

**Identification of Major Risk Drivers and Contaminants of Potential Concern for a Complex Groundwater Aquifer – 14350**

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**ABSTRACT**

This paper presents a three-pronged process for identifying contaminants of potential concern (COPC) and major risk drivers for a complex groundwater aquifer adjacent to a major river. The study site is located on the U.S. Department of Energy (DOE) Hanford Site in Southeastern Washington, which is currently managed by contractor CH2M HILL Plateau Remediation Company. The site is located at the banks of the Columbia River, a vital natural resource to the Northwest. The study site features the 100-DH decision areas located along the Columbia River and includes source Operable Units (OUs), a groundwater OU, and the adjacent surface water.

The three prongs of the COPC identification process are summarized and results presented. The first approach is to evaluate individual contaminant measurements from a long time series to identify individual measurements above cleanup levels. This is completed in Nature and Extent evaluation part of the Remedial Investigation effort. The second approach is a detailed process which includes the quantitative evaluation of exposure point concentrations to action levels and is documented within the Baseline Risk Assessment of the Remedial Investigation effort. Finally, the third approach involves the most detailed quantitative evaluation of risk and hazard using a residential exposure scenario (U.S. Environmental Protection Agency's (EPA's) Tap Water scenario) to evaluate the contribution of each contaminant to cancer risk and adverse health effects; including the evaluation of ingestion, inhalation, and dermal exposure. All three approaches are used to identify COPCs for the groundwater area. The major risk and hazard drivers move forward into the feasibility study where remedial alternatives are evaluated.

**INTRODUCTION**

The 100-D/H area is situated between the 100-N and 100-F decision areas and borders the Columbia River at the Hanford Site. The 100-D/H Area encompasses 20 km<sup>2</sup> (7.8 mi<sup>2</sup>) in the northern portion of the Hanford Site in the 100 Area. Groundwater beneath the 100-D/H area is currently contaminated (also known as the 100-HR-3 groundwater OU). The primary sources of contamination in 100-D/H decision area are three water-cooled nuclear reactors (105-D, 105-DR, and 105-H) and the structures (for example, fuel storage basins) and processes (for example, sodium dichromate process) associated with reactor operations. The primary release mechanism is migration of contaminated liquids through the vadose zone column through infiltration, percolation, or leaching to the groundwater [2].

The 100-HR-3 Groundwater OU includes all groundwater in the 100-D, 100-H, and horn area. There are four primary groundwater plumes within the 100-HR-3 Groundwater OU. Contaminant plume areas are identified geographically as the 100-D southern plume, 100-D northern plume, 100-H plume, and horn area plume, and are mainly based on the distribution of hexavalent chromium concentrations. Other contaminants are primarily collocated with the hexavalent chromium plume [1].

A Remedial Investigation/Feasibility Study (RI/FS) is being conducted for the 100-D/H decision area. One of the key activities associated with this report is to identify COPCs and the major risk

drivers in groundwater. A "contaminant of potential concern" is defined as a constituent suspected of being associated with site-related activities, which represent a potential threat to human health or the environment, and whose data are of sufficient quality for use in a quantitative baseline risk assessment." An outcome of the baseline risk assessment is the identification of the "major risk drivers". For the 100-D/H area, these contaminants are either widespread (nitrate and hexavalent chromium) or are present in localized areas (strontium-90) at concentrations greater than federal or State risk thresholds for protection of human health and the environment. The major risk drivers move forward into the feasibility study where remedial alternatives are evaluated.

Uncertainties were identified with the quality of the existing groundwater data set. To reduce the uncertainties associated with the data set, groundwater samples were collected during the Remedial Investigation work plan. A three-pronged approach is used to identify COPCs and primary contributors to risks and hazards in groundwater. This approach allowed for the use of a larger population of data (larger number of wells and longer time frame) with known uncertainties and the use of a smaller population of data (fewer wells and shorter time frame) collected to reduce uncertainties. Individual measurements from the larger and smaller data sets were compared to chemical-specific applicable relevant and appropriate requirements (ARARs) or risk-based concentrations to identify COPCs and identify areas of localized contamination (hot spots). EPA's tap water scenario was used to identify the major contributor to cancer risks and noncancer hazards. Together all comparisons and evaluations represent the three-pronged approach.

