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Superfund Record of Decision:

Velsicol Chemical, TN

50272-101

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

The 242-acre Velsicol Chemical site is a former plant waste landfill located near the city of Toone, Hardeman County, Tennessee. Land use in the area is predominantly agricultural with a wetlands area, 26 residences, and numerous creeks located within 1 mile of the site. In addition, part of the site overlies a surficial aquifer that was used as a potable water supply in the area. From 1964 to 1973, Velsicol Chemical Corporation used the site to dispose of industrial and chemical plant wastes. Waste was disposed of in trenches excavated on 27 acres of the property. The site was closed in 1973 because of the possibility of contaminated ground water migrating offsite. By late 1978, State and Federal investigations had confirmed ground water contamination in private wells, and a public water supply was provided in early 1979. In 1980, a 35-acre low permeability clay cap was placed over the disposal area to control and minimize additional impacts from the site. This Record of Decision (ROD) addresses offsite ground water contamination, as Operable Unit 1 and will prevent additional onsite ground water contamination from migrating from the disposal areas. Future RODs will address other site contamination and principal threats. The primary

(See Attached Page)

17. Document Analysis a. Descriptors

Record of Decision - Velsicol Chemical, TN
First Remedial Action
Contaminated Medium: gw
Key Contaminants: VOCs (carbon tetrachloride, chloroform, toluene, xylenes), other organics (pesticides)

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) None	21. No. of Pages 72
	20. Security Class (This Page) None	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

Abstract (Continued)

contaminants of concern affecting the ground water are VOCs including carbon tetrachloride, chloroform, toluene, and xylenes; and other organics including pesticides.

The selected remedial action for this site includes installing extraction wells onsite and offsite to restore the contaminated ground water to acceptable drinking water standards; constructing an onsite ground water treatment plant and treating contaminated ground water using solids removal, air stripping, and final ground water polishing prior to discharge; discharging the treated water onsite to nearby surface water bodies; treating off-gases with carbon adsorption; monitoring ground water; maintaining the ground water treatment system and the disposal area cover; and implementing institutional controls including deed and ground water use restrictions. The selected remedial action is contingent upon the performance data collected during operation. If the selected remedy cannot meet the specified remediation goals, contingency measures may include alternating pumping at wells to eliminate stagnation points; pulse pumping at wells to allow aquifer equilibration and encourage adsorbed contaminants to partition into ground water; and installing additional extraction wells to facilitate or accelerate cleanup of the contaminant plume. The estimated present worth cost for this remedial action is $11,644,000, which includes an annual O&M cost of $696,000.

PERFORMANCE STANDARDS OR GOALS: Chemical-specific ground water clean-up goals are based on SDWA MCLs and health-based criteria, and include carbon tetrachloride 0.005 mg/l (MCL), chloroform, 0.006 mg/l, toluene 1 mg/l (MCL), and xylenes 10 mg/l (MCL).

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SUMMARY OF REMEDIAL ALTERNATIVE SELECTION

RECORD OF DECISION
REMEDIAL ALTERNATIVE SELECTION

VELSICOL/HARDEMAN COUNTY LANDFILL
GROUNDWATER, OPERABLE UNIT I
TOONE, TENNESSEE

PREPARED BY:
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV
ATLANTA, GEORGIA

RECORD OF DECISION
Remedial Alternative Selection
First Operable Unit

SITE NAME AND LOCATION

Velsicol/Hardeman County Landfill
First Operable Unit (Groundwater)
Toone, Tennessee

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Groundwater Operable Unit of the Velsicol/Hardeman County Landfill site in Toone, Tennessee developed in accordance with CERCLA, as amended by SARA, and to the extent practicable, the National Contingency Plan.

This decision is based upon the contents of the Administrative Record for the Velsicol/Hardeman County Landfill site.

The United States Environmental Protection Agency and the State of Tennessee agree on the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision ("ROD"), may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

This Operable Unit is the first of at least two that are planned for the site.

This Operable Unit remedy addresses remediation of the on-site and off-site groundwater contamination by eliminating or reducing the risks posed by the site through treatment, engineering and institutional controls.

The major components of the selected remedy include:

> Install and maintain approximately five extraction wells along the northern boundary of the disposal areas located within the site developing a hydraulic gradient to prevent groundwater contamination above MCLs from leaving the disposal area.
>
> Install and maintain approximately ten extraction wells into the off-site groundwater contamination plume to control the groundwater contaminant migration and remediate the groundwater off-site to MCLs.
>
> Build and operate a groundwater treatment system for the removal of contaminants from the extracted groundwater to NPDES requirements prior to the water being discharged to a nearby surface water body. The groundwater treatment is expected to be performed using, at a minimum, settling tanks for precipitation of dissolved solids, an air stripper and a carbon adsorption system.

Monitor groundwater contaminant levels to verify that remediation goals are reached.

Impose groundwater use restrictions for the affected area and post appropriate hazardous waste disposal signs on and around the site.

Maintain the disposal area including fences and soil cover.

Identify and evaluate possible additional remedial actions (Operable Units) required for addressing the contamination of the entire site including the contaminant source (the disposal areas) and possible environmental/ecological concerns.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action and is cost-effective. This remedy utilizes permanent solutions and alternative treatment (or resource recovery) technologies, to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment that reduces toxicity mobility, or volume as a principal element.

As this remedy will initially result in hazardous substances remaining on site above health-based levels, a review will be conducted within five years after the commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

6/27/91
Date

Patrick M Tobin
for Greer C. Tidwell
Regional Administrator

SUMMARY OF REMEDIAL ALTERNATIVE SELECTION

RECORD OF DECISION
REMEDIAL ALTERNATIVE SELECTION

VELSICOL/HARDEMAN COUNTY LANDFILL
GROUNDWATER, OPERABLE UNIT I
TOONE, TENNESSEE

PREPARED BY:
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REGION IV
ATLANTA, GEORGIA

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GROUNDWATER, OPERABLE UNIT I
TOONE, TENNESSEE

INTRODUCTION

The Velsicol/Hardeman County Landfill was proposed for inclusion on the National Priorities List ("NPL") in December of 1982 and was finalized onto the NPL in September of 1983. On 242 acres in Hardeman County, Tennessee, Velsicol Chemical Corporation operated the 27 acre landfill for the disposal of plant waste generated at their Memphis, Tennessee plant. The Remedial Investigation ("RI") report which examines air, sediment, soil, surface water, and groundwater contamination was completed in April 1991. The Operable Unit I Feasibility Study ("FS") which develops and examines alternatives for remediation of the groundwater was submitted to the public information repository with the RI Report in April of 1991.

This Record of Decision ("ROD") has been prepared to summarize the remedial alternative selection process and to present the selected remedial alternative, in accordance with Section 113(k)(2)(B)(v) and Section 117(b) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA"), as amended by the Superfund Amendments and Reauthorization Act (("SARA") P.L. 99-499). The Administrative Record for the Velsicol/Hardeman County Landfill Site forms the basis for the Record of Decision contained herein.

SITE NAME, LOCATION, AND DESCRIPTION

The Velsicol/Hardeman County Landfill is located on an approximately 242-acre parcel approximately one mile north of Tennessee State Hwy 100 on the east side of Toone-Teague Road (see Figure 1). The Velsicol/Hardeman County Landfill and the contaminated areas associated with the landfill will hereinafter be referred to as the "Site".

The 242-acre parcel was purchased by Velsicol Chemical Corporation ("Velsicol") for use as a landfill and is presently owned by a holding company for Velsicol. From 1964 to 1973, the landfill was operated by Velsicol for the disposal of their Memphis, Tennessee pesticide manufacturing plant's production waste.

Waste from the plant was disposed of in trenches excavated on 27 acres of the property (the "disposal areas"). The top of the disposal areas is generally flat; however, the sides of the disposal areas slope down toward the drainage areas and creeks. The disposal areas are located on the west side of Pugh Creek and are approximately one mile south of Clover Creek which contains a large wetlands area. The creeks are used recreationally but are not used as a drinking water source.

The Site is located in a rural part of Hardeman County, Tennessee and most of the land use in the area is agricultural. Groundwater beneath the Site property is encountered at approximately 30 feet below land surface down to a depth between 110 to 170 feet. An artesian aquifer is located at approximately 220 feet below land surface. The surficial aquifer beneath the Site property, comprised of the Wilcox and Claiborne Formations, was used as a potable water supply in the area. Approximately 26 residences are located within 1 mile of

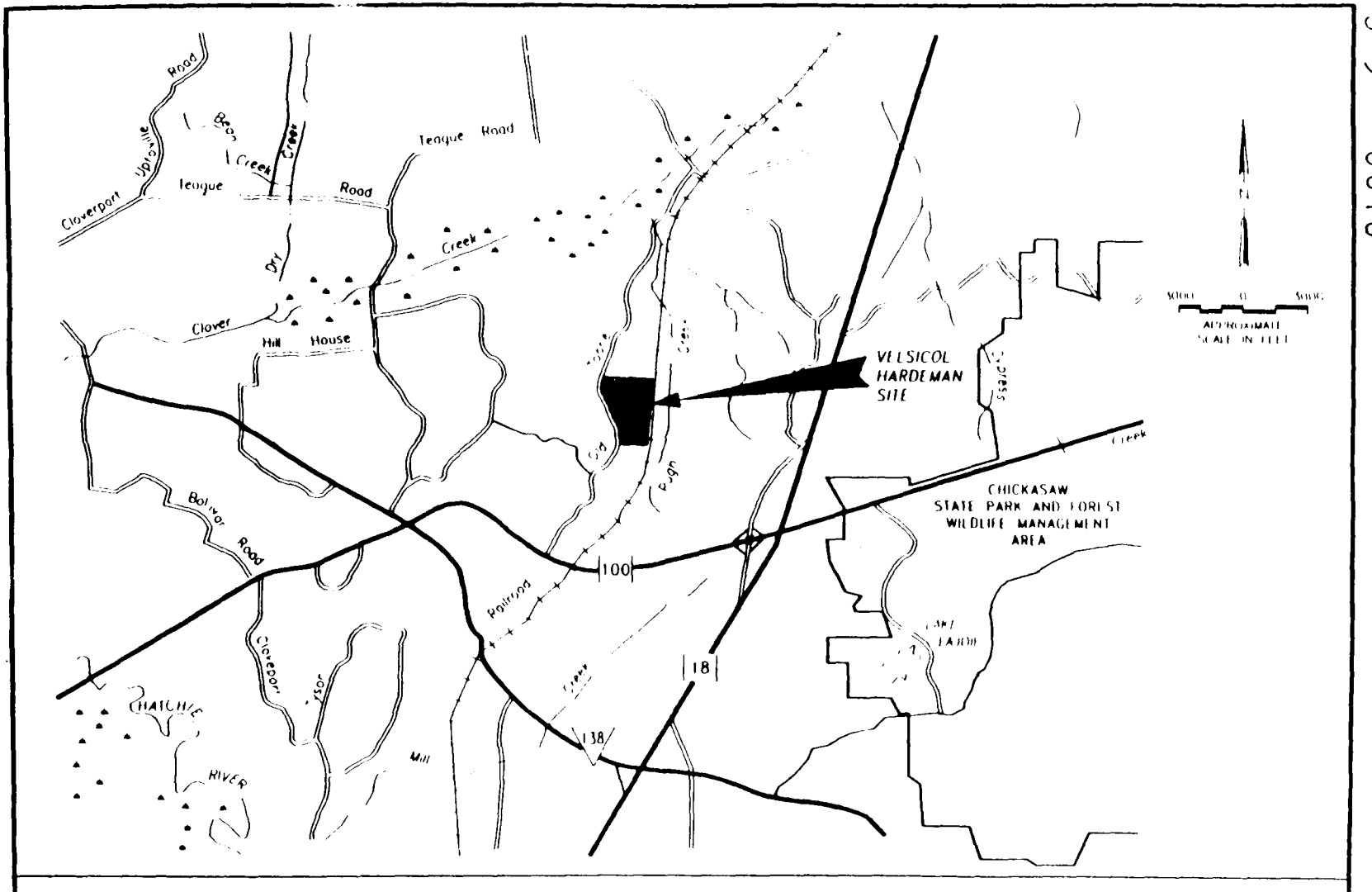

Figure 1. SITE LOCATION - VELSICOL/HARDEMAN COUNTY LANDFILL

the disposal areas with the nearest residence within one-quarter of a mile from the disposal areas.

Due to the disposal of the industrial and chemical wastes in the disposal areas, government agencies and the nearby community have raised concerns regarding potential impact from the Site.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

Historical Landfilling Practices

In July 1964, Velsicol purchased the 242 acres of land in Hardeman County, Tennessee, specifically for use as a landfill to dispose of plant waste from Velsicol's Memphis, Tennessee plant. The property, shown on Figure 1, is bound by the Toone-Teague Road to the west and Pugh Creek to the east.

Immediately upon purchasing this property, Velsicol began erecting a fence around a portion of the property where the landfilling was to commence. The purpose of the fence was to prevent local livestock from wandering onto the area during active landfilling. The fence was comprised of three strand barbed wire. A gate was provided at the access point off of the Toone-Teague Road.

The landfilling operation commenced in October 1964 and continued until June 1973. At the time of closure, waste had been disposed of in three specific disposal areas which covered a total area of approximately 27 acres. It was initially estimated that an equivalent of approximately 300,000 drums of plant waste from Velsicol's Memphis plant were disposed of in these three disposal areas. During the development of the RI Work Plan, Velsicol completed a more detailed estimate of waste volumes based on extensive evaluations of detailed plant production rates. A more accurate estimate of waste quantity and type, based on this second review by Velsicol, is summarized in Table 1.

Development of the landfill began in October 1964 with the northern disposal area since it was the only area on the property which was cleared of trees. Waste disposal commenced along the east side of the north disposal area and was carried out longitudinally in the direction of the property ridges. The middle and south disposal areas were developed sometime in the late 1960s or early 1970s. Subsequent to a public meeting held in Jackson, Tennessee in March 1971, the Tennessee Department of Health and Environment ("TDHE") evaluated the landfilling operation at the Site. On the basis of this evaluation, a Commissioner's Order was issued to Velsicol by TDHE which required Velsicol to cease disposal operations in the south disposal area in August 1972, but allowed limited waste disposal in the middle and north disposal areas until June 1973. Therefore, after closure of the south disposal area, selected wastes continued to be disposed of in the north and middle disposal areas until the landfill was permanently closed in June 1973.

Plant waste was disposed of in trenches which were excavated longitudinally along the top of the property ridges. Velsicol's records indicate that each trench was excavated to a depth of 12 to 15 feet; to a width of 10 to 12 feet; and to a length of 200 to 500 feet. Trenches were placed approximately four to eight feet apart.

As each transport vehicle arrived at the disposal areas, the containerized waste was dumped off the truck into one of the excavated disposal trenches.

TABLE 1

SUMMARY OF WASTE DISPOSAL AT HARDEMAN COUNTY LANDFILL
HARDEMAN COUNTY LANDFILL RI/FS

Waste	Weight Density (lbs/gal)	Total Weight (lbs)	Total Volume (Gal)	Equivalent # of Drums	Method of Disposal	Equivalent # of Drums Landfilled
Heptachlor Catalyst	10.1	2,539,000	251,386	4,571	H	4,571
Heptane Residue	6.3	14,539,000	2,307,778	41,960	I/B	
Fiber Drums	--	--	--	45,417	H	45,417
IPA Still D-30 Bottoms	12.0	16,128,000	1,344,000	24,436	*I/H	15,883
AN2K	--	--	994,605	18,084	I/B	
Acetic Acid Bottoms	19.9	19,351,000	972,412	17,680	*I/H	11,492
R-2 Bottoms	7.1	13,854,940	1,951,400	35,480	*I/H/S	23,062
Chlorendic Anhydride Still Bottoms	10.8	10,125,000	937,500	17,045	*I/H	11,079
PCL Bottoms J-11	14.1	13,988,000	992,057	18,037	*I/H	11,724
Carbon Beds	9.4	1,515,000	161,170	2,930	H	2,930
Bandane Filter Cake	15.6	3,122,000	200,128	3,639	H	3,639
		95,161,940	10,112,436	229,279		129,797

Notes:

H - Disposal by landfilling at Hardeman County Landfill
I - Disposal by incineration at Memphis Plant Site
B - Disposed as fuel in plant boiler
S - Disposal by discharging to the local sanitary sewer
* Waste disposed of by incineration. However, when incinerator was not operating (65 percent of time), waste disposed of by landfilling at Hardeman County Landfill.

On occasion, drums were set upright in the trenches upon disposal. In most cases, however, the containerized waste was left in the trench in the random order and orientation of which it had been dumped. Disposed waste was covered daily with soil excavated from the trenches. Upon filling with waste, each trench was covered with a minimum of three feet of soil which had previously been excavated from the area. The cover material was placed and compacted with a bulldozer and was mounded over the backfilled trenches to allow for future settlement. Periodically, as the backfilled areas settled, repairs were made by backfilling with additional soil.

Investigations and Studies Completed to Date

Investigative studies at the Site were started as early as 1967 when the United States Geological Survey ("USGS") reported on the potential of the disposed wastes to contaminate the groundwater beneath the disposal areas. Findings of these studies lead to the above-referenced Commissioner's Order limiting additional disposal in the trenches and finally closing the disposal areas in 1973. By late 1978, State and Federal investigations had confirmed groundwater contamination in private wells. The use of wells by residences in the vicinity of the disposal areas for domestic water supply was halted, and in early 1979, a public water supply replaced the private drinking water wells. In 1980, based on studies prepared by the United States Environmental Protection Agency ("USEPA"), TDHE, USGS and contractors working for Velsicol, a low permeability clay cap covering approximately 35 acres was placed over the disposal areas to control and minimize additional impacts from the Site.

After the completion of the cap, a monitoring program was implemented by Velsicol and overseen by USEPA and TDHE to assess the effectiveness of the cap. The monitoring program included the regular monitoring of groundwater quality, surface water and sediment quality in Pugh and Clover Creeks, a regional groundwater elevation survey surrounding the Site and the installation of lysimeters beneath the clay cap.

In December 1982, the Site was proposed for inclusion on the NPL. The results of the monitoring program were presented in February of 1985, and on November 5, 1985, TDHE issued a notice to Velsicol stating that a Remedial Investigation/Feasibility Study ("RI/FS") would have to be performed for the Site. USEPA and TDHE entered into a Site Enforcement Agreement in July of 1986 making TDHE the lead agency responsible for enforcing the remedial activities performed at the Site. On January 7, 1987, TDHE issued a Commissioner's Order requiring Velsicol to perform the RI/FS for the Site. In late 1988, EPA Region IV became the lead agency, and in February of 1989 entered into an Administrative Order on Consent with Velsicol to complete the RI/FS. The RI and FS reports were completed in early April of 1991 and were placed in the information repository along with the Administrative Record ("AR") prior to April 15, 1991.

HIGHLIGHTS OF COMMUNITY PARTICIPATION

During the early 1980s, numerous community relations meetings were held to address community concerns. After contaminated well usage was replaced with public water, and the landfill was covered with the low-permeability cap, the community was informed through fact sheets, information placed in the Site repository, and contact with State and Federal officials.

In February of 1988, as part of the RI, a Community Relations Plan ("CRP") was prepared by the TDHE with assistance from the University of Tennessee. This document lists contacts and interested parties throughout government and the local community. It also establishes communication pathways to ensure timely dissemination of pertinent information. Based on the CRP, a public meeting was held to discuss the RI/FS process with the community.

In April of 1991, the RI/FS and the Proposed Plan for the groundwater Operable Unit ("Proposed Plan") were released to the public.

All of these documents were made available in the Administrative Record located at USEPA, Region IV and the information repository maintained at the Bolivar-Hardeman County Public Library.

