for remediation by RTD (characterized per the 100-N Area sampling and analysis plan) and increases the total cost 38% to $67,510,386.
Explanation of Significant Difference for the 100-NR-1 and 100-NR-2 Operable Units Interim Remedial Action Record of Decision, Hanford Site, Benton County, Washington (EPA 2013)	ESD	08/2013	Adds 2 additional waste sites in the 100-NR-1 OU for remediation by RTD and increases the total cost by $401,500.
Record of Decision			
Title: *Interim Remedial Action Record of Decision Declaration, U.S. Department of Energy 100 Area, 100-NR-1 Operable Unit, Hanford Site, Benton County, Washington* (EPA/ROD/R10-00/120) **ROD Type:** CERCLA Interim Action ROD for 2 RCRA TSDs and an associated site **Area:** 100-N **Date Approved:** January 2000 **Initial Decision:** RTD of 116-N-1 and 116-N-3 Cribs with ERDF disposal; backfill and revegetate; any pipelines will be removed or sampled and left in place based on sample results.			
Revision Title	**Type**	**Date**	**Revised Decision**
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 (EPA/ESD/R10-03/605)	ESD	05/2003	Removes July 31 annual ICs requirement and consolidates reporting with the Sitewide IC annual report; eliminates requirement to evaluate applying 30 in. of irrigation water to determine if remaining contaminants will impact groundwater; identifies need for additional ICs to preclude access to contaminated groundwater for 116-N-1which will be incorporated into Sitewide IC document.
Record of Decision			
Title: *Declaration of the Record of Decision for the 100-BC-1, 100-BC-2, 100-DR-1, 100-DR-2, 100-FR-2, 100-HR-2 and the 100-KR-2 Operable Units* (EPA/ROD/R10-00/121) **ROD Type:** CERCLA Interim Action ROD **Area:** 100 **Date Approved:** September 2000 **Initial Decision:** Remove contaminated soil, structures, and debris; treat as needed; dispose at ERDF; backfill and revegetate. Applies to 45 burial grounds in 100 Area.			

Table B-1. CERCLA Records of Decision and Associated Changes. (7 pages)

Revision Title	Type	Date	Revised Decision
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) (EPA 2007b)	ESD	11/2007	Established limit of RTD excavation at the 118-B-1 Burial Ground considering the balancing factors in the ROD and required additional ICs for protection of groundwater and the Columbia River.
Record of Decision			
Title: *Record of Decision 221-U Facility (Canyon Disposition Initiative), Hanford Site, Washington* (EPA 2005b) **FINAL** **ROD Type:** CERCLA Final ROD **Area:** 200 West **Date Approved:** October 2005 **Initial Decision:** Remove waste from vessels and equipment in the facility with levels of transuranic isotopes greater than 100 nCi/g and eventual disposal at WIPP; removal of liquids from the facility or treatment to remove liquids; partial removal of contaminated equipment and piping from the gallery side of the facility and dispose at ERDF; demolition and subsequent stabilization of the railroad tunnel, 271-U, 276-U, 291-U, and 292-U structures and 291-U-1 and 296-U-10 stacks and dispose of at ERDF; construct an engineered barrier; planting semiarid-adapted vegetation on the barrier; ICs; post-closure care; and ongoing barrier performance and groundwater monitoring.			
Record of Decision			
Title: *Record of Decision, Hanford 200 Area, 200-ZP-1 Operable Unit Superfund Site, Benton County, Washington* (EPA 2008) **FINAL** **ROD Type:** CERCLA Final ROD **Area:** 200 West; 200-ZP-1 OU **Date Approved:** September 2008 **Initial Decision:** P&T to address carbon tetrachloride, nitrate, chromium, trichloroethylene, I-129, Tc-99, and tritium; monitored natural attenuation; flow-path control through injection of treated water; and ICs.			
Record of Decision			
Title: *Record of Decision, Hanford 200 Area, Superfund Site 200-CW-5 and 200-PW-1, 200-PW-3 and 200-PW-6 Operable Units Hanford Site, Benton County, Washington* (EPA 2011c) **FINAL** **ROD Type:** CERCLA Final ROD **Area:** 200 East and 200 West **Date Approved:** September 2011 **Initial Decision:** RTD of soil and debris to specified depths cleanup levels for plutonium-contaminated soils and subsurface structures/debris. Soil vapor extraction at three 200-PW-1 waste sites will continue until vadose zone cleanup levels are met. Soil covers will be used to a depth of at least 15 ft over cesium-contaminated soils. Removal of sludge followed by tank stabilization for two tanks. No action for two waste sites. ICs and long-term monitoring for waste sites where contamination is left in place and an unrestricted land use is precluded.			

