

1 Introduction

The 100-KR-4 Groundwater Operable Unit (OU) contains groundwater contaminated by releases from facilities and waste sites associated with past operation of the KE and KW Reactors. The hexavalent chromium (Cr(VI)) released from these facilities and waste sites poses a risk to human health and/or the environment and was identified in EPA/ROD/R10-96/134, *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units Interim Remedial Actions, Hanford Site, Benton County, Washington*, as the primary groundwater contaminant of concern (COC) in the 100-KR-4 OU.

1.1 Project Scope and Objective

This document, as amended by TPA-CN-0853 and TPA-CN-0869, presents the groundwater sampling and analysis plan (SAP) to support DOE/RL-2017-30, *KW Soil Flushing/Infiltration Treatability Test Plan*, which will evaluate the practicality and effectiveness of in situ soil flushing to remove residual Cr(VI) within the vadose zone at the specified 100-KR-2 Source OU. The goal of soil flushing is to remove Cr(VI) from the deep portions of the vadose zone where it presents a secondary source of groundwater contamination, and to capture it with the active pump and treat (P&T) system. The test is designed to determine if soil flushing, using treated groundwater from the K West (KW) P&T system, will enhance Cr(VI) migration through the vadose zone and if the contaminant mass can be adequately captured and extracted by the KW P&T system, thereby removing the Cr(VI) from the environment.

The 100-KR-4 OU has a standalone SAP for installing and sampling new wells (DOE/RL-2013-36, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan*.) The SAP is routinely amended to add new wells. For that reason, a separate SAP addendum (DOE/RL-2013-36-ADD6, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan, Addendum 6: Wells 199-K-235 and 199-K-236*) has been prepared to guide vadose zone soil sampling activities and well installation activities for two new groundwater monitoring wells associated with the overall soil flushing/infiltration treatability test plan (DOE/RL-2017-30).

The 100-KR-4 OU is located in the northern portion of the U.S. Department of Energy (DOE) Hanford Site (Figure 1-1). The KW P&T system is located near the KW Reactor, which operated from 1955 to 1970. Cooling water treatment chemicals, including concentrated acidic sodium dichromate solution, were used during that period and contributed to the observed Cr(VI) groundwater contamination. Figure 1-2 identifies the proposed soil flushing/infiltration area and nearby groundwater monitoring wells that will be sampled as a part of this SAP.

Soil flushing/infiltration to remove contaminants from the vadose zone and periodically rewetted zone (PRZ) was a retained component as part of Alternative 2 for optimized groundwater P&T for the 100-K Area, as identified in DOE/RL-2010-97, Draft A, *Remedial Investigation/Feasibility Study for the 100-KR-1, 100-KR-2, and 100-KR-4 Operable Units*.

The presence of persistent Cr(VI) plumes in 100-KR-4 OU groundwater indicates continuing contribution of Cr(VI), likely from a secondary source within the vadose zone overlying the unconfined aquifer. The KW Reactor area has been selected for this treatability test based on knowledge and understanding of persistent plume behavior at this location derived from groundwater monitoring, P&T system operational monitoring, historical release information, and subsurface soil characterization during excavation and remediation of the facilities in the area. The selected test location includes the area near the former 183.1KW Headhouse (hereinafter referred to as the KW Headhouse) and the former sodium dichromate solution storage tank site.