## **BACKGROUND**

Groundwater contamination at the 100-D/H area is monitored to fulfill a variety of state and federal regulations, including the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Restoration Compensation and Liability Act (CERCLA), the Atomic Energy Act of 1954; and Section 173 of the Washington Administrative Code. Because the monitoring data are collected under a variety of regulatory programs, there are uncertainties associated with their use. Uncertainties specifically include the following: different target analytes analyzed at each well, different sampling frequencies (quarterly, semiannually or triennially), and different method detection limits ([MDLs] or reporting limits) for the same target analyte. These differences are generally because the information is used to meet different requirements.

Additional groundwater samples were collected during the work plan phase of the RI/FS to address the uncertainties associated with the existing groundwater data set. At the time of the work plan there were 98 monitoring or compliance wells screened in the unconfined aquifer. A subset of 52 monitoring wells was selected to spatially represent the entire 100-D/H area (20 wells in 100-D area, 13 wells in 100-H area, and 19 wells in the Horn area). All wells were analyzed for the same target analytes using a methods-based approach; target analytes included metals, volatile organic compounds, anions, and radionuclides. The work plan identified 31 target analytes requiring MDLs to achieve risk-based concentrations. Three sampling rounds were conducted at each monitoring well to characterize the dynamic groundwater conditions, sampling was conducted during periods when the river stage and water table were high, when both were low, and at interval transitional to extreme conditions. This data set was specifically used to calculate exposure point concentrations for each of the three decision areas (100-D, 100-H, and Horn area).

## **GROUNDWATER DATA SETS**

Two different data sets were used to confirm that a complete set of COPCs were identified. The first groundwater data set represents only those analytical results that were collected to address uncertainties identified in the RI/FS work plan. As described previously, this data set included three sampling rounds from 52 monitoring wells screened in the unconfined aquifer; these samples were collected over an 8-month period between October 7, 2009 and June 11, 2010. Samples collected from early October 2009 to early November 2009 represent the aquifer when the river is at its lowest elevation. Samples collected from mid-March to mid-April 2010 represent the aquifer when the river is transitioning from high to low river stage.

The second data set contains all analytical results collected from the 98 monitoring or compliance wells screened in the unconfined aquifer over a 6-year time frame (January 2006 through December 2012). This data set also includes the data collected for the RI/FS work plan. This analysis is included to confirm that analytes that are identified as COPCs using RI data are consistent with the observations and characteristics of the data from a larger population of wells and analytical results collected over a longer period of time.

Due to the large number of contaminants reported only a subset of contaminants from the 100-H Area are further discussed.

## **Data Processing and Reduction**

Both data sets included the following types of information:

- Analytical results from both unfiltered and filtered samples
- Data qualification and data validation flags, including rejected results
- Results for a given analyte reported by more than one analytical method
- Parent, field duplicate, and field split sample results

All analytical results were processed and reduced in accordance with guidance outlined in Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A), Interim Final [5].

## **IDENTIFICATION OF ACTION LEVELS**

Action levels are screening levels derived from chemical-specific ARARs and/or risk-based concentrations using default exposure assumptions. The lowest value of the chemical-specific ARARs or the risk-based concentration is selected for comparison purposes because it is protective of human and ecological receptors. The sources of action levels from federal regulations include the following:

- “National Primary Drinking Water Regulations” (40 CFR 141), MCLs, secondary MCLs, and nonzero MCLGs established under the Safe Drinking Water Act of 1974 (SDWA)
- National Recommended Water Quality Criteria (EPA, 2009b), Ambient Water Quality Criteria (AWQC) established under Section 304 of the Clean Water Act of 1977
- “Water Quality Standards” (40 CFR 131) for states not complying with Section 303 of the Clean Water Act of 1977

The sources of the action levels from Washington State regulations include the following:

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- “Water Quality Standards for Surface Waters of the State of Washington” (WAC 173-201A)
- “Groundwater Cleanup Standards” (WAC 173-340-720)<sup>1</sup>
- “Group A Public Water Supplies,” “Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)” (WAC 246-290-310)

While surface water and AWQC standards are considered for the identification of action levels, these standards only apply for groundwater where it enters the Columbia River. For the upland parts of groundwater, only drinking water standards are applicable. A summary of action levels for select contaminants is provided in Table 1.

