DEVELOPMENT OF CLEANUP STANDARDS FOR GROUNDWATER AT THE TOOELE ARMY DEPOT, UTAH

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ABSTRACT

An unlined evaporation pond at the Tooele Army Depot near Salt Lake City, Utah received more than 125,000 gallons of industrial wastewater and stormwater daily for more than 20 years. The infiltration of wastewaters from this pond eventually contaminated the underlying aquifer. The U.S. Army closed the pond under RCRA regulations and instituted a comprehensive groundwater cleanup plan. This paper describes the process for negotiating cleanup standards with State and Federal regulatory officials during a period of developing policies for groundwater cleanup. The paper details the rationale and methodology which were used to negotiate cleanup standards for 18 groundwater contaminants consistent with emerging practice and the policies of the Utah Solid and Hazardous Waste Management Committee.

INTRODUCTION

The Tooele Army Depot (TEAD) is located about 35 miles southwest of Salt Lake City. The primary activities of TEAD are storage and demilitarization of conventional and chemical ammunition and rebuilding military equipment. TEAD consists of two areas: the North Area, which occupies about 39 square miles in Tooele Valley; and the South Area, which occupies about 30 square miles in Rush Valley, located about 10 miles south of the North Area. Hazardous materials have been used, generated, or disposed of in the North Area at the Industrial Waste Lagoon (IWL) and several other locations. The IWL was an unlined evaporation pond measuring approximately 400 feet x 200 feet, into which an average of more than 125,000 gallons of industrial wastewater and stormwater were discharged daily until November, 1988. The total amount of wastewater discharged to the IWL is unknown. Wastewater sent to the IWL was alkaline and contained elevated levels of chromium, lead, and organic solvents such as 1,1,1-trichloroethane (TCA), trichloroethene (TCE), toluene, carbon tetrachloride, and other organic compounds. These contaminants are typical of those being found at government and industrial facilities across the nation.

Although other hazardous constituents were also present to some degree, TCE was detected in groundwater samples near and downgradient from the IWL more frequently and at higher concentrations than any of the other contaminants. Other volatile organic compounds (VOCs), especially TCA and carbon tetrachloride, were found to occur in areally extensive plumes in the groundwater system near the IWL, but none of these plumes approached the size of the TCE plume. Also, few of the concentrations of other VOCs exceeded water quality criteria. TCE concentrations in groundwater ranged from less than 0.1 μg/l to 250 μg/l. Metals such as lead, cadmium, and arsenic were detected in soil and sludge but not in groundwater samples. Of metals, only chromium was detected in the groundwater system in the immediate vicinity of the IWL.

As a result of the groundwater contamination discovered near the IWL, TEAD signed a Consent Decree with the State of Utah to conduct a comprehensive groundwater quality assessment. The purpose of this assessment was to define the extent and magnitude of groundwater contamination caused by materials leaking from the IWL and associated conveyance ditches and to prepare a plan for closing the IWL and cleaning up the groundwater.

Under the terms of the Consent Decree, the Army was allowed to submit a petition for groundwater cleanup levels after completion of the groundwater quality assessment. This paper describes the development of the cleanup levels that were accepted following that petition. The cleanup levels represent a milestone in remedial activities because that acceptance was the first approval of groundwater cleanup standards by the State of Utah.

CLEANUP PLAN

The groundwater cleanup plan for TEAD includes two components: elimination of the source contaminants by closing the IWL and wastewater ditches; and extraction and treatment of contaminated groundwater. The IWL has been closed and a multi-layer cap, designed according to RCRA guidelines, was placed over the top. After the sludge in the lagoon was mixed with clean fill to absorb free liquid and compacted, it was covered with soil excavated from the wastewater ditches, followed by a two-foot layer of clay. A synthetic membrane was placed on top of the clay layer, followed by a six-inch thick permeable drainage layer, which was composed of uniformly sized sand. Finally, the drainage layer was covered with 18 inches of clean backfill and six inches of topsoil. Native vegetation is being established in the topsoil to minimize erosion.

