INSTALLATION OF REACTIVE METALS GROUNDWATER COLLECTION AND TREATMENT SYSTEMS

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ABSTRACT

Three groundwater plumes contaminated with volatile organic compounds (VOCs) and radionuclides at the Rocky Flats Environmental Technology Site are scheduled for remediation by 1999 based on the Rocky Flats Cleanup Agreement (RFCA) (DOE, 1996). These three plumes are among the top 20 environmental cleanup sites at Rocky Flats. One of these plumes, the Mound Site Plume, is derived from a previous drum storage area, and daylight seeps near the South Walnut Creek drainage. Final design for remediation of the Mound Site Plume has been completed based on use of reactive metals to treat the contaminated groundwater, and construction is scheduled for early 1998.

The two other plumes, the 903 Pad/Ryan's Pit and the East Trenches Plumes, are derived from VOCs either from drums that leaked or that were disposed of in trenches. These two plumes are undergoing characterization and conceptual design in 1998 and construction is scheduled in 1999. The contaminants of concern in these plumes are tetrachloroethene, trichloroethene, carbon tetrachloride and low levels of uranium and americium.

The RFCA includes a two phase groundwater strategy: 1) to remove the source of contamination, and 2) to prevent contamination of surface water by applying action levels to groundwater which are protective of surface water. Collection and treatment of the contaminated groundwater plume derived from the Mound Site is consistent with this strategy.

The objective for RFETS and EnviroMetal Technology Inc. (ETI) was to design and install a simple intercept and treatment system for the Mound Site Plume

to protect surface water to the extent practicable, treat contaminated groundwater to levels consistent with the RFCA for unrestricted discharge, to minimize the generation of low level mixed waste, and to demonstrate a low cost and effective technology for other contaminated groundwater plumes at RFETS and at other DOE sites. The selected treatment system will utilize an innovative, primarily passive, reactive metals treatment system for VOC and radionuclide removal. The Mound Site Plume collection system is designed to be effective for a low flow, low permeability claystone regime.

EPA's SITE Program will monitor the operation of the Mound Site Plume. The data gathered from the monitoring program will be used by RMRS and ETI to optimize the design of the collection and treatment systems for the 903 Pad/Ryan's Pit and East Trenches Plumes.

INTRODUCTION

The Mound Site Plume contains chlorinated organic compounds, americium and uranium in excess of action levels defined in the RFCA. The proposed action will consist of constructing a subsurface groundwater collection system coupled with a passive reactive metals treatment system to treat contaminated groundwater from the Mound Site Plume and surface water seeps to the surface water action levels specified in the RFCA. The project will be conducted in accordance with RFCA, DOE Orders and RFETS policies and procedures. Funding for this project was provided by DOE EM50 - Subsurface Contaminant Focus Area.

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Background

The Mound Site Plume is located on the east side of the RFETS Industrial Area, and east of the protected area fence (Figure 1). This plume of primarily volatile organic compound (VOC) contaminated groundwater is believed to originate from the Mound Site, and extend northward to where the plume discharges as seeps and subsurface flow into the South Walnut Creek drainage. Low levels of uranium and metals below background levels have been detected at a seep (Figure 1).

Most of the groundwater contamination is believed to be derived from the Mound Site where approximately 1,405 intact drums were stored on the ground surface, covered with soil between April 1954 and September 1958. The drums contained uranium and beryllium-contaminated lathe coolant (a mixture of approximately 70 percent hydraulic oil and 30 percent carbon tetrachloride). Historical information also indicates that some of the coolant contained low levels of plutonium. In 1970, all drums along with some radiologically-contaminated soil were removed from the Mound Site. Approximately 10 percent of the drums were thought to be leaking at the time of removal. However, there are no records of the volume of contaminants released to the soils at the Mound Site (DOE 1992).

An accelerated removal action was completed in Spring 1997 to excavate the soil contaminated with VOCs above action levels from the Mound Site (DOE 1997a).

Hydrogeologic Setting

At the source area for the Mound Site Plume, bedrock unconformably underlies approximately 12 feet of surficial deposits and consists of weathered claystone and minor sandstones of the Cretaceous Arapahoe and Laramie Formations (DOE 1995, DOE 1997a) (Figure 2). The Arapahoe No. 1 Sandstone subcrops under the northwest corner of the Mound Site, and is truncated to the north by the South Walnut Creek drainage. Groundwater within the Arapahoe No. 1 Sandstone exits into the colluvium, causing a higher water table, and an increase in vegetation (DOE 1995, RMRS 1996a). The Arapahoe No. 1 Sandstone is absent under the eastern portion of the Mound Site.

Near the distal end of the plume, clay-rich colluvium partially derived from the Rocky Flats Alluvium unconformably overlies Laramie Formation claystone (DOE 1995, EG&G 1995a, EG&G 1995b, RMRS 1996c, and RMRS 1996a). The elevation to bedrock is variable as this area has been extensively disturbed by landslides and/or slumps. Aerial photographs showed that the area

was extensively regraded in 1962. The bedrock surface forms a shallow trough plunging to the north, which probably directs groundwater flow. Depth to the bedrock surface varies from 5 to 15 feet over much of the area. At the eastern extent, bedrock is 25 feet below ground surface due to fill material brought in for the eastern perimeter road.

The groundwater occurs in the alluvium, colluvium, in the weathered bedrock, and in the underlying Arapahoe No. 1 Sandstone. Groundwater flow is primarily to the north and follows the bedrock surface. Recharge occurs primarily through local infiltration of precipitation or local runoff. Geometric mean hydraulic conductivities are 6×10^{-04} cm/sec for the Rocky Flats Alluvium and 8×10^{-08} cm/sec for the weathered claystone (DOE 1995). Geometric mean hydraulic conductivity for the colluvium is 9×10^{-05} cm/sec (EG&G 1995b).

The groundwater discharges through subsurface seeps from the bedrock into the colluvium along the hillside, seeps on the south bank of South Walnut Creek, and through evapotranspiration. Infiltration into the underlying unweathered claystone is limited (DOE 1995, EG&G 1995b). Depending on the season, unsaturated areas may occur within the plume (DOE 1996b, EG&G 1995b, RMRS 1996a). At seep SW059, groundwater containing low levels of VOCs with trace amounts of radionuclides discharges at a rate averaging less than 0.5 gallons per minute. The seep water is currently collected, transported and treated onsite (DOE 1995, RMRS 1996b).

Based on historical flow rates from seep SW059, available hydrogeologic data, and typical rates for other groundwater drains at the Site, the groundwater flow for the Mound Site Plume was calculated to be 0.1 to 2 gallon per minute.

Mound Site Plume Contamination Data Summary

Tetrachloroethene is the predominant contaminant found in soil and groundwater at the Mound Site, with the highest historic groundwater concentration of 528,000 ug/l in Well 0174. Concentrations decrease towards South Walnut Creek, which supports the Mound Site as the source area for the contaminants seen in this plume.

From the source area to the distal end of the groundwater plume, the most commonly detected groundwater contaminants in the Mound Site Plume are tetrachloroethene and trichloroethene. Carbon tetrachloride is detected only on the western side of the plume; at seep SW059 and at location 10397. This may indicate that there is a separate source of contamination in the road fill. Both dichloroethene and vinyl chloride are

Figure 1
Mound Site Plume Area

- EXPLANATION**
- Saturated Area Boundaries
 - Approximate Location of Collection Trench
 - Approximate Location of Piping and Treatment System
 - Approximate Location of 72" Storm Sewer
 - Large Diameter Culvert
 - Surface Water
 - Monitoring Locations
 - Groundwater Monitoring Wells & Piezometers
 - EPA Groundwater Sampling Locations
 - Rainholes
 - Recent Gasprobe Sampling Locations
 - SMO 90 Holding Tank
 - 2 Foot Contours
- Standard Map Features**
- Buildings
 - Lakes and ponds
 - Streams, ditches, or other drainage features
 - Fences
 - Rocky Plume boundary
 - Paved roads
 - Dirt roads
- All features shown on this map were obtained from the following sources:
1. Aerial photography
2. Ground survey
3. Existing maps
4. Other sources as noted
- Scale = 1" = 1400'
1 inch represents approximately 117 feet
- State Plane Coordinate Projection
California Central Zone
Datum: NAD27

Figure 2
Mound Groundwater Plume
 Hydrogeologic Cross Section

present in the distal portion of the plume, and are degradation products of trichloroethene and tetrachloroethene (RMRS 1996a, DOE 1995, DOE 1996b).

Soil and groundwater samples were collected near the distal end of the plume during Spring 1997 to support the design of the collection and treatment system. The

analyses indicate that the highest groundwater concentrations in the distal end of the plume are trichloroethene (TCE) at 844 ug/l, tetrachloroethene (PCE) at 260 ug/l, and cis-1,2 dichloroethene at 808 ug/l seen at location 10797, directly downgradient of the Mound Site source area. Table 1 summarizes the groundwater results of this investigation.

Table 1. Groundwater Contaminants of Concern from Recent Investigation Results (in ug/l)

Compound	Minimum	Maximum	Average	Number of Detects	Tier I ALF	Tier II ALF
Vinyl Chloride	nd	55.0	13.0	5	200	2
1,1 Dichloroethene	nd	94.2	18.0	8	700	7
cis 1,2 Dichloroethene	nd	808.0	169.0	9	7000	70
Carbon Tetrachloride	nd	6.6	0.8	1	500	5
Chloroform	nd	177	17	6	10000	100
Trichloroethene	nd	844	195	9	500	5
Tetrachloroethene	nd	261	66	8	500	5
Methylene Chloride	nd	18	4	3	500	5
Americium 241*	0.25	0.25	0.25	1	15	0.15
Gross Beta*	3.1	28	8	14		19**
Uranium 234*	3.4	3.4	3.4	1	298	3

* Insufficient water to obtain radiological analyses, data is from seep SW059

** Surface water action level for Walnut Creek

PROJECT APPROACH

A downgradient capture system will be installed in 1998 near South Walnut Creek to intercept contaminated groundwater and to minimize impacts to surface water. A subsurface groundwater collection system will be coupled with a passive reactive metals treatment system to treat contaminated groundwater from the Mound Site Plume to the appropriate surface water action level specified in the RFCA (DOE 1996). The downgradient capture system was chosen as the best remediation method following an evaluation of other more traditional options in the Groundwater Conceptual Plan (RMRS 1996a). The passive treatment system was chosen as it effectively treats VOCs and radionuclides to below action levels at a lower operations and maintenance cost than other treatment options. The treated water will be discharged to surface water.

Proposed Action

A funnel (impermeable barrier groundwater collection system) and gate (treatment system) will be keyed into the underlying claystone for flow cut-off and treatment of the collected groundwater (Figure 1). Based on the available data, to capture the contaminant plume, a groundwater collection system will be installed that

extends from the western road approximately 250 feet to the east.

The variable elevation of the bedrock surface and the similarity between the clay-rich colluvium and bedrock makes it difficult to install a collection system keyed a certain depth into bedrock. The clay-rich colluvium and bedrock have similar properties, effective collection of the contaminated groundwater is not dependent on being keyed into bedrock. Therefore, the collection system will be installed at a variable depth of approximately 8 to 15 feet across the site, at least 6 inches, but up to several feet, into claystone, without regard to whether this is colluvium or bedrock (Figure 3). The contaminated groundwater will be treated in a series of cells containing reactive iron filings to remove VOCs and radionuclides. Under normal operations, the treated water will be discharged to groundwater using an infiltration galley located adjacent to South Walnut Creek. However, the system is designed to allow discharge directly to surface water in South Walnut Creek.

Installation of Funnel and Gate System

Conventional excavation/trenching techniques will be used to install the funnel and gate system. Silt fences will be installed downgradient of the excavation to control potential release of sediment to the drainages. During

Figure 3
Mound Groundwater Plume
 Cross Section Along Collection Trench

trench construction, the material removed from the trench will be stockpiled adjacent to the trench. A horizontal groundwater-collection line will be installed on the upgradient side of the impermeable barrier. Filter pack or pea gravel will be installed from the top of the claystone to the level of the horizontal collection line. The trench will then be backfilled and excess fill will be spread over the top of the collection system (Figure 3).

Treatment and Discharge

A reactive metals treatment system will be used to degrade dissolved VOCs and remove radionuclides from groundwater. The reactive metal media works by inducing conditions that cause substitution of hydrogen for chlorine in the chlorinated VOCs. The end-products of the process are completely dehalogenated hydrocarbons and non-toxic salts. Examples of end-products of chlorinated VOCs degraded by this process are ethene, ethane, and chloride ions. Radionuclides are removed by undergoing a reduction and/or absorption process.

The treatment system was designed based on the results of laboratory treatability studies conducted by Envirometal Technologies, Inc. (ETI), the patent holder for the reactive iron filings technology, and by Sandia

National Laboratories (Sandia) for radionuclide removal. ETI's and Sandia's recommendations on the volume of reactive media and retention times required to meet the surface water action levels were incorporated into the final design of the treatment system.

Sandia tested the ability of media to remove the metals and radionuclides found in Mound Site seep water by performing column test using a surrogate water sample. Their results show removal of metals and radionuclides in approximately 12 minutes.

For their laboratory treatability study, ETI used uncontaminated groundwater from RFETS and spiked it to the maximum contaminants levels expected for the three RFETS VOC plumes. Initial concentrations used in the column testing and concentrations in the treated effluent are shown in Table 2.

All VOCs, with the exception of methylene chloride (dichloromethane) were removed to below surface water action levels. The concentrations of methylene chloride in the Mound Site Plume (Table 2) are already not detectable or low level, and surface water action levels would be met.

Table 2. Results of ETI Bench Scale Testing - Connelly Iron

Compound	Influent Conc. (ug/L)	Effluent Conc. (ug/L)	Surface Water Action Level (ug/L)
Carbon Tetrachloride	1,004	nd	5
Trichloromethane	110	nd	8
Dichloromethane	111	105	5
Tetrachloroethene	5,496	nd	5
Trichloroethene	5,250	nd	5
Cis-1,2-dichloroethene	64	nd	70
1,1-Dichloroethene	318	nd	7
Vinyl Chloride	102	nd	2
1,1,1-Trichloroethane	37	nd	200

nd = non detect

CONCLUSIONS

Treatability studies have shown that reactive (zero valent) iron will treat contaminated groundwater in the three RFETS VOC plumes to regulatory action levels. After the Mound Site Plume's containment and treatment system is installed, the EPA's SITE Program will monitor the system for up to one year to obtain operating data. The operating data will be used by the Site to refine the design and installation of similar containment and treatment systems for other VOC plumes at RFETS.

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