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CONTROL OF GROUNDWATER POLLUTION AT A LIQUID CHEMICAL WASTE DISPOSAL SITE

W. E. KELLY

University of Rhode Island, Kingston, Rhode Island (USA)

M. A. POWERS

Goldberg-Zoino & Associates, Inc., Providence, Rhode Island (USA)

P. P. VIRGADAMO

Environmental Resources Associates, Inc., Warwick, Rhode Island (USA)

ABSTRACT

Waste chemicals dumped in open pits have polluted groundwater and nearby domestic wells. The existing situation has been evaluated by field studies and predictions tested with analytic dispersion models. A renovation scheme involving recovery of contaminated groundwater, air stripping and vapor recovery, and recharge to the groundwater has been developed and approved for final design.

INTRODUCTION

The purpose of this paper is to present a partial case history of a site in northern Rhode Island, USA, where uncontrolled dumping of hazardous waste has taken place. Aspects of particular interest include: the use of analytic dispersion models for a preliminary assessment of the extent of pollution, the need for multi-level monitoring devices, and an assessment of viable renovation schemes.

The disposal of chemicals took place in a former sand and gravel pit. Tarkiln Brook, a small stream, flows through the site and discharges to the Slatersville Reservoir about 1500 feet (450m) downstream. The reservoir, which is not a public water supply (see Figure I), is fed and drained by the Branch River. Between the site and the reservoir are more than twenty single-family homes which derive their water from individual wells.

Since 1975 a portion of the site has been used for the disposal of a variety of liquid wastes. Contents of tank trucks were dumped into open pits or trenches. In February 1980 it was estimated that there were roughly 80,000 gallons (300,000 liters) of chemical wastes on site. In mid-1980 the US Environmental Protection Agency (USEPA) pumped and removed the chemicals, probably eliminating the major contamination source.

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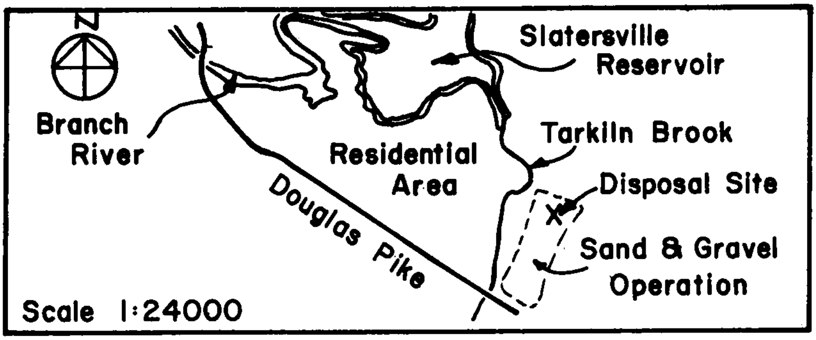

FIGURE I — LOCUS PLAN

Testing by the Rhode Island Department of Environmental Management (DEM) and the USEPA revealed the presence of a variety of organic constituents (volatiles, extractables, and PCB's) often in high concentrations, up to 550,000 ppb. Groundwater samples also exhibited organic chemical contamination (volatiles) as high as 120,000 ppb. Tarkiln Brook contained significant volatile organics (20-500 ppb) adjacent to the site, but only trace levels 1000 to 1500 feet (300-500m) downstream. Limited testing of the Slatersville Reservoir indicated no measurable effects.

The areal geology has been described (Richmond and Allen, 1951) and consists of ice-contact deposits overlying discontinuous glacial till which in turn overlies an igneous bedrock. Test borings indicate that the overburden varies from about 90 feet (27m) thick beneath Tarkiln Brook to less than 30 feet (9m) thick east of the disposal area. The stratified glacial deposits consist of fine sands with occasional coarser layers. Immediately west of the lagoons the upper fine sands are interbedded with coarser materials and at depth a much coarser gravelly material is found. These coarser materials appear to be associated with an esker which, once, extended along Tarkiln Brook.

Precipitation averages about 46 inches (115cm) per year of which about half runs off. Natural groundwater quality is generally good, being soft, slightly acidic, and generally containing less than 100mg/l of dissolved solids (Johnston and Dickerman, 1974).