Under a conceptual groundwater cleanup plan, groundwater will be pumped from well fields installed near the north boundary and near former wastewater ditches.

The extracted groundwater will then be passed through an air stripper treatment system and returned to the aquifer through injection wells. Figure 1 shows one arrangement of existing monitoring wells, the extraction wells and injection wells, and the location of the proposed water treatment plant.

As part of the groundwater cleanup process, it was necessary to negotiate cleanup levels under the "Draft Corrective Action Cleanup Standards Policy" proposed by the Utah Solid and Hazardous Waste Management Committee (USHWMC) in 1987. This policy established four evaluation criteria for cleanup standards:

- The impact or potential impact of the contamination on public health.
- The impact or potential impact of the contamination on the environment.
- Economic considerations and cost effectiveness of cleanup options.
- The technology available for use in cleanup.

In addition, USHWMC proposed policy would not allow levels of contamination in groundwater to degrade beyond existing levels.

James M. Montgomery, Consulting Engineers, Inc. (JMM) assisted the U.S. Army during the development and negotiation of cleanup standards with the USHWMC. This paper describes the process of developing proposed standards that were acceptable to the USHWMC.

DETERMINATION OF CLEANUP LEVELS

Table I shows the concentrations of contaminants detected in TEAD groundwater. Neither Utah drinking water standards nor adequate RCRA precedents existed, so cleanup standards from previous Records of Decision (RODs) at Superfund sites were reviewed to determine precedents. Most of the examples that were available at the time were from RODs published in 1985 and 1986, which preceded the Superfund Amendments and Reauthorization Act of 1986 (SARA) and promulgation of drinking water standards for VOCs. Consequently, most of the cleanup standards were based on one in one million (10^{-6}) risk levels for carcinogens and at toxicity levels for non-carcinogens, which were the only standards at that time. Very few of the RODs established cleanup levels at background. Final rules regarding maximum concentration levels (MCLs) were not available until July 8, 1987. More recent RODs have established cleanup levels at the MCL of 5 μg/l for TCE.

Several of the RODs addressed drinking water supplies, where the nature of groundwater contamination was similar to TEAD. These RODs included well fields at Rock-

