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EPA Superfund Record of Decision:

Velsicol Chemical Corporation, Hardeman County (O.U. 2), TN 9/26//1995

VELSICOL\HARDEMAN COUNTY LANDFILL SUPERFUND SITE

OPERABLE UNIT #2

RECORD OF DECISION

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

U.S. Environmental Protection Agency
Region IV

September 26, 1995

RECORD OF DECISION

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1.0 DECLARATION

SITE NAME AND LOCATION

Velsicol/Hardeman County Landfill, Operable Unit #2
Toone-Teague Road
Toone, Tennessee

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Velsicol Hardeman County Landfill, Operable Unit #2, in Toone, Hardeman County, Tennessee. This action is chosen in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the National Contingency Plan. This decision is based on the Administrative Record for this Site.

The State of Tennessee concurs with 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 ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE REMEDY

This operable unit is the final action of two operable units for the Site. The first operable unit at this Site involved groundwater remediation. This action addresses the source of groundwater contamination.

The remedy includes capping the 27-acre landfill with a RCRA composite cap to reduce infiltration of surface water through the waste and contaminated soil. The RCRA composite cap consists of:

- scarifying existing vegetative cover and recompacting;
- a 40-mil high density polyethylene (HDPE) synthetic liner or equivalent, placed over the recompacted clay surface;
- a sand drainage blanket with a minimum hydraulic conductivity of 1×10^{-3} cm/sec placed over the liner to provide lateral drainage;
- the sand will be covered with a filter fabric and a layer of common fill and topsoil;
- a vegetative cover will be established to prevent erosion of the fill and topsoil materials; and

- routine monitoring of the RCRA cap in order to maintain the integrity of the cap.

The current network of monitoring wells established by OU #1 will provide the long-term means of monitoring the effectiveness of this remedy.

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 technologies, to the maximum extent practicable for the Site. However, because treatment of the principal threats of the Site was not found to be practicable, this remedy does not satisfy the statutory preference for treatment as a principal element.

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

26 SEP 95
Date

Richard D. Green, Associate Director
Office of Superfund and Emergency Response

2.0 DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

The Velsicol/Hardeman County Landfill is located on Toone-Teague Road, Hardeman County, Tennessee. The property is located approximately one mile north of Tennessee State Highway 100 (see Figure 2.1) and approximately one mile south of Clover Creek. The property, shown on Figure 2.2, is bound by Old Toone road to the west and railroad right-of-way to the east. Approximately 27 acres of the 242-acre property were operated as a landfill between 1964 and 1973 for the disposal of pesticide waste generated at the Velsicol Memphis, Tennessee Plant.

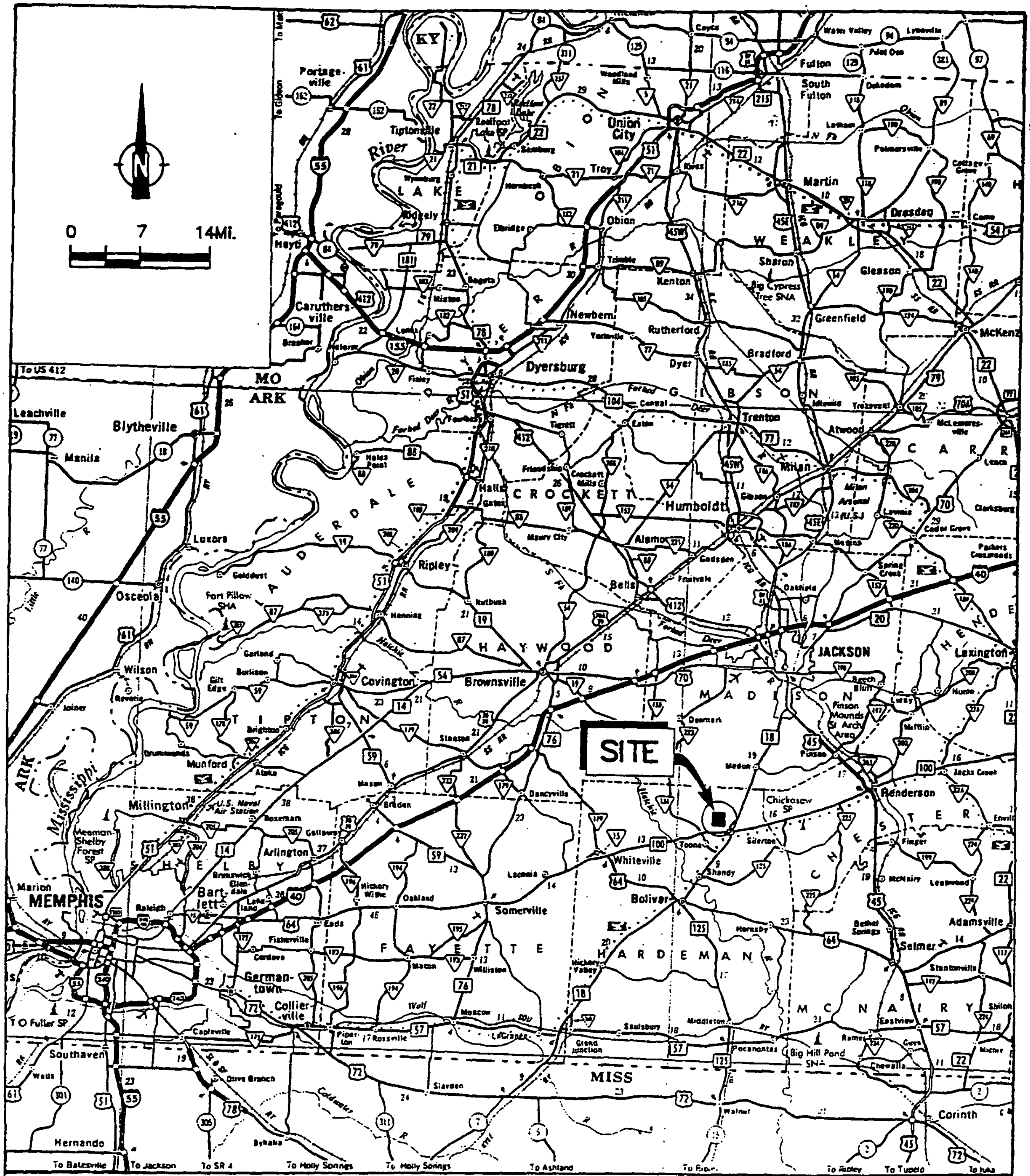
2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.2.1 Site History

In July 1964, Velsicol Chemical Corporation purchased 242 acres of land in Hardeman County, Tennessee, specifically for use as a landfill to dispose of waste from Velsicol's Memphis, Tennessee Plant Site. At the time Velsicol purchased the property, and prior to commencing landfilling operations, Velsicol consulted with the United States Geological Survey (USGS) about the location of aquifers in the area and their relationship to the Memphis Sand Aquifer. In an attempt to address this issue, Velsicol installed a well in the immediate vicinity of the proposed disposal area. The purpose of the well was to establish a water supply well in an aquifer that would supply a sufficient potable water supply and to provide a means of sampling the groundwater beneath the Site for evidence of contamination. The borehole was completed to a depth of approximately 224 feet below the ground surface at which point an artisan groundwater condition was encountered. A well was installed in this borehole.

Immediately upon purchasing the property, Velsicol erected a fence around a portion of the property where the landfilling was to commence. 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 areas which covered a total area of approximately 27 acres. During the development of the Remedial Investigation (RI), Velsicol completed a detailed estimate of waste volumes based on plant production rates. A detailed and accurate estimate of waste quantity and type, based on this review by Velsicol, is summarized in Table 2.1.

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 continued longitudinally in the direction of the Site 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



SOURCE: TENNESSEE OFFICIAL HIGHWAY MAP

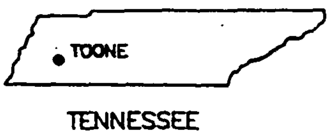


FIGURE 2.1

SITE LOCATION
HARDEMAN COUNTY LANDFILL
Hardeman County, Tennessee

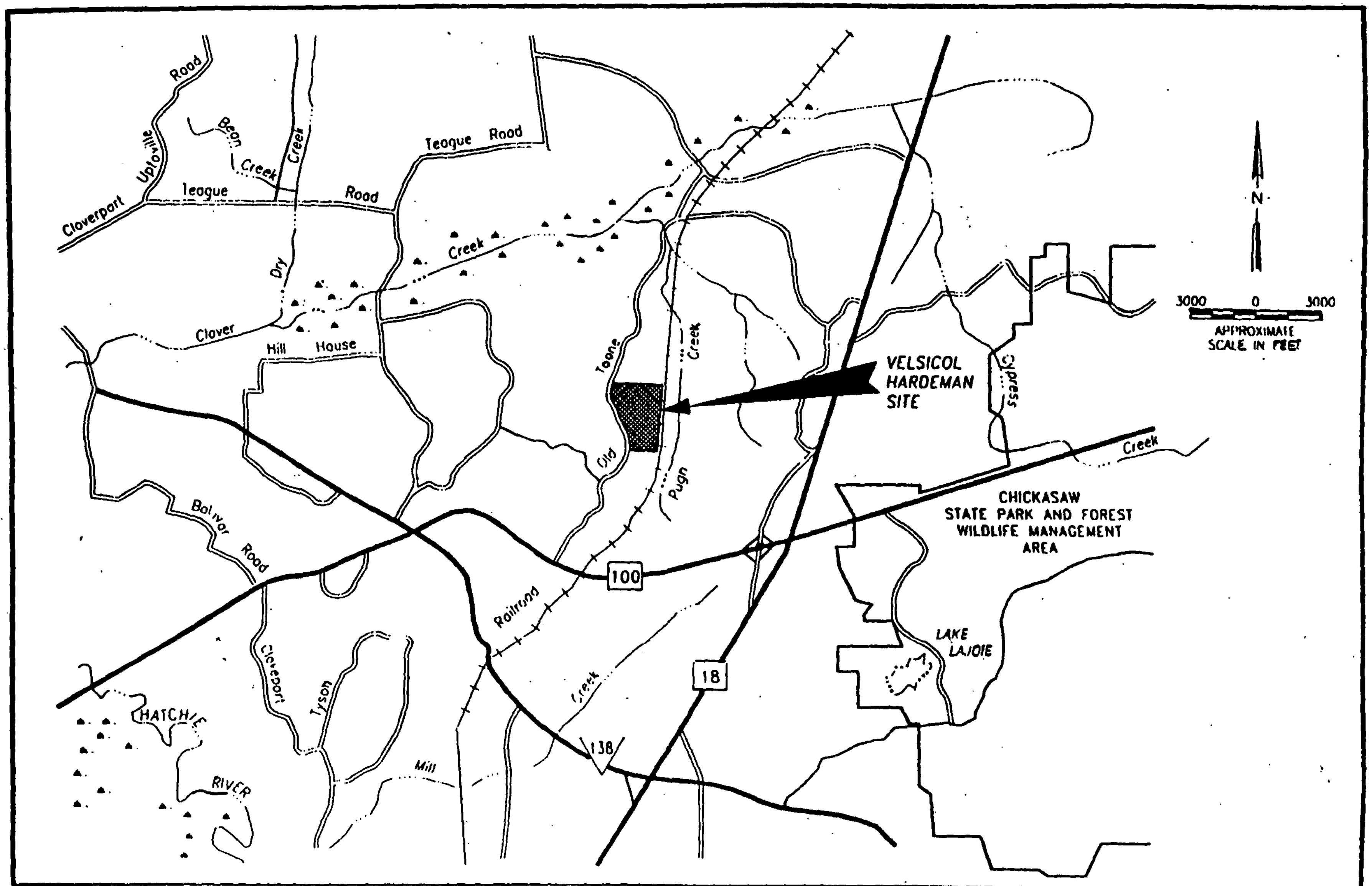


FIGURE 2.2 SITE LOCATION - VELSICOL/HARDEMAN COUNTY LANDFILL

TABLE 2.1

SUMMARY OF WASTE DISPOSAL AT HARDEMAN COUNTY LANDFILL

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

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.

at the Hardeman County Site. On the basis of this evaluation, a Commissioner's Order was issued to Velsicol 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 Site was permanently closed in June 1973.

Plant waste was disposed of in trenches which were excavated longitudinally along the top of Site ridges. It has been reported 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. Approximately four to eight feet were maintained between each trench when excavated.

As each transport vehicle arrived at the landfill the containerized waste was dumped off of the truck into one of the excavated disposal trenches. 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 each trench, the trench of containerized waste was covered with a minimum of three feet of soil which had also been excavated from the trenches. 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. The repair of settled areas was carried out on a regular basis and in most cases the settling over the disposal areas had subsided within five years of initial backfilling. All backfilled areas were seeded, fertilized and limed to prevent erosion.

2.2.2 Enforcement Activities

The Velsicol/Hardeman County Landfill was included on the National Priorities List in December 1982. The studies completed to date have shown that contamination of the local groundwater has occurred. The extent of contaminant migration from the Site is such that the use of groundwater as a domestic water supply by residences within the immediate vicinity of the Site was halted in 1979.

In order to minimize the impact caused by the disposed waste, the Site was remediated in the fall of 1980 by constructing a low permeability clay cap over the disposal areas. The scope of the remedial work was outlined in a letter dated July 10, 1980 from Velsicol to the TDHE. The TDHE approved the Scope of Work in a July 10, 1980 letter to Velsicol.

Subsequent to completing the Site cap, a three-year monitoring program was implemented to assess the effectiveness of the cap. The results of this monitoring program were presented in a final report entitled "Environmental Evaluation and Assessment of Control Measures at the Velsicol Disposal Site-Hardeman County Tennessee" ERM Southeast Inc. (ERM) February 1985. The results of ERM's study and modeling confirmed that the cap was effective in reducing contaminant migration from the Site.

Upon completion of the monitoring program, TDHE issued a notice letter to Velsicol on November 5, 1985 which required Velsicol to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the Site. The RI/FS was designed and implemented to meet the requirements of the State Superfund procedures, the National Contingency Plan, Federal Superfund procedures as presented in the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) as amended by the Superfund Amendment and Reauthorization Act (SARA), and the eventual agreement between TDHE and USEPA Region IV.

During the progress of the RI/FS work, TDHE relinquished oversight responsibilities for the RI/FS to USEPA. Based on this change in responsibility, USEPA negotiated an Administrative Order on Consent (AOC) with Velsicol. The AOC was signed by Velsicol on January 26, 1989 and became effective on February 17, 1989.

Velsicol subsequently completed the RI/FS for the Site in April 1991 an USEPA prepared a Record of Decision (ROD), dated June 27, 1991, for the Site. The outline of proposed remedial activities, as selected by USEPA, is embodied in the ROD for the Site.

From July to September 1991, negotiations were conducted with the Velsicol Chemical Corporation to perform and pay for the Remedial Design/Remedial Action (RD/RA). An agreement could not be reached with Velsicol to perform the work by the end of the negotiation period. Subsequently, USEPA issued a Unilateral Administrative Order (UAO) that requires Velsicol to conduct the RD/RA for the contaminated groundwater, hereinafter referred to as Operable Unit #1 (OU #1). The Order also includes USEPA's Statement of Work (SOW) for the RD/RA. The Order was signed by USEPA on October 17, 1991 and became effective November 29, 1991.

In addition to conducting the RD/RA for OU #1, Velsicol is required to conduct an FS for the landfill area operable unit (OU #2). Velsicol and USEPA negotiated a First Amendment to the February 17, 1989 RI/FS Consent Order (First Amendment) to address OU #2 FS. The First Amendment was signed by Velsicol on October 21, 1991 and became effective on November 4, 1991. The First Amendment includes an FS SOW.

The purpose of the OU #2 FS is to develop and evaluate additional potential remedial action alternatives for remediating the source of the contamination (the wastes in the disposal areas) at the Site.

The OU #2 FS Work Plan includes provisions for an environmental risk evaluation for purposes of assessing current and potential future risks to the environment caused by the disposed waste. The requirements of the environmental risk evaluation include ecological studies, and additional soil sampling to supplement the existing ecological database at the Site. Velsicol completed the required supplementary field investigations during the summer of 1992. This has been completed and approved by USEPA (Environmental Evaluation Report, April 1993) and showed that the Site posed no risk to the environment. Additionally, in support of the remedial action alternatives evaluation, Velsicol conducted, at USEPA's request, landfill waste and soil sampling analysis, and technology-specific treatability studies on samples of landfill soil and waste. These USEPA-approved studies are presented in the Landfill Waste Sampling and Data Evaluation Report (March 1993) and the Landfill Waste Treatability Study Evaluation Report (February 1994).

The OU #2 FS augmented the evaluation of corrective action alternatives developed within the original FS. This OU #2 FS evaluated additional remedial alternatives which were not considered in the original FS and included the results of the treatability studies. In all cases where remedial action alternatives were evaluated, the evaluations consider the selected groundwater containment remedy (OU #1) as an integral component of each landfill source control alternative.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

In April of 1991, EPA issued a Fact Sheet which summarized the proposed alternatives for remediating the groundwater. Following a public comment period, EPA signed a Record of Decision (ROD) in June 1991 which presented the selected remedy. A Superfund Fact Sheet Update was mailed to interested citizens in April 1992.

The OU #2 additional investigations, FS and Proposed Plan were released to the public in July 1995. These documents were made available to the public in the Administrative Record and the information repository maintained at the EPA Docket Room in Region 4 and at the Bolivar-Hardeman County Public Library. The notice of the availability of these two documents was published in the Bulletin-Times and the Jackson Sun on July 5, 1995.

A public comment period was held from July 13, 1995 to August 12, 1995. No written public comments were received during this period. No request for an extension to the public comment was made. In addition, a public meeting was held on July 13, 1995. At this meeting, representatives from EPA and the Tennessee Department of Environment and Conservation (TDEC) answered questions relating to the Site and the remedial alternatives under consideration. A Bulletin-Times reporter and a local Jackson TV news-station, WBBJ, attended the public meeting. A transcript of the public meeting is included in the Responsiveness

Summary, which is part of this ROD.

