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REMEDIAL INVESTIGATION REPORT
AND
FEASIBILITY STUDY OF ALTERNATIVES

HELEVA LANDFILL SITE
LEHIGH COUNTY, PENNSYLVANIA

EPA WORK ASSIGNMENT
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SUBMITTED FOR NUS BY:

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EXECUTIVE SUMMARY

Introduction

The Heleva Landfill Site consists of a 20-acre landfill located on a 93-acre tract of land owned by Stephen Heleva in North Whitehall Township in Lehigh County, Pennsylvania. The site was originally a large open-pit iron ore mining operation. The site began operations as a sanitary landfill in 1967, receiving 250-350 tons/day of general mixed refuse, paper, wood, and orchard wastes from the Allentown area. In addition, an undetermined amount of industrial wastes was reported to have been sent to the site as early as 1967. These wastes included, or were believed to include, chlorinated hydrocarbon solvents, of which several were aromatics, esters, ethers, benzene, and phenols. Trichloroethene (TCE), an industrial cleaning solvent, was reportedly deposited in numerous areas of the landfill.

An application for a State Solid Waste Permit was denied in 1977, and the landfill was ordered closed. The landfill operators then filed an appeal with the Environmental Hearing Board. To resolve the permit appeal, the Pennsylvania Department of Environmental Resources (PADER) and the landfill owner signed a consent order in 1980, in which he agreed to control soil erosion entering Todd Lake, control leachate, limit dumping, cease dumping in previously filled areas, and initiate a biostimulation pilot project for trichloroethene (TCE) reduction. However, the results of the biostimulation pilot project never satisfied the regulatory agencies. The landfill was ordered closed by PADER in 1981 because of operational deficiencies, and the operators were required to cover the landfill with two feet of soil and revegetate it.

The only major remedial actions to date have been the covering of the landfill with soil and the closing in 1978 of the West Ormrod Water Association Well because of volatile organic contamination, with the connection of the 35 homes previously served by this well to a permanent outside source.

The entire site is covered by clayey soil obtained from an adjacent borrow area. Because of low fertility, this soil does not support significant vegetation. Consequently, the cap has eroded, parts of the landfill are becoming exposed, and precipitation percolates into the landfill.

The principal concern, stemming from conditions at the site, is the contamination or potential contamination of potable water supplies from migration of contaminants off site from the landfill.

A comprehensive Remedial Investigation (RI) was performed at the Heleva Landfill Site. The RI consisted of a sampling program and a subsurface investigation involving literature research; seismic studies; drilling, logging, and installing monitoring wells; structural mapping; and groundwater sampling.

Samples were collected from monitoring wells, from residential wells, from ponds adjacent to the landfill, from soil on site, from Coplay Creek, from Ranger Lake, from an abandoned quarry south of the site, from two small ponds or quarries between Ormrod and Coplay Creek, from monitoring wells installed by Stephen Heleva in 1977, and from the air in several locations on and around the site.

Site Features Investigation

The site is located in eastern Pennsylvania, five miles north of the city of Allentown. Allentown and the adjacent city of Bethlehem have a combined population of over 183,000 and a large integrated industrial base.

The area within a 3-mile radius of the site is primarily rural, with a high density of farmlands and pasturelands. Large areas of cropland and grazing lands surround the site, with some croplands located on the Heleva Landfill Site property adjacent to the landfill.

Ormrod, a village of 35 families, is located about 1/4 mile southeast of the site. Ironton, a village of 40 families, is located 1/4 mile west of the site.

Limestone quarrying for cement and for aggregate is a commercial industry throughout the area. At one time, iron ore mining was a major industry in the area. Some light industry is located in Ironton and Ormrod.

The natural resources in the area include the agricultural lands, the groundwater and surface waters in the area, and the cement and aggregate limestones. The groundwater and surface waters are the natural resources threatened by the site. One community drinking water well has already been closed because of contamination, and residential wells are threatened. Coplay Creek and other nearby surface water bodies, such as Ranger Lake, are threatened with possible contamination.

Geophysical Investigation

Geophysical surveys were conducted at the Heleva Landfill Site to aid in determining subsurface conditions and to provide correlations with monitoring well data. A seismic refraction survey was conducted to delineate the top surface of the bedrock. Porosity of the bedrock surface was then calculated. The porosity of some areas of the bedrock indicate that the bedrock is relatively unfractured in these areas. In another area, the porosity of the bedrock surface indicates a higher degree of fracturing. This area corresponds with a fault zone encountered during the drilling of monitoring wells and field mapping.

The electromagnetic conductivity (EM) and vertical electrical sounding (VES) surveys were conducted to evaluate horizontal and vertical variations in shallow subsurface structure and in groundwater quality. The data from the EM survey suggest that the unconsolidated material in the area of the landfill is homogeneous. In addition, the conductivities measured during the EM survey were relatively consistent, preventing definition of any possible contaminant plume.

The results of the VES survey did not indicate a detectable contaminant plume moving in the direction of groundwater flow.

The results of the geophysical surveys also indicate that the southeastern field may be a filled quarry.

Geologic and Hydrogeologic Investigations

Geologic and hydrogeologic investigations performed at the Heleva Landfill Site focused on determining subsurface geologic conditions, groundwater flow paths, and mechanisms of contaminant transport. The investigations consisted of literature review, geologic mapping, and monitoring well installation.

The Heleva Landfill Site is located in the Great Valley section of the Valley and Ridge Province of eastern Pennsylvania. The site is underlain by Ordovician and Cambrian Age sedimentary rocks, which may be as thick as 4,000 feet. Only rocks of Ordovician Age were encountered during field mapping and drilling.

These included, from youngest to oldest, the Martinsburg Formation, the Jacksonburg Formation, and the Beekmantown Group. The Martinsburg Formation is exposed as a shale north of the site. The Jacksonburg Formation consists of an upper facies which is a black argillaceous limestone known locally as the "cement rock" and a lower facies which is comprised of a massive gray to black crystalline limestone refined to as the "cement limestone". A massive bedded light-brown gray dolomite represents the Beckmantown Group at the site. Extensive and extreme folding and faulting caused by tectonic episodes have deformed all of the rocks in the area of the landfill.

The Heleva Landfill Site is located at the southern end of a very large recumbent anticline or nappe, which trends northeasterly into New Jersey. Only remnants of this feature remain today, and the site is situated on a remnant of the lower limb of this nappe.

The regional hydrogeology varies greatly in the Allentown area. Water availability is affected by rock type, fracture spacing, and precipitation changes. The majority of the fresh water supplies are within 1,000 feet of the surface, with wells less than 300 feet deep typically supplying enough water for domestic use.

Groundwater in the region is highly responsive to precipitation. A regional water table map shows the regional groundwater flow is to the southeast.

The water balance of the Heleva Landfill Site shows that of the 46 inches of precipitation that falls on the site during a year, 26 inches are removed by evapotranspiration, runoff accounts for 16 inches, and the remainder, or 4 inches, recharges the groundwater system. Runoff from the site drains south into Coplay Creek, a tributary of the Lehigh River. In addition, runoff from the landfill enters two quarries that border the landfill.

Groundwater elevations in clustered well locations are nearly equal; therefore, the bedrock aquifer can be considered unconfined. The groundwater occurring in the rock in the landfill area moves through joint sets, faults, bedding planes, solution channels, and along cleavage planes, causing difficulty in mapping the direction of groundwater flow in the bedrock aquifer.

Groundwater flow at the site occurs in both the bedrock and in the unconsolidated deposits. The results of permeability tests conducted on unconsolidated wells may indicate more porous zones are present in the fill or that some upward vertical component from the bedrock may have caused the contamination of the aquifer in the fill material. The results of permeability tests conducted on bedrock wells varied significantly, probably the result of differences in fracture occurrences. Because of this variation in the bedrock, only regional aquifer characteristics for the bedrock units were used in the preparation of this report.

The results of groundwater sampling indicate the highest level of TCE is southeast of the site, which is downgradient of the site, and confirm that contaminant transport follows the direction of groundwater flow. TCE has also been found in Whitehall Quarry, Ranger Lake, and Coplay Creek. The contamination flows predominantly from the landfill through rock into the abandoned quarry and into Coplay Creek. This supports the conclusion that Coplay Creek is a discharge point for groundwater in the area.

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Occurrence, Distribution, and Probable Transport of Chemical Contaminants

Ambient air samples were collected at strategic locations on and around the landfill to determine if hydrocarbons were volatilizing from soils and surface water. An evaluation of the air sampling data indicates that most of the observed levels of the contaminants are typical of ambient air. However, some of the observed levels indicate the possibility of low-level volatilization and airborne transport to the atmosphere. The highest levels of contamination occurred at an area where TCE was known to have been spilled and above a leachate stream in this TCE spill area. Offsite migration of air contaminants is possible, but because the contaminants are diluted rapidly in the atmosphere, offsite contaminant levels do not exceed background values measured at the site.

Samples of soil from two locations on the landfill were collected. The analyzed results of these samples indicate low levels of contamination are present, but these low levels are not unusual and are not felt to represent a significant impact.

Sampling and analyses of surface water and sediment were conducted to determine if the contaminants disposed at the site were being transported to other locations. Sampling locations included onsite ponded surface water bodies, flowing surface leachate and runoff streams, and offsite surface water bodies. The majority of samples indicating contamination were from onsite leachate streams and impounded surface water bodies. The analysis of samples from onsite leachate streams indicated contamination by a mixture of halogenated aliphatics, monocyclic aromatics, and 2-butanone (methyl ethyl ketone [MEK]). The analysis of samples from offsite surface waters southeast of the landfill indicated low levels of contamination. The analysis of sediment samples from Coplay Creek downstream of the site showed that the sediment contained appreciable quantities of site-associated chemicals, confirming that the contamination is migrating offsite.

The surface drainage in the southern area of the landfill could transport contaminants offsite, but surface water and sediment samples taken in this area indicate that this is not a major contaminant migration path. Drainage from the

northwest portion of the site enters Todd Lake. Samples of leachate in this area and at Todd Lake indicate that transport of contaminants to Todd Lake is probably not occurring. Contaminants from the site have been found in Coplay Creek, southeast of the site. Coplay Creek flows into the Lehigh River southeast of the site and could possibly contribute contaminants to the Lehigh River. Under current site conditions and contaminant concentrations in Coplay Creek, it seems unlikely that contaminants would have an appreciable impact on the Lehigh River because of the large dilution factor along the creek and the tendency of the contaminants to volatilize from water.

Twenty monitoring wells were installed at various locations around the site to provide a means to sample the groundwater and determine the nature and extent of groundwater contamination. The wells were concentrated at the south end of the landfill in the pathway of regional groundwater flow. Analytical results of samples from these wells indicate that 10 of the 20 wells had contamination. In addition, three wells previously installed by the landfill's consultant were sampled, and the analytical results show that two of these wells are contaminated. Contamination was observed more often in the deeper wells. The contaminants found in the groundwater varied noticeably from those found in the surface water.

The analytical data indicate that the contaminants found in the groundwater are being transported through the subsurface along the path of the regional groundwater flow. Flow in rock fractures may locally occur in different directions; however, the overall direction follows the regional trend. Contamination found in two wells north of the site (upgradient) is believed to be caused by volatilization of the contaminants in the landfill, movement of the volatilized contaminants off site, and condensation of the contaminants off site in the area of the wells.

Samples of offsite domestic wells were also collected. The analytical results for samples from these wells indicate the presence of site-associated contaminants in three of the wells. Two of these wells are located east of the site, while the third is located northeast of the site.

Public Health and Environmental Concerns

The risk assessment for the Heleva Landfill Site is based on hydrogeological and chemical analytical data obtained during previous investigations and the RI conducted between February and November 1984. The objective of this assessment is to define the health risks associated with the presence of hazardous contaminants on and around the site and to define the potential environmental impacts connected with the contaminants in site-specific circumstances.

In order for a health risk to occur, contaminants having known chemical and biological toxic characteristics must be present, actual or potential exposure pathways must be present, and human environmental receptors must be located in the exposure paths.

Typically, the risk assessment procedures address the development of the details of the location and demographics of the receptor population and most sensitive environmental receivers. The risk assessment involves assessing the significant contaminant migration routes and exposure pathways, identification of the hazardous compounds of greatest concern, and an evaluation of possible effects in the context of probable exposure scenarios.

The major contaminant transport path, causing potential exposure of human receptors to the landfill contaminants, is the groundwater flow beneath the site. There are also several minor routes of transport of contaminants. Volatilization of organic contaminants to ambient air, with the contaminated air moving off site, has occurred. Surface water runoff, mingling with contaminated leachates emanating from the deposited wastes, may affect the environment in drainage receptor areas.

Potential receptors include nearby users of groundwater for drinking purposes, nearby users of groundwater for all other purposes, persons using the nearby surface waters for recreational purposes, persons eating edible food crops grown in nearby fields, and persons eating grazing animals fed from nearby fields. They also include those who consume milk of animals fed from nearby fields or consume

aquatic biota in affected surface water, terrestrial fauna using affected aquatic animals as a food source, vegetation that may be stressed, and onsite remediation workers. Only those individuals using water from contaminated residential wells have been directly exposed to site contaminants.

Of the chemicals detected in samples collected during previous investigations and the RI, vinyl chloride; trichloroethene (TCE); toluene; 1,2-trans-dichloroethene; 1,1,1-trichloroethane; and tetrachloroethene (PCE) were selected as the critical contaminants found at and around the Heleva Landfill Site. The major potential exposure to TCE at Heleva Landfill is via the ingestion of contaminated drinking water. Minor exposure to TCE can occur to persons using surface water for recreational purposes and ingesting contaminated surface water or aquatic organisms. In addition, there is a slight potential for exposure to TCE vapors at extremely low levels in ambient air.

Individuals at risk for exposure to vinyl chloride would include remedial investigation workers or persons trespassing on the site; they may encounter vaporous vinyl chloride emanating from the leachate streams. However, because of the dilution factors in ambient air, this exposure would be of a low concentration and brief duration. Ingestion of vinyl chloride in contaminated drinking water has not been identified, but if the migration of vinyl chloride continues, the potential increases.

At the Heleva Landfill Site, ingestion of contaminated drinking water is the primary exposure for 1,2-trans-dichloroethene. Inhalation and dermal contact are also potential routes of exposure. Because of the low levels of 1,2-trans-dichloroethene detected at the site and the contaminant's low toxicity character, adverse health effects from 1,2-trans-dichloroethene are unlikely at the Heleva Landfill Site. None of the other critical contaminants were determined to be posing a risk to receptors.

The toxic effect of TCE and 1,2-trans-dichloroethene on aquatic flora and fauna would be unlikely because of the low levels of the contaminants detected in surface waters.

Screening of Remedial Action Technologies

Numerous technologies can be used at the Heleva Landfill Site. Some technologies can be removed from further consideration, based on the information obtained about the site during the Remedial Action Master Plan (RAMP) and the Remedial Investigation (RI). The following technologies were screened:

- No action
- Monitoring
- Surface capping
- Groundwater barriers
- Alternative water supply
- Leachate collection
- Gas collection and treatment
- Surface regrading and revegetation
- Surface water diversion
- Contaminated soil/sediment removal
- Excavation
- Source reduction
- Groundwater collection
- Treatment technologies
- Disposal technologies

Each technology has been studied and reviewed in accordance with the following four categories of criteria:

- Technical Considerations
- Environmental and Public Health Considerations
- Institutional Considerations
- Cost Considerations

The technologies identified during the RI, as well as technologies encompassing treatment or disposal that were thought to be of importance, were discussed and evaluated. If the technology is rejected for use at the Heleva Landfill Site in a particular category, it is dropped from further consideration.

The technologies remaining for further consideration include no remedial action with monitoring, alternative water supply, surface capping, surface water diversion, leachate collection, gas collection and treatment, groundwater pumping, and excavation. In addition, treatment technologies, including filtration, precipitation, neutralization, carbon adsorption, air stripping, incineration, biological treatment, offsite disposal, and onsite disposal, were retained for further consideration. These technologies were then developed into candidate alternatives that meet the site-specific remedial action objectives and the criteria for evaluation of alternatives. The remedial objectives used to screen the candidate alternatives included maintaining public health and safety; maintaining the quality of the local groundwater and surface water; and providing remedial actions that are technically feasible, socially acceptable, and cost-effective.

Development and Evaluation of Remedial Action Alternatives

In order to study a range of responses for each site, alternatives are developed that fall into one of five different categories. These categories are described below.

- No action: No-action alternatives could include monitoring activities.
- Alternatives that meet the CERCLA goals of preventing or minimizing present or future migration of hazardous substances and protect human health and the environment, but do not attain all of the applicable or relevant standards. (This category may include an alternative that closely approaches but does not meet the level of protection provided by the applicable or relevant standards.)

- Alternatives that meet the CERCLA goals and attain all applicable or relevant Federal public health or environmental standards, guidance, or advisories.
- Alternatives that exceed all applicable or relevant Federal public health and environmental standards, guidance, and advisories.
- Alternatives specifying offsite storage, destruction, treatment, or secure disposal of hazardous substances at a facility approved under the Resource Conservation and Recovery Act (RCRA). Such a facility must also be in compliance with all other applicable EPA standards.

Listed below are brief descriptions of the alternatives generated for each category.

No-Action - Monitoring

This is a base line alternative that will be used for comparison against other alternatives in which remedial actions will be taken.

Alternatives That Meet CERCLA Goals

Two alternatives have been developed that provide varying levels of remediation. The first alternative is for installation of an alternate water supply and continued monitoring. This alternative will address the direct health threat, which results from residential consumption of the contaminated water supply but will not reduce the low-level contamination being seen in the downgradient surface waters.

The second alternative in this category provides an alternative water supply, installation of an impermeable cap with a flow layer and frost protection (a RCRA cap) with gas collection and treatment, and monitoring. Implementation of this alternative will provide better protection to the landfill and will control the onsite leachate. It does not address the groundwater problem.

Alternatives That Satisfy All Applicable Standards

One alternative has been developed for this category. That alternative is the provision of an alternative water supply, installation of a RCRA cap with gas collection and treatment, installation of a source reduction program, and monitoring. This alternative will be designed to meet all applicable standards.

Alternatives That Exceed All Applicable Standards

The first alternative developed for this category calls for excavation of the wastes from the landfill, disposal in an onsite RCRA landfill, backfilling and grading as needed, providing an alternate water supply, and monitoring.

The second alternative developed for this category calls for excavation of the wastes from the landfill, destruction by incineration on site, disposal of ash in an off site RCRA landfill, backfilling and grading as needed, providing an alternative water supply, and monitoring.

Alternatives That Specify Offsite Disposal

Under this alternative, the wastes would be excavated and transported to an offsite RCRA landfill. The site excavation would be backfilled, graded, and revegetated. An alternate water supply would be provided, and a monitoring program would be implemented.

AR300198

1.0 INTRODUCTION

1.1 Site Background

The Heleva Landfill Site consists of a 20-acre landfill, which is part of a 93-acre tract of land owned by Stephen Heleva in North Whitehall Township, Lehigh County, Pennsylvania. The site is bounded by Legislative Route 39049 on the south and east, Township Route 687 on the north, and Legislative Route 39038 on the west. The center of the site is located at 40° 40' 15" north latitude and 75° 33' 40" west longitude. Figure 1-1 shows the site location, and Figure 1-2 shows the study area.

In the late 1800s, the site was a large open-pit iron ore mining operation. The mining operations, which ended around the turn of the century, left four open, water filled pits, lying on an east-west line across the site. The western most pond is now known as Todd Lake, while the eastern most pond is the unnamed body of water called "Pond No. 1" during the Remedial Investigation (RI). Both of the remaining ponds were covered over during the landfilling operation. One of those was located under the shallow pond which was identified as the collection or retention basin during the RI, while the other was located midway between the collection pond and Todd Lake.

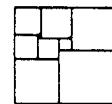
The site began operations as a sanitary landfill in 1967 and accepted between 250-350 tons/day of general mixed refuse, paper, wood, and orchard wastes from the Allentown area. In addition to the municipal wastes, industrial wastes were reported to have been sent to the site as early as 1967. The landfill was closed in 1981, and the owner covered the fill with a layer of soil taken from borrow pits located south of the site. Attempts to seed the covered areas have not been effective due to the low fertility of the cover material; much of the land has little vegetation, and there are many erosion gullies present. The top of the fill is about 500 feet above mean sea level (MSL), and the land slopes gently to the southeast corner of the site.



ORIGINAL

(Rec)

FIGURE 1-1



INUS CORPORATION



A Halliburton Company

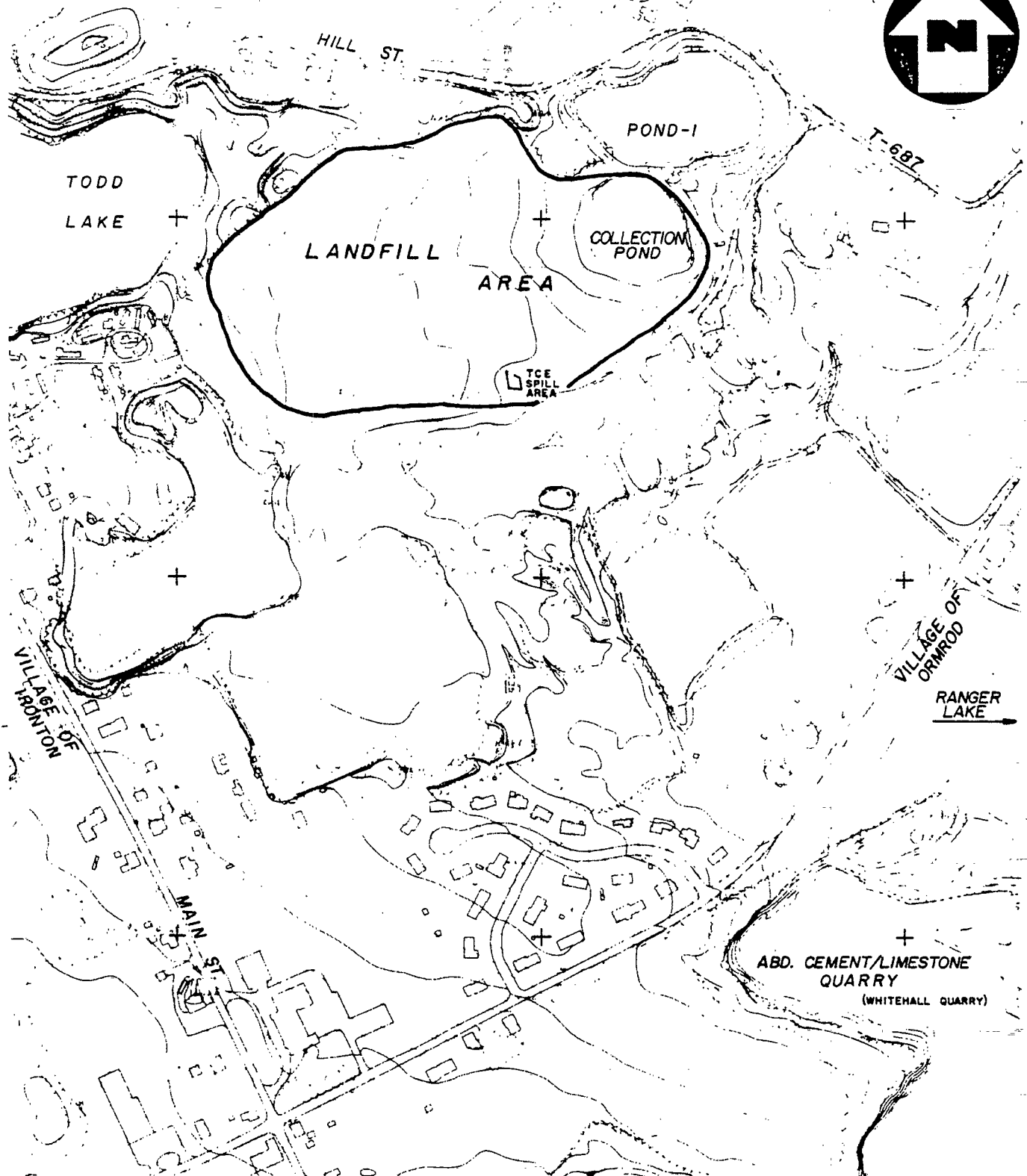
LOCATION MAP

HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

SCALE: 1"=3000'

AR300200

ORIGINAL
(Red)



SITE STUDY AREA
HELEVA LANDFILL SITE
NORTH WHITEHALL TWP., PA

SCALE: 1" = 400'

1-3AR300201

FIGURE 1-2

The site operated without a permit until May 3, 1977, when Heleva Landfill, Inc., submitted an application to the Pennsylvania Department of Environmental Resources (PADER) for a Solid Waste Permit. On July 8, 1977, this permit application was denied, and the landfill was ordered to cease operation by the PADER. On July 22, 1977, the corporation filed an appeal with the Environmental Hearing Board to have the permit denial overturned. Subsequently, a consent order was signed by the PADER and Heleva Landfill, Inc., on May 19, 1980 to settle the permit appeal. In this consent order, the corporation agreed to control erosion to Todd Lake, control leachate, limit dumping, cease dumping in currently filled areas, and initiate a biostimulation pilot project for trichloroethene (TCE) reduction. On November 25, 1980, PADER's Bureau of Solid Waste Management again denied Heleva Landfill, Inc.'s application to expand the landfill operation because of the corporation's failure to completely implement the biostimulation project. The site continued operation until its closure by PADER on May 1, 1981 because of operational deficiencies. As part of the closure procedures, the corporation was required to cover the landfill with two feet of topsoil and then revegetate it.

The site was listed as potentially hazardous on November 15, 1979 by PADER and EPA. A Hazard Ranking model was first generated on August 4, 1982, and updated on September 2, 1982, resulting in the placement of the Heleva site on the National Priorities List (NPL).

The major remedial action to date focused on the West Ormrod Water Association Well which served 35 homes. Because this well was contaminated with volatile organics, these homes were supplied with water from a permanent outside source in 1978. One other remedial action directed at the groundwater contamination was a biostimulation project by Heleva to reduce Trichloroethene (TCE), BOD, phenols, and other organics. Although the site operator claimed that tests showed reductions in the contaminants, PADER never concurred. Besides covering the site and closing the well, no other remedial activities have occurred prior to listing the site on the NPL.

1.2 Nature and Extent of Problem

Approximately 20 acres were used for industrial and sanitary waste disposal at the Heleva Landfill Site. Although domestic solid wastes make up the largest part of the fill, an undetermined amount of industrial wastes was deposited in the landfill. Among those wastes known or reported to have been sent to the landfill are wastes categorized as chlorinated hydrocarbon solvents, of which several were aromatics, elastomers, esters, ethers, benzene, and phenols. Of note is the presence of the solvent trichloroethene (TCE), an industrial cleaning solvent. This liquid was reportedly disposed in many areas of the landfill. One area which this solvent was discharged is noted as the TCE spill area on Figure 1-2.

The site remains to a large degree as it was when following its closure in 1981. It is covered by a clayey soil obtained from an adjacent borrow area. The material does not support significant vegetation, or completely prevent the percolation of surface waters into the fill material. The cover has eroded to the point where parts of the fill are exposed. At the northern perimeter of the site there is an area where a blue-grey ashlike material is exposed.

Principal concerns stemming from the site conditions are contaminant migration via surface water and groundwater transport. Potable water service supplied by a single well to 35 homes in the Village of Ormrod had to be discontinued when TCE was found in the well. Local domestic wells are threatened by the migration of contaminants via groundwater transport offsite.

Contaminant transport by surface water runoff is a potential concern as more of the landfill material becomes exposed due to erosion of the cover. Onsite ponds are collection points for contaminated surface water runoff. Because these ponds are all connected to the groundwater table, offsite quarry ponds and streams are also potential receptors of contaminants. Approximately one half mile to the south and east of the site lies Coplay Creek. Surface water drainage from the site also discharges into this stream. This creek eventually discharges into the Lehigh

River, which is a potential potable water source for communities downstream of the site. Several abandoned quarries lie near the site. Of note is Todd Lake to the west, Ranger Lake, just east of Coplay Creek, and the abandoned Whitehall Cement Quarry.

1.3 Remedial Investigation Summary

A comprehensive remedial investigation was performed at the Heleva Landfill Site in order to characterize the nature and extent of contamination at the site. This remedial investigation consisted of a multimedia environmental sampling program and a subsurface investigation, involving literature research, seismic studies, borehole drilling and logging, monitoring well installation, structural geology mapping, and groundwater sampling from the newly installed wells.

Environmental sampling was performed on several occasions. First, residential wells were sampled during the site reconnaissance to determine if any were contaminated. Next, samples were taken of surface water and sediments at ponds located adjacent to the landfill. These samples were taken to determine if contamination was entering these ponds to such an extent that aquatic organisms in these ponds would need to be sampled.

A major sampling program was conducted in April, 1984, once the monitoring wells were installed. Samples were taken of the monitoring wells, of surface water and sediments in the ponds on site, of soils on site, of water and sediments in Coplay Creek (upstream and downstream of the site), of water in Ranger Lake and in an abandoned quarry south of the site, and of water and sediments in leachate streams on site. In addition, air samples were taken at several points on and around the site.

In September, 1984, a repeat of the April sampling was performed, with the exception that, no leachate or air samples were taken since no leachate flows were observed, and previous air samples had shown no contamination. Instead, samples were taken of residential wells and of two additional small ponds or quarries located between the Village of Ormrod and Coplay Creek. In October 1984,

groundwater samples were taken from three monitoring wells installed in 1977 by Stephen Heleva.

With the exception of the April air samples and the samples taken in September and October, all samples were analyzed for all substances on the EPA's Hazardous Substance List (HSL). The September samples were analyzed only for the volatile substances on the HSL, and the October samples were analyzed for HSL Organics.

1.4 Overview of the Report

The following sections will discuss the results of the investigative activities at the site. Sections of this report will include the results of background research, of the field work, chemical and toxicological interpretation of the results.

Section 2 describes the physical features with respect to the site. Pertinent information concerning land use and the area demography is included in this section as support material to be used for the evaluation of alternatives in the Feasibility Study. A review of the local natural resources and climatology is also included.

Included in the discussion of the hydrogeologic investigation in Sections 3 and 4 are the descriptions, results, and conclusions associated with the subsurface investigation conducted on site. This investigation was focused around the completion of a monitoring well installation program, and included geophysical, geologic, and groundwater studies. This investigation was conducted primarily in order to understand the geology of the site, to identify the location of water bearing zones, and to determine aquifer properties, including contaminant types and migration potentials.

Section 5 presents the results of the environmental monitoring investigation. This section gives a summary of the analytical results of the local surface water bodies, sediments, and surface soils, with a tabulation of the sampling results presented in the appendices. In addition, this section includes an assessment of the local drainage patterns and possible contaminant migration routes.

AR300205

Section 6 includes an assessment of the potential threat that onsite contaminants pose to the public health, welfare, and the environment. Potential receptors are identified, and the potential effects of contaminant migrations to the local populace are discussed. A toxicological evaluation of the contaminants is also presented.

Elements of the feasibility study are included in the remaining sections. Section 7 is a review and screening of the remedial action technologies that may be appropriate for use at this site. The various technologies are presented, and those which are not applicable to the site are eliminated from further consideration. Section 8 uses the remaining technologies to develop remedial alternatives which will provide varying degrees of remediation. These alternatives are evaluated as to their effectiveness and cost, and inappropriate alternatives are eliminated.

AR300207

2.0 SITE FEATURES INVESTIGATION

2.1 Demography and Land Use

The site is located in eastern Pennsylvania, five miles north of the City of Allentown. Allentown and the adjacent City of Bethlehem have a combined population in excess of 183,000 and a large integrated industrial base.

The area within a three-mile radius of the site is primarily rural with a high density of farm and pasturelands. Although agricultural activities are important, much of the employment for the area residents is in industry or mining. A large percentage of the population lives in small single-family residential communities that pocket the area surrounding the site.

Ormrod, a village of approximately 35 families, is located about 1/4 mile southeast of the site. Irontown, located approximately 1/4 mile west of the landfill has a population of about 150 residents. The Ironton Elementary School is located within 1,500 feet south of the site.

Land use within the vicinity of the landfill is largely agricultural with some competing industrial use. Large croplands and grazing lands surround the site. Some croplands are located on the Heleva Landfill Site property itself adjacent to the landfill.

Area industrial activities have included mining and quarrying. Limestone quarrying for cement and for aggregate is an active industry throughout the area, with a recently abandoned quarry located about 1/2 mile south of the landfill and two active quarries several hundred feet further southeast. Iron ore mining is no longer pursued. In addition to the quarrying activities, some light industry is located in the Ironton and Ormrod communities.

2.2 Natural Resources

The area has several natural resources worth noting. These include the agricultural lands, the groundwater and surface waters, and the mineral resources, such as the aggregate and cement limestones in the area. Only two of these resources, the groundwater and surface waters, are potentially threatened by the site.

One of the natural resources threatened by the presence of contaminants in the landfill is the area's groundwater. The West Ormrod Community Association Well has already been closed due to the identification of contaminants. This well, located approximately 1,500 feet southeast of the site, was shut down in 1978 because high levels of chlorinated hydrocarbon solvents were found in its water by EPA and PADER.

Surface water, in bodies such as Ranger and Todd Lake and Coplay Creek, is the other resource potentially threatened by offsite migration of contaminants. These waters are the receptor of any runoff from the site. Contaminants carried off site by surface water runoff will eventually flow into these waterbodies.

2.3 Climatology

Allentown is located in the east central section of the state known as the Lehigh River Valley. Twelve miles to the north is Blue Mountain, a ridge ranging from 1,000 to 1,800 feet above MSL. The South Mountain, 500 to 1,000 feet above MSL, fringes upon the southern edge of the city. Otherwise, the country is generally rolling with numerous small streams. A moderate climate prevails; temperatures are usually moderate, and precipitation is generally ample and dependable. The largest amounts of precipitation occur during the summer months as shown. General climatological features of the area are slightly modified by the mountain ranges so that at times during the winter there is a temperature difference of 10 to 15 degrees lower in Allentown than in Philadelphia, which is only 50 miles to the south.

Maximum temperatures during most years are not excessively high, and temperatures above 100°F are seldom recorded. However, the average humidity in the valley is quite high and causes periods of discomfort.

Winters in the valley are comparatively mild. Minimum temperatures during December, January, and February are usually below freezing, but are infrequently below 0°F. The prevailing wind is from the west, with an average speed of 9 miles per hour (mph).

The average monthly temperatures and rainfalls for Allentown, Pennsylvania, about 4 miles to the southeast of the site are shown as follows (National Oceanic and Atmospheric Administration, 1981).

	<u>Average Temperature (°F)</u>	<u>Rainfall (Inches)</u>
January	27.4	3.26
February	29.4	2.93
March	38.7	3.68
April	49.8	3.79
May	60.1	3.88
June	69.3	3.65
July	74.0	4.21
August	72.0	4.23
September	64.7	3.98
October	53.6	2.81
November	42.6	3.60
December	<u>31.3</u>	<u>3.64</u>
Annual Average	51.1	Annual Total 43.66

AR300211

3.0 GEOPHYSICAL INVESTIGATIONS

3.1 Introduction

Geophysical surveys were conducted at the Heleva Landfill Site during this study to aid in determining subsurface conditions and to provide correlations with monitoring well data. A seismic refraction survey was performed in order to delineate the top of bedrock and to determine the location of faults thought to be present, based on chemical analyses of the monitoring wells. Electromagnetic conductivity (EM) and vertical electrical sounding (VES) surveys were done to evaluate horizontal and vertical variations in shallow subsurface geological structure and groundwater quality. A magnetometer survey was considered for the Heleva Landfill Site as a screening tool for the presence of large quantities of barrels in the landfill. However, since the landfill is located in an old iron ore mine, it was concluded that the survey would not be able to distinguish masses of barrels from the background, so no magnetometry was performed.

Field operations and data reduction techniques are described in Appendix I.

3.2 Interpretation

3.2.1 Seismic Refraction Survey

Seismic line locations are shown on Figure 3-1, and the corresponding cross-sections are shown on DN 0760.15-01, which is included in a packet at the back of this report.

All seismic cross-sections show the same three layers. A weathered soil layer covers the site. This layer has a seismic wave velocity of about 700 to 1,300 ft/sec, and ranges in depth from 8 feet at the northeast end of Line 1, to 25 to 30 feet along Line 0, to a maximum depth of 50 feet along the western half of Line 3. This depth can be attributed to a high deposition rate caused by erosion of

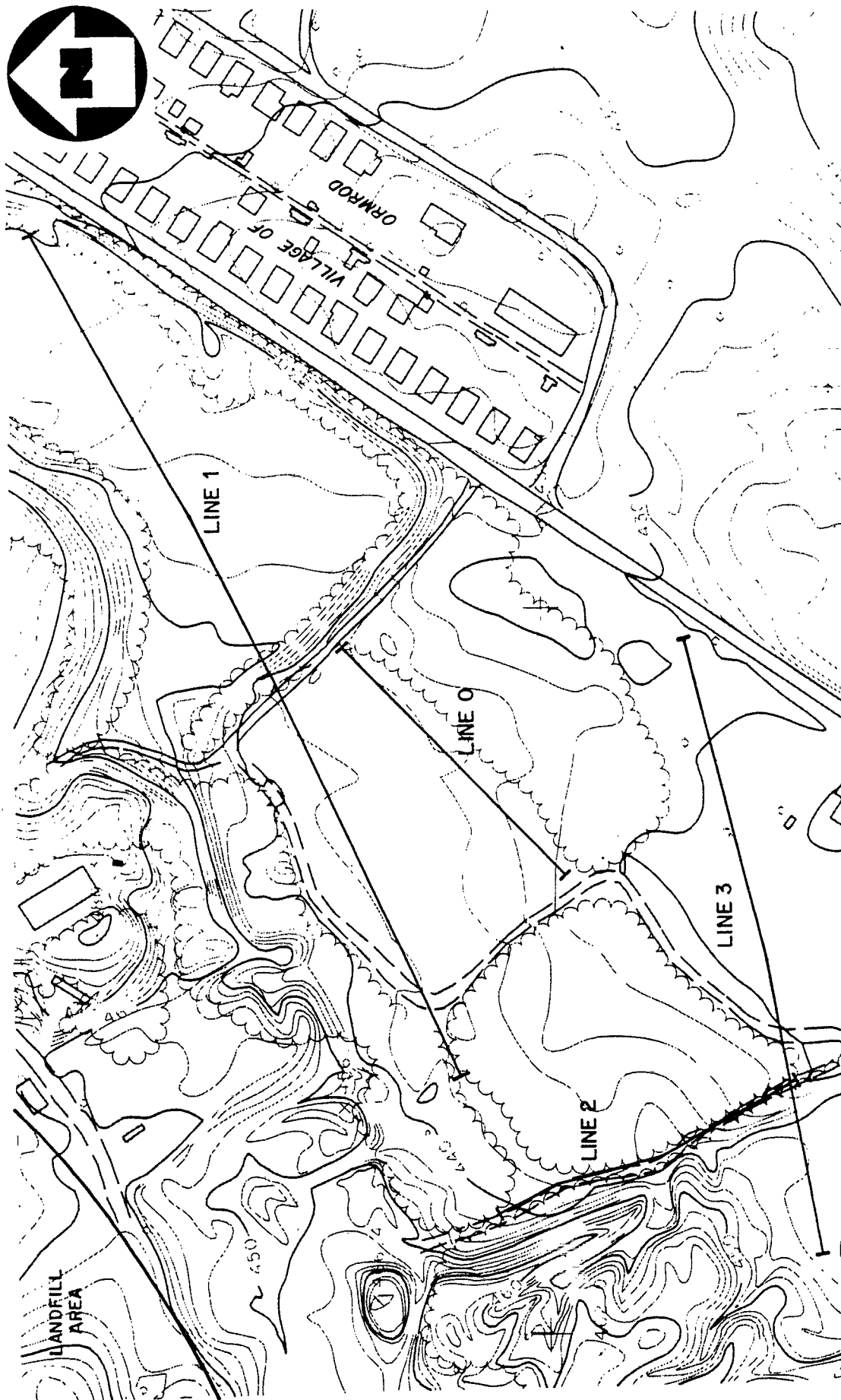


FIGURE 3-1

SEISMIC SURVEY LINES
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

SCALE 1"=200'

ORIGINAL
(200)

the clay to the north during periods of heavy rainfall. Wash channels can be seen leading from the higher portions of the site down to the area along Line 2. Following a storm, this area turns into a bog, allowing deposition of this clay.

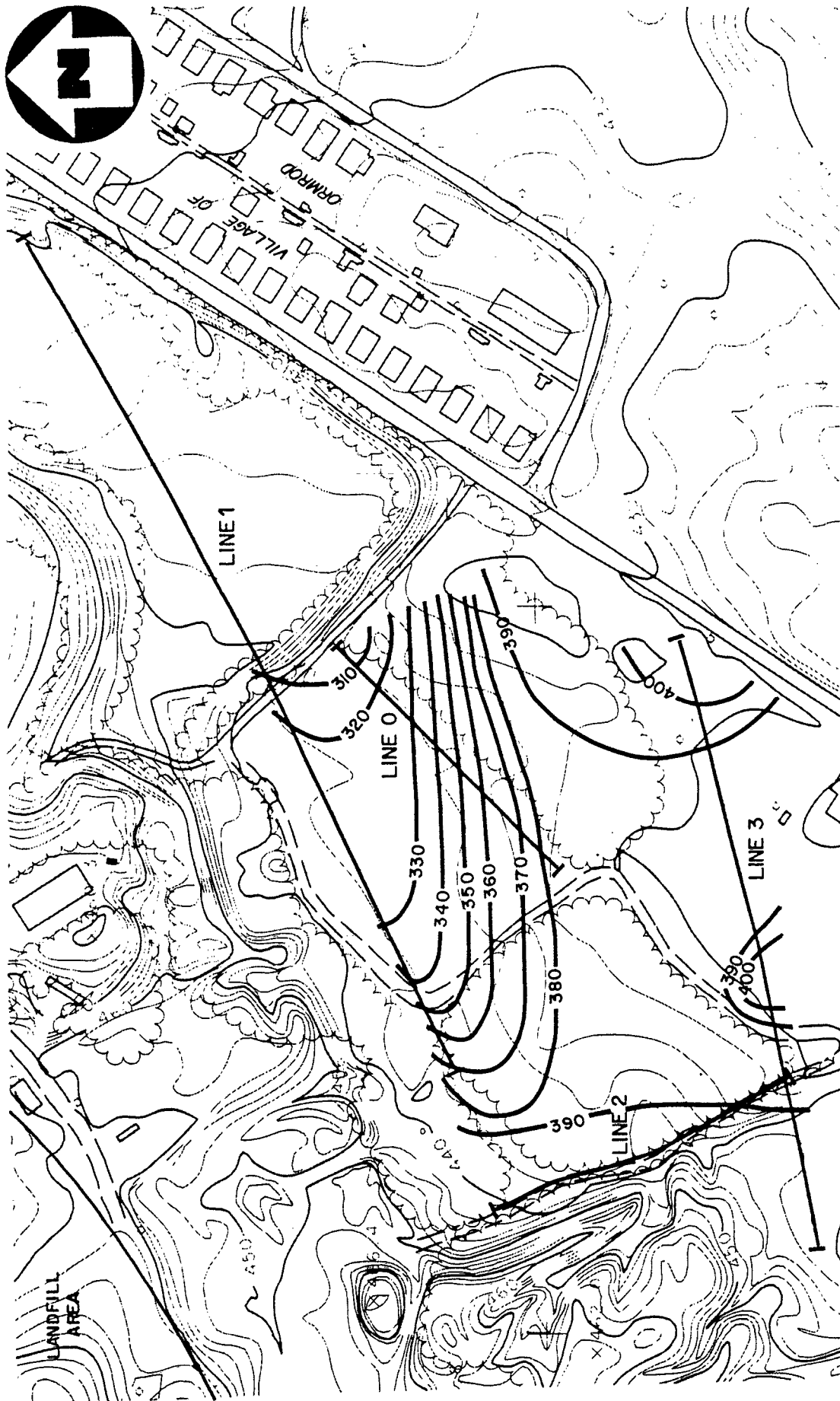
An intermediate layer lies at depths of 7 to 143 feet. It attains its maximum thickness and depth along the northeast half of Line 1, and pinches out toward the southwest, along Lines 0 and 1. It is visible only in small areas across Line 2. This layer has an average seismic wave velocity of 5,600 to 6,700 ft/sec, which is typical of sediments and clean fill.

The approximate bedrock surface is at a depth ranging from 18 feet along the middle of Line 3, to 143 feet at the northeast end of Line 1. Seismic wave velocities for this layer are between 13,000 and 16,300 ft/sec. These velocities are indicative of relatively unfractured limestone and dolomite. A contour map of this bedrock surface is shown in Figure 3-2.

Data from Lines 2 and 3 suggest a transitional zone of steadily increasing velocity between the middle layer and bedrock. This may indicate fractured bedrock in these areas. Lines 0 and 1 do not show this transition.

Porosity of the bedrock surface was calculated using M. R. J. Wyllie's time-average equation (Wyllie, et al., 1958). This equation calculates porosity based on observed and experimental seismic velocities.

The porosities of limestone and dolomite average approximately 10 to 20 percent (Telford, Geldart, Sheriff, and Keys, 1982). Bedrock under Line 1 has a calculated porosity of 9 percent, indicating that the bedrock is relatively unfractured. Data from Lines 2 and 3 yielded porosities of 15 to 20 percent. From this, it can be concluded that the bedrock in the southwestern portion of the seismic survey area has a higher degree of fracturing. This area also coincides with the fault zone mentioned in the Geology and Hydrogeology, Section 4, indicating possible faulting.



ORIGINAL
(Red)

FIGURE 3-2



A Halliburton Company

BEDROCK ELEVATION
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

SCALE 1" = 200'

3.2.2 EM Survey

Under certain conditions conductivity and resistivity surveys are capable of detecting inorganic contamination. Organic chemicals, however, are generally nonpolar and, therefore, cannot be detected by these types of surveys.

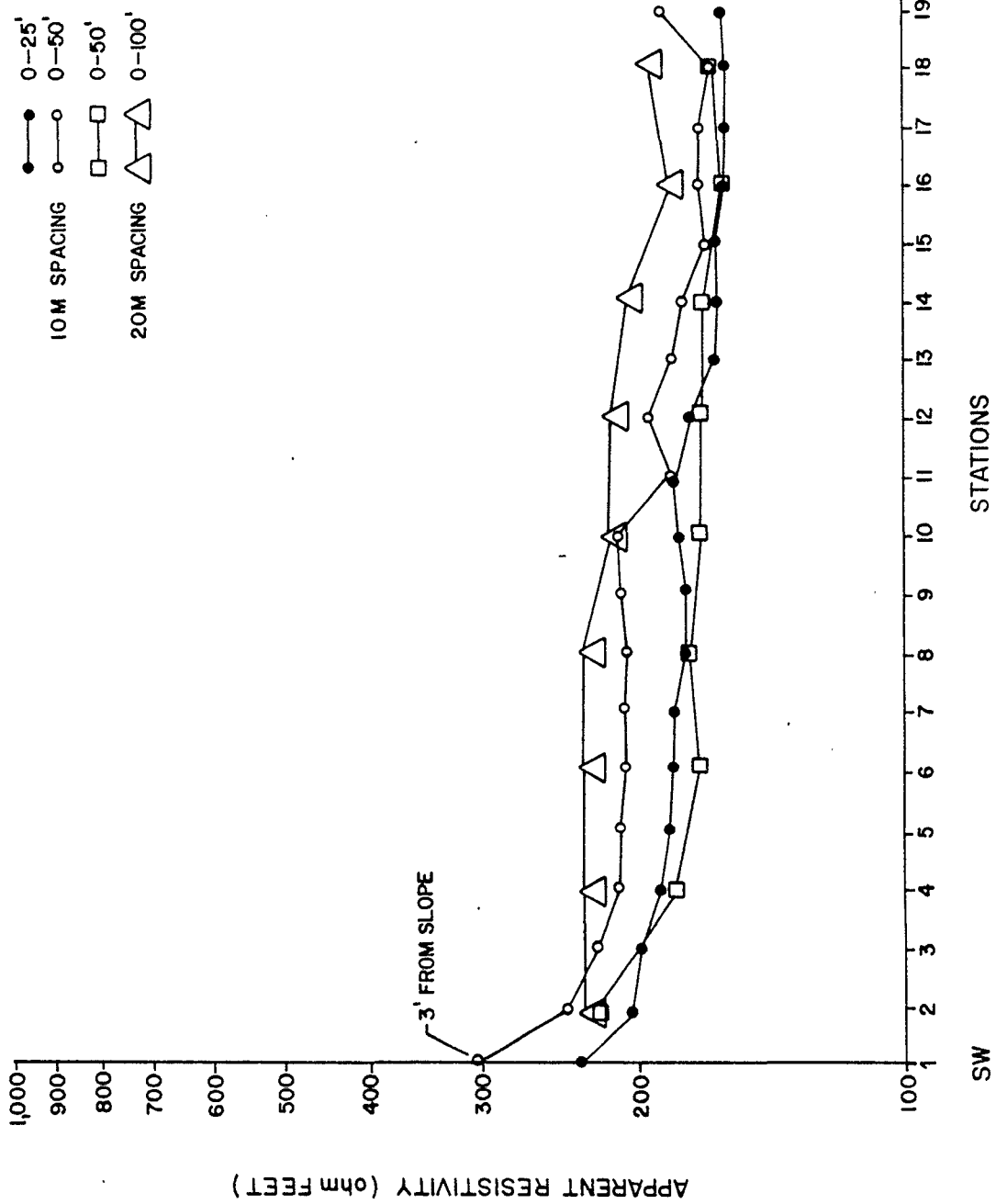
At all EM survey locations, conductivity values were relatively consistent over the range of 150 to 300 ohm-feet. The background lines to the north of the site exhibited similar readings. Figure 3-3 shows the EM profile of Line 8, located in the upper field, southeast of the site. This line was surveyed with both 10 and 20 meter intercoil spacings, allowing coverage to a depth of approximately 100 feet. This profile is typical of homogeneous unconsolidated material. Contour maps based on monitoring well data indicate that water is present at a depth of 15 to 25 feet in the area of EM Line 8. This roughly coincides with the boundary between Seismic Layers 1 and 2 (DN 0760.15-01). Slight saturation of this entire layer would result in conductivity readings as measured. Data from other lines, located in the lower field, indicated a similar situation.

The uniformity of the conductivity data precludes the definition of any possible inorganic contaminant plume.

3.2.3 VES Survey

Vertical electrical sounding locations are shown in Figure 3-4. Soundings 1 and 5 were performed north of the site, in order to determine possible background resistivity values. These soundings produced values of 300 to 500 ohm-feet to a depth of approximately 10 feet, then slowly increasing to greater than 1,000 ohm-feet at depths below 100 feet.

Sounding data from VES 2 and VES 4 are shown in Figure 3-5. Both soundings exhibit apparent resistivities of 290 to 350 ohm-feet near the surface. VES 2 increases to approximately 600 ohm-feet at a depth of 75 feet, while VES 4 data increases to greater than 1,000 ohm-feet at a similar depth. VES 3 exhibited similar readings, with resistivity approaching 2,000 ohm-feet at 100 feet depth.



ORIGINAL
(Red)

FIGURE 3-3



EM PROFILE, LINE 8
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

ORIGINAL
(Red)

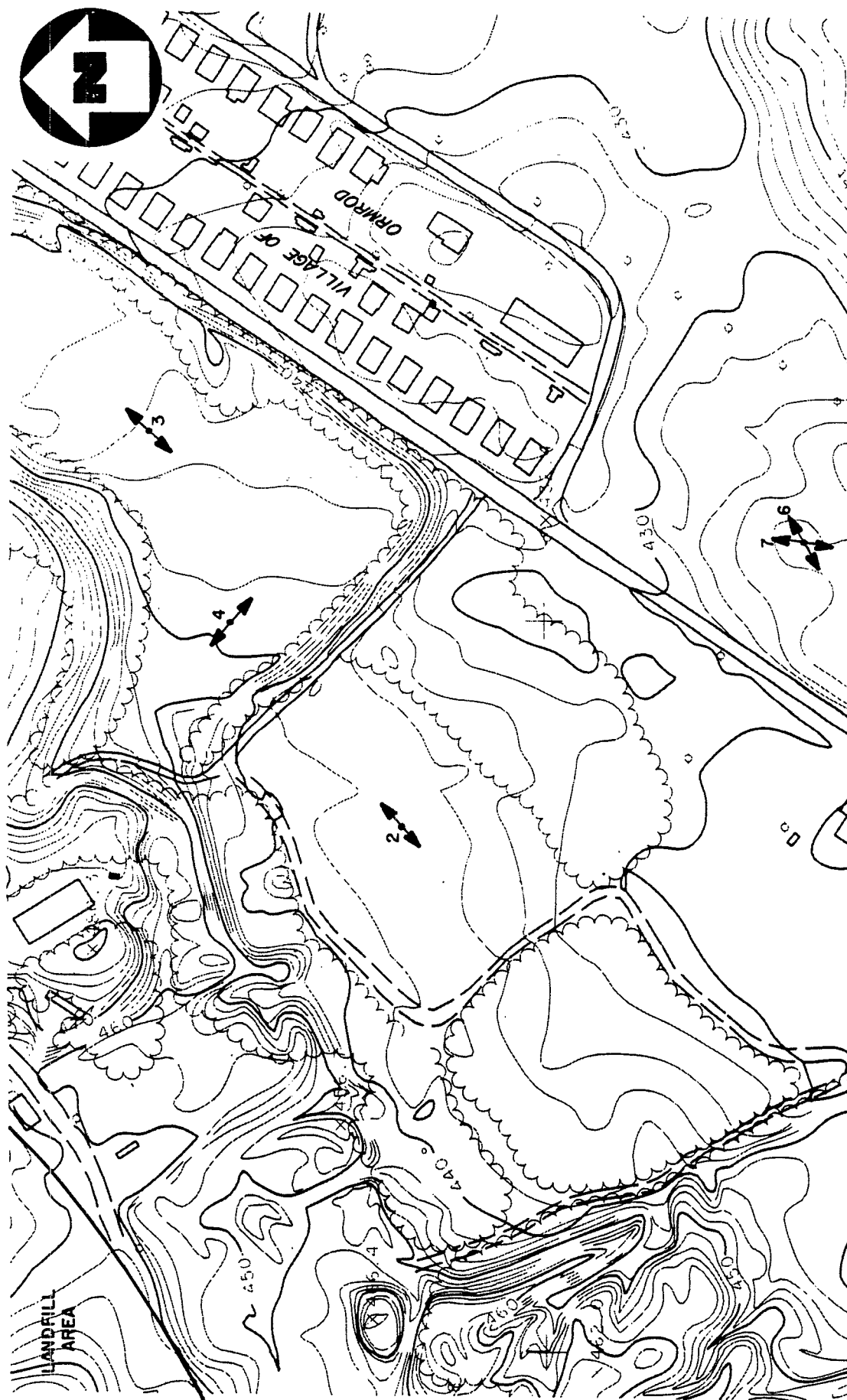
FIGURE 3-4

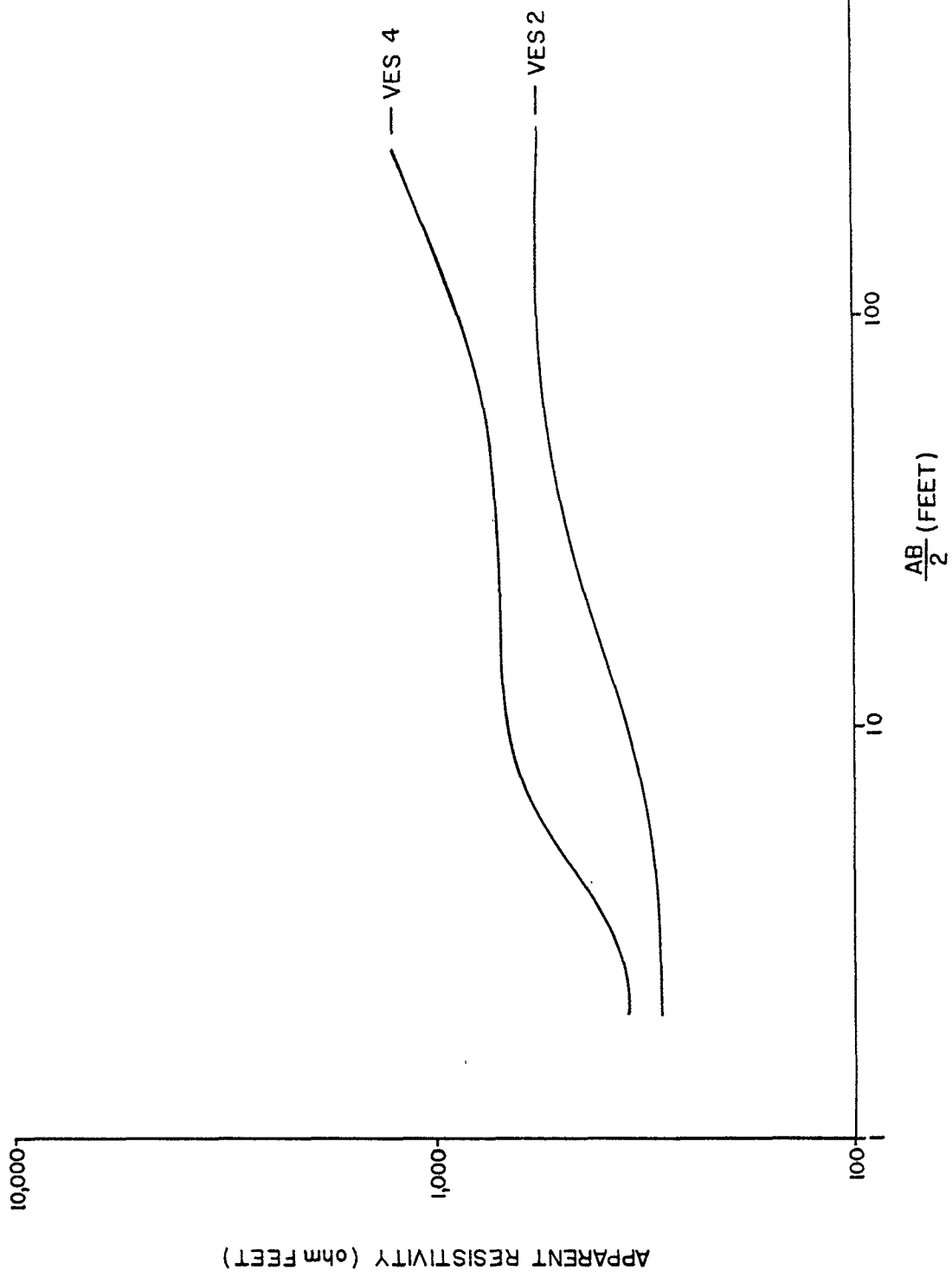


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A Halliburton Company

VES LOCATIONS
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

SCALE 1"=200'





3-8

AR300219

ORIGINAL
(Red)

FIGURE 3-5



VERTICAL ELECTRICAL SOUNDINGS
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

Soundings 6 and 7 were performed downgradient in the direction of groundwater flow. They were placed in the plowed field across the road from the site in an attempt to track the flow of a possible contaminant plume. Results from these soundings are much the same as those of soundings 2, 3, and 4. The similarity between values of the background and downgradient survey data sets indicate that there is no detectable inorganic contaminant plume moving in this direction.

3.3 Conclusions

Chemical analyses of monitoring well samples indicate that a contaminant plume may be moving southward through the area in which the geophysical surveys were performed. The contaminants were thought to be flowing through fault zones trending southward away from the site. Seismic Line 1, placed in such a way as to cross any such fault, found the bedrock to be very flat and at a depth of about 140 feet. This does not preclude the existence of a fault, but indicates that a jutting fault block is not present, probably because of previous mining activities. Seismic and drill hole data suggest that this survey area is a filled quarry.

Lines 2 and 3 seem to show a transition zone of increasing velocity, indicative of fractured bedrock. These fractures could allow downward migration of contaminants into bedrock. Lines 0 and 1, however, do not clearly show a zone of fracturing; therefore, in the area of these lines, the bedrock surface is much more competent, and contaminants cannot migrate vertically below this surface.

Conductivity and resistivity surveys performed in the survey area suggest that the unconsolidated material is homogeneous, at least to a depth of approximately 100 feet, the lower limit of these surveys. If these were natural sediments, resistivity would be expected to change with depth, due to compaction over long periods of time. An area recently filled with mine tailings, however, would exhibit relatively constant resistivity values throughout its thickness.

These surveys also indicate that there is no inorganic contaminant plume flowing southward from the landfill. Based on these survey results, nothing can be determined concerning the presence of an organic contaminant plume. However,

chemical analyses of monitoring well samples indicate that a contaminant plume may be moving southward through the area in which the geophysical surveys were performed.

No available maps clearly show an active or abandoned quarry in this exact area. Miller, et al. (1942), show an abandoned quarry in this vicinity, as well as those others mentioned in the Geology and Hydrogeology, Section 4, but because of the small size of their map, it is difficult to locate this quarry exactly on a current map.

AR300222

4.0 GEOLOGIC AND HYDROGEOLOGIC INVESTIGATIONS

Geologic and hydrogeologic investigations performed by NUS at the Heleva Landfill Site focused on determining subsurface geologic conditions, groundwater flow paths, and mechanisms of contaminant transport. The work included a literature review to understand site conditions and develop a drilling program, monitoring well installation, and geologic mapping. The work performed before this Remedial Investigation (RI) at the site is summarized in Section 4.1. The NUS geologic and hydrogeologic investigations are discussed in Section 4.2. Sections 4.4 and 4.5 discuss the general characteristics and properties of the regional and local geology and hydrogeology based on the findings from the NUS and previous investigations. Chemical data for the local groundwater and its relationships to groundwater conditions are in Section 4.5.

4.1 Previous Geologic and Hydrogeologic Investigations

Many reports have been written about the geology of Lehigh County and northeastern Pennsylvania. Primarily this interest has been due to economic quantities of cement grade limestone, aggregate, brown hematite, and zinc. Selected references include Prime (1875, 1878), Lesl y (1883), Miller (1926, 1934, 1937, 1941, 1944), Stose and Jonas (1935), Sherwood (1964), Drake (1968, 1969), and Geyer and Wilshausen (1972). These reports deal entirely with the stratigraphy, structural geology, and economic geology of the region. The detailed list of references is located in the References section.

Hydrogeologic research has been limited in the area; however, information is available on a regional scale. Several selected references are Meisler (1963), Wood, et al. (1972), Poth (1972), Parizek (1976), Wood and Machachian (1978), and The Delaware River Basin Commission (1982).

Site-specific geologic and hydrogeologic investigations were conducted by Nassaux-Hemsley, Inc., for Mr. Stephen Heleva, the owner of the landfill, to obtain information for an application for a State permit to operate the site. During the period 1974 to 1981, fifteen wells were installed at the site to determine geologic

and hydrogeologic conditions. Drill logs for 13 of the wells are included in Appendix E; however, exact location coordinates are not available. Approximate locations are on DN 0760.16-01, which is included in a pocket at the back of this report.

4.2 Methods of Investigation

The investigation conducted by NUS characterized the geology/hydrogeology of the Heleva Landfill Site by employing four methods: a review of pertinent literature, a drilling program, a well installation program, and a field mapping program. These methods are summarized in the following section.

4.2.1 Literature Review

A literature review was conducted by obtaining numerous reports on the region from 1875 to 1982. Selected references used are noted in Section 4.1. The complete citations are presented in the Reference section.

From the literature review, additional knowledge was gained concerning the direction of groundwater flow, structure and stratigraphy, and the previous mining history. This information was utilized in developing the boring program for the site.

Of particular interest was the discovery of abandoned iron ore mines in the study area. Two of these pits are believed to underlie the landfill. The literature search also indicated that the site has very complex structure, as the rocks are highly folded and faulted.

4.2.2 Drilling and Sampling

The drilling program for this study consisted of twenty holes drilled around the Heleva Landfill Site during April of 1984 (DN 0760.16-01). The wells were placed in locations to acquire upgradient and downgradient sampling sites, as determined by results of previous studies. Two wells were installed where water was present in unconsolidated materials and rock. The unconsolidated material consists of natural

soil, and till and mine tailings (waste). An effort was also made to intercept the pathway from the landfill to the spring in the quarry, where previous investigations found high TCE levels. Well locations MW7A,B, MW8A,B, and MW12A,B were located to intercept the pathway. Twelve of the holes were drilled into bedrock and ranged in depth from 40 to 120 feet. The drill hole was advanced by 6-1/4 inch O.D., hollow stem augers to bedrock. The hole was then cased and advanced through bedrock by a 4-inch air hammer or NX coring. Bedrock competency and borehole integrity dictated whether the bore hole would be screened or not screened. Six of the twelve deep holes have been left as unscreened wells. The other six holes required installation of screen and riser pipe.

When a water zone was encountered in the soil during the drilling of a deep hole, a shallow hole was augered to the top of bedrock for well installation. Using this criterion eight shallow holes, ranging in depth from 20 to 53 feet, were installed. Well locations are shown on DN 0760.16-01, which is included in a pocket at the back of this report. Drilling logs, sample locations, and well completion diagrams are presented in Appendix E.

Samples were taken during drilling to aid in identifying the rock and soil types. Portions of MW-4B, 9B, 11B, and 13B were cored (NX-size) to collect intact rock samples. The remaining deep holes have grab samples from cuttings that represent 5-foot intervals for the entire depth of the hole. Due to the complex structural geology (faulted and fractured rock), in some instances drill return was lost; therefore, there are no samples for those intervals. Holes with significant loss of return fluids or air included MW-3B (40') and MW-5B (40'). All holes were logged during drilling and logs were recorded.

Split-barrel samples and blow counts were taken in the soil interval at locations prescribed by the site geologist at all deep holes, with the exceptions of MW-11 and 12. At these two distant locations, only grab samples were taken because of the drilling method (air rotary) used.

4.2.3 Well Installation

The well screen slot size, selected by sieve analysis, for NUS-installed wells was No. 6 slot (0.006 inch). The screens were two-inch I.D., stainless steel. Ten-foot lengths of screen were placed in all screened wells, with the exception of MW-11B, which has an 8-foot length. Casing consists of various lengths of 2-inch threaded flush joint stainless steel pipe. All screened wells have approximately 2-foot stickup.

Gravel packs consisted of clean, siliceous sand with a "00" grain size (0.02 inches). The sand was placed around the screen and at least 2 feet above the top of the screen. Approximately 25 pounds of bentonite pellets were then placed on top of the sand, followed by backfilling the remaining annulus with gravel. Completion diagrams for all wells are in Appendix E.

Deep holes that did not require screening were left unsecured. Four-inch I.D. lengths of galvanized steel casing were installed through the soil and at least two feet into bedrock and were cemented in place. Remaining drilling was performed through this permanent casing to the desired depth.

Six-inch diameter carbon steel protective casings, of approximately 5-foot lengths, were cemented in place around all well heads. The protective casings have lockable caps, are painted orange, and are numbered.

All wells were developed by surging with compressed air until clear water was obtained. Soil wells occasionally needed to have potable water pumped into them during development, due to extremely slow recovery rates. Wells were used to obtain groundwater elevations, groundwater samples, and aquifer conductivities. Table 4-1 summarizes the details of NUS monitoring wells.

4.2.4 Field Mapping

Highly fractured bedrock resulted in poor sample recovery during drilling. Therefore, additional field work was required to obtain needed geologic

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TABLE 4-1

SUMMARY OF MONITORING WELL COMPLETIONS
HELEVA LANDFILL SITE

<u>Well Number</u>	<u>Well Depth (Feet)</u>	<u>Stick Up (Feet)</u>	<u>Well Elevation (Feet, MSL)</u>	<u>Screen Interval (Feet)</u>	<u>Open Well Interval (Feet)</u>	<u>Top of Bedrock Elevation (Feet)</u>
MW-2A	19.0	1.91	473.37	8.5-18.5	-	-
MW-2B	43.5	2.05	473.55	34-44	-	450
MW-3B	70.0	1.80	471.57	-	39-70	436
MW-4B	120.0	2.12	478.56	-	20-120	465
MW-5B	68.0	1.72	470.65	-	14-68	457
MW-6A	55.5	1.32	442.54	45.5-55.5		
MW-6B	85.0	1.95	443.31	-	50-85	386
MW-7A	24.0	2.39	441.41	9-19	-	-
MW-7B	65.0	2.33	441.78	55-65	-	412
MW-8A	37.0	1.90	431.16	27-37	-	-
MW-8B	75.0	1.79	430.70	-	50-75	381
MW-9A		2.20	440.48	38-48	-	-
MW-9B	70.5	1.72	440.19	56-66	-	393
MW-10B	68.0	2.30	458.38	58-68	-	445
MW-11A	39.0	2.36	431.86	29-39	-	-
MW-11B	51.0	2.39	431.88	43-51	-	391
MW-12A	45.0	1.82	431.66	35-45	-	-
MW-12B	63.0	2.29	431.94	53-63	-	383
MW-13A	51.5	2.06	488.69	41-51	-	-
MW-13B	85.5	1.48	487.68	-	58-85.5	435

Note: This is a summary of all of NUS wells installed at the site.

information. NUS field geologists visited limestone quarries and rock outcrops in the vicinity of the Heleva Landfill Site to obtain this information. Physical measurement of rock structures, using a pocket transit compass, showed the geologic structure that was mapped on a standard 7-1/2 minute U.S.G.S. topographic map. These results and those found in the literature review aided in understanding the complex structural geology of the area.

4.3 Regional Geology

4.3.1 Stratigraphy

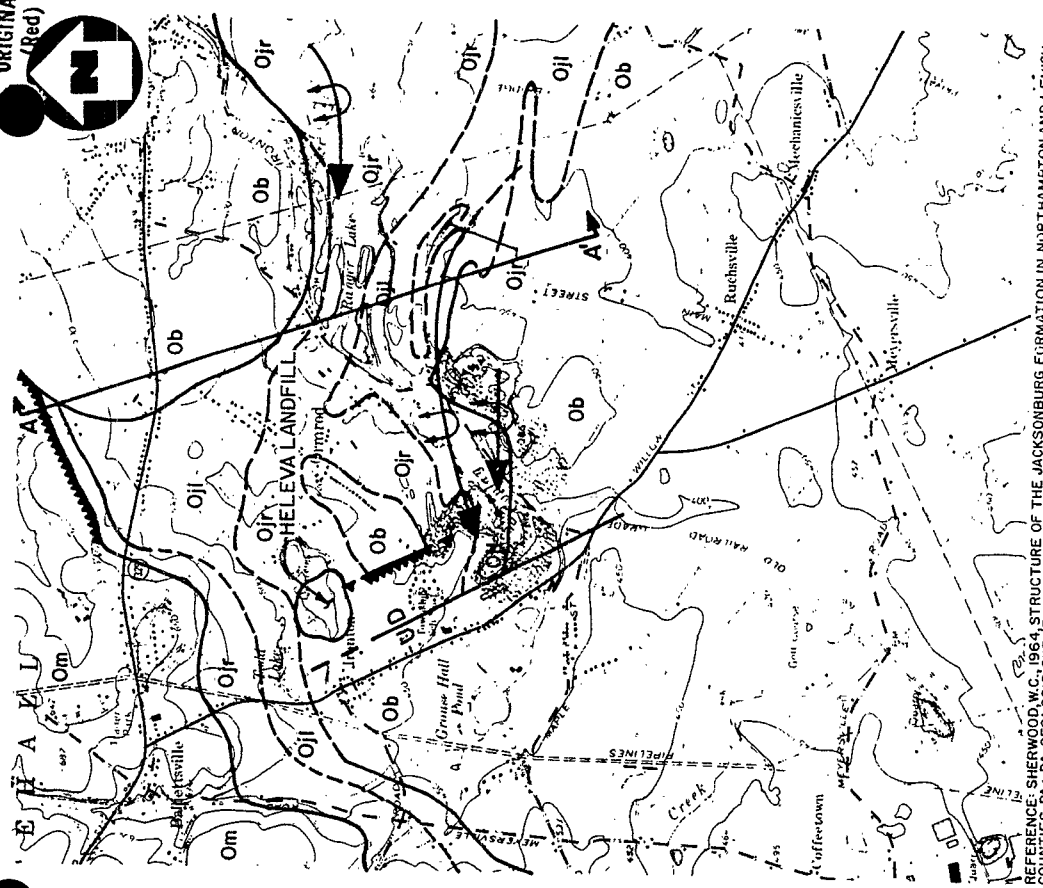
The Heleva Landfill Site is located in the Great Valley Section of the Valley and Ridge Province of Eastern Pennsylvania. The site is immediately underlain by sedimentary rocks of Ordovician Age which may be as thick as 4,000 feet. The regional geologic map is presented in Figure 4-1. The rocks are described in subsequent text from youngest to oldest. Faulting and folding in the area has sometimes caused a disruption of the sequence.

The youngest rock observed was a shale of the lower Martinsburg Formation. This unit was found in a road cut north of the site. This confirmed that the Martinsburg outcrops considerably north of the site.

At the time of deposition, the Martinsburg Formation at the Heleva Landfill Site was conformably over the Jacksonburg Formation. Subsequent organic activity has complicated the stratigraphic relationship of these units. In the area of the Heleva Landfill Site, two facies, distinct lithologic units of the Jacksonburg, are apparent. The upper facies is the cement rock and is a dark gray to black argillaceous (clayey) limestone. This unit is thinly bedded and has a slatey cleavage. Calcite and quartz are commonly found in veins in rocks at the Heleva Landfill Site, paralleling bedding or filling tension fractures typical of this type of geology and structural history.

The cement rock grades (a gradual change from one rock type to another) down into the underlying cement limestone facies. This rock is generally gray to black

ORIGINAL
(Red)



REFERENCE: SHERWOOD, W.C. 1964. STRUCTURE OF THE JACKSONBURG FORMATION IN NORTHAMPTON AND LEHIGH COUNTIES, PA.: PA GEOLOGIC SURVEY, REPORT 645.

FIGURE 4-1



MARTINSBURG FORMATION

Om	Slate
Oms	Sandstone
Oml	Limestone

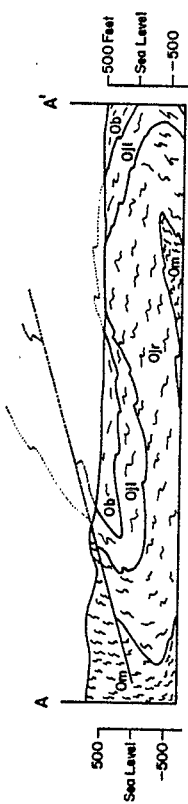
JACKSONBURG FORMATION

Ojr	Cement rock facies-Argillaceous limestone
Ojl	Cement limestone facies-bedded limestone

BEEKMANTOWN GROUP

Ob	Bedded dolomite
Obd	Dolomite, limestone, and chert

ORDOVICIAN



LEGEND

- Contact (Dashed where gradational or approximate)
- Thrust fault (Dashed where approximate)
- Unclassified fault (Dashed where inferred)
- Bearing and plunge of axis of overturned anticline
- Line of cross section
- Normal fault with up(U) and down(D) displaced blocks

REGIONAL GEOLOGIC MAP
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA
HORIZONTAL SCALE: 1"=2000'

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and crystalline. It has a massive bedding, and is a calcarenite (a limestone with crystalline texture).

Underlying the Jacksonburg Formation is the older Beekmantown Group. A disconformity divides these units according to previous investigations. The Beekmantown is a light brown-gray dolomite (magnesium-rich limestone). It has massive bedding and is extremely hard. Locally, it was observed to contain calcite-filled vugs (former cavities or holes in the rock).

4.3.2 Structure

Extensive and extreme folding and faulting has deformed all of the rocks in the area. This deformation was caused by our tectonic episodes, the last during the Triassic period, which uplifted Precambrian rocks south of the area near Reading, Pennsylvania.

The deformation occurred at the same time as the formation of iron ore deposits in the area. Hydrothermal fluids flowing along fractures enriched the limestones with lowgrade iron ore deposits. In places, these deposits were economical and were mined at the site.

The Heleva Landfill Site area is located at the southern end of a very large recumbent anticline or nappe, which trends northeasterly into New Jersey. A recumbent fold is one in which the axial plane is horizontal, and younger rocks can be found below older ones. Because of subsequent erosion, only remnants of this feature are present today, as illustrated in Figure 4-1. The site area is situated on a remnant of the lower limb of this nappe. Hence, the younger Jacksonburg Formation is found underneath the older Beekmantown Formation. Complicating the structure further is a fault that parallels Main Street, Ironton. To the west, this fault placed the Beekmantown dolomite adjacent to Jacksonburg cement rock (Figure 4-1).

Extensive joint sets are also common. Primary, secondary, and tertiary sets were measured in the field. Primary sets appear to be subparallel to the axis of the

nappe, while secondary and tertiary sets depend on local structure and lithology (DN 0760.16-01).

This large nappe was formed as a result of several orogenies, the greatest during the Appalachian orogeny during the Permian Period. Final tectonic activity that deformed the rocks in this region occurred during the Triassic Period.

4.3.3 Hydrogeology

The regional hydrogeology varies greatly in the Allentown area. Water availability is affected by rock type, fracture spacing, and precipitation changes. The majority of the fresh water supplies are within 1,000 feet of the surface, and wells less than 300 feet in depth typically supply enough water for domestic use. The most productive rocks are the carbonates.

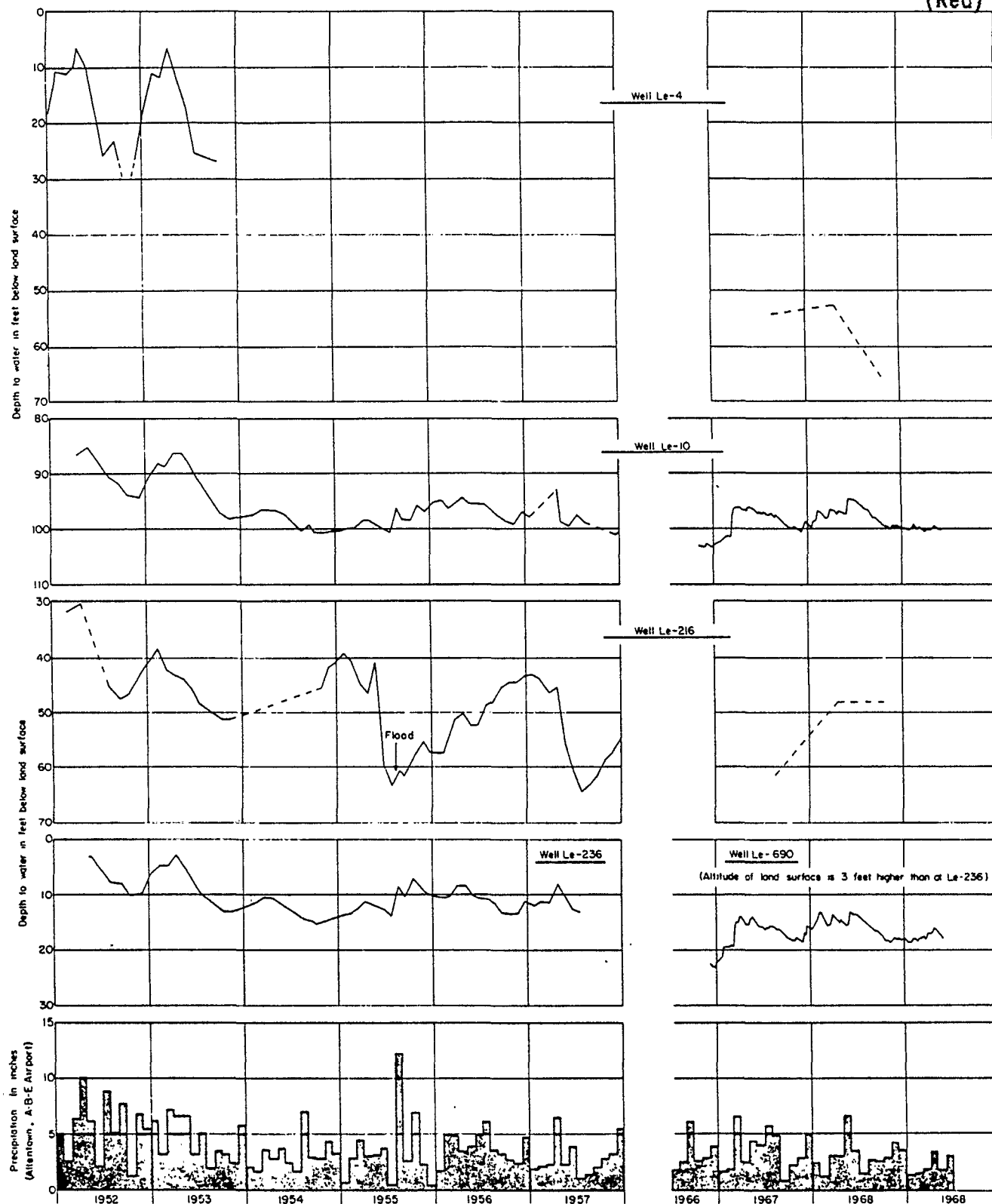
The Martinsburg Formation, which is a noncarbonate fine-grained rock, is composed of three members of similar hydrogeologic characteristics. Median yields of slightly less than 50 gallons per minute (gpm) and specific capacities of 0.5 gallons per minute (gpm) per foot of drawdown are reported for wells open to the formation.

The Jacksonburg Formation is subdivided into an upper cement rock facies (thin-bedded argillaceous limestone) and a lower cement limestone facies (thick-bedded crystalline limestone). The median specific capacities for these units are reported as 0.22 and 5.0 gpm per foot of drawdown, respectively. The cement rock facies has a median yield of 25 gpm, whereas the cement limestone facies is 300 gpm.

The Beekmantown Group is a dolomite with interbedded limestone with nodular chert zones. This unit has a median specific capacity of 34 gpm per foot of drawdown. A high median yield of 1,000 gpm has been recorded for this unit.

Groundwater in the region is highly responsive to precipitation. Figure 4-2 is an example of hydrographs for wells in the carbonate rocks in the region. This

ORIGINAL
(Red)



NOTE: FROM WOOD C. R. et. al., 1972, WATER RESOURCES OF LEHIGH COUNTY, PA: WATER RESOURCES REPORT 31, PA GEOLOGICAL SURVEY.

REGIONAL CARBONATE ROCK WELL HYDROGRAPHS
HELEVA LANDFILL SITE,
NORTH WHITEHALL TWP., PA

4-10

FIGURE 4-2



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diagram depicts the seasonal and annual changes in water levels and the precipitation recorded at the Allentown-Bethlehem-Easton Airport. There is a strong correlation between depth to water and precipitation. During high periods of precipitation, the depth to water is shallower than during dry periods. Some wells show annual fluctuations greater than 20 feet.

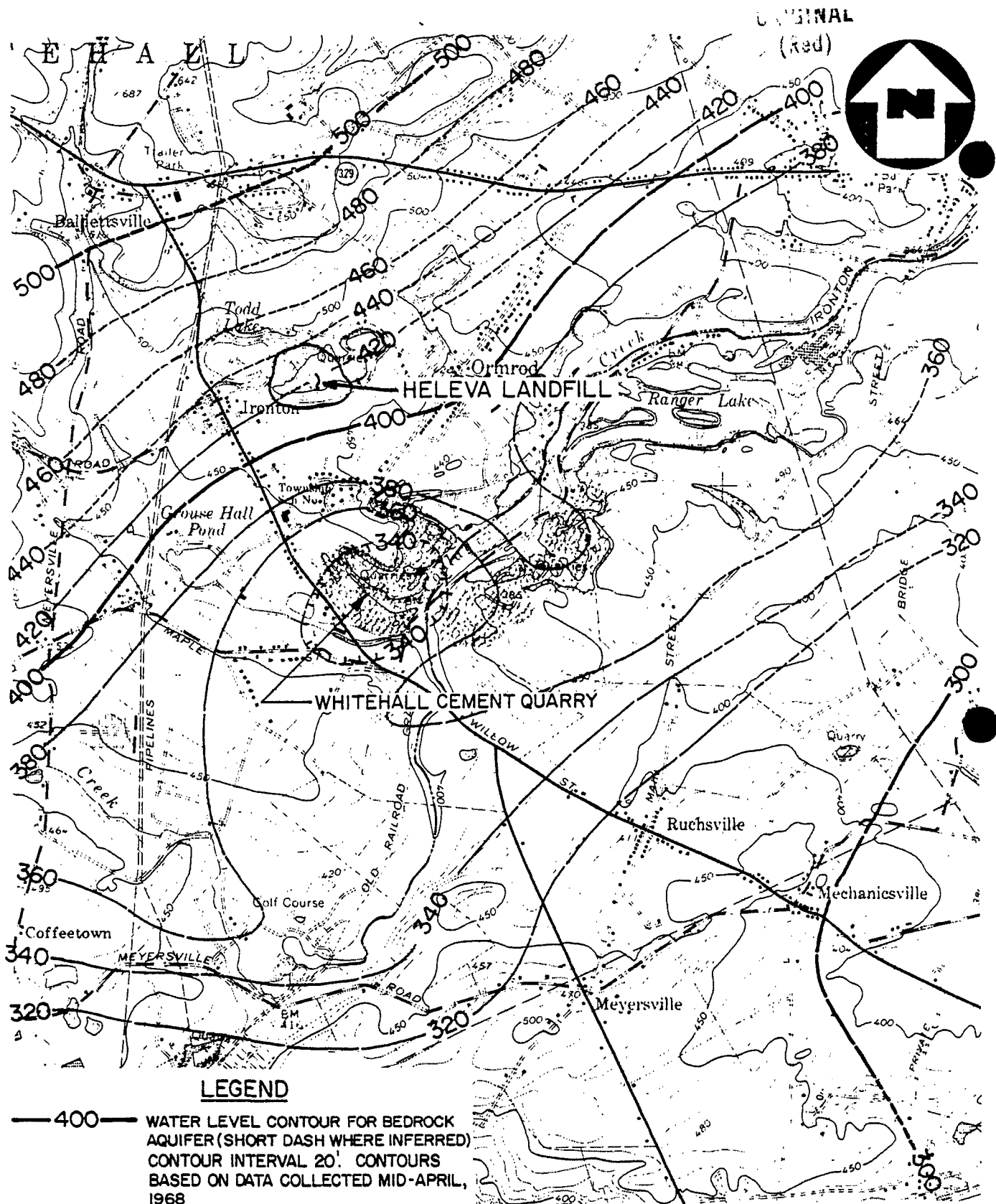
A regional water-table map for the carbonate rocks was developed from water levels in mid-April, 1968. An excerpt of this map is presented in Figure 4-3. The map indicates a southeasterly flow of groundwater. A large cone of depression is observed around a quarry, just south of the Heleva Landfill Site. All of the groundwater entering the quarry, which was active at that time, was being pumped out of the bottom of the quarry and into Coplay Creek. This pumping caused the depression and led to water levels more than 30 feet lower than water levels just a few hundred feet away from the quarry.

The regional contour map has an elongated depression that extends from Oreville to the Lehigh River. Poth and others (1972) suggested that large fractures in the carbonate rocks transmit underflow from Jordan (approximately 1.5 miles south of the site) and Coplay Creeks. They calculated that an average groundwater flow of 17 million gallons per day (MGD) from the Jordan Creek basin and 10 MGD from the Coplay Creek basin is transmitted to the Lehigh River by these fractures.

4.4 Site-Specific Geology and Hydrology

4.4.1 Geology

The drilling and field mapping program confirms the regional geology of the area. The site is located in very complex structural province that is characterized by thrust faults and overturned folds. Three major rock types present in the vicinity include the Martinsburg shale, Jacksonburg cement rock and cement limestone, and the Beekmantown dolomite. In addition to the complex structure, subsequent mining for iron ore and limestone has further complicated interpretation of the geology.



BASE MAP IS A PORTION OF THE U.S.G.S. CEMENTON, PA QUADRANGLE (7.5 MINUTE SERIES, 1964, PHOTOREVISED 1972). CONTOUR INTERVAL 20'. REFERENCE: WOOD, C.R., FLIPPO, H.N., JR., LESCINSKY, J.B., BARKER, J.L., 1972, WATER RESOURCES OF LEHIGH COUNTY, PA: WATER RESOURCES REPORT 31, PA. GEOLOGICAL SURVEY.

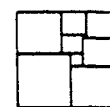
REGIONAL GROUNDWATER CONTOUR MAP

HELEVA LANDFILL SITE
NORTH WHITEHALL TWP., PA

SCALE: 1" = 2000'

4-12

FIGURE 4-3



NUS
CORPORATION



A Halliburton Company

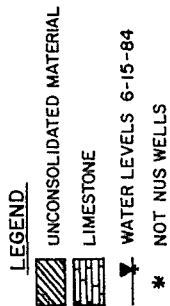
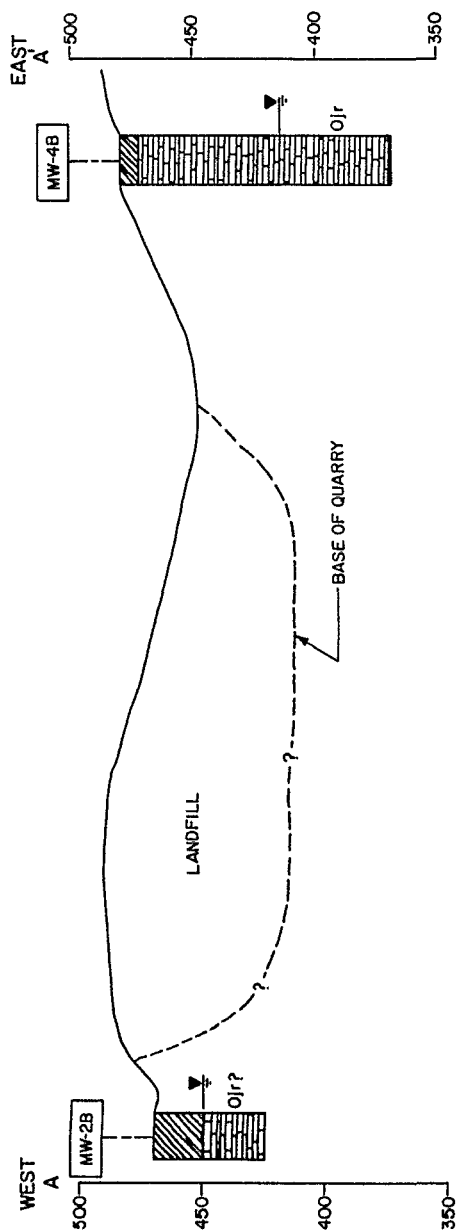
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Cross sections were constructed perpendicular (Figure 4-4) and parallel (Figure 4-5) to this axis. Figure 4-5 illustrates the interrelationships parallel to the direction of the groundwater flow.

Field mapping of the Whitehall Cement Co. Quarry immediately south of the site indicated a small thrust fault on the northernmost high wall of the quarry. The throw of the fault could not be determined; however, the fault line trended north toward the Heleva Landfill Site. The fault thrust the Jacksonburg cement limestone up and over the Jacksonburg cement rock. The northern extent of the fault appears to be between wells MW-4 and MW-10. Logs of the holes describe the rock in MW-4 to be Jacksonburg cement rock and rock in MW-10 to be Jacksonburg cement limestone.

During the literature search, a map of quarries at Iron-ton was found in Frederick Prime, Jr.'s "Report of Progress of Brown Hematite Core Ranges of Lehigh County," Pennsylvania Geologic Survey, 2nd Series, 1875. This map outlined three active brown hematite quarries within the Heleva Landfill Site. In 1875, quarry depths were on the order of 60 feet. Outlines at the quarries' edges shown on DN 0760.16-01, Prime (1875), indicate that the ore is actually altered slate beds that are interbedded in the dolomites and limestones of the area. These quarries underlie portions of the landfill and may contribute to the complex bedrock hydrology of the site. A local resident indicated that three shafts extend in a southeasterly direction from the landfill toward the town of Ormrod. No evidence for these shafts was found during the field investigation or literature.

Soil on site is believed to consist predominantly of fill containing mine spoil or tailings. However there is in-place till in the area. Puth (1972) reports Illinoian Till and Wisconsin drift in the region. Their importance as a water resource are minor. Mapping of these units has not been completed. As seen on the site map, elevated, flat areas surround the western and southern portions of the property. These flat areas probably delineate most of the spoil piles. Many of these areas, especially south of the site, were investigated by seismic refraction. Details of this study are presented in Section 3.0 (Geophysical Investigations).



NOTE: ALL SECTIONS LOOKING NORTH FROM WHITEHALL CEMENT CO. QUARRY. CROSS-SECTION LOCATIONS ARE ON DRAWING 0760.16-OI. MONITORING WELLS NOT TO HORIZONTAL SCALE.

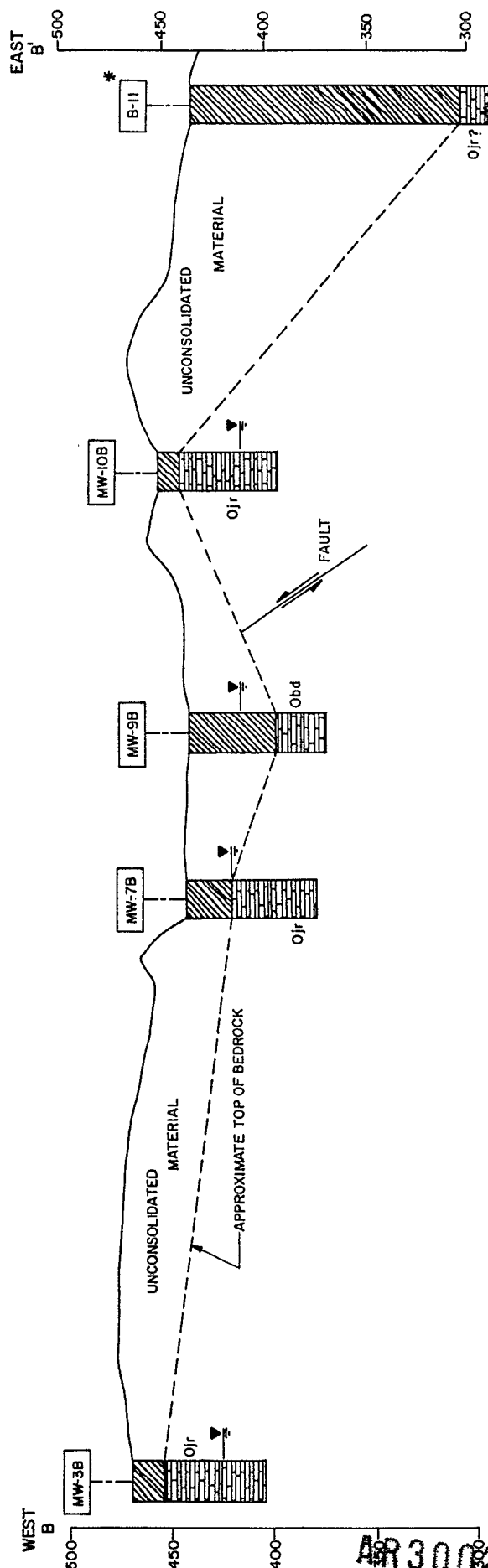


FIGURE 4-4



4-14

GEOLOGIC CROSS-SECTIONS A-A' AND B-B'
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA
SCALE: 1" = 50' VERT., 1" = 200' HORIZ.

AR 300236

ORIGINAL
(Red)

SEE DRAWING 0760.16-01 FOR CROSS-SECTION LOCATION

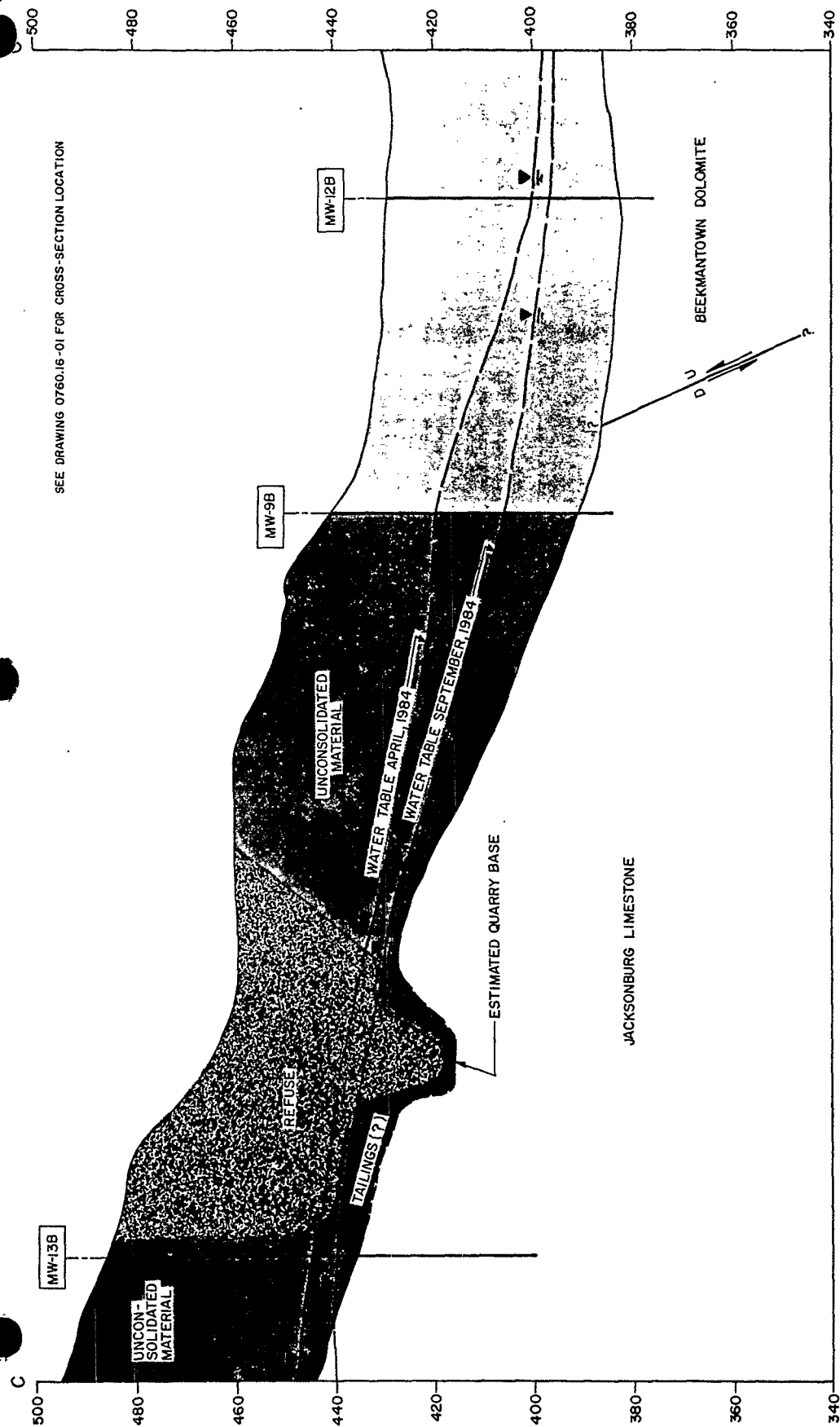


FIGURE 4-5

GEOLOGIC CROSS-SECTION C-C'
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP, PA

SCALE: 1" = 20' VERT., 1" = 200' HORIZ.



AR300237

4.4.2 Surface Water Hydrology

According to weather records, Heleva Landfill Site receives approximately 46 inches of precipitation annually. Evapotranspiration removes approximately 26 inches, while runoff accounts for about 16 inches. The remaining 4 inches recharge the groundwater system by percolation.

Water from the Heleva Landfill Site drains south into Coplay Creek, a tributary of the Lehigh River. The entire region is part of the Delaware River drainage basin. The site was previously quarried, as mentioned earlier in this report. Two water-filled quarries presently border the landfill. Observation of erosion gullies shows that surface water, in addition to groundwater, flows in both quarries. Additionally, the area immediately south of the landfill was excavated for cover. Erosion gullies trend south through the excavation and cause pools of surface water in the field below. Observations made during drilling indicated that the area tends to become marshy following a rain storm.

4.4.3 Hydrogeology

4.4.3.1 Groundwater Elevations

Groundwater elevations were measured in NUS wells during April, September, and October 1984. Results are listed in Table 4-2. All sets of measurements were taken by NUS technicians using a galvanometer. Groundwater elevation averaged 9 feet lower from April to October. Above-average rainfall during the spring may have caused water levels to be higher than normal in April, thus accounting for this large drop in the water table.

Groundwater flow has been altered significantly over the years. The Whitehall Cement Company had been pumping approximately 1,000 gpm from its quarry to the southeast portion of the site for over 15 years. Pumping ceased in mid-1983 when economic reserves were exhausted and the quarry was allowed to fill with water. When operations were terminated, the quarry had reached a depth of 300 feet.

ORIGINAL
(Red)

TABLE 4-2
WATER LEVEL MEASUREMENTS
HELEVA LANDFILL SITE

Water Elevations

<u>Well</u>	<u>April 1984</u>	<u>September 1984</u>	<u>October 1984</u>
MW-2A	462.23	---	457.31
MW-2B	456.10	---	450.19
MW-3B	435.06	420.08	415.68
MW-4B	412.82	407.20	403.77
MW-5B	429.06	413.52	409.47
MW-6A	416.58	403.54	402.05
MW-6B	417.27	404.30	402.76
MW-7A	---	---	---
MW-7B	414.29	404.78	401.79
MW-8A	411.80	401.81	400.73
MW-8B	412.56	404.01	398.38
MW-9A	415.24	405.30	402.30
MW-9B	415.15	405.43	402.29
MW-10B	412.04	405.08	402.49
MW-11A	401.57	395.21	394.00
MW-11B	401.34	395.53	394.09
MW-12A	400.94	394.05	393.14
MW-12B	399.47	394.20	392.80
MW-13A	446.40	444.00	441.79
MW-13B	445.82	443.32	441.71

--- Not Measured

AR300239

C. H. H. L.
(RCD)

The groundwater map of the Heleva Landfill Site in the Nassaux-Hensley, Inc., report of 1981 shows groundwater contours forming a concave pattern on the southeast corner of the map as shown on Figure 4-6. The depression, also present on the 1968 water contour map (Figure 4-3), was probably formed by pumping of the Whitehall quarry.

Since 1983 when pumping was ceased, groundwater flow has re-established the natural gradient to the east-southeast, rather than southeast toward the quarry. The groundwater contours in April 1984, September 1984, and October 1984 are shown on Figures 4-7, 4-8, and 4-9, respectively.

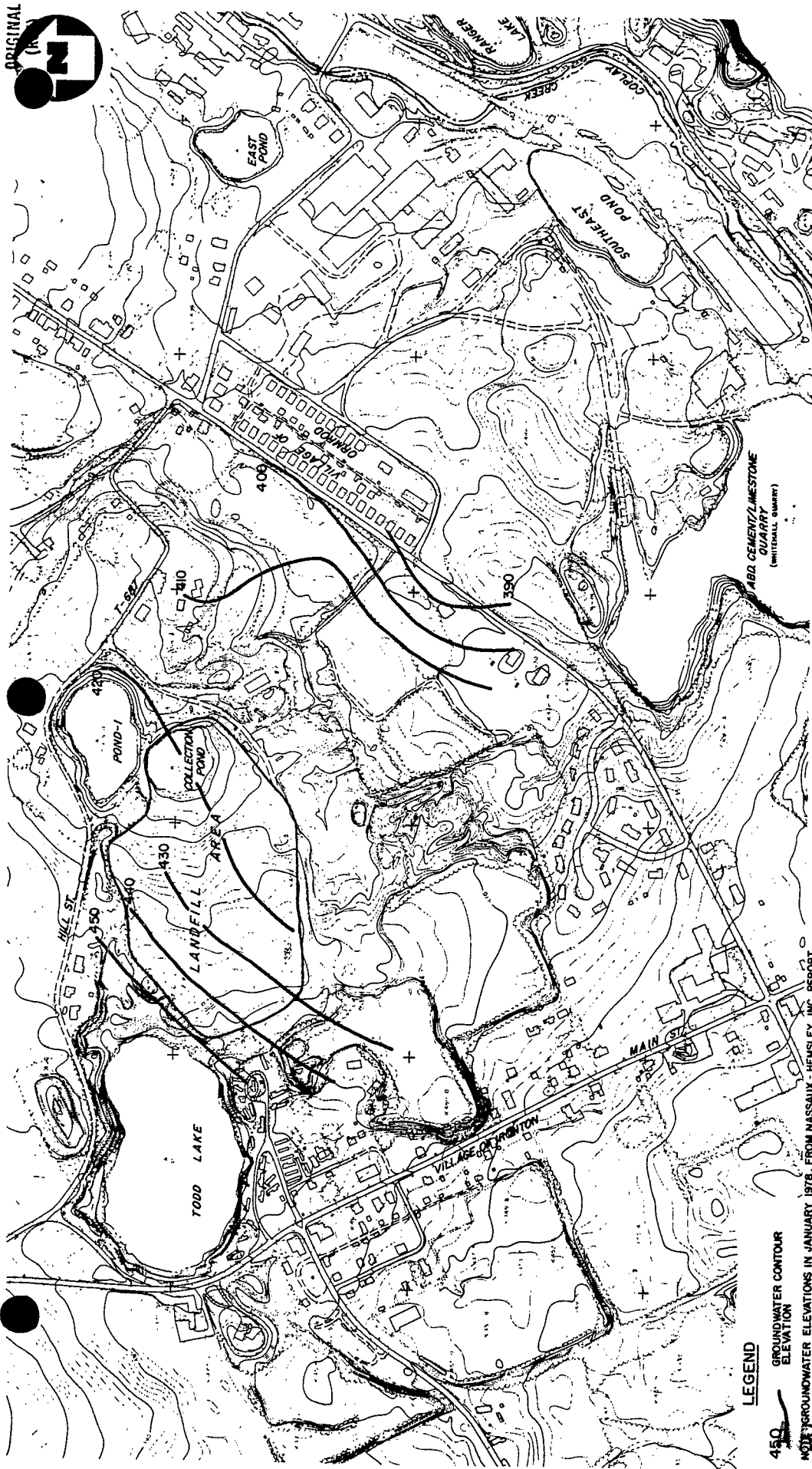
Groundwater elevations in clustered well locations (i.e., 2A and 2B, 6A and 6B, etc.) are nearly equal; therefore, the bedrock aquifer can be considered unconfined. Groundwater elevation maps should only be viewed as indications of regional flow direction. Actually, groundwater occurring in rock in this area moves through joint sets, faults, bedding planes, solution channels, and along cleavage planes, which may not always be parallel to the overall groundwater flow direction.

During the structural mapping at the Eastland Cement Quarry, located southeast of the site, only small quantities of water were present in the quarry pit. The base of the pit is apparently 80 feet below the surface of adjacent Ranger Lake. These observations indicate the strong impact that local structure has on water flow. At this location, the cleavage in the slaty cement rock prevents appreciable amounts of water from flowing across the cleavage planes and into the quarry.

4.4.3.2 Groundwater Flow

As seen on Figures 4-7, 4-8, and 4-9, groundwater flow is to the east-southeast. The piezometric surfaces between the April and September sampling rounds indicate that precipitation has a quick and substantial impact on the groundwater table.

Groundwater flow at the site occurs in both rock and unconsolidated deposits. Southeast of the landfill, the flow is through pores in the unconsolidated materials.



LEGEND

450 GROUNDWATER CONTOUR
ELEVATION

NOTE: GROUNDWATER ELEVATIONS IN JANUARY 1978, FROM NASSAUX - HENSLEY, INC. REPORT.

300241

FIGURE 4-6

GROUNDWATER CONTOURS JANUARY, 1978
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

SCALE: 1"=400'



4-19



A Halliburton Company

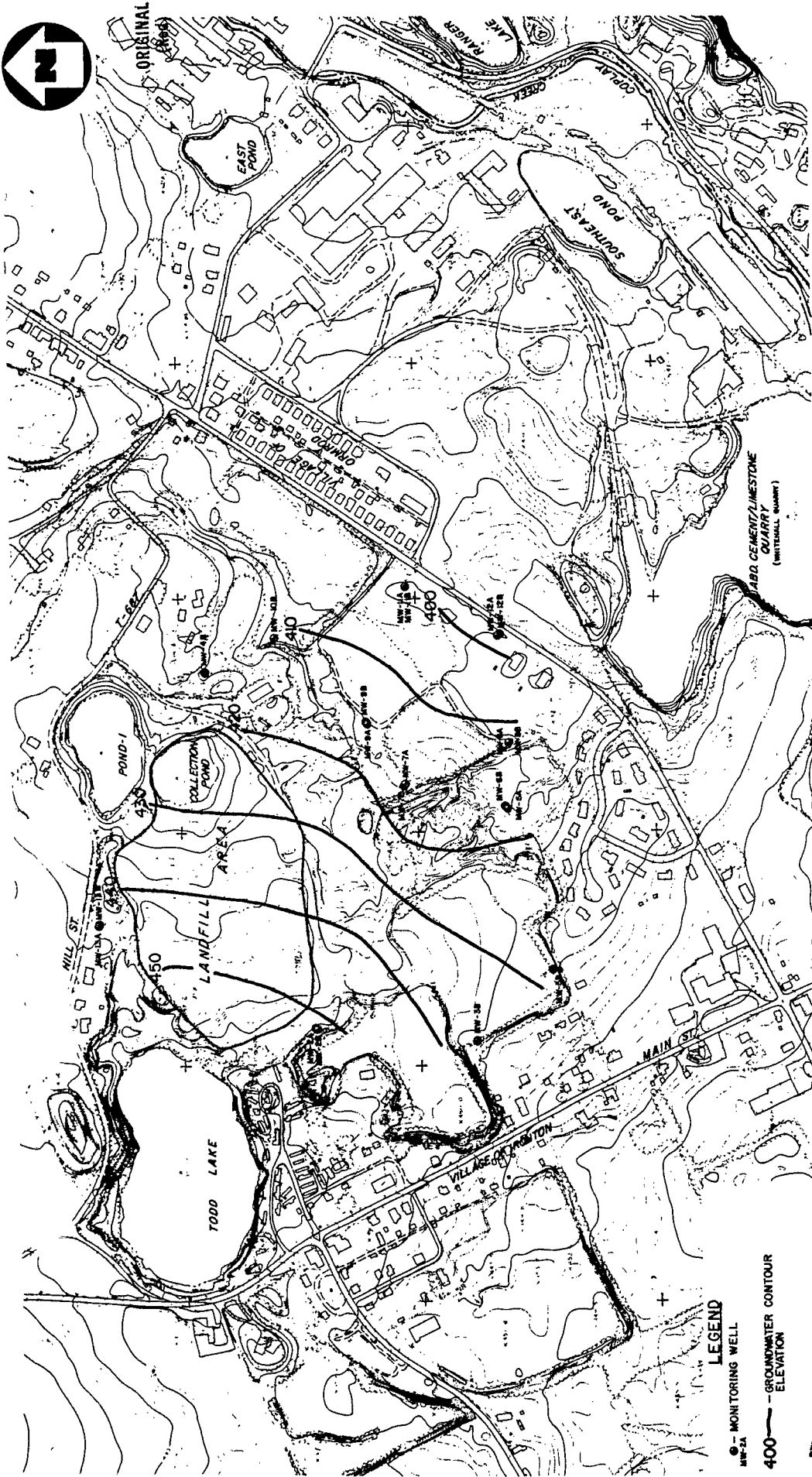


FIGURE 4-7



4-20

GROUNDWATER CONTOURS APRIL 23-29, 1984
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA.
SCALE: 1" = 400'

AR300242

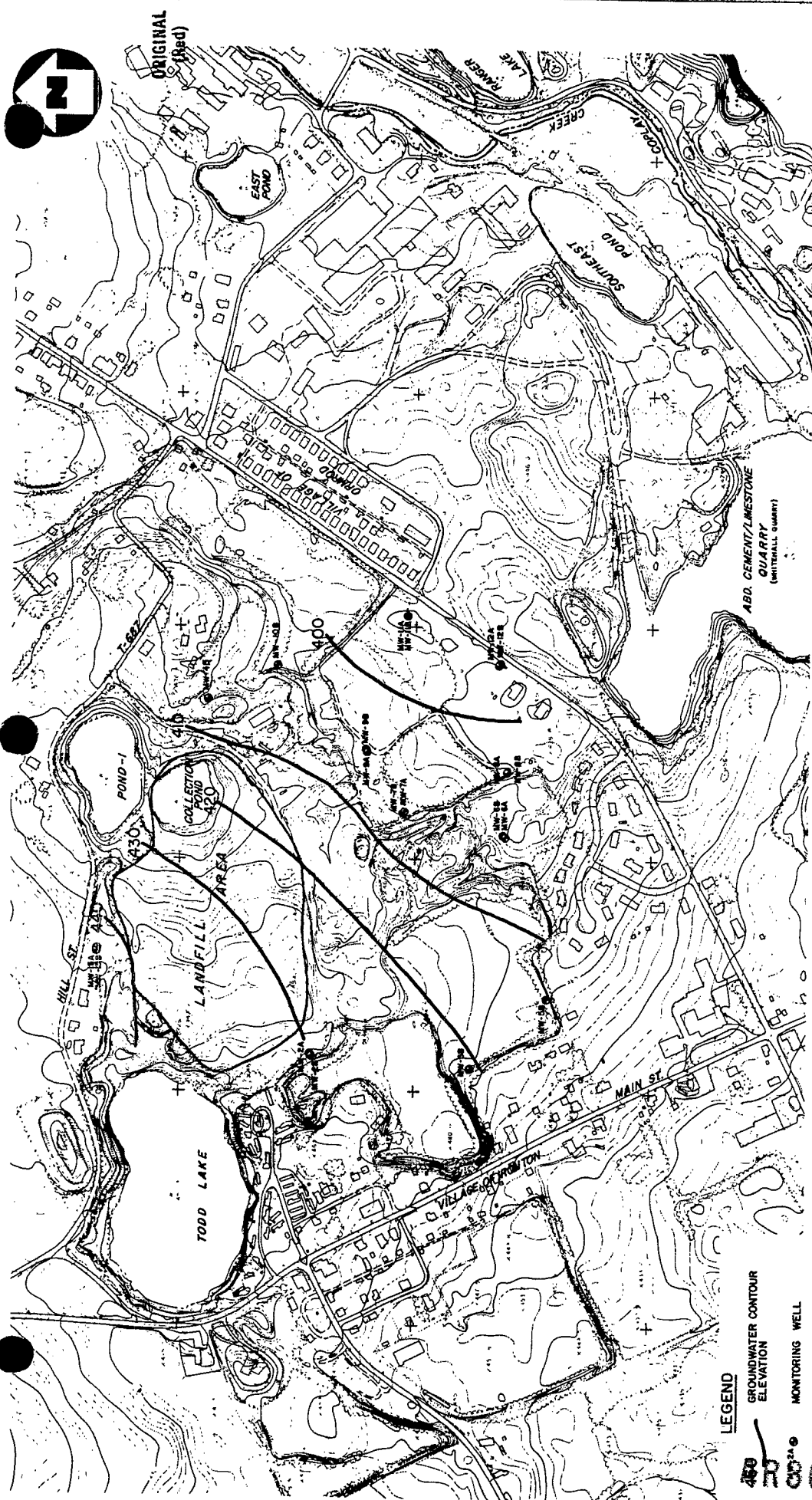


FIGURE 4-8

GROUNDWATER CONTOURS SEPTEMBER 19-21, 1984
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA
SCALE: 1"=400'

48 R800243

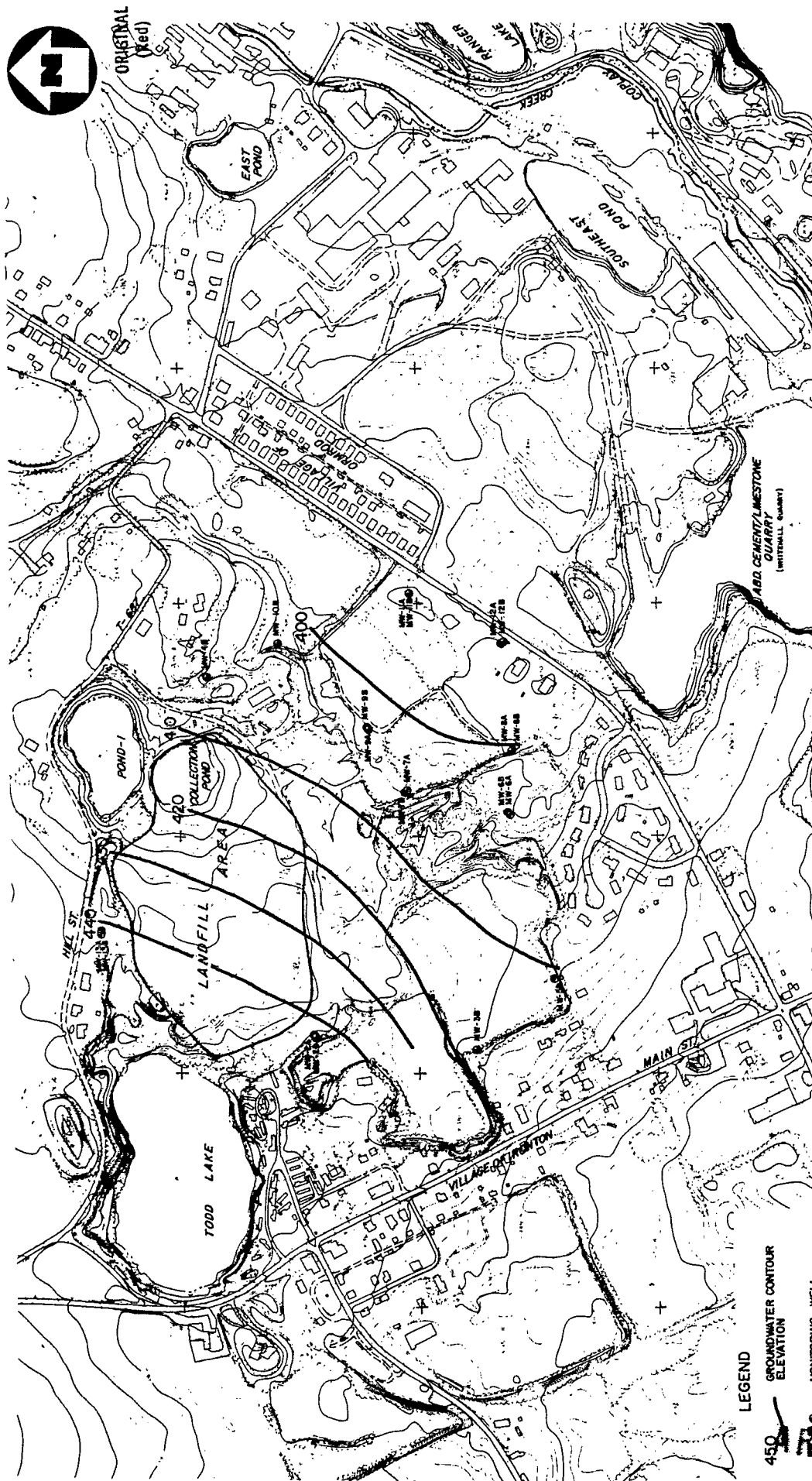


FIGURE 4-9



4-22

GROUNDWATER CONTOURS OCTOBER 25, 1984
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA
SCALE: 1"=400'

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This flow can be quantified and studied through standard Darcian flow equations. Flow through rock, however, is through secondary permeability features such as fault zones, joints, cleavage and bedding planes, and solution cavities. This type of flow is difficult to model or determine without extensive drilling and pump tests. For estimation of flow and hydraulic characteristics of rock, NUS performed permeability tests by boring the wells and recording recovery. The permeabilities were calculated by the Bouwer and Rice equation for slug tests. These data, coupled with results of chemical analyses, provide working knowledge of quality and direction of movement of groundwater from the fill.

From data obtained in this and previous investigations, it was determined that flow through rock is the primary method of groundwater flow in the area.

Permeability tests were conducted on four wells in unconsolidated materials (MW-8A, MW-9A, MW-11A, and MW-12A) and four bedrock wells (MW-2B, MW-7B, MW-10B, and MW-13B). Results of these tests were as follows:

<u>Well</u>	<u>Permeability (cm/sec)</u>
MW-8A	5.0×10^{-7}
MW-9A	8.4×10^{-7}
MW-11A	1.6×10^{-7}
MW-12A	1.2×10^{-6}
MW-2B	5.4×10^{-6}
MW-7B	1.0×10^{-5}
MW-10B	6.9×10^{-6}
MW-13B	3.5×10^{-7}

The permeability tests in the mine spoil are typical for the predominantly clay and silt material. Using the permeability data and the piezometric surface maps, groundwater flow velocity can be calculated as follows:

$$V = \frac{Ki}{n}$$

Where:

- V = Velocity (ft/day)
- K = Average permeability (ft/day)
- i = Hydraulic gradient (ft/ft)
- n = Effective porosity (dimensionless)

The average permeability for the NUS soil wells was 6.8×10^{-7} cm/sec or 1.93×10^{-3} feet/day. The average hydraulic gradient was 0.01 feet/feet. Based on soil sample descriptions, the effective porosity was conservatively estimated at 0.10. Substituting this into the above equation results in a velocity of only 0.07 feet/year. Based on the presence of contaminants in distant wells and knowing the age of the fill, the flow velocity should be substantially higher. This may indicate that more porous zones are present in the fill or that some upward vertical component from the bedrock may have caused contamination of the aquifer in the fill materials. Nassaux-Hemsley permeabilities of unconsolidated materials were 10^{-5} cm/sec. This would result in flow velocities of about 10 feet per year. These are significantly below the observed rate of travel, as exhibited by contamination in the Ormrod Well.

Bedrock permeabilities ranged from 1×10^{-5} to 3.5×10^{-7} cm/sec. This is probably the result of differences in fracture occurrence. It is entirely possible that flows can be several orders of magnitude greater if a more fractured zone is tested. For this reason, and the general highly anisotropic nature of rock, no flow velocities will also be highly variable depending on the permeability used. An average velocity may be the estimate based on appearance of TCE at the Ormrod Well. Regional aquifer characteristics for the rock units are presented in Section 4.3.3. These values indicate a significantly better yield than exhibited in the NUS wells. The reason for this difference is that NUS drill locations did not encounter productive fracture zones. At this well, contamination was detected 3 years after the landfill started operation. This corresponds to travel times of about 500 feet/year.

Nassaux-Hemsley also conducted permeability tests in its rock wells. Permeabilities were highly variable and ranged from 9.81×10^{-4} to 1.56×10^{-9} cm/sec. The permeabilities depend on rock type and the degree of fracturing. Since flow velocity by Darcian methods applies to unconsolidated materials, no velocities are presented. The high permeability values indicate that fracture flow is very important at the site. Comparing the Nassaux-Hemsley results with the NUS results also indicates the variability of rock permeability.

Twenty-four hour pump tests were also conducted by Nassaux-Hemsley. They determined specific capacities in B-7 and B-9 were 0.86 and 20.7 gpm/ft of drawdown.

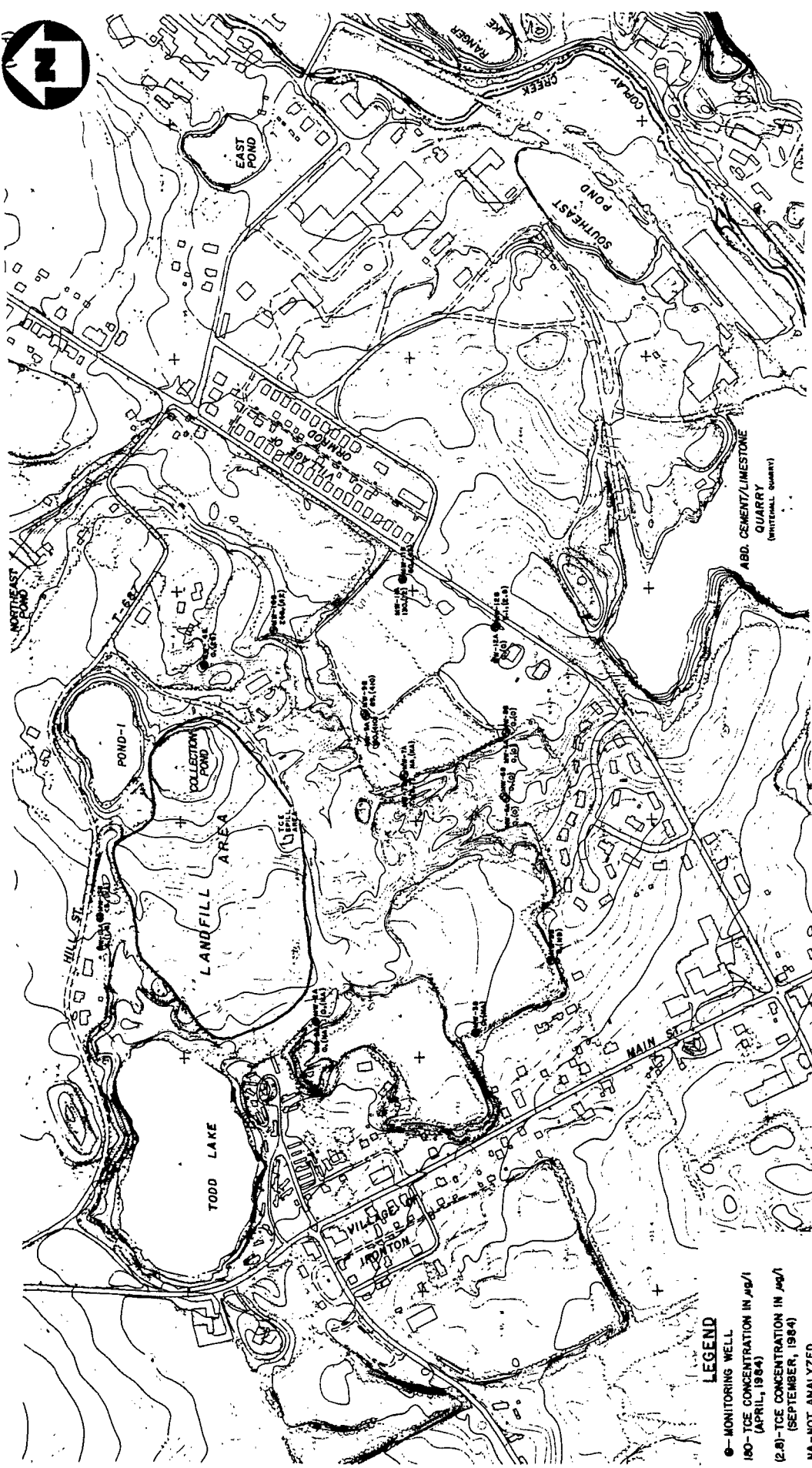
4.4.3.3 Groundwater Contamination

The character of groundwater contamination is presented in greater detail in section 5.1.4, in the context of migration and possible exposure of human and environmental receptors. Hazards, probability of exposure, and risk evaluation associated with the contamination of groundwater at this site are evaluated in Section 6, the risk assessment.

Figure 4-10 depicts the distribution of TCE in monitoring wells at the site. TCE is present at highest concentrations southeast of the site. This area is downgradient of the landfill and confirms that contaminant transport follows the direction of groundwater flow.

TCE has also been found in the Whitehall Quarry, Ranger Lake, and Coplay Creek. This supports the conclusion by Poth et al. (1972), that Coplay Creek acts as a discharge area for groundwater from the site. Contaminated water from the landfill flows predominantly through rock, into the abandoned quarry. Natural discharge and past pumping from the quarry has resulted in the contaminated water's entering Coplay Creek.

Wells in the south and southwest portion of the site (MW-3B and MW-5B) are not contaminated with TCE. There are at least two reasons for this. First, the wells



LEGEND

- MONITORING WELL
- 180-TCE CONCENTRATION IN $\mu\text{g/l}$
(APRIL, 1984)
- (28)-TCE CONCENTRATION IN $\mu\text{g/l}$
(SEPTEMBER, 1984)
- NA - NOT ANALYZED
- ND - NOT DETECTED

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FIGURE 4-10



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TCE CONCENTRATION MAP
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA
SCALE: 1"=400'

are located slightly to the west of the major groundwater flow direction. Second, these wells are located near the axis of a major overturned anticline. Bedding planes and cleavage are aiding in the prevention of groundwater flow through the rock (to the southwest). This geologic condition is similar to the condition that produced the absence of groundwater in the Eastland Quarry next to Ranger Lake (Section 4.4.3.1).

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5.0 OCCURRENCE, DISTRIBUTION, AND PROBABLE TRANSPORT OF CHEMICAL CONTAMINANTS

5.1 Introduction

The Heleva Landfill Site accepted an unknown volume of organic solvents for disposal in conjunction with municipal wastes during its operation. Background data from the Remedial Action Master Plan (RAMP) indicate that organic contamination was first confirmed in 1970 and 1971 when ethyl acetate and trichloroethene (TCE) were detected in the chemical analyses of groundwater taken from wells¹. Well sampling and analyses was conducted in response to complaints of odors from users. TCE was detected in monitoring well samples ranging from less than 0.1 to 148 mg/l in the fall of 1976². More detailed analyses are not included in the available data base. An assessment of the early investigations is limited because the quality and validity of this historical data cannot be established from the available information. The same Nassaux-Hemsley Well samples (B-7 and B-9) indicated biological contamination from leachate, due to the processing of sanitary wastes. Surface water taken from Todd Lake showed only trace concentration of TCE and no effects from the landfill in January 1977³. Samples taken during a pump test conducted in the spring of 1977 detected approximately 20 mg/l and 5 mg/l in Wells B-7 and B-9, respectively.

Between August 1979 and April 1983, the EPA and the Pennsylvania Department of Environmental Resources (PADER) sampled and analyzed the groundwater around and beneath the Heleva Landfill Site⁴. These actions were prompted by concerns voiced by local citizens and officials. Nassaux-Hemsley monitoring wells B-7 and

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- 1 General Testing Laboratories, Inc. (GTL) test analyses for Nassaux-Hemsley, Inc., dated May 7, 1974.
 - 2 Betz Environmental Engineer's Report of December 22, 1976.
 - 3 Ibid. Report of January 25, 1977.
 - 4 Remedial Action Master Plan, NUS Corporation, January 1984.

B-9 have consistently contained groundwater contaminated with TCE in concentrations as high as 240 mg/l. A number of other volatile organic priority pollutants were found in the most highly contaminated groundwater.

During the closure of the site, when soils were placed over the landfill, some of the Nassaux-Hemsley monitoring wells were lost. However, Nassaux-Hemsley Well B-7 was still available for sampling groundwater on the landfill site.

Prior to development of the Work Plan and initiation of the Remedial Investigation, ambient air quality had not been addressed by any sampling program. Since the onsite soils are mainly cover material placed during closure of the site, there was no soil sampling implemented prior to the RI. Some surface water samples, in Todd Lake, indicated minor contamination with TCE. Sediments had not been analyzed prior to the implementation of the RI.

A sampling and analysis program was implemented during the course of the RI to provide the chemical analytical data needed to define the site contamination. This information could then be used to determine the health and environmental risks posed by the presence of hazardous substances in and around the site. It will also be used as input data for the selection of Remedial Action Alternatives necessary to reduce the defined risks to acceptable levels.

Table 5-1 illustrates the scope of the sampling program performed at this site. It includes the sampling episodes carried out prior to the RI where the same locations were further utilized to obtain environmental samples.

The RI Sampling and Analysis Program implemented during the field phase included the following elements.

TABLE 5-1
SCOPE OF SAMPLING AND CHEMICAL ANALYSES DATA BASE
HELEVA LANDFILL SITE

<u>Sampler</u>	<u>Date</u>	<u>Media Sampled</u>	<u>Sample Locations</u>	<u>Laboratory Analysis</u>
NUS	4/23/84	Ambient Air (Tenax Adsorbent)	5 locations (1 background) onsite/offsite	Level "B"
PADER	4/12/83	Surface Water	2-Quarry Spring; 2 leachates	Level "B"
NUS - Round 1	2/22/84 2/22/84	Surface Water Sediment	7 locations 4 locations	Level "A"
NUS - Round 2	4/23/84 4/23/84	Surface Water Sediment	14 locations 13 locations	Level "A" and Level "B"
NUS - Round 3	9/20/84	Surface Water	8 locations	Level "B"
NUS - Round 2	4/23/84	Soils (Surface)	2 locations	Level "A"
Nassaux-Hemsley	2/11/74 5/7/74 6/24/76	Groundwater	Landfill monitoring wells and Heleva House Well	Landfill parameters ¹ only-use for historical purposes
Nassaux-Hemsley	9/14/76 12/6/76 1/10/77 3/29/77	Groundwater Groundwater Groundwater Groundwater	Landfill monitoring wells, house well & association well MW B-7, MW B-10 B-7 B-7, B-9	Landfill parameters- + TCE TCE TCE TCE + landfill- parameters
EPA	8/31/79 12/31/79	Groundwater Groundwater	B-7, B-11 B-12, B-13, B-14, B-9	Level "A" Level "A"

TABLE 5-1
SCOPE OF SAMPLING & CHEMICAL ANALYSES DATA BASE
HELEVA LANDFILL SITE
PAGE TWO

<u>Sampler</u>	<u>Date</u>	<u>Media Sampled</u>	<u>Sample Locations</u>	<u>Laboratory Analysis</u>
PADER	4/11/83	Groundwater	B-6, B-7, B-10, B-13	Level "A" + Landfill parameters-
	6/2/82		2 wells - Unspecified B-7, B-9	Level "A" + Landfill parameters-
NUS - Round 2	4/27/84	Groundwater	MW-2 (A&B), MW-3B, MW-4B, MW-5B, MW-6 (A&B), MW-7B, MW-8 (A&B), MW-9 (A&B), MW-10B, MW-11 (A&B), MW-11A (Dup.), MW-12 (A&B), MW-13 (A&B), Blank	Level "A" + pH, Cond., Temperature
NUS - Round 3	9/21/84	Groundwater	MW-3B, MW-4B, MW-5B, MW-6 (A&B), MW-7B, MW-8 (A&B), MW-9 (A&B), MW-11 (A&B), MW-12 (A&B), MW-13 (A&B)	Level "B" +
NUS - Round 4	10/27/84	Groundwater	B-7, B-8, B-11	Level "B" +
Nassaux-Hemsley	2/11/74	Residential Wells Groundwater	Heleva House Well	Landfill parameters
Nassaux-Hemsley	6/24/76	Groundwater	House Well	Landfill parameters
Nassaux-Hemsley	7/8/76	Groundwater	House Well	Landfill parameters
Nassaux-Hemsley	9/21/76	Groundwater	House Well	Landfill param.+TCE
Nassaux-Hemsley	9/21/76	Groundwater	Association Well	Landfill param.+TCE
Nassaux-Hemsley	12/6/76	Groundwater	House Tap	TCE
EPA	12/31/79	Residential-D.W. ⁴	Com. Assoc. Well	Level "A" +
EPA	12/31/79	Residential-D.W.	Eastern Ind. Assoc.	Level "A" +
EPA	12/31/79	Residential-D.W.	Windy Hts. Water Co.	Level "A" +
EPA	12/31/79	Residential	Lakeview Mobile Home	Level "A" +

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TABLE 5-1
SCOPE OF SAMPLING & CHEMICAL ANALYSES DATA BASE
HELEVA LANDFILL SITE
PAGE THREE

<u>Sampler</u>	<u>Date</u>	<u>Media Sampled</u>	<u>Sample Locations</u>	<u>Laboratory Analysis</u>
NUS - Round 1 Appendix A	2/15/84	Residential-D.W.	Horwith, Sterner, Cincilla, Taylor, Lakeview Mob. Home, Drabic, Fronheiser, Heleva, Mutz.,	Level "A"*, pH, Temp., Cond.
NUS - Round 3 Appendix A	9/21/84	Residential-D.W.	Horwith, Sterner, Cincilla, Taylor, Fronheiser, Heleva Tele- phone Co., Mutz,	Level "B"*, pH, Temp., Cond., Alkalinity & Hardness
Weston (TAT)	12/18/84	Residential-D.W. Residential-Non D.W. Groundwater	A. Heleva, Horwith, Sterner Cincilla Horse Well	Level "B"* Level "B"* Level "B"

*Level "A" = Full Priority Pollutant Scan
Organics - Volatiles, Semi-volatiles (A, B/N, P, PCB, Dioxin)
Inorganics

***Level "B" = Volatile Organics Only**

1 Landfill parameters include: pH, hardness, alkalinity, Ca, Mg, Na, K, Fe, Chloride, Sulfate, Phosphate, Organic Nitrogen, NH₃, Cond. BOD, Co D, Suspended Solids, TOC.

2 Residences in the Village of Ormrod

3 Ormrod Water Association

4 D.W. = Drinking Water

- Initial field sampling: residential wells, surface water and sediments. Full priority pollutant scan through the Technical Advisory Team (TAT) and Contract Laboratory Program (CLP) program. See Appendix A for the trip report.
- Air sampling: ambient air sampling, five locations (1-background). Volatile organic/priority pollutants only. See Appendix B for the survey trip point.
- Second field sampling round: groundwater (monitoring wells), additional surface water and sediment, and soils. See Appendix A for a detailed description of samples and sampling methods.
- Third field sampling round: groundwater (monitoring wells), groundwater (residential wells), surface water samples. Analyzed for volatile organics only. See Appendix A for the trip report.
- Fourth field sampling round: groundwater (Nassaux-Hemsley monitoring wells) analyzed for HSL volatile organics. See Appendix A for the trip report.

All of the chemical analytical results that were accepted by the validation process are tabulated in Table C-1 in Appendix C. Also included in Appendix C are the validation reports for each sample case, by case number and sample number. Abridged tables displaying the results in this section are designed for discussion purposes. Some of the data that appear in the total data base table in Appendix C have been excluded as follows.

- All results that were rejected by the validator.
- All results that were detected below the method detection limits, unless they are important in denoting a trend.
- All of the "not detected" entries.

5.1.1 Sampling Round One - Initial Survey, February 1984

An evaluation of the chemical analytical data from the initial sampling survey indicated that the surface waters and sediments in the site runoff pattern were contaminated with hydrocarbon solvent-type chemicals. Sampling locations and general site features are shown on Figure 5-1. The most concentrated contaminant was toluene at 51 $\mu\text{g/l}$ in the leachate stream flowing to the onsite Collection Pond. Other volatile organic pollutants found in the leachate were TCE (maximum concentration (C_{max} , 1.7 $\mu\text{g/l}$), and ethylbenzene (C_{max} , 4.8 $\mu\text{g/l}$). Similar detections were observed in samples taken from onsite sediments, though at higher concentrations. TCE was observed in two residential wells at low levels (3 and 4 $\mu\text{g/l}$). None of the metals, for which analysis was performed, were in the surface water and groundwater in concentrations exceeding EPA Primary Drinking Water Standards-Maximum Contaminant Levels (DWS-MCLs). Pesticides and PCBs were not detected in any of the media samples. Summary results are shown in Table 5-2A.

5.1.2 Sampling Round Two - Comprehensive Study, April 1984

Following installation of monitoring wells, a comprehensive environmental sampling and analysis program was implemented. See Table 5-1 (pages 5-3 and 5-4) for a tabular description of the scope of the program; summary results are shown in Table 5-2A.

An evaluation of the analytical results shows that generally low concentrations of chemicals, felt to be indicative of ground water contamination, have been found in the likely offsite receiving bodies. Most notably, TCE was detected in Coplay Creek, Whitehall Quarry, and Ranger Lake. The maximum observed TCE concentration was 41 $\mu\text{g/l}$ (Whitehall Quarry). Groundwater was also contaminated with organic chemicals; TCE was most prominent (TCE, C_{max} , 240 $\mu\text{g/l}$, MW10B). Volatile organics were observed in concentrations above background in one of the air samples.



- LEGEND**
- SURFACE WATER SAMPLES
 - SEDIMENT SAMPLES
 - ✕ SOIL SAMPLES
 - SURFACE WATER FLOW
- (1) FEBRUARY 1984-ROUND 1
 (2) SEPTEMBER 1984-ROUND 2
 (3) SEPTEMBER 1984-ROUND 3

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FIGURE 5-1



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SURFACE WATER, SEDIMENT AND SOIL SAMPLE LOCATIONS
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

SCALE: 1" = 400'

TABLE 5-2A

MAJOR ORGANICS FROM THE INITIAL AND SECOND SAMPLING ROUNDS¹
HELEVA LANDFILL SITE
(FEBRUARY AND APRIL 1984)

	Air	Soil	Sediment	Surface Water	Groundwater	Drinking Water
	Obs./Sample, Cmax	Obs./Sample, Cmax	Obs./Sample, Cmax	Obs./Samples, Cmax	Obs./Sample, Cmax	Obs./Samples, Cmax
Benzene	5/5, 1/08 µg/m ³	-	-	-	-	-
Chloroform	1/5, 1.7 µg/m ³	-	-	-	1/19, 7.3 µg/l	-
2-Butanone	-	-	-	4/23, 8030 µg/l	-	-
1,2-trans-	1/5, 7.9 µg/m ³	-	1/20, 3.8 µg/Kg	6/23, 40.8 µg/l	6/19, 730 µg/l	-
Dichloroethene						
Ethylbenzene	2/5, 15 µg/m ³	-	-	3/23, 7.6 µg/l	-	-
Tetrachloroethene	5/5, 3.8 µg/m ³	-	-	-	2/19, 16 µg/l	-
Toluene	5/5, 11.7 µg/m ³	-	-	8/23, 282 µg/l	-	-
Trichloroethene	2/5, 533 µg/m ³	-	1/20, 2.6 µg/Kg	7/23, 41 µg/l	7/19, 240 µg/l	2/9, 4 µg/l
Vinyl Chloride	-	-	-	3/23, 9.6 µg/l	2/19, 62 µg/l	-
Xylenes	1/5, 36.6 µg/m ³	-	-	2/23, 8030 µg/l	-	-
1,1,1-Trichloroethane	-	-	1/20, 10 µg/l	-	6 µg/l	-

¹ Note Units used in Table are:

- Observations/Number of Samples
- Maximum Concentrations Observed

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5.1.3 Sampling Round Three - Confirmative Study, September 1984

Sampling and analysis in the third round was directed primarily at confirming the earlier observations of groundwater, nearby drinking water, and offsite surface water contamination. Table 5-2B summarizes the third round sampling and analytical data. All of the sampling points that indicated contamination with site associated chemicals were confirmed. The concentrations of TCE varied somewhat from the first two sampling rounds. Higher levels of TCE were found during the third round in the drinking waters, in Coplay Creek (downstream), and in Ranger Lake. New observations of site-related chemical contamination in the offsite waters included the small pond east and the pond southeast of the site. See Figures 5-1 and 5-2 for sampling locations.

5.1.4 Sampling Round Four - Followup Study, October 1984

A final round of sampling was conducted to obtain followup data in support of the then developing hypothesis, which indicated a large source of contaminants in the landfill. Three Nassaux-Hemsley monitoring wells in the area of the landfill were sampled and the groundwater was analyzed.

Concentrations of TCE, 1,2-trans-dichloroethene, 1,1,1-trichloroethane and vinyl chloride, markedly higher than those detected in the NUS monitoring wells, were observed in two of the Nassaux-Hemsley Wells (B-7 and B-8). Low concentrations of 1,1-dichloroethene, 1,1-dichloroethane, tetrachloroethene and xylenes were also detected in Nassaux-Hemsley Wells B-7 and B-8. The well (B-11), showed no site-related contaminants.

In summary, it appears that chemical contamination has occurred at the site; primarily surface waters and groundwaters have been affected. Offsite transport of contaminants through these media appears to be the major exposure path for human and environmental receptors. There is no evidence of hazardous heavy metal, pesticide, or PCB contamination of any of the media associated with the site.

TABLE 5-2B

MAJOR ORGANICS FROM THE THIRD SAMPLING ROUND
HELEVA LANDFILL SITE

	Surface Water		Groundwater		Domestic Water	
	Obs./Samples	Cmax	Obs./Samples	Cmax	Obs./Samples	Cmax
1,2-trans-Dichloroethene	5/7	49 µg/l	9/20	7000 µg/l	3/9	31 µg/l
1,1,1-Trichloroethane	-	-	2/20	1100 µg/l	-	-
Trichloroethene	4/7	21 µg/l	9/20	15000 µg/l	3/9	200 µg/l
Vinyl Chloride	-	-	1/20	69 µg/l	-	-
2-Butanone	-	-	1/20	56 µg/l	-	-
Chloroform	1/7	6 µg/l	-	-	-	-
Tetrachloroethane	1/7	12 µg/l	2/20	<10 µg/l	1/9	12 µg/l
Benzene	-	-	2/20	10 µg/l	-	-
Toluene	-	-	1/20	17 µg/l	-	-
1,1-Dichloroethane	-	-	2/20	5.9 µg/l	1/9	2 µg/l

Note:

Units used in table are:

- Observations/Number of Samples
- Maximum Concentration Observed

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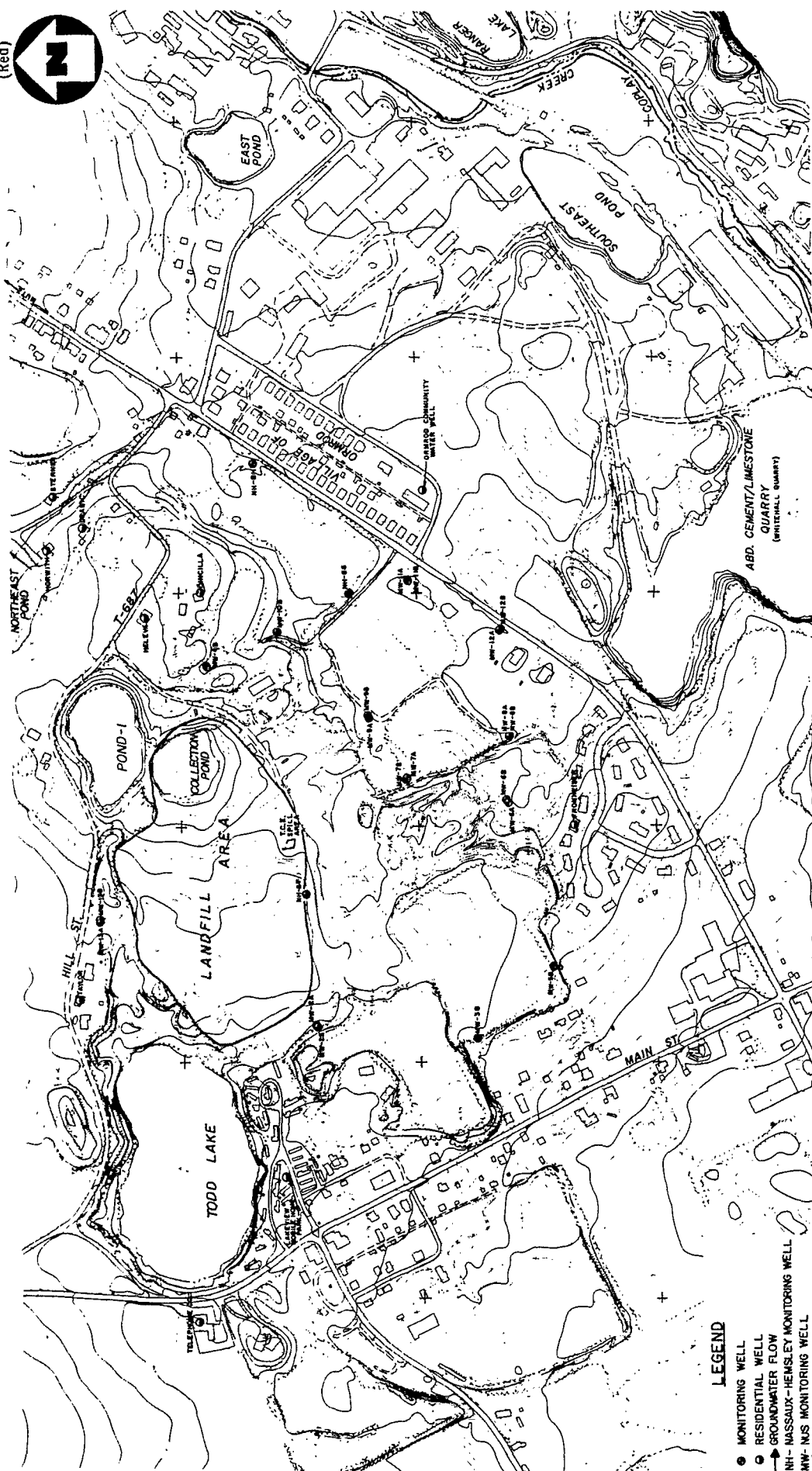


FIGURE 5-2



5-12



MONITORING & RESIDENTIAL WELL LOCATIONS
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA

SCALE: 1"=400'

LEGEND

- MONITORING WELL
 ○ RESIDENTIAL WELL
 → GROUNDWATER FLOW
 NH - NASSAUX - HEMSLEY MONITORING WELL
 MW - NUS MONITORING WELL

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5.2 Occurrence and Distribution

5.2.1 Air

Ambient air contaminants were collected at strategic locations on and around the landfill to determine if hydrocarbon chemicals were volatilizing from soils and surface waters to the air. This program would show the occurrence of contamination above background levels. Airborne contaminants were collected using a Tenax sorbent tube method and analyzed by Gas Chromatography/Mass Spectrometry (GC/MS). Tables 5-3 and 5-4 summarize the data from the air sampling survey. Sampling locations are shown on Figure 5-2. Appendix B contains a detailed report of the air quality survey.

An evaluation of the air sampling data indicates that most of the contaminants (e.g., benzene, 0.8 ppb, toluene, 1.3 ppb) at the observed concentration are typical of ambient air. However, some results (TCE, 1,2-trans-dichloroethene, tetrachloroethene) are also typical of the site contaminants and may be indicative of low level volatilization with airborne transport to the atmosphere. With the exception of one TCE and one xylene observation, airborne organic contaminant levels are slightly higher than those observed in a similar mid-Atlantic rural area (Batsto, NJ), and generally below those observed in an urban mid-Atlantic region (Rutherford, NJ). See Table 5-4 for a comparison of ambient air at the site and some general areas studied in New Jersey. The observed average benzene concentration ($0.81 \mu\text{g}/\text{m}^3$) is not associated with the site, since it is in the range normally presumed to be background. It was detected only one other time among all environmental samples which is considered a spurious observation. Toluene observations are near ambient background.

Volatilization of xylene, tetrachloroethene, and trichloroethene may be occurring at the site, in particular from the TCE spill area. Maximum concentrations of these contaminants were observed at one meter above the ground surface within the TCE spill area. This location included the only detection of xylene ($36.6 \mu\text{g}/\text{m}^3$), the maximum tetrachloroethene observation ($3.8 \mu\text{g}/\text{m}^3$), and the obviously high maximum TCE observation ($533 \mu\text{g}/\text{m}^3$).

TABLE 5-3

MAJOR CONTAMINANTS
AIR SAMPLING SURVEY
HELEVA LANDFILL SITE
(BASED ON FIVE SAMPLES)

<u>Contaminant</u>	<u>Observations</u>	<u>Average Concentration</u>	<u>Maximum Concentration</u>
Benzene	5	0.81 $\mu\text{g}/\text{m}^3$ (0.25 ppb)	1.1 $\mu\text{g}/\text{m}^3$ (0.34 ppb)
Chloroform	1	-	1.7 $\mu\text{g}/\text{m}^3$ (0.35 ppb)
1,2-trans- Dichloroethene	1	-	7.9 $\mu\text{g}/\text{m}^3$ (2.0 ppb)
Ethylbenzene	2	8.3 $\mu\text{g}/\text{m}^3$ (1.84 ppb)	15 $\mu\text{g}/\text{m}^3$ (3.32 ppb)
Tetrachloroethene	5	2.0 $\mu\text{g}/\text{m}^3$ (0.28 ppb)	3.8 $\mu\text{g}/\text{m}^3$ (0.54 ppb)
Toluene	5	6.2 $\mu\text{g}/\text{m}^3$ * (1.58 ppb)	11.7 $\mu\text{g}/\text{m}^3$ (2.98 ppb)
Trichloroethene	2	267 $\mu\text{g}/\text{m}^3$, ⁴ (47.75 ppb)	533 $\mu\text{g}/\text{m}^3$ (95.33 ppb)
Xylene	1	-	36.6 $\mu\text{g}/\text{m}^3$ (8.1 ppb)

Notes

- Guaranteed analytical limit of detection: 60 nanograms. However, the laboratory reported values as low as 7 nanograms (Benzene, sample 03B).
- Sample Volume: 0.012 m^3 (12 liters).
- Methylene Chloride, Acetone, Ethanol, Heptanol, Hexane, and unknown substances were observed in some of the samples. These are felt to be laboratory contaminants.

$$\text{ppb (v/v)} = \mu\text{g}/\text{m}^3 \times \frac{23.5 \text{ l/mole}}{\text{mw (grams/mole)}} ;$$

23.5 is the specific volume for a gas at 57°F.

- * Data is biased by small sample size. See footnote 2 on Table 5-3 for discussion.

TABLE 5-4

SELECTED CONTAMINANTS IN AIR OBSERVATIONS
HELEVA LANDFILL SITE

Contaminant	Upwind Sample	TCE Spill Area Sample	Downwind of TCE Spill Area August 3 Observations	Batsto Village New Jersey (Rural) (1)	Rutherford New Jersey (Urban) (1)
Benzene	0.75 $\mu\text{g}/\text{m}^3$ (0.22 ppb)	1.58 $\mu\text{g}/\text{m}^3$ (0.48 ppb)	1.06 $\mu\text{g}/\text{m}^3$ (0.32 ppb)	1.6 $\mu\text{g}/\text{m}^3$ (0.32 ppb)	8.5 $\mu\text{g}/\text{m}^3$ (2.56 ppb)
Toluene	3.3 $\mu\text{g}/\text{m}^3$ (0.84 ppb)	11.7 $\mu\text{g}/\text{m}^3$ (2.98 ppb)	5.4 $\mu\text{g}/\text{m}^3$ (1.38 ppb)	2.1 $\mu\text{g}/\text{m}^3$ (0.54 ppb)	30.1 $\mu\text{g}/\text{m}^3$ (7.68 ppb)
Xylene(o)	Not Detected -	36.7 $\mu\text{g}/\text{l}^3$ (8.12 ppb)	Not Detected -	0.6 $\mu\text{g}/\text{m}^3$ (0.13 ppb)	5.5 $\mu\text{g}/\text{m}^3$ (1.22 ppb)
Tetrachloroethene	Not Detected -	3.83 $\mu\text{g}/\text{l}^3$ (0.54 ppb)	1.7 $\mu\text{g}/\text{m}^3$ (0.24 ppb)	0.4 $\mu\text{g}/\text{m}^3$ (0.06 ppb)	11.8 $\mu\text{g}/\text{m}^3$ (1.67 ppb)
Trichloroethene	Not Detected -	533.3 $\mu\text{g}/\text{l}^3$ (95.35 ppb)	0.7 $\mu\text{g}/\text{m}^3$ * (0.13 ppb)	0.4 $\mu\text{g}/\text{m}^3$ (0.07 ppb)	6.2 $\mu\text{g}/\text{m}^3$ (1.11 ppb)

(1) Kebbekus, B.B., Bozzelli, J.W. 1983, (EPA-600/53-83-022)

* Trichloroethene was detected in one of the three downwind samples.

5.2.2 Soils

Shallow soil samples (composites of 8-10 inches in depth) were taken at two locations on the site. One sample, taken at the north edge of the landfill, was of a gray-colored surface material, that was uncharacteristic of the rest of the site. The second sample was taken at the southern edge of the site along the main southerly drainage route and was intended to characterize any materials that might have been transported by erosion. The contaminant di-n-butyl phthalate was detected in both samples at 700 $\mu\text{g}/\text{kg}$. Sampling locations are shown on Figure 5-1. The observation of this contaminant at the low level cited is not unusual and not felt to represent a significant impact on the site assessment.

5.2.3 Surface Water and Sediments

Sampling and analysis of surface water and sediment both on site and off site was conducted to determine if the contaminants disposed at the site were being transported by surface water mechanisms to other locations on site and off site. Sampling locations included onsite ponded surface water bodies, flowing surface leachate and runoff streams, and offsite surface water bodies. When sediment samples were taken in conjunction with a water sample, the shallow sediment directly below the water sampling point was sampled.

Contamination of surface waters by site-associated chemicals was observed on site and off site. Onsite surface water contaminants included a mixture of halogenated aliphatics, monocyclic aromatics, and 2 butanone (methyl ethyl ketone [MEK]). The offsite contaminants were comprised mainly of halogenated aliphatics. Table 5-5 lists the major surface water contaminants and their frequency of detection and distribution, as determined by the first and second sampling episodes. Sampling locations are shown on Figure 5-1. These data were used as a rationale for the followup or third sampling round, which focused specifically on the offsite surface waters and groundwaters.

Twenty-one of the twenty-nine observations (72 percent) were from leachate streams and surface water bodies physically on the landfill. Most of the onsite

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TABLE 5-5
SELECTED SURFACE WATER^{1,2}
CONTAMINATION OBSERVATIONS
HELEVA LANDFILL SITE
(BASED ON 23 SAMPLES FROM APRIL 1984)

Chemical Contaminant	Observations			Average Concentration	Maximum Concentration
	Total	Onsite	Offsite		
2-Butanone	4	4	0	2,259 µg/L	8,030 µg/l
1,2,-trans-Di- chloroethene	6	2	4	21.4 µg/L	40.8 µg/l
Ethylbenzene	3	3	0	4.7 µg/L	7.6 µg/l
Toluene	6	6	0	56 µg/L	282 µg/l
Trichloroethene	7	3	4	11 µg/L	41 µg/l
Vinyl Chloride	<u>3</u>	<u>3</u>	<u>0</u>	9.0 µg/L	9.6 µg/l
Total	29	21	8 ³		

¹ Other observations included: 2-Hexane, 4-Methyl-2 Pentanone, 4-Methyl-2-Pentanone, Acetone, Fluorotrichloromethane, Methylene, Chloride, Styrene. These observations are considered spurious not indicative of site contaminants, and are believed to be laboratory contaminants.

² See Figure 5-1A for sample locations.

³ These observations were verified by the followup survey conducted in October, 1984. See Table 5-7 for offsite surface water contamination detail.

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observations (16 of 21) were from leachate streams emanating from the landfill, that flow intermittently as a result of rainfall on the site. The distribution of contaminants in the three major onsite leachate streams is summarized in Table 5-6A. The remaining observations (5 of 21) were from impounded surface water bodies on the site. Table 5-6B contains a summary of these observations.

Organic chemicals indicative of the site contaminants were observed in offsite surface waters south of the site. Table 5-7 details the contaminant observations in the offsite surface waters from the April and September sampling surveys. TCE and 1,2-trans-dichloroethene were the predominant chemicals observed in the offsite surface waters in both sampling episodes. The data indicate that the offsite surface water contaminant concentrations, at least over the period of observation (four months) did not differ markedly.

A sediment sample taken at the Coplay Creek Downstream location (HL-SW-006, and HL-SW-102) was found to contain both TCE and 1,2-trans-dichloroethene in appreciable quantities (2.6 $\mu\text{g/l}$ and 3.8 $\mu\text{g/l}$, respectively). This observation adds further confirmation to the data indicating that these site-associated chemicals are migrating off site. No other detections of site associated chemicals in offsite sediments were observed.

5.2.4 Groundwater

Monitoring wells were installed at various locations around the site, concentrating on the southern periphery in the pathway of the regional groundwater flow from the site. In addition to providing information required for characterizing the site geology, the monitoring wells provided a means for sampling the groundwater and determining the nature and extent of groundwater contamination. Where possible, two wells were installed together to detect and monitor contaminants in a vertical plane. One well, designated the "A" well, was installed to the top of the bedrock at a depth ranging from 30-50 feet. The second well, the "B" or deep well, was generally set into the bedrock at depths ranging from 55-120 feet.

TABLE 5-6A

CONTAMINANTS OBSERVED IN ONSITE LEACHATE STREAMS
HELEVA LANDFILL SITE

<u>Leachate Stream</u>	<u>Major Chemical Contaminants Concentrations</u>
NW - To Todd Lake	TCE, 1.7 µg/l*
East to the Collection Pond	Ethyl Benzene, 4.8 µg/l, 7.6 µg/l Toluene, 51 µg/l, 282 µg/l, 85 µg/l TCE, 1.7 µg/l, 14 µg/l Vinyl Chloride, 8.9 µg/l, 8.6 µg/l, 9.6 µg/l 1,2-trans-Dichloroethene, 26 µg/l, 32.6 µg/l MEK, 8,030 µg/l, 920 µg/l
South Drainage Channel	MEK, 95 µg/l

TABLE 5-6B

CONTAMINANTS OBSERVED IN ONSITE
SURFACE WATER BODIES
HELEVA LANDFILL SITE

<u>Onsite Surface Water Body</u>	<u>Chemical Contaminants</u>
Todd Lake	No Organics Observed
Leachate Pond NW (Behind Trailer Court)	Toluene; 2.3 µg/l
Retention Basin (aka Runoff Pond)	Toluene; 12 µg/l, 6.8 µg/l MEK; 85.3 µg/l Ethylbenzene; 1.6 µg/l
Pond No. 1 (aka Contamination Pond)	None Observed

TABLE 5-7
MAJOR OFFSITE SURFACE WATER CONTAMINANTS¹
HELEVA LANDFILL SITE

Sampling Site	April 1984			September 1984		
	Sample Number	1,2-trans Dichloroethene	TCE	Sample Number	1,2-trans Dichloroethene	TCE
Quarry Background	(HL-SW-009)	7.0 µg/l	4.7 µg/l	(HL-SW-104)	Not Observed	Not Observed
Quarry Spring	(HL-SW-008)	40.8 µg/l	41 µg/l	(HL-SW-103)	7 µg/l	5 µg/l
Coplay Creek (Downstream)	(HL-SW-006)	13.0 µg/l	6.6 µg/l	(HL-SW-102)	49 µg/l	21 µg/l
Ranger Lake	(HL-SW-007)	8.8 µg/l	7.1 µg/l	(HL-SW-105)	24 µg/l	20 µg/l
Lake East of Site	---	Not Sampled	Not Sampled	(HL-SW-109)	19 µg/l	11 µg/l
Lake Northeast of Site	---	Not Sampled	Not Sampled	(HL-SW-106)	Not Observed	Not Observed
Lake Southeast of Site	---	Not Sampled	Not Sampled	(HL-SW-119 -119A)	2.0 µg/l	Not Observed
					Average 1,2-trans Dichloroethene	Average TCE
					---	---
					23.9 µg/l	23 µg/l
					31 µg/l	13.8 µg/l
					16.4 µg/l	13.6 µg/l
					---	---
					---	---
					---	---

¹ Chloroform was observed once at 6 µg/l (Lake Southwest of Site)

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Based on the occurrence of TCE and 1,2-trans-dichloroethene, the data presented in Tables 5-8 and 5-9 indicate that the groundwater was contaminated in 10 out of 20 NUS wells (monitoring wells 4B, 7B, 9A, 9B, 10B, 11A, 11B, 12B, 13A, and 13B), and in the two of the three Nassaux-Hemsley wells (monitoring wells B-7 and B-8). Contamination was generally more prevalent (observed more often) in the deep wells.

Additionally, the data obtained from sampling and analysis of the Nassaux-Hemsley wells (B-7, B-8, and B-11), which were installed to greater depths than the NUS wells (B-7, 100 feet; B-8, 200 feet; and B-11, 165 feet), showed TCE and 1,2-trans-dichloroethene concentrations in wells B-7 and B-8 significantly higher than those observed in any of the shallower NUS wells. No site-associated contaminants were detected in well B-11. Also, 1,1,1-trichloroethane was observed in Nassaux-Hemsley monitoring well B-7 at a concentration (1,100 µg/l) that is appreciably higher than in any other water samples.

A very notable variation between the groundwater and surface water contaminants is the general absence in groundwater of the nonchlorinated solvents, particularly toluene, MEK, and ethylbenzene, which were frequently observed in the surface water samples. Though it is not presently known why this distinction has occurred, it could reflect a pattern of dumping. However, it is more likely that the individual densities of the chemicals have dictated their downward movement through the landfill. TCE and 1,2-trans-dichloroethene are both heavier than water (densities 1.5 and 1.3 @ 20°C, respectively); whereas, toluene, MEK, and ethylbenzene are all lighter than water (densities 0.9, 0.9, and 0.8 @ 20°C, respectively). On this basis, it is likely that a stratification, based on the tendency of the chemicals to sink or float in the water table within the landfill, has occurred.

With the exception of monitoring wells 13A and 13B, all of the wells in Table 5-9 are located on the southeast perimeter of the site in the pathway of the suspected hypothesized regional groundwater flow. This observation indicates that chemicals have migrated from the site and that they are being transported through the subsurface along the path of the groundwater flow. Groundwater samples taken

TABLE 5-8

SELECTED GROUNDWATER CONTAMINATION
OBSERVATIONS ¹
HELEVA LANDFILL SITE

<u>Chemical</u>	<u>Total Observations</u>	<u>Average Concentration</u>	<u>Maximum Concentration</u>	<u>Standard Deviation</u>	<u>No. Wells Contaminated</u>
1,2-trans Dichloroethene	15	173.7 µg/l	730 µg/l	182.4	9
Trichloroethene	18	97.9 µg/l	410 µg/l	131.1	9
Vinyl Chloride ²	7	133.5 µg/l	5,700 µg/l	2112.6	5
Tetra- chloroethene	3(2)	14.5	16	--	2

¹ Other observations include benzene (1), MEK (1), 1,1 dichloroethene (3), 1,1,1 trichloroethane (2), chloroform (2), 1,1,2,2 tetrachloroethane (1), toluene (2), and ethylbenzene (1). These observations were either detected below the contract detection limit or not confirmed by follow up sampling and analysis.

² One confirming observation was reported as below the contract limit of detection (<10 µg/l MW 13A, September 1984) and does not figure in the average. The average vinyl chloride concentration is biased by the maximum concentration observation (5700 µg/l). Omitting this observation yields the following:

C Average, 9.29 µg/l, C Maximum, 560 µg/l, Standard Deviation 209.9.

TABLE 5-9

MAJOR GROUNDWATER CONTAMINANT CONCENTRATIONS
BY MONITORING WELL AND SAMPLING EPISODE
HELEVA LANDFILL SITE

Source	April 1984		September 1984		Average 1,2-trans Dichloroethene	Average TCE
	1,2-trans Dichloroethene	TCE	1,2-trans Dichloroethene	TCE		
MW4B	Not Observed	Not Observed	8 µg/l	25 µg/l	---	---
MW7B	Not Observed	7.1 µg/l	Not Observed	3.7 µg/l	---	5.4 µg/l
MW9A	140 µg/l	180 µg/l	220 µg/l	410 µg/l	180 µg/l	295 µg/l
MW9B	65 µg/l	89 µg/l	139 µg/l	410 µg/l	102 µg/l	249.5 µg/l
MW10B	730 µg/l	240 µg/l	280 µg/l 330 µg/l	36 µg/l 42 µg/l	446.7	159 µg/l
MW11A	170 µg/l 160 µg/l	64 µg/l 130 µg/l	24 µg/l	12 µg/l	118 µg/l	68.9 µg/l
MW11B	170 µg/l	60 µg/l	130 µg/l	43 µg/l	150 µg/l	51.5 µg/l
MW12B	<5.0 µg/l ¹	5.1 µg/l	3.2 µg/l	2.8 µg/l	---	3.95 µg/l
MW13A	44 µg/l	<5 µg/l	6.2 µg/l 13 µg/l 13 µg/l	1.8 µg/l 9 µg/l <5 µg/l	19.1 µg/l	5.4 µg/l
MW13B	18 µg/l	<5 µg/l	Not Observed	Not Observed	---	---
Nassaux- Hemsley (B-7)2,3	Not Sampled	Not Sampled	7,000 µg/l	15,000 µg/l	---	---

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(Red)

TABLE 5-9
MAJOR GROUNDWATER CONTAMINANT CONCENTRATIONS
BY MONITORING WELL AND SAMPLING EPISODE
PAGE TWO

Source	April 1984		September 1984		Average 1,2-trans Dichloroethene	Average TCE
	1,2-trans Dichloroethene	TCE	1,2-trans Dichloroethene	TCE		
Nassaux- Hemsley (B-8)	Not Sampled	Not Sampled	6,600 µg/l	2,300 µg/l	---	---
Nassaux- Hemsley (B-11)	Not Sampled	Not Sampled	Not Observed	<5 µg/l ⁴	---	---

- 1 Less than values (<) indicate that the compound was detected at a level below the contract limit of detection and not counted in averages.
- 2 Sampling the Nassaux-Hemsley wells was not in the original Work Plan but incorporated when additional data regarding the contaminant source was deemed necessary. Nassaux-Hemsley monitoring well data has not been validated at this time. Sampling actually occurred in October 1984 - Sampling Round 4.
- 3 1,1,1 Trichloroethane detected at 1,100 µg/l.
- 4 Not counted as an observation of TCE contamination.

0 11
(1100)

from monitoring wells south and west of the site (2A, 2B, 3B, 5B, 6A, 6B, 8A, and 8B) did not contain contaminants. This indicates that contaminants are not migrating toward these locations. See Figure 5-2 for the monitoring well locations and general groundwater flow pattern.

Monitoring wells 13A and 13B were installed directly north of the site and were the designated upgradient or background wells. This was based on the presumption of northwest to southeast groundwater flow. It was felt they should be free of contamination. Subsequent sampling and analysis of groundwater taken from these two wells indicated that they were contaminated with site-associated contaminants at very low levels. A verified explanation of this occurrence is not available; however, analysis of groundwater contours indicates that these wells may not be "upgradient" especially if significant mounding occurs in the landfill. No wells are present in the fill to verify the extent of groundwater mounding.

Followup sampling and analysis in September confirmed that both wells are definitely contaminated and, hence, cannot serve as a background comparison well. Instead, the domestic well serving the Taylor residence, which is also located on the northern edge of the site, but unaffected by site-associated contaminants, can be used for comparison purposes. No contaminants have been observed in this well over two sampling episodes.

5.2.5 Domestic Water

Contamination of three domestic wells by site-associated chemicals due to groundwater transport is indicated by the data in Table 5-10. Sample locations are shown on Figure 5-2. The Heleva and Cincilla Wells are located adjacent to the site to the east, and the Horwith Well is located approximately 600 feet northeast of the site boundary. Contamination in the Heleva and Cincilla Wells was very low in February 1984 (TCE 4 $\mu\text{g/l}$ and 3 $\mu\text{g/l}$, respectively). However, when re-sampled and analyzed in September, 1984, the levels of contamination had increased substantially (TCE 180 $\mu\text{g/l}$ and 200 $\mu\text{g/l}$, respectively). A reason for the increased contaminant levels in the Heleva and Cincilla wells over the seven month period between sampling episodes has not been determined. In addition,

TABLE 5-10
DRINKING WATER CONTAMINATION
HELEVA LANDFILL SITE

Location	February 1984		September 1984	
	1,2-trans Dichloroethene	TCE	1,2-trans Dichloroethene	TCE
Lakeview Mobile Home Park	Not Observed	Not Observed	Not Sampled	Not Sampled
Horwith (Before Softener)	Not Observed	Not Observed	9 µg/l	5 µg/l
Horwith (After Softener)	Not Observed	Not Observed	Not Observed	Not Observed
Fronheiser	Not Observed	Not Observed	Not Observed	Not Observed
Sterner	Not Observed	Not Observed	Not Observed	Not Observed
Taylor	Not Observed	Not Observed	Not Observed	Not Observed
Mutz	Not Observed	Not Observed	Not Observed	Not Observed
Heleva	Not Observed	4 µg/l	26 µg/l 29 µg/l	180 µg/l 170 µg/l
Cincilla	Not Observed	3 µg/l	31 µg/l	200 µg/l

1,2-trans-dichloroethene was observed in both sources in the September, 1984 (26 $\mu\text{g/l}$ and 31 $\mu\text{g/l}$, respectively), which further indicates site-associated contamination.

Site-associated contaminants were observed in the Horwith water supply in the September, 1984 sampling (TCE: 5 $\mu\text{g/l}$, 1,2-trans-dichloroethene; 5 $\mu\text{g/l}$) when sampled on the inlet side of the water softener. However, the contaminants were absent on the discharge side of the water softener.

5.3 Environmental Transport and Migration Pathways

5.3.1 Introduction

As indicated in Section 5.1, chemical contamination, mainly of groundwater, has occurred at and around the Heleva Landfill Site. Section 5.1 data also indicate that chemicals can be released from the in situ matrix where they presently are, with subsequent migration through the environment by one or several pathways.

The volatile organics, as a class, have similar chemical and physical properties such as water solubility and vapor pressure. Tables 5-11 and 5-12 provide a summary of some of the important environmental transport and properties of the major site contaminants. The approach taken in this evaluation of migration potential is to use the most representative chemical based on the following aspects: (1) the chemical is found on and off the site in significant concentrations; (2) it exhibits release and transport properties sufficiently similar to the other detected contaminants to be a typical characterization for all; (3) it can be measured in the various media and; (4) it has appreciable health ramifications and environmental impacts. TCE is believed to be the dominant site contaminant and exhibits all of the above characteristics. It has been released, it has migrated offsite, and it can be measured in all of the environmental media. In addition, exposure to TCE has significant human toxicological implications. Therefore, environmental transport and migration pathways will be identified using TCE as the representative contaminant.

TABLE 5-11

PHYSICAL AND CHEMICAL PROPERTIES AFFECTING
MIGRATION POTENTIAL

Chemical	Molecular Weight ¹ g/mole	Vapor Pressure mm Hg	Water Solubility ¹ mg/l	Boiling ² Point	Specific Gravity ² (H ₂ O = 1)
2-Butanone	72.1	77.5 @ 20°C	353 X 10 ³	79.6°C	0.8 @ 20/4°C (MEK)@ 10°C
Chloroform	119.4	160 @ 20°C	8000 @ 20°C	62°C	1.5 @ 20°C
1,2-trans-Dichloroethene	96.9	200 @ 14°C	600 @ 20°C	48°C	1.3 @ - *
Ethylbenzene	106.2	7 @ 20°C	152 @ 20°C	136.2°C	0.9 @ 20°C
Tetrachloroethene	165.8	14 @ 20°C	150 @ 20°C	121.4°C	1.6 @ 20°C
Trichloroethene	131.4	60 @ 20°C	1100 @ 20°C	86.7°C	1.5 @ 20°C
Toluene	92.1	28.7 @ 25°C	534.8 @ 20°C	110.8°C	0.9 @ 20°C
Vinyl Chloride	62.5	2660 @ 25°C	1.1 @ 25°C	-13.9°C	0.9 @ 15/4°C
Xylene	106.2	5 @ 20°C	175 @ 20°C	144.4°C	0.9 @ - *
1,1,1-Trichloroethane	133.4	100 @ 20°C	4,400 @ 20°C	71/81°C	1.4 @ 20/4°C

* Temperature not cited, presumed 20°C

1 USEPA 440/4-79-029, 1979

2 Verschueren, 1977

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TABLE 5-12

TRANSPORT COEFFICIENTS AND ENVIRONMENTAL FATE CHARACTERISTICS
OF MAJOR SITE CONTAMINANTS

Chemical	Kow ¹	Koc ²	H ³	Major ⁴ Environmental		Environmental ⁴ Fate	Biodegradable ⁴	Bioaccumulative ⁴
				Transport Mechanism				
2-Butanone (MEK)	66.1	10.7	8.6×10^{-4}	Not Cited		Not Cited	Unknown	Presumed not Significant
Chloroform	93.3	34.6	0.12	Volatilization		Atmospheric Oxidation	Unknown	Weak to Moderate
1,2-trans Dichloroethene	30.2	130.3	1.76	Volatilization		Atmospheric Oxidation	Very Slowly	Not Significant
Ethylbenzene	1112	829	0.27	Volatilization		Atmospheric Oxidation	Unknown	Not Significant
Tetra- chloroethene	758.6	334	0.82	Volatilization		Atmospheric Oxidation	Possibly	Marine Systems Only
Trichloroethene	195	123	0.39	Volatilization		Atmospheric Oxidation	Probably Not	Possible- Probably Not Significant
Toluene	708	363	0.27	Volatilization		Atmospheric Oxidation	Possible	Probably Not Significant
Vinyl Chloride	4	3414	8.2×10^3	Volatilization		Atmospheric Oxidation	Probably Not Significant	Not Significant

TABLE 5-12
TRANSPORT COEFFICIENTS AND ENVIRONMENTAL FATE CHARACTERISTICS
OF MAJOR SITE CONTAMINANTS
PAGE TWO

Chemical	Kow ¹	Koc ²	H ³	Major ⁴ Environmental		Biodegradable ⁴	Bioaccumulative ⁴
				Transport Mechanism	Fate		
Xylene	4786	292	0.21	Not Cited	Not Cited	Unknown	Probably Not Significant
1,1,1-Tri- chloroethane	148	57.6	1.24	Volatilization	Atmospheric Oxidation	Very Slowly	Probably Not Significant

1 Kow: The octanol/water partition coefficient(Kow) is the theoretical ratio of a chemical's concentration in the organic phase (octanol) and in the aqueous phase (water). Kow is used to estimate the tendency of the chemical to partition itself between an organic phase (fish, soil carbon, etc.) and an aqueous phase. Large Kows indicate the chemical will tend to be absorbed in an organic phase.

2 Koc = $\frac{\mu\text{g adsorbed/g carbon (in soil)}}{\mu\text{g/ml solution}}$

The adsorption coefficient (Koc) estimates the extent to which an organic chemical partitions itself between the solid and solution phases of water-saturated or unsaturated soil, or runoff water and sediment. Koc is a useful index of leachability and is roughly independent of the particular soil. Large Kocs indicate that the chemical will tend to be adsorbed on soil organic materials, i.e., less mobile. Loc of 32 is considered mobile.

TABLE 5-12
TRANSPORT COEFFICIENTS AND ENVIRONMENTAL FATE
CHARACTERISTICS OF MAJOR SITE CONTAMINANTS
PAGE THREE

Footnotes Continued:

3 Henry's Constant,

$$H = \frac{\text{Concentration of a chemical in air}}{\text{Concentration of a chemical in water}}$$

H estimates the extent to which an organic chemical will volatilize from a chemical/water solution. The concentration of the chemical in air is that observed directly above the water in the gas-liquid-equilibrium phase. The higher the value of H, the greater the tendency the chemical has to volatilize from the solution.

4 EPA, 1979.

As Tables 5-11 and 5-12 indicate, the individual chemical and physical properties and environmental fates may vary between the listed pollutants. If there are significant variations from TCE mobilization behavior for the other contaminants, they will be noted.

5.3.2 Airborne Transport

Volatilization of chemicals from soils in the unsaturated zones, leachates, and surface waters is occurring as indicated by the detection of TCE at elevated concentrations (above background) in the air samples. Volatilization, dispersion, and subsequent oxidation in the atmosphere, where TCE has an estimated half-life of 1-4 days, then occurs. This is generally considered to be the ultimate environmental transport and fate of TCE in water-based environmental systems.

When TCE is released from the in situ matrix (soil, soil water, surface water, groundwater), it is dispersed and diluted very rapidly due to unlimited ambient air volume and rapid air movement. The maximum observed concentration of TCE was $533 \mu\text{g}/\text{m}^3$, one meter above the leachate stream in the TCE spill area. A concurrent sample taken at a distance of approximately 130 feet and slightly out of the direct downward plume showed no TCE. Ambient air (non concurrent) sampled 800 feet directly downwind of the TCE spill location contained TCE at a concentration of $0.7 \mu\text{g}/\text{m}^3$. This level is equal to, not above, background values measured at the site.

On the basis of the ambient air data, it appears that TCE is evaporating from the soils. The levels of TCE measured are low except in the TCE spill area. The TCE concentrations at the site periphery are indistinguishable from background. With the exception of MEK, the other major site contaminants have Henry's Constant values comparable to or greater than TCE. Therefore, we would expect volatilization patterns for the other chemicals to be similar to TCE's. MEK has a low Henry's Constant and will tend not to volatilize from a water medium.

5.3.3 Surface Water Transport

TCE is comparatively soluble in water (1,100 mg/l), as are all of the other major site contaminants (see Table 5-11). This property makes it amenable to leaching and dissolution with transport in surface water. However, contamination levels are limited to saturation concentrations, due to the opportunity for evaporation and entrance into the air media.

The site drainage pattern is from the crown of the landfill to areas in the watershed located west, east, and south of the landfill. (See Figure 5-1 for runoff patterns). The entire landfill is practically devoid of vegetation; hence, immobilization of contaminants along any of the pathways is limited to adsorption onto soil particles containing organic constituents. Percolation will also occur. The migration of chemicals via surface water runoff or leaching is also influenced by erosion of the cover. The effect of the overland transport could be a trailing band of the major site chemicals. However, sediment samples do not confirm this possibility.

Based on air sampling data, sampling and analysis of leachate, and field observation of erosion gullies, the TCE spill area located on the southeast side of the landfill is the major contributor of contamination to landfill surface water. The major drainage patterns are described below. See Figure 5-1 and Tables 5-6A, 5-6B for supporting details.

- The runoff and leachate seep drainage flowing to the east of the site appears to be the major surface water migration path for chemicals associated with the TCE spill area. Sampling and analysis have confirmed that the leachate streams flowing from the TCE spill area and the east side of the landfill contained some of the major site contaminants including TCE, 1,2-trans-dichloroethene, toluene, ethylbenzene, vinyl chloride, and MEK. The collection pond receives this surface flow and is contaminated by low levels of MEK, toluene, and ethylbenzene. Directly north of the collection pond and at a lower elevation is Pond No. 1. The two are separated by a berm and do not appear to be in direct contact by

surface water streams. With the exception of 1,1,1-trichloroethane detected in one sediment sample, Pond No. 1 does not appear to be contaminated. The regional groundwater is the recharge for Pond No. 1, and the two are in communication. This may constitute a cross connection for surface water contaminant migration into the groundwater should leachate or surface water containing site-associated chemicals contaminate the pond.

- The southern surface drainage (run off and leachate) is conveyed through a large channel south and west of the TCE spill area. MEK was the only major site contaminant detected in this leachate stream (95 µg/l). This observation indicates that site contamination could be transported by this route but it is minor compared to the eastern route. The occurrence of MEK in the outlying surface water transport regions (in the south channel) is probably due to its high water solubility (353×10^3 mg/l @ 10°C), relatively low K_{oc} (10.7), and low Henry's constant ($H=8.6 \times 10^{-4}$). Additionally, MEK, having a density less than water (Sp. Gr. = 0.8), would tend to enhance its transport in the water media. Physiographically, this route is similar to the rest of the landfill (devoid of vegetation) until it reaches the flat cornfield south of the site. The cornfield and more southerly regions are vegetated, and hence, contaminants traveling over and just below the surface would be subject to adsorption onto the relatively abundant organic materials in the soils. They might also be taken up by the plants and vegetation. However, the major site associated contaminants are not usually associated with plant uptake. During periods of heavy rain, runoff water from the site tends to accumulate on the surface of the cornfield due to the high water table in the area. Given the lack of evidence of major site contaminants in the surface water and nearby soil samples, it appears that this route is not a major contaminant migration pathway.
- Drainage of surface water runoff and leachate seeps flows into Todd Lake from the northwestern portion of the site. As such, it should not be appreciably influenced by the contaminants from the TCE spill area. TCE

was observed in the leachate stream at 1.7 µg/l in the preliminary (February) sampling survey but not in the lake. This observation (TCE in the leachate stream) was not confirmed by sampling and analysis conducted later in the RI. When evaluated again during the RI, major site contaminants were not observed in the leachate stream or water from the lake or sediments. Surface water transport of contaminants to Todd Lake does not appear to be occurring.

Coplay Creek is a tributary of the Lehigh River; the two meet approximately 2.5 miles southeast of the site. The Lehigh River then joins the Delaware River near Easton, Pennsylvania. Contaminants in Coplay Creek could theoretically travel this route to receptors along the path. Under present site conditions and contaminant concentrations in Coplay Creek, it seems unlikely that TCE would reach the Lehigh River in appreciable concentrations. This is due to the obviously large dilution factor along the creek and the tendency of TCE to volatilize from water ($H = 0.34$). Coplay Creek is a fairly shallow stream with pool and riffle sequences causing turbulent flow that would tend to promote volatilization. As indicated in Table 5-12, volatilization to the air media and atmospheric oxidation are the primary environmental fates of TCE and most of the other site contaminants.

There are no scheduled users of Coplay Creek water for domestic purposes from the site to the Lehigh River. Additionally, water authorities in the cities of Allentown, Bethlehem, and Easton indicate that there are no current municipal users of water from the Lehigh River from the Coplay Creek confluence to the confluence with the Delaware River.

5.3.4 Groundwater Transport

Hydrogeologic and analytical data collected during the RI confirm that contaminant transport through the subsurface was, and is, occurring. This finding is based on the data obtained from sampling and analysis of groundwater collected from the NUS monitoring wells, Nassaux-Hemsley wells, and the surface waters.

Contamination of the groundwater by migrating pollutants has resulted in contamination of the Heleva, Cincilla, and Horwith wells and probably the (now closed) Ormrod Community Well. Additionally, contaminants have moved through the subsurface with the groundwater to result in contamination of the surface water bodies south of the site. Subsurface transport of contaminants is the most significant exposure pathway for human and ecological exposure to the site associated contaminants.

The migration pathway for contaminants leaving the site follows the groundwater flow in the southeasterly direction. A detailed discussion of the site geology and hydrogeology can be found in Section 4.0 of this report.

The source of groundwater contamination is liquid volatile organic solvents reportedly dumped at the landfill. Analytical data on groundwater taken from one Nassaux-Hemsley well (located in the landfill B-7) sampled in October, 1984 indicated contamination of groundwater at a depth of 100 feet as follows:

- TCE-15,000 $\mu\text{g/l}$
- 1,2-trans-Dichloroethene 7,000 $\mu\text{g/l}$
- 1,1,1-Trichloroethane 1,100 $\mu\text{g/l}$

From the site, the contaminants travel with the groundwater downgradient in an east-southeast direction through the unconsolidated deposits and fractured bedrock. The unconsolidated deposits have much lower flow velocity and are not as important a pathway as the bedrock. This unconsolidated layer is composed largely of mine tailings and natural material, that extends generally to a depth of 25-40 feet, though it may extend to 100 feet below the surface in some areas. Permeability in the unconsolidated region is low (see Section 4.4.3.2). TCE concentrations average 149 $\mu\text{g/l}$ in the groundwater obtained from the unconsolidated layer south of the site. This is based on data from two monitoring wells (9A and 11A) sampled in the spring and fall sampling episodes.

Contaminant infiltration moving through the unconsolidated material will be subject to some attenuation by adsorption onto soil organic materials. Given

sufficient carbonaceous material in the unconsolidated region, TCE will be moderately absorbed (Koc, 123). This will likely result in a trailing band of contamination in the organic material along the migration path. Desorption and further transport, volatilization, and decomposition are also possible. TCE will also tend to percolate downward, due to its high specific gravity, and it may congregate in the lower depths of the saturated zone.

Transport in the unconsolidated deposits is a relatively slow process. NUS estimates a groundwater velocity of 0.07 feet/year. Nassaux-Hemsley estimates the velocity to be approximately 10 feet/year. However, these estimates are not consistent with the observations of contamination in the more distant monitoring wells such as 11A, which is roughly one thousand feet from the edge of the landfill. This further indicates that fracture controlled flow is probably the dominant pathway.

Sampling and analysis of groundwater from the deep monitoring wells southeast of the landfill shows that they also are contaminated with site-associated chemicals (TCE average concentration 80 $\mu\text{g/l}$). These wells were installed into the bedrock, typically to a depth of around 55-85 feet from ground surface, although MW4B extends approximately 120 feet below the ground surface. Additionally, two Nassaux-Hemsley wells (B-8, B-11) were sampled and the groundwater analyzed. Well B-8, installed to a depth of 200 feet, was found to contain 2300 $\mu\text{g/l}$ of TCE and 6,600 $\mu\text{g/l}$ of 1,2-trans-dichloroethene. Well B-11, installed to a depth of 165 feet, was found to contain no site-associated contaminants. In all probability, Nassaux-Hemsley monitoring well B-11 does not bisect one of the contaminant transport fractures.

Fracture flow through rock is the most significant flow path at the site. The movement of groundwater and fluid-mobile contaminants will be controlled by the fractured configuration of the bedrock. Movement will be through joint sets, faults, bedding planes, solution channels and along cleavage planes that are not necessarily perpendicular to the apparent south-southeasterly groundwater flow found in the upper unconfined layer. Movement in this manner is akin to channelized flow and would most likely have a higher velocity than that in the

consolidated deposits. The contaminants move downgradient in the rock to the southeast where they are discharged in abandoned quarries, Coplay Creek, and Ranger Lake.

Conceivably, a portion of the aquifer groundwater flow passes beneath the discharge zone and proceeds in its east-southeasterly direction. Channelized flow accounts for the rapid movement at site-associated contamination to the Ormrod Community Well, the bedrock wells, and the southern groundwater recharge receptors.

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6.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

6.1 Introduction

This section of the RI report is a risk assessment of the Heleva Landfill Site, located in Lehigh County, Pennsylvania. It is based on hydrogeological and chemical analytical data obtained by previous investigations and by the RI conducted from February to November 1984. The objective of this assessment is directed toward defining the health risks associated with the presence of hazardous contaminants on and around the site. Another aspect of the appraisal concerns the potential environmental impacts connected with the contaminants in site-specific circumstances.

In order for a health risk to occur, three factors must be present at and around the site: (a) there must be contaminants having known chemical and biological toxic characteristics (b) there must be actual or potential exposure pathways; and (c) there must be human and environmental receptors in the exposure paths. In order to measure the public health and environmental impacts, three ingredients require development: (1) documentation and description of the occurrences and distribution patterns of the hazardous contaminants, (2) definition of the actual and potential exposure paths, and (3) details of the location and demographics of the receptor population and most sensitive environmental receivers. The first two components have been presented in Section 5.0 of this report.

Typically, the risk assessment procedure addresses the remaining element. It involves assessing the significant contaminant migration routes and exposure pathways, identifying the hazardous compounds of greatest concern, and evaluating possible effects in the context of probable exposure scenarios. Several factors must be considered during the implementation of this evaluation. They include the following:

- Present site conditions, as defined by the RI and supplementary historical data pertinent to the risk assessment
- Physical, chemical, and biological factors affecting the environmental fate and mobility of the contaminants
- Health effects and environmental impacts associated with exposure to the contaminants, including, additive, synergistic, or antagonistic effects.

Any limitations imposed on the extent to which these factors can be evaluated will constrain the scope of the risk assessment and the conclusions that can be inferred. Such limitations may include quality of laboratory analytical data, relevance of toxicological data to site-specific exposure scenarios, and the degree to which probabilities of exposure may be calculated or predicted.

This risk assessment is based primarily on validated chemical analytical data, hydrogeological conditions described in Section 3.0, and contaminant migration pathways presented in Section 5.0. The major limitations of this risk assessment are due to (1) constraints imposed by the chemical analytical procedures, i.e. the need for sample dilution and the lack of specificity of the data, as it relates to contaminant detections at or near the limit of detection; (2) the lack of comparability among sampling episodes, owing to unknown sampling locations in the historical data; and (3) the scope of the data base, which is limited by budgetary and time constraints. Specific limitations will be discussed, as appropriate, in the sections that follow.

6.2 Potential Exposures

An exposure pathway is the route a contaminant may take to reach a susceptible receptor. In order for an exposure pathway to be complete, three factors must be present: a source of contamination, a route of contaminant transport, and an exposure to the contaminants. The mode of exposure and its duration have some influence on the impacts. Modes of exposure are usually categorized as inhalation, ingestion, and dermal (direct contact). There may be indirect exposures by

ingestion of contaminated foods, by dermal and inhalation exposure, or by recreational use (swimming, fishing, and boating). Exposure durations are separated into two main classes, i.e., acute, which is of short time duration and frequency; and chronic, which implies long-term (months and years) and continuous or frequent exposure.

6.2.1 Source of Contamination

Based on the operational history of the Heleva Landfill Site (a sanitary landfill, located in an old pit where refuse was placed in the water table), any bulk liquid contaminants discharged in the disposal area would move very rapidly and vertically into groundwater through the uncompacted permeable sub-base. Consequently, the entire site must be considered to be the source of contamination for this risk assessment. Surface contaminant releases to ambient air may be sufficiently differentiated to define one source as the "trichloroethene (TCE) Spill Area" identified on the sample location drawings (Figures 5-1 and 5-2).

6.2.2 Routes of Transport

The major contaminant transport path for potential exposure of human receptors is via movement of groundwater (containing the contaminants) under the site. Groundwater flow and direction are defined in Sections 4.0 and 5.0 of this report. Hydrogeological parameters controlling the flow are presented in Section 3.0. The groundwater flow regime can be summarized as follows.

- The most critical contaminant, TCE, is migrating in a plume toward the east and southeast, where several residential wells and one public water supply well (Ormond Community Water Well) were affected.
- Areas south, west, and north of the site have not been appreciably affected. Geological conditions provide a barrier to groundwater flow south of the contaminant source.

- Groundwater may be recharging the surface water accumulations south, southeast, and north (onsite) of the contaminant source, with concomitant contamination of a lower order.

Some minor routes of transport of contaminants from the site include the following:

- Volatilization of organic contaminants to ambient air, with the contaminated air moving off site, may affect areas downwind.
- Surface water runoff, mingling with contaminated leachates emanating from the deposited wastes, may affect the environment in drainage receiving areas.

Some usual modes of release and migration of contaminants are absent from this particular site.

- Contaminated dust migrating in the air media is not likely at this location, owing to the uncontaminated cover material that was placed over the deposited refuse during closure.
- Sediments do not appear to be grossly contaminated. This may be because of the nature of the eroded cover material; chemical characteristics of the critical contaminants, i.e., volatile organic pollutant that volatilize from water during turbulent flow; and the intermittent nature of the leachate seeps allowing evaporation to take place.
- Contaminants are not likely to be carried off site during normal onsite activities, owing to the absence of surface soil contamination.

6.2.3 Receptors

Based on the present site conditions and data gathered during the RI, potential human and environmental receptors include the following:

- Nearby users of groundwater for drinking purposes (ingestion).
- Nearby users of groundwater for all other purposes, which may include bathing and laundry use, sanitary systems (toilets), and irrigation/lawn watering (inhalation of evaporated, volatilized contaminants).
- Persons using the nearby surface waters for recreational purposes, i.e., swimming (dermal exposure) and fishing (accidental dermal exposure and ingestion of contaminated food fish).
- Persons eating edible foods crops (cornfield) and consuming milk or grazing animals, if the corn is not for human consumption.
- Environmental receptors include aquatic biota in affected surface waters, terrestrial fauna using aquatic animals as a food source (birds and land animals), and vegetation that may be stressed.
- Onsite remediation workers.

