The 100-C-7 Remediation Project

An Overview of One of DOE's Largest Remediation Projects - 13260

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ABSTRACT

The U.S. Department of Energy Richland Operations Office (RL), U.S. Environmental Protection Agency (EPA) and Washington Closure Hanford LLC (WCH) completed remediation of one of the largest waste sites in the U.S. Department of Energy complex. The waste site, 100-C-7, covers approximately 15 football fields and was excavated to a depth of 85 feet (groundwater). The project team removed a total of 2.3 million tons of clean and contaminated soil, concrete debris, and scrap metal. 100-C-7 lies in Hanford's 100 B/C Area, home to historic B and C Reactors. The waste site was excavated in two parts as 100-C-7 and 100-C-7:1. The pair of excavations appear like pit mines. Mining engineers were hired to design their tiered sides, with safety benches every 17 feet and service ramps which allowed equipment access to the bottom of the excavations.

The overall cleanup project was conducted over a span of almost 10 years. A variety of site characterization, excavation, loadout and sampling methodologies were employed at various stages of remediation. Alternative technologies were screened and evaluated during the project. A new method for cost effectively treating soils was implemented - resulting in significant cost savings. Additional opportunities for minimizing waste streams and recycling were identified and effectively implemented by the project team. During the final phase of cleanup the project team applied lessons learned throughout the entire project to address the final, remaining source of chromium contamination. The C-7 cleanup now serves as a model for remediating extensive deep zone contamination sites at Hanford.

INTRODUCTION

The U.S. Department of Energy Richland Operations Office (RL), U.S. Environmental Protection Agency (EPA) and Washington Closure Hanford LLC (WCH) completed remediation of one of the largest waste sites in the U.S. DOE complex. The waste site, 100-C-7, covers approximately 15 football fields and was excavated to a depth of 85 feet (groundwater). It lies in Hanford's 100 B/C Area, home to historic B and C Reactors. The waste site was excavated in two parts as 100-C-7 and 100-C-7:1. The pair of excavations appear like pit mines. Mining engineers were hired to design their tiered sides, with safety benches every 17 feet and service ramps to get equipment to the bottom. The project team removed a total of 2.3 million tons of clean and contaminated soil, concrete debris, and scrap metal. *Figure 1*

The River Corridor at U.S. DOE's Hanford Site is a 220-square-mile area along the Columbia River and is DOE's largest environmental closure project. Cleanup of the waste sites in the River Corridor is part of the $2.3 billion River Corridor Closure Project. The River Corridor is home to Hanford's nuclear reactors and fuel development facilities. The reactors are located next to the Columbia River and were used to produce plutonium for atomic weapons during World War II and the Cold War. Between 1944 and 1964, sodium dichromate was added to the cooling water systems of the plutonium production reactors to reduce pipe deterioration. Millions of gallons of river water flowed through the reactors per second, resulting in massive quantities of hexavalent chromium being added to the water. The sodium dichromate entered the environment through leaks, and spills at transfer areas where loading and unloading operations took place. As a result, hexavalent chromium contamination is one of the primary contaminants of concern at Hanford in both the soil and groundwater.

Hexavalent chromium is the primary contaminant of concern at the 100-C-7 waste site. The source of contamination at 100-C-7 is believed to be the result of a 1966 spill near C Reactor's 183-C Head House (see Hall Report) as well as other significant spills which occurred during historic reactor operations.

Hexavalent chromium is a highly mobile contaminant which with enough time, can migrate to groundwater and can pose challenges in characterizing and remediating deep vadose zone soils. Treatment of groundwater contaminated with hexavalent chromium throughout the Hanford Site has cost hundreds of millions of dollars during the last two decades. RL, EPA and WCH determined that because contamination was so widespread at 100-C-7 and extended all the way to groundwater that the project should remove the source of contamination.

The 100 B/C Reactor Area has a low level groundwater plume of hexavalent chromium and parties believed it would be prudent to remove the source of contamination before the groundwater became worse. Groundwater is currently being treated at four of six Hanford reactor areas due to extensive hexavalent contamination. Running a pump and treat groundwater system has significant short and long term costs. There is currently no groundwater Record of Decision for the 100 B/C Area, however groundwater exceeds both the Washington State MCL and the AWQC. In general, the hexavalent chromium plume is a large, fairly dilute plume. The remediation goal for the 100-C-7 waste site is to clean up soil contaminated with hexavalent chromium before more of the chromium could be spread to the underlying groundwater and eventually drain into the Columbia River less than one mile away.