A public comment period was held from April 25, 1991 to May 24, 1991. In addition, a public meeting was held on April 25, 1991 to present the results of the RI/FS and the preferred alternative as presented in the Proposed Plan. All comments which were received by USEPA prior to the end of the public comment period, including those expressed verbally at the public meeting, are addressed in the Responsiveness Summary which is attached, as Appendix A, to this Record of Decision.

SCOPE AND ROLE OF RESPONSE ACTION

The scope of this response action is to address the off-site groundwater contamination and prevent additional contamination from leaving the disposal areas via migration through the groundwater. This response action is the first of two or more Operable Units ("OP Unit") or remediation phases that will be used to address the contamination of the entire Site including the landfill wastes and any long term environmental effects caused by the migration of waste from the disposal areas. The preferred alternatives for the groundwater OP Unit ("OP Unit #1") will address the remediation of contamination in the groundwater beyond the disposal areas boundaries prior to its discharge into the nearby surface water bodies of Clover and Pugh Creeks.

A remedy for the groundwater is proposed to protect public health and the environment by controlling exposure to the contaminated groundwater and controlling migration of the contamination through the groundwater to soils, sediments and surface water bodies. The groundwater is being addressed first for a number of reasons:

1. Contaminants in the groundwater are above Maximum Contaminant Levels ("MCLs") for drinking water and pose a health risk for anyone using the groundwater. Presently, homes in the area are being supplied water due to the groundwater contamination.

2. Groundwater treatment can be started while additional studies are performed and evaluated. These additional studies are required for determining remediation technologies for controlling the source are performed and evaluated.

3. Groundwater is presently discharging into the nearby surface water bodies, and higher levels of contaminants will be discharging to the creeks over the next four years.

Future response actions will address other Site contamination and principal threats completing remediation of the entire Site.

SUMMARY OF SITE CHARACTERISTICS

The source of the Site contamination including the groundwater is the 27-acre waste disposal areas (see Figure 2) located within the Site.

Sampling of the disposal areas, nearby soils, surface water, sediments and groundwater was performed during the Remedial Investigation ("RI"), and the results of the sampling are contained in the April 1991 RI report. This Record of Decision for OP unit #1 will address only the results of the groundwater portion of the RI since additional studies are required to evaluate final disposal area remedies.

Geology and Stratigraphy

The Site is located on the eastern flank of the Mississippi Embayment (see Figure 3). The embayment is a thick suite of sediments deposited in a large syncline or geologic trough, covering approximately 100,000 square miles in the Gulf Coastal Plain. The axis of the syncline plunges to the south, i.e. the sediments thicken to the south, with its axis roughly following the Mississippi River. A cross section of the area is shown in Figure 4.

The Porter's Creek Clay is a thick sequence, averaging approximately 120 feet of largely gray to black Paleocene clay, with noncontinuous subordinate lenses of sand. This sequence of clays effectively seals off the lower formations from any contamination in the overlying Wilcox and Claiborne (Eocene) Formations.

The Wilcox Formation unconformably overlies the Porter's Creek Clay, i.e. there is an erosional break between the two formations. The Wilcox, estimated to be 75 to 125 feet thick in the study area, is a heterogeneous unit of sand with some silt and clay, with occasional beds of lignite, kaolin, and siderite ($FeCO_3$). These sediments are interbedded and interlensed, and are not laterally persistent. They are typical of nonmarine fluvial or deltaic deposits. This lack of lateral continuity is one of the key factors in questioning the ability of the formations to receive continuous reinjection of treated groundwater at the Site.

The Claiborne Formation is similar to the Wilcox with many vertical and horizontal discontinuities. The Claiborne is comprised predominantly of interbedded sands with lenses and thin beds of clay and sandy clay, and some thin lenses of kaolin. Its maximum thickness in western Tennessee is up to 1100 feet, but in the study area it ranges from 0 to 125 feet.

The Wilcox-Claiborne contact usually is not discernible in Tennessee because (1) the lithologies are similar, (2) the stratigraphies of the two formations are so variable, and (3) the boundary between the two is erosional and, therefore, not at all uniform.

Quaternary alluvial sediments overlie most of the Claiborne Formation in this area. This alluvium is similar to the Claiborne sediments and could not be differentiated from them in the study area. The alluvium is usually capped by

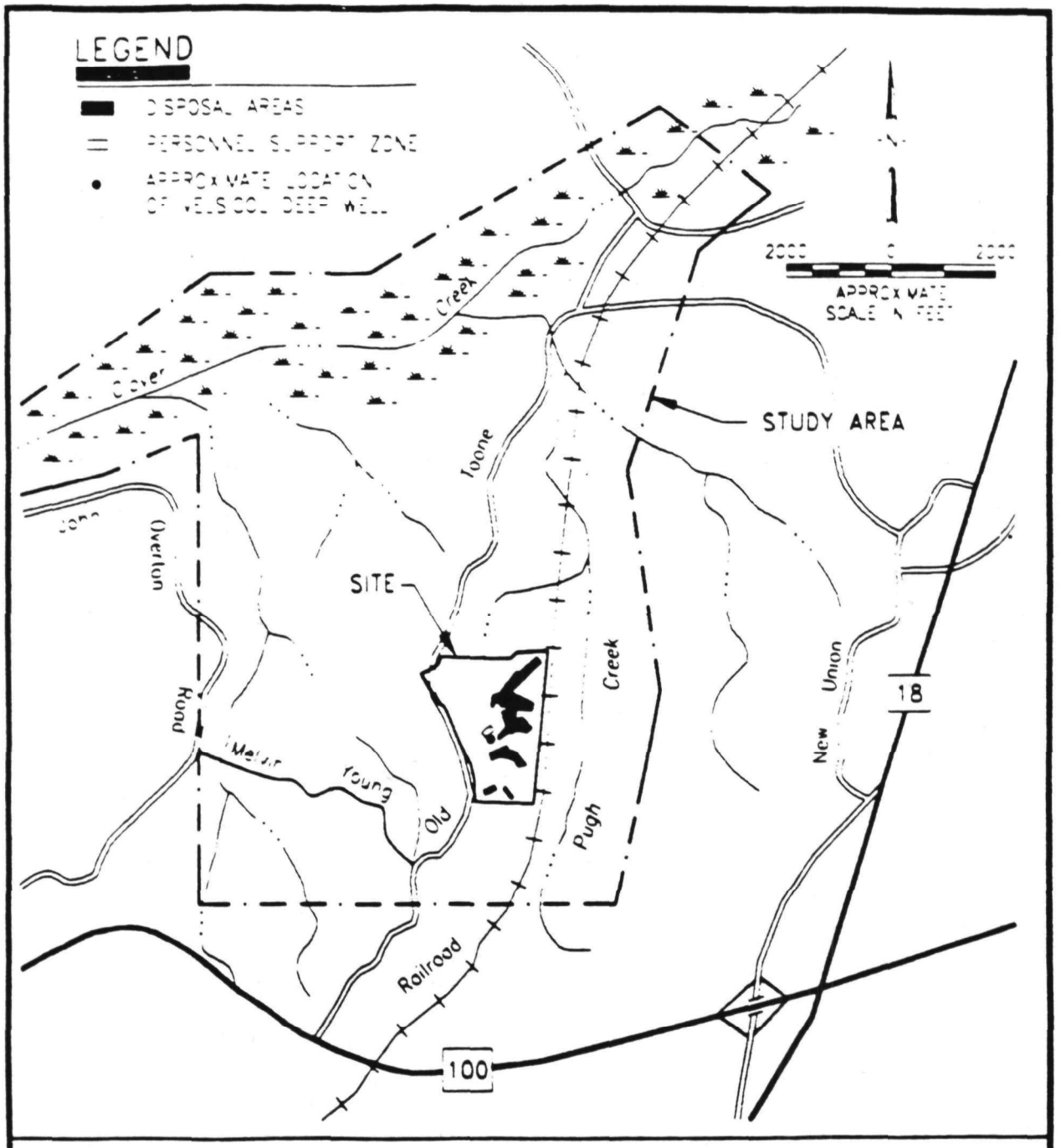

Figure 2. DISPOSAL SITE - VELSICOL CHEMICAL CORPORATION

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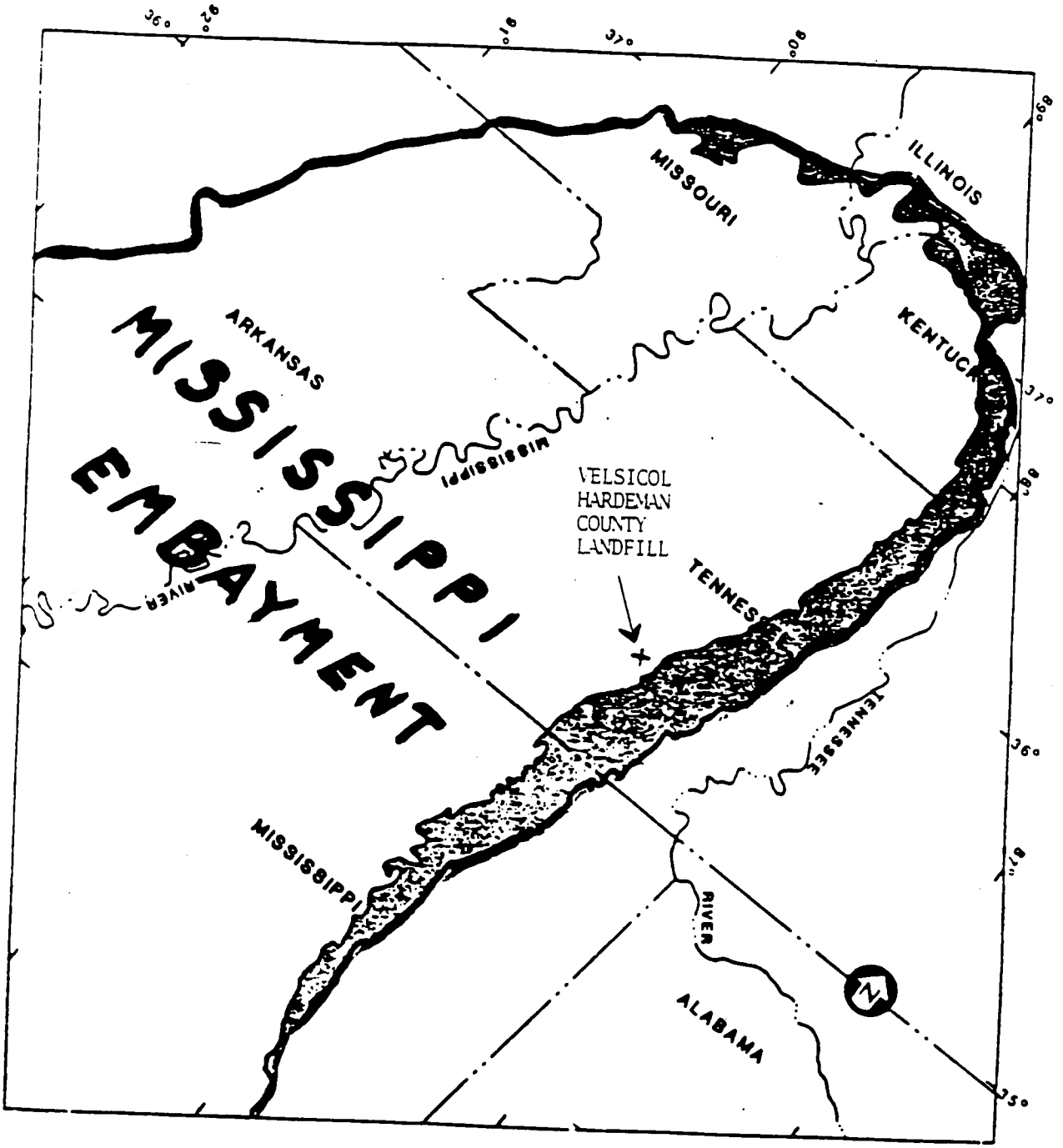

FIGURE 3
MISSISSIPPI EMBAYMENT

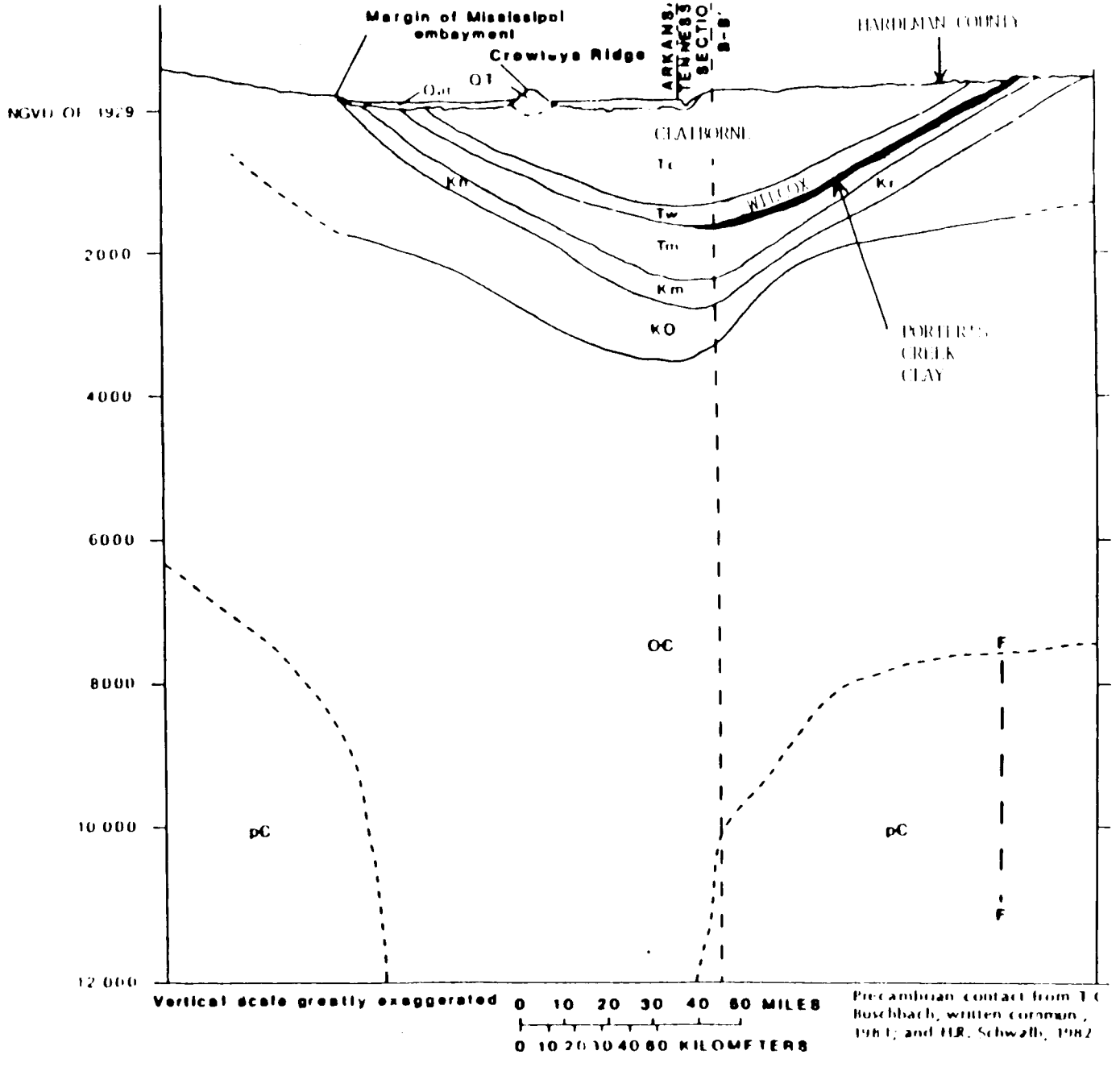

FIGURE 4
AREA CROSS SECTION

loess, which is glacially derived, wind blown, very angular silt. Silt was present at the surface at 9 of 12 well locations drilled near the Site. The thickness of the loess deposits ranges from 0 to about 12 feet.

Hydrogeology

The Porter's Creek Clay is an aquitard that forms the lower boundary of the water table aquifer in northern Hardeman County. The sands of the Wilcox and Claiborne Formations are hydrologically connected and form one hydrostratigraphic unit as the water table aquifer. This aquifer ranges from approximately 65 to 125 feet thick in the study area and is considered a Class IIa aquifer.

Precipitation is the principal source of groundwater recharge. On a broad, regional scale, movement of groundwater generally follows the dip of the sediments, which is to the west toward the Mississippi River. Flow directions within the water table aquifer in the outcrop area, such as at the Site, are primarily controlled, however, by the local topography and nearby stream systems. Clover Creek and the Hatchie River are the primary discharge areas for the water table aquifer in northern Hardeman County, with Clover Creek establishing the direction of groundwater flow to the north and northwest in the area of the site (see Figure 5).

The water table aquifer is the primary source of groundwater in northern Hardeman County. Cross sections from south to north are shown in Figures 6 and 7. Sand thicknesses are circled to indicate the many potential pathways for contaminant movement through these heterogeneous strata. Although there are many low permeability lenses, studies near the edge of the Site showed that perched water on top of these lenses is seldom found.

Corresponding well placements and the elevations of the groundwater and ground surface are shown in Figures 8 and 9. At the disposal areas, contaminants have to diffuse and percolate through 75 to 95 feet of sediments in the unsaturated zone before they reach the groundwater. A two-foot thick clay cap installed on the disposal areas in 1980 has substantially reduced percolation through the trenches and waste.

Although private wells in the vicinity of the disposal areas were monitored extensively during the early phases of groundwater contamination, these wells have been largely abandoned or plugged after Velsicol provided for an alternative water supply to the residences affected by the downgradient contamination. All groundwater monitoring is now done from carefully installed and logged monitoring wells.

Vertical hydraulic gradients were calculated for each monitoring well nest. Well nests are indicated schematically on Figures 8 and 9 by multiple screens at the same location. Downward gradients ranging from 0.0004 to 0.02 feet/foot were found at five of the eleven locations; while upward gradients ranging from 0.002 to 0.18 feet/foot were determined at the remaining six wells. The relatively low magnitudes of the downward gradients adjacent to Pugh and Clover Creeks, however, suggests that horizontal flow parallel to and beneath the creeks is occurring in some reaches. The complete groundwater and surface water elevation data support the conclusion that these creeks form the hydrologic boundaries of the groundwater flow from the Site.