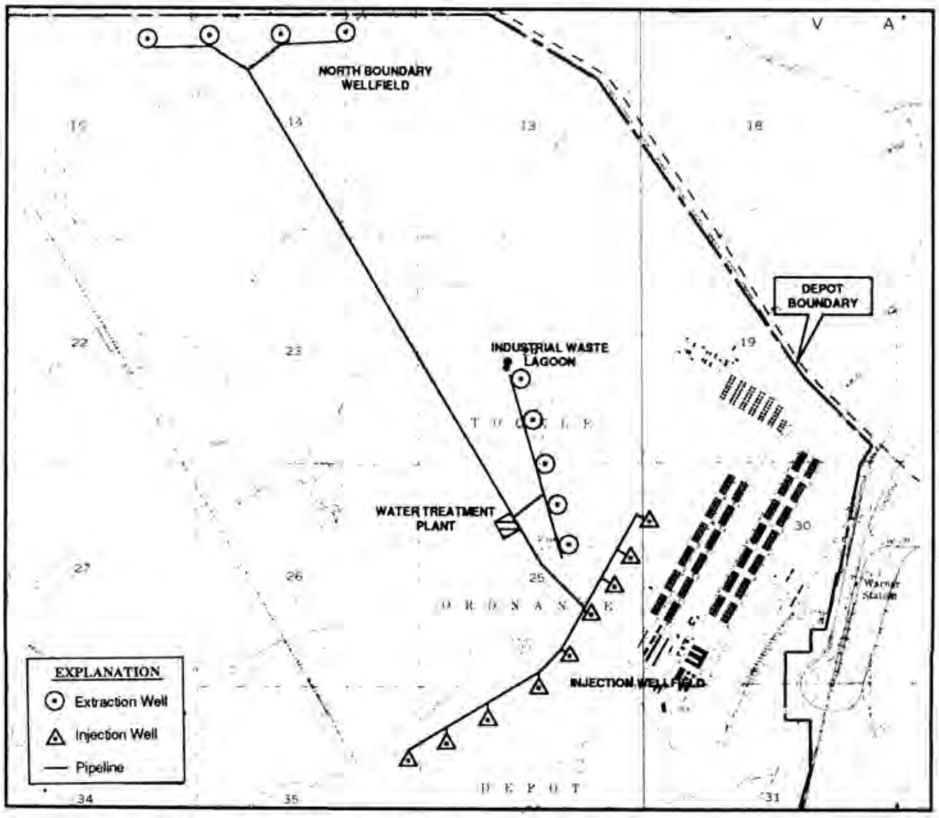

Fig. 1. Conceptual Design of the Groundwater Remediation System.

TABLE I

Contaminants Detected In Tead Groundwater and Existing Standards

Contaminant	Range of Concentrations (μg/l)	Numbers of Samples Above the Detection Limit
Carcinogens		
Trichloroethene	<0.1 - 250	32
Carbon Tetrachloride	<0.1 - 7.6	11
Benzene	<0.1 - 21	9
1,2-Dichloroethane	<0.1 - 0.2	1*
Methylene Chloride	<0.1 - 20	3
Chloroform	<0.1 - 2.1	8
Tetrachloroethene	<0.1 - 0.3	2*
1,2-Dichloropropane	<0.1 - 1.4	5
Bis (2-chloroethyl) ether	<9.1 - 13.3	1**
Non-Carcinogens		
1,1,1-Trichloroethane	<0.1 - 45	20
Toluene	<0.5 - 45	9
Xylenes	<0.1 - 3.2	2
1,1-Dichloroethene	<0.1 - 7.3	6
1,1-Dichloroethane	<0.1 - 170	13
Phenol	<5.0 - 330	1
Ethylbenzene	<0.1 - 1.0	2
Chloroethane	<1.0 - 1.3	1
2,4-Dimethylphenol	<5.0 - 940	1
Metals		
Chromium (total)	<29 - 190	8

This information is based on the first round of groundwater analyses from September, 1986, except for the asterisked (*) numbers, which are from the second round during November, 1986 (42 samples analyzed in each round).

**Bis (2-chloroethyl) ether was detected in only one of 17 samples collected in January, 1986 and is considered to be a sampling or analytical artifact.

away Borough, New Jersey, Olean, New York, Brewster, New York, and an infiltration system in Des Moines, Iowa. In the 1986 ROD for the Rockaway Borough, New Jersey Well Field, drinking water was obtained from three municipal wells until TCE, PCE, and 13 other VOCs were detected in the water. A granular activated carbon (GAC) treatment system was constructed to remove TCE and PCE to 5 μg/l (1). At the Olean Well Field, high concentrations of TCE, TCA and trans-1,2-dichloroethene were detected in water from three municipal wells and in many private wells in the area. The selected remedial action for this pit included constructing two packed tower air stripping systems to treat water from the three municipal wells to the MCL of 5 μg/l for TCE. The air strippers were designed to remove the other VOCs to the 10^{-6} risk level (2). The principal contaminants in the 1986 ROD for the Brewster, New York Well Field were TCE, PCE and 1,2-DCE, which were detected in drinking water from two well fields. Under an agreement with EPA, the village installed a packed tower air stripper to remove TCE to 5μg/l, and the treated effluent was reinjected into the aquifer (1). In Des Moines, TCE, PCE, 1,2-DCA and vinyl chloride contaminated an underground infiltration gallery system, which is a source for the City's water supply. The 1986 ROD for this site selected a remedial action which included installation of extraction wells, treatment with an air stripper system to 5μg/l, and the treated water to be discharged to a nearby river (1).