DESCRIPTION

Initial Remediation

Remedial action at 100-C-7:1 was initiated in December 2004 with excavation of a stained surface soil area located north of the 183-C Headhouse to a depth of approximately 15 feet. Excavation included the area approximately 250 feet south of the stained surface soil and adjacent to the north side of the 183-C Headhouse, where outdoor chemical storage tanks were once located. In-process sampling indicated residual hexavalent chromium contamination exceeded the cleanup criteria of 2 mg/kg (based on protection of surface water). Hexavalent chromium staining was also observed on the outside foundation wall of the 183-C Sedimentation Basins exposed in the east sidewall of the excavation.

In April 2005 a pothole was excavated at the bottom of the 100-C-7:1 excavation to a total depth of 33 feet below ground surface to characterize the extent of chromium contamination. Soil contamination was present at 33 feet with hexavalent chromium at 1,620 mg/kg. Discolored soil was observed in the sidewalls of the pothole.

In 2007 eight characterization test pits and several boreholes were constructed in the vicinity of 100-C-7 soil staining to further assess the extent of hexavalent chromium contamination at depth, to determine how much additional contaminated soil required removal, to estimate the volume of soil that will require waste treatment to meet the Environmental Restoration and Disposal Facility (ERDF) waste acceptance criteria prior to disposal, and to evaluate remediation alternatives. Sampling data confirmed significant, widespread contamination throughout the site and at depth to groundwater (85 feet bgs) ranging from 1,620 mg/kg hexavalent chromium 33 ft bgs to 31 mg/kg 85 ft bgs (at the groundwater interface).

Alternative technologies were considered. In-situ treatment was evaluated but not selected as the remedial technology due to uncertainties of the vadose zone's lithology (homogenous vs heterogeneous), technical uncertainties of in-situ treatment, the goal of completing cleanup along the River Corridor by 2015, and, non-acceptance by Stakeholders of the concept of applying vast quantities of water to the 100-C-7 waste site as either part of a pilot study for in situ treatment or full-scale treatment which could potentially spread contamination to the underlying aquifer.

Cleanup Requirements

The extent of cleanup necessary to achieve the specified level of remediation at the 100-C-7 waste site is defined in an Interim Action Record of Decision signed by U.S. DOE, the U.S. Environmental Protection Agency and the State of Washington Department of Ecology. The Interim Action Record of Decision established the following Remedial Action Objectives for the 100-C-7 waste site: (1) Protect human and ecological receptors from exposure to contaminants in soils, structures, and debris by dermal exposure, inhalation, or ingestion of radionuclides, inorganics or organics, and, (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.

The Hanford Reach is the nation's last, non-tidal free-flowing segment of the Columbia River. Forty-three species of fish have been documented as occurring in the Hanford Reach. Upper Columbia Spring Chinook, listed as a federally threatened species, also use the Hanford Reach for migration, as well as both the Middle Columbia River Steelhead and Upper Columbia River Steelhead both of which are federally threatened species. One of the largest populations of Fall Chinook salmon in the Columbia River spawn and rear throughout the Hanford Reach. Adult Fall Chinook salmon spawning in the Hanford Reach has ranged from 20,000 to 90,000 over the last 35 years. Many other species of fish inhabit the Hanford Reach including white sturgeon, smallmouth bass, common carp, mountain whitefish, mountain sucker, sandroller, paiyte sculpin, and reticulate sculpins.

Hexavalent chromium is particularly toxic to young salmon and other aquatic life. The cleanup requirement for hexavalent chromium at Hanford is to reduce ground water contamination to 20 ppb hexavalent chromium before it reaches the Columbia River to meet Ambient Water Quality Criteria of 10 ppb. Federal and state groundwater and surface water protection requirements have resulted in a soil protection cleanup level of 2.0 mg/kg for hexavalent chromium at the 100-C-7 waste site. Removing the source of contamination before it migrates to the aquifer is a more conservative and more cost effective alternative than pumping and treating groundwater. The 100-C-7 remediation project recovered larger quantities and higher concentrations of hexavalent chromium than expected. In all, approximately 66 tons of chromium was removed from the100-C-7 waste site – significantly more than that removed from all of Hanford's groundwater pump and treat systems combined.