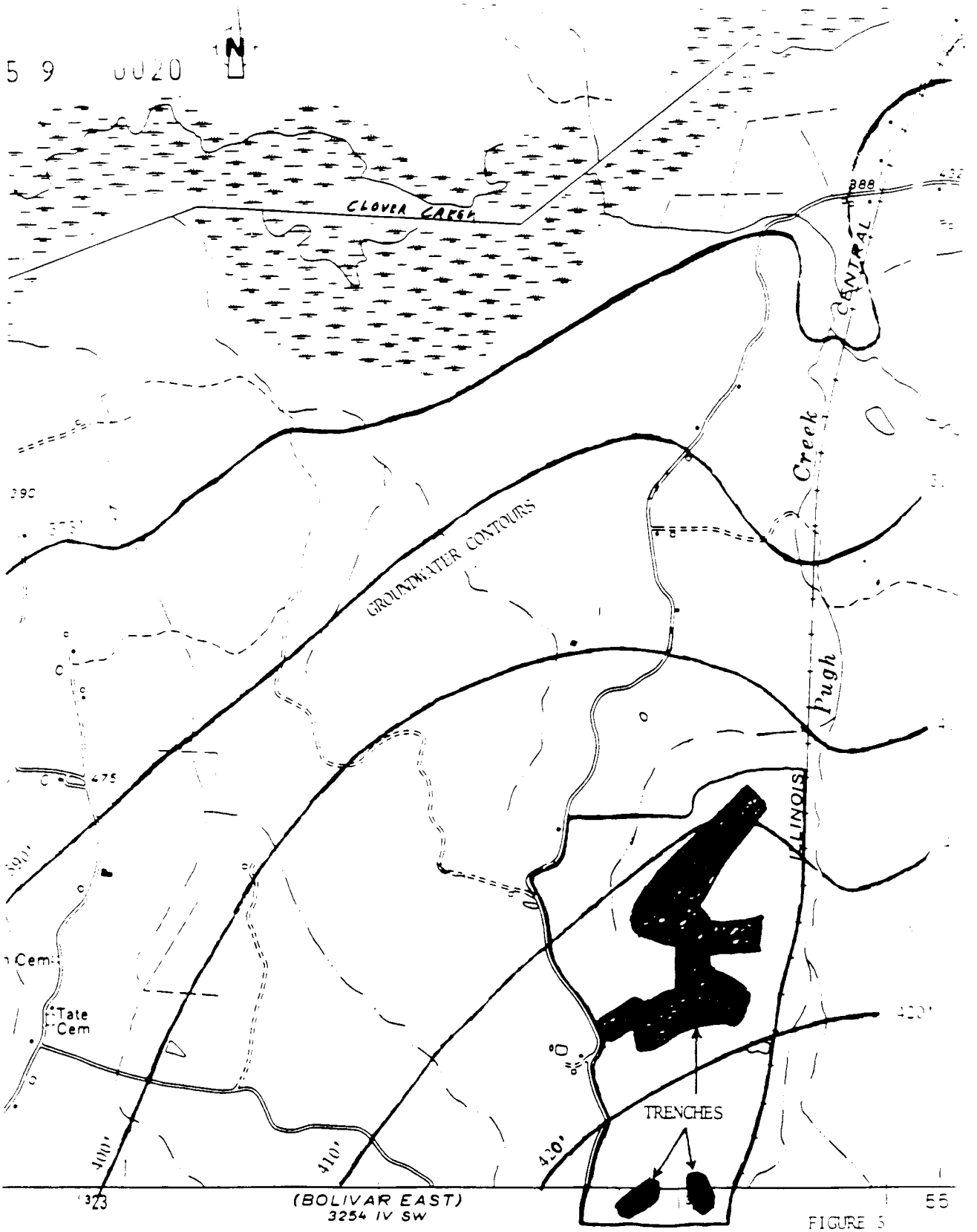

FIGURE 5
GROUNDWATER CONTOURS

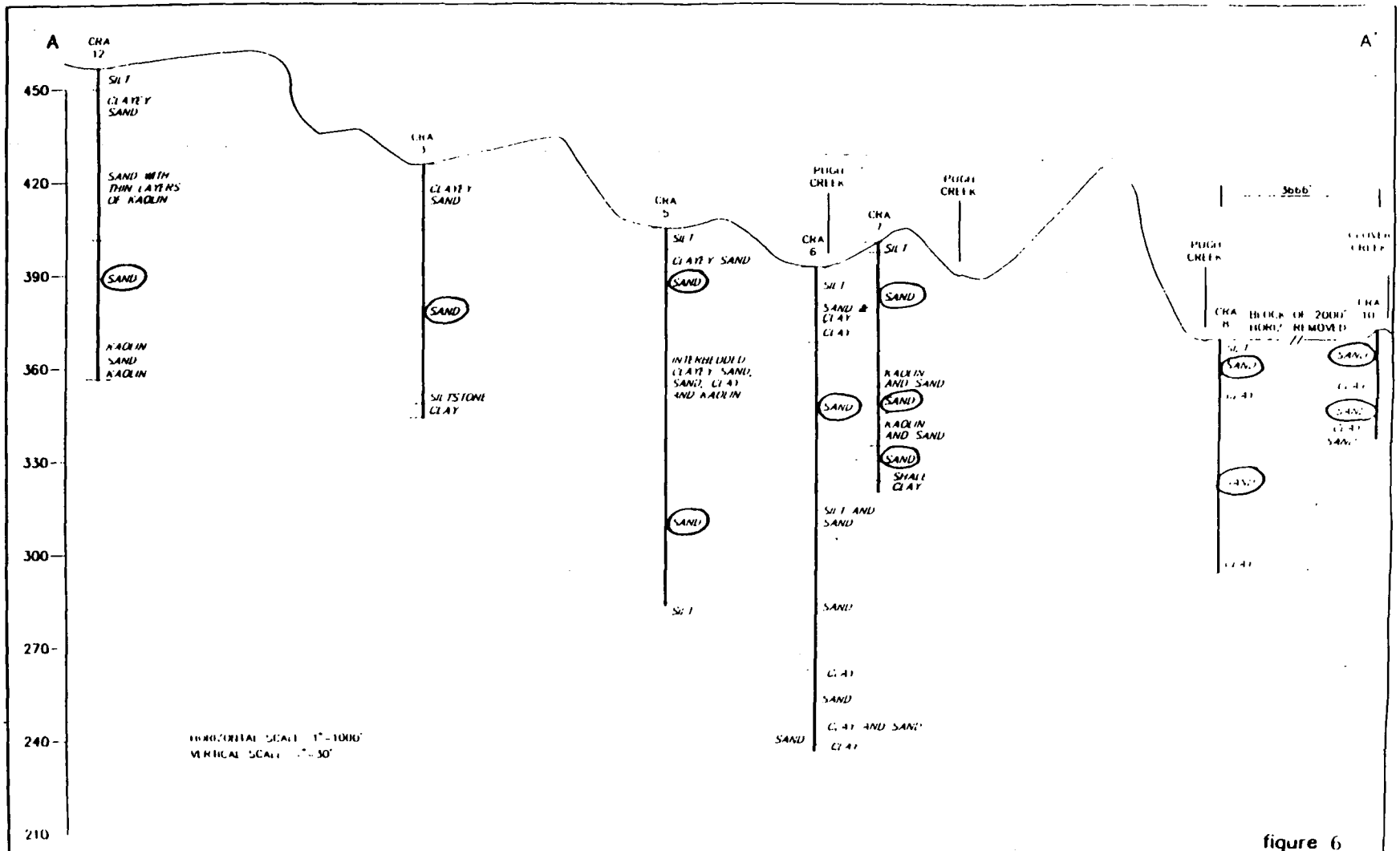

figure 6

GEOLOGIC CROSS SECTION A–A'
Velsicol Chemical Corporation

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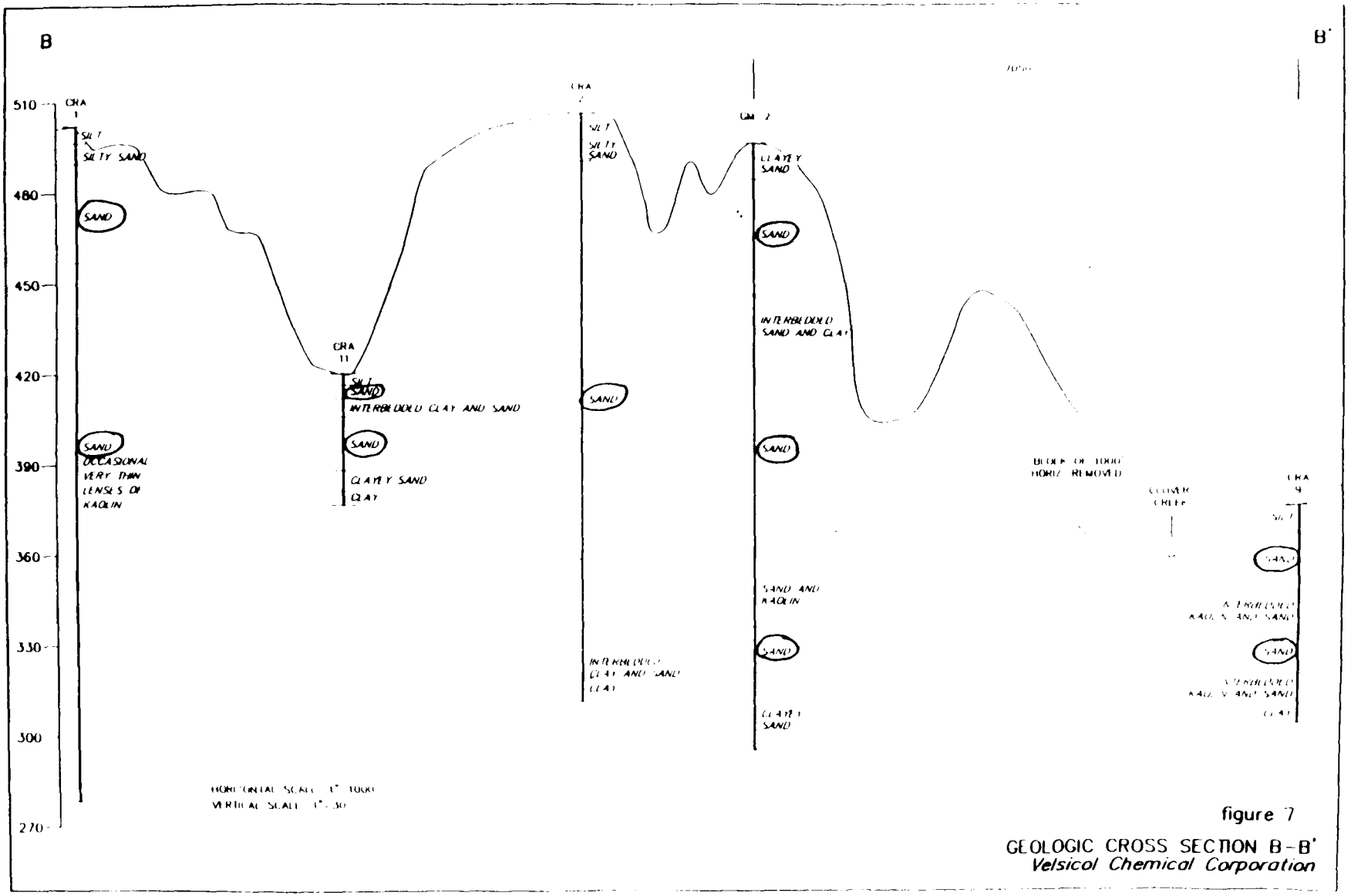

figure 7

GEOLOGIC CROSS SECTION B-B'
Velsicol Chemical Corporation

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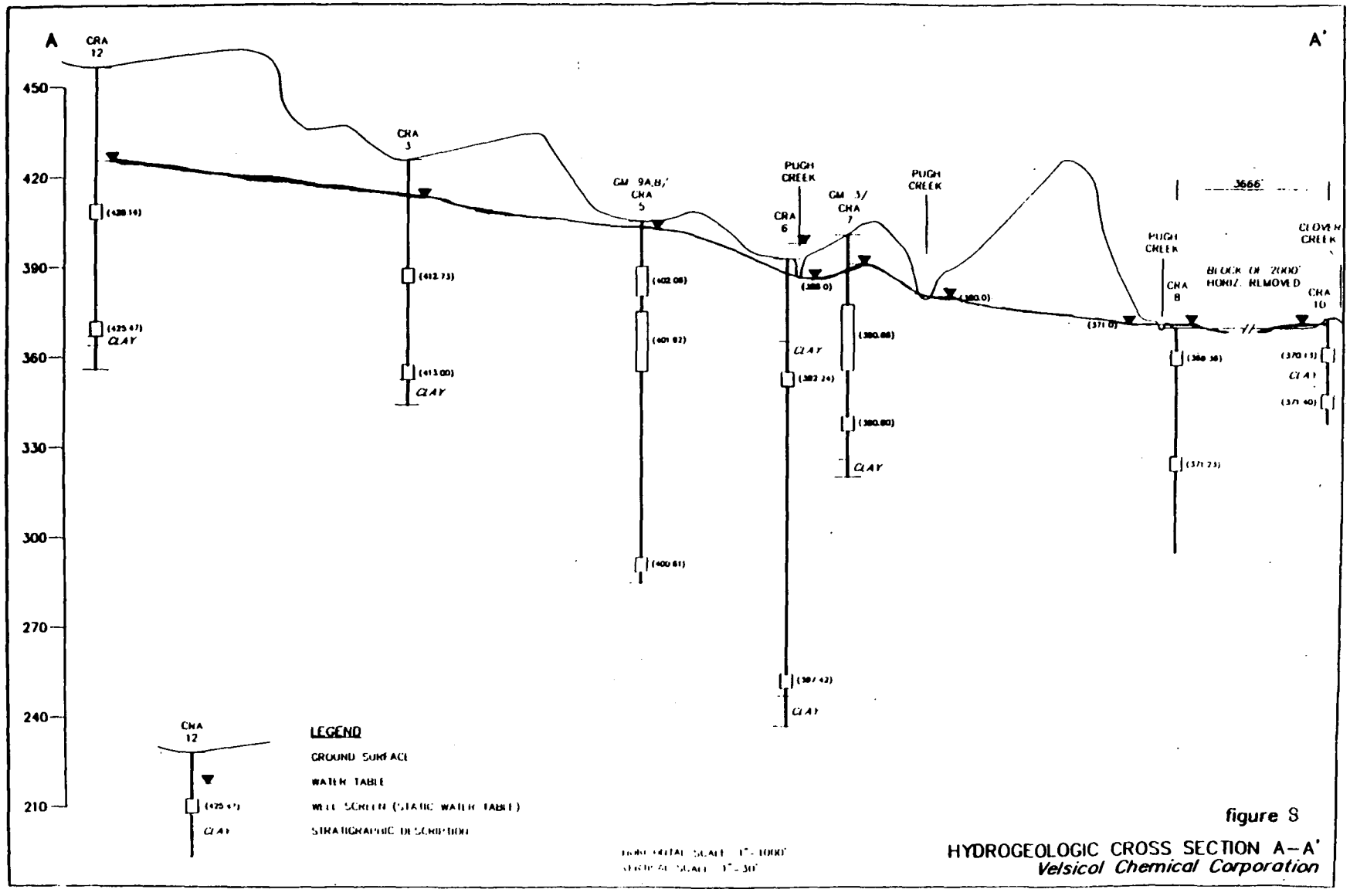

figure 8

HYDROGEOLOGIC CROSS SECTION A–A'
Velsicol Chemical Corporation

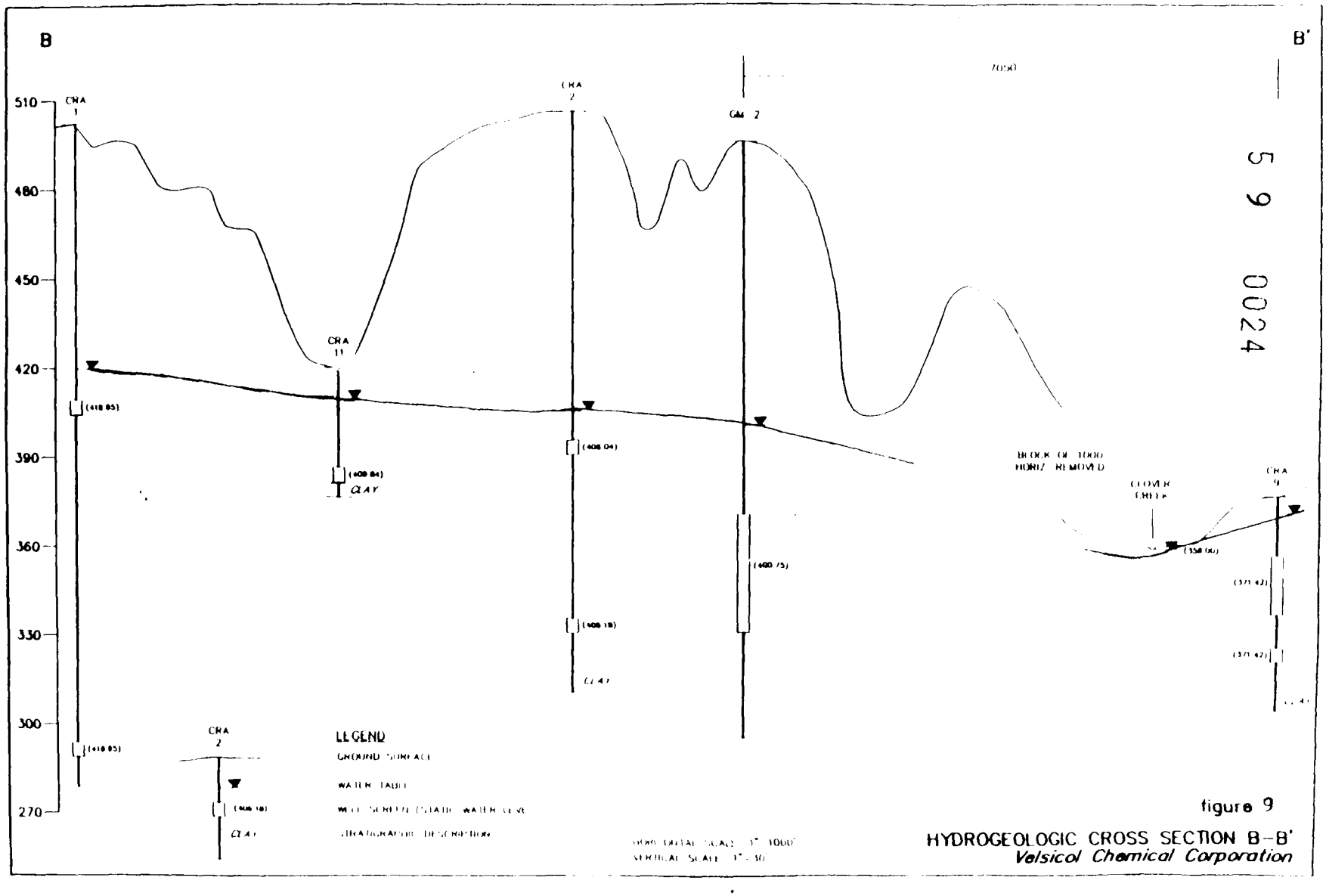

figure 9

HYDROGEOLOGIC CROSS SECTION B–B'
Velsicol Chemical Corporation

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Nature and Extent of Contamination

In monitoring the downgradient movement of contaminants beyond the disposal areas, only carbon tetrachloride (CCl_4) and chloroform ($CHCl_3$) were detected in 1989 in all six samples from two rounds of sampling (in samples from each of three selected downgradient wells as shown in Table 2).

Contaminants detected in five of the six samples were acetone (which may have been a result of laboratory contamination), methylene chloride, and tetrachloroethylene.

Two contaminants were detected in four of the six samples: chlorobenzene and toluene.

These mobile contaminants are all volatile organic compounds ("VOCs") characterized by:

high vapor pressures,

moderate to high solubilities,

relatively high Henry's Law constants (partitioning between air and water), and

relatively weak sorption to soil organic matter.

Pesticides and related compounds were either not found at all in the groundwater or were mainly found in the groundwater on-site.

Groundwater flow and contaminant transport were modeled with a two-dimensional integrated depth model, GWPGM3, developed by J. F. Sykes at the University of Waterloo, Waterloo, Ontario, in 1987. This is a finite element, numerical model used for two-dimensional analyses of steady state flow and mass transport in variably saturated cross-sections and integrated depth confined or phreatic (water table) aquifers.

The finite element mesh used for the model is shown in Figure 10. Simulations of predicted carbon tetrachloride concentrations are shown in Figures 11 to 13, with a predicted concentration profile shown in Figure 14. Similar distributions of chloroform were developed; its concentration profile is shown in Figure 15.