FIELD STUDIES

To supplement information available from twelve existing monitoring wells, ten explorations were made using wash boring techniques, split spoon soil sampling, and borehole permeability testing. Groundwater monitoring devices, consisting of slotted PVC pipe or multi-level sampling devices, were installed in completed boreholes.

Soil samples collected by split spoon sampling were classified and logged. Head space in soil sample jars were tested with a Century Systems model OVA-128 organic vapor analyzer with gas chromatograph option. The testing was used primarily to evaluate the relative concentration of volatile organic chemicals in the samples from a single boring.

Permanent non-retrievable multi-level groundwater sampling devices were installed in six boreholes. These consisted of one to three gas drive BarCad brand samplers and one steel observation well per boring. The locations of sampling instruments were determined based on lithologic logs, permeability test data, and results from the organic vapor content analysis described above.

More than 100 water samples were collected and tested. The majority of this testing was performed by the Rhode Island Department of Health (DOH) Laboratories and was directed towards assessing concentrations of volatile organic substances found on the USEPA priority pollutant list. The work was performed by using Gas Chromatograph/Mass Spectrograph techniques.

A three-day, constant rate, 80 GPM (300 L/min) pumping test was executed in the immediate vicinity of one of two chemical disposal pits. This test indicates a transmissivity of about 1340 ft^2/day (125 m^2/day) and a permeability of about 22 ft/day (7 m/day).

ASSESSMENT OF IMPACT

Several domestic wells exist downstream of the site and an assessment was made to assess the potential impact if no corrective actions were taken. Chloroform or thrichloromethane (CHC13) was found in significant concentrations beneath the site. It was estimated that a "slug" of pollutant containing an average 2300 ppb of chloroform existed beneath the site. Assuming that only dispersion would occur, and using a point source analytical model (Hunt), it was estimated that 1600 feet (490m) downgradient a concentration of 150 ppb of chloroform should eventually be seen. Concentrations measured at a multi-level monitoring well approximately 1600 feet (490m) downgradient ranged from less than 2 ppb near the surface to 28 ppb near the base of the aquifer.

By contrast the potential impact of the estimated volumes of waste in the ground on the reservoir appeared to be negligible. Based on this analysis, which was substantiated by limited testing, it was established that the major impact of the chemicals would be on private wells downgradient of the site.

RESTORATION/RENOVATION APPROACHES

Methods for "in-ground" and above-ground treatment were considered for renovation of the groundwater. In-ground treatment would require the use of chemical or biological agents to break down or oxidize pollutants in situ. Above-ground treatment would require withdrawal of contaminated groundwater which would then be processed through a treatment plant and recharged back to the aquifer. Due to the broad range of contaminants, it was determined that the end products of in-ground treatment could not be accurately predicted. For this reason the in-ground alternative was eliminated.

Above-ground treatments were evaluated using laboratory bench scale tests which were later substantiated with an on-site demonstration. The initial goal was to remove volatile organic solvents; however, as the study proceeded, it became apparant that other contaminants were present.

Laboratory evaluations of air stripping, adsorption, and metal precipitation were made. Air stripping was found to be highly effective for removal of volatile organics. Activated carbon was selected for testing over other synthetic adsorbants tested. Activated carbon adsorption beds effectively removed the volatile organics however, short bed life made adsorption impractical. It was decided to integrate the air stripping and precipitation and adsorption schemes. Air stripping was used as a first stage to remove the majority of organic solvents; next sodium hydroxide was used to neautralize the groundwater and precipitate the heavy metals and, finally, activated carbon adsorption was used to polish the groundwater.

During a three-day pumping test, an integrated system was operated continuously at about 100ml/min. The results of this field test generally confirmed the laboratory studies. Table I shows the levels of treatment achieved by the system.

TABLE I

Contaminant	Untreated Groundwater (mg/L)	Treated Groundwater (mg/L)	Removed
Dichoromethane	48.	0.07	99.9
Chloroform	1.1	0.001	99.9
Trichloroethylene	4.0	0.006	99.8
Iron	230.	3.6	98.4
Copper	7.8	0.11	98.5

Laboratory analyses indicated that significant levels of alcohols remained after nearly all the volatile organics were removed by air stripping. Therefore final recommendations were to eliminate the activated carbon step and replace it with a biological stabilization pond for removal of alcohols.