EXCAVATION TO GROUNDWATER

Excavation to groundwater at 100-C-7 was conducted from June 8, 2010 to January 30, 2013. (U.S. DOE also completed removal of 40,000 tons of contaminated soil prior to 2004 under a prior cleanup contract). The waste site was excavated in two parts as 100-C-7 and 100-C-7:1. Mining engineers were hired to design their tiered sides, with safety benches every 17 feet and service ramps which allowed equipment access to the bottom of the excavations. The pair of excavations appear like pit mines. *Figure 2*

The project team removed a total of 2.3 million tons of clean and contaminated soil, concrete debris, and scrap metal. About 650,000 tons of material was contaminated and shipped to the Environmental Restoration Disposal Facility (ERDF) at Hanford. Of that, 65,000 tons of Land Disposal Restriction (LDR) material required treatment to prevent leaching at ERDF. Total disposed: 962,000 tons (to date), Total Concrete to U-Canyon: 212,000 tons, Total disposed at ERDF during 2004-2005 campaign: 40,000 tons, 630 tons of scrapmetal and rebar recycled. The estimate at completion (EAC), including the west wall plume of C-7:1 will equal 1.2 million tons disposed.

Waste Minimization/Recycling of Concrete and Rebar

On June 10, 2010 WCH began demolition of the reinforced concrete substructures associated with the 183-C Headhouse, 183-C Sedimentation Basins, the 183-C Filter Building, and the 183-C Clearwell pads in the vicinity of the 100-C-7 and 100-C-7:1. Demolition of the concrete foundations included shearing asbestos wrapped pipes and rebar and staging concrete rubble to the designated staging areas. Concrete, enmeshed with rebar, was demolished and removed to a depth of 35 ft. Significantly more concrete was encountered than initially estimated in dated designs and as-built drawings.

A total of 212,000 tons of concrete rubble from 100-C-7 was staged at the U Plant in central Hanford, where it will be used as fill material for a cap over the former plutonium processing canyon. Not having to dispose of the clean material in the ERDF saved valuable disposal space and eliminated substantial disposal costs. A total of 630 tons of scrap metal, including piping, rebar and structural steel from 100-C-7 and 100-C-7:1 was recycled by a local company after being subjected to a robust radiological survey plan to ensure no contaminated waste entered the debris stream.

Following subsurface concrete demolition, remedial activities to remove contaminated soil and portions of inactive pipeline resumed on January 27, 2011 and continued through January 30, 2013.

DISCUSSION

Field Constraints

An active, 42-inch concrete export water line was located along the northern edge of the 100-C-7 waste site. DOE, EPA, and WCH decided to relocate the export water line further north to support remedial activities of 100-C-7:1 before excavation to groundwater began (December 2010 to January 2011). Rerouting Hanford's main export water line, which supplies millions of gallons of water per second to the rest of the Hanford Site, was a major undertaking at $1.2 million.

To help determine the northern extent of the chromium contamination, two boreholes were drilled north of the site to ensure the relocation of the waterline fell outside the extent of contamination. Neither showed chromium contamination.

A plume of contamination extending from the western wall of C-7:1 was discovered during remediation with soil samples exceeding 300mg/kg for hexavalent chromium. The quantity of west wall plume material is estimated to be 125,000 BCMs and is anticipated to extend to groundwater. A high-voltage 230kV Bonneville Power Administration line was relocated and rerouted one-mile to accommodate the additional plume to be remediated. The cost for the powerline relocation was approximately $1.3 million.

Land Disposal Restriction (LDR) Treatment of Contaminated Soils

65,000 tons of contaminated material had enough contamination that it was required to be treated for chromium contamination prior to disposal at ERDF. To treat chromium contaminated soil, ferrous sulfate is used to convert hexavalent chromium (more soluble form) to trivalent chromium (less soluble form).
A new waste treatment formula was developed consisting of 5% ferrous sulfate (prior formula used 15%). Cost savings as a result of this effort was ~$3.4M. WCH treated about 36 containers of chromium contaminated soil per day (over 700 tons/day). The new formula saves about $1,000 per container.

In Process Sampling

Visual observation, XRF measurements, and in-process samples were collected throughout the duration of the 100-C-7:1 waste site remediation to guide excavation and identify contaminated soil. Following completion of remedial activities at 100-C-7:1, with the exception of the west sidewall, in-process sampling was performed across the floor of the excavation (approximately one to two feet above the groundwater level) to determine the residual hexavalent chromium present at the bottom of the excavation. The intent of in-process sampling of the excavation floor was for information purposes only to determine the most feasible location for installation of a groundwater monitoring well. Ten samples were focused at locations where XRF measurements identified higher potential concentrations of chromium. Analytical results showed a maximum concentration of 39.6 mg/kg for hexavalent chromium.