The review of RODs demonstrated the large number of sites at which MCLs had been established as cleanup levels for drinking water aquifers. EPA recognized the difficulty of treating groundwater to background or zero levels. Instead, cleanup levels were usually assigned non-zero concentrations, which reflected an acceptable risk and available remediation technology.

Initially, Utah wanted groundwater at TEAD cleaned up to background levels. After JMM's review of prior RODs, it was argued that the appropriate level of cleanup would be to MCLs or, if the contaminant is a carcinogen and there was no published MCL, to a concentration that represents a 10^{-6} lifetime cancer risk from drinking the water. These cleanup levels appeared consistent with emerging EPA practice based on the RODs. The USHWMCs proposed policy regarding no further degradation was more stringent, however, because it precluded contaminant levels that were below these values from ever being allowed to rise. In the end, the cleanup standards for groundwater contamination from the IWL were developed and approved based on a combination of MCLs, 10^{-6} cancer risk, and the proposed "non-degradation" policy of the USHWMC.

The cleanup standards finally negotiated for contaminated groundwater at the Tooele Army Depot were of two kinds: 1) cleanup levels which were established if the observed levels of the contaminant exceeded either an MCL or, if there was no MCL for that contaminant and it is a carcinogen, a concentration based on a 10^{-6} lifetime cancer risk; and 2) "significance levels" when the contaminant levels were below an MCL or a 10^{-6} risk concentration. The concept of significance levels came from the USHWMC's policy of prevention of further degradation. The significance levels were set at the highest existing contamination level observed in monitoring wells at the site. MCLs have been established for almost all of the organic and inorganic contaminants detected in groundwater at TEAD. Federal drinking water standards were proposed because Utah had no formally promulgated or consistently applied drinking water standards for most of the contaminants.

How the cleanup levels were derived for contaminants without MCLs can be illustrated using the case of methylene chloride, also called dichloromethane. Although this compound has been shown to cause cancer in laboratory animals, it is not known to cause cancer in humans (EPA, Integrated Risk Information System, Rev. January, 1989). However, EPA has classified methylene chloride as a probable carcinogen. Its oral cancer potency factor is 7.5×10^{-3} $(\mathrm{mg/kg/day})^{-1}$ (3). For a 70-kg person who ingests two liters of water per day for 30 years, the maximum permissible concentration of this compound in the water ingested (x μg/l) for a 10^{-6} cancer risk can be determined by solving the equation:

$$\frac{x\,\mathrm{mg}}{\mathrm{l}} \times \frac{7.5 \times 10^{-3}}{\mathrm{mg/kg/day}} \times \frac{2\,\mathrm{l}}{\mathrm{day}} \times \frac{1}{70\,\mathrm{kg}} = 10^{6}$$

This gives a maximum permissible concentration of 4.67×10^{-3} mg/l or approximately 5μg/l.

Seven contaminants were shown to exceed either MCLs or, for carcinogens for which there is no MCL, a concentration based on a 10^{-6} lifetime risk. These contaminants were trichloroethene, carbon tetrachloride, benzene, methylene chloride, chloroform, 1,1-dichloroethene, and chromium. One contaminant, 2,4-dimethylphenol, a non-carcinogen, had no EPA-established ambient water quality criterion, although the EPA had suggested a 400 μg/l concentration limit. The cleanup standards for all other contaminants were set at the significance level (i.e., the existing level of contamination observed at TEAD) because those existing levels exceed neither an MCL or, if an MCL had not been established, a concentration based on a 10^{-6} lifetime risk. Table II shows the cleanup standards proposed and accepted for remediation of contaminated groundwater beneath the IWL (4).