Disposal of the treated groundwater was then considered. Since the site is remote, the options are to discharge to Tarkiln Brook or back to the groundwater. The latter option, although technically more involved, would allow contaminated water to be controlled until treatment is considered complete and was therefore selected.

Because of the depth of contamination, collection will have to be with recovery wells. In evaluating recovery schemes a major consideration was the volume of water that would have to be treated and consequently the time the treatment system would have to be operated. It was decided to first propose treatment only in the immediate disposal area, with the option to relocate the plant in the future. The scheme adopted utilizes a single well, pumping about 25 gpm (95 l/m), and recharging through a "U" shaped trench upgradient of the recovery well (see Figure II). Discharging effluent below ground will help to control any potential odor problem.

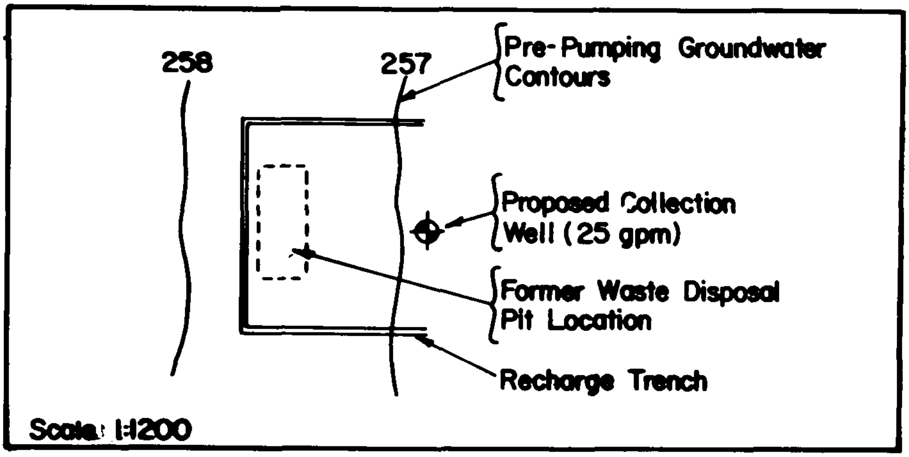

FIGURE II — COLLECTION/RECHARGE SCHEME

It is estimated that with this scheme about four months will be required to treat one volume of the contaminated groundwater upgradient of the recovery well. More than one cycle may be required for treatment and a treatment duration of six to twelve months has been estimated.

SUMMARY AND CONCLUSIONS

Waste chemicals dumped in open pits have polluted the groundwater. The contamination plume is highly stratified with the greatest concentration of pollutants occurring near the base of the aquifer. Off-site effects on a private well are already significant and will probably increase in the future. The probable effects on surface water are, by comparison, minor.

In-ground and above-ground treatment methods were evaluated to determine the preferred process for removing volatile organics, heavy metals, color, odor, and other organics from the groundwater. In-ground treatment by chemical oxidation was found to be unacceptable due to only partial removal of contaminants and the unpredictable generation of by-products. Air stripping and chemical precipitation were shown to be effective for removing volatile organics and heavy metals respectively.

An above-ground treatment system involving air stripping and vapor recovery was selected and has been approved for installation. The system is currently being designed and is expected to be operational sometime during the spring or summer of 1981.

Some additional testing is planned to refine estimates of off-site impacts and to monitor performance of the treatment process and the recovery-recharge system.

ACKNOWLEDGEMENTS

The work outlined was performed for the DEM and was part of a larger effort to assess and correct contamination problems at a site in northern Rhode Island.

REFERENCES

1 BarCad Systems, Inc., P.O. Box 424, Concord, MA, 01742, USA.
2 B. Hunt, Jour. Hyd. Div. ASCE, 104 (1978) 503-513.
3 H.E. Johnston and D.C. Dickerman, U.S.G.S. Water Resources Invest. 18-74, 1974, p.
4 G.M. Richmond, and W.B. Allen, Geological Bull. 4, R.I. Port and Ind. Dev. Comm., 1951, p.