### **METHODS USED TO IDENTIFY CONTAMINANTS OF POTENTIAL CONCERN**

Two different methods were used to identify COPCs for the 100-H area.

#### **Comparison of Individual Measurements to Action Levels**

Individual groundwater measurements from samples are compared to the action levels. Summary statistics and comparison of groundwater results to action levels for data collected over the past six years are provided in Table 2. Summary statistics and comparison of groundwater results to action levels for the RI work plan data set are provided in Table 3. Three comparisons are performed for each analyte

- Were the MDLs adequate to confirm the contaminant is absent at a concentration less than or equal to the action level
- Were there any reported concentrations of a contaminant above the action level
- Were the detections associated with a trend at a given well.

#### **EPA Tap Water Scenario**

A baseline risk assessment is required to identify the contaminants that are the major contributors to the total cumulative excess lifetime cancer risk. The EPA Tap Water scenario is consistent with a residential exposure scenario because it incorporates default residential exposure assumptions.

EPA guidance provided in “Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions” [4] describes how to use the baseline risk assessment to make risk management decisions such as determining whether remedial action under CERCLA Section 104 or Section 106 is necessary. The “Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions” [4] describes the following conditions when a CERCLA action is generally warranted:

- The baseline risk assessment indicates that a cumulative site risk to an individual using reasonable maximum exposure assumptions for either current or future land use exceeds the  $10^{-4}$  excess lifetime cancer risk (ELCR) end of the risk range.

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<sup>1</sup> These are risk-based concentrations that are calculated using default exposure assumptions with a target risk level of  $1 \times 10^{-6}$  or a hazard quotient of 1.

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Table 1. Summary of Federal and State Water Quality Criteria used as Action Levels

Analyte Name	Units	Groundwater				Surface Water					Action Level Value	
		40 CFR 141 <sup>a</sup>	WAC 246-2 90-310 <sup>b</sup>	WAC 173-340-720 <sup>c</sup>		Clean Water Act (CWA) National Recommended Water Quality Criteria <sup>d</sup>		WAC 173-201A <sup>e</sup>	40 CFR 131 <sup>f</sup>			
		Federal MCL	State MCL	Groundwater Method A Cleanup Levels	Groundwater Method B Unrestricted Land Use	Acute Freshwater CMC	Freshwater CCC	Freshwater CCC	Freshwater CMC	Freshwater CCC	Action Level	Action Level Basis
Antimony	µg/L	6.0	6.0	--	6.4	--	--	--	--	--	6.0	Federal MCL
Cadmium	µg/L	5.0	5.0	--	8.0	2.0	0.25	0.91	3.9	1.0	0.25	CWA-- Freshwater CCC
Carbon tetrachloride	µg/L	5.0	--	--	0.63	--	--	--	--	--	0.63	WAC 173-340-720
Chromium	µg/L	100	100	--	24,000	570	65	156	550	180	65	CWA-- Freshwater CCC
Cobalt	µg/L	--	--	--	4.8	--	--	--	--	--	4.8	WAC 173-340-720
Copper	µg/L	1,300	--	--	640	13	9.0	--	17	11	9.0	Clean Water Act -- Freshwater CCC
Hexavalent chromium	µg/L	--	--	--	48	16	11	10	15	10	10	WAC 173-201A
Nickel	µg/L	--	100	--	320	470	52	137	1,400	160	52	Clean Water Act -- Freshwater CCC
Nitrate	µg/L	45,000	45,000	--	113,600	--	--	--	--	--	45,000	Federal MCL
Silver	µg/L	100	100	--	80	3.2	--	2.6	3.4	--	2.6	WAC 173-201A
Strontium-90	pCi/L	8.0	--	--	--	--	--	--	--	--	8.0	Federal MCL
Zinc	µg/L	5,000	5,000	--	4,800	120	120	91	110	100	91	WAC 173-201A

a. 40 CFR 141, "National Primary Drinking Water Regulations."

b. WAC 246-290-310, "Group A Public Water Supplies," "Maximum Contaminant Levels (MCLs) and Maximum Residual Disinfectant Levels (MRDLs)."

c. WAC 173-340-720(4)(b)(ii)(A) and (B), "Groundwater Cleanup Standards," "Noncarcinogens and Carcinogens."

d. EPA, 2009, *National Recommended Water Quality Criteria*.

e. WAC 173-201A, "Water Quality Standards for Surface Waters of the State of Washington."

f. 40 CFR 131, "Water Quality Standards."