Table III shows the carcinogenic risk resulting from simultaneous ingestion of cancer-causing contaminants at the concentration limit specified by the cleanup standards. It can be seen that if an individual ingests all of the cancer-causing contaminants at the limit value for a lifetime, the

TABLE II

Approved Cleanup Levels and Significance Levels

Contaminant	Proposed Level (μg/l)	Basis	Type
Carcinogens			
Trichloroethene	5	MCL	Cleanup level
Carbon Tetrachloride	5	MCL	Cleanup level
Benzene	5	MCL	Cleanup level
1,2-Dichloroethane	0.2	ND	Significance level
Methylene Chloride	5	10^{-6} risk	Cleanup level
Chloroform	0.5	10^{-6} risk	Cleanup level
Tetrachloroethene	0.3	ND	Significance level
1,2-Dichloropropane	1.4	ND	Significance level
Non-Carcinogens			
1,1,1-Trichloroethane	45	ND	Significance level
Toluene	45	ND	Significance level
Xylenes	3.2	ND	Significance level
1,1-Dichloroethene	7	MCLG	Cleanup level
1,1-Dichloroethane	170	ND	Significance level
Phenol	330	ND	Significance level
Ethylbenzene	1.0	ND	Significance level
Chloroethane	1.3	ND	Significance level
2,4-Dimethylphenol	400	*	Significance level
Chromium	50	MCL	Cleanup level

MCL indicates maximum contaminant level
MCLG indicates maximum contaminant level goal
ND indicates a significance level to prevent further degradation of groundwater quality

* USEPA had not established an ambient water quality criterion for 2,4-dimethylphenol, but had suggested a criterion of 400 μg/l based on organoleptic concerns.

TABLE III

Carcinogenic Risk for Proposed Cleanup Standards

Contaminant	Proposed Level (μg/l)	Basis	Excess Risk
Trichloroethene	5	MCL	1.6×10^{-6}
Carbon Tetrachloride	5	MCL	1.9×10^{-5}
Benzene	5	MCL	7.4×10^{-6}
1,2-Dichloroethane	0.2	ND	5.2×10^{-7}
Methylene Chloride	5	10^{-6} risk	1.1×10^{-6}
Chloroform	0.5	10^{-6} risk	1.2×10^{-6}
Tetrachloroethene	0.3	ND	4.4×10^{-7}
1,2-Dichloropropane	1.4	ND	2.5×10^{-6}
		TOTAL =	**3.4×10^{-5}**

ND indicates a significance level to prevent further degradation of groundwater quality

excess cancer risk is 3.4×10^{-5}, within the 10^{-4} to 10^{-7} range suggested by EPA.

The largest contributor to the risk (56 percent) shown in Table III is carbon tetrachloride, whose cleanup level was determined by the MCL. The next three largest contributors are trichloroethene and benzene, with cleanup levels also set at the MCL, and 1,2-dichloropropane, which had a cleanup level set at the highest observed concentration, which was below the MCL goal. The two contaminants whose cleanup levels were set by the 10^{-6} risk criterion show risks slightly higher than 10^{-6} because of roundoff in setting the standard.

SUMMARY

A set of cleanup standards for a particular plume of contaminated groundwater at the Tooele Army Depot was developed, proposed, and accepted by the Utah Solid and Hazardous Waste Management Committee. The bases for these cleanup standards were:

ŇMCLs which were applicable for drinking water sources, such as the Tooele Valley Aquifer. A 10^{-6} excess lifetime cancer risk for each carcinogenic contaminant for which an MCL did not exist.

Existing contamination levels which exceed neither the MCL nor the 10^{-6} lifetime risk in the absence of an MCL.

The total carcinogenic risks represented by the proposed levels is 3.4×10^{-5} excess cancers per lifetime. This falls in the 10^{-4} to 10^{-7} range which is acceptable to the EPA, and is based on very conservative health-based assumptions.

The acceptance and approval of these cleanup levels are significant because they represent the first set of cleanup standards for a federal facility in Utah and are for contaminants which are common at other Department of Defense and Department of the Energy facilities located across the country.

REFERENCES

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3. Superfund Public Health Evaluation Manual. EPA 540/1-86/060, October, 1986.

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