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차단벽을 이용한 DNAPL 오염지역의 복구

Remediation of A DNAPL Contaminated Site Using Containment WALL

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ABSTRACT

In the present study, the design method of containment walls is proposed by utilizing an existing site. The selected remedy for the Source Area of Operable Unit 2 at Hill Air Force Base stipulated containment of the pure-phase trichloroethylene contamination. The in-place-mixed wall construction was selected because of the irregular topography, small area of the site, and the requirement to reach depths of greater than 90 feet below ground surface. Bench-scale compatibility studies were performed for the containment wall mix design on three commercial bentonite clays. The samples were subject to screening tests and long-term tests for evaluation of changed soil properties when exposed to the contaminated groundwater.

Key Word : remediation, contaminated soil, containment wall, groundwater, landfill

I. INTRODUCTION

110,000 gallons of waste chlorinated solvents were disposed at Operable Unit 2 (OU2) As a result of industrial processes for aircraft and missile maintenance at Hill Air Force Base. The waste solvents primarily consisted of trichloroethylene (TCE). Disposal of the solvents occurred between 1967 and 1975. Interim pump and treat remedial actions initiated in 1993 have recovered approximately 33,000 gallons of dense non-aqueous phase liquid (DNAPL) from the source area (Oolman et al., 1995). The Selected Remedy for the site included a requirement for installation of a source encircling containment wall (USEPA, 1996). The application of containment wall technologies to the OU2 DNAPL site involved particular consideration of the physical constraints of the site, the location on a large landslide, and chemical compatibility with the contamination. The source area and dissolved plume at OU2 are located on a hillside that is the site of a former landslide of several million cubic yards in size. In the source area, the downward migration of the DNAPL was impeded by the Alpine Formation. The Alpine Formation is a low permeability deltaic deposit composed primarily of silty clay with numerous thin silt lenses and occasional thin silty sand lenses. Contaminant recovery is primarily from the large pools of DNAPL retained at the source area.

Samples of the DNAPL obtained during the Remedial Investigation indicated the following compounds and range of percentages: trichloroethylene (TCE) (53% to 63%), 1,1,1,-trichloroethane (TCA) (5% to 12%), tetrachloroethylene (PCE) (3% to 5%), with freon TF, oil and grease, methylene chloride, and water making up the remainder.

Ⅱ. PHYSICAL INVESTIGATION

The proposed site(HAFB) is located approximately 25 miles north of Salt Lake City, Utah. HAFB is located on a terrace of the Weber delta, which is approximately 300 feet above the surrounding valley floors in Davis County, Utah. Operable Unit 2(OU2) is located along the northeastern boundary of the Base. The distribution of TCE concentration is shown in Figure 1. Figure 1 also shows the steep escarpment that drops approximately 140 feet in elevation between the Source Area and the toe of the plume. Numerous seeps and springs occur on the hillside. In 1993 the canal was lined with concrete across the contaminated area of OU2 to reduce infiltration due to canal leakage. Recent slope movement is evident in localized areas of the hillside. The movement is generally occurring at the lateral scarp areas where the slope has been over steepened during canal excavation. These actively moving areas coupled with evidence of springs indicate a high potential for slope instability in some areas of the hillside complex. There is evidence of three shallow unconfined groundwater systems within the extent of the plume as shown in Figure 2. These consist of a shallow system extending from the source area to a north-south transverse ridge located near the bottom of the hill; a second shallow system located east of the transverse ridge; and a third shallow system contained in the Weber River alluvium of the valley bottom to the east of South Weber Drive. The degree of hydrogeologic continuity between these systems is difficult to define because of the complex nature of the geology observed in the off-Base area. Description of the subsurface is further complicated because the steep escarpment is part of the Weber Delta Landslide Complex (Pashley and Wiggins, 1971). A conceptual geologic section is also shown in Figure 2

Figure 1. Distribution of TEC Contaminant

Figure 2. Conceptual Geologic Section

In considering geologic formation, the Weber Delta primarily consists of two Pleistocene age sediments of the Lake Bonneville Group. The Provo Formation terrace deposit consisting primarily of sand and gravel which caps the delta deposits and underlies most of the Hill AFB facilities, and the Alpine Formation, a cyclically deposited deltaic formation consisting primarily of silty clay to clay with locally discontinuous sand and gravel lenses. Uplift along the Wasatch Front coupled with lowering of ancient Lake Bonneville, to the existing Great Salt Lake, caused down-cutting of the Weber River through these deltaic deposits. This down-cutting resulted in the formation of the Weber River Valley and the steep terrace slope that characterizes the eastern boundary of Hill AFB.