At the completion of the sampling, the final excavation lift was removed to a depth of ~0.5 m above the current groundwater elevation to prevent ponding in the bottom of the excavation. The final lift was staged in a separate stockpile area for additional waste characterization prior to disposal at ERDF.

Closeout Verification Sampling

Based on discussions between DOE and EPA, it was agreed that as a lift of material was completed, the field personnel would map the stockpile boundary using a hand-held GPS instrument. Each lift was then divided into approximate quadrants, and a sample was collected from each quadrant. Each sample consisted of 25 aliquots collected across the surface of the quadrant, combined into one sample for analysis. Each sample was submitted for full protocol analysis for ICP metals, mercury, and hexavalent chromium.

The general guideline for verification sampling of overburden/layback stockpiles was performed by field personnel to the extent practicable. Due to safety concerns with ongoing remediation, the rigorous remediation schedule, and additions of overburden/layback materials to the sides of the stockpiles, sampling had to be performed whenever possible. This resulted in a higher number of samples being collected, per stockpile lift, than was originally anticipated. Each stockpile lift contained at least four samples, and some contained as many as twelve.

Verification sampling of the 100-C-7:1 upper sidewalls was performed prior to completion of remedial activities due to fall hazard and safety concerns - the expected depth of the final excavation was approximately 89 feet. Gradual sloughing occurred along some benches. Various sampling alternatives were considered and a couple locations were relocated towards lower, accessible locations within the excavation.

Groundwater Study

During remediation dust suppression water was used and likely had an impact, driving some contamination into the aquifer. A downgradient monitoring well experienced a significant increase in hexavalent chromium resulting in a groundwater study being performed by PNNL at the bottom footprint of the C-7:1 excavation.

The PNNL study had two primary goals: 1) Help define the extent and level of contamination in the shallow groundwater beneath C-7:1 that may be contributing to the new chromium concentration spike observed in the down gradient well, 2) Conduct a tracer study to refine estimates of groundwater flow rate and direction. Current modeling is that groundwater flow is extremely slow, however, this is inconsistent with the observation of the new down gradient spike occurring in a relatively short time-frame after remediation began.

The actual work involved placing a grid of temporary GW sample points using direct push technology to install a grid of about 10 sample locations in the bottom of the excavation. In addition a grid of up to 5 additional points was used for a monitoring network for the tracer study. The groundwater concentrations and tracer movement were evaluated over a several month period and then sample points/wells were decommissioned prior to when WCH planned to begin backfilling in October 2012.

The PNNL study concluded, "The hexavalent chromium (Cr(VI)) data collected from project installed aquifer tubes showed a short-lived and relatively small pulse of Cr(VI) was released to groundwater at the excavation site during the study period. This release occurred in response to the seasonal rise in the water table, and associated saturation of excavation-bottom sediments, resulting from an increase in Columbia River stage. By the end of the study period, even though the water table was still high, Cr(VI) concentrations had dissipated with no significant continuing source observed, providing direct evidence that sorption of Cr(VI) to vadose zone or aquifer sediments is minimal and that Cr(VI) present in the lower vadose zone is readily mobilized when the sediments become saturated." *Figure 3*

CONCLUSIONS

Deep excavation of soils to groundwater has been completed at the 100-C-7 and 100-C-7:1 waste sites located within the Hanford 100 B/C Reactor Area. Excavation of the original remedial designs was completed on February 27, 2012. To date, approximately 261,414 BCMs of contaminated soil was excavated for disposal at ERDF, and 373,403 BCM of overburden/layback soil was excavated and stockpiled at the site for use as backfill material. Approximately 66% of the original excavated material will be returned as backfill at C-7 and C-7:1. Revegetation of backfilled areas will be performed with native plant species.

An additional plume of hexavalent contamination was discovered on the west wall of C-7:1. An estimated 125,000 BCMs of material was removed in order to remediate the remaining contamination plume to groundwater. Excavation to groundwater is scheduled to be completed January 30, 2013.

Hexavalent chromium poses significant characterization and remediation challenges. Removing the source of contamination before it migrates to the aquifer was found to be a more conservative and more cost effective alternative than spending hundreds of millions of dollars pumping and treating groundwater for decades. The 100-C-7 remediation project recovered greater quantities and higher concentrations of hexavalent chromium than expected. In all, approximately 66 tons of chromium was recovered from the 100-C-7 waste site – significantly more than that removed from all of Hanford's groundwater pump and treat systems combined.

Figure 1: 100-C-7 and 100-C-7:1 Aerial View, January 2012.

Figure 2: Excavation to groundwater at 100-C-7.

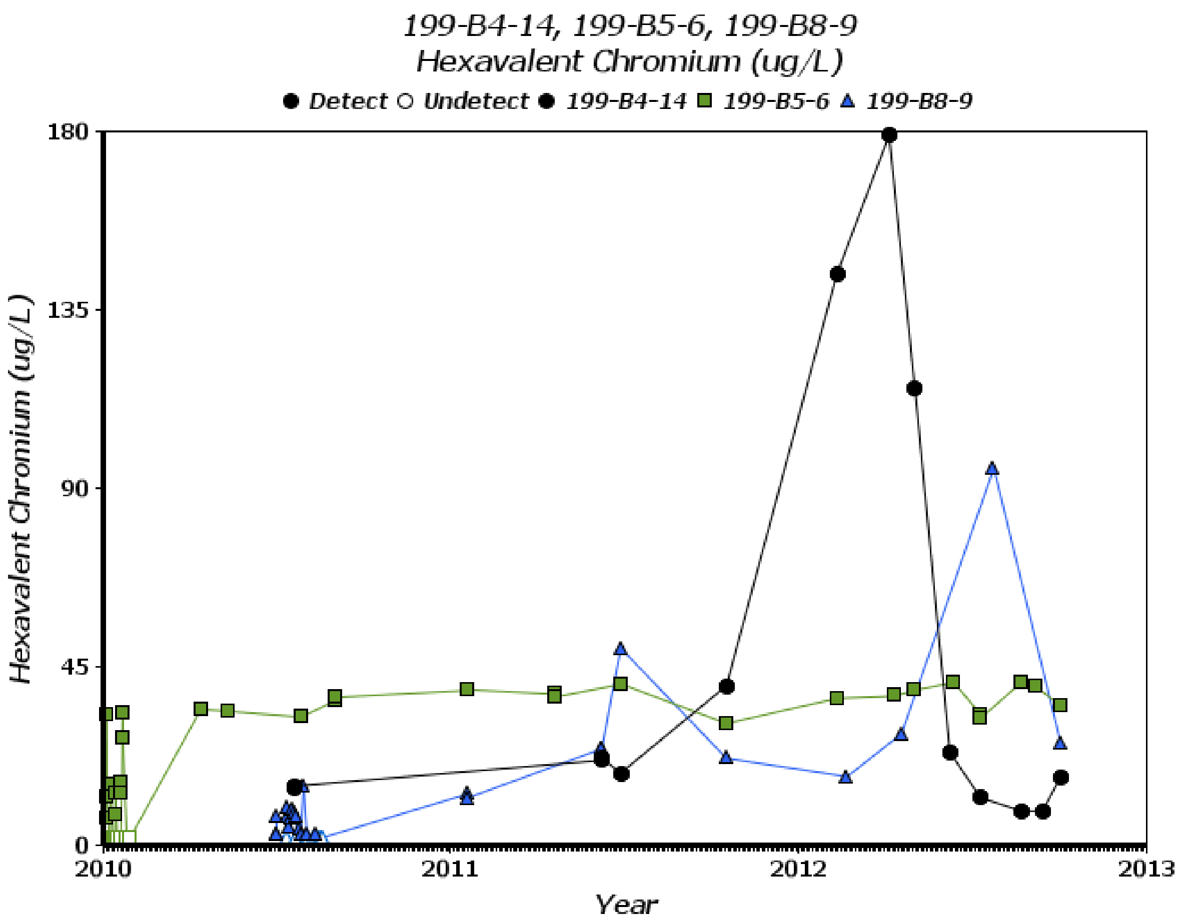

Figure 3: PNNL Groundwater Study at 100-C-7:1.

REFERENCES

1. BATTELLE-NORTHWEST, "Contamination Release To the Environs, Hall Report," September 23-24, 1966.

2. TRUEX, MJ (et al), "Investigation of Hexavalent Chromium Flux to Groundwater at the 100-C-7:1 Excavation Site," PNNL-21845, RPT-DVZ-AFRI-005, September 2012.