Table B-1. CERCLA Records of Decision and Associated Changes. (7 pages)

Record of Decision
Title: *Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1 Hanford Site, Benton County, Washington* (EPA and DOE, 2013) **FINAL** **ROD Type:** CERCLA Final ROD **Area:** 300; 300-FF-1, 300-FF-2 and 300-FF-5 **Date Approved:** November 2013 **Initial Decision:** This ROD selects a remedy for the waste sites in 300-FF-2, a remedy for the groundwater in 300-FF-5 and amends the remedy for three 300-FF-1 waste sites. The interim action remedy for 300-FF-5, selected in 1996 and the interim action remedy for 300-FF-2 selected in 2001 are replaced with this final action remedy. The remedy for 300-FF-1 selected in 1996 is amended for additional remedial action of uranium from three sites. Contaminated buildings are being removed in accordance with CERCLA Action Memoranda and are not part of the OUs addressed by this ROD. The major components of the selected remedy for the 300-FF-2 OU are: • Remove, treat and dispose (RTD) at waste sites • Temporary surface barriers and pipeline void filling • Enhanced attenuation of uranium using sequestration in the vadose zone, PRZ and top of the aquifer • ICs, including the requirement that DOE prevent the development and use of property that does not meet residential cleanup levels at the 300 Area Industrial Complex and 618-11 for other than industrial uses, including use of property for residential housing, elementary and secondary schools, childcare facilities and playgrounds. The major components of the selected remedy for the 300-FF-5 OU are: • Monitored Natural Attenuation • Groundwater monitoring • Enhanced attenuation of uranium at the top of aquifer • ICs. The major component of the amended remedy for 300-FF-1 is Enhanced attenuation of uranium using sequestration in the vadose zone, periodicalrely wetted zone and top of the aquifer.
Record of Decision
Title: *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (EPA 2014) **FINAL** **ROD Type:** CERCLA Final ROD **Area:** 100 Area **Date Approved:** September 2014 **Initial Decision:** RTD at 91 waste sites, ICs at 15 waste sites, no additional action due to interim remedial actions completed at 198 waste sites, monitored natural attenuation to address nitrate, hexavalent chromium, trichloroethene, and strontium-90 in 100-FR-3 groundwater and ICs.

ARAR	= applicable or relevant and appropriate requirement.
CERCLA	= *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.*
EPA	= U.S. Environmental Protection Agency.
ERA	= expedited response action.
ERDF	= Environmental Restoration Disposal Facility.
ESD	= explanation of significant difference.
IC	= institutional controls.
ISRM	= in situ redox manipulation.
MCL	= maximum contaminant limit.
OU	= operable unit.
P&T	= pump-and-treat.
PCB	= polychlorinated biphenyl.
RCRA	= *Resource Conservation and Recovery Act of 1976*.
RDR/RAWP	= remedial design report/remedial action work plan.
ROD	= record of decision.
RTD	= remove, treat, and dispose.
TSD	= treatment, storage, and disposal.
WIPP	= Waste Isolation Pilot Plant.

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APPENDIX C
SOIL AND GROUNDWATER CLEANUP LEVELS FOR 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-1 AND 100-IU-2 OPERABLE UNITS

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APPENDIX C
SOIL AND GROUNDWATER CLEANUP LEVELS FOR 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2 AND 100-IU-6 OPERABLE UNITS

C1.0 CLEANUP LEVEL TABLES

Tables C-1 through C-3 are Tables 5 through 7, respectively, from *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units* (EPA 2014).