This decision document presents the selected remedial action for the Velsicol/Hardeman County Landfill Superfund Site, OU #2, in Hardeman County Tennessee. The remedial action chosen, is in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the National Contingency Plan. The decision for this Site is based on the Administrative Record.

2.4 SCOPE AND ROLE OF OPERABLE UNIT

As with many Superfund sites, the problems at the Velsicol/Hardeman County Landfill OU #2 are complex. As a result, EPA organized the work into two operable units (OUs). These are:

- OU #1: Contamination in the aquifer.
- OU #2: Contamination in the soils.

Remedial action objectives for both the waste disposal areas and off-Site groundwater were developed and presented in the original FS. Since the selected groundwater extraction and treatment system for OU #1 (which now forms part of the final Site remedy under OU #2) has been designed to meet off-Site groundwater remedial action objectives, only the remedial action objectives specifically for the waste disposal areas remain to be addressed. Construction for OU #1 will be completed by December 1995.

Waste contained within the three waste disposal areas and soils directly beneath the wastes have been characterized through a detailed review of historic plant production records from Velsicol's Memphis Tennessee plant and analysis of soil samples collected from beneath the wastes during the RI. Additional waste and soil samples were collected during 1992 from boreholes drill through the landfilled waste and underlying soil.

Concentrations of chemical constituents identified in the soils beneath the waste materials exceed the potential health-based chemical-specific target levels for soils. These target level concentrations are based upon contact and associated ingestion hazards as a result of direct exposure to the wastes and contaminated soil.

The construction of a low permeability clay cap over the waste disposal areas in 1980 by Velsicol has eliminated the potential health risk for direct contact or ingestion of waste materials and contaminated soil.

In addition to direct contact and ingestion being potential routes of exposure to contaminants in the disposed waste, the disposed waste could be a continuing source of contaminants to the groundwater beneath the Site. Monitoring through the use of lysimeters and groundwater monitoring has demonstrated that the clay cap has been effective in reducing infiltration and percolation of precipitation through the wastes into the groundwater. Therefore, although it has been demonstrated that the clay cap has substantially reduced the potential for the disposed waste to be a source of groundwater contamination, the presence of the wastes and contaminated soil beneath the wastes still remains as a potential source of contamination to the groundwater.

Specific remedial action objectives for the waste disposal areas including soils directly beneath the landfill wastes include:

i) prevent human exposure through direct contact or ingestion of landfill wastes or soils directly beneath the wastes which have chemical constituent concentrations in excess of the criteria levels identified in Table 2.8 (see Section 2.6.4); and

ii) prevent further degradation of the groundwater beneath and downgradient of the waste disposal areas by chemical constituents found within the waste.

This second operable unit will be the final response action for this Site.

2.5 SITE CHARACTERISTICS

2.5.1 Demography

The Site is located in the sparsely populated northeast corner of Hardeman County, Tennessee. According to 1990 census data, the total population of Hardeman County is 23,377 persons with a density of 35.0 persons per square mile, as compared to the overall density of 118.3 for the state. Approximately 74 percent of the residents in Hardeman County live outside of urban areas, leaving 26.3 per square mile on a rural basis.

There are three small towns close to the Site with the following populations:

Toone (3 miles south):	279	(1990 Census)
Cloverport (5 miles west):	100	(approximately)
Teague (2 miles north):	15	(approximately)

There are approximately 60 persons within a one-mile radius of the Site. Historically, there have been 26 residences supplied with an alternative water source from the town of Toone, as a result of their private wells being contaminated.

According to the 1990 Census, employment in Hardeman County is distributed between a variety of urban and rural occupations with the principal industries as follows:

Manufacturing	-	29.5%
Retail Trades	-	16.1%
Health Services	-	10.9%
Construction	-	6.7%
Educational Services	-	5.7%
Transportation and Communication	-	5.5%
Public Administration	-	3.8%
Finance	-	3.3%
Agriculture and Forestry	-	3.3%
Professional Services	-	3.2%
Other	-	12%

The total number of employed persons within Hardeman County is 8,962 or 38.3 percent of the county population.

Residents in the vicinity of the Site are either self-employed farmers, or commute to surrounding rural towns such as Toone or cities such as Bolivar (10 miles south) or Jackson (20 miles north).

Based on growth rates from 1980 to 1990, the Toone division of Hardeman County experienced an 11 percent population decline, compared with 2 percent decline for the County and 21 percent decline for the Town of Toone itself.

2.5.2 Land Use

Although there is some agriculture and forestry in the Toone region, the rough topography of the area in the vicinity of the Site generally limits land use to recreational activities. The three disposal areas are situated on maturely eroded upland fluvial terraces encompassed by fairly steepsided gullies and ravines. These uplands are approximately 80 to 100 feet above the marshy plains of the surrounding creeks and wetlands.

Recreational use is primarily hunting, with some fishing on Clover Creek. The area is well known for its wilderness characteristics as a good hunting ground for deer.

There is a local commercial catfish hatchery on Clover Creek downstream of the Site and in the groundwater discharge area for the Site.

2.5.3 Natural Resources

The region of the county near the Site is sparsely populated with people and may be regarded as wilderness, farmland and wetlands, with dense forests supporting many indigenous species of wildlife.

The terrestrial ecosystem has been described as consisting mainly of deer, rabbits, opossum, raccoons, squirrels and snakes. Previous studies have shown contaminants above detection levels with heptachlor epoxide in the muscle, liver, kidney and fat tissues of several collected species, and hex vinyl chloride and endrin also detected in snake tissues. According to the 1981 study results [Environmental Evaluation and Assessment of Control Measures at Velsicol Disposal Site (ERM)], the levels of contamination in deer were reported to be well below the existing (1992) USDA action levels and indicated no health hazard for consumption of game; however, certain tissue and fat levels of heptachlor epoxide detected at that time were half the USDA action limit of 300 ppb for rabbits. One of the three raccoons had heptachlor epoxide in its fat exceeding 300 ppb. Of all the opossums captured, only one had heptachlor epoxide in its tissue (liver) exceeding 300 ppb. This concentration, 1,160 ppb is the highest level detected at the Site. The results of these studies represent Site conditions prior to securement of the Site with the clay cap.

The aquatic ecosystem of Clover and Pugh Creeks has been described as consisting mainly of typical benthic organisms such as crayfish, snails and clams. Although contamination levels in benthic organisms were reported in a 1980 study, these results were questioned with a study in 1981 that found detection of organic compounds in benthic organisms occurred in only 3 percent of the analyses. Sporadic concentrations of heptachlor and endrin were reported in subsequent surveys; however, no organic compounds were reported during 1983 sampling. It was concluded that no significant bioaccumulation was occurring in the aquatic macroinvertebrates based on the contaminant transport mechanisms at that time.

The surface water resource has been used for fishing. Bioassays of bluegill fish were conducted in 1981 at five locations on Pugh Creek indicating no acute toxicity in the 96-hour study period. There have been no warnings of health risk issued or banning of consumption, since there was very little contamination apparent at that time of these previous studies. The studies recently completed as part of the OU #2 environmental evaluation verify the previous studies showing that there has been no adverse effects to the surface water bodies immediately adjacent to the Site.

The groundwater resource is used by residents in the region as a drinking water source. Following the detection of organic chemical contamination in private wells immediately downgradient of the Site, an alternate potable water supply from the town of Toone was constructed in 1979 for 26 residences in a on-mile radius of the Site. Subsequent to 1979 all future residents within the defined contaminant plume have been serviced by the Town of Toone water supply. Deed restrictions are in effect as part of the Ou#1 remedy to ensure that future residents of property with contaminated groundwater will be serviced by the Town of Toone water supply.

2.5.4 Climatology

Although the Site is approximately 70 miles east of Memphis, Tennessee, the climate is generally similar with the exception of being a few degrees cooler than Memphis with some variation in monthly precipitation. The closest weather observation station is located 10 miles south of the Site at the Bolivar Public Works Department. The prevailing winds are from the south. Wind data were selected from the Jackson station 20 miles north of the Site.

The annual 30-year normal temperature for the area is 59.6°F with January being the coldest month (mean temperature 38.0°F) and July being the warmest month (mean temperature of 79.4°F). The average annual precipitation is 51.3 inches with the greatest monthly precipitation generally occurring in the winter and early spring (approximately 30 percent each season compared with 20 percent for each of the summer and fall seasons).

2.5.5 Site Stratigraphy

The sediments underlying the Site are dominated by sand. The Claiborne Formation outcrops in areas of Hardeman County and is underlain by the Wilcox Formation. The two formations are not differentiated in western Tennessee and combine to form a fairly thick sequence of sand and silty sand with subordinate clay and silt. The Claiborne Formation is mantled by a thin discontinuous deposit of Quaternary alluvium and loess.

The Quaternary deposits are present across most of the study area. The alluvium is similar to the underlying Claiborne sediments and could not be differentiated from the Claiborne Formation in the study area. The alluvium is usually capped by loess which is glacially derived wind blown silt. The thickness of the loess deposits ranges from 0 to approximately 12 feet.

The stratigraphy generally encountered in the first 20 feet is consistent across the Site. Clay or silt is almost always present from the ground surface to three or five feet below ground surface (BGS). The silt usually grades downward to silty sand which, in turn, grades to clean or slightly silty sand. Low permeability soils were encountered (below the surface sediments) in eight boreholes. They were usually very thin clay or silt layers interbedded with sand. Total thickness of the low permeability layers was generally less than 1 foot.

The Claiborne/Wilcox sand consists of fine to medium grained quartz. Coarse-grained sand and gravel is rare. It is usually well to medium-well sorted. Slightly silty to silty fine sand is common. Colors range from light gray, pinkish gray, beige, orange-brown to dark reddish brown. It is sparsely to very micaceous. Limonite concretions and limonite cemented sand is present but uncommon. Kaolin is often present as thinly interbedded lamination.

The clay layers in the Claiborne and Wilcox Formations are usually less than 2 feet thick. Thicker layers are often interbedded with clayey or silty sand. The clay is typically silty and slightly sandy and has a low to medium plasticity. Colors range from white and pinkish white (kaolin) to dark gray and brown.

The total thickness of the Claiborne and Wilcox Formations was not determined during the investigation. The Wilcox Formation rests unconformably on the Porter's Creek Clay. The top of the Porter's Creek Clay is estimated to occur at an elevation of 220 to 240 feet above mean sea level (AMSL) beneath the landfill. Previous studies have indicated that the Porter's Creek Clay is approximately 120 feet thick.

2.5.6 Site Hydrogeology

The geologic conditions beneath the Site were found to be much different that previously presented in Rima et al., 1964. The hydrogeology of the study area is consistent with that of the northern Hardeman County region. The water bearing sands of the Claiborne and Wilcox Formations are essentially unconfined and therefore comprise a single water table aquifer. The water table elevations range from 425 feet to 370 feet AMSL from south to north across the study area. The Porter's Creek Clay is believed to form the north lower boundary of the Water Table Aquifer. Also, this area is in the recharge zone of the Memphis Sand Aquifer.

The Claiborne-Wilcox hydrostratigraphic unit is the only unit which was investigated during the RI. The Porter's Creek Clay is an aquitard and is believed to be the base of the groundwater flow system at the Site.

The hydraulic conductivity of the Claiborne-Wilcox unit, as determined from the grain-size curves, ranges from 2×10^{-3} to 9×10^{-2} cm/sec with a geometric mean of 2×10^{-2} cm/sec. The in situ hydraulic conductivity, as determined by the slug-injection tests, ranges from 4.4×10^{-5} cm/sec to 1.1×10^{-2} cm/sec, with a geometric mean of 1.0×10^{-3} cm/sec. For most of the monitoring wells tested the hydraulic conductivity is in the range of 9×10^{-3} to 1.6×10^{-4} cm/sec. Pump tests conducted in 1993 during the remedial design for OU #1 indicated hydraulic conductivities of 3.4×10^{-3} to 3.5×10^{-3} cm/sec. Subsequent calibration of a numeric model indicated that use of an aquifer hydraulic conductivity of 2.5×10^{-3} cm/sec would be appropriate for design purposes. The variation of hydraulic conductivity between monitoring wells reflects the silt and clay beds that are found within the unconfined sand aquifer.

Water level elevations were collected from a total of 35 monitoring wells in August 1989, November 1991, May 1993, and October 1993. The data indicate that there is little seasonal variation in the water level elevations in the Water Table Aquifer and that the water level elevations are generally consistent with the elevation presented in ERM's February 1985 document.

Groundwater in the study area flows from south to north, with an average horizontal gradient of 0.004 ft/ft. The water table contours also indicate that the unsaturated zone beneath the disposal areas is 75 to 95 feet thick.

The actual water table elevations in the vicinity of Pugh and Clover Creeks indicate that they are in fact discharge boundaries and groundwater originating from the Site does not flow beneath these streams. Elevations at the supplemental wells west of the Site show that the unnamed tributary southwest of the Site is also a discharge boundary. The major discharge area is Clover Creek and the lower reaches of Pugh Creek. In its upper reaches upgradient of the Site, Pugh Creek is intermittent indicating a poor hydraulic connection with the groundwater.

Using a horizontal hydraulic gradient of 0.004, a hydraulic conductivity of 3×10^{-3} cm/sec and an assumed porosity of 0.25, a velocity of 4.8×10^{-5} cm/sec or 50 feet per year was estimated in the RI. A maximum value for groundwater velocity was calculated using a hydraulic conductivity of 1.11×10^{-2} cm/sec (highest value from the single well response tests), a horizontal gradient of 0.004 and an assumed porosity of 0.2. These values yielded a velocity of 2.2×10^{-4} cm/sec or 230 feet per year.

The presence of the numerous clay beds and lenses within the Water Table Aquifer would have the effect of reducing the effective porosity. In addition, gravel seams have been identified in some boreholes noted above. This, in fact, is the case at the Site because if the maximum flow rates stated above were used, it would take approximately 26 years for groundwater beneath the Site to reach Clover Creek. However, Site-related contaminants have already been detected in the groundwater adjacent to the Clover Creek. Therefore, it is believed, based on the historical data, that the groundwater velocity is on the order of double the calculated velocity.

2.5.7 Waste Characterization

2.5.7.1 Characterization by Waste Inventory Records

Characterization of the landfill waste was completed in order to verify the volume estimates which were previously developed, identify indicator parameters which best represented the waste at the Site as wells as to identify specific waste constituents which may not have been identified to date. Special emphasis was placed on relatively mobile contaminants having the potential to migrate from the Site. The characterization of landfill waste was primarily accomplished by conducting a detailed analysis of historic waste generation records from Velsicol's Memphis, Tennessee Plant Site and by the collection and analyses of angled boring samples taken from directly beneath the waste disposal areas.

Table 2.1 presents a summary of the waste volume estimate. The wastes summarized in the table contained specific hazardous constituents which may or may not potentially migrate from the Site. The relative mobility of each of these constituents was evaluated along with their toxicity to determine the potential impact each may have in the long term on the groundwater.

2.5.7.2 Characterization by Landfill Waste Sampling

Angled Boring Program, 1988-1989

In order to confirm the results of the waste characterization by inventory records, angled borings were completed to sample soil immediately beneath the waste disposal areas. The angled borings were completed as an alternative to drilling directly through the waste on the basis of safety and environmental concerns.

In total, 13 angled borings were installed beneath the waste disposal areas. During the installation of the borings, shelby tube samples were collected at 5-foot intervals along the axis of the borehole for chemical analyses. Each 5-foot interval was analyzed for TCL VOCs, BNAs and Pesticides/Herbicides including PCBs. In addition, samples were analyzed for TAL metals and cyanide. Two rounds of soil boring samples were collected during the RI field program. Due to problems identified through the associated QA/QC data review, the data from the first round of angled boring samples (August 1988) were used for qualitative purposes only. In order to generate data which could be used for quantitative purposes, a second round of angled boring samples was collected during November/December 1989. Not all of the angled borings completed in the first round were duplicated during the second round of sampling. A total of six sample borings were completed. The six sample locations were selected based upon their relatively easy access to the sampling site and because they were found to have the highest concentrations of Site-specific constituents in the soil samples collected during the first round of sampling. In addition, sample sites were selected to be representative of all three disposal areas. The QA/QC review for the second round of data confirmed that the data could be used for both quantitative and qualitative evaluation of the landfill waste.

Table 2.2 presents a summary of the analytical data for the second round of angled boring sampling. The analytical data summary presents the range of positive detections for the second sampling round. A detailed summary and discussion of all of the angled boring analytical data is presented in the RI.