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**Table 2. Groundwater Summary Statistics for 100-H Area (6-year Data Set) - Unconfined Aquifer**

Analyte	Units	Number of Results	Number of Detects	Frequency of Detects (%)	Min MDL	Max MDL	Min Detect	Max Detect	Action Level	No. of Detects > Action Level
Antimony (Total)	µg/L	170	16	9.41	0.3	72	0.61	42	6.0	2
Antimony (Dissolved)	µg/L	184	15	8.15	0.3	72	0.34	41	6.0	3
Cadmium (Total)	µg/L	170	2	1.18	0.1	4.1	2.4	4.1	0.25	2
Cadmium (Dissolved)	µg/L	184	3	1.63	0.1	4.1	0.39	1.8	0.25	3
Carbon tetrachloride	µg/L	55	2	3.64	0.063	1	0.088	2	0.63	1
Chromium (Total)	µg/L	170	131	77.06	7	14	4.8	215	65	6
Chromium (Dissolved)	µg/L	184	126	68.48	1	14	4.9	79	65	5
Cobalt (Total)	µg/L	170	21	12.35	0	7	0.062	27	4.8	2
Cobalt (Dissolved)	µg/L	184	37	20.11	0.1	7	0.083	29	4.8	6
Copper (Total)	µg/L	170	41	24.12	0.2	7	0.12	28	9.0	4
Copper (Dissolved)	µg/L	184	22	11.96	0.1	10	0.17	13.3	9.0	2
Cr(VI) (Total)	µg/L	489	456	93.25	0	3.7	1	94	10	279
Cr(VI) (Dissolved)	µg/L	275	245	89.09	2	5	2	75	10	126
Nickel (Total)	µg/L	170	61	35.88	2.4	66.5	4	37	52	0
Nickel(Dissolved)	µg/L	184	45	24.46	4	66.5	0.72	36	52	0
Nitrate	µg/L	217	217	100	--	--	416	253,000	45,000	7
Silver(Total)	µg/L	170	10	5.88	0.1	11	0.10	30	2.6	9
Silver(Dissolved)	µg/L	184	7	3.8	0.1	11	0.32	33	2.6	5
Strontium-90	pCi/L	171	72	42.11	-7.8	2.6	1.5	110	8.0	27
Zinc (Total)	µg/L	170	51	30	4	9.6	1	236	91	2
Zinc (Dissolved)	µg/L	184	37	20.11	4	20	1.6	88.1	91	0

Sources: 40 CFR 141, "National Primary Drinking Water Regulations."

*National Recommended Water Quality Criteria.*

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."

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**Table 3. Groundwater Summary Statistics for 100-H Area (RI Data Set) - Unconfined Aquifer**