While the model was calibrated against measured contaminant concentrations in the field, these modeling results can only be interpreted qualitatively. The heterogeneous nature of the geology of the area precludes an accurate prediction of future conditions, which must be modeled from the assumptions of hydraulic conductivity, longitudinal and transverse dispersivity, etc. Using these assumptions, the calibrated hydraulic conductivity used in the model was 0.005 cm/sec. This value is significantly lower than the maximum value of 0.0111 cm/sec as determined by slug tests. Yet even the value of 0.0111 cm/sec resulted in a calculation of a travel time of approximately 26 years for groundwater beneath the disposal areas to reach Clover Creek; whereas the actual travel time was less than 23 years. The actual transport time must necessarily be the result of groundwater flow through the many interconnected, highly permeable sand lenses highlighted in Figures 6 and 7.

TABLE 2

EXPOSURE POINT CONCENTRATION (mg/L)
GROUNDWATER - DOWNGRADIENT PLUME
HARDEMAN COUNTY LANDFILL RI/FS

Chemical	Round 1 *			Round 2		
	GM-5	13	GMP-5	GM-5	13	GMP-5
Acetone	3.38	7.88	0.021	1.68	7.73	0.00
Carbon Tetrachloride	2.76	2.57	2.19	12.0	5.05	3.08
Chlorobenzene	0.009	0.038	0.00	0.006	0.051	0.00
Chloroform	0.707	0.914	0.807	2.85	2.09	0.789
Methylene Chloride	0.503	0.491	0.00	0.244	0.542	0.010
Tetrachloroethylene	0.014	0.021	0.00	0.010	0.036	0.006
Toluene	0.125	0.302	0.00	0.095	0.401	0.00
Xylene	0.00	0.007	0.00	0.00	0.00	0.00
Bis(2 ethylhexyl)phthalate	0.00	0.00	0.200	0.087	0.00	0.00
Di-n-butylphthalate	0.00	0.00	0.00	0.00	0.00	0.00
Di-n-octylphthalate	0.00	0.00	0.010	0.00	0.00	0.00
2-4-Dichlorophenol	0.00	0.00	0.00	0.00	0.00	0.00
Endrin	0.00	0.00	0.00	0.00	0.00	0.00
Endrin ketone	0.00	0.00	0.00	0.00	0.00	0.00
Endrin Aldehyde	0.00	0.00	0.00	0.00	0.00	0.00
Heptachlor	0.00	0.00	0.0002	0.00	0.00	0.00