Table C-1. Soil Cleanup Levels for Protection of Human Health.[1]

Media: Soil and Debris Site Area: 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs			
Contaminant of Concern	**Units**	**Cleanup Level (≤4.6 m [15 ft] bgs)**	**Basis for Cleanup Level**
Radionuclides			
Cesium-137	pCi/g	4.4	Direct contact residential scenario
Cobalt-60	pCi/g	1.4	Residential interim remedial action cleanup level
Europium-152	pCi/g	3.3	Residential interim remedial action cleanup level
Europium-154	pCi/g	3.0	Residential interim remedial action cleanup level
Nickel-63	pCi/g	608	Direct contact residential scenario
Strontium-90	pCi/g	2.3	Direct contact residential scenario
Chemicals			
Arsenic	mg/kg	20	MTCA Method A
Hexavalent Chromium	mg/kg	240	MTCA Method B
Lead	mg/kg	250	MTCA Method A
Mercury	mg/kg	24	MTCA Method B
Nitrate	mg/kg	568,000	MTCA Method B
Aroclor 1254	mg/kg	0.50	MTCA Method B
Aroclor 1260	mg/kg	0.50	MTCA Method B
Benzo(a)pyrene	mg/kg	0.14	MTCA Method B
TPH–Diesel Range	mg/kg	2,000	MTCA Method A
TPH–Motor Oil (High Boiling)	mg/kg	2,000	MTCA Method A

[1]Source: EPA, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*, Table 5, U.S. Environmental Protection Agency, Washington, D.C.
MTCA = Washington State's Model Toxics Control Act
MTCA Method A and B = Soil Cleanup Levels for Unrestricted Land Use
bgs = below ground surface

Table C-2. Soil Cleanup Levels for Protection of Groundwater and Surface Water.[1]

Media: Soil and Debris Site Area: 100-FR-1, 100-FR-2, 100-IU-2, and 100-IU-6 OUs			
Contaminant of Concern	**Soil Cleanup Levels for Protection of Groundwater and Surface Water (Ground Surface to Water Table)**		
	100-FR-1 and 100-FR-2	**100-IU-2**	**100-IU-6**
Radionuclides (pCi/g)			
Cesium-137	—	—	—
Cobalt-60	—	—	—
Europium-152	—	—	—
Europium-154	—	—	—
Nickel-63	—	—	—
Strontium-90	24,600	64,200	104,000
Chemicals (mg/kg)			
Arsenic	—	—	—
Hexavalent Chromium	2.0	2.0	2.0
Lead	—	—	—
Mercury	—	—	—
Nitrate	1,790	6,360	11,300
Aroclor 1254	—	—	—
Aroclor 1260	—	—	—
Benzo(a)pyrene	—	—	—
TPH–Diesel Range	2,000	2,000	2,000
TPH–Motor Oil (High Boiling)	2,000	2,000	2,000

[1]Source: EPA, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*, Table 6, U.S. Environmental Protection Agency, Washington, D.C.
TPH = total petroleum hydrocarbon
Note: Basis for soil cleanup level for groundwater and surface water protection is the soil leach model in the 100-F/IU RI/FS.

Table C-3. Cleanup Levels for 100-FR-3 COCs – Groundwater.[1]

Media: Groundwater Site Area: 100-FR-3 OU Available Use: Drinking water and all other uses			
Contaminant of Concern	**Units**	**Cleanup Level**	**Basis for Cleanup Level**
Strontium-90	pCi/L	8	DWS
Hexavalent chromium	µg/L	10/48[2]	WAC 173-201A/WAC 173-340-720
Trichloroethene	µg/L	4	Risk-based MTCA cleanup level for drinking water
Nitrate	mg/L	45	DWS

[1]Source: EPA, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*, Table 7, U.S. Environmental Protection Agency, Washington, D.C.
[2]Cleanup levels for hexavalent chromium are 48 µg/L in the upland groundwater and 10 µg/L where groundwater discharges to surface water.
DWS = drinking water standard (Maximum Contaminate Levels [MCLs] and non-zero Maximum Contaminant Level Goals [MCLGs])
WAC = Washington Administrative Code
WAC 173-201A = "Water Quality Standards for Surface Waters of the State of Washington."
WAC 173-340-720 = "Model Toxics Control Act—Cleanup," "Groundwater Cleanup Standards

C2.0 REFERENCES

EPA, 2014, *Record of Decision, Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*¸ U.S. Environmental Protection Agency, Washington, D.C. Available on line at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0082927H.