Analyte	Units	# of Results	#of Detects	Frequency of Detects (%)	Min Non- Detect	Max Non- Detect	Min Detect	Max Detect	Action Level	No. of Detects > Action Level
Antimony (Total)	µg/L	39	4	10.3	0.3	0.6	0.61	1.02	6.0	0
Antimony (Dissolved)	µg/L	39	2	5.1	0.3	0.6	0.34	0.69	6.0	0
Cadmium (Total)	µg/L	39	0	0.0	0.055	0.2	--	--	--	0
Cadmium (Dissolved)	µg/L	39	1	2.6	0.1	0.2	0.39	0.39	0.25	1
Carbon tetrachloride	µg/L	39	2	5.1	0.063	1	0.088	2.0	0.63	1
Chromium (Total)	µg/L	39	39	100	--	--	7.31	34	65	0
Chromium (Dissolved)	µg/L	39	38	99.4	1	1	4.89	33	65	0
Cobalt (Total)	µg/L	39	16	41.0	0.05	0.1	0.062	0.90	4.8	0
Cobalt (Dissolved)	µg/L	39	23	59	0.1	0.1	0.083	0.59	4.8	0
Copper (Total)	µg/L	39	21	53.8	0.1	0.2	0.12	2.82	9.0	0
Copper (Dissolved)	µg/L	39	8	20.5	0.1	0.2	0.17	1.6	9.0	0
Cr(VI) (Total)	µg/L	39	34	87.2	2	2	2.6	29	10	17
Cr(VI) (Dissolved)	µg/L	39	37	94.9	2	2	2.2	28.8	10	16
Nickel (Total)	µg/L	39	12	30.8	4.0	4.0	2.4	17.8	52	0
Nickel (Dissolved)	µg/L	39			4.0	4.0	4.0	36.8	52	0
Nitrate	µg/L	38	38	100	--	--	16,700	46,900	45,000	1
Silver(Total)	µg/L	39	0	0	0.04	0.2	--	--	2.6	0
Silver(Dissolved)	µg/L	156	3	1.92	0.04	0.2	0.294	0.413	2.6	0
Strontium-90	pCi/L	39	12	30.8	-14	2.6	3.2	27	8.0	6
Zinc (Total)	µg/L	39	9	23.1	4	9.6	1	30	91	0
Zinc (Dissolved)	µg/L	39	2	5.1	6.0	6.0	16	32.1	91	0

Sources: 40 CFR 131, "Water Quality Standards."

40 CFR 141, "National Primary Drinking Water Regulations."

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."

**Table 4. 100-H Source Exposure Area - Summary of Tap Water Scenario Cancer Risk Results for Nonradiological and Radiological Analytes in Groundwater**

Analyte Name	90 <sup>th</sup> Percentile Concentration in Groundwater (mg/L or pCi/L)	Volatile <sup>a</sup>	Risk (Ingestion)	Risk (Dermal)	Risk (Inhalation)	Total Risk	% Contribution
Antimony	0.00061	--	--	--	--(b)	--	--
Carbon tetrachloride	0.0010	Yes	1.93E-06	4.99E-07	7.45E-08	2.51E-06	14
Chromium	0.031	--	--	--	--(b)	--	--
Cobalt	0.00043	--	--	--	--(b)	--	--
Copper	0.0013	--	--	--	--(b)	--	--
Cr(VI)	0.026	--	--	--	--(b)	--	--
Nickel	0.0089	--	--	--	--(b)	--	--
Nitrate	40	--	--	--	--(b)	--	--
Zinc	0.016	--	--	--	--(b)	--	--
Strontium-90	14	--	1.48E-05	--	--(b)	1.48E-05	86
<b>Total Cumulative ELCR</b>			9.17E-05	4.99E-07	2.37E-07	1.73E-05	100

a. Volatile contaminants as defined by EPA, 2009a, "Regional Screening Levels for Chemical Contaminants at Superfund Sites," or as defined by EPA 540-R-97-036, *Health Effects Assessment Summary Tables: FY 1997 Update*, "April 16, 2001 Update: Radionuclide Toxicity," "Radionuclide Table: Radionuclide Carcinogenicity – Slope Factors."

b. Nonvolatile constituents are not considered in the inhalation exposure route.

-- = Indicates toxicity criteria not available to quantify contaminant's cancer risk via this exposure route.

Shading identifies analytes with a contribution greater than 1 percent to total cumulative risk.