* WELL LOCATIONS ARE SHOWN ON FIGURE 11

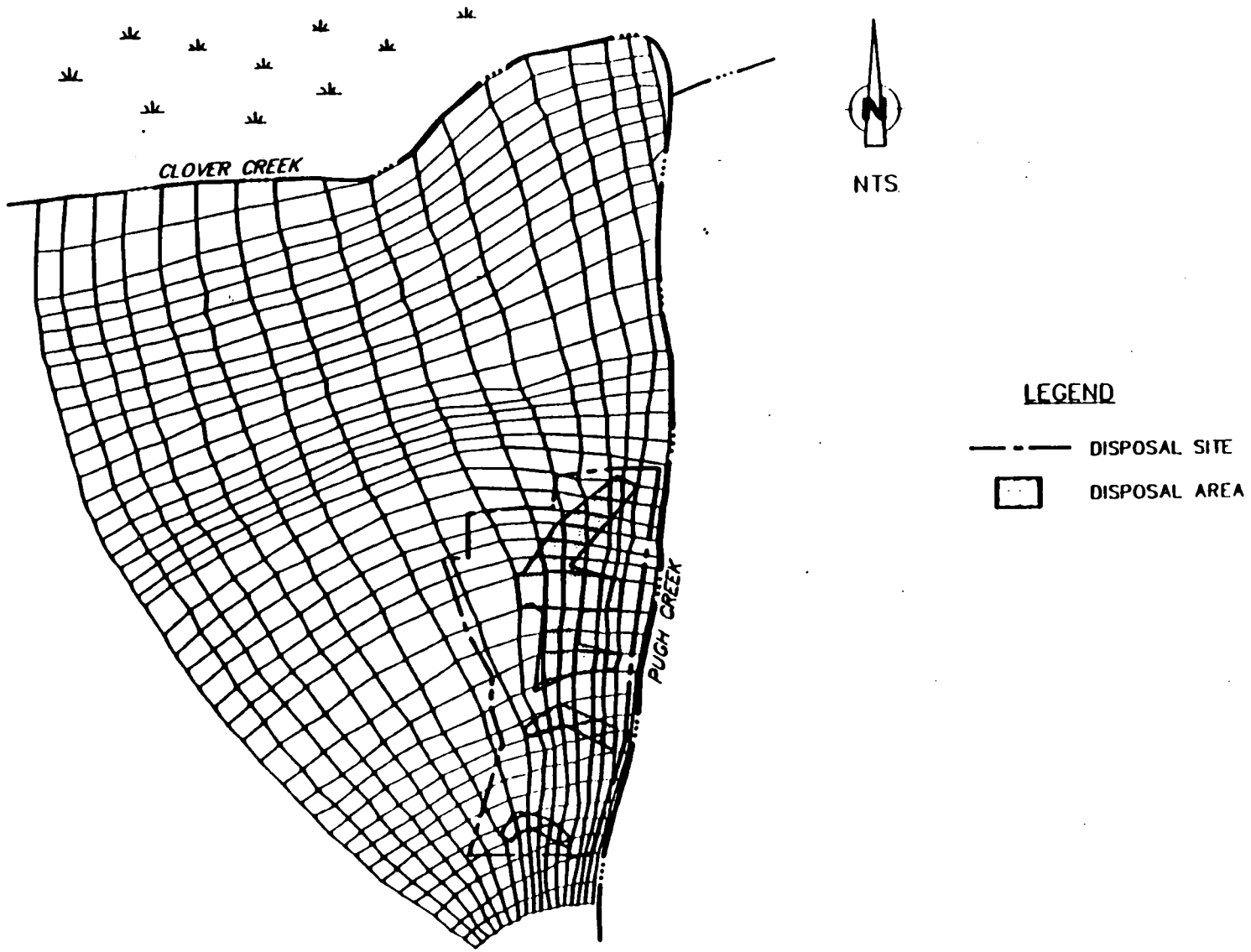


figure 10

FINITE ELEMENT MESH

Velsicol Chemical Corporation

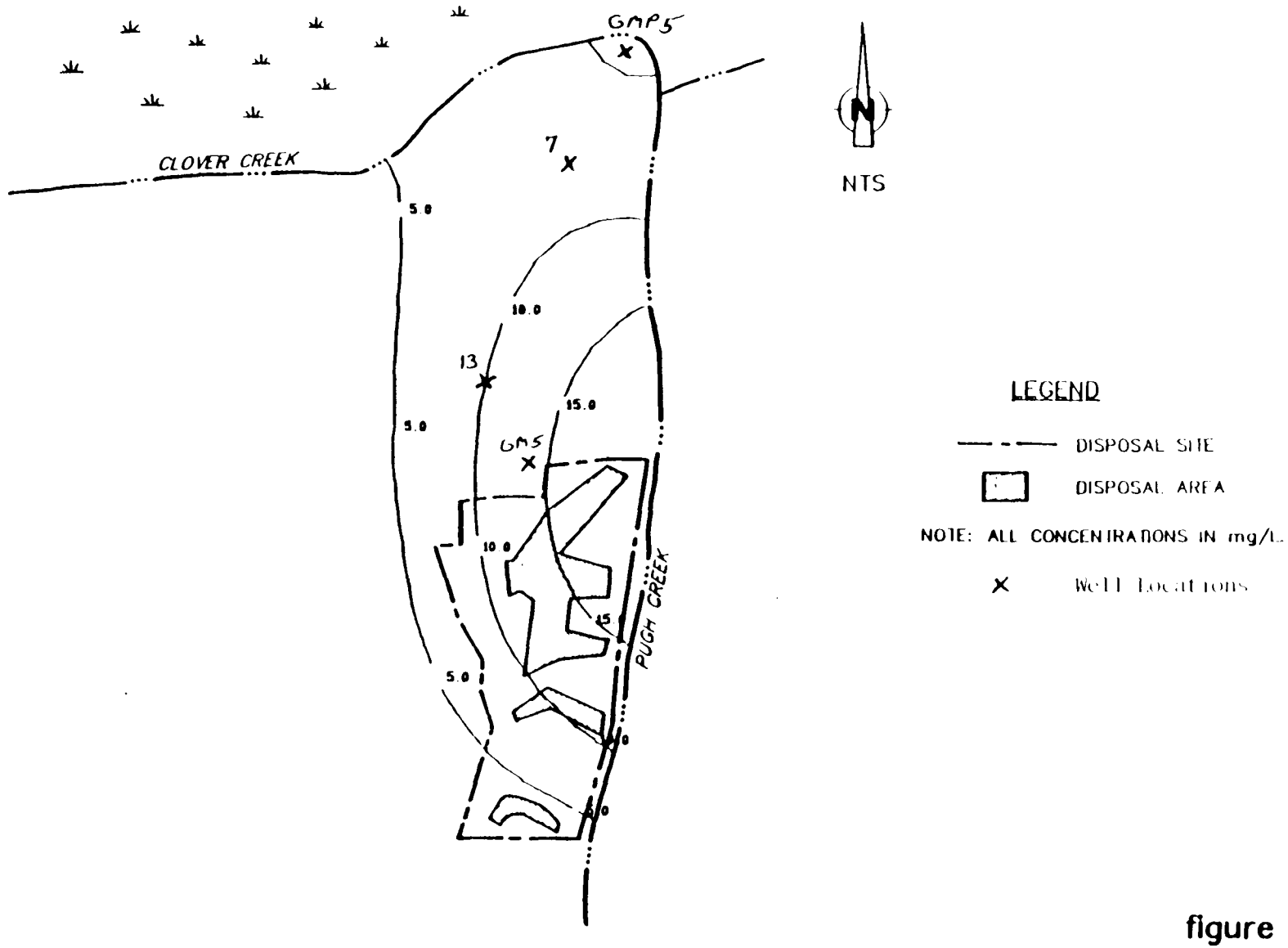


figure 11

CALCULATED CARBON TETRACHLORIDE DISTRIBUTION FOR THE YEAR 1990

Velsicol Chemical Corporation

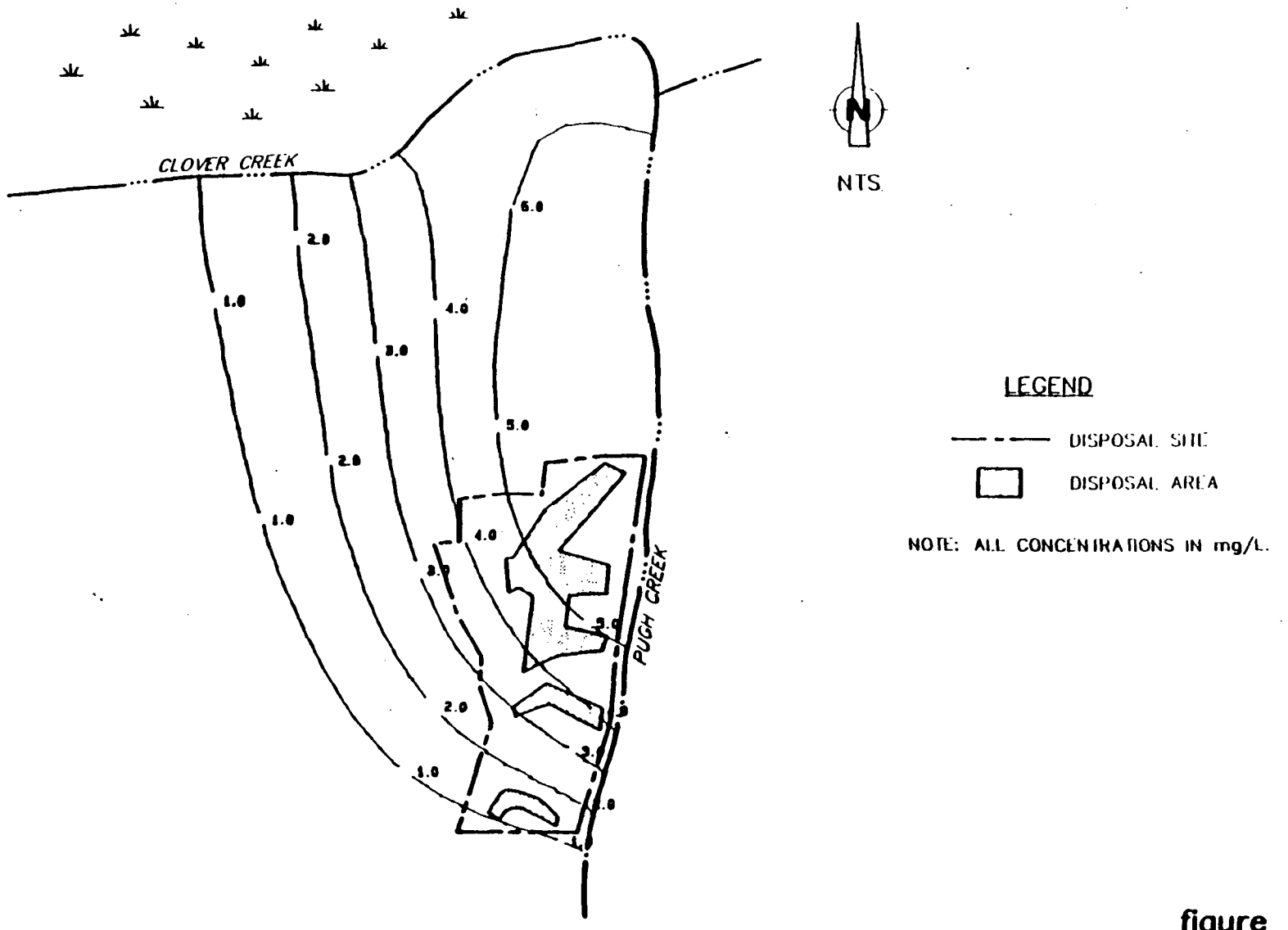


figure 12

CALCULATED CARBON TETRACHLORIDE DISTRIBUTION FOR THE YEAR 2000

Velsicol Chemical Corporation

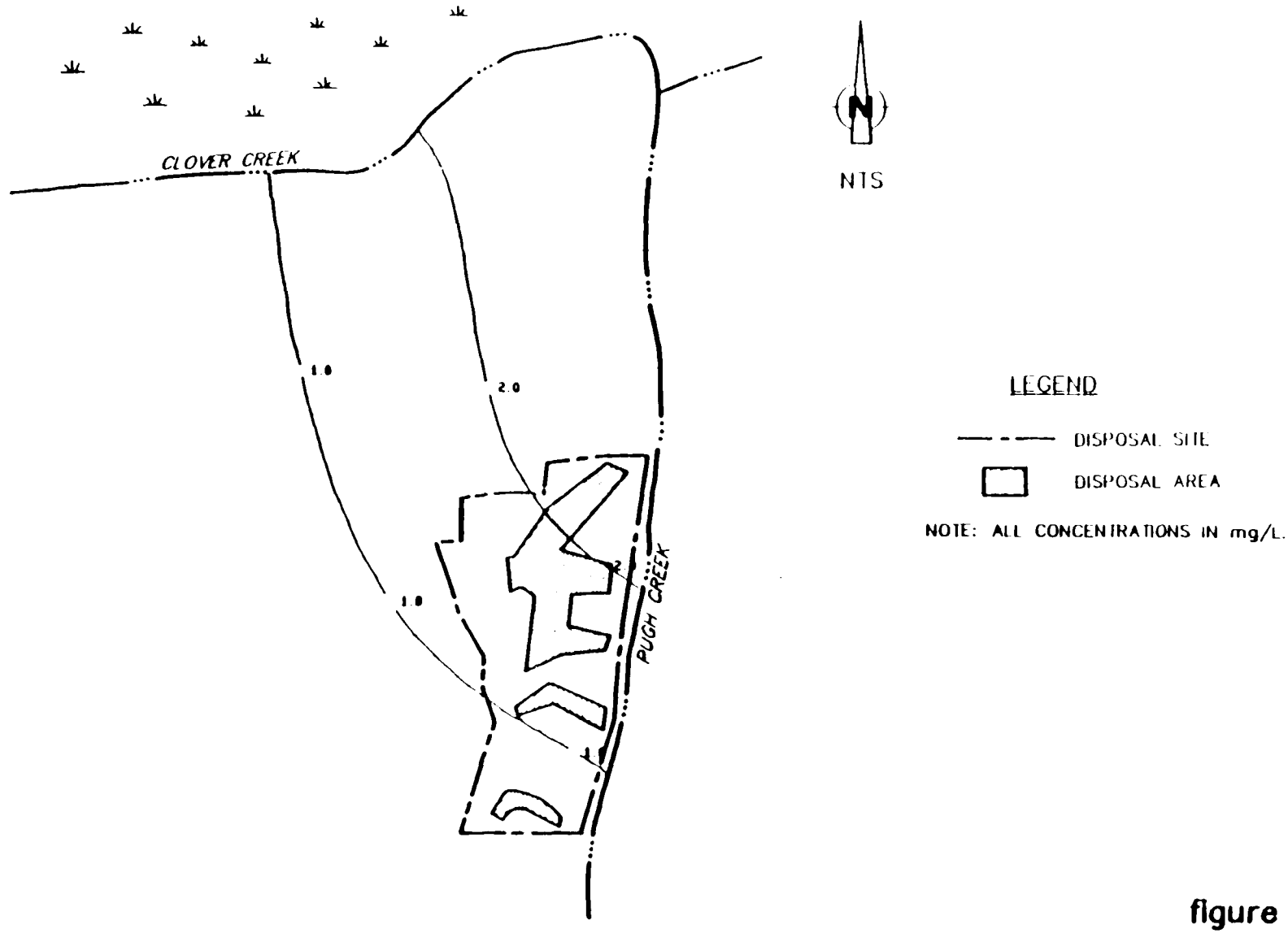


figure 1

CALCULATED CARBON TETRACHLORIDE DISTRIBUTION FOR THE YEAR 2010

Velsicol Chemical Corporation

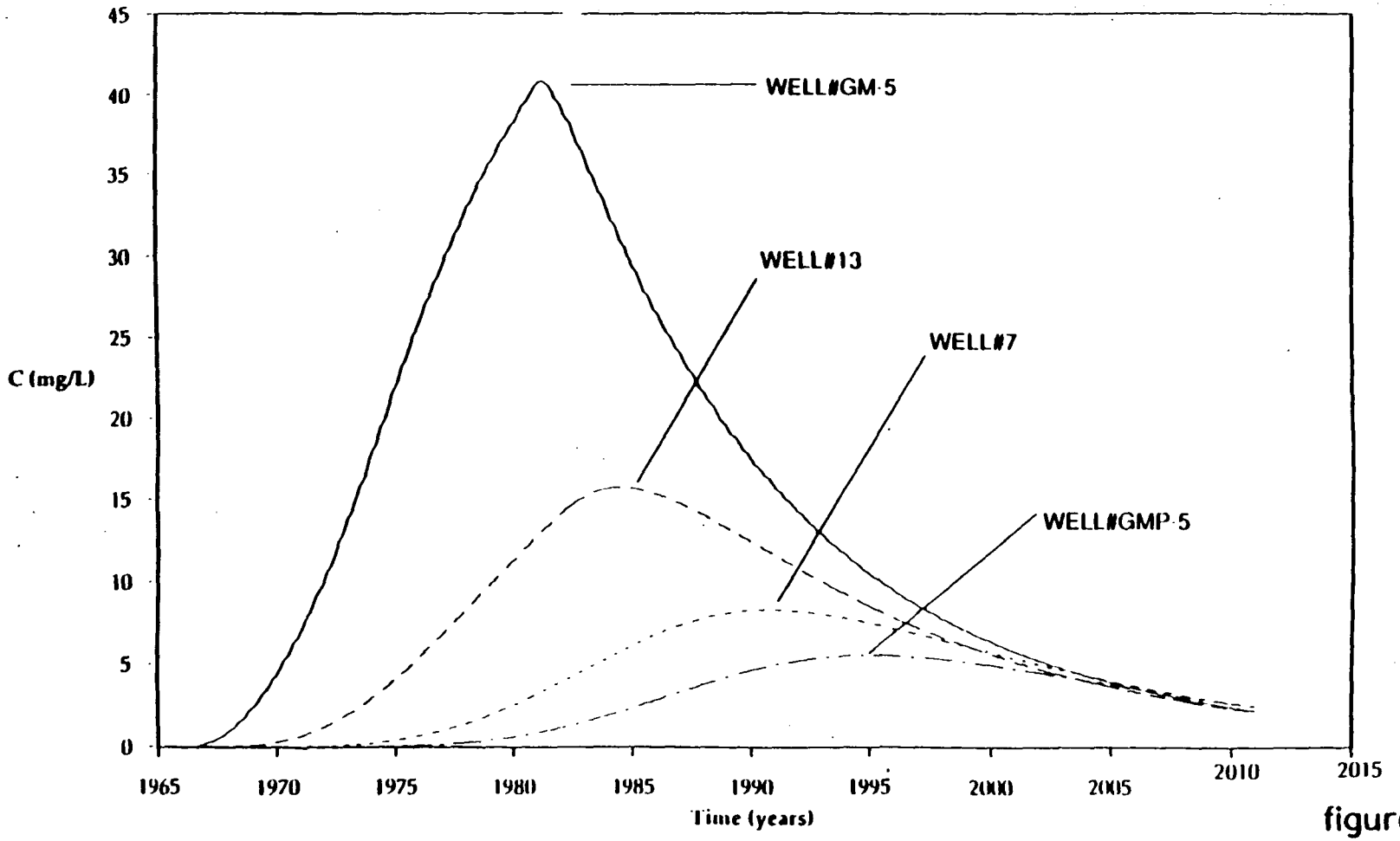


figure 1-1

PREDICTED CARBON TETRACHLORIDE CONCENTRATION PROFILE

Velsicol Chemical Corporation

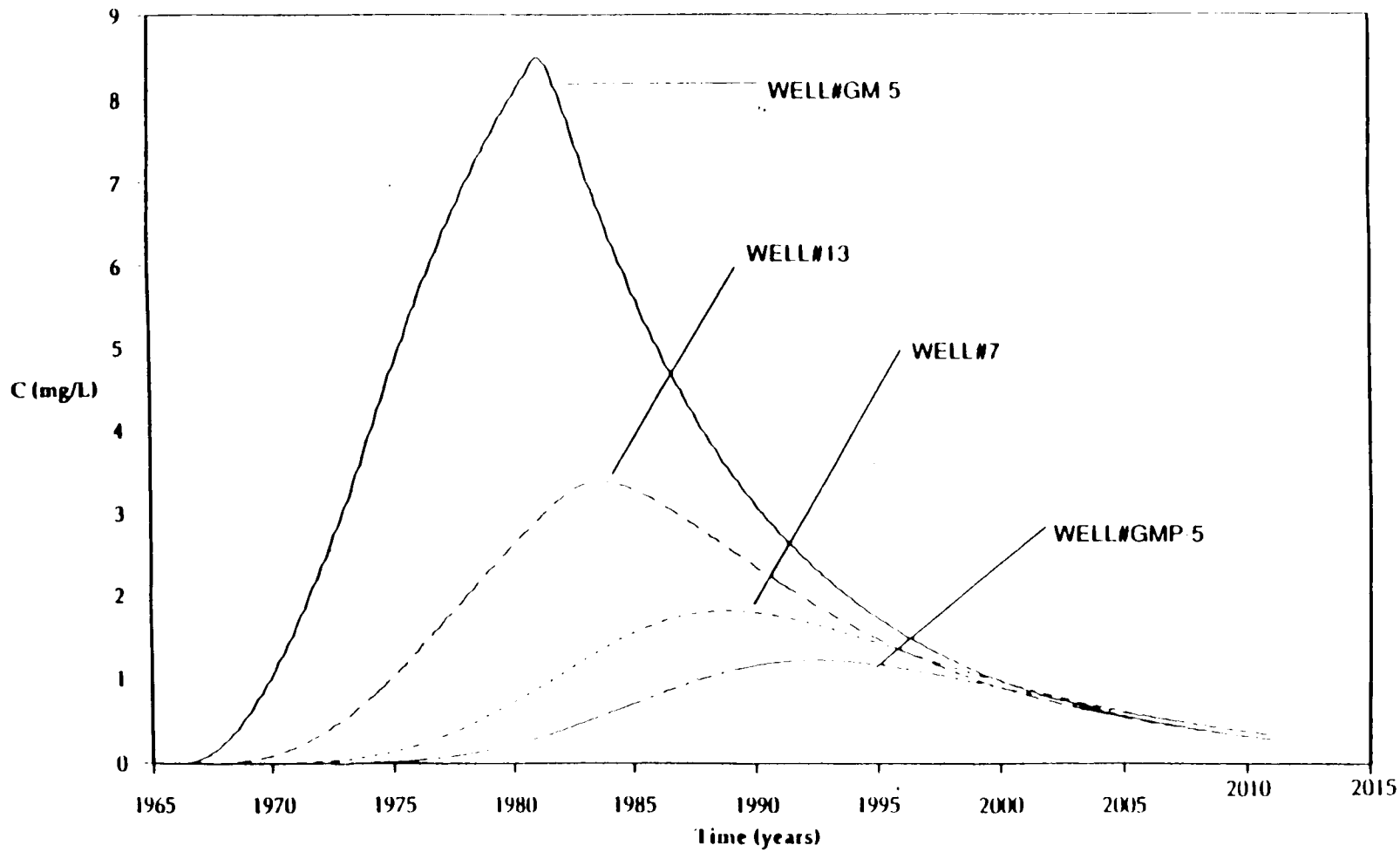


figure 15

PREDICTED CHLOROFORM CONCENTRATION PROFILE
Velsicol Chemical Corporation

SUMMARY OF SITE RISKS

A baseline risk assessment was conducted for the Site and is presented in the RI report. The risk assessment consisted of a chemicals of concern identification, an exposure assessment, a toxicity assessment and a risk characterization for human health effects.

Environment risks were briefly discussed based on available data; however, additional information is required, and an environmental evaluation will be conducted as a part of OP Unit #2.

Identification of Chemicals of Concern

The identification section involves the selection of the contaminants of concern ("COCs") used in evaluating the risks associated with the Site. The COCs are detected contaminants which have inherent toxic/carcinogenic properties that are likely to pose the greatest concern with respect to the protection of public health and the environment. Selected contaminants of concern at the Site include:

Carbon tetrachloride	Bis (2-ethylhexyl)phthalate
Chlorobenzene	Di-n-butyl phthalate
Chloroform	Di-n-octyl phthalate
Tetrachloroethene	2,4-Dichlorophenol
Toluene	Endrin
Xylene	Endrin Ketone
Acetone	Endrin Aldehyde
Methylene Chloride	Heptachlor

All of the contaminants above except Methylene Chloride and 2,4 - Dichlorophenol (which were detected only in groundwater) were detected in both soil and groundwater beneath the disposal areas.

Exposure Assessment

The exposure assessment identified potential pathways and routes for contaminants of concern to reach the receptors and the estimated contaminant concentration at the points of exposure. Contaminant release mechanisms from environmental media, based on relevant hydrologic and hydrogeologic information (fate and transport, and other pertinent Site-specific information, such as local land and water use or demographic information), were also presented.

At the Site, the current receptor population was identified as limited to the residential community surrounding the disposal areas.

Groundwater is the current release medium which can transport chemicals from the Site. Prior to capping the disposal areas in October 1980, direct contact with the waste and surface water transport was a potential release medium. However, the graded and grassed cap presently precludes any direct contact with wastes or erosion of wastes into surface water. The cap also limits air dispersion of volatile organic chemicals from the waste. The aquifer under the Site was the aquifer from which local residents' wells previously drew water for household use. Although the present residents now receive their household water from a public water supply, the potential to use the aquifer for residential water exists and thus has been evaluated as a potential exposure pathway. This pathway includes the consumption of contaminated groundwater and the inhalation of volatiles through bathing.

The contaminated groundwater discharges to the surface either at seeps or directly to Pugh and Clover Creeks. All of the identified continuous seeps presently flow into Pugh or Clover Creek. Because of the remote locations of the seeps, direct human contact is considered unlikely. However, if contact did occur, it would most likely be single or occasional exposure resulting in an insignificant total dose. Therefore, potential human exposure to the seep contamination is considered to be via the surface water in Pugh and Clover Creeks.

Because the volatile organics which are migrating from the Site biodegrade and volatilize in open waters, they are not persistent in the above-ground environment. This lack of persistence significantly limits their potential risk and hazard to human health when evaluating the surface water exposure pathway.

Potential exposure to the water in Pugh and Clover Creeks is through recreational activities, primarily fishing and hunting. Although fishing would probably be limited to Clover Creek, since Pugh Creek is too shallow to support a game fish population of fishing size, data from both creeks has been evaluated. Game animals could drink from either Pugh Creek or Clover Creek. Human exposure would be limited to eating fish caught in Clover Creek or eating game animals which might drink from the creeks. Although neither Pugh nor Clover Creek would be expected to be used for swimming, a swimming scenario has been included in the assessment to conservatively address any occasional wading, swimming, or water contact by residents.

The following human exposure pathways were evaluated for potential exposure point concentrations, estimated daily intake and potential risk and/or hazard:

- the use of contaminated groundwater for household use,
- recreational fishing and fish consumption from Clover Creeks,
- occasional skin contact while fishing, swimming, or wading, and
- inhalation of volatile compounds detected in Clover Creek while fishing.

Three levels of assumptions are presented for each scenario. "Level 1" assumptions present the average or mean value for the exposure assumption, "Level 2" presents assumptions which will include, statistically, 90 to 95 percent of the population, and "Level 3" presents assumptions that are considered maximum worst case assumptions which are individually possible. For example, occupancy of a residence at one location for 10 years is considered to represent the average length of time that individuals will preside at one location ("level 1"). The "90th" percentile value for length of occupancy for one residence is 30 years ("level 2"). It is possible that an individual could spend their entire life in a single location so the Level 3 value is assumed to be 70 years.

The mean of all sample concentrations, including non-detects at half the detection limit, in the media being evaluated is used for the Level 1 calculations, and the statistical 95th percentile on this mean is applied for the Level 2 calculations. For the Level 3 calculations, the mean of only the analytically detected values is used as the applicable media concentration for

a possible maximum exposure. In those cases where a single well or sampling location is evaluated, the single value is evaluated using all three exposure levels of each applicable scenario.

To evaluate the exposure to groundwater under present conditions, the reported concentrations of the chemicals of concern were evaluated in Wells GM-5, 13 and GMP-5 for sampling rounds in February/March 1989, November 1989, and November 1989 (Table 2). Selection of these wells provides information on concentration along the approximate center line of the plume between the northern boundary of the disposal areas and the edge of Clover Creek.

The concentrations of carbon tetrachloride and chloroform were estimated in wells GM-5, 13, 7 and GMP-5 for the years 1968-2011. Years 1995, 2000 and 2010 were evaluated for potential risk and hazard. The calculated concentrations of carbon tetrachloride and chloroform in each of the four wells for these three time intervals are summarized in Table 3.

The only expected human exposures to potential contamination in the surface water is by consumption of fish which have been exposed to contaminated water, the consumption of wild terrestrial animals which may drink contaminated water, the occasional skin contact while wading or while fishing or the potential inhalation of volatile compounds which could potentially volatilize from the surface water while fishing.

Tables 4 and 5 summarize the environmental data from Pugh and Clover Creeks. Only Clover Creek appears large enough to support a game fish population. Game animals could drink from either creek. The analytical data indicate that there is no consistency in the reported concentrations. Acetone, bis(2-ethylhexyl)phthalate, di-n-octyl phthalate, and endrin ketone are reported in upstream locations which are not impacted by the contaminated groundwater plume from the Site. Heptachlor, heptachlor epoxide and b-BHC were reported in only a single sample in the two sampling rounds. Based on the presence of pesticides in the upstream samples and the pattern of positive detects it presently appears that the pesticides detected in the creek water are not exclusively, if at all, from the discharge of contaminated groundwater from the Site.

Carbon tetrachloride and chloroform are the only chemicals reported in the creeks which appear to be Site related. Although these volatile organics are migrating from the Site and may enter the creeks, their volatility and susceptibility to degradation apparently prevent their accumulation in the creeks at concentrations that are consistently detectable. Although the source is not definite, the concentrations of the volatiles reported in the creeks (Tables 4 and 5, Round 2) were evaluated for their potential exposure and estimated total incremental risk and hazard to human health.

To evaluate public health impacts of Site-related chemicals in Clover Creek and Pugh Creek, it was assumed that game fish were caught and consumed in areas where water contained Site-related chemicals and that the same individual also used Clover Creek and Pugh Creek for recreational swimming.

A scenario for potential exposure from consumption of game animals and birds which may drink the contaminated water was not developed. The chemicals of concern which are discharging into the stream from the Site (carbon

TABLE 3

ESTIMATED EXPOSURE POINT CONCENTRATIONS FOR GROUNDWATER FUTURE MODELED CONDITIONS - DOWNGRADIENT PLUME HARDEMAN COUNTY LANDFILL RI/FS

Well	*Year*	*Carbon Tetrachloride (mg/L)*	*Chloroform (mg/L)*
GM-5	1995	10.989	1.824
	2000	6.689	1.029
	2010	2.513	0.331
13	1995	8.855	1.542
	2000	5.846	0.936
	2010	2.410	0.327
7	1995	7.654	1.463
	2000	5.892	1.003
	2010	2.771	0.387
GMP-5	1995	5.526	1.173
	2000	5.025	0.917
	2010	2.723	0.391

TABLE 4

CLOVER CREEK WATER CHEMISTRY (µg/L)
HARDEMAN COUNTY LANDFILL RI/FS

Chemical	Round 1				Round 2			
	C2a*	C2*	C3b	C4	C2a*	C2*	C3b	C4
Acetone	13.2		13.7		23.5			
Carbon Tetrachloride						8.67		15
Chloroform								
Bis(2-ethylhexyl)phthalate		470						
Di-n-octylphthalate								
Endrin	0.224							
Endrin Ketone				0.52				
Heptachlor				0.172				
Heptachlor Epoxide**				0.118				
Hexachlorocyclohexane (b-BHC)**				0.163				

Notes:

(1) * Locations upstream of area where contaminated downgradient plume discharges to creek.
(2) ** Constituents not detected in angled borings and not selected as contaminants of concern.
(3) Other contaminants of concern not detected in Clover Creek samples.

TABLE 5

PUGH CREEK WATER CHEMISTRY (µg/L)
HARDEMAN COUNTY LANDFILL RI/FS

Chemical	Round 1						Round 2					
	P6*	P2a*	P2b*	P3a	P4	P5	P6**	P2a**	P2b**	P3a**	P4	P5
Acetone		18.8		43								
Carbon Tetrachloride				44.9	25.9	51.3					29	[illegible]
Chloroform											[illegible]	
Bis(2-ethylhexyl)phthalate		23										
Di-n-octylphthalate		100	31	10	15	11						
Endrin												
Endrin Ketone	0.196	0.4	0.4	0.67	0.35							[illegible]
Heptachlor												
Heptachlor Epoxide+												
Hexachlorocyclohexane (b-BHC)+												
PCB (Aroclor 1242)+				2.94								

Notes

1) * Background sampling locations which do not receive groundwater from under Site.
2) — Location not analyzed this round.
3) + Constituents not detected in angled borings and not selected as contaminants of concern.
4) Other contaminants of concern not detected in Pugh Creek samples.

tetrachloride and chloroform) would be metabolized and/or excreted from animals or birds. Due to the low levels of Site-related volatile compounds in the surface water samples, bioconcentration and tissue retention are expected to be negligible in mammals and birds who ingest the water. Concentrations of carbon tetrachloride and chloroform in game animals and game birds as a result of drinking water from Clover Creek or Pugh Creek would be de minimis.

As noted, carbon tetrachloride and chloroform are the main contaminants presently expected to migrate in high concentrations into the creeks. The potential Clover Creek concentrations at the years 1995, 2000 and 2010 are summarized in Table 6.

To evaluate potential inhalation exposure of fisherman to chemicals in the Creek, an estimated air concentration at the air water interface was estimated by applying the same air/water partition constant ("PR") as was used to evaluate the shower/bath exposure scenario for household use (see the RI, Section 6). Applying the PR of 1.3 to the highest water concentration of carbon tetrachloride predicted in Clover Creek of 1.164 mg/L, the estimated air concentration would be 1.5 mg/L. Assuming an immediate air dilution factor of 10 at the creek surface and an additional 10-fold dilution due to mixing from the water surface zone to the breathing zone, the inhaled concentration would be 0.015 mg/L.

This would be in the general range of odor detection and approximately 50% of the time weighted average ("TWA") for an acceptable level in the workplace. Considering that the water concentration is based on the 3Q20 (low flow) estimate, that a fisherman would be exposed to the air on a contaminated area of the Creek only a few days per year, and that any wind velocity would greatly diminish exposure levels beyond the 100-fold assumption, the estimated potential air levels and related exposure levels are conservatively high and are not a health concern.

Toxicity Assessment

The toxicity assessment presents available human health and environmental criteria based on pertinent standards, advisories and guidelines developed for the protection of human health and the environment. An explanation of how these values were derived and how they should be applied is presented below.

Cancer potency factors ("CPFs") have been developed by EPA's Carcinogenic Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. CPFs, which are expressed in units of $(mg/kg/day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg/day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper-bound" reflects the conservative estimate of the risks calculated from the CPF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Cancer potency factors are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation has been applied.

Reference doses ("RfDs") have been developed by EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg/day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals.

TABLE 6

ESTIMATED CLOVER CREEK CHEMISTRY (mg/L)
FUTURE MODELED CONDITIONS
HARDEMAN COUNTY LANDFILL RI/FS

Year	Carbon Tetrachloride			Chloroform		
	3Q20 (1) Low Flow	Overall (2) Average Flow	Annual (3) Average Flow	3Q20 (1) Low Flow	Overall (2) Average Flow	Annual (3) Average Flow
1995	1.164	0.069	0.088	0.238	0.014	0.018
2000	1.000	0.059	0.075	0.182	0.011	0.014
2010	0.549	0.033	0.041	0.082	0.005	0.006

Notes:

(1) Lowest average daily flow over a 3 day period during 20 years.

(2) Annual average daily flow calculated from 17 measurements from 1980 through 1987.

(3) Average daily flow based on the average annual flow from 1980 through 1987

Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. The ratio of dose over RfD gives the hazard index ("HI"). Values of HI greater than 1 indicate an unacceptable exposure. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict the effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur.

In evaluating the hazard from the non-carcinogenic effects of chemicals, the average daily exposure was based on potential shorter term (non-lifetime) exposure estimates, generally the average daily exposure for a year. To maintain a conservative approach, if the average daily exposure was significantly greater for a young child than for an adult (shower/bath and swimming), the child's exposure was used to estimate the potential hazard.

The RfDs used to calculate the hazard indices are presented in Table 7. These RfD values are taken from the Integrated Risk Assessment Information System ("IRIS") data base, if available from that source, or from the Health Effects Assessment Summary Tables ("HEAST"). No reference values were found for endrin ketone and endrin aldehyde, therefore the values for endrin are applied as surrogate values. The RfD value for di-n-butyl phthalate is applied to di-n-octyl phthalate as a surrogate value. These surrogate substitutions should result in conservative evaluations based on structure-activity relationships.