Table 1-1. 100-KW Soil Flushing/Infiltration Treatability Testing Data Needs

Data Need	Media of Interest	Location	Sampling Method	Action Level	Frequency	Practical Constraints	Analytical Method	Potential Source of Data
Mineralogical composition of Cr(VI)-bearing material in the test area vadose zone	Subsurface vadose zone soil	Former well 199-K-195; selected subsurface samples from depths of 12 to 25 m (39.4 to 82 ft) bgs	Examination of archived soil samples collected during drilling	Presence or absence of chromate-substituted calcium carbonate	One time	None noted	Electron microscopy/electron microprobe	Analysis of existing soil samples
Presence of mobile constituents in infiltration water and groundwater underlying the treatability test zone	Infiltration water and groundwater	KW P&T effluent; existing wells 199-K-166, 199-K-205, 199-K-223, and 199-K-224; two new water table monitoring wells installed as part of this test (199-K-235 and 199-K-236)	Pumped samples from wells, filtered and unfiltered aliquots collected from in-plant sample taps for the extraction wells and process effluent; and from a depth of <1 m (3.3 ft) below the water table from monitoring wells	Concentration increase of mobile constituents above that observed prior to initiating vadose flush activity	<ul style="list-style-type: none"> Once before initiating vadose flush activity Alternate daily <u>Daily</u> measurements after start of vadose flush activity and continuing until a peak concentration is observed; for Cr(VI), specific conductance and pH in wells 199-K-205 and 199-K-236 the two new shallow wells (199-K-235 and 199-K-236) Weekly <u>Monthly</u> measurement of mobile constituents at wells 199-K-166, 199-K-205 and the two new monitoring wells (199-K-223 and 199-K-224) for the first two weeks of each phase, followed by alternate weeks thereafter <u>then</u> During mound dispersion periods, Cr(VI) will be collected in 199-K-205 and 199-K-236 every other day for the first two weeks, then weekly for two weeks, then alternating weeks. For all other wells in the test network, Cr(VI) will continue monthly. Measurements of mobile contaminants will be collected monthly. 	Will require coordination between plant operation staff and groundwater sampling personnel	Filtered Cr(VI), chloride, sulfate, sodium, aluminum, specific conductance, and pH in filtered and unfiltered aliquots Filtered Cr(VI), specific conductance, and pH Filtered Cr(VI), chloride, sulfate, sodium, aluminum, specific conductance, and pH in filtered and unfiltered aliquots	Sampling and analysis of water samples from specified locations
Alkalinity of infiltration water and groundwater to support evaluation of movement of the flushing water through the treatability test area	Infiltration water and groundwater	KW P&T effluent and existing wells 199-K-166, 199-K-205, 199-K-235, and 199-K-236	Pumped samples from wells and process effluent sample taps	Not applicable	Weekly for the first two weeks, then alternate weeks <u>monthly for 199-K-205 and 199-K-236</u> . All <u>other wells in the test network</u> will be collected monthly.	Will require coordination between plant operation staff and groundwater sampling personnel	Alkalinity in unfiltered aliquots	Sampling and analysis of water samples from specified locations
Cr(VI) concentration time series in groundwater following application of vadose flush action	Groundwater	Existing extraction well 199-K-205 <u>and monitoring well 199-K-236; two new water table monitoring wells installed within the treatability test footprint (199-K-235 and 199-K-236)</u>	Pumped groundwater samples	Cr(VI) concentration in groundwater >20 µg/L	<ul style="list-style-type: none"> Alternate daily <u>Daily</u> measurements after start of vadose flush activity and continuing until a peak concentration is observed, then reduce to two times a week, then weekly <u>for two weeks, then alternating weeks</u>. During mound dispersion periods, measurements of Cr(VI) will be collected in 199-K-205 and 199-K-236 	None noted	Filtered Cr(VI)	Sampling and analysis of water samples from specified locations

Table 1-1. 100-KW Soil Flushing/Infiltration Treatability Testing Data Needs

Data Need	Media of Interest	Location	Sampling Method	Action Level	Frequency	Practical Constraints	Analytical Method	Potential Source of Data
					every other day for the first two weeks, then weekly for two weeks, then alternating weeks. For 199-K-235, measurements of Cr(VI) will be collected monthly.			
Concentration of dissolved and suspended manganese in infiltration water and groundwater	Infiltration water and groundwater	Existing extraction wells 199-K-166 and 199-K-205; two new water table monitoring wells installed within the treatability test footprint; KW P&T process effluent	Pumped groundwater samples	Detectable concentrations and increasing trend	Weekly during first vadose flush volume, then alternate weeks Monthly for all locations.	None noted	Total metals in filtered and unfiltered aliquots	Sampling and analysis of water samples from specified locations
Concentration of suspended and dissolved nontarget toxic metals (i.e., mercury, selenium, vanadium, total chromium, copper, and lead) in infiltration water and groundwater	Infiltration water and groundwater	Existing extraction wells 199-K-166 and 199-K-205; two new water table monitoring wells installed within the treatability test footprint (199-K-235 and 199-K-236); KW P&T process effluent	Pumped groundwater samples	Detectable and increasing above pre-flushing concentrations	Weekly during first vadose flush volume, then alternate weeks Monthly for all locations	None noted	Total metals in filtered and unfiltered aliquots	Sampling and analysis of water samples from specified locations
Post-soil flushing concentrations of contaminants to confirm depletion of secondary source material	Groundwater	Existing extraction wells 199-K-166 and 199-K-205; two new water table monitoring wells (199-K-223 and 199-K-224), KW P&T process influent and effluent	Pumped groundwater samples	Stable or decreasing trends at or below applicable standards	Quarterly for up to a year	None noted	Filtered and unfiltered aliquots of all identified contaminants	Sampling and analysis of water samples from specified locations

bgs = below ground surface

Cr(VI) = hexavalent chromium

P&T = pump and treat

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Table 3-6. Target Analytes and Monitoring Frequency for Third and Subsequent Phases of Flushing