Table 5. 100-H Source Exposure Area - Summary of Tap Water Scenario Noncancer Hazard Results for Nonradiological Analytes in Groundwater

Analyte Name	90 <sup>th</sup> Percentile Concentration in Groundwater C <sub>w</sub> (mg/L)	Volatile <sup>a</sup>	HQ (Ingestion)	HQ (Dermal)	HQ (Inhalation)	Total HQ	% Contribution
Antimony	0.00061	--	0.042	<0.01	--(b)	0.043	6.8
Carbon tetrachloride	0.0010	Yes	0.039	0.011	<0.01	0.050	7.9
Chromium	0.031	--	<0.01	<0.01	--(b)	<0.01	0.013
Cobalt	0.00043	--	0.039	<0.01	--(b)	0.039	6.2
Copper	0.0013	--	<0.01	<0.01	--(b)	<0.01	0.14
Cr(VI)	0.026	--	0.23	0.097	--(b)	0.33	52
Nickel	0.0089	--	0.012	<0.01	--(b)	0.013	2.0
Nitrate	40	--	0.15	<0.01	--(b)	0.16	24
Zinc	0.016	--	<0.01	<0.01	--(b)	<0.01	0.23
<b>Total HI</b>			0.52	0.11	<0.01	0.63	100

a. Volatile contaminants as defined by EPA, 2009a, "Regional Screening Levels for Chemical Contaminants at Superfund Sites."

b. Nonvolatile constituents are not considered in the inhalation exposure route.

-- = Indicates toxicity criteria not available to quantify contaminant's hazard via this exposure route.

Shading identifies analytes with a contribution of greater than 1 percent to HI.

- For groundwater actions, MCLs and nonzero maximum contaminant limit goals (MCLGs) will generally be used to gauge whether remedial action is warranted.

## **DISCUSSION**

The results of each COPC identification method are discussed below.

### **Comparison of Individual Results**

Summary statistics and comparison of groundwater results to action levels for data collected over the past six years are provided in Table 2. Summary statistics and comparison of groundwater results to action levels for the RI work plan data set are provided in Table 3.

#### **Antimony**

For the six-year data set, approximately 75 percent of the antimony data set reported MDLs greater than the federal MCL of 6 µg/L. Antimony results with elevated MDLs were analyzed by EPA Method 6010, *Inductively Coupled Plasma-Atomic Emission Spectrometry* [3]. Whereas, antimony results with MDLs less than the federal MCL were reported by EPA Method 200.8, *Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry* [3]. Five antimony results (two total and three dissolved) were greater than the federal MCL; all were reported at different wells and were not associated with an upward or downward trend.

For the RI data set, all antimony MDLs and all detected antimony concentrations were less than the federal MCL. All antimony results were reported by EPA Method 200.8.

#### **Cadmium**

For the six-year data set, up to 75 percent of the cadmium data set reported MDLs greater than the AWQC of 0.25 µg/L. However, all the cadmium MDLs are less than the federal MCL of 5 µg/L. Cadmium results with elevated MDLs were analyzed by EPA Method 6010 [3]. Whereas, cadmium results reported with MDLs less than the AWQC were analyzed by EPA Method 200.8 [4]. Five cadmium results (two total and three dissolved) were greater than the AWQC; all were from different wells and were not associated with an upward or downward trend.

For the RI data set, all cadmium MDLs were less than the AWQC. A single detection of cadmium was reported above the AWQC; the associated unfiltered sample was reported as a nondetected concentration less than the AWQC. This cadmium result does not suggest it is associated with an upward or downward trend. All cadmium results were reported by EPA Method 200.8.

#### **Carbon Tetrachloride**

For the six-year data set, 38 percent of the carbon tetrachloride data set reported MDLs greater than the state groundwater cleanup level of 0.63 µg/L. Two samples were reported with detectable concentrations of carbon tetrachloride; one sample result was greater than the state groundwater cleanup level. Both carbon tetrachloride results were from different wells and results suggest that concentrations were not associated with an upward or downward trend.

For the RI data set, 24 percent of the MDLs were greater than the state groundwater cleanup level of 0.63 µg/L. Detected concentrations of carbon tetrachloride are the same as those for the six-year data set.

### **Chromium**

For the six-year data set, all MDLs were less than the AWQC of 65 µg/L. Eleven chromium results (six total and five dissolved) were greater than the AWQC. Chromium concentrations from filtered samples were reported above the AWQC at two wells. One well (H3-5) reporting chromium concentrations consistently above the AWQC and one well (H3-4) with chromium concentrations trending above the AWQC over the past year. Two additional wells (H4-9 and H4-18) reported chromium concentrations above the AWQC in unfiltered samples, however filtered concentrations were less than the AWQC. All chromium results were reported by EPA Method 6010.