In evaluating the hazard from the carcinogenic effects, the average daily exposure is based on lifetime exposure estimates. Lifetime estimated average exposure levels are based on exposure for 10, 30, or 70 years of a 70-year lifetime. To maintain a conservative approach in each case, 6 years are considered to be childhood years and the daily dose for those 6 years were based on assumptions for a child's weight and exposure to estimate the potential additional lifetime cancer risk.

The CPFs used to calculate the additional lifetime cancer risks are presented in Table 7. These CPF values are taken from the IRIS database, if available from that source, or from HEAST.

Water quality standards, criteria and advisories are also presented in Table 7 for comparison with the reported concentrations in groundwater and surface water.

Absorption efficiency of individual chemicals is not applied in the assessments of water exposure. Orally ingested and inhaled doses are assumed to have 100% absorption. For dermal absorption, the permeability constant for water is used to determine water absorptions and the chemicals are assumed to be absorbed with the water in a proportional manner based on the reported concentration.

The toxicity and chemical information for the contaminants of concern which was applied in this assessment is summarized in Table 7.

Risk Characterization

Excess lifetime cancer risks are determined by multiplying the intake level

TABLE 7

SUMMARY OF TOXICOLOGY AND CHEMICAL CONSTANTS
HARDEMAN COUNTY LANDFILL RI/FS

Chemical	Mol.Wt.	Vapor Pressure mmHg/30°C	Solubility mg/l (25C)	log Kow	Koc	BCF l/kg	CPI l/(mg/kg/d)	RfD mg/kg/d	Primary Target Organs	MRL mg/kg/d
Acetone	58 08	270	394950	0 24	2 2E+00	1 0E+00	NA	1 0E-01		0 007
Carbon Tetrachloride	153 84	1 37	810	2 83	1 1E+02	1 9E+01	1 3E-01	7 0E-04	Liver, Kidney	0 04
Chlorobenzene	112 56	26	488	2 84	3 3E+02	1 0E+01	NA	2 0E-02	Liver, Kidney	0 03
Chloroform	119 38	245	7710	1 97	3 1E+01	2 9E+00	6 1E-03	1 0E-02	Liver	0 08
Methylene Chloride	84 93	511	19700	1 30	8 8E+00	5 0E+00	7 5E-03	6 0E-02	Liver	0 08
Tetrachloroethylene	165 93	24	485	2 88	3 6E+02	3 1E+01	NA	1 0E-02	Liver	
Toluene	92 14	37	570	2 7	3 0E+02	1 1E+01	NA	2 0E-01		
Xylene (Total)	106 16	10	198	3 3	2 4E+02		NA	2 0E+00		
Bis(2 ethylhexyl)phthalate	390 57	6 2E-08	0 30	5 11	5 0E+05		1 4E-02	2 0E-02	Liver	0 02
Di n butylphthalate	278 35	1 0E-05	400	4 6	1 7E+05	2 1E+01	NA	1 0E-01	Reproductive	0 62
Di n octylphthalate	390 57	1 4E-04	3	9 2	1 7E+05	2 1E+01	NA	1 0E-01		
2,4 Dichlorophenol	163 00	8 9E-02	4500	3 2	3 8E+02	4 1E+01	NA	3 0E-03		
DDT	354 49	7 3E-07	0 003	6 2			3 4E-01	5 5E-04		
Endrin	380 90	7 0E-07	0 26	5 34	8 3E+03		NA	3 0E-04	Liver, Kidney	0 0003
Endrin Ketone (2)	381 92	2 0E-07	0 26	5 6	8 3E+03		NA	3 0E-04		
Endrin Aldehyde (3)	380 89	2 0E-07	0 26	3 15	7 2E+02		NA	3 0E-04		
Heptachlor	373 32	1 6E-03	0 32	5 44	1 2E+04	1 6E+04	4 5E+00	1 3E-05		
Heptachlor Epoxide	389 32	2 6E-06	0 35	5 40			9 1E+00	1 3E-05		

TABLE 7

WATER STANDARDS AND CRITERIA
HARDEMAN COUNTY LANDFILL RI/FS
(mg/L)

Chemical	pMCL (µg/L)		Water Quality Criteria (mg/L) Water Only	Water & Fish	Fish Only	Drinking Water Health Advisors (mg/L) One Day 10 kg	Ten day 10 kg	10 kg	Longer Term 70 kg	Lifetime 70 kg	Unit Cancer Risk	Tennesee Drinking Water Standard
Acetone	700					ND	ND	ND	ND	ND	NA	
Carbon Tetrachloride		5 (final)	0.00042	0.0004	0.00694	4	0.16	0.071	0.25	ND	1.7E-06	EPA
Chlorobenzene	100		0.499	0.488		ND	ND	ND	ND	ND	NA	MCLs
Chloroform		100 (final)	0.00019	0.00019	0.0157	ND	ND	ND	ND	ND	1.7E-07	or
Methylene Chloride			0.00019	0.00019	0.0157	13.1	1.5	0.5	1.75	NA	2.1E-07	WQCs
Tetrachloroethylene	0.005		0.00088	0.0008	0.0088	2	2	1.4	5	1.0E-02	NA	
Toluene	2000		15	14.3	424	20	1	1	10	1.0E-00	NA	
Xylene (Total)	10000					40	40	40	100	10	NA	
Bis(2-ethylhexyl)phthalate	14		15	15	50	ND	ND	ND	ND	ND	1.0E-07	
Di-n-butylphthalate			44	34	154	ND	ND	ND	ND	ND	NA	
2,4-Dichlorophenol			3.09	3.09	3.09	ND	ND	ND	ND	ND	NA	
Endrin		0.002 (final)	0.001	0.001		0.02	0.02	0.003	0.01	0.002	NA	
Endrin Ketone (2)											NA	
Endrin Aldehyde (3)											NA	
Heptachlor	0.0004		1.1E-05	2.8E-07	2.9E-07	0.01	0.01	0.005	0.0175	ND	1.3E-04	

Notes.

MOL. WT = Molecular Weight
mm Hg/30 C = Milliliters Mercury Pressure at 30 Degrees Celcius
Solubility: Solubility in water at 30 Degrees Celcius
log Kow = Logarithm to base 10 of the Octanol/Water ratio at equilibrium
Koc = Water/Carbon concentration ratio when carbon and water at equlibrium
BCF = Bioconcentration factor from water to fish
CPF = Cancer Potency Factor (also termed Cancer Slope Factor), based on statistical model from animal data
RfD = Reference dose or dose not expected to cause adverse non-carcinogenic effects
Primary Target Organs = The main organs affected by chemical
MRL = Minimum Risk Level or level below which non-carcinogenic effects would not be expected in humans
MCL = EPA Maximum Contaminant Level for Drinking Water
Water Quality Criteria = EPA published criteria for high quality water
Values for non-carcinogens are based on 1E-06 added lifetime cancer risk
Drinking water health advisories = EPA advisories for consumption by child (10 kg) or adults (70 kg) for various time periods
Unit Cancer Risk = Cancer Risk estimate resulting from 0.001 mg/L of chemical in drinking water
Heptachlor RfD based on Heptachlor Epoxide RfD

with the cancer potency factor. These risks are probabilities that are generally expressed in scientific notation (e.g., $1x10^{-6}$ or 1E-6). An excess lifetime cancer risk of $1x10^{-6}$ indicates that, as a plausible upper bound, an individual has a one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site. The Agency considers individual excess cancer risks in the range of 10^{-4} to 10^{-6} as protective.

Potential concern for noncarcinogenic effects of a single contaminant in a single medium is expressed as the hazard quotient ("HQ") (or the ratio of the estimated intake derived from the contaminant concentration in a given medium to the contaminant's reference dose). By adding the HQs for all contaminants within a medium or across all media to which a given population may reasonably be exposed, the Hazard Index ("HI") can be generated. The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media.

Estimated total incremental lifetime cancer risk from future household use of groundwater using present conditions was calculated for Wells GM-5, 13 and GMP-5. These wells are located on the approximate center line of the downgradient plume and are positioned between the northern boundary of the disposal area and the edge of Pugh and Clover Creeks.

The risk and hazards from individual chemicals show that the calculated risks and hazards are related primarily to the presence of carbon tetrachloride which accounts for over 90% of the total risk and hazard at each well.

The chemicals of concern at the Site are primarily liver toxicants and as such it is appropriate to sum the incremental risks and hazards for the several primary chemicals reported in groundwater. Since the exposures would all relate to the local population, it is also appropriate to sum the risks from the two household uses of groundwater, namely drinking and bathing. The total incremental risks and hazard presented by household use of the groundwater are summarized in Table 8 based on level 1 assumptions (see page 26). It is apparent that the risks and hazards all exceed acceptable levels by several orders of magnitude. This is to be expected since the reported concentrations exceed Water Quality Criteria for drinking water by several orders of magnitude and the Health Advisories for drinking water by 2 to 3 orders of magnitude.

The additional lifetime risk of cancer and the non-carcinogenic hazard from exposure to surface waters of the creeks based on the Site-specific indicator chemicals are summarized in Table 9.

In the single instance where the assessment shows unacceptable risk from surface water (eating fish from Pugh Creek, P3a), the risk is almost totally from the reported level of PCBs which is probably not originating from the Site. As discussed earlier, the reported concentrations of pesticides, PCBs and phthalates are apparently from background sources or are analytical artifacts, and are not considered to be Site-related. The reported concentrations of organic solvents in the Round 2 creek samples could reasonably be Site-related although the upstream sample from location C2a has the highest concentration of carbon tetrachloride reported in Clover Creek.

TABLE 8

SUMMARY OF CANCER RISK AND HAZARD INDEX
AVERAGE EXPOSURE SCENARIO (1)
GROUNDWATER IN DOWNGRADIENT PLUME
HARDEMAN COUNTY LANDFILL RI/FS

	Cancer Risk		*Hazard Index*	
Well I.D.	*Round 1*	*Round 2*	*Round 1*	*Round 2*
On-Site Average	1.4E-01	1.1E+00	1.4E+04	1.1E+05
GM-5	4.2E-01	1.8E+00	4.4E+04	1.9E+05
13	3.9E-01	7.7E-01	4.1E+04	1.2E+05
GMP-5	3.3E-01	4.7E-01	3.5E+04	4.9E+04

(1) Average exposure scenario is the Level 1 scenario for future household use from current carbon tetrachloride and chloroform levels in groundwater

TABLE 9

SUMMARY OF CANCER RISK AND HAZARD INDEX
AVERAGE EXPOSURE SCENARIO (1)
PRESENT REPORTED CONCENTRATIONS
SURFACE WATER IN CLOVER AND PUGH CREEKS
HARDEMAN LANDFILL SITE RI/FS

	Cancer Risk		*Hazard Index*	
Well I.D.	*Round 1*	*Round 2*	*Round 1*	*Round 2*
Clover Creek				
C2a Upstream	0.0E+00	1.3E-07	9.5E-02	1.4E-02
C2 Upstream	1.4E-06	4.7E-08	3.9E-02	5.1E-03
C3b	0.0E+00	NA	3.2E-05	NA
C4	4.0E-05	8.1E-08	3.8E+00	8.9E-03
Pugh Creek				
P2a Upstream	7.0E-08	NA	1.9E-01	NA
P2b Upstream	0.0E+00	NA	1.9E-01	NA
P3a	3.3E-03	NA	5.6E-01	NA
P4	1.4E-07	1.6E.07	2.1E-01	1.7E-02
P5	3.3E-07	6.5E-06	3.6E-01	4.2E-01
P6	0.0E+00	NA	9.5E-02	NA

Notes:

NA - Not Analyzed

(1) Average Exposure Scenario is the Level 1 Scenario

Assuming the carbon tetrachloride is Site-related, examination of the risk and hazard assessment results show that the reported concentrations do not present a concern for fish consumption or for occasional skin contact. The swimming exposure component of the assessment calculations would greatly exceed any casual skin exposure component related to wading or fishing.

Based on the results of the risk calculations, it is evident that the potential exposure to volatile compounds in the air due to specific chemicals volatilizing from the surface waters while fishing does not represent a significant risk to the general public.

By the application of appropriate modeling techniques, water concentrations of carbon tetrachloride and chloroform were predicted in the wells downgradient of the landfill and in the creeks. Values predicted for the years 1995, 2000 and 2020 in Wells GM-5, 13, 7, and GMP-5 were evaluated for potential total incremental lifetime cancer risk and non-carcinogenic hazard using the same household exposure or recreation scenarios as were used for evaluation of present conditions. The summary data are presented in Tables 10 (groundwater) and 11 (surface water).

Upon examination of Table 10, it is apparent that the estimated risks and hazards are still far in excess of acceptable levels, even in the year 2010 after an additional 20 years of migration of the plume without further remediation.

The predicted concentrations of carbon tetrachloride and chloroform in Clover Creek are estimated to peak in the year 1994. Table 11 shows a gradual decrease of estimated potential risk and hazard after the year 1995. At the estimated period of peak flux to the creek between the years of 1993 and 1995, estimated potential risks are below the target range of 1E-04 to 1E-06 estimated total incremental lifetime risk of cancer. The estimated total hazard level is also below a level of concern even applying the more conservative conditions of 3Q20 creek flow where the estimated groundwater flux from the plume area makes up approximately one-half of the total creek flow.

Uncertainties

Regardless of the type of risk estimate developed, it should be emphasized that all estimates of risk are based upon numerous assumptions and uncertainties. In addition to limitations associated with Site-specific chemical data, other assumptions and uncertainties that affect the accuracy of the Site-specific risk characterizations result from the extrapolation of potential adverse human health effects from animal studies, the extrapolation of effects observed at high-dose to low-dose effects, the modeling of dose response effects, and route-to-route extrapolation.

The use of acceptable levels (established standards, criteria and guidelines) and unit cancer risk values which are derived from animal studies introduces uncertainty into the risk estimates. In addition, the exposure assumptions used in estimating individual dose levels are often surrounded by uncertainties. As such, these estimates should not stand alone from the various assumptions and uncertainties upon which they are based. In developing numerical indices of risk, an attempt is made to evaluate the effect of the assumptions and limitations on the numerical estimates.

TABLE 10

SUMMARY OF CANCER RISK AND HAZARD INDEX
FUTURE ESTIMATED CONCENTRATIONS
GROUNDWATER IN DOWNGRADIENT PLUME
HARDEMAN LANDFILL SITE RI/FS

	Cancer Risk (1)			*Hazard Index*		
Well I.D.	*1995*	*2000*	*2010*	*1995*	*2000*	*2010*
GM-5	1.7E+00	1.0E+00	4.2E-01	1.8E+05	1.1E+05	4.3E+04
13	1.4E+00	8.9E-01	3.7E-01	1.4E+05	9.3E+04	3.8E+04
7	1.2E+00	9.0E-01	4.2E-01	1.2E+05	9.4E+04	4.4E+04
GMP-5	8.4E-01	7.7E-01	3.9E-01	8.8E+04	8.0E+04	4.1E+04

(1) Risk estimates presented for the average (level 1) scenario for groundwater exposure from drinking and bathing exposure to carbon tetrachloride and chloroform

TABLE 11

SUMMARY OF CANCER RISK AND HAZARD INDEX
FUTURE ESTIMATED CONCENTRATIONS
SURFACE WATER IN CLOVER CREEK
HARDEMAN LANDFILL SITE RI/FS

	Cancer Risk(1)			*Hazard Index(2)*		
Well I.D.	*1995*	*2000*	*2010*	*1995*	*2000*	*2010*
Carbon Tetrachloride	3.7E-07	3.2E-07	1.8E-07	6.9E-01	5.9E-01	3.2E-01
Chloroform	1.5E-09	1.2E-09	5.5E-10	5.9E-03	4.5E-03	2.0E-03
Totals	3.7E-07	3.2E-07	1.8E-07	6.9E-01	5.9E-01	3.3E-01

(1) Addative cancer risk based on level 1 exposure assumptions for all relevent pathways

(2) Hazard index based on "3Q20" estimates

The uncertainty factors which are incorporated into the risk estimates are believed to be conservative. As such, when they are considered collectively, exposure and subsequently risk may be overestimated. On the other hand, these estimated risk calculations were based on present conditions at the Site, including the cap, and no major increases of contaminants already in the aquifer. Additional risk could occur should the concentrations increase or the cap erode.

In conclusion, based on the results of the risk assessment, actual or threatened releases of hazardous substances from Site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

Environmental Risks

As previously stated in this ROD, the final potential environmental risks associated with the Site will be addressed as part of the second operable unit.

Previous studies have generally indicated that the contaminants migrating from the Site are not presenting an environmental risk since the contaminants are highly volatile and do not concentrate or bioaccumulate in the environment. However, additional studies concerning these wastes and the more persistent compounds located in the disposal areas are required for a final analysis. Also, although previous investigations have not identified any endangered species in the area of the Site, it has recently been determined, and will have to be verified, that an endangered species of bat may exist in the vicinity of the Site.

DESCRIPTION OF ALTERNATIVES

The surficial aquifer is under consideration for remediation due to the unacceptable risk associated with the consumption of the contaminated groundwater.

Based on the contamination detected in the aquifer at different locations, the groundwater has been divided into two areas: on-site and off-site. The on-site groundwater is that portion of the aquifer located directly beneath the disposal areas. The off-site groundwater is that portion of the aquifer located beneath all properties surrounding the disposal areas. The off-site groundwater contains mainly the highly mobile contaminants like carbon tetrachloride and chloroform. The following is a list of the remedial alternatives under consideration for the contaminated groundwater. The FS Report contains a more detailed evaluation of each alternative.

1) No action (A1 and B1 in the FS).

2) On-site Groundwater Extraction through wells, Treatment, and Surface Water Discharge (A4 in the FS).

3) Institutional Controls (B2 in the FS).

4) Off-site Groundwater Extraction through wells and a collection trench along Pugh and Clover Creeks, Treatment and Surface Water Discharge (B4in FS).

5) Off-site Groundwater Extraction through a collection trench along Pugh and Clover Creeks, Treatment and Surface Water Discharge (B6 in FS).

6) Off-site Groundwater Extraction through wells, Treatment, and Surface Water Discharge (B8 in FS).

It should be noted that groundwater reinjection was considered in the FS for each of the groundwater treatment remedies. However, groundwater reinjection is not considered feasible due to concerns over the ability of the aquifer to accept all of the reinjected water, the affects of the reintroduced water on contaminant flow, and the long-term maintenance of the injection wells, which may plug up over time due to mineral precipitation.

All of these alternatives except "No Action" involve restrictions on land and well use in the vicinity of the Site, upkeep of the fence and property, and monitoring to assess the effectiveness of the remedy. Each alternative also includes identifying and evaluating possible additional remedial actions required for addressing the contamination of the entire Site including the contaminant source (the disposal areas) and possible environmental/ecological concerns.

ALTERNATIVE 1: NO ACTION

Present Worth (PW) Cost $0.00
Years to Implement: 0

CERCLA requires that the "No Action" alternative be considered at every site. Under this alternative, no groundwater containment or treatment would take place. The only reduction of contaminant levels would occur via natural processes such as dispersion and attenuation. Since monitoring is already part of the disposal areas maintenance, additional cost would not be incurred.

ALTERNATIVE 2: ON-SITE GROUNDWATER EXTRACTION, TREATMENT AND SURFACE WATER DISCHARGE

Present Worth Cost: $7,266,000
PW Capital Cost: 3,146,500
PW O&M Cost: 4,120,000/30 yr.
Years to Implement: 2

Alternative 2 provides for the hydraulic containment of the contaminated on-site groundwater along the northern boundary of the disposal areas. Approximately 5 extraction wells would be installed to develop a hydraulic gradient along this northern boundary line preventing on-site groundwater contamination above MCLs from leaving the disposal areas. Extracted on-site groundwater would be pumped to a treatment system located on the Site property for treatment of groundwater to National Pollutant Discharge Elimination System ("NPDES") concentrations established as part of the Clean Water Act for surface water discharges. The contamination, particularly carbon tetrachloride, chloroform, and naturally occuring metals, would be treated using settling tanks for solids removal, air stripping and carbon adsorption. Treated

on-site groundwater would be discharged to one of the nearby surface water bodies (Pugh or Clover Creek) and would comply with NPDES discharge requirements.

ALTERNATIVE 3: INSTITUTIONAL CONTROLS

Present Worth Cost: $1,088.00
PW Capital Cost: 60,000
PW O&M Cost: 1,028,000/30 yrs.
Years to Implement: 50

Alternative 3 provides only for the restrictions of land and groundwater use in the contaminated areas. It includes the monitoring of the contamination and its migration off-site. Reduction of contaminants to acceptable levels would occur only through natural processes and will require an estimated 50 years before cleanup goals would be met.

ALTERNATIVE 4: OFF-SITE GROUNDWATER EXTRACTION THROUGH WELLS AND A COLLECTION TRENCH ALONG PUGH AND CLOVER CREEKS, TREATMENT AND SURFACE WATER DISCHARGE

Present Worth Cost: $11,791,500
PW Capital Cost: 6,568.500
PW O&M Cost: 5,223,000/30 yrs.
Years to Implement: 2

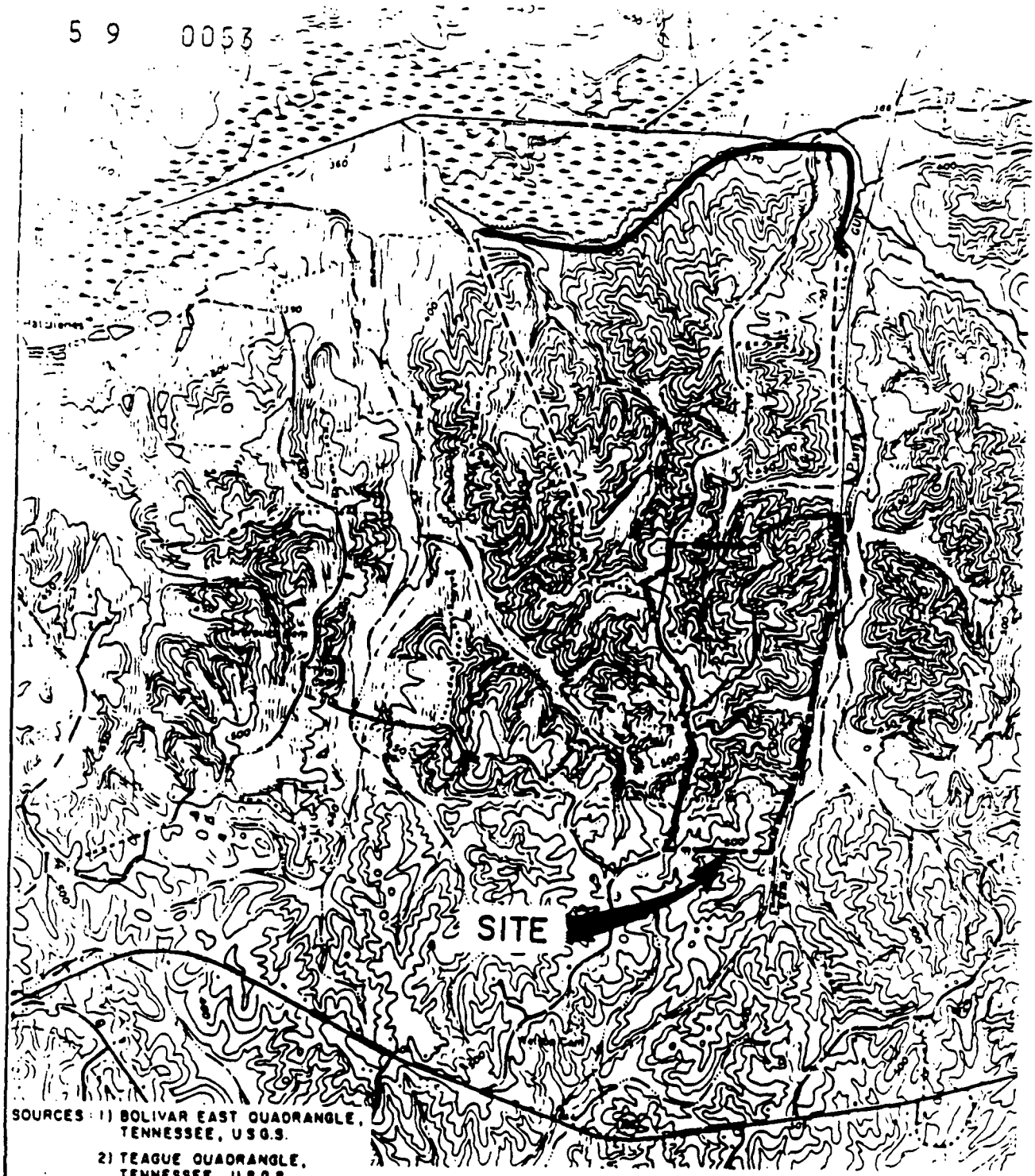
Alternative 4 addresses the containment and recovery along Clover Creek and the extraction of off-site groundwater in the areas of highest contamination. A slurry wall and collection tile system would be placed along Clover Creek station at the confluence of Clover Creek and Pugh Creek for approximately 8,000 feet (see Figure 16) to the western limit of the plume to collect contamination already entering the creeks.

Approximately 10 extraction wells would be installed into the high concentration areas of the off-site groundwater to control further migration of the plume toward the creeks and to treat the groundwater to MCL concentration levels. The extracted water would be pumped to an off-site system for treatment. The system would consist of settling tanks, air stripping and carbon absorption. Treated groundwater would be discharged to one of the nearby surface water bodies and would comply with NPDES discharge requirements.

ALTERNATIVE 5: OFF-SITE GROUNDWATER EXTRACTION THROUGH A COLLECTION TRENCH ALONG PUGH AND CLOVER CREEKS, TREATMENT AND SURFACE WATER DISCHARGE

Present Worth Cost: $9,384,000
PW Capital Cost: 4,727,000
PW O&M Costs: 4,657,000/30 yrs.
Years to Implement: 2

Alternative 5, like Alternative 4, addresses the containment and recovery of off-site contaminated groundwater along Clover Creek. A slurry wall and collection tile system would be placed along Clover Creek; however, no



SOURCES: 1) BOLIVAR EAST QUADRANGLE, TENNESSEE, U.S.G.S.

2) TEAGUE QUADRANGLE, TENNESSEE, U.S.G.S.

LEGEND

- - - - APPROXIMATE LIMITS OF PLUME

——— COLLECTION DRAIN ALIGNMENT

FIGURE 3
COLLECTION DRAIN

extraction wells would be installed in the high concentration areas of the groundwater plume. The contaminated groundwater would be treated and discharged in the same manner described in Alternative 4.

ALTERNATIVE 6: OFF-SITE GROUNDWATER EXTRACTION THROUGH WELLS, TREATMENT AND SURFACE WATER DISCHARGE

Present Worth Cost: $4,378,000
PW Capital Cost: 1,936,000
PW O&M Cost: 2,442,000/30 yrs.
Years to Implement: 2

Alternative 6 provides for the removal of contaminated off-site groundwater from the plume in the areas of highest concentration. Approximately 10 wells would be installed into the high concentration areas of the off-site plume to control the groundwater contaminant migration and remediate the off-site groundwater to MCL concentration levels. The off-site groundwater treatment and discharge would be the same as Alternative 4 and would comply with NPDES requirements.

ARARS

Any remedy implemented for OP Unit #1 shall meet the performance standards set forth below which are the Applicable or Relevant and Appropriate Requirements ("ARARs") identified for these remedial alternatives.

Remediation of contaminated groundwater for a Class IIa aquifer is required to meet MCLs as established under the Safe Drinking Water Act (40 CFR 141, 143) and, if possible, to attain Maximum Contaminant Level Goals ("MCLGs"). MCLGs can not be enforced as cleanup levels since they are sometimes technically impossible to meet; however, groundwater sampling will monitor for MCLGs as a possible result of the groundwater extraction and treatment. The groundwater remediation levels for the contaminants of concern in the aquifer are identified in Table 12. Reduction of the contaminants to these levels will reduce the risk posed from the consumption of contaminated water from an absolute risk over a ten year period to a risk of 8.2×10^{-5} for a 70 kg adult over a lifetime (70 years). This risk falls within EPA's acceptable risk range of 10^{-4} to 10^{-6}.

Any discharge to a nearby surface water body is required to meet NPDES standards established by the Clean Water Act and regulated by the State of Tennessee. Pugh and Clover Creeks are classified for fish and aquatic life, recreation, irrigation, livestock watering and wildlife. The allowable in-stream contaminant levels based on State and Federal regulations are identified in Table 13. Final discharge levels will be determined by surface water flow information, contaminant levels, and biological testing that will be established by the State of Tennessee. The surface water discharge will be required to meet the NPDES limits that are established.

Since contaminants are presently still leaching from the disposal areas, a Point of Compliance, as defined under regulations promulgated pursuant to the Resource Conservation and Recovery Act ("RCRA") (40 CFR Section 264.95) is relevant and appropriate for determining the point or line on the Site beyond which contaminant levels in the groundwater must be remediated to MCLs. The

TABLE 12
GROUNDWATER REMEDIATION LEVELS FOR
CONTAMINANTS OF CONCERN AT THE
VELSICOL/HARDEMAN COUNTY NPL SITE

CONTAMINANTS OF CONCERN	GROUNDWATER REMEDIATION LEVEL(1) (mg/l)		MCLG(2) (mg/l)	RISK(3)
VOLATILE ORGANICS				
Acetone	0.7	(4)	-	-
Carbon Tetrachoride	0.005		0.0	1.9×10^{-5}
Chlorobenzene	0.1		0.1	-
Chloroform	0.006	(5)	-	1.0×10^{-6}
Methylene Chloride	0.005		0.0	1.1×10^{-6}
Tetrachloroethene	0.005		0.0	7.5×10^{-6}
Toluene	1.0		1.0	-
Xylenes	10.0		10.0	-
BNAs				
Bis (2-ethylhexyl) phthalate	0.004		0.0	1.6×10^{-6}
Di-n-butyl phthalate	0.7	(4)	-	-
Di-n-octyl phthalate	0.14	(4)	-	-
2,4 - Dichlorophenol	0.1	(4)	-	-
PESTICIDES				
Endrin	0.0002	(6)	0.0002	-
Endrin Aldehyde	0.0002	(6)	0.0002	-
Endrin Ketone	0.0002	(6)	0.0002	-
Heptachlor	0.0004		0.0	5.2×10^{-5}
TOTAL CARCINOGENIC RISK				8.2×10^{-5}

(1) Maximum Contaminant Levels (MCLs) as promulgated under the Safe Drinking Water Act (40CFR 141,143) were used as the remediation level for all contaminants that have an MCL. Contaminants without MCLs are identified numbers, and the source of the remediation level is identified in the footnotes.

(2) MCLG - Maximum Contaminant Level Goal. A non-enforceable concentration of a drinking water contaminant that is protective of adverse human health effects and allows an adequate margin of safety.

(3) Risk is calculated for the carcinogenic compounds

(4) Lifetime Health Advisory (LHA). A lifetime exposure concentration protective of adverse, non-cancer health effects, that assumes a relative source contribution (RSC) of 20% of the contaminant in a drinking water source. (January 31, 1991, Federal Register, page 3535.)

(5) Level set for a lifetime risk (70 years) of 10^{-6} (one in one million excess cancer risk level for drinking water).

(6) On July 25, 1990, a MCL and MCLG of 0.002 mg/l was proposed but is not final for endrin. Should the MCL be made final, 0.002 mg/l will be the endrin remediation level. The other endrin compounds are based on the level set for endrin.

TABLE 13

PLANNING LIMITS-INSTREAM
VELISCOL CHEMICAL DUMP, HARDEMAN COUNTY

The following instream limits are provided for planning purposes and are valid for one year. Any limits to be included in a discharge permit are subject to the Public Notice process, the exact location of the discharge and the relative size of the discharge.

	Compounds	Instream limit, mg/L. (chronic/acute)
VOLATILES	Acetone	-
	Benzene	0.005*
	Carbon disulfide	-
	Carbon tetrachloride	0.005/0.044
	Chlorobenzene	-
	Chloroform	47.0
	Methylene chloride	16.0
	Tetrachloroethene	0.088
	Toluene	0.010*
	Trichloroethene	0.005/0.807
	Xylenes	0.010*
BNAs	Bis(2-ethylexyl)phthalate	0.059
	Di-n-butyl phthalate	12.0
	Di-n-octyl phthalate	-
	2,4-Dichlorophenol	-
	Naphthalene	-
PESTICIDES	Dieldrin	1.9×10^{-6}/0.0025
	Endrin	2.3×10^{-6}/0.00018
	Endrin Aldehyde	-
	Endrin Ketone	-
	Heptachlor	2.0×10^{-6}
METALS	Aluminum	0.087/0.75
	Arsenic	0.19/0.36
	Barium	-
	Cadmium	0.0007/0.002
	Calcium	-
	Chromium VI	0.011/0.016
	Total	0.01 chronic
	Copper	0.007/0.009
	Iron	1.0/2.0
	Lead	0.001/0.034
	Magnesium	-
	Manganese	-
	Mercury	1.2×10^{-5}/0.0024
	Nickel	0.088/0.79
	Potassium	-
	Selenium	0.005/0.020
	Silver	0.001 acute
	Sodium	-
	Zinc	0.059/0.065

* Technology based limit applies to the discharge.

Point of Compliance ("POC") for this ROD is established by identifying the disposal areas and setting the POC at the edge of these areas as shown in Figure 17. Due to the steep relief along the edge of the disposal areas at this Site especially along the northern and eastern sides, the POC is set at the base of the grade of the disposal areas.

Land Disposal Restrictions ("LDRs") as set forth in regulations promulgated pursuant to RCRA (40 CFR Part 268) may be applicable to the residuals of the groundwater treatment facility, specifically the sludge from the settling tanks which may require RCRA disposal. Spent carbon from the treatment process should be able to be regenerated for additional use.

The Clean Air Act is an ARAR for the releases to air from the air stripper. Releases from the stripper will comply with Federal and State Clean Air Standards.

Any work performed in the area of Clover Creek could affect the wetlands along Clover Creek, and 40 CFR Part 6, Appendix A concerning responses in a wetlands would apply.

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The remedial alternatives developed during the Site FS were evaluated by USEPA using the following nine criteria. The advantages and disadvantages of each alternative were then compared to identify the alternative providing the best balance among these nine criteria.

1. Overall protection of Human Health and the Environment addresses whether or not an alternative provides adequate protection and describes how risks are eliminated, reduced or controlled through treatment and engineering or institutional controls.

2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) addresses whether or not an alternative will meet all of the applicable or relevant and appropriate requirements or provide grounds for invoking a waiver.

3. Long-term Effectiveness and Permanence refers to the ability of an alternative to maintain reliable protection of human health and the environment, over time, once cleanup objectives have been met.

4. Reduction of Toxicity, Mobility or Volume is the anticipated performance of the treatment technologies an alternative may employ.

5. Short-term Effectiveness involves the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup objectives are achieved.

6. Implementability is the technical and administrative feasibility of an alternative, including the availability of goods and services needed to implement the solution.

LEGEND

- DISPOSAL AREAS
- STUDY AREA
- DISPOSAL SITE
- PERSONNEL SUPPORT ZONE
- APPROXIMATE LOCATION OF VELSICOL DEEP WELL
- Point of Compliance

FIGURE 17
POINT OF COMPLIANCE

7. Cost includes capital costs, as well as operation and maintenance costs.

8. Agency Acceptance indicates whether, based on its review of the RI/FS and Proposed Plan, TDHE agrees with USEPA on the preferred alternative.

9. Community Acceptance indicates the public support of a given alternative. This criteria is discussed in the Responsiveness Summary.

Table 14 contains an evaluation and comparison of the six (6) alternatives for the groundwater using seven of the nine criteria. State and Community Acceptance are discussed below.

State Acceptance

TDHE has assisted USEPA in the review of reports and Site evaluations. TDHE has reviewed and concurs with the selected remedy for the groundwater (See Appendix B).

Community Acceptance

Community response to the alternatives is presented in the Responsiveness Summary (Appendix A) which addresses comments received during the public meeting and public comment period. Although the public had general questions concerning the remedy, no comments were received that indicated the need for a major change in the remedy selected.

SELECTED REMEDY

The selected remedy for the contaminated groundwater is a combination of Alternatives 2 and 6. This remedy involves the hydraulic containment of the on-site groundwater using extraction wells to prevent the on-site groundwater above MCLs from leaving the disposal areas and the extraction of contaminated off-site groundwater to remediate the contaminated aquifer beyond the POC down to MCLs. After groundwater is extracted, it will be treated and then discharged to a nearby surface water body (Pugh or Clover Creek).