The thickness of the Provo Formation in the Source area ranges from approximately 20 to 50 feet. At lower elevations on the hillside, the Alpine formation is exposed at the ground surface with exception of local colluvium cover. The thickness of the Alpine Formation deposits is estimated to be 300 feet or more.

Ⅲ. CONTAINMENT WALL DESIGN

1. Design Alternatives:

The purpose of the containment wall is to hinder horizontal migration of the highly contaminated groundwater and the source area DNAPL pools. An associated objective is the reduction of groundwater flow into the source area thereby requiring less groundwater to be extracted and treated. Several alternatives were considered during development of the containment wall design. The design alternative's evaluation included the following structures:

- sheet pile walls with grouted joints
- structural soil-cement-bentonite wall
- conventional soil-bentonite slurry wall
- IPM soil-bentonite slurry wall

The IPM method was selected for the design because of its ability to produce a low-permeability wall having properties comparable to a conventional slurry wall, its ability to achieve depths of 90 feet below ground surface, and its ability to negotiate the corners and constraints of a small site with existing structures.

2. Compatibility Tests:

Bench-scale tests for chemical compatibility were performed to evaluate the effects of site contaminated groundwater on the geotechnical properties of various barrier wall mix design recipes. The tests were conducted using four commercially available high swelling sodium bentonite clays. The bentonite was mixed with native clay samples and a composite native sand sample. Compatibility testing was performed and included initial screening tests, mix design and test sample preparation, and long-term permeability compatibility tests. The testing program included initial compatibility screening, blow-out testing, and long-term permeability testing. The native clay sample tests were terminated after 200 days when three pore volumes had passed through the samples. The testing results are shown in Table 1.

Table 1. The Results of Permeability Tests

Mixture \ permeability	Permeants		Remarks
	Tap water	Groundwater	
Sand-mixture (cm/sec)	$6.5x10^{-7}$ ~ $1.4x10^{-6}$	$6.0x10^{-7}$ ~ $3.0x10^{-6}$	2% bentonite by dey weight
Clay-mixture (cm/sec)	$6.0x10^{-9}$ ~ $8.0x10^{-9}$	$2.5x10^{-9}$ ~ $6.0x10^{-9}$	2% bentonite by dey weight

Ⅳ. SUMMARY AND CONCLUSIONS

The long-term permeability tests indicate the clay-bentonite samples performed well when subject to highly concentrated site groundwater. The sand-bentonite samples were significantly affected by the contaminated groundwater. This result was expected because the chlorinated solvents are able to collapse the double-layer structure of the bentonite clay. The sand-bentonite tests represented a worst-case condition that is not expected to be encountered under operating conditions. Groundwater flow and slope affect to efficiency of containment wall. The IPM was found to be suited for use in a confined area.

REFERENCES

1. CH2M HILL, *Draft Remedial Design Investigation Technical Memorandum for Operable Unit 2.* Hill Air Force Base, Ogden Air Logistics Center, March 1996.

4. Montgomery Watson, *Sheet Pile Constructability Evaluation Report Operable Units 1, 2, and 4,* Hill Air Force Base, Ogden Air Logistics Center, October 1993

5. Oolman, T., Godard, S.T., Pope, G.A., Jin, M., and Kirchner, K., *DNAPL Flow Behavior in a Contaminated Aquifer: Evaluation of Field Data,* Journal of Groundwater Monitoring and Remediation, Vol. 15, No. 4, 1995.