For the RI data set, all chromium MDLs and all detected chromium concentrations were less than the AWQC. All chromium results were reported by EPA Method 6010.

### **Cobalt**

For the six-year data set, up to 14 percent of the cobalt data set reported MDLs greater than the state groundwater cleanup level of 4.8 µg/L. Cobalt results with elevated MDLs were analyzed by EPA Method 6010 [3]. Whereas, cobalt results with MDLs less than the state groundwater cleanup level were reported by EPA Method 200.8 [4] or equivalent trace analytical method. Eight cobalt results (two total and six dissolved) were greater than the state groundwater cleanup level; all results were reported at different wells and were not associated with an upward or downward trend.

For the RI data set, all cobalt MDLs and all detected cobalt concentrations were less than the state groundwater cleanup level. All cobalt results were reported by EPA Method 200.8 or equivalent trace analytical method [3].

### **Copper**

For the six-year data set, only three of 291 MDLs were greater than the AWQC of 9 µg/L. Copper results with elevated MDLs were analyzed by EPA Method 6010 [3]. Six copper results (four total and two dissolved) were greater than the AWQC. Copper concentrations from filtered samples were reported above the AWQC at three wells. All three wells (H4-13, H4-3, and H4-5) reported single concentrations above the AWQC but are not associated with an increasing trend. Two additional wells (H4-8 and H4-18) reported copper concentrations above the AWQC in unfiltered samples, however filtered concentrations were less than the AWQC.

For the RI data set, all copper MDLs and all detected copper concentrations were less than the AWQC. All copper results were reported by EPA Method 200.8 or equivalent trace analytical method.

### **Hexavalent Chromium**

For the six-year data set, all MDLs were less than the state surface water quality standard of 10 µg/L. Hexavalent chromium concentrations from unfiltered samples were reported above the state water quality standard in 24 of the 30 wells. Concentrations of hexavalent chromium are consistently at or above the state water quality standard in all 24 wells. Concentrations of hexavalent chromium were consistently below the state water quality standard in six wells. Concentrations of hexavalent chromium in filtered samples were similar to those in the unfiltered samples.

For the RI data set, all hexavalent chromium MDLs were less than the state surface water quality standard. Hexavalent chromium concentrations from unfiltered samples were reported above the state water quality standard in 10 of the 13 wells. The remaining wells consistently reported

concentrations below the state surface water quality standard.

### **Nickel**

For the six-year data set, only five of 248 MDLs were greater than the AWQC of 52 µg/L. Nickel results with elevated MDLs were analyzed by EPA Method 6010 [3]. There were no detected concentrations of nickel greater than the AWQC.

For the RI data set, all nickel MDLs and all detected nickel concentrations were less than the AWQC. All nickel results were reported by EPA Method 6010.

### **Nitrate**

For the six-year data set, nitrate was detected in all groundwater samples collected from the 100-H area. Three wells report nitrate concentrations from unfiltered samples above the federal MCL value of 45,000 µg/L. Two wells (H4-46 and H4-3) report nitrate concentrations consistently above the federal MCL; well H4-46 is showing a steady downward trend. Well (H6-1) reports a single nitrate detection above the federal MCL, also showing a steady downward trend. All remaining wells consistently reported nitrate concentrations below the federal MCL.

For the RI data set, nitrate was detected in all groundwater samples collected from the 100-H area. One well reports nitrate concentrations from unfiltered samples above the federal MCL. A single detection of nitrate was reported in well H4-46 with the remaining concentrations less than the federal MCL.

### **Silver**

For the six-year data set, approximately 75 percent of the silver data set reported MDLs greater than the state surface water quality standard of 2.6 µg/L. Silver results with elevated MDLs were analyzed by EPA Method 6010 [3]. Whereas, silver results with MDLs less than the state surface water quality standard were reported by EPA Method 200.8 [3]. Fourteen silver results (nine total and five dissolved) were greater than the state surface water quality standard. Silver concentrations from filtered samples were reported above the AWQC at four wells. Three wells (H4-13, H4-5, and H4-8) reported single concentrations above the state standard however MDLs associated with these wells were also greater than the State standard. One well (H4-9) reported two silver results above the state standard, similarly MDLs were also greater than the state standard. Four additional wells (H3-2A, H4-6, H4-49 and H6-1) reported silver concentrations above the state standard in unfiltered samples, however filtered concentrations were less than the state standard.