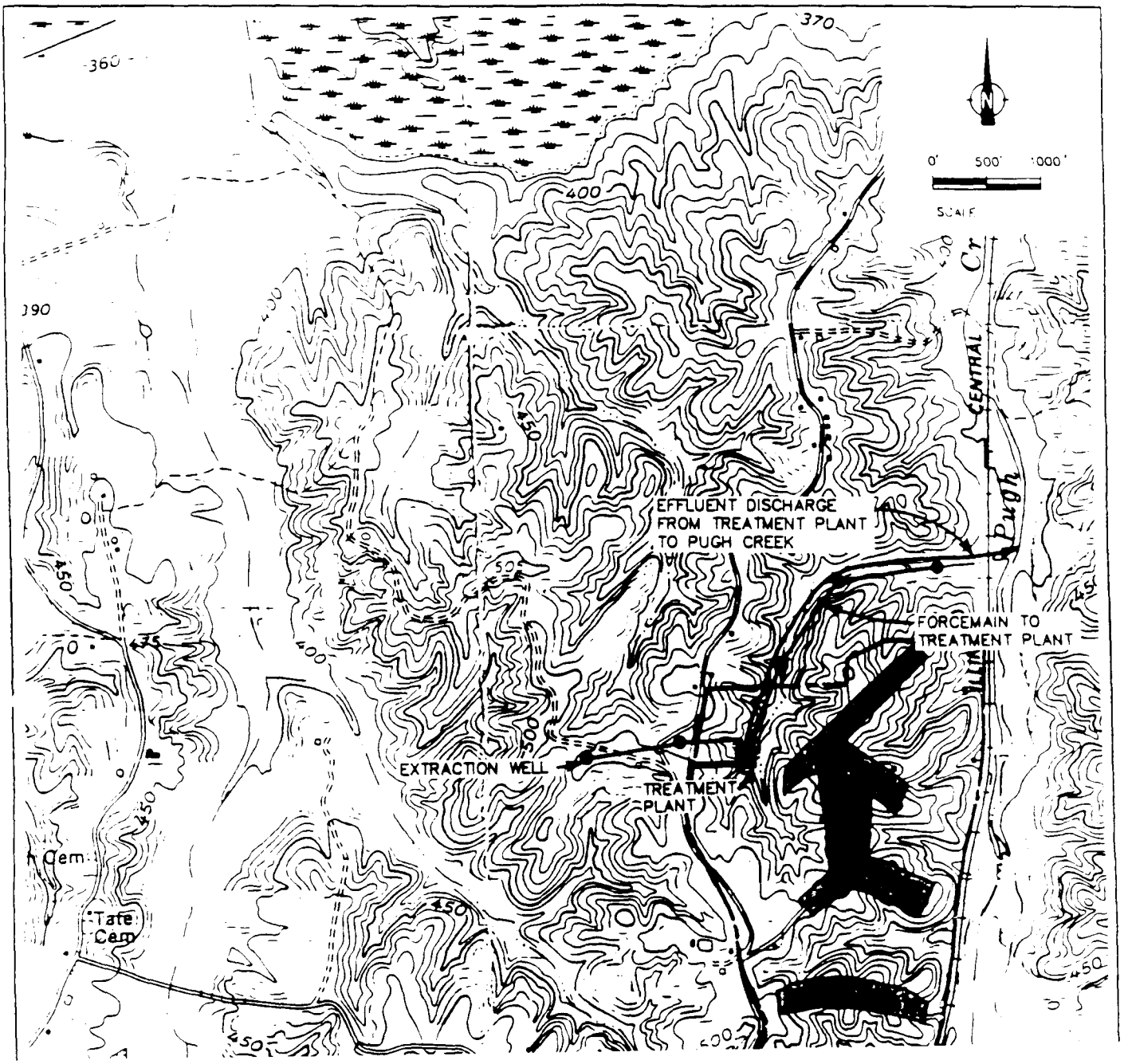
The selected remedy will include the following:

i) Extraction wells (approximately five (5)) and pumping systems will be installed to achieve an effective hydraulic capture of contaminants in on-site groundwater at the POC (see Page 46). Approximate locations of these extraction wells are shown in Figure 18; however, locations of these wells will change to comply with the POC. It is estimated that these wells must collectively recover approximately 200 gpm to achieve hydraulic containment. Piezometers may be installed within the projected containment area to demonstrate capture.

ii) Extraction wells (approximately ten (10)) and pumping systems will be installed to restore the contaminated off-site groundwater beyond the POC to within acceptable drinking water standards by removing groundwater from the areas of peak contaminant concentration. It

TABLE 14: Evaluation of Groundwater Remedial Alternatives

Evaluation Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Overall Protection of Public Health and the Environment	No protection provided	Will provide overall protection of public health. Will not immediately protect the environment from off-site groundwater contamination	Will provide overall protection of public health, will not protect the environment from groundwater contamination	Will provide overall protection of public health and the environment specified by the O.P. Unit's objectives	Same as Alternative 4	Same as Alternative 4
Compliance with ARAR's (State and Federal Regulations)	Does not comply with any regulations.	Complies with all applicable state and federal regulations for on-site groundwater contamination.	Does not comply with state and federal regulations concerning groundwater remediation.	Complies with all applicable state and federal regulations for off-site groundwater contamination	Same as Alternative 4	Same as Alternative 4
Long-term effectiveness and Permanence	Does not remediate contaminated ground water.	Long-term remediation of off-site groundwater will eventually occur once the release of contamination to off-site groundwater has been prevented.	Only prevents public use of groundwater. Does not permanently remediate contamination.	Will remove contaminants from off-site groundwater, but does not address contaminant release from the site. May cause permanent changes in the wetlands	Will remove contaminants prior to them entering the creek, but does not remediate the off-site groundwater. May change wetlands	Remediations off-site groundwater eventually removing contaminants entering the creeks.
Reduction of Toxicity, Mobility, or Volume	Does not reduce or eliminate any hazardous waste.	Reduces groundwater contamination, leaving the site to MCLs.	Same as Alternative 1.	Reduces groundwater off-site to MCLs	Reduces contamination entering the creeks. Doest not reduce groundwater contaminant concentrations	Same as Alternative 4
Short-Term Effectiveness	No short-term protection of public health or the environment will occur	Prevents additional migration of contaminants, but does not address contaminants already off-site and moving toward the creeks	Short-term public health protection is provided, but does not remove contamination from the environment	Addresses contaminant levels in the groundwater and entering the creeks. Construction may cause impacts to the area	Does address contamination entering the creeks. Does not address off site groundwater contamination. Construction may cause impacts to the area	Does not immediately affect contaminants entering the creeks. Does address high concentrations in off-site groundwater.
Implementability	Not applicable	Groundwater extraction and treatment is feasible and should not cause major implementation problems	Not applicable	Slurry wall may not prevent water flow from the creek into the collection trench. Construction may cause damage to the wetlands	Same as Alternative 4	Same as Alternative 2
Cost Estimate	$0.00	$7,266,000	$1,088,000	$11,791,500	$9,384,000	$4,378,000


370
360
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FROM TREATMENT PLANT
TO PUGH CREEK
FORCEMAIN TO
TREATMENT PLANT
EXTRACTION WELL
TREATMENT
PLANT
Cem
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Cem

is estimated that these extraction wells will have a pumping rate of approximately 30 gpm each. Approximate locations of these extraction wells are shown in Figure 19; however, locations of these wells could change based on movement of the contaminant plume.

iii) Groundwater from all extraction wells will be pumped via a forcemain system to the treatment plant on the Site property as shown in Figure 19. It is estimated that approximately 8000 to 9000 lineal feet of forcemain will be required to connect all of the extraction wells and the treatment plant.

iv) Contaminated groundwater will be treated in the treatment plant using a system conceptually designed to consist of settling tanks for solids removal, air stripping and final carbon adsorption treatment for off gas treatment and final groundwater polishing prior to discharge. A conceptual design of the system is shown schematically in Figure 20. It is estimated that the plant will be treating approximately 550 gpm of water contaminated with an approximate total VOC concentration of 15 mg/L. The treatment system will be required to comply with air emissions standards and NPDES requirements (see Page 49) prior to surface water discharge and may be modified to meet these requirements.

v) Treated water will be discharged to one of the nearby surface water bodies (Pugh or Clover Creek) in compliance with NPDES requirements via a forcemain piping system.

vi) Groundwater monitoring will be conducted to determine the effectiveness of the groundwater extraction and verify that groundwater remediation goals (Table 12) are reached for the off-site groundwater beyond the POC.

vii) Deed restrictions, signs, and institutional controls will be established to identify the presence, quantity and nature of wastes in the disposal area and groundwater and limit uses of both until remediations are complete.

viii) Maintain the groundwater treatment system and the disposal areas' cover. Maintenance of the disposal areas will include:

a) periodic inspection of the disposal areas' surface including slopes;

b) periodic inspection of the monitoring well network and property fence;

c) periodic mowing of the vegetation over the disposal areas' cover;

d) the application of fertilizer at a specified frequency;

e) re-establishment of vegetation over distressed areas;

f) periodic repair of areas eroded by surface water runoff,

g) maintenance of the property fence and signs; and

h) control of burrowing animals.

FIGURE 19

ALTERNATIVE 6 -REMEDIAL COMPONENTS

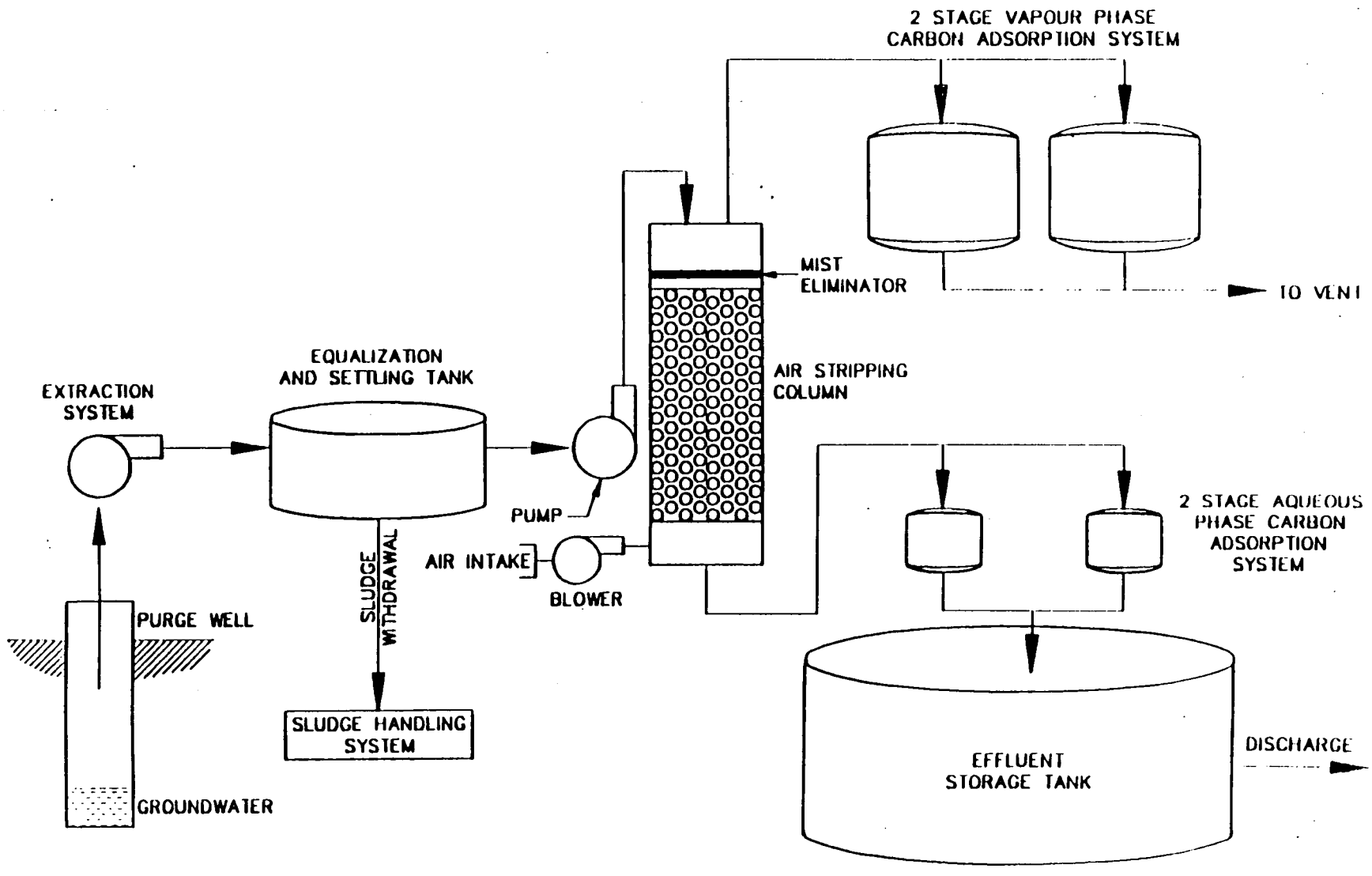

FIGURE 20

PROPOSED GROUNDWATER TREATMENT SYSTEM

ix) Identify and evaluate possible additional remedial actions required for addressing the contamination of the entire Site including the contaminant source (disposal areas) and possible environmental/ ecological concerns and prepare a feasibility study to discuss the alternatives. Possible treatability studies and/or additional sampling may be required.

In addition to the above activities, various support activities including the implementation of a worker health & safety program and environmental monitoring for indicator chemical emissions will be conducted.

The estimated costs of alternatives 2 and 6 are shown in Tables 15 and 16. The combined cost for this selected remedy, excluding the cost for the work identified in paragraph ix above, is estimated to be approximately 11,644,000 dollars.

Contingency Measures

The goal of this remedial action is to restore the groundwater to its beneficial use, which is that of a drinking water source. Based on information obtained during the remedial investigation and the analysis of all remedial alternatives, EPA believes that the selected remedy may be able to achieve this goal.

It may become apparent, during implementation or operation of the groundwater extraction system and its modifications, that contaminant levels have ceased to decline and are remaining constant at levels higher than the remediation goals in Table 12 over some portion of the contaminated plume. In such a case, the remediation goals and/or the remedy may be reevaluated.

If the selected remedy cannot meet the specified remediation goals, at any or all of the monitoring points during implem tation, the contingency measures and goals described in this section may replace the selected remedy and goals for these portions of the plume. Such contingency measures will, at a minimum, prevent further migration of the plume and include a combination of containment technologies and institutional controls. These measures are considered to be protective of human health and the environment, and are technically practicable under the corresponding circumstances.

The selected remedy will include groundwater extraction for an estimated period of 30 years, during which time the system's performance will be carefully monitored on a regular basis and adjusted as warranted by the performance data collected during operation. Modifications may include any or all of the following:

a) at individual wells where cleanup goals have been attained, pumping may be discontinued;

b) alternating pumping at wells to eliminate stagnation points;

c) pulse pumping to allow aquifer equilibration and encourage adsorbed contaminants to partition into groundwater; and

d) installation of additional extraction wells to facilitate or accelerate cleanup of the contaminant plume.

TABLE 15

REMEDIAL COST ESTIMATE - ALTERNATIVE A2
HARDEMAN COUNTY LANDFILL SITE

Item	*Description*	*Capital Costs*	*Annual O&M Costs*	*Present Worth of O&M Costs*	*Total Present Worth Costs*
1.	Institutional Controls	$ 35,000	$ 68,000	$ 641,000	$ 676,000
2.	Maintain Existing Clay Cap	–	9,000	85,000	85,000
3.	On-Site Hydraulic Containment	550,000	25,000	235,500	785,500
4.	Groundwater Treatment	1,385,000	325,000	3,064,000	4,449,000
5.	Discharge	200,000	10,000	94,000	294,000
6.	Indirect Capital Costs	976,500	0	0	976,500
	Subtotals	$ 3,146,500	$ 437,000	$ 4,120,000	
	Total Estimated Present Worth Cost - Alternative A2				$ 7,266,000

5 9 0067

TABLE 16

REMEDIAL COST ESTIMATE - ALTERNATIVE A6
HARDEMAN COUNTY LANDFILL SITE

Item	*Description*	*Capital Costs*	*Annual O&M Costs*	*Present Worth of O&M Costs*	*Total Present Worth Costs*
1.	Institutional Controls	$ 40,000	$ 109,000	$ 1,028,000	$ 1,068,000
2.	Off-Site Hydraulic Removal	970,000	40,000	377,000	1,347,000
3.	Groundwater Treatment (additional costs)	275,000	100,000	943,000	1,218,000
4.	Discharge	50,000	10,000	94,000	144,000
5.	Indirect Capital Costs	601,000	0	0	601,000
	Subtotals	$ 1,936,000	$ 259,000	$ 2,442,000	
	Total Estimated Present Worth Cost - Alternative A6				$ 4,378,000

To ensure that the remediation goals continue to be maintained, the aquifer will be monitored at those wells where pumping has ceased on an occurrence of every quarter for 5 years following discontinuation of groundwater extraction.

If it is determined, on the basis of the preceding criteria and the system performance data, that certain portions of the aquifer cannot be restored to their beneficial use, any or all of the following measures involving long-term management may occur, for an indefinite period of time, as a modification of the existing system:

a) engineering controls such as physical barriers, or long-term gradient control provided by low level pumping, as containment measures;

b) chemical-specific ARARs will be waived for the cleanup of those portions of the aquifer based on the technical impracticability of achieving further contaminant reduction;

c) institutional controls will be provided/maintained to restrict access to those portions of the aquifer which remain above remediation goals;

d) continued monitoring of specified wells; and

e) periodic reevaluation of remedial technologies for groundwater restoration.

The decision to invoke any or all of these measures may be made during a periodic review of the remedial action, which will occur at least once every five (5) years. If any or all of these measures are determined to be necessary, an Explaination of Significant Differences ("ESD") or a ROD Ammendment will be issued to inform the public of these actions.

STATUTORY DETERMINATIONS

Under its legal authorities, EPA's primary responsibility at Superfund sites is to undertake remedial actions that achieve adequate protection of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences. These specify that when complete, the selected remedial action for this Site must comply with applicable or relevant and appropriate environmental standards established under Federal and State environmental laws unless a statutory waiver is justified. The selected remedy also must be cost effective and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

Based on the Site risk assessment, long term exposure to contaminants through the consumption and use of contaminated groundwater is the identified risk associated with the Site. Although no excessive risk was identified for exposure to the wastes contained in the disposal areas, this risk level was

based on present conditions which include a temporary cover over the disposal areas.

The selected remedy protects human health and the environment through extraction and treatment of the contaminated groundwater. The contaminants will be permanently removed from the groundwater by air stripping. The volatile dissolved gases will be transferred to the air stream for treatment by carbon adsorption and release to the atmosphere in compliance with Clean Air Act regulations.

Extraction of the contaminated groundwater also will eventually eliminate the threat of exposure to the most mobile contaminants from direct contact or from ingestion of contaminated groundwater. The future carcinogenic risks associated with these exposure pathways are as high as a one in one for consumption of the contaminated groundwater. By extracting the contaminated groundwater and treating, the cancer risk in the consumption of off-site groundwater will be reduced to about 8.2×10^{-5} and an Hazard Indices (HI) ratio of less than 1. These levels are within the range of acceptable exposure levels of between 10^{-4} and 10^{-6} and an HI ratio of less than 1. There are no short-term threats associated with the selected remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from the remedy.

The contingency remedy, if required, will provide overall protection of human health and the environment through a combination of mass reduction and institutional and/or engineering controls.

Compliance with ARARs

The selected remedy of hydraulic containment and treatment of the on-site groundwater at the POC and extraction and treatment of the off-site groundwater beyond the POC will comply with all Applicable or Relevant and Appropriate Requirements (ARARs) or the contingency remedy will attain or justify the waiver of any ARARs. The ARARs are presented below:

Action Specific ARARs:

* Clean Water Act (40 CFR Part 122)
* Tennessee Water Quality Control Act, TN Code 69-3-104
* Clean Air Act (40 CFR Parts 50-62)

Chemical Specific ARARs:

* Safe Drinking Water Act (40 CFR Parts 141, and 143)
* Tennessee Water Quality Criteria (1200-4)

Location Specific ARARs

* Response in a Floodplan or Wetlands (40 CFR Part 6, Appendix A)
* RCRA (40 CFR Section 264.95)
* Clean Water Act (Section 404) (40 CFR Part 230) (33 CFR Parts 320-330)

RCRA LDRs are not generally applicable to the groundwater extraction and treatment process; however, should levels in the waste residuals in the sludge from the treatment process exceed allowable standards, the sludge will be disposed of in accordance with LDRs.

Cost Effectiveness

The selected remedies are cost-effective because they have been determined to provide overall effectiveness proportional to their costs. Alternatives 2 and 6 have an estimated net present worth value of $11,644,000. Alternative 6 is the least costly and the mostly easily implemented of Alternatives 4,5 and 6 which meet all off-site ARARs.

Utilization of Permanent Solutions and Alternative Treatment Technologies (or Resource Recovery Technologies) to the Maximum Extent Practicable

The State of Tennessee and EPA have determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for OP Unit #1. Of those alternatives that are protective of human health and the environment and comply with ARARs, the State of Tennessee and EPA have determined that this selected remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume achieved through treatment, short-term effectiveness, implementability, cost, also considering the statutory preference for treatment as a principal element and considering State and community input.

The selected remedy reduces the toxicity, mobility, and volume of the contaminants in the groundwater; complies with ARARs; provides short-term effectiveness; and protects human health and the environment. The selected remedy will be easier to implement technically because it requires less construction and is less likely to destroy the wetlands around Clover Creek. Finally, the off-site portion of the remedy costs the least of the equally protective off-site alternatives. The major tradeoffs that provide the basis for this selection decision are long-term effectiveness, implementability, and cost.

The selected remedy is more reliable and can be implemented more quickly, with less difficulty and at less cost that the other treatment alternatives and is therefore determined to be the most appropriate solution for the contaminated groundwater caused by the release of hazardous substances from or at the Site.

Preference for Treatment as a Principal Element

By treating the contaminated groundwater in an on-site treatment plant consisting of an air stripper and carbon adsorption then discharging the treated effluent to one of the nearby surface water bodies, the selected remedy addresses the principal threat of future direct contact/ingestion of contaminated groundwater posed by the Site through the use of treatment technologies. Therefore, the statutory preference for remedies that employ treatment as a principal element is satisfied.