TABLE 2.2

SUMMARY OF ANALYTICAL DATA
ANGLED BORING SAMPLES - ROUND 2

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Compounds	*Number of Positive Detections*	*Number of Samples Analyzed*	*Range of Positive Detections (mg/kg)*	*Arithmetic Average of Positive Detections (mg/kg)*
VOCs				
Acetone	11	45	1.57 - 10.3	6.12
Benzene	1	45	N/A	0.660
Carbon tetrachloride	8	45	0.805 - 342	135
Chlorobenzene	4	45	1.67 - 6.06	3.52
Chloroform	8	45	0.765 - 86.7	19.0
Chloromethane	1	45	N/A	235
Ethyl benzene	6	45	0.850 - 10.6	3.30
1,1,2,2-Tetrachloroethane	1	45	N/A	0.654
Tetrachloroethene	13	45	1.37 - 16.6	6.28
Toluene	17	45	1.24 - 94.3	19.7
Xylenes	12	45	1.45 - 67.8	11.2
BNAs				
Acenaphthene	10	45	0.520 - 2.50	1.49
Benzoic acid	1	45	N/A	2.50
Bis(2-ethylhexyl)phthalate	8	45	0.390 - 13.0	2.33
Di-n-butyl phthalate	1	45	N/A	5.40
Di-n-octyl phthalate	3	45	0.400 - 1.30	0.760
Dibenzofuran	1	45	N/A	11.0
Fluorene	11	45	0.430 - 19.0	4.75
Hexachlorobenzene	16	45	1.30 - 61.0	16.1
Hexachlorobutadiene	16	45	0.390 - 40.0	10.6
Hexachlorocyclopentadiene	16	45	0.430 - 1200	298.
Hexachloroethane	5	45	1.50 - 11.0	6.34
2-Methylnaphthalene	18	45	0.490 - 270	104
Naphthalene	16	45	1.40 - 210	63.3
Pesticides/PCBs				
Aldrin	18	45	1.50 - 98.0	23.3
Dieldrin	19	45	1.70 - 280	60.9
Endrin	19	45	1.80 - 640	126
Endrin aldehyde	17	45	3.60 - 540	98.8
Heptachlor	12	45	35.00 - 3000	1050

TABLE 2.2

SUMMARY OF ANALYTICAL DATA
ANGLED BORING SAMPLES - ROUND 2

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Compounds	*Number of Positive Detections*	*Number of Samples Analyzed*	*Range of Positive Detections (mg/kg)*	*Arithmetic Average of Positive Detections (mg/kg)*
<u>METALS</u>				
Aluminum	44	45	660 - 9770	4530
Arsenic	33	45	1.00 - 11.2	3.70
Barium	36	45	5.60 - 57.3	20.1
Calcium	26	45	52.7 - 556	179
Chromium	42	45	2.60 - 17.3	7.77
Iron	44	45	1580 - 71100	9850.
Lead	7	45	5.10 - 11.2	7.88
Magnesium	41	45	25.3 - 825	296.
Manganese	41	45	3.20 - 291	43.1
Mercury	11	45	0.120 - 0.220	0.152
Potassium	29	45	33.7 - 223	105.
Selenium	1	45	N/A	0.650
Silver	5	45	1.10 - 2.30	1.40
Sodium	39	45	50.0 - 351	136.
Vanadium	37	45	5.10 - 36.8	14.4
Zinc	41	45	3.10 - 574	34.1

Note:

N/A - Presentation of a range of detection not applicable because only detected once.

Soil Sampling and Analysis Program, 1992

A soil sampling and analyses program at the Site was conducted in July/August 1992. The Landfill Waste Sampling and Data Evaluation Report detailed within Section 2.9.5.1 presents the results of the 1992 sampling and analysis program. Table 2.3 presents a summary of the analytical data for this sampling and analyses program.

2.5.8 Contaminant Migration

Migration Pathways

Three potential contaminant migration pathways exist at the Hardeman County Landfill Site. These are: air, surface water runoff and groundwater migration. Each of these potential pathways is discussed below.

Migration in Air

Contaminants may be released to the atmosphere from the surface and near-surface soil material by volatilization or by entrainment of soil-bound contaminants. In addition, some contaminants may be released to the atmosphere by volatilization at seeps and along Pugh and Clover Creeks where they discharge. Once released the contaminants may be transported by the wind.

The remedial activities completed by Velsicol in October 1980 which included the construction of a clay cap over the disposal areas has minimized the volatilization of contaminants from waste as well as particulate transport. Therefore, the air migration pathway is not considered a significant pathway in this area of disposed waste. This conclusion was accepted by TDHE and USEPA and consequently, air monitoring was not included in the Scope of Work as presented in the RI Work Plan which was reviewed and approved by TDHE and USEPA. Air migration could be a potential pathway at the seeps and in Pugh and Clover Creeks due to volatilization. The air route of exposure was considered as part of the RI and public health evaluation and found not to represent a significant route of exposure.

Surface Water Runoff

Surface water runoff or overland flow may carry particulate or dissolved contaminants from surface soil and/or at surface groundwater discharges. Surface water from the Site drains into ditches and streams which eventually flow into Pugh Creek. The placement of the cap has prevented surface water contact with the waste and therefore eliminated any sediment transport from the Site. While some Site-related contaminants were detected in some surface water and sediment samples, it is believed that these compounds are the result of past surface water

TABLE 2.3

SUMMARY OF DETECTED COMPOUNDS - SOIL BORING PROGRAM - 1992

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Compound	*Range of Positive Detections* (mg/kg)	*Average of Positive Detections* (mg/kg)	*Number of Positive Detections*	*Number of Samples Analyzed*
Volatile Organic Compounds (VOCs)				
toluene	0.788 - 726	96.952	29	84
acetone	1.32 - 167	30.496	25	84
carbon tetrachloride	0.881 - 2,700	251.162	24	84
xylenes	0.84 - 841	156.226	14	84
chloroform	0.688 - 1,390	135.975	13	84
tetrachloroethene	0.813 - 58.1	10.158	13	84
methylene chloride	0.668 - 1870	268.644	7	84
ethyl benzene	1.38 - 182	95.774	5	84
benzene	1.72	1.72	1	84
chlorobenzene	1.03	1.03	1	84
chloromethane	50.9	50.9	1	84
Base/Neutrals and Acids (BNAs)				
hexachlorocyclopentadiene	0.433 - 7,520	1,121	25	84
hexachlorobenzene	0.347 - 675	91.925	23	84
methylnaphthalene, 2-	1.02 - 996	211.096	21	84
naphthalene	1.6 - 448	91.639	15	84
fluorene	0.8 - 11.9	6.078	8	84
hexachlorobutadiene	0.634 - 65.4	27.918	8	84
dichlorophenol, 2,4-	1.17 - 413,000	75,014	6	84
dinitrotoluene, 2,6-	0.871 - 2.83	1.282	5	84
hexachloroethane	11.8 - 833	187.8	5	84
acenaphthene	0.568 - 5.25	3.24	4	84
bis(2-ethylhexyl)phthalate	0.471 - 28.2	7.756	4	84
acenaphthylene	0.545	0.545	1	84
dibenzofuran	0.951	0.951	1	84
dichlorobenzidine, 3,3-	5.29	5.29	1	84
fluoranthene	0.721	0.721	1	84
pyrene	0.345	0.345	1	84

TABLE 2.3

SUMMARY OF DETECTED COMPOUNDS - SOIL BORING PROGRAM - 1992
FEASIBILITY STUDY
HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Compound	Range of Positive Detections (mg/kg)	Average of Positive Detections (mg/kg)	Number of Positive Detections	Number of Samples Analyzed
Metals				
Aluminum	141 - 19,100	4,414	82	82
Iron	303 - 75,000	7,090	82	82
Chromium	1.1 - 404	12.851	77	82
Manganese	2.1 - 275	33.228	75	82
Zinc	2.3 - 59.9	10.374	58	82
Vanadium	6 - 37	14.019	53	82
Potassium	96 - 1,530	341.490	49	82
Arsenic	1.1 - 9.2	3.219	32	82
Barium	20.7 - 89	47.813	16	82
Magnesium	534 - 3,180	1,575	11	82
Copper	3 - 44	13.125	8	82
Lead	6 - 39	12.625	8	82
Nickel	6 - 357	51.875	8	82
Calcium	611 - 14,900	5,228	4	82
Cobalt	7 - 16	11.5	2	82
Mercury	0.12	0.12	1	82
Selenium	0.9	0.9	1	82
Sodium	1,230	1,230	1	82
Pesticides				
Heptachlor	0.391 - 4,943	584.767	26	86
Endrin	0.199 - 972	116.897	21	86
Endosulfan, alpha	0.184 - 732	74.893	16	86
Dieldrin	0.162 - 468	68.114	14	86
Aldrin	0.141 - 67.1	25.217	13	86
Endrin aldehyde	0.448 - 546	116.902	12	86
Endrin ketone	0.207 - 1769	225.073	12	86
DDT,4,4'-	1.74 - 46.9	21.973	9	86
Methoxychlor	3.38 - 76.6	24.616	8	86
Heptachlor epoxide	0.105 - 68.5	15.503	5	86
DDE,4,4'-	1.28 - 72.4	24.465	4	86
DDD,4,4'-	0.103 - 3.06	1.598	3	86
Endosulfan sulfate	1.5 - 68.4	34.933	3	86
Endosulfan, beta	2.51 - 59.7	27.270	3	86
BHC, beta	8.3 - 31.9	20.1	2	86

discharges during the active landfilling operation, the discharge of contaminated groundwater into Pugh and Clover Creeks, background contamination caused by local agricultural use of pesticides and herbicides and/or local residential use of pesticides and herbicides and miscellaneous commercial products.

Therefore, based on the data collected during the RI, and on the specific constituents detected in the surface water, surface water runoff from the Site has been demonstrated not to be a significant contaminant pathway for the Hardeman County Landfill. The significance of the seeps are discussed under the groundwater migration section.

Groundwater Migration

Contaminants have been released to the groundwater beneath the Site by the percolation of precipitation through the waste disposal areas. Soluble contaminants were dissolved by the infiltrating waters and have migrated through the unsaturated zone to the water table.

These contaminants have migrated with the groundwater from the source areas (former waste disposal areas) to the north, east and west. The contaminated groundwater has been shown to be discharging at isolated seeps at surface water locations and into Pugh and Clover Creeks. Some Site-related contaminants have been detected in Pugh Creek as a result of this direct groundwater discharge to the surface (and from seeps/springs).

Therefore, based on the Site characterization completed to date and the extent of groundwater contamination defined at the Site, groundwater is considered to be the most significant contaminant pathway, a pathway to be addressed by the groundwater containment solution for OU #1.

Physical and Chemical Properties of Contaminants

Contaminant mobility depends upon the physical and chemical properties of the contaminants and the properties of the media in which they are found. Such properties include water solubility, liquid density, vapor pressure and affinity for organic matter. Partitioning of contaminants between media is controlled by such mechanisms as sorption, volatilization, dissolution and bioaccumulation. During the RI, it was determined that VOC contaminants in the groundwater and soil samples from beneath the Site are relatively soluble, moderately to highly volatile and moderately to highly mobile. Contaminants detected in the groundwater and in soil samples from beneath the waste (mainly BNAs and pesticides) have low solubilities and are relatively immobile.

2.5.9 Results of Supplementary Field Investigations

2.5.9.1 Landfill Waste Sampling and Data Evaluation Report

A soil sampling and analyses program at the Site was conducted in July/August 1992. The Landfill Waste Sampling and Data Evaluation Report presents the results of the program conducted at the Site and describes the tasks required to complete the bench-scale treatability study for selected technologies for OU #2 at the Site.

Site Investigation

A total of ten boreholes were completed in the landfill area at the Site. Each borehole was located by means of an electromagnetic survey. At each borehole location one soil sample was collected for chemical analyses from each of the following depth intervals as measured from the base of the landfill cap:

1. 0-5 feet;
2. 5-10 feet;
3. 10-20 feet;
4. 20-30 feet;
5. 30-40 feet;
6. 40-50 feet;
7. 50-70 feet;
8. 70-90 feet.

All samples were described and classified according to the Unified Soil Classification System (USGS) and described in terms of moisture, texture, color, and staining.

Subsurface Conditions

Based on the field observations made during the landfill waste sampling, the landfill mass consists largely of soil with discrete placements of individual drums, groups of empty drums, earthen waste products and packaging materials. Where drums were encountered they were typically empty, and only fragments and solid residues remain.

Summary of Analytical Data

The soil boring program included the collection of 86 investigative samples which were analyzed for TCL VOCs, TCL BNAs, TCL Pesticides, and TAL metals. Table 2.3

summarizes data in terms of range, average, and frequency of detection.

The compounds detected and their relative frequency of detection are similar to those detected in the Round 2 angled boring program summarized previously in Table 2.2. Non-detect results with elevated detection limits were reported in many of the volatile organic analyses completed due to the high concentration of compounds in the samples. Given the large number of non-detects with elevated detection limits, the identification of a clearly defined pattern of concentrations versus depth was not possible. However, the data were sufficiently detailed to generally characterize the nature of the disposed waste and to develop an assessment of the occurrence of the more highly concentrated organic analytes significant to remediation of the waste.

The data indicate that concentrations were generally highest in the upper 20 feet of each borehole, corresponding to the waste trenches. BNAs were typically found at the highest total concentrations at this depth with total concentrations ranging between 400,000 mg/kg (2,4-dichlorophenol) and 100 mg/kg, followed by pesticides with concentrations ranging between 5,000 mg/kg and 1 mg/kg and VOCs with concentrations ranging between 1,000 mg/kg and 10 mg/kg. Below the base of the trenches, the contaminants typically decreased in concentration although remained relatively high from 20 feet to 40 feet below the base of the trenches.

In general, the VOCs that were identified during the waste sampling program are consistent with those compounds identified to be present in the RI angle borings (April 1991) and the waste inventory characterization.

The BNAs identified in the soil boring program consisted of polynuclear aromatic hydrocarbons (PAHs), phthalates, nitrotoluenes, and phenolic compounds. As well, hexachlorocyclopentadiene, hexachlorobenzene, hexachlorobutadiene and hexachloroethane which are intermediate products used by Velsicol were also present.

The presence of pesticides in the soil borings was identified to be wide spread with all but five TCL pesticides being detected in at least one sample. The seven most detected pesticides included heptachlor, endrin, alpha endosulfan, dieldrin, aldrin, endrin ketone, and endrin aldehyde.

The metals analyses indicated that metals were present at concentrations consistent with background levels at the Site.

2.5.10 Contaminant Distribution and Migration

The visual observations and the analytical data generated from the sampling through the landfill largely verified the historical and geologic data available for the landfill. Specifically, the soil boring program shows that the waste is concentrated in discrete trenches covered by approximately three feet of clayey fill and overlying approximately 50 feet to 70 feet of fine to medium sand of the Claiborne and Wilcox Formations. Groundwater was encountered approximately 70 feet to 90 feet beneath the ground surface.

The soil boring program verified that a significant proportion of the wastes were delivered to the Site in boxes and that their contents are now intimately mixed with the filled soil. Drums in which some of the waste was contained have largely deteriorated and their contents have migrated from the drums and containers into the surrounding soil matrix and the subsurface soil below. The deterioration of the drums is not unexpected, based on the combined effects of the methods used to dispose of the drums and 20 years to 30 years of weathering and the corrosive nature of many of the wastes disposed of at the Site.

The analytical data shows that the concentration of analytes is high within the soil matrix of the trenches. Below the trenches, the concentration of VOCs, BNAs and pesticides remain relatively high to approximately 20 feet to 40 feet below the base of the trenches, below which the concentrations decrease.

Although the waste trenches and underlying soils were found to be contaminated with relatively high concentrations of VOCs, BNAs and pesticides, the BNAs and pesticides are not as frequently detected as VOCs.

VOCs are two to three orders of magnitude more soluble in water than most BNAs and all of the pesticides listed. The partitioning coefficients of VOCs are similarly one to two orders of magnitude lower than the BNAs and pesticides which indicate that the VOCs are more mobile than the BNAs or pesticides. However, due to the low organic carbon content of the sandy Site soils, the partitioning coefficient is probably not as major a factor in the selective migration of the Site contaminants as is aqueous solubility.

With the exception of 2,4-dichlorophenol and 2,6-dinitrotoluene, BNAs and pesticides, relative to VOCs, are much less soluble in water. Any migration which has occurred, has likely been assisted by the presence of the VOCs. For example, acetone, which is present in the waste at relatively high concentrations can dissolve phthalates and other polar compounds. Acetone is totally miscible in water; therefore, in the presence of water, acetone would provide a mechanism for the movement of polar molecules. The fact that phthalates are the most frequently detected non-VOC in the groundwater, although at very low concentrations, reinforces this mechanism. The relative significance of acetone in assisting in the migration of contaminants at the Site was limited by the fact that the majority of the contaminants, particularly the more frequently detected contaminants, were not soluble in acetone.

In fact, the majority of commonly detected non-VOC compounds in the waste and underlying soil are halogenated (e.g., pesticides, hexachlorocyclopentadiene, hexachlorobenzene). These halogenated non-VOC compounds are themselves more soluble in halogenated VOCs such as chloroform, carbon tetrachloride, tetrachloroethene and methylene chloride. However, the lower aqueous solubility of the halogenated VOCs (0.1 to 0.005 percent) relative to acetone has rendered this mechanism (i.e., dissolution of the halogenated non-VOC in a halogenated VOC itself dissolved in infiltrating water) a limited mechanism for the movement of halogenated non-VOCs to the groundwater table. Therefore, the infrequent detection of pesticides in the groundwater table is likely due to the relatively lower aqueous solubility of the halogenated VOCs, in comparison to acetone.

Prior to the cap being placed over the landfill, the mechanism for the movement of the pesticides and BNAs likely involved their dissolution in the VOCs and the subsequent dissolution of the VOCs in water percolating through the contaminated soil. Following the capping of the landfill and the reduction of infiltration of rainwater, the movement of BNAs and pesticides was further reduced.

2.5.11 Treatability Study

In support of the remedial alternatives evaluation process, treatability studies were performed on samples of soil and waste collected from below the landfill waste disposal areas. A total of four treatment technologies were examined in accordance with the FS Work Plan and included:

i) biotreatability study on soil and waste;

ii) solidification/fixation study on soil and waste;

iii) thermal desorption study on waste; and

iv) incineration study on waste.

In summary, treatability study results clearly indicated that bioremediation is not an effective treatment option for landfill wastes and soils and that the thermal process options would likely meet performance goals and objectives. Solidification/fixation was not demonstrated to be effective, although it was concluded that solidifying/stabilizing agents other than those used in the study potentially could be effective. Treatability study results are documented in the Treatability Study Evaluation Report, dated February 1994.

2.6 SUMMARY OF SITE RISKS

2.6.1 Environmental Evaluation Report

General

The Environmental Evaluation Report presents the results of an environmental evaluation study completed by CRA on behalf of Velsicol in the summer and fall of 1992 at the Site in Hardeman County, Tennessee. The environmental evaluation study was undertaken as part of the data collection activities for the OU #2 FS.

Scope of Work

The environmental evaluation included four principal activities as follows:

1. review of existing data and historic studies;
2. bioassay study;
3. gray bat study; and
4. soil sampling at seeps.