For the RI data set, all silver MDLs and all detected antimony concentrations were less than the federal MCL. All silver results were reported by EPA Method 200.8 [3].

### **Strontium-90**

For the six-year data set, all strontium-90 minimum detectable activities (MDAs) were less than the federal MCL of 8 pCi/L. Strontium-90 concentrations from unfiltered samples were reported above the federal MCL in nine wells. Concentrations of strontium-90 are consistently above the federal MCL in one well (H4-16). Strontium-90 was detected above the MCL in one or more samples in two wells (H4-16 and H4-45) with concentrations trending upwards. Single detections of strontium-90 above the federal MCL were reported in two wells (H4-11, H6-1) with concentrations trending downwards. Single detections of strontium-90 above the federal MCL were reported in four wells (H3-2A, H4-10, H4-18, and H4-48) these detections were not associated with a trend.

For the RI data set, all strontium-90 MDAs were less than the federal MCL. Strontium-90 concentrations from unfiltered samples were reported above the federal MCL in three wells. All strontium-90 concentrations are above the federal MCL in one well (H4-13). Two of three strontium-90 concentrations were above the federal MCL in one well (H4-45). And, one of three strontium-90 concentrations were above the federal MCL in one well (H4-11).

### **Zinc**

For the six-year data set, all MDLs were less than the AWQC of 91 µg/L. Two zinc results (two total) were greater than the AWQC. Two wells (H4-13 and H4-46) reported single zinc detections above the AWQC in unfiltered samples, however all remaining unfiltered concentrations and all filtered concentrations were less than the AWQC. All zinc results were reported by EPA Method 6010.

For the RI data set, all zinc MDLs and all detected zinc concentrations were less than the AWQC.

### **Baseline Risk Assessment**

Table 4 and Table 5 show the details of contribution to risk and hazard, respectively.

The total excess lifetime cancer risk is  $1.7 \times 10^{-5}$  and is within the EPA range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$ . As shown in Table 4, the major contributors to the total cumulative ELCR (those analytes that contribute greater than 1 percent of total cumulative ELCR) are strontium-90 ( $1.5 \times 10^{-5}$ ; 84 percent contribution) and carbon tetrachloride ( $2.5 \times 10^{-6}$ ; 14 percent contribution).

As shown in Table 5, the HI is 0.63, which is less than the EPA target HI of 1.0. All individual analytes (antimony, carbon tetrachloride, chromium, cobalt, copper, hexavalent chromium, nitrate, nickel, and zinc) that contribute greater than one percent of the HI also report a HQ less than 1.

### **CONCLUSIONS**

The results of the baseline risk assessment indicate that remedial action at the 100-H Area is not warranted because the excess lifetime cancer risk and hazard index results are less than the EPA risk thresholds for protection of human health and the environment. No major risk drivers were identified as a result of the risk assessment.

Except for hexavalent chromium, comparison of individual measurements to action levels indicates that contaminant concentrations within the 100-H area are not widely distributed. For nitrate and strontium-90, there are localized wells which report concentrations above MCLs.

For hexavalent chromium, the results of the baseline risk assessment indicate remedial action is not warranted for protection of human health. However, comparison of concentrations to state surface water quality standards indicates that hexavalent chromium is a risk driver for aquatic receptors that warrants evaluation of remedial alternatives.

Finally, the evaluation of the data set representing the six-year time frame identified six metals (antimony, cadmium, cobalt, chromium, nickel, and silver) that did not have adequate detection limits for confirming their absence at concentrations that are protective of humans or aquatic receptors. These uncertainties were identified during the RI/FS work plan and the subsequent sampling determined that with the correct analytical methods, MDLs could be attained that confirm the absence at low concentrations. However, it is recommended that the overall sampling program be

modified to accommodate better method detection limits.

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