River Corridor Summary and Recommendations

River Corridor Groundwater Summary and Recommendations

The Hanford Reach of the Columbia River begins upstream of the Hanford Site at Priest Rapids Dam and extends 82 kilometers downstream to the upper end of Lake Wallula, impounded by McNary Dam. Although flow volume and water levels are controlled by upstream dams, the Hanford Reach is essentially the only free-flowing stretch of the Columbia River in the United States. The River Corridor of the Hanford Site is situated on the boundary of the Hanford Reach, which forms a discharge boundary for Hanford Site groundwater.

This section summarizes the results of remediation and groundwater monitoring in the River Corridor for 2012. Results of monitoring the Columbia River and shoreline springs (seeps) are also summarized. References are provided for other DOE activities focused on the Columbia River at the Hanford Site. Finally, recommendations are made for future groundwater-related activities in the River Corridor.

Soil and Groundwater Remediation

Cleaning up the River Corridor of the Hanford Site is a high priority for DOE because discharge of contaminated groundwater to the Columbia River is a pathway for contaminants to reach human or ecological receptors. Approximately 75 percent of the River Corridor sites identified as potentially having received waste have been remediated under interim records of decision or were reclassified as not requiring remediation. Most of the remaining sites are scheduled to be cleaned up in the next few years.

Since the mid-1990s, interim remediation of groundwater has been under way in the 100 Area to protect human health and the environment. The following remedial action objectives were defined for the 100-KR-4 and 100-HR-3 Operable Units under the interim action ROD (EPA/ROD/R10-96/134):

- Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.
- Protect human health by preventing exposure to contaminants in the groundwater.
- Provide information that will lead to the final remedy.

Pump-and-treat systems were installed at both 100-HR-3 and 100-KR-4 to meet the interim remedial action objectives, and have since been expanded. Initially, pump-and-treat was also the selected remedy for 100-NR-2, but proved ineffective at remediating the primary groundwater contaminant strontium-90. An amended interim action ROD for the 100-NR-2 Operable Unit (EPA, 2010) describes expansion of a permeable reactive barrier to immobilize strontium-90 in the ground and prevent it from reaching the Columbia River.

Final decisions regarding methods to clean up the remaining contamination in the River Corridor will be based on data collected during remedial investigation studies conducted in recent years. Reports that present the results of these studies and make recommendations for solutions are in progress.

Groundwater Monitoring Results

During 2012, groundwater staff sampled 492 wells in the River Corridor groundwater interest areas (Table RC_Summ-1). Many of the wells were sampled numerous times, for a total of 2,639 successful well sampling trips. During the year, 347 aquifer tubes were sampled, with samples collected from a total of 681 sampling trips. Additional trips are required at times because: 1) if there is problem getting a sample during the first visit and the sampling team has to go return, and 2) there are some aquifer tubes that are sampled more than once per year.

Table RC_Summ.1 Maximum Concentrations of Selected Groundwater Contaminants in River Corridor Interest Areas in 2012

Interest Area	Number of Wells Sampled	Number of Successful Well Trips	Number of Aquifer Tubes Sampled	Number of Successful Aquifer Tube Trips
100-BC-5	24	52	31	46
100-KR-4	80	554	47	101
100-NR-2	68	122	61	183
100-HR-3-D	113	883	73	149
100-HR-3-H	83	671	61	96
100-FR-3	27	30	31	34
300-FF-5	84	309	29	46
1100-EM-1	13	18	1	1
200-BP-5*	--	--	5	9
200-PO-1*	--	--	8	16
Total	492	2639	347	681

Note: A successful sampling trip is determined by the presence of data in HEIS. A trip may consist of routine sampling, characterization sampling, or sampling conducted to support groundwater remediation systems.

*Aquifer tubes in the 200-BP-5 and 200-PO-1 Operable Units are reported here as part of the River Corridor. Wells in those Operable Units are included in Chapter 3.

Table RC_Summ-2 lists maximum concentrations of groundwater contaminants detected in River Corridor wells and aquifer tubes during 2012. The 2012 data did not result in any major reinterpretations of the nature and extent of groundwater contamination. The following paragraphs summarize River Corridor groundwater contamination and results of monitoring. For additional summary information, see the Executive Summary of this report.

Hexavalent chromium contaminant plumes with concentrations above the 10 µg/L surface water quality standard (Table 240(3) of WAC 173-201A-240, "Water Quality Standards for Surface Waters of the State of Washington," "Toxic Substances") are present in the unconfined aquifer in all of the 100 Areas and in the Ringold upper mud unit in the 100-HR-3 operable unit. This lower aquifer appears to be connected to the unconfined aquifer at 100-H. The highest plume concentrations in 2012, nearly 200 times the 48 µg/L groundwater cleanup standard, were detected in 100-HR-3. Expanded pump-and-treat systems are reducing the concentration and size of these plumes, and minimizing impacts to the Columbia River. Remediation of a former waste disposal site in 100-BC-5 mobilized hexavalent chromium, which 2012 data show is migrating in the upper part of the aquifer. Completion of the surface remediation in 2013 will eliminate the source of this contamination. There are no distinct hexavalent chromium plumes within the 100-NR-2 OU, however some chromium appears to have migrated into the area from the 100-KR-4 OU. Ongoing remediation of waste sites in 100-D and 100-H are also mobilizing hexavalent chromium, however the groundwater contamination is generally captured by the pump-and-treat systems in those areas.