The purpose of the above activities was to characterize and evaluate the potential impact of Site contaminants on the ecology of the area.

Previous Ecological Studies

Numerous habitat assessments and community surveys have been completed historically around the Site to monitor and identify any environmental impact posed by chemical releases from the Site. These investigative studies, completed by ERM-Southeast and Dr. Raymond Harbison, are summarized as follows:

1)	July 1980 - June 1983	Comprehensive three-year Monitoring Program, ERM-Southeast • Stream Water Quality • Stream Sediment • Stream Biology • Terrestrial Survey

2)	September 1984	Stream Assessment Report, ERM-Southeast
3)	February 1985	Environmental Evaluation and Assessment of Control Measures at the Velsicol Disposal Site, ERM-Southeast
4)	October 1985	Preliminary Hazard Assessment for the Velsicol Disposal Site at Hardeman County, Tennessee, Dr. Raymond Harbison

Conclusions from these investigative studies indicated that contaminants are reaching the nearby surface waters of Pugh Creek and Clover Creek, but levels reported do not pose any environmental impact on the aquatic habitats and communities in Pugh Creek and Clover Creek or, on resident mammalian communities in the vicinity of the Site.

Bioassay Study

Chronic bioassays were conducted in October 1992 to evaluate the potential impact on growth and reproduction of aquatic life at and around the Site caused by contaminants in Pugh Creek which may have migrated from the Site. A total of three water samples were collected from each of four locations along Pugh Creek (three locations downgradient of the landfill and one location upgradient of the landfill). Fathead minnow (Pimephales promelas) larvae and Ceriodaphnia dubia were introduced to samples of the Pugh Creek surface water at various dilution factors to determine the impact of the creek water on survival and on growth/reproduction.

The results of the acute and chronic bioassay tests are summarized in Table 2.4. The result of the TCL and TAL analyses are summarized in Table 2.5.

Gray Bat Study

The purpose of the gray bat study conducted in July 1992 was to determine if the gray bat, an endangered species, habitats the area of the landfill. In the event that gray bats were found to be present, a field study and laboratory program would then be performed to determine if invertebrate (i.e., may flies, stone flies, mosquitoes, etc.) in Pugh Creek had been impacted by the contaminant migration from the landfill. The invertebrate study, if required, would determine if the gray bats have been or could be affected by the contaminants detected in the surface water, since the invertebrates are the primary food supply of the gray bat. Based on the findings of this study and a literature review

TABLE 2.4

SUMMARY OF BIOASSAY RESULTS
ENVIRONMENTAL EVALUATION REPORT SUMMARY

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

CERIODAPHNIA DUBIA

Parameter	*Sample Location*			
	BIO-1	***BIO-2***	***BIO-3***	***BIO-4***
Acute				
48-Hour LC_{50} (1)	>100%	>100%	>100%	>100%
Chronic				
NOEC (Survivial) (2)	100%	100%	100%	100%
NOEC (Reproduction)	25%	75%	100%	100%

PIMEPHALES PROMELAS

Parameter	*Sample Location*			
	BIO-1	***BIO-2***	***BIO-3***	***BIO-4***
Acute				
48-Hour LC_{50}	>100%	>100%	>100%	>100%
Chronic				
NOEC (Survivial)	100%	100%	75%	100%
NOEC (Growth)	75%	75%	100%	50%

Notes:

(1) LC_{50} - Lethal Concentration for 50 percent of the samples.
(2) NOEC - No observable effect concentration.

ABLE 2.5

EEK WATER ANALYTICAL DATA

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Sample Location:	***BIO-1***	***BIO-2***	***BIO-2***	***BIO-3***	***BIO-4***
Sample ID:	***W-921020-JO-2000***	***W-921020-JO-2001***	***W-921020-JO-2003***	***W-921020-JO-2002***	***W-921020-JO-2004***
Laboratory ID:	***9206737***	***9206738***	***9206740***	***9206739***	***9206741***
Date Sampled:	***October 20, 1992***	***October 20, 1992***	***DUP of 2001***	***October 20, 1992***	***October 20, 1992***
VOCs					
carbon tetrachloride	ND (5)	350	388	83.1	163
chloroform	ND (5)	79.3	90	24.5	40.1
methylene chloride	ND (5)	ND (50)	ND (50)	ND (5)	ND (5)
BNAs					
2,4-dinitrophenol	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
phenol	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
2,4-dichlorophenol	ND (10)	82.3	86.3	29.5	ND (10)
Metals					
Aluminum	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)
Cadmium	ND (5)	ND (5)	ND (5)	12	ND (5)
Chromium	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Iron	540	1580	1620	1400	1200
Manganese	52	680	681	401	411
Potassium	ND (1000)	ND (1000)	ND (1000)	ND (1000)	ND (1000)
Zinc	ND (20)	28	ND (20)	ND (20)	ND (20)

Notes:

(1) All results reported in µg/L.
(2) Pesticides were not detected in any samples at a detection limit of 0.05 mg/L. The detection limit for chlordane was 1.0 mg/L.
ND - Not detected at specified practical quantitation limit (PQL). PQL is shown in parentheses.

TABLE 2.5

SUMMARY OF PUGH CREEK WATER ANALYTICAL DATA

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Sample Location:	*BIO-1*	*BIO-2*	*BIO-2*	*BIO-3*	*BIO-4*
Sample ID:	*W-921022-JO-2006*	*W-921022-JO-2007*	*W-921022-JO-2008*	*W-921022-JO-2009*	*W-921022-JO-2010*
Laboratory ID:	*9206794*	*9206793*	*9206792*	*9206791*	*9206798*
Date Sampled:	*October 22, 1992*	*October 22, 1992*	*DUP of 2007*	*October 22, 1992*	*October 22, 1992*
VOCs					
carbon tetrachloride	ND (5)	386	337	87.5	167
chloroform	ND (5)	92.3	80	27.7	62.3
methylene chloride	ND (5)	ND (50)	ND (50)	ND (5)	6.0
BNAs					
2,4-dinitrophenol	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
phenol	10.3	ND (10)	ND (10)	ND (10)	11.2
2,4-dichlorophenol	ND (10)	87.9	86.3	26.8	ND (10)
Metals					
Aluminum	ND (200)	ND (200)	ND (200)	ND (200)	ND (200)
Cadmium	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)
Chromium	ND (10)	ND (10)	ND (10)	ND (10)	163
Iron	490	1580	1520	1460	2560J
Manganese	54	675	616	462	498
Potassium	ND (1000)	ND (1000)	ND (1000)	ND (1000)	ND (1000)
Zinc	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)

Notes:

(1) All results reported in μg/L.
(2) Pesticides were not detected in any samples at a detection limit of 0.05 mg/L. The detection limit for chlordane was 1.0 mg/L.
ND - Not detected at specified practical quantitation limit (PQL). PQL is shown in parentheses.
J - Estimated Value.

TABLE 2.5

SUMMARY OF PUGH CREEK WATER ANALYTICAL DATA

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Sample Location:	*BIO-1*	*BIO-2*	*BIO-3*	*BIO-3*	*BIO-4*
Sample ID:	*W-921023-JO-2013*	*W-921023-JO-2014*	*W-921023-JO-2015*	*W-921023-JO-2016*	*W-921023-JO-2017*
Laboratory ID:	*9206803*	*9206802*	*9206801*	*9206800*	*9206805*
Date Sampled:	*October 23, 1992*	*October 23, 1992*	*October 23, 1992*	*DUP of 2015*	*October 23, 1992*
VOCs					
carbon tetrachloride	ND (5)	376	98.6	97.2	157
chloroform	ND (5)	107	32.1	33.0	48.1
methylene chloride	ND (5)	ND (50)	ND (50)	ND (5)	6.2
BNAs					
2,4-dinitrophenol	ND (10)	44.8	22.1	27.0	ND (10)
phenol	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
2,4-dichlorophenol	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Metals					
Aluminum	250	ND (200)	ND (200)	ND (200)	370
Cadmium	ND (5)	ND (5)	ND (5)	11	8
Chromium	ND (10)	10	ND (10)	100	109
Iron	570	1900	1880	2160	1960
Manganese	62	712	542	502	345
Potassium	ND (1000)	1030	ND (1000)	ND (1000)	ND (1000)
Zinc	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)

Notes:

(1) All results reported in µg/L.

(2) Pesticides were not detected in any samples at a detection limit of 0.05 mg/L. The detection limit for chlordane was 1.0 mg/L.

ND - Not detected at specified practical quantitation limit (PQL). PQL is shown in parentheses.

it was concluded that the Site does not present a suitable habitat for the gray bat and therefore does not pose any ecological impact to the gray bat. Based on this conclusion it was not necessary to perform the previously mentioned study on the invertebrate food sources for the gray bat.

Soil Sampling at Seeps

The purpose of soil sampling at the seeps in August 1992 was to determine if the Site-specific constituents were present within soil at the seeps and to evaluate the environmental risk, if any, at the seep locations caused by the soil contamination. Based on the detected organic constituents in the soil samples there is no discernible correlation between the water quality in the groundwater and seeps, and the detected constituents in the soil. Table 2.6 presents a summary of the detected organic compounds within seep soil samples. Table 2.7 presents a summary of the detected metal compounds within seep samples. An ecological evaluation of seep data concludes that seeps would not significantly impact the surface water quality of Pugh Creek and Clover Creek.

Environmental Evaluation Report Conclusions

The information collected as part of the Environmental Evaluation Report has supplemented existing information and verified the conclusions presented in previous ERM reports, the RI Report and the original FS Report concerning the impact of the landfill on the local ecology. The following conclusions were presented:

- Stream Water Quality
  Organic compounds detected in the streams are present at levels which do not pose any risk to aquatic or terrestrial life.

- Stream Sediment
  Levels of organic compounds detected in the sediment have attenuated since the monitoring program conducted by ERM; indicating that placement of the cap had improved stream sediment quality. Further, samples for which there were detections of organic compounds were few and similar in proportion to samples collected in upstream locations. The latter suggested that some detection were artifacts of sampling or analysis, or were from other sources.

- Stream Biology
  Presence of organic compounds in benthic organisms has indicated that there are no consistent trends in concentration and that the most recent data are showing no detectable levels. Bioassays with bluegill fish indicated no acute toxicity.

TABLE 2.6

SUMMARY OF DETECTED ORGANIC COMPOUNDS IN SEEP SOIL SAMPLES

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Borehole #:	***Seep 3***	***Seep 3***	***Seep 5***	***Seep 7***	***Seep 8***	***Seep 9***
Sample ID:	***S-920819-CA-09A***	***S-920819-CA-09B***	***S-920818-CA-01A***	***S-920818-CA-03A***	***S-920818-CA-04A***	***S-920819-CA-07A***
Laboratory ID:	***9205095***	***9205096***	***9205069***	***9205073***	***9205075***	***9205091***
Sample Depth (ft):	***0-2***	***4.5-5.5***	***0-2***	***0-1.5***	***0-2***	***0-2***
<u>VOCs</u>						
carbon tetrachloride	ND (0.625)	ND (0.625)	1.15	ND (0.625)	ND (0.625)	ND (0.625)
toluene	ND (0.625)	ND (0.625)	4.12	ND (0.625)	ND (0.625)	ND (0.625)
<u>BNAs</u>						
bis(2-chloroisopropyl)ether	ND (0.33)	ND (0.33)	ND (0.33)	1.15	ND (0.33)	ND (0.33)
bis(2-ethylhexyl)phthalate	ND (0.33)	ND (0.33)	ND (0.33)	ND (0.33)	2.08	ND (0.33)
dinitrotoluene, 2,6-	0.908	0.880	ND (0.33)	ND (0.33)	ND (0.33)	ND (0.33)
<u>Pesticides</u>						
DDT,4,4'-	ND (0.05)	ND (0.05)	6.65	ND (0.05)	ND (0.05)	ND (0.05)
Endrin	ND (0.05)	ND (0.05)	5.81	ND (0.05)	ND (0.05)	7.24

Note:

All concentrations are reported in mg/kg.
ND - Not detected at specified practical quantitation limit shown in parentheses.

TABLE 2.7

SUMMARY OF DETECTED METAL COMPOUNDS IN SEEP SOIL SAMPLES

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Borehole #:	*Background Samples (1)*		*Seep 1*	*Seep 1*	*Seep 3*	*Seep 3*	*Seep 3*	*Seep 5*
Sample ID:	*Range of*	*Average of*	*S-920819-CA-08A*	*S-920819-CA-08B*	*S-920819-CA-09A*	*S-920819-CA-10A*	*S-920819-CA-09B*	*S-920818-CA-01A*
Laboratory ID:	*Positive*	*Positive*	*9205093*	*9205094*	*9205095*	*9205097*	*9205096*	*9205069*
Sample Depth (ft):	*Detections*	*Detections*	*0-2*	*3.5-4*	*0-2*	*DUP of 09A*	*4.5-5.5*	*0-2*
Aluminum	2750 - 21900	15308	634	10500	7670	7910	10800	9850
Arsenic	3.8 - 14.0	9.4	ND (1.5)	1.5	ND (1.5)	2.2	1.5	8.8
Barium	46 - 102	73	ND (29)	70.2	105	79.1	159	133
Calcium	1690 - 2100	1895	ND (730)	880	ND (730)	ND (560)	ND (750)	ND (660)
Chromium	3 - 17	13	2.7	15.8	8.4	7.8	12.9	11.6
Cobalt	6 - 7	6	ND (7.3)	ND (6.5)	ND (7.3)	ND (5.6)	ND (7.5)	8
Copper	3 - 16	12	ND (2.9)	6	ND (2.9)	ND (2.2)	ND (3.0)	ND (2.6)
Iron	4190 - 28000	20948	539J	7540J	5700J	6480J	3950J	15300J
Lead	6 - 19	15	ND (7.3)	6	11	10	6	ND (6.6)
Magnesium	1780 - 2010	1918	ND (730)	1030	ND (730)	506	ND (750)	889
Manganese	96 - 188	161	13.8	20.6	95.9	79.9	27.8	1860
Nickel	4 - 19	14	ND (5.9)	7	ND (5.9)	ND (4.5)	ND (5.9)	7
Potassium	162 - 1360	281	ND (150UJ)	7.85J	407J	373J	473J	619J
Vanadium	7 - 36	28	ND (7.3)	19	10	11	15	16
Zinc	8.7 - 59	38	ND (2.9)	29.6	18.8	18.8	18.5	26.2

Note:

All concentrations are reported in mg/kg.
(1) Background soil sample results as reported in RI (April 1991).
ND - Not detected at specified practical quantitation limit shown in parentheses.
J - Estimated value.

TABLE 2.7

SUMMARY OF DETECTED METAL COMPOUNDS IN SEEP SOIL SAMPLES

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Borehole #:	*Background Samples (1)*		*Seep 5*	*Seep 6*	*Seep 6*	*Seep 7*	*Seep 7*	*Seep 8*
Sample ID:	*Range of*	*Average of*	*S-920818-CA-01B*	*S-920818-CA-02A*	*S-920818-CA-02B*	*S-920818-CA-03A*	*S-920818-CA-03B*	*S-920818-CA-04A*
Laboratory ID:	*Positive*	*Positive*	*9205070*	*9205071*	*9205072*	*9205073*	*9205074*	*9205075*
Sample Depth (ft):	*Detections*	*Detections*	*4-5*	*0-2*	*4.5-5.5*	*0-1.5*	*5-6*	*0-2*
Aluminum	2750 - 21900	15308	2640	1880	7050	7580	12100	5740
Arsenic	3.8 - 14.0	9.4	ND (1.2)	ND (1.5)	1.3	5.9	6.6	1.7
Barium	46 - 102	73	25.3	ND (30)	69.4	44.2	41.4	59.0
Calcium	1690 - 2100	1895	ND (620)	ND (750)	ND (620)	ND (550)	ND (590)	ND (690)
Chromium	3 - 17	13	16.8	4.7	11.2	11.8	23.6	7.3
Cobalt	6 - 7	6	ND (6.2)	ND (7.5)	ND (6.2)	ND (5.5)	ND (5.9)	ND (6.9)
Copper	3 - 16	12	ND (2.5)	ND (3.0)	ND (2.5)	ND (2.2)	5	ND (2.8)
Iron	4190 - 28000	20948	8610J	1070J	5960J	10300J	21100J	6610J
Lead	6 - 19	15	ND (6.2)	8	ND (6.2)	7	10	ND (6.9)
Magnesium	1780 - 2010	1918	ND (620)	ND (750)	513	601	551	562
Manganese	96 - 188	161	107	35.7	104	139	171	398
Nickel	4 - 19	14	ND (5.0)	ND (5.9)	5	ND (4.4)	8	ND (5.6)
Potassium	162 - 1360	281	168J	362J	513J	711J	504J	352J
Vanadium	7 - 36	28	9	ND (7.5)	18	14	21	9
Zinc	8.7 - 59	38	8.0	9.4	23.8	18.0	22.8	16.6

Note:

All concentrations are reported in mg/kg.
(1) Background soil sample results as reported in RI (April 1991).
ND - Not detected at specified practical quantitation limit shown in parentheses.
J - Estimated value.

TABLE 2.7

SUMMARY OF DETECTED METAL COMPOUNDS IN SEEP SOIL SAMPLES

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Borehole #:	*Background Samples (1)*		*Seep 8*	*Seep 9*	*Seep 9*
Sample ID:	*Range of*	*Average of*	*S-920818-CA-04B*	*S-920819-CA-07A*	*S-920819-CA-07B*
Laboratory ID:	*Positive*	*Positive*	*9205076*	*9205091*	*9205092*
Sample Depth (ft):	*Detections*	*Detections*	*5-6*	*0-2*	*5-6*
Aluminum	2750 - 21900	15308	4270	10900	12800
Arsenic	3.8 - 14.0	9.4	1.3	4.3	6.4
Barium	46 - 102	73	26.4	67.0	74.0
Calcium	1690 - 2100	1895	ND (630)	ND (550)	ND (570)
Chromium	3 - 17	13	6.4	11.5	15.8
Cobalt	6 - 7	6	ND (6.3)	ND (5.5)	6
Copper	3 - 16	12	ND (2.5)	ND (2.2)	ND (2.3)
Iron	4190 - 28000	20948	5590J	11840J	19600J
Lead	6 - 19	15	ND (6.3)	8	11
Magnesium	1780 - 2010	1918	ND (630)	1080	1280
Manganese	96 - 188	161	112	324	1270
Mercury	0.11 - 0.12	0.12	0.34	ND (0.11)	ND (0.11)
Nickel	4 - 19	14	ND (5.0)	7	10
Potassium	162 - 1360	281	276J	1040J	807J
Vanadium	7 - 36	28	8	18	27
Zinc	8.7 - 59	38	9.5	33.6	30.7

Note:

All concentrations are reported in mg/kg.
(1) Background soil sample results as reported in RI (April 1991).
ND - Not detected at specified practical quantitation limit shown in parentheses.
J - Estimated value.

Chronic toxicity was not monitored.

- Terrestrial Survey
  The terrestrial survey has indicated that animals whose habitat included the exposed landfill (i.e., prior to capping) may have accumulated chemicals in their vital organs, although levels were well below action levels set by the USEPA. Direct contact with the buried waste has been eliminated by capping the Site; therefore, current conditions should be improved.

- Stream Assessment
  An assessment which compared overall stream habitat for fish and invertebrates, population characteristics, water quality and organic compounds in fish tissues to two control streams showed that Pugh Creek had not been detrimentally impacted by the landfill.

- Preliminary Hazard Assessment
  A preliminary hazard assessment based on detected limits of carbon tetrachloride in Pugh Creek indicated that concentrations were below acute aquatic criteria. Due to the low level of bioaccumulation of carbon tetrachloride, it was also concluded that it did not pose a chronic risk.

- Seep Water Quality
  Analysis of seep water indicated that it had no detrimental impact on any aquatic life or terrestrial life.

- Bioassay Study
  The bioassay has indicated that the NOEC for survival (acute toxicity) of the test species exposed to creek water was 100 percent. Chronic toxicity, as measured by reproduction or growth, was found to be marginally impacted; however, a bioassay test with a sample upstream of the Site showed a more severe to similar effect on comparison to downstream samples. Concentrations of organic compounds were below USEPA aquatic criteria and are not contributing to the toxic impact. Natural hardness and alkalinity in combination with high heavy metal (cadmium, chromium) concentrations were identified as potential contributors to the chronic toxicities. Data collected to date have not associated the metals (cadmium and chromium) with the Site. Identification of cadmium at background well locations (GM-4) and the sporadic detections of both chromium and cadmium during the RI sampling program support this conclusion.

- Gray Bats
  No endangered gray bats were found in the area. This was expected in light of

the distance of the Site from the nearest known cave available for the gray bat habitat.

- Soil Sampling at Seeps
  Sampling indicated no discernible correlation in previous seep sampling and sporadic low levels of some organic compounds, which were sufficiently low to be of no concern. The risk to burrowing animals which could potentially be most impacted is not considered significant due to the high water table.

In summary, the Environmental Evaluation Report concluded that the Site is presently not detrimentally impacting the local ecology and that any potential impact has been limited by the placement of the cap. In the future, the environmental impact will be further reduced by the implementation of the groundwater remediation program.

2.6.2 Human Health Evaluation

This section summarizes the findings of the Human Health Evaluation as presented in the RI Report.

Because of the time elapsed since the chemicals first migrated from the Site, the comparatively high permeability of the soils, the high affinity of many of the constituents found in the waste to soil (i.e., limited mobility), the past remedial activities by Velsicol including placement of a low permeability clay cap, as well as the pattern of groundwater flow over time, chemicals which have not migrated to off-Site wells (particularly GM-5) at this time are not expected to migrate significant distances in the future or possibly not at all.

The following potentially complete 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 Creek;
- hunting in the area and consumption of meat from game which have drunk from Pugh or Clover Creeks; and
- occasional skin contact while fishing or wading.

Calculations based upon residential use of current Site-contaminated groundwater at several locations revealed total additional lifetime cancer risk levels in exceedence of the risk levels deemed acceptable by USEPA.

Future groundwater concentrations of carbon tetrachloride and chloroform were predicted based upon groundwater flow models. Values predicted for the years 1995, 2000, and 2010 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 estimated risks and hazards resulting from such exposure were in excess of acceptable levels, even after an additional 20 years of plume migration in the absence of further remediation.

Calculations assuming recreational exposure (recreational fishing and fish consumption) to Site-related contaminants present in surface water demonstrate that the reported concentrations do not present a concern for fish consumption or for occasional skin contact.

Future concentrations of carbon tetrachloride and chloroform in Clover Creek are predicted to peak in the year 1994. At the estimated peak flux to the creek, estimated potential risks are well below the target range of 1E-04 to 1E-06 estimated total incremental lifetime risk of cancer. The estimated total hazard level is also well below a level of concern when 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.

Game animals could potentially be exposed to Site-related compounds through the consumption of contaminated downgradient surface water. However, these would be metabolized and/or excreted from animals or birds. There would be no bioconcentration, and in fact, there would be no tissue retention expected from ingestion by mammals or birds of the trace levels of these chemicals reported in the creeks. The exposure via this exposure pathway would be de minimis and the potential cancer risk or non-carcinogenic hazard index was not evaluated.

2.6.3 Soil Action Levels for Groundwater Protection

The Summers Model in conjunction with the Hydrologic Evaluation of Landfill Performance (HELP) Model were utilized to determine whether the existing clay cap could meet the specific remedial action objective of preventing further degradation of the groundwater beneath and downgradient of the waste disposal areas. This evaluation was completed using Site-specific chemical constituents found within the waste.

The Summers Model was used to calculate maximum allowable Site-specific contaminant concentrations within leachate which would not result in exceedances of groundwater concentrations of the same Site-specific contaminants above water quality goals, in this case the Maximum Contaminant Level (MCL). For constituents where MCLs are not established, Drinking Water Equivalent Levels (DWEL) were selected/calculated utilizing known Reference Dose (RfD) values for the respective constituents.

Once the maximum allowable contaminant concentration in the leachate was determined, the maximum allowable contaminant concentration in the waste and soil was calculated. This calculated value represents the waste and soil cleanup level which must be obtained in order to be protective of the groundwater as specified within the remedial action objective.

The following table demonstrates that under the existing clay cap infiltration scenario average, contaminant concentrations within the waste and impacted soil beneath the waste exceed Soil Action Levels which must be met to be protective of groundwater.

Contaminant	*Average Contaminant Concentrations*		*Soil Action Levels*	
	Waste (1) (mg/kg)	*Soil (2) (mg/kg)*	*Waste (1) (mg/kg)*	*Soil (2) (mg/kg)*
Acetone	0.0	*9.6	NA	0.5428
Carbon Tetrachloride	*216.1	*15.5	1.1205	1.0543
Chloroform	*78.7	*1.8	0.8031	0.1919
Methylene Chloride	*100.4	*0.2	0.8031	0.0391
Tetrachloroethene	*9.8	*1.6	5.9389	0.6676
2,4-Dichlorophenol	*18,302.8	*68.5	99.5202	29.1442
Hexachlorobenzene	*193.9	11.6	113.1280	NA
Endrin	55.1	*23.5	NA	18.5302
Endrin Aldehyde	2.9	*18.6	NA	0.3151
Endrin Ketone	83.2	*6.4	NA	2.0968

Note:

* Exceedance of Soil Action Levels
(1) Values taken from FS-Appendix C, Table C.8.
(2) Values taken from FS-Appendix C, Table C.5.
NA Not Applicable, no exceedance of soil action levels.

2.6.4 Soil Action Levels for Direct Contact

All three disposal areas were covered with a 3-foot low permeability (hydraulic conductivity of 1.0×10^{-7}) clay cover in 1980 which effectively eliminated any potential for human exposure via direct contact with the landfilled waste or soils impacted by the waste disposal. Chemical specific target concentrations were developed based on reference doses and cancer slope factors, Tables 2.8 and 2.9. Human exposure via direct contact or ingestion of waste and soils would be a pathway of concern for any remedial action requiring excavation through the clay cap or through any maintenance of the clay cap in problem areas cause by major erosion.

2.7 DESCRIPTION OF ALTERNATIVES

2.7.1 Alternative A-1 - No Further Action

2.7.1.1 Description

Under this alternative no further remedial action beyond what has already been implemented (i.e., the clay cap constructed in 1980 and the selected OU #1 remedy) would take place.

This alternative employs the processes of natural attenuation for the reduction of contaminants in the unsaturated soil. Natural attenuation is the tendency of contaminant concentrations to decrease through physical, chemical and biological processes in the natural environment. Surface water leaching through the waste material would be minimal due to the presence of the existing clay cap. Contaminated groundwater would be contained and treated on Site as part of the OU #1 remedy. A long-term monitoring and maintenance program would be implemented as part of this alternative to maintain the integrity of the existing clay cap over the waste disposal areas and to monitor the performance of the OU #1 groundwater treatment system and groundwater beneath the Site. Specific features of the OU #1 remedy include the following:

i) Five extraction wells and pumping systems will be installed to achieve an effective hydraulic capture of contaminants in on-Site groundwater at the north end of the landfill. These wells must collectively recover approximately 160 gpm to achieve hydraulic containment. Piezometers may be installed within the projected containment area to demonstrate capture.

ii) Four extraction wells and pumping systems will be installed to restore the contaminated off-Site groundwater beyond the landfill to within acceptable

TABLE 2.8

CHEMICAL-SPECIFIC TARGET LEVELS

Target concentrations presented within Table A.1 are based on chemical-specific reference doses, and are calculated as follows:

$$\text{Target Conc. (mg/kg)} = \frac{RfD_{oral} * BW * AT}{(IR * EF * ED * CF) + (SA * ABS_{dermal} * AF * EF * ED * CF)}$$

where:

RfD_{oral}	=	oral Reference Dose (chemical-specific, mg/kg-day)
BW	=	body weight (70 kg)
AT	=	averaging time (10,500 days)
IR	=	oral ingestion rate (100 mg/day)
SA	=	skin surface area exposed (5,300 cm^2/day)
ABS_{dermal}	=	dermal absorption factor; assumed to be 10 percent for VOCs, and 1 percent for SVOCs and pesticides
AF	=	soil-to-skin adherence factor (1 cm^2/day)
EF	=	exposure frequency (days)
EF_{oral}	=	350 days/year
EF_{dermal}	=	180 days/year
ED	=	exposure duration (30 years)

Target concentrations based on chemical-specific Cancer Slope Factors are calculated as follows:

$$\text{Target Conc. (mg/kg)} = \frac{\text{Risk Level}/CSFs * BW * AT}{(IR * EF * ED * CF) + (SA * ABS_{dermal} * AF * EF * ED * CF)}$$

Risk Level	=	1.0E-06 risk
CSF_{oral}	=	oral Cancer Slope Factor

TABLE 2.9

POTENTIAL CHEMICAL-SPECIFIC GUIDELINES (TO BE CONSIDERED)

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Compound	*Oral Reference Dose (mg/kg-day)*	*Oral Cancer Slope Factor (1/(mg/kg-day))*	*Dermal Abs. (%/100)*	*Target Concentration Based on Reference Dose*[1] *(mg/kg)*	*Target Concentration Based on Cancer Slope Factor*[1] *(mg/kg)*	
					10^{-4}	10^{-6}
<u>Volatile Organic Compounds</u>						
carbon tetrachloride	7.00×10^{-4}	0.130	0.1	137	352	3.52
chloroform	0.0100	6.10×10^{-3}	0.1	1,959	7,495	74.95
toluene	0.200	NC	0.1	39,187	NV	NV
xylenes	2.00	NC	0.1	391,871	NV	NV
acetone	0.100	NC	0.1	19,594	NV	NV
tetrachloroethene	0.0100	0.0510	0.1	1,959	896	8.96
<u>BNAs</u>						
2,4-dichlorophenol	3.00×10^{-3}	NA	0.01	1,721	NV	NV
2,6-dinitrotoluene	1.00×10^{-3}	0.680	0.01	574	197	1.97
fluorene	4.00×10^{-2}	NC	0.01	22,946	NV	NV
hexachlorobenzene	8.00×10^{-4}	1.60	0.01	459	84	0.84
hexachlorocyclopentadiene	7.00×10^{-3}	NA	0.01	4,015	NV	NV
bis(2-ethylhexyl)phthalate	2.00×10^{-2}	0.0140	0.01	11,473	9,561	95.61
hexachlorobutadiene	2.00×10^{-3}(under review)	0.0780	0.01	1,147	1,716	17.61
2-methylnaphthalene	NA	NC	0.01	NV	NV	NV

TABLE 2.9

POTENTIAL CHEMICAL-SPECIFIC GUIDELINES (TO BE CONSIDERED)

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Compound	*Oral Reference Dose (mg/kg-day)*	*Oral Cancer Slope Factor (1/(mg/kg-day))*	*Dermal Abs. (%/100)*	*Target Concentration Based on Reference Dose[1] (mg/kg)*	*Target Concentration Based on Cancer Slope Factor[1] (mg/kg)*	
					10^{-4}	*10^{-6}*
Pesticides						
aldrin	3.00×10^{-5}	17.0	0.01	17	8	0.08
4,4'-DDT	5.00×10^{-4}	0.340	0.01	287	394	3.94
4,4'-DDE	NA	0.340	0.01	NV	394	3.94
4,4;-DDD	NA	0.240	0.01	NV	558	5.58
dieldrin	5.00×10^{-5}	16.0	0.01	29	8	0.08
methoxychlor	5.00×10^{-3}	NA	0.01	2,868	NV	NV
endosulfan sulfate	NA	NA	0.01	NV	NV	NV
endosulfan I	0.006	NA	0.01	NV	NV	NV
endrin aldehyde	3.00×10^{-4}	NA	0.01	172	NV	NV
endrin ketone[2]	3.00×10^{-4}	NA	0.01	172	NV	NV
heptachlor	5.00×10^{-4}	4.50	0.01	287	30	0.30
heptachlor epoxide	1.30×10^{-5}	9.10	0.01	7	15	0.15

<u>Notes</u>:

NV No Value
NC Not Carcenogenic
NA Not Available
(1) Assume a residential exposure for a 70 kg adult; with ingestion rate of 100 mg of soil per day, for 350 days per year, for 30 years and dermal contact with 5300 cm^2 skin, for 6 months (180 days) per year for 30 years with a soil-to-skin adherence factor of 1 mg/cm^2.
(2) Values for endrin used.

drinking water standards by removing groundwater from the areas of peak contaminant concentration. It is estimated that these extraction wells will collectively have a pumping rate of 310 gpm.

iii) Groundwater from all extraction wells will be pumped via a forcemain system to the treatment plant.

iv) Contaminated groundwater will be treated in the treatment plant using a system designed to consist of air stripping and final carbon adsorption treatment for off gas treatment and final groundwater carbon polishing prior to discharge.

v) Treated water will be discharged to Pugh 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 of Record of Decision are reached for the off-Site groundwater.

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) The groundwater treatment system and the disposal areas' cover will be maintained. 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.

2.7.1.2 Assessment

Overall Protection of Human Health and the Environment

The primary threat to human health according to the reports detailed within Section 2.6.2 is the ingestion of contaminated groundwater by the residents of the area. All residents are supplied potable water by the Town of Toone there is no risk to the local residents. Contact with surficial soils (clay cap) and surface water within the area of the landfill pose no threat to human health since the Site has been effectively capped. Groundwater contained on Site and downgradient of Site will be treated to regulatory levels under the OU #1 remedy and then discharged to the environment. Therefore, the "No Further Action" alternative is protective of human health. The groundwater beneath the waste disposal areas will still be degraded, therefore this alternative is not completely protective of the environment.

Compliance with ARARs

The aquifer below the site is potentially a drinking water supply, therefore Federal Drinking Water regulations may be relevant or appropriate. However, installation of the OU #1 remedy in conjunction with alternate water supply provided to local residents nullifies the impact. However, in the context of OU #2, further degradation of the groundwater will continue under this alternative in that the relevant and appropriate MCLs will be exceeded at the water table below the Site and at the downgradient Site boundary. As a result, this alternative is not in compliance with ARARs.

Long-Term Effectiveness and Permanence

Implementation of this alternative would result in no further remedial action being taken, hence, the magnitude of contaminated waste and soil would remain the same within the landfill. Contaminant concentrations are expected to decrease over time due to natural attenuation and dispersion processes.

Reduction of Toxicity, Mobility and Volume

The existing landfill cap by itself provides no further reduction in toxicity or volume of waste and contaminated soil as demonstrated by the Summers Model results presented within Appendix C. The existing clay cap reduces the surface water infiltration by up to 98 percent resulting in a decrease of contaminant mobility. This reduction in infiltration is not sufficient to reduce the mobility of contaminants migrating to the groundwater to limit concentrations below MCLs (Section 2.6.3). The remaining waste and contaminated soil will still remain in a volume and toxicity to pose a threat to human health if exposed at surface.

Short-Term Effectiveness

There would be no additional risks to the community or the environment as a result of the implementation of this alternative in the short term.

Implementability

Since no further action beyond the OU #1 remedy would be undertaken, this alternative is considered readily implementable.

Cost

There are no construction costs associated with this alternative. Total present worth Operation and Maintenance (O & M) costs amount to $529,100.

2.7.2 Alternative A-2 - In Situ Soil Vapor Extraction

2.7.2.1 Description

In situ soil vapor extraction (ISVE) is a technique used to remove volatile organic compounds (VOCs) from the vadose zone. Removal of semi-volatiles is very limited.

This technology includes the installation of withdrawal wells within areas of soil contamination and air injection wells at the periphery of the contaminated soil zone. Withdrawing air from the withdrawal wells and injecting air at the injection wells establishes an airflow from the periphery to contaminated areas. The air which moves through the soil, entrains vapors evolved from liquid or aqueous phase VOCs and is brought above ground level through the withdrawal wells. The VOC vapors are then treated prior to releasing to the atmosphere. Over 100 extraction/ injection wells, several distribution centers and a vapor treatment unit would be required for a period of 1 - 7 years to substantially decrease the levels of VOCs within the vadose zone. To monitor progress, soil gas probes would be installed throughout the Site and sampling points would be established throughout the treatment train. Maintenance of the existing cap would consist of minor repairs to correct damage due to vehicular traffic, erosion, settling or animal damage.

2.7.2.2 Assessment

Overall Protection of Human Health and the Environment

The health threat from contaminated groundwater would be mitigated by the OU #1 remedy. Potential exposure to Site soils that pose a potential health risk is eliminated by the presence of the existing cap. ISVE would further aid the OU #1 remedy by removing several VOCs from the vadose zone before those VOCs have the opportunity of reaching the water table. ISVE would not remove SVOCs and pesticides from the waste and contaminated soil as outlined within the paragraph "Long-Term Effectiveness and Permanence". Contaminant concentrations unaffected by ISVE would (according to the Summers Model), continue to contribute to further degradation of the groundwater. Therefore, this alternative fails to prevent further degradation of the groundwater below the Site and therefore is not completely protective of the environment.

Compliance with ARARs

The results of vadose zone modeling has indicated that the present clay cap does not sufficiently reduce surface water infiltration to prevent degradation of the groundwater beneath the Site. ISVE would not remove those SVOCs and pesticides identified in the paragraph "Long-Term Effectiveness and Permanence" within this Section. SVOCs and pesticides would continue to be a source of contamination to the groundwater based on the results presented within Section 2.6.3. As such, the results of implementing this alternative would contravene the relevant and appropriate requirements of the Safe Drinking Water Act regulations and as such, is not in compliance with ARARs.

Long-Term Effectiveness and Permanence

The high efficiency of ISVE to remove VOCs is well documented within the USEPA Engineering Bulletin "In Situ Soil Vapor Extraction Treatment", EPA/540/2-91/006 dated May 1991.

The efficiency of ISVE to remove VOCs based on this Engineering Bulletin could be greater than 99 percent (dependent on Site conditions). VOC removal at the Hardeman County Landfill Site utilizing ISVE is therefore not anticipated to pose a problem.

The efficiency of ISVE to remove SVOCs and pesticides is very low, if not non-existent. The Engineering Bulletin states "It would be difficult to remove soil contaminants with low vapor pressures and/or high solubilities from a site. The lower limit of vapor pressure for effective removal of a compound is 1 mm Hg." Based on the previous statements, the following Site compounds are not expected to be influenced by ISVE as their vapor pressures are below 1 mm Hg:

- 2,4-dichlorophenol
- di-n-butyl phthalate
- fluorene
- hexachlorobenzene
- hexachlorocyclopentadiene
- 2-methylnaphthalene
- naphthalene
- aldrin
- 4,4-DDT
- dieldrin
- endosulfan, alpha
- endrin
- endrin aldehyde
- endrin ketone
- heptachlor

Lack of ISVE efficiency for SVOC and pesticide removal can also be presented in terms of Henry's coefficients. A contaminant mass removal rate equation based upon Henry's coefficients is presented within an article entitled "Appropriate Criteria for Soil Vapor Extraction System Design" by Walter Weinig presented within the 1994 Federal Environmental Restoration III Conference Proceedings, Hazardous Materials Control Research Institute, Rockville, Maryland (pages 1247-1256). In this article, the maximum rate of contaminant mass removal from a unit volume of soil can be calculated. Using this equation indicates that removal of SVOCs and pesticides from the vadose zone to soil action levels (determined through vadose zone modeling presented in Section 2.6.3) would not take place utilizing ISVE.

Reduction of Toxicity, Mobility and Volume

ISVE may reduce the toxicity, mobility and volume of some of the VOCs that are within the vadose zone although over a potentially long time-frame. Installation of the extraction and injection wells may also increase mobility by permitting greater surface water infiltration through the punctures in the existing cap and by providing a high permeability conduit in gravel surrounding the wells from the waste to the lower levels of the vadose zone. The toxicity, mobility and volume of SVOCs and pesticides would not be influenced by ISVE. The SVOCs and pesticides within the waste and contaminated soil would still pose a potential threat to human health if exposed.

Short-Term Effectiveness

Short-term impacts to human health and the environment due to air emissions from the incineration of extracted soil gas and due to ground invasive activities (during drilling) are expected as a result of the implementation of this alternative. Installation of ISVE extraction/injection wells would likely require workers to don respiratory protective gear. Air emissions that come about as a result of these ground invasive activities would need to be controlled and monitored for throughout the duration of construction activities. Short-term effectiveness of the existing cap as a barrier to infiltration would be reduced by the many well holes that are required. Pilot scale tests would need to be conducted to determine the in situ effectiveness of the ISVE system.

Generally treatment of this recovered vapor falls into two classes: recovery of vapors on Site with disposal of condensed vapors off Site or destruction of vapors on Site. In the case of recovering the vapors in a liquid form for off-Site disposal the nearest facility that could accept halogenated solvents for destruction is located approximately 150 miles away. On-Site destruction of halogenated solvents without the production of residuals requiring further treatment can only be accomplished through incineration.

The potential for accidents when transporting/handling treatment residuals (i.e., concentrated organics) off Site and when transporting/handling caustic chemicals (for incinerator scrubber) required for treatment on Site is further amplified by the length of time required for any ISVE alternative.

The length of time (greater than 40,000 years) required to remove SVOCs and pesticides indicates that utilization of ISVE for their removal is not an effective course of action. Based on the article presented in Long-Term Effectiveness and Permanence, removal of chloroform, carbon tetrachloride, methylene chloride and tetrachloroethane to soil action levels is anticipated to take at least 1 to 7 years. The remaining VOCs would require up to 26 years to reach soil action levels. The length of time required to remove these remaining VOCs indicates that ISVE is not an effective course of action.

Other studies have demonstrated that removal times for VOCs may in fact be much longer, by factors of two to five or more. These studies indicate that whereas the above equation assumes equilibrium transfer of contaminants to the vapor phase, in fact the transfer is non-equilibrium, and that there is a long tailing behavior which hampers removal. Where the soil is heterogeneous (such as the landfilled waste) removal from non-permeable zones may never occur.

<u>Implementability</u>

Removing VOCs from the vadose zone utilizing ISVE is technically feasible based upon the existing sandy stratigraphy of the area and successful past performances of the ISVE system at other Sites. However ISVE has never been implemented previously to the depths proposed for this Site and may pose a significant obstacle to successful removal of the VOCs even in the vadose zone. The remediation of the waste utilizing ISVE would be technically difficult if not impossible due to the presence of containerized waste and debris and frequent zones of silty materials. It is expected that some removal of VOCs from within the waste may occur, but only in permeable zones directly connecting with an extraction well. There is also a risk to human health inherent with installing the required ISVE injection/extraction wells. Additional remedial actions such as upgrading the existing cap or removing waste soils would be difficult due to the expanse of injection/extraction wells and distribution centers over the landfill. The provision of roadways to access each well would also hinder future additional remedial actions.

Soil vapor probes and sampling ports would provide a means to monitor the effectiveness of this remedy. The decision to select the appropriate treatment for recovered vapor would be based upon the results of the pilot studies. Securing a portable incinerator for vapor destruction is contingent upon the availability of the necessary equipment and specialists, both of which are not readily available within Hardeman County. For a project of this duration, building a dedicated incineration system on Site would be the most effective course of action. Large amounts of water produced by the ISVE process would require treatment subsequent to discharge off Site.

Cost

The construction cost associated with this alternative is $17,268,600. O & M present worth costs amount to $13,339,000. Total present worth is $30,607,600.

2.7.3 Alternative A-3 - RCRA Composite Cap

2.7.3.1 Description

This alternative utilizes a RCRA composite cap to reduce infiltration of surface water through the waste and contaminated soils (demonstrated by HELP Model). A reduction in infiltration would result in decreased leachate production and subsequent contamination of groundwater.

2.7.3.2 Assessment

Overall Protection of Human Health and the Environment

Potential human exposure to Site soils and wastes that pose a health risk is virtually eliminated by the presence of the existing cap. The additional soil and synthetic membrane cover provided by a RCRA composite cap would further distance any potential receptors from contact with the waste and contaminated soil. This alternative provides protection to human health and virtually eliminates the effects of wastes and underlying contaminated soil on the environment. This alternative satisfies the specific remedial action objectives.

Compliance with ARARs

By preventing further degradation of the groundwater from occurring this alternative conforms to the relevant and appropriate requirements of the SDWA. This alternative is in compliance with all other ARARs.

Long-Term Effectiveness and Permanence

This alternative is effective over the long term at reducing contact with waste material and reducing surface water infiltration. Long-term effectiveness of this alternative would be guaranteed contingent upon the continued maintenance of the cap and presence of institutional controls.

Reduction of Toxicity, Mobility and Volume

The Summers Model demonstrates that the addition of a RCRA composite cap would greatly reduce the mobility of contaminants within the waste and contaminated soil. The reduction in the mobility of the contaminants is achieved by the virtual elimination of surface water infiltrating through the waste (only 0.0001 inches/year for a RCRA cap compared to 0.8733 inches/year for the existing clay cap). HELP Model results indicate that a RCRA cap would have a reduction in infiltration effectiveness of 99.9998 percent. This alternative would favorably impact the OU #1 remedy as contaminant concentrations and volume of water migrating to the saturated zone would be decreased. The waste and contaminated soil would still remain in a volume and toxicity to pose a threat to human health if exposed.

Short-Term Effectiveness

Short-term impacts to human health and the environment due to dust emissions are expected as a result of the implementation of this alternative. Noise and construction traffic would also negatively affect local residents. Implementing this alternative would take between 6 to 12 months.

Implementability

Construction of a RCRA composite cap is technically feasible. There are no concerns regarding the reliability of this alternative provided that maintenance of the cap is continued. With the exception of those future alternatives requiring waste to be excavated it would be relatively easy to undertake additional remedial actions. The current network of monitoring wells to be utilized under the OU #1 remedy will provide the long-term means to monitor the effectiveness of this alternative at reducing the volume and toxicity of contaminants being introduced to groundwater. There are no concerns regarding the availability of the necessary materials, equipment or personnel to implement this alternative.

Cost

The construction cost associated with this alternative is $3,530,000. O & M present worth costs amount to $529,100. Total present worth is $4,059,100.

2.7.4 Alternative A-4 - RCRA Composite Cap; In Situ Soil Vapor Extraction

2.7.4.1 Description

This alternative is a combination of Alternatives A-2 and A-3. In overview, soil vapor withdrawal wells are placed at the points of soil contamination and air injection wells are placed at the periphery of the contaminated soil zone and then an airflow is established from edge to center. The air during passage through the soil contains vapors evolved from liquid or aqueous phase VOCs and is brought above the ground by the withdrawal wells where the VOC vapors are thermally desorbed or destroyed on Site. Over 100 extraction/injection wells, several distribution centers and a vapor treatment unit would be required. The existing cap would be upgraded to RCRA composite cap to virtually eliminate surface water infiltration through the waste and contaminated soil. The soil vapor withdrawal wells would be installed through the cap.

2.7.4.2 Assessment

Overall Protection of Human Health and the Environment

Potential human exposure to Site soils and wastes that pose a health risk is virtually eliminated by the presence of the existing cap. The additional soil cover and synthetic membrane cover provided by a RCRA cap would further distance any potential receptors from the contaminated soil. ISVE will further aid the OU #1 remedy by removing VOCs from the vadose zone before these VOCs have the opportunity to reach the water table. However, in light of the effectiveness of the RCRA cap to reduce the generation of leachate consistent with the requirements of the specific remedial action objectives, ISVE would provide little additional improvement. SVOCs and pesticides are expected to remain as contaminants as they are not directly influenced by ISVE. The mobility of these contaminants is virtually eliminated due to the presence of the RCRA cap. This alternative, in conjunction with the OU #1 remedy, provides protection to safeguard human health and virtually eliminates the effects of the wastes on the environment, hence satisfying the specific remedial action objectives.

Compliance with ARARs

Alternative A-4 like Alternative A-3 complies with ARARs provided all air emission standards and transportation regulations are satisfied.

Long-Term Effectiveness and Permanence

The RCRA cap would virtually eliminate the infiltration of surface water through the waste and soil, hence limiting the migration of contaminants. The likelihood of leaks as a result of the ISVE extraction/injection wells piercing the cap is anticipated to become a long-term problem which may result in a decrease in effectiveness and a resultant decrease in contaminant containment. ISVE is a technology which would likely be effective in permanently reducing the volume of VOCs within the unsaturated zone underlying the waste disposal areas although the time frame of removal may be lengthy and it would in no way impact the SVOCs and pesticides. In fact, the high effectiveness of the RCRA cap would render the ISVE system redundant for the remediation process.

Reduction of Toxicity, Mobility and Volume

Virtually eliminating surface water infiltration through the waste and soil by the addition of a RCRA cap would remove the primary transport mechanism for the contaminants. This alternative would reduce the toxicity, mobility and volume of VOCs that are within the vadose zone and would prevent further degradation of the groundwater due to VOCs. The SVOCs and pesticides within the waste and contaminated soil would still remain in a volume and toxicity to pose a threat to human health if exposed. Mobility of SVOCs and pesticides is eliminated due to the virtual elimination of surface water infiltration. However installation of the extraction/injection wells may also improve mobility by permitting greater surface water infiltration through the punctures in the existing cap and by providing a high permeability conduit in gravel surrounding the wells from the waste to the lower levels of the vadose zone.

Short-Term Effectiveness

Short-term impacts to human health and the environment due to air emissions are expected as a result of the implementation of this alternative. Air and dust emissions would be generated by the construction activities required for this alternative. Installation of ISVE extraction/injection wells would require workers to wear respiratory protective gear. Residents downwind of activities may be affected if engineering controls fail to control emissions. Short-term effectiveness of the RCRA cap as a horizontal barrier to surface water infiltration would be reduced by the many well holes that are required to pierce the cap. Reduction of VOCs from the vadose zone is forecast to take between 1 to 7 years but perhaps much longer. Pilot scale tests would need to be conducted to determine the in situ effectiveness of the ISVE system.

The potential for accidents when transporting/handling treatment residuals off Site and when transporting/handling caustic chemicals required for treatment on Site is further amplified by the length of time required for any ISVE alternative.

Implementability

Removing VOCs from the vadose zone utilizing ISVE is technically feasible based upon the existing sandy stratigraphy of the area and successful past performances of the ISVE system at other similar sites. However ISVE has never previously been implemented to the depths proposed for this Site and may pose a significant obstacle to successful removal of the VOCs from the vadose zone. The remediation of contaminated soil directly below the waste disposal areas utilizing ISVE would be technically difficult, if not impossible, due to the presence of containerized waste and debris and frequent silty zones. It is expected that some removal of VOCs from within the waste may occur, but only in permeable zones directly connecting with an extraction well. The ability of ISVE to remediate difficult areas and the extent of risk to human health inherent with installing the required extraction/injection wells would need to be determined through pilot scale studies. Additional remedial actions would be difficult due to the expanse of extraction/injection wells and distribution centers placed over the landfill. The provision of roadways to access each well would also hinder further additional remedial actions. Soil vapor probes, sampling ports and lysimeters would provide a means to monitor the effectiveness of this remedy. The decision to select the appropriate treatment of recovered vapor would be based upon the results of pilot studies and cost analyses. Treatment of the recovered vapor would likely be by incineration (or equivalent destruction method) due to the relatively high volume and concentration of contaminants expected to be produced from the Site. Utilizing a carbon adsorption or thermal desorption treatment technology would result in large volume of residuals requiring off-Site treatment subject to RCRA LDRs.

For a project of this duration building an on-Site incinerator would be an effective course of action. The availability of equipment and specialists to build such a system is not anticipated to be a problem.

Cost

The construction cost associated with this alternative is $20,572,200. O & M present worth costs amount to $13,505,100. Total present worth is $34,077,300.

2.7.5 Alternative A-5 - Excavate Waste and Contaminated Soil; On-Site Thermal Treatment; Replace Existing Clay Cap

2.7.5.1 Description

Actions under this alternative would completely remove the waste and contaminated soil using conventional excavation methods. Excavation, treatment and ash placement would deal with 3,668,700 c.y. of waste and contaminated soil. The volume of soil to be treated includes waste and contaminated soil within the associated vadose zone for 27 acres. Once excavated, waste and contaminated soil would be thermally treated on Site. A description of thermal treatment can be found in Section 4.2.5.2. In overview, thermal treatment utilizes heating to increase the relative volatilities between the contaminants and waste/soil matrix enough to cause vaporization of the organics and moisture into a gas stream. Organics and moisture are either oxidized in a secondary chamber or are condensed out of the gas stream and subsequently separated for further treatment. In order to complete remediation the organics must be destroyed either on the Site or off the Site. To ensure LDRs are satisfied thermal treatment would ensure that there are no residual concentrations of contaminants exceeding regulatory criteria (40 CFR 268) within the ash. Treated ash and soil would then be placed into the excavated landfill. Once backfilled and compacted the treated ash and soil would be capped by utilizing the existing clay cap.

2.7.5.2 Assessment

Overall Protection of Human Health and the Environment

Removing the contaminants from Site soils would eliminate the original health risk associated with exposed contaminated soils. Emplacing the existing clay cap would virtually eliminate any exposure to the treated ash and soil. The health threat from contaminated water would be significantly reduced by the implementation of this alternative and that of the OU #1 remedy. This alternative, in conjunction with the OU #1 remedy provides protection to human health and eliminates the effects of the waste and contaminated soil on the environment.

Compliance with ARARs

This alternative complies with ARARs provided all air emission and residual contaminant levels within the waste and contaminated soil are within regulatory levels.

Long-Term Effectiveness and Permanence

This alternative would eliminate the health risk previously associated with exposed contaminated waste and soils.

This alternative is a highly effective and permanent solution to the present situation on Site.

Reduction of Toxicity, Mobility and Volume

Thermally treating 3,668,700 c.y. of waste and soil would permanently eliminate the toxicity, mobility and volume of all contaminants. No contaminant residuals above regulatory levels would exist after treatment. The vadose zone directly influenced by the waste and contaminated soil would be treated and hence would cease to be a source of contamination to the groundwater.

The presence of the existing clay cap would reduce surface water infiltration through the vadose zone. Migration of residual contaminants (existing at below regulatory levels) to the groundwater would be mitigated due to the presence of the existing clay cap. Human exposure to low risk treated waste and soil would be virtually eliminated by the presence of the existing clay cap.

Short-Term Effectiveness

This alternative would involve the excavation of a large volume of waste (653,400 c.y.) and contaminated soil (3,015,300 c.y.). Based on the contaminant characteristics and concentrations within the waste and soil observed during the waste sampling program in 1992 any alternative involving excavation would produce air and dust emissions which would impact the workers and local residents. In order to determine the impacts on workers and local residents, air emission modeling was conducted for the excavation of waste only (653,400 c.y.). Particulate emissions are considered to be a potential problem, however, only VOC emissions were modeled as it was determined that VOC emissions would be the more dangerous and hence would govern the conduct of the remedial alternative. These results clearly indicate that day-sized excavation areas result in air emission magnitudes above regulatory levels. A day-sized excavation area assumes an excavation rate of 810 c.y. of clean soil and 1,620 c.y. of contaminated soils each 10-hour day. Modeling also does not add the cumulative effects of air emissions over a period of days. For these reasons, modeled air emission are considered to be minimum values and may, on implementation of this alternative, be magnitudes higher, in turn presenting an even greater health risk. Engineering controls would need to be implemented in order to limit air emissions to acceptable levels. Air emissions in the excavation and stockpile areas would require workers to wear respiratory protection. Air emissions from the thermal treatment may pose additional health risks. Excavation and thermal treatment of Site waste and soils would take 5 to 7 years. Dust, construction traffic and noise would negatively impact local residents throughout the implementation of this alternative. The excavation associated with this alternative would potentially become a source of contaminated runoff which may, if not managed through engineering controls, affect both human health and the environment around and "down-stream" of the Site.

Implementability

This alternative involves excavating 27 acres of waste and contaminated soil to a depth of approximately 70 feet. The nature of Site soils (i.e., sand) would preclude the use of vertical-walled excavations. Excavations with sloping sides angled at 2:1 or 1:1 would result in substantially more soil being excavated. This soil would need to be managed in order to ensure that cross contamination with Site waste would not take place. The limiting topography and vegetation of the Site would make management of any excavated soil difficult. Excavation to a depth of 70 feet is technically difficult given the nature of Site soils and contamination. Excavated areas would need to be securely covered in order to control air emissions and eliminate the infiltration of surface water through the waste and contaminated soil during construction. Additional remedial actions would, dependent on the action, be relatively easy to implement following the completion of this alternative. Testing of treated soil and ash would provide a means to monitor the effectiveness of this alternative. Groundwater monitoring wells as part of the OU #1 remedy would monitor the long-term resultant decrease in contaminant concentrations within the groundwater as a result of implementing this alternative.

The construction of an on-Site thermal treatment unit would be required for project of this size and duration. The availability of equipment and specialists to build such a system is not anticipated to be a problem.

Cost

The construction cost associated with this alternative is $1,836,035,700. O & M present worth costs amount to $529,100. Total present worth is $1,836,564,800.

2.7.6 Alternative A6 - Excavate Waste and Place in On-Site RCRA Landfill; RCRA Cap for Soil

2.7.6.1 Description

This alternative would completely remove the waste from the disposal areas using conventional excavation methods. Excavation would deal with 653,400 c.y. of waste. Once excavated, waste would be placed in an on-Site RCRA Landfill away from the existing disposal area. The excavated area would be capped with a RCRA composite cap.

2.7.6.2 Assessment

Overall Protection of Human Health and the Environment

Removing the waste and placing it within an on-Site RCRA landfill would eliminate the health risk associated with potential human exposure to said waste and significantly reduce the volume of contaminated leachate generated. The additional RCRA cap placed over the remaining contaminated soil would further distance any potential receptors from contact with the waste and contaminated soil. This alternative eliminates the effects of the waste and underlying contaminated soil on the environment. This alternative satisfies the remedial action objectives.

Compliance with ARARs

Excavation and redeposition of a waste constitutes a disposal/placement action under RCRA as defined by 40 CFR 268. Disposal/placement actions are subject to LDRs. This alternative does not comply with LDRs, in that organic compounds with a chloride concentration equal to or greater than 1,000 ppm are being disposed of within the on-Site RCRA landfill without first being treated. The vadose zone modeling demonstrates that contaminants within the waste when covered by a RCRA cap do not contribute to further degradation of the groundwater. This alternative, therefore, complies with ARARs if the on-Site RCRA landfill is designated as a CAMU. Capping of the remaining underlying contaminated soil with a RCRA cap also was demonstrated not to contribute to further degradation of the groundwater.

Long-Term Effectiveness and Permanence

This alternative is a permanent solution that would eliminate the health risk previously associated with exposed waste. Long-term effectiveness and permanence of this alternative would be guaranteed by continued maintenance of the cap and continued institutional controls.

Reduction of Toxicity, Mobility and Volume

The Summers Model demonstrates that the addition of a RCRA composite cap would greatly reduce the mobility of contaminants within the soil and prevent further degradation of the groundwater. Disposal/placement of the waste within an on-Site RCRA landfill would further enhance this reduction in mobility. The volume and toxicity of waste would not change, however due to the waste being contained and construction of a RCRA cap over the soil, there would be no further degradation of the groundwater.

Short-Term Effectiveness

This alternative would involve the excavation of a large volume of waste (653,400 c.y.) and exposure to a large volume of contaminated soil. Based on the contaminant characteristics and concentrations within the waste and soil observed during the waste sampling program of 1992 any alternative involving excavation would produce air emissions which would impact the workers and local residents. In order to determine the impacts on workers and local residents, air emission modeling was conducted for the excavation of the waste. Particulate emissions are considered to be a potential problem; however, only VOC emissions were modeled as it was determined that VOC emissions would be the more dangerous and hence would govern the conduct of the remedial alternative. These results clearly indicate that day-sized excavation areas result in contaminant air emissions magnitudes above the regulatory level. A day-sized excavation area assumes an excavation rate of 810 c.y. of clean soil and 1,610 c.y. of contaminated soils each 10-hour day. Air emissions in the excavation and stockpile areas would require workers to wear respiratory protection. Engineering controls would need to be implemented in order to limit air emissions to acceptable levels. Dust, construction traffic and noise would negatively impact local residents throughout the implementation of this alternative. The excavation associated with this alternative would potentially become a source of contaminated runoff, which may, if not managed through engineering controls, affect both human health and the environment around and "down-stream" of the Site.

Implementability

This alternative involves excavating 27 acres of waste to a depth of 15 feet. The nature of Site soils would preclude the use of vertical-walled excavations. Sloping excavations with sides angled at 2:1 or 1:1 would result in additional soil being excavated. This additional soil would likely be contaminated and hence would have to be managed accordingly. The limiting topography and vegetation of the Site would make management of any excavated soil difficult. Excavating 15 feet of soil is not technically difficult. Excavated areas would need to be covered in order to control emissions and eliminate the infiltration of surface water through the waste and contaminated soil.

Cost

The construction cost associated with this alternative is $57,150,100. O & M present worth costs amount to $695,300. Total present worth is $57,845,400.

2.7.7 Alternative A-7 - Excavate Waste and Place in On-Site RCRA Landfill; Replace Existing Clay Cap; In Situ Soil Vapor Extraction

2.7.7.1 Description

This alternative would completely remove the waste from the waste disposal areas using conventional excavation methods. Excavation and subsequent deposition of waste into an on-Site RCRA landfill would contend with 653,400 c.y. of waste. Once excavated the area would be capped utilizing the existing clay cap. Excavated waste would be deposited into a RCRA landfill located on Site away from the existing waste disposal areas. Following capping over 100 soil vapor extraction/injection wells and several distribution centers would be constructed to treat the 3,015,300 c.y. of contaminated soil within the vadose zone. Off-gas produced by ISVE would need to be destroyed on Site by means of incineration (or equivalent destruction method) or collected by condensation or granular activated carbon and subsequently destroyed off Site.

2.7.7.2 Assessment

Overall Protection of Human Health and the Environment

Removing the waste and placing it within an on-Site RCRA landfill would eliminate the health risk associated with potential human exposure to said waste and significantly reduce the volume of contaminated leachate generated. ISVE would, with time, remove the VOCs from the vadose zone before these contaminants have the opportunity to reach the water table. SVOCs and pesticides are expected to remain as contaminants as they are not directly influenced by ISVE. Emplacing the existing clay cap would virtually eliminate any human exposure to the remaining contaminated soils of the vadose zone.

This alternative provides on-Site protection to human health, eliminates the potential effects of the waste and reduces VOC concentrations within the vadose zone.

This alternative does not remove SVOCs and pesticides within the vadose zone. The surface water infiltration associated with the existing clay cap to be utilized within this alternative results in continued degradation of the groundwater (as demonstrated by the Summers Model which in turn demonstrates that this alternative does not comply with the specific remedial action objectives.

Compliance with ARARs

Excavation and redeposition of a waste constitutes a disposal/placement action under RCRA as defined by 40 CFR 268. Disposal/placement actions are subject to LDRs. This alternative does not comply with LDRs, in that organic compounds with chloride concentrations equal or greater than 1,000 ppm are being disposed of without being first treated. Vadose zone modeling demonstrates that contaminants within the soil when covered by a RCRA cap do not contribute to further degradation of the groundwater. Disposing of untreated waste into a secure landfill would further ensure that degradation of the groundwater due to the landfilled waste would not occur. This phase of the alternative would comply with ARARs if the on-Site RCRA landfill was designated a CAMU.

SVOCs and pesticides remaining in the vadose zone are subject to the surface water infiltration associated with the existing clay cap. Vadose zone modeling has demonstrated that these conditions would result in further degradation of the groundwater, contrary to the relevant and appropriate requirements of the Safe Drinking Water Act MCLs. Therefore, this alternative does not comply with ARARs.

Long-Term Effectiveness and Permanence

This alternative is a permanent solution that would eliminate the health risk previously associated with potential human exposure to waste. This alternative greatly reduces the magnitude of VOCs within the vadose zone although the time frame for removal may be lengthy. This alternative would not remove the SVOCs and pesticides within the vadose zone which would continue to contribute to the degradation of the groundwater.

Reduction of Toxicity, Mobility and Volume

Placement of the waste within a secure landfill effectively limits the mobility of hazardous contaminants. The volume and toxicity of waste would not change, however due to the contaminants being contained these parameters would not contribute to the further degradation of conditions at the Site. The volume, toxicity, and mobility of the SVOCs and pesticides within the vadose zone would not be affected by the ISVE component of this alternative. However, the presence of the ISVE extraction wells may increase mobility by permitting greater surface water infiltration through the punctures in the cap and by providing a high permeability conduit for movement of contaminants to the lower levels of the vadose zone.

Short-Term Effectiveness

This alternative would involve the excavation of a large volume of waste (653,400 c.y.) and worker exposure to a large volume of contaminated soil. Based on the contaminant characteristics and concentrations within the waste and soil observed during the waste sampling program of 1992 any alternative involving excavation would produce air emissions which would impact the workers and local residents. In order to determine the impacts on workers and local residents air emission modeling was conducted for the excavation of the waste (653,400 c.y.). Particulate emissions are considered to be a potential problem, however only VOC emissions were modeled as it was determined that VOC emissions would be the more dangerous and hence would govern the conduct of the remedial alternative. These results clearly indicate that day-sized excavation areas result in contaminant air emissions magnitudes above typical regulatory levels. A day-sized excavation area assumes an excavation rate of 810 c.y. of clean soil and 1,610 c.y. of contaminated soil each 10-hour day. Engineering controls would need to be implemented in order to limit air emissions to acceptable levels. Air emissions in the excavation and stockpile areas would require workers to wear respiratory protection.

Incinerator emissions associated with vapor destruction may also pose a health risk. In situ soil vapor extraction of vadose zone soils would take at least 1 to 7 years but perhaps much longer. Installation of ISVE extraction/injection wells would also require workers to wear respiratory protection. Dust, construction traffic and noise would negatively impact local residents throughout the implementation of this alternative. The excavation associated with this alternative would potentially become a source of contaminated runoff, which may, if not managed through engineering controls, affect both human health and the environment around and "down-stream" of the Site.

Implementability

This alternative involves excavating 27 acres of waste to a depth of 15 feet. The nature of Site soils would preclude the use of vertical-walled excavations. Sloping excavations with sides angled at 2:1 or 1:1 would likely result in additional soil being excavated. The limiting topography and vegetation of the Site would make management of any excavated soil difficult. Excavating 15 feet of soil is not technically difficult. Excavated areas would need to be covered in order to control emissions and eliminate the infiltration of surface water through the waste and contaminated soil. Removing VOCs from the vadose zone utilizing ISVE is technically feasible although the time frame may be excessive.

Additional remedial action would be difficult due to the expanse of injection/extraction wells and distribution centers placed over the landfill. The provision of roadways to access each well would also hinder future additional remedial actions. Future additional remedial actions would have to contend with SVOCs and pesticides within the vadose zone.

The construction of an on-Site incinerator (or equivalent destruction method) would be required for vapor destruction for a project of this size and duration. The availability of equipment and specialized personnel to build the incinerator and ISVE systems is not anticipated to be a problem.

Cost

The construction cost associated with this alternative is $78,389,300. O & M present worth costs amount to $13,575,900. Total present worth is $91,965,200.

2.8 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

General

This section provides a comparison between alternatives for all seven evaluation criteria. Table 2.10 provides the evaluation criteria and factors. Table 2.11 provides a ranking of alternatives.

2.8.1 Overall Protection of Human Health And The Environment

Specific remedial action objectives presented within Section 2.2.2 detail the required goals that must be attained to ensure overall protection of human health and the environment. The following alternatives do not satisfy the specific remedial action objectives:

		Prevents Direct Contact	*Prevents Further Degradation of Groundwater*
Alternative A-1	No Further Action	Yes	No
Alternative A-2	In Situ Soil Vapor Extraction	Yes	No
Alternative A-7	Excavate Waste and Place in On-Site RCRA Landfill; Replace Existing Cap; In Site Soil Vapor Extraction	Yes	No

TABLE 2.10

DETAILED ANALYSIS CRITERIA AND FACTORS
OPERABLE UNIT #2
HARDEMAN COUNTY LANDFILL RI/FS
HARDEMAN COUNTY, TENNESSEE

Evaluation Criteria	*Evaluation Factors*
Overall Protection of Human Health and Environment	• How alternative provides human health and environmental protection
Compliance with ARARs	• Compliance with Chemical-specific ARARs • Compliance with Action-specific ARARs • Compliance with Location-specific ARARs • Compliance with other criteria, advisories and guidelines
Long-Term Effectiveness and Permanence	• Magnitude of residual risk • Adequacy of controls • Reliability of controls
Reduction of Toxicity, Mobility and Volume through Treatment	• Treatment process used and materials treated • Amount of hazardous materials destroyed or treated • Degree of Expected Reductions in Toxicity, Mobility and Volume • Degree to which treatment is irreversible • Type and quantity of residuals remaining after treatment

TABLE 2.10

DETAILED ANALYSIS CRITERIA AND FACTORS
OPERABLE UNIT #2
HARDEMAN COUNTY LANDFILL RI/FS
HARDEMAN COUNTY, TENNESSEE

Short-Term Effectiveness	• Protection of community during remedial actions • Protection of workers during remedial actions • Environmental impacts • Time until objectives and protection are achieved
Implementability	• Ability to construct and operate the technology • Reliability of the technology • Ease for undertaking additional remedial actions, if necessary • Ability to monitor effectiveness of remedy • Ability to obtain approvals from other agencies • Coordination with other agencies • Availability of off site treatment, storage and disposal services and capacity • Availability of necessary equipment and specialists • Availability of prospective technologies
Cost	• Capital costs • Operating and Maintenance Costs • Present Worth Cost

TABLE 2.11
COMPARISON OF ALTERNATIVES
HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Alternative Description		Achieves RAOs (3)	Overall Protection of Human Health and Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Cost	Total (1)	Ranked Preferable Alternative (2)
Number	Description										
A-1	No Further Action	NO	NO	NO	7	7	5	1	1	21 (20)	5 (4)
A-2	In Situ Soil Vapor Extraction	NO	NO	NO	6	6	6	3	3	24 (21)	6 (5)
A-3	RCRA Composite Cap	YES	YES	YES	3	4	1	2	2	12 (10)	1 (1)
A-4	RCRA Composite Cap	YES	YES	YES	2	2	2	4	4	14 (10)	2 (1)
	In Situ Soil Vapor Extraction										
A-5	Excavate Waste and Contaminated Soils	YES	YES	YES	1	1	4	6	7	19 (12)	3 (2)
	On-Site Thermal Treatment										
	Replace Existing Clay Cap										
A-6	Excavate Waste	YES	YES	YES	4	3	3	5	5	20 (15)	4 (3)
	Place in On-Site RCRA Landfill										
	RCRA Composite Cap Over Soil										
A-7	Excavate Waste	NO	NO	NO	5	5	7	7	6	30 (24)	7 (6)
	Place in On-Site RCRA Landfill										
	Replace Existing Clay Cap										
	In Situ Soil Vapor Extraction										

Notes:

(1) Totals reflect sum of rankings, therefore a lower total indicates a more preferable alternative. Number in bracket is total, not including cost.

(2) Number in bracket is ranking, not including cost.

(3) RAO - Remedial Action Objective.

The following alternatives do satisfy the specific remedial action objectives:

Alternative A-3	RCRA Composite Cap;
Alternative A-4	RCRA Composite Cap, In Situ Soil Vapor Extraction;
Alternative A-5	Excavate Waste and Contaminated Soils, On-Site Thermal Treatment, Replace Existing Clay Cap; and
Alternative A-6	Excavate Waste and Place in On Site RCRA Landfill, RCRA Composite Cap For Soil

2.8.2 Compliance with ARARs

Alternatives A-1, A-2 and A-7 do not comply with ARARs in that further degradation of the groundwater will take place in contravention of the relevant and appropriate requirements of the SDWA.

2.8.3 Long-Term Effectiveness and Permanence

Utilizing the evaluation factors as yields the following alternatives ranked in order of long-term effectiveness and permanence:

The alternatives that are effective in the long term and provide a permanent solution are:

Alternative A-5 — Excavate Waste and Contaminated Soil, On-Site Thermal Treatment

- no contaminants, no treatment residuals on Site

The alternatives that are effective in the long-term and provide a permanent solution provided O & M is maintained are:

Alternative A-4 — RCRA Composite Cap, In Situ Soil Vapor Extraction

- SVOCs and pesticides on Site, high maintenance requirement

Alternative A-3	RCRA Composite Cap	
	-	all contaminants on Site, minimum maintenance requirement
Alternative A-6	Excavate Waste and Place in On-Site RCRA Landfill, RCRA Composite Cap Over Soil	

The following alternatives are non-effective:

Alternative A-7	Excavate Waste and Place in On-Site RCRA Landfill, Replace Existing Clay Cap, In Situ Soil Vapor Extraction
Alternative A-2	In Situ Soil Vapor Extraction
Alternative A-1	No Further Action

2.8.4 Reduction of Toxicity, Mobility and Volume

Utilizing the evaluation factors yields the following alternatives in order of their ability to reduce toxicity, mobility, and/or volume.

The alternatives that would eliminate the toxicity, mobility and volume of contaminants are:

Alternative A-5 — Excavate Waste and Contaminated Soil, On-Site Thermal Treatment

- virtually no toxicity, no mobility and no volume of contaminants remain

The alternatives that would substantially affect toxicity, mobility and/or volume of contaminants enough to attain the specific remedial action objectives are:

Alternative A-4 — RCRA Composite Cap, In Situ Soil Vapor Extraction

- toxicity and volume due to VOCs is eliminated
- toxicity and volume due to SVOCs and pesticides remain unchanged
- mobility of all contaminants virtually eliminated

Alternative A-6 — Excavate Waste and Place in On-Site RCRA Landfill, RCRA Composite Cap Over Soil

- mobility of all contaminants is virtually eliminated
- toxicity and volume remain unchanged

Alternative A-3 — RCRA Composite Cap

- toxicity and volume of all contaminants remain unchanged
- mobility of all contaminants virtually eliminated

The alternatives that would not substantially affect toxicity, mobility and/or volume of contaminants such that attainment of the specific remedial action objectives is not possible are:

Alternative A-7 — Excavate Waste and Place in On-Site RCRA Landfill, Replace Existing Clay Cap, In Situ Soil Vapor Extraction

- toxicity and volume of contaminants within waste remains
- mobility of contaminants within waste virtually eliminated
- toxicity, mobility and volume of VOCs within vadose zone virtually eliminated
- toxicity, mobility and volume of SVOCs and pesticides within vadose zone remains unchanged

Alternative A-2 — In Situ Soil Vapor Extraction

- toxicity, mobility and volume of VOCs virtually eliminated
- toxicity, mobility and volume of SVOCs and pesticides remains unchanged

Alternative A-1 — No Further Action

- toxicity, mobility and volume of all contaminants remains unchanged

2.8.5 Short-Term Effectiveness

Utilization of the evaluation factors yields the following alternatives ranked in order of their short-term effectiveness:

Alternatives in which specific remedial action objectives are achieved and workers and the community are protected during remedial actions are:

Alternative A-3 — RCRA Composite Cap
- 6 to 12 months duration

The alternative in which specific remedial action objectives are achieved and workers and the community are potentially impacted by the remedial action is:

Alternative A-4 — RCRA Composite Cap, In Situ Soil Vapor Extraction
- years duration
- 6 to 12 months for RCRA cap, 1 to 7 years for ISVE to remove VOCs
- potential air impacts

Alternative A-6 — Excavate Waste and Place in On-Site RCRA Landfill, RCRA Composite Cap Over Soil
- one year duration
- air emissions from excavation
- contaminated runoff from excavation

Alternative A-5 — Excavate Waste and Contaminated Soil, On-Site Thermal Treatment
- 5 to 7 years duration
- air emissions from excavation and thermal treatment
- contaminated runoff from excavation

The following alternatives do not satisfy the specific remedial action objectives or they pose an unacceptable risk to humans or the environment and hence, are not effective in the short term:

Alternative A-1 — No Further Action
- potential threat to community through ingestion of contaminated water

Alternative A-2 — In Situ Soil Vapor Extraction
- 1 to 7 years duration, or perhaps much longer
- potential threat to community from air emissions

Alternative A-7 — Excavate Waste and Place in On-Site RCRA Landfill, Replace Existing Clay Cap, In Situ Soil Vapor Extraction
- 1 to 7 years duration, or perhaps much longer
- air emissions from excavation require engineering controls
- contaminated runoff from excavation

2.8.6 Implementability

Utilizing the evaluation factors yields the following alternatives in order of their ability to be implemented:

Alternative A-1 — No Further Action

Alternative A-3 — RCRA Composite Cap
- no concerns regarding this alternative

Alternative A-2 — In Situ Soil Vapor Extraction
- implementable, moderately complex technically

Alternative A-4 — RCRA Composite Cap, In Situ Soil Vapor Extraction
- potential short- and long-term problems associated with In Situ Soil Vapor Extraction
- complex to implement In Situ Soil Vapor Extraction
- complex logistically

Alternative A-6 — Excavate Waste and Place in On-Site RCRA Landfill, RCRA Composite Cap Over Soil
- excavation difficult

Alternative A-5 — Excavate Waste and Contaminated Soil, On-Site Thermal Treatment
- excavation difficult
- technically difficult

Alternative A-7 — Excavate Waste and Place in On-Site RCRA Landfill, Replace Existing Clay Cap, In Situ Soil Vapor Extraction
- implementable
- complex technically
- complex logistically

2.8.7 Cost

A summary of costs associated with each alternative is presented within Table 2.12. Ranking of total present worth from least to most expensive yields.

Alternative A-1	No Further Action - $529,100
Alternative A-3	RCRA Composite Cap - $4,059,100
Alternative A-2	In Situ Soil Vapor Extraction - $30,607,600
Alternative A-4	RCRA Composite Cap, In Situ Soil Vapor Extraction - $34,077,300
Alternative A-6	Excavate Waste and Place in On-Site RCRA Landfill, RCRA Composite Cap Over Soil - $57,845,400
Alternative A-7	Excavate Waste and Place in On-Site RCRA Landfill, Replace Existing Clay Cap, In Situ Soil Vapor Extraction - $91,965,000
Alternative A-5	Excavate Waste and Contaminated Soils, On-Site Thermal Treatment, Replace Existing Clay Cap - $1,836,564,800

2.8.8 State Acceptance

EPA and the TDEC have cooperated throughout the RI/FS process. The State has participated in the development of the RI/FS - reviewing and commenting on planning and decision documents relating to the Site; and through frequent contact between EPA and TDEC. EPA and TDEC are in agreement on the selected alternative. Please refer to the Responsiveness Summary which contains a letter of concurrence from TDEC.

TABLE 2.12

SUMMARY OF ALTERNATIVE COSTS

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Alternatives		*Construction Costs*	*O & M Costs*	*Total Present Worth Cost (1)*
Alternative	*Description*			
A - 1	-No Further Action	$0	$529,100	$529,100
A - 2	-In Situ Soil Vapor Extraction	$17,268,600	$13,505,100	$30,773,700
A - 3	-RCRA Composite Cap	$3,530,000	$529,100	$4,059,100
A - 4	-RCRA Composite Cap -In Situ Soil Vapor Extraction	$20,572,200	$13,505,100	$34,077,300
A - 5	-Excavate Waste and Contaminated Soil -On-Site Thermal Treatment -Replace Existing Clay Cap	$1,836,035,700	$529,100	$1,836,035,700
A - 8	-Excavate Waste -Place in On-Site RCRA Landfill -RCRA Composite Cap Over Soil	$57,150,100	$695,300	$57,845,400
A - 9	-Excavate Waste -Place in On-Site RCRA Landfill -Replace Existing Clay Cap -In Situ Soil Vapor Extraction	$78,389,300	$13,575,900	$91,965,200

Note:

(1) 30-year present worth cost in 1995 is based on a discount factor of 5 percent.

2.8.9 Community Acceptance

During the public meeting held on July 13, 1995, town residents and local officials expressed interest and support for the selected remedy presented by EPA. Please see the Responsiveness Summary which contains a transcript of the public meeting.

2.9 SELECTED REMEDY

Based upon consideration of the requirements of CERCLA, the detailed analysis of the alternatives using the nine criteria, and public comments, both EPA and the State have determined that Alternative 3 - RCRA cap is the most appropriate remedy for the Velsicol/Hardeman County Operable Unit #2.

The RCRA composite cap will reduce surface water infiltration through the waste and contaminated soils. The existing vegetative cover will be scarified to a depth of approximately 6 inches and recompacted. A 40-mil high density polyethylene (HDPE) synthetic liner will be place over the recompacted clay surface. A sand drainage blanket with a minimum hydraulic conductivity of 1×10^{-3} cm/sec will be placed over the liner to provide lateral drainage. The sand will be covered with a filter fabric and a layer of common fill and topsoil. A vegetative cover will be established to prevent erosion of the fill and topsoil materials.

The RCRA cap will be routinely monitored in order to maintain the integrity of the cap. The current network of monitoring wells established by Operable Unit #1 will provide the long-terms means of monitoring the effectiveness of this alternative.

The construction costs associated with this alternative is $3,530,000 (Table 2.13). The Operation and Maintenance present worth costs are $529,000. The total present worth is $4,059,100.

2.10 STATUTORY DETERMINATIONS

2.10.1 Overall Protection of Human Health and the Environment

The selected remedy will provide the best overall protection to human health and the environment by:

- Containing the landfill mass by capping and immobilizing hazardous constituents, minimizing leachate generation.

TABLE 2.13

ALTERNATIVE A - 3 COST ESTIMATE
"RCRA CAP"

HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Item	*Description*	*Unit*	*Quantity*	*Unit Cost*	*Present Worth Cost* (1)
CONSTRUCTION COSTS					
A.	**General Requirements**				
A-1	Bonds	LS	—	—	$56,000
A-2	Insurance	LS	—	—	$42,000
A-3	Permitting & Legal	LS	—	—	$14,000
B.	**Mobilization**				
B-1	Mobilization, Setup and Project Startup	LS	—	—	$28,000
C.	**Health and Safety**				
C-1	Provision of Health and Safety Plan	LS	—	—	$20,000
C-2	Provision of Health and Safety Officer	Manday	180	$350	$63,000
C-3	Provision of Custodian	Manday	180	$200	$36,000
D.	**Construction Facilities and Temporary Controls**				
D-1	Soil Erosion and Sediment Control	LS	—	—	$10,000
D-2	Site Security	Manday	180	$100	$18,000
E.	**Project Closeout**				
E-1	Demobilization and Project Closeout	LS	—	—	$14,000
F.	**RCRA Cap**				
F-1	Scarify, Remove Existing Vegetation and Proof Roll	Acre	35	$500	$17,500
F-2	40-mil HDPE Flexible Membrane Liner	SY	169,400	$4.50	$762,300
F-3	Sand Drainage Layer (12")	CY	55,900	$6	$335,400
F-4	Filter Fabric	SY	169,400	$1.50	$254,100
F-5	Common Fill & Topsoil (12")	CY	55,900	$9	$503,100
F-6	Seed & Mulch Top Cap	Acre	25	$1,400	$35,000
F-7	Sod Slopes	Acre	10	$14,500	$145,000
OPERATION & MAINTENANCE COSTS					
G.	**Administration and Site Management**				
G-1	Project Management	Year	30	$10,000	$153,700
G-2	Site Evaluation (at 5 year intervals)	Each	6	$30,000	$83,500

TABLE 2.13

ALTERNATIVE A - 3 COST ESTIMATE
"RCRA CAP"
FEASIBILITY STUDY
HARDEMAN COUNTY LANDFILL, OPERABLE UNIT #2
HARDEMAN COUNTY, TENNESSEE

Item	*Description*	*Unit*	*Quantity*	*Unit Cost*	*Present Worth Cost* (1)
H.	**General Site Care**				
H-1	Maintain Access Road	Year	30	$3,100	$47,700
H-2	Maintain Grass Cover	Year	30	$2,000	$30,700
I.	**RCRA Cap Maintenance**				
I-1	Erosion Repair	Year	30	$8,100	$124,500
I-2	Fertilizing, Seeding & Mulching	Year	30	$1,300	$20,000

Subtotal Construction Costs:	$2,353,400
Construction Supervision (10%)	$235,300
Bid Contingency (10%)	$235,300
Scope Contingency (15%)	$353,000
Engineering Design & Management	$353,000
Total Construction Cost:	**$3,530,000**
Subtotal O & M Costs:	$460,100
Contingency (15%)	$69,000
Total O & M Cost:	**$529,100**
TOTAL PRESENT WORTH:	**$4,059,100**

Note:

(1) See Table 6.10 for discussion of Present Worth Costs.

- Preventing/eliminating direct exposure to the landfill wastes and contaminated soils by human and ecological receptors.

Implementation of the selected remedy will reduction in surface water infiltration effectiveness of 99.9998 percent. This alternative will favorably impact the OU #1 remedy as contaminant concentrations and volume of water migrating to the saturated zone will be decreased to the point that no further degradation of groundwater will take place.

2.10.2 Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

The selected remedy will meet the Federal ARARS identified below. No state ARARs were identified for the selected remedy.

Chemical Specific:

1. Safe Drinking Water Act (SDWA) (Maximum Contaminant Levels (MCLs))(40 CFR Part 141) requirements are used as a goal for remediation of groundwater and as such are relevant and appropriate. Site-specific soil action levels were developed based upon MCLs. The RCRA cap will meet the soil action levels.

Action-Specific:

1. RCRA Subtitle C (Hazardous Waste Management) (40 CFR 264.310) requirements for landfill closure and post-closure care are considered applicable to the selected remedy.

Other Criteria, Advisories, or Guidance To Be Considered (TBCs):

1. Covers for Uncontrolled Hazardous Waste Sites, EPA/540/2-85/002, September 1985 Guidance Document

2. Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, USEPA Office of Research and Development, EPA/600/R-93/182, September 1993

3. Technical Guidance Document: Construction Quality Management for Remedial Action and Remedial Design Waste Containment Systems, USEPA Office of Research and Development, EPA/540/R-92/073, October 1992

4. Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments, USEPA Office of Solid Waste and Emergency Response, EPA/530-SW-

89-047, July 1989.

5. Seminar Publication: Design and Construction of RCRA/CERCLA Final Covers, USEPA Office of Research and Development, EPA/625/4-91/025, May 1991.

2.10.3 Cost-Effectiveness

EPA believes this remedy will virtually eliminate the effects of wastes and underlying contaminated soil on the environment at an estimated cost of $4,059,100. The selected remedy provides an overall effectiveness proportionate to its costs, such that it represents a reasonable value for the money that will be spent. A cost estimate is provided in 2.13.

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

EPA and TDEC have determined that the selected remedy utilizes permanent solutions and treatment technologies to the maximum extent practicable. However, because treatment of the principal threats of the Site was not found to be practicable, this remedy does not satisfy the statutory preference for treatment as a principal element.

EPA and TDEC have determined that this selected remedy provides the best balance of trade-offs in terms of long-term effectiveness and permanence, reduction of toxicity, mobility, or volume achieved through containment, short-term effectiveness, implementability, and cost. The selected remedy treats the principal threat posed to groundwater by soils, achieving significant reduction in contaminant mobility.

2.10.5 Preference for Treatment as a Principal Element

The selected remedy does not satisfy the statutory preference for treatment due to the impracticability of treating large volumes of contaminated waste.

3.0 RESPONSIVENESS SUMMARY OVERVIEW

In April of 1991, EPA issued a Fact Sheet which summarized the proposed alternatives for remediating the groundwater. Following a public comment period, EPA signed a Record of Decision (ROD) in June 1991 which presented the selected remedy. A Superfund Fact Sheet Update was mailed to interested citizens in April 1992.

The OU #2 additional investigations, FS and Proposed Plan were released to the public in July 1995. These documents were made available to the public in the Administrative Record and the information repository maintained at the EPA Docket Room in Region 4 and at the Bolivar-Hardeman County Public Library. The notice of the availability of these two documents was published in the Bulletin-Times and the Jackson Sun on July 5, 1995.

A public comment period was held from July 13, 1995 to August 12, 1995. No written public comments were received during this period. No request for an extension to the public comment was made. In addition, a public meeting was held on July 13, 1995. At this meeting, representatives from EPA and the Tennessee Department of Environment and Conservation (TDEC) answered questions relating to the Site and the remedial alternatives under consideration. A Bulletin-Times reporter and a local Jackson TV news-station, WBBJ, attended the public meeting.

This decision document presents the selected remedial action for the Velsicol/Hardeman County Landfill Superfund Site, OU #2, in Hardeman County Tennessee. The remedial action chosen, is in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the National Contingency Plan. The decision for this Site is based on the Administrative Record.

The Proposed Plan, official transcript of the Public Hearing, and the State of Tennessee's concurrence letter are provided as Attachments A, B, and C.