Location Name	Well ID	Plant ID	Location Type	Hexavalent Chromium (EPA Method 7196 ^a)	Metals (Filtered and Unfiltered)									Anions		Groundwater Properties						
					Aluminum	Chromium (Total)	Copper	Lead	Manganese	Mercury	Selenium	Sodium	Vanadium	Chloride	Sulfate	Dissolved Oxygen	Temperature	Turbidity	pH	Oxidation-Reduction Potential	Specific Conductance	Water Level
199-K-166	C6452	WE6	Current extraction well downgradient of soil flushing area	<u>M</u> <u>W</u> ^c	W <u>M</u>	<u>M</u> E	<u>M</u> E	<u>M</u> E	<u>M</u> E	E <u>M</u>	<u>M</u> E	<u>M</u> W	<u>M</u> E	<u>W</u> M	<u>M</u> W	b	b	b	b	b	b	b
199-K-205	C8292	WE11	Current extraction well in soil flushing footprint	<u>D</u> <u>A</u> ^c	W <u>M</u>	<u>M</u> E	<u>M</u> E	<u>M</u> E	<u>M</u> E	E <u>M</u>	<u>M</u> E	<u>M</u> W	<u>M</u> E	<u>W</u> M	<u>M</u> W	b	b	b	b	b	b	b
199-K-235	C9973	N/A	Planned groundwater well within soil flushing footprint	<u>D</u> <u>M</u> <u>W</u> ^c	W <u>M</u>	<u>M</u> E	<u>M</u> E	<u>M</u> E	<u>M</u> E	E <u>M</u>	<u>M</u> E	<u>M</u> W	<u>M</u> E	<u>M</u> W	<u>M</u> W	b	b	b	b	b	b	b
199-K-236	C9974	N/A	Planned groundwater well within soil flushing footprint	<u>D</u> <u>A</u> ^c	W <u>M</u>	<u>M</u> E	<u>M</u> E	<u>M</u> E	<u>M</u> E	E <u>M</u>	<u>M</u> E	<u>M</u> W	<u>M</u> E	<u>M</u> W	<u>M</u> W	b	b	b	b	b	b	b
199-K-223	C9595	N/A	Existing downgradient groundwater well	<u>M</u> <u>W</u> ^c	W <u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>	<u>W</u> <u>M</u>	<u>M</u>	<u>M</u> W	<u>M</u> W	b	b	b	b	b	b	AWLN ^b
199-K-224	C9596	WE13	Current extraction well downgradient of soil flushing area	<u>M</u> <u>W</u> ^c	W <u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>	<u>M</u>	<u>W</u> <u>M</u>	<u>M</u>	<u>M</u> W	<u>M</u> W	b	b	b	b	b	b	b
KW P&T facility	N/A	T-W3	Effluent tank	<u>M</u> <u>W</u> ^c	W <u>M</u>	<u>M</u> E	<u>M</u> E	<u>M</u> E	<u>M</u> E	E <u>M</u>	<u>M</u> E	<u>M</u> W	<u>M</u> E	<u>M</u> W	<u>M</u> W				<u>M</u> <u>W</u>		<u>M</u> <u>W</u>	

Note: Subsequent flushing (and drainage) phases may also be completed based on ongoing review of data and results.

a. EPA Method 7196 is included in SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition; Final Update V*, as amended.

b. Groundwater properties and water levels will be measured every well trip. Wells 199-K-223, 199-K-235, and 199-K-236 are also monitored by the AWLN. Sample depth for monitoring wells will be <1 m (3 ft) below the top of the water table. Samples from wells 199-K-205 and 199-K-224 and KW P&T facility effluent will be obtained from in-plant sample taps.

c. After the first two weeks of sampling, a graded approach to scaling back sampling will be followed in accordance with Table I-1.

A = alternate days until a peak concentration is observed or as determined by the project technical lead

AWLN = automated water-level network

D = daily measurements until a peak concentration is observed or as determined by the project technical lead

E = every other week M = monthly

N/A = not applicable

P&T = pump and treat

W = weekly