Tritium concentrations exceed the 20,000 pCi/L drinking water standard in 100-BC-5, 100-KR-4, 100-NR-2, and 300-FF-5 (at the 618-11 Burial Ground). Tritium was more widespread in the River Corridor in the past, and the plumes are gradually attenuating through radioactive decay, dispersion, and migration to the river.

Strontium-90 contamination persists beneath each of the 100 Areas at concentrations above the 8 pCi/L drinking water standard. The most extensive, concentrated plume is in 100-NR-2, where levels exceed the 1,100 pCi/L derived concentration standard. The strontium-90 plumes tend to be stable in size because this constituent sorbs to sediment grains and is relatively immobile. Concentrations are gradually declining in most areas as a result of radioactive decay.

Nitrate is a common groundwater contaminant in the River Corridor. Contaminant plumes with concentrations exceeding the 45 mg/L drinking water standard are present in 100-KR-4, 100-NR-2, 100-HR-3, 100-FR-3, and 1100-EM-1, although the latter plume originated offsite. The largest onsite plume is in 100-FR-3. Concentrations are generally steady or declining.

Carbon-14 exceeds the 2,000 pCi/L drinking water standard in portions of 100-KR-4. The plumes did not change significantly in 2012.

Uranium forms a persistent plume with levels above the 30 µg/L drinking water standard in portions of 300-FF-5. Concentrations vary with seasonal changes in the water table elevation. The positive correlation between water table elevation and uranium concentration suggests that at or near these locations, uranium remains in the lower portion of the vadose zone and is available to be remobilized during periods of high water table conditions. Near the 183-H solar evaporation basin in 100-H, uranium was detected above the drinking water standard in one well, 199-H4-3, in the fall of 2012.

Trichloroethene concentrations exceed the 5 µg/L drinking water standard in the unconfined aquifer at 100-FR-3 and 100-KR-4. The plume is naturally attenuating at 100-FR-3. At 100-KR-4, the trichloroethene is degrading slowly, but is also being recirculated through the aquifer by the pump-and-treat system. In 300-FF-5, trichloroethene concentrations exceeded the drinking water standard once in one well. During drilling in 2006, trichloroethene was encountered in groundwater associated with an interval of finer grained sediment. Because this finer-grained interval has a very low permeability and does not readily yield groundwater, monitoring wells have not been screened in this interval. Contamination slowly migrates within these sediments and into adjacent permeable sediment, as evidenced by periodic detections of trichloroethene in aquifer tube samples screened near this contact. *Cis*-1,2-dichloroethene concentrations at 300-FF-5 exceeded the drinking water standard (70 µg/L) at one well in the lower portion of the unconfined aquifer and at one well in the mid-portion of the unconfined aquifer.

Remedial investigations have provided additional information about the vertical distribution of groundwater contamination in the River Corridor. Geographically, the unconfined aquifer thickness decreases and becomes thinner from west to east from 100-BC-5 (up to 48 meters thick) to the 100-H area (as little as one meter thick). In addition, aquifer characterization revealed that younger, more permeable sediment (i.e., Hanford fm.) forms the majority of the unconfined aquifer in the eastern portion of the river corridor. In most locations and for most constituents, concentrations are highest near the top of the unconfined aquifer and decrease with depth. An exception includes hexavalent chromium concentrations in western 100-BC-5, which are highest at the top and bottom of the unconfined aquifer, and lower in between. This exception may indicate different periods of contaminant release. In some locations in 100-KR-4, hexavalent chromium concentrations were higher in the lower half of the aquifer. In 100-HR-3, vertical distribution of contaminants was not consistent and no pattern was discernible. It should be noted that the aquifer is thinner at 100-KR-4 and in the 100-D area of 100-HR-3 than observed at 100-BC-5. In the 100-H area of 100-HR-3, the aquifer is quite thin making vertical distribution less likely.

Interim action performance monitoring continued to indicate that the groundwater remediation systems are functioning as designed and are meeting remedial action objectives. Contaminant concentrations in compliance wells remained above threshold values at some locations in 2012, and the remediation systems will continue to operate in 2013.

RCRA groundwater monitoring continued in 2012 at facilities in the 100-NR-2, 100-HR-3, and 300-FF-5 (Table RC_Summ-3). Results did not reveal any new impacts to groundwater, with the exception of uranium at 100-HR-3, which had concentrations rise to 37.1 µg/L, slightly above the 30 µg/L drinking water standard, in October. The sites will continue to be monitored under existing requirements.