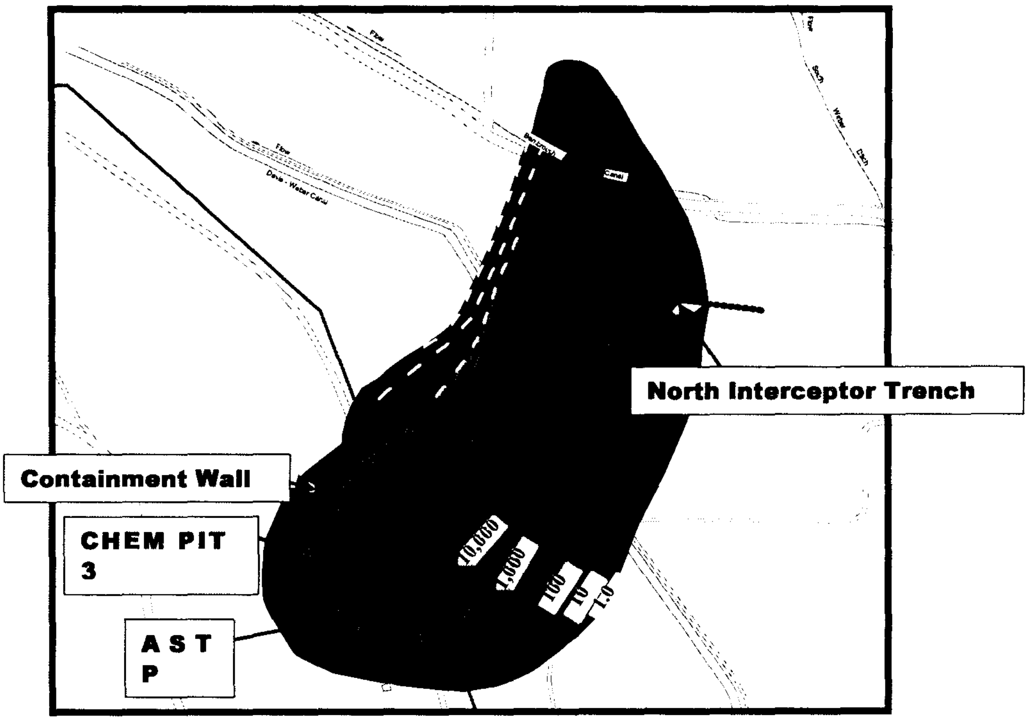

Figure 1

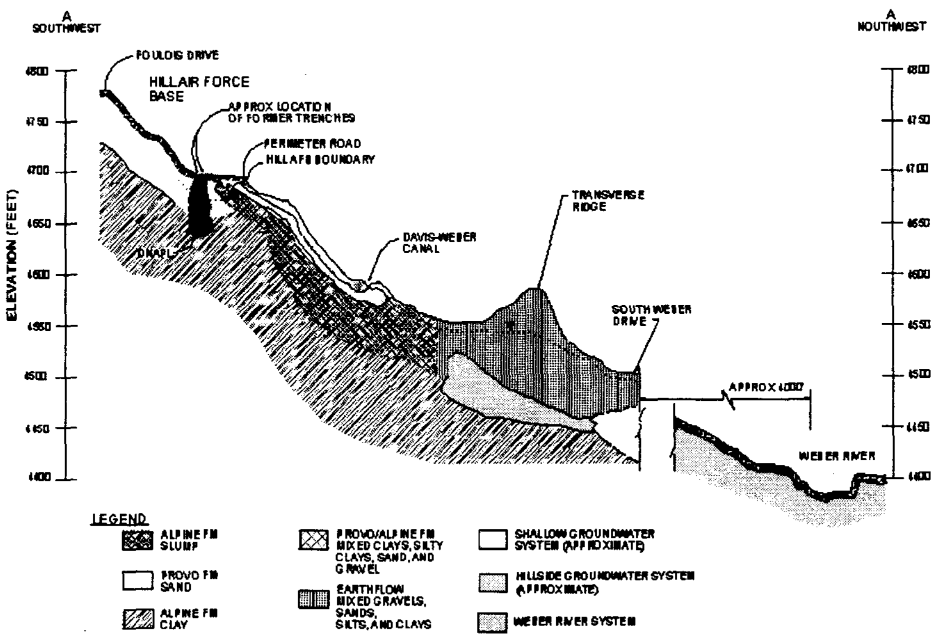

Figure 2