Table RC_Summ.2 Maximum Concentrations of Selected Groundwater Contamination in River Corridor Interest Areas in 2012

Contaminant, Units	Water Quality Criteria[a]	100-BC-5		100-KR-4		100-NR-2		100-FR-3		100-HR-3-D		100-HR-3-H		300-FF-5		1100-EM-1 /Richland North	
		Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes	Wells	Tubes
Radionuclides																	
Carbon-14, pCi/L	2,000	NA	NA	9,230	385	806	54.6	NA	NA	NA	NA	NA	NA	ND	NA	ND	NA
Gross alpha, pCi/L	15	4.3	2.3	8.3	9	6.4	NA	8.6	NA	24	NA	51	ND	280	56	26	ND
Gross beta, pCi/L	4 mrem/yr	12	38	410	22	24,600	3,500	16	NA	100	NA	330	18	190	33	46	4
Iodine-129, pCi/L	1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	NA	0.342	ND	0.306	NA
Plutonium-239/240, pCi/L	N/A	NA	NA	NA	NA	0.038	NA	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA
Strontium-90, pCi/L	8	39	49	220[d]	7.1	15,000	1,000	200	9.6	40	5.6	30	8.2	1.3	NA	ND	NA
Technetium-99, pCi/L	900	ND	24	51	24	37.9	NA	NA	NA	8.8	NA	120	ND	180	25	51	NA
Tritium, pCi/L	20,000	21,000	22,000	130,000	7,800	35,000	11,000	2,500	ND	19,000	3,800	5,900	NA	1,100,000	10,000	151	NA
Uranium, µg/L	30	NA	NA	7.16	NA	NA	NA	26.9	NA	6.2	NA	37.1	1.49	838	133	31.8[c]	3.74
Metals[b]																	
Arsenic (filtered), µg/L	10	3.24	NA	8.4	3.41	15.2	NA	NA	NA	8.22	NA	3.14	NA	3.48	NA	NA	NA
Arsenic, µg/L	10	3.29	NA	8.31	3.6	17.2	NA	NA	NA	8.27	1.25	3.99	NA	3.3	NA	NA	NA
Barium (filtered), µg/L	2,000	39.2	69.4	79.7	97.2	212	541	97.3	127	174	48.5	118	41.1	234	71.4	112	19.8
Barium, µg/L	2,000	40.1	75.3	82.8	102	216	549	94	135	169	233	117	44.8	236	75.7	152	19.5
Beryllium (filtered), µg/L	4	ND	ND	5.4	0.47	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Beryllium, µg/L	4	ND	ND	ND	ND	ND	ND	4.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chromium (filtered), µg/L	100	137	44	434	51.2	189	7.3	39.2	6.7	8,090	15.9	158	9	17	7	5.7	ND
Chromium, µg/L	100	136	44	764	50.6	189	56.4	38.5	13.8	15,800	23.8	164	8.6	18.6	ND	5.8	ND
Hexavalent Chromium (filtered), µg/L	48	NA	NA	NA	NA	NA	NA	NA	NA	384	NA	NA	NA	NA	NA	NA	NA
Hexavalent Chromium, µg/L	48	179	39.1	428	65.5	182	4.9	43.6	3.2	22,400	24.7	179	33.9	NA	2.7	NA	NA
Mercury (filtered), µg/L	2	NA	NA	0.166	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury, µg/L	2	NA	NA	0.194	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium (filtered), µg/L	50	ND	NA	3.73	1.6	3.42	NA	NA	NA	NA	NA	0.766	NA	ND	NA	NA	NA
Selenium, µg/L	50	ND	NA	3.64	ND	2.7	NA	NA	NA	4.09	NA	1.13	NA	ND	NA	NA	NA
Anions																	
Fluoride, mg/L	4	0.352	0.212	0.41	0.156	0.668	1.06	0.61	0.166	0.793	0.213	0.377	0.214	3.2	0.256	1.37	0.134
Nitrate, mg/L	45	29.4	53.6	87.7	28.9	149	65.5	161	25.8	78.4	19.4	135	33.8	116[c]	26.1	286[c]	5.4
Nitrite, mg/L	3.3	0.188	0.231	0.391	0.68	1.32	0.545	0.617	0.218	1.7	0.233	0.47	0.411	0.532	0.434	1.17	ND
Organics																	
Benzo(a)pyrene, µg/L	0.2	NA	NA	ND	NA	0.26	ND	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA
Carbon tetrachloride, µg/L	5	ND	NA	ND	ND	0.53	NA	ND	NA	ND	NA	1.2	NA	ND	2.3	1.4	NA
Chloroform, µg/L	80	2.6	NA	1.8	0.13	5	NA	1.1	NA	1.9	NA	4.2	NA	1.1	2.7	ND	NA
cis-1,2-Dichloroethene, µg/L	70	ND	NA	ND	ND	ND	NA	ND	NA	ND	NA	ND	NA	200	9	ND	NA
Methylene chloride, µg/L	5	ND	NA	3.6	1.8	0.48	NA	ND	NA	ND	NA	ND	NA	2	ND	ND	NA
Tetrachloroethene, µg/L	5	ND	NA	ND	ND	0.29	NA	ND	NA	ND	NA	ND	NA	ND	2.2	ND	NA
Toluene, µg/L	1,000	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA	ND	NA	3	ND	ND	NA
Trichloroethene, µg/L	5	2.8	NA	6.5	0.98	ND	NA	12	NA	ND	NA	ND	NA	14	420	1.2	NA

Note:
Table lists highest value for 2012 for each groundwater interest area, excluding those flagged F, R, or Y, or non-routine samples (e.g. characterization). Blue cells exceed water quality standard. Provided values based on HEIS as of Feb. 6, 2013.

a. References for water quality standards are listed in Table 1-3.

b. Antimony, cadmium, and thallium excluded because detection limits are typically higher than drinking water standards, creating false exceedances near the detection limits. Nickel excluded because it typically indicates corrosion of stainless steel well screens and casing.

c. From offsite sources.

d. Does not take into account extrapolated values and is therefore likely non-representative of conditions.

ND = not detected above method detection limits or minimum detectable activity

NA = not analyzed for

Table RC_Summ.3 RCRA Monitoring Status for the River Corridor, 2012

RCRA Unit	Report Section	Status for Reporting Period
1301-N (116-N-1) LWDF	Section 2.4.9.1	Continued indicator evaluation.*
1324-NA (120-N-1) and 1324-N (120-N-2) Ponds	Section 2.4.9.2	Continued indicator evaluation.*
1325-N (116-N-3) LWDF	Section 2.4.9.3	Continued indicator evaluation.*
116-H-6 (183-H) Evaporation Basins	Section 2.5.7	Corrective action alternative program during interim remedial action; chromium and nitrate.
316-5 (300 Area) Process Trenches	Section 2.7.8	Compliance/corrective action; organics.

* Analysis of RCRA contamination indicator parameters provided no evidence of groundwater contamination with dangerous waste or dangerous waste constituents from the unit.

Seep and River Monitoring

DOE conducts water quality monitoring in the Columbia River environment as part of its Public Safety and Resource Protection Program, with the purpose of monitoring offsite migration of contaminants of Hanford Site origin via multiple pathways (Section III.A of DOE/RL-91-50, *Environmental Monitoring Plan United States Department of Energy Richland Operations Office*). The Surface Environmental Surveillance Project monitors shoreline seepage areas (springs), river water, and river sediment. In addition, the Soil and Groundwater Remediation Project collects seep samples from some of the 100 Areas as part of groundwater monitoring programs. Hanford Site shoreline monitoring is further discussed in Section 1.2 of *Water Quality Sampling Locations Along the Shoreline of the Columbia River, Hanford Site, Washington* (PNNL-19052), which also provides detailed location maps for near-river monitoring.

DOE collects samples from seeps in the fall when the river stage is low. Samples are analyzed for a variety of chemicals and radionuclides, and the results are published annually in the Hanford Site environmental report (Section 7.4 of DOE/RL-2011-119, *Hanford Site Environmental Report for Calendar Year 2011*). The 2012 report was not available at the time of this writing, but fall 2012 results are available in HEIS and are summarized in the following paragraph.

Table RC_Summ-4 lists concentrations of contaminants of interest in seeps along each shoreline segment sampled in fall 2012. Concentrations of hexavalent chromium exceeded the 10 µg/L surface water quality standard in one seep in 100-D Area (SD-110-2), with a value of 16 µg/L. Tritium continued to exceed the 20,000 pCi/L drinking water standard in one seep at the Hanford town site, though concentrations have declined since the early 1990s. Strontium-90 was detected at 4.6 pCi/L in a 100-N seep located in the groundwater plume. In 2011, strontium-90 results in the 100-N seep were approximately 0.0227 pCi/L, well below the Washington State ambient surface water quality criterion of 8 pCi/L. 2011 and 2012 was the first time in many years that this seep was flowing and could be sampled. Prior to this time, since 1997, no visible riverbank seeps have been observed along the 100-N shoreline where strontium-90 concentrations in groundwater have been most elevated (DOE/RL-2011-119). Nitrate, trichloroethene, and uranium concentrations were below the drinking water standard in all samples.

DOE monitors Columbia River water by collecting samples along several cross-river transects and at near-shore river locations adjacent to groundwater plumes, where humans and aquatic biota are potentially exposed to contaminants. The surveillance data provide a historical record of radionuclides and chemicals in the environment. The results of water quality monitoring along the shoreline and in the river are presented annually in the Hanford Site environmental report (Section 7.2 and Tables C.4 and C.5 of DOE/RL-2011-119). Fall 2011 results are summarized in the following paragraph.

Radionuclide concentrations in river water samples collected three times during the year at the city of Richland were less than applicable water quality standards in 2011. As explained above, the 2011 Environmental Report is the most recent available.

Table RC_Summ.4 Hanford Site Contaminants in Columbia River Seeps

Groundwater Interest Area	Seep Names Sampled Fall 2012	Maximum Concentration, Fall 2012					
		Chromium[a] (µg/L)	Nitrate (mg/L)	Strontium-90[b] (pCi/L)	Tritium[b] (pCi/L)	TCE (µg/L)	Uranium (µg/L)
100-BC-5	100-B SPRING 38-3	2.22 B	4.9	U	1,090 ±178	--	--
100-KR-4	100-K SPRING 63-1	3.7 B	1.9 D	--	U	--	--
100-KR-4	100-K SPRING 68-1	2 U	5.1	--	2,890 ±608	0.3 U	0.68
100-KR-4	100-K SPRING 82-2	5 U	1.9 D	--	U	--	--
100-KR-4	SK-057-3	5 U	2.2 D	--	U	--	--
100-KR-4	SK-077-1	5 U	0.75 BD	--	U	--	--
100-NR-2	100-N SPRING 8-13	2.5 B	6.3	U	1,280 ±381	--	0.65
100-NR-2	100-N SPRING 89-1	2 U	1.8	4.6 ±0.7	886 ±289	--	0.76
100-HR-3	SD-098-1	2 U	--	--	--	--	--
100-HR-3	100-D SPRING 110-1	4.1	4.5	0.66 ±0.125 X	603 ±236	--	0.66
100-HR-3	SD-110-2	16	--	--	--	--	--
100-HR-3	SH-144-1	2 U	--	--	--	--	--
100-HR-3	100-H SPRING 145-1	2 U	5.1	U	275 ±174	--	0.84
100-HR-3	100-H SPRING 150-1	2 U	--	--	--	--	--
100-HR-3	100-H SPRING 152-2	2.8 B	--	--	--	--	--
100-HR-3	100-H SPRING 153-1	2.1 B	--	--	--	--	--
100-FR-3	SEEP 187-1	2 U	4.3	--	U	--	--
100-FR-3	SEEP 190-4	2 U	5.9	--	U	--	--
100-FR-3	100-F SPRING 207-1	2 U	1.6	--	U	--	--
200-PO-1 (old Hanford town site)	HANFORD SPRING 28-2	--	18.5	--	32,600 ±6,340	--	--
300-FF-5	300 AREA SPRING DR 42-2	--	13.7	--	3,430	0.31 J	48.6 pCi/L[c]

Source: Hanford Environmental Information System (HEIS) database.
a. Hexavalent chromium, where available, or total chromium in filtered samples (equivalent to hexavalent chromium)
b. Reported result plus or minus total analytical error
c. Total of uranium isotopes. Other uranium data are for total uranium in µg/L.
d. Duplicate sample at this location had a result of 339 ± 246 pCi/L. The reported maximum is under review.

Data Flags

- B = Less than required detection limit but greater than method detection limit
- D = Reported at a secondary dilution factor
- J = Estimated value; less than required detection limit but greater than method detection limit
- U = Undetected
- X = Flagged due to suspected interference

The average tritium (38 ± 50 pCi/L) and uranium (0.48 ± 0.14 pCi/L) concentrations at the City of Richland were slightly higher than at Priest Rapids Dam (18 ± 12 pCi/L and 0.41 ± 0.11 pCi/L, respectively). Strontium-90, technetium-99, cesium-137, and plutonium-239/240 were below detection limits in all samples collected at the City of Richland. Tritium and uranium occur naturally in the environment in addition to being present in Hanford Site groundwater. Uranium from non-Hanford Site sources, such as fertilizer use, is also known to enter the Columbia River from agricultural runoff at off Site locations.

All metal and anion concentrations in river water, including dissolved chromium, were less than the surface water quality standards in 2011.

River Corridor Baseline Risk Assessment

A critical step in developing final remedial action decisions for portions of the Hanford Site along the Columbia River is the completion of a quantitative baseline risk assessment. The River Corridor Baseline Risk Assessment addresses potential risk to human health and the environment from post-remediation, residual contaminant concentrations in the 100 and 300 Areas, as well as the Hanford and White Bluffs town sites. This assessment also investigates risks related to the potential transport of Site contaminants to Columbia River riparian and near-shore environments adjacent to the former operational areas. Some recent documents associated with this effort include the following:

- DOE/RL-2007-21, Volume I, Part 1, River Corridor Baseline Risk Assessment, Volume I: Ecological Risk Assessment (August 2011)
- DOE/RL-2007-21, Volume II, Part 2, River Corridor Baseline Risk Assessment Volume II: Human Health Risk Assessment (August 2011)

Columbia River Component Risk Assessment

DOE investigated Hanford Site contaminant releases to the Columbia River (DOE/RL-2008-11, *Remedial Investigation Work Plan for Hanford Site Releases to the Columbia River*). The contaminants, their concentrations, and their locations may have undesirable health effects for humans, animals, and plants that use or live in the Columbia River. The information obtained from this investigation will ultimately be used to help make final cleanup decisions for Hanford Site contaminants that are present in and along the Columbia River. Results of the study are presented in *Data Summary Report for the Remedial Investigation of Hanford Site Releases to the Columbia River, Hanford Site, Washington* (WCH-398).

During the study, which concluded in 2010, samples of pore water (i.e., groundwater upwelling beneath the river bottom into the space between rocks and sediment of the river bed), river sediment, river water, fish, and island soil were collected. Pore water in some of the 100 Area samples had concentrations of hexavalent chromium above the surface water standard, and strontium-90 exceeded the drinking water standard in some 100-N Area samples. Tritium concentrations exceeded the drinking water standard in some pore water samples near the former Hanford town site, and uranium near the 300 Area.

Data collected as part of this investigation contributed to the development of an ecological risk assessment and a baseline human health risk assessment for the Columbia River component of the River Corridor Baseline Risk Assessment. These risk assessments were published in 2012:

- DOE/RL-2010-117, Columbia River Component Risk Assessment, Volume I: Screening Level Ecological Risk Assessment
- DOE/RL-2010-117, Columbia River Component Risk Assessment, Volume II: Human Health Risk Assessment

Recommendations for River Corridor Groundwater

This section presents recommendations regarding future groundwater monitoring and remedial action evaluations. Where possible, these recommendations provide sufficient detail to describe and plan the activity. As with any such recommendation, these warrant further review and their implementation depends on technical priorities and available funding. Recommendations from the 2011 annual report (Section 2.9 of DOE/RL-2011-118) are listed first, along with their status. New recommendations are also presented.

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Table RC_Summ.5 Third CERCLA Five-Year Review* Issues and Actions for the River Corridor

Issues and Actions	Action Due Date	Status
Issue 1. Permeable reactive barrier test has not been conducted in the upper vadose zone.	9/30/2015	Vadose zone PRB treatability test completed in 2011.
Action 1.1. Initiate permeable reactive barrier test to determine implementability and effectiveness of the sequestration technology.		
Issue 2: 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.	4/30/2014	Remediation of 100-D-100 is ongoing.
Action 2.1: Remove, treat, and dispose of the chromium source discovered in the deep vadose zone at 100-D-100.		
Issue 3: Leakage and spills from the 182-D Reservoir and export water system may contribute to movement of contaminants into the vadose zone.	3/31/2012	Completed. Evaluation of the 182-D reservoir is discussed in the 100-D/H RI/FS Report (DOE/RL-2010-95, Draft A) and *Hanford Site Water System Master Plan* (HNF-5828).
Action 3.1: 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.		
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.	12/31/2011	Completed. *Proposed Plan for the Remediation of 300-FF-1, 300-FF-2, and 300-FF-5 Operable Units* (DOE/RL-2011-47, Draft A) submitted in December 2011.
Action 4.1. Submit proposed plan for a ROD to support meeting groundwater remediation goals.		

*DOE/RL-2011-56, *The Hanford Site Third CERCLA Five-Year Review Report*.

Multiple Interest Areas

- **Previous Recommendation**: Conduct an analysis of wells near the Columbia River to evaluate the sensitivity of the wells to changes in river stage. This information will be used to support the refinement of near-river sampling schedules and is a component to ongoing sample optimization activities. **Status:** completed and published as ECF-Hanford-12-0076, *Evaluation of the Relationship Between River Stage and Sampled Value for Several Analytes in the Hanford 100 Areas*).
- **Previous Recommendation**: Conduct a workshop and develop a strategy to assess the suitability of aquifer tube data in near-shore performance monitoring. The strategy will define methods of evaluating the representativeness of aquifer tube data and a decision framework for incorporating aquifer tube data in remediation performance monitoring. **Status:** Not completed at this point. Task is appropriate and planning will and work executed in Q4.
- **Previous Recommendation**: Update groundwater sampling and analysis plans for 100-BC-5, 100-KR-4, 100-HR-3, 100-FR-3, and 300-FF-5 to include new monitoring wells and to revise constituents and sampling frequency based on recent remediation activities and groundwater data. **Status:** This work is underway in some cases and in some will require 2014 authorization
    - 100-BC-5 revised via TPA-CN-522
    - 100-KR-4 in progress 2013, includes an RD/RA work plan update and new Monitoring Plan.
    - 100-HR-3 in progress 2013, includes an RD/RA work plan update and new Monitoring Plan.
    - 100-FR-3 to be revised in FY 2014
    - 300-FF-5 to be revised in FY2013 and FY2014
- **Previous Recommendation**: Implement actions from the third CERCLA five-year review (DOE/RL-2011-56). **Status:** Table RC_Summ-5 presents the status of the actions that pertain to the River Corridor.
- **Previous Recommendation**: As the Hanford Site moves from describing the extent of contamination to active cleanup, meaningful benchmarks for measuring cleanup progress are under development. As new data evaluation and reduction tools are implemented, establish final long-term benchmarks for measuring the progress of cleanup and remedy performance. **Status:** Task has begun, presentation material prepared and delivered to RL on cleanup goals and strategy. Work will continue.
- **Previous Recommendation**: Re-establish expanded functionality of the Automated Water Level Network (AWLN) to provide high-frequency groundwater elevation monitoring. These data are particularly important in the 100 Areas where the effects of seasonal river stage transients must be technically evaluated. There is scope to make the necessary improvements in both 2013 and 2014.
- **New Recommendation**: Continue to work through the CERCLA RI/FS process and establish final cleanup actions through RODs for groundwater remediation in 100-KR-4, 100-NR-2, 100-HR-3, 100-FR-3, and 300-FF-5. **Status:** underway in 2013.

100-BC-5

- **Previous Recommendation:** Increase monitoring frequency for hexavalent chromium concentrations downgradient of 100-C-7 and 100-C-7:1 waste sites. Status: implemented in 2012 per *Tri-Party Agreement Change Notice Form: DOE/RL-2009-80, Investigation Derived Waste Purgewater Management Work Plan, Revision 0* (TPA-CN-552).

- **New Recommendation:** Implement additional studies of the groundwater and hyporheic zone to reduce uncertainties per Tri-Party Agreement Change Notice Form: DOE/RL-2009-44, *Sampling and Analysis Plan for the 100-BC-1, 100-BC-2, and 100-BC-5 Operable Units Remedial Investigation/Feasibility Study, Rev. 0* (TPA-CN-559). Status: in progress in 2013.

100-KR-4

The following recommendations for additional and/or replacement wells and modifications to the groundwater monitoring network at 100-KR-4 OU were identified in the 2011 annual report:

- **Previous Recommendation:** Implement the SIR-700 resin full time at the 100-K pump-and-treat systems. **Status:** complete.
- **Previous Recommendation:** Connect wells 199-K-198 and 199-K-199 to the KX pump-and-treat system as extraction wells. **Status:** This activity is planned for implementation during FY 2013.
- **Previous Recommendation:** Continue to sample wells 199-K-36 and 199-K-187, upgradient of the 183.1-KE headhouse, to investigate variable hexavalent chromium concentrations. **Status:** sampled in 2012; ongoing in 2013.
- **Previous Recommendation:** Due to a lack of wells to monitor groundwater (as a result of facility demolition activates), the historic concentrations have migrated. Track strontium-90 concentrations in wells downgradient of K East as the plume front migrates downgradient. Status: sampled in 2012; ongoing in 2013.
- **Previous Recommendation:** Install replacement wells in the vicinity of the 183.1-KW headhouse to monitor hexavalent chromium groundwater at that apparent source area during remediation. **Status:** Replacement wells and locations have been identified, but not yet installed. Planning action are proceeding.
- **Previous Recommendation:** Install replacement wells in the vicinity of the 116-KE-1 and 116-KE-3 cribs to monitor carbon-14, tritium, nitrate, and strontium-90 conditions during remediation. **Status:** Replacement wells and locations have been identified, but not yet installed. Planning action are proceeding.
- **New Recommendation:** Conduct a data quality objectives analysis to determine data needs for performance monitoring of the KW, KR, and KX systems in 2013. Document the evaluation, and develop a new monitoring plan for 100-KR-4. **Status:** In progress.
- **New Recommendation:** Evaluate the realignment and/or addition of specific wells to the KW, KR and KX pump-and-treat system well network in 2013, and prepare a written report. **Status:** Completed in the pump-and-treat annual report (DOE/RL-2013-13).
- **Previous Recommendation:** Install a packer at 6 meters below the water table in well 199-K-185. Very high nitrate and high carbon-14 levels were identified during drilling at the top of the aquifer. Results were significantly lower during subsequent monitoring because the well has a long screen. A packer would eliminate water from the lower portion of the aquifer from entering the pump during sampling and provide more representative results of upper aquifer conditions. **Status:** This well has not been modified.
- **Current recommendations** for installation of new and replacement wells for groundwater monitoring and enhancement of pump-and-treat operations at 100-KR-4 OU are presented in a technical memorandum (SGW-54543, *Recommendations and Technical Justification for New and Replacement Wells and Re-alignment of Existing Wells Associated with Interim Remedial Actions at 100-K Area*). The following general areas are identified as currently having inadequate well coverage:
    - The former 183-KW Head House area, where wells 199-K-35 and 199-K-195 were decommissioned to support soil remediation in that area. Well 199-K-195 had previously exhibited the highest hexavalent chromium concentration in groundwater at 100-K.
    - The former 183-KE Head House area, where well 199-K-36 has historically exhibited elevated hexavalent chromium concentration in groundwater. Although well 199-K-36 was restored to service as a monitoring well after being damaged during demolition, it would not be serviceable as an extraction well.
    - The area downgradient of 105-KW Fuel Storage Basin and 116-KW-1 Reactor Gas Dryer Condensate Crib. These locations have historically exhibited elevated strontium-90, carbon-14, and nitrate concentrations in groundwater. These historical plumes have migrated away from the existing wells and into areas that are no longer effectively monitored. The highest historical concentration of carbon-14 was measured in this area. This area still exhibits the highest nitrate concentrations in 100-K, although the highest concentrations are likely downgradient of the source areas.

- The area downgradient of 105-KE Fuel Storage Basin and 116-KE-1 Reactor Gas Dryer Condensate Crib, where wells 199-K-109A, 199-K-27, 199-K-28, 199-K-29, and 199-K-30 were decommissioned to support D4 and soil remediation in the area. This area exhibited the highest historical strontium-90 concentration, as well as high concentrations of tritium and carbon-14.
- The area within, and around, the 118-K-1 Burial Ground where substantial residual tritium was observed in the deep vadose zone during source remediation of that waste site. The area between 116-KE-1 Gas Condensate Crib and the River and eastward to the 116-K-1 Crib. This area is inferred to be a historical preferential pathway for migration of high concentration contaminants from the 116-KE-1 Crib.
- The area inland of 116-K-2 Trench generally between wells 199-K-172 and 699-77-54. This area is not effectively monitored and may exhibit hexavalent chromium in excess of the cleanup target concentrations.
- The footprint of former 116-KE-3 Crib/Reverse Well, where a characterization boring will be placed; it will be effective to complete the boring as a well and permit groundwater monitoring and vadose zone release detection.
- The footprint of the former 105-KE Fuel Storage Basin, where a characterization boring will be placed in the vicinity identified as UPR-100-K-1; it will be effective to complete the boring as a well to permit groundwater monitoring and vadose zone release detection.

100-NR-2

- **Previous Recommendation:** Prepare an integrated sampling and analysis plan to include CERCLA and RCRA groundwater monitoring. **Status:** ongoing in 2013.
- **Previous Recommendation:** Evaluate the 1324-N/NA monitoring network with respect to flow direction changes, and incorporate the site into the integrated groundwater monitoring plan. **Status:** ongoing in 2013.
- **Previous Recommendation:** Conduct additional sampling in 100-NR-2 to investigate the total organic carbon increases in groundwater at the 1324-N/NA facilities. **Status:** Complete. DOE received verbal confirmation from Ecology that the elevated total organic carbon concentration in well 199-N-165 was not associated with the 1324-N/NA facilities (169299, “Groundwater and Source Operable Units; Facility Deactivation, Decontamination, Decommission, and Demolition (D4); Interim Safe Storage (ISS); Field Remediation (FR); Mission Completion; and 100-K Sludge Treatment Project and 100-K Facility Demolition and Soil Remediation Projects”).
- **Previous Recommendation:** Evaluate additional apatite injections in the permeable reactive barrier in response to increasing strontium-90 concentrations. **Status:** schedule dependent on funding priorities

100-HR-3

- **Previous Recommendation:** Evaluate the effectiveness of the new DX and HX pump-and-treat systems in 2013, using groundwater concentration data, hydraulic head data, capture zone analyses, and further modeling to optimize the operation of the systems. Include a comparison of DX and HX to the HR-3 and DR-5 systems, and prepare a written report. **Status:** Completed in the pump-and-treat annual report (DOE/RL-2013-13).
- **Previous Recommendation:** Conduct a data quality objectives analysis to determine data needs for performance monitoring of the new DX and HX systems in 2013. Document the evaluation, and develop a new monitoring plan for 100-HR-3. **Status:** In progress.
- **Previous Recommendation:** Evaluate the realignment and/or addition of specific wells to the DX and HX pump-and-treat system well network in 2013, and prepare a written report. **Status:** Completed in the pump-and-treat annual report (DOE/RL-2013-13).
- **Previous Recommendation:** Conduct additional sampling of 100-HR-3 wells 199-H1-27 and 199-H4-75 and nearby wells in 2013 to investigate the persistence and extent of nitrate contamination observed in 2011. **Status:** 2011 nitrate data were reviewed and found to be in error. Data were corrected in HEIS. No further action needed.
- **Previous Recommendation:** Sample 100-HR-3 well 199-D5-93 and nearby wells for beta-emitting radionuclides in 2013 to investigate the cause and extent of elevated gross beta levels observed in 2011. **Status:** Implemented in 2013.
- **New Recommendation:** Install two new wells at 100-H to the south of well 199-H3-10 and complete within the Ringold upper mud unit to better delineate the plume in that area as described in *Recommendations and Technical Justification for New and Replacement Wells and Re-alignment of Existing Wells Associated with Interim Remedial Actions at 100-D/H Area* (SGW-54542).
- **New Recommendation:** Convert existing wells 199-D8-68, 199-D8-53, 199-D4-34, and 199-D4-14 to extraction wells, and realign well 199-D8-55 as an extraction well to improve capture of the hexavalent chromium plume at 100-D (SGW-54542). Status: Wells 199-D8-68 and 199-D8-53 have been connected to DX. Design is underway for connecting wells 199-D4-14 and 199-D4-34 to DX.
- **New Recommendation:** Install new wells at 100-D and 100-H to improve capture of the hexavalent chromium plume in areas of breakthrough, as outlined in the annual pump-and-treat report (DOE/RL-2013-13) and SGW-54542.
- **New Recommendation:** Install one upgradient and one downgradient well in the Horn, near existing well 699-97-48C. Complete these wells in the Ringold upper mud unit to delineate the hexavalent chromium contamination identified in that area (SGW-54542).

100-FR-3

- **Previous Recommendation:** Monitor temporary wells 199-F5-55 and 199-F5-56. **Status:** implemented in 2012 and ongoing in 2013.
- **Previous Recommendation:** Monitor strontium-90 in wells near the F Reactor to determine the extent of contamination in temporary well 199-F5-56. **Status:** implemented in 2012 and ongoing in 2013.

300-FF-5

- **Previous Recommendation:** Increase monitoring frequency for metals at the 618-10 Burial Ground during remediation activities to assess the impact of dust suppression water on contaminant mobility. **Status:** implemented in 2012.

1100-EM-1

- **Previous Recommendation:** Prepare a groundwater sampling and analysis plan for 1100-EM-1 to include monitoring objectives for tracking Hanford Site and offsite plumes and trends. **Status:** in progress in 2013.

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River Corridor References and Terms

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Terms

AEA	Atomic Energy Act of 1954
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE	U.S. Department of Energy
Ecology	Department of Ecology
EPA	Environmental Protection Agency
FS	Feasibility Study
ICs	institutional controls
ISRM	In Situ Redox Manipulation
OU	operable unit
P&T	Pump and Treat
RCRA	Resource Conservation and Recovery Act of 1976
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RUM	Ringold Formation Upper Mud unit
SAP	Sampling Analysis Plan
TCE	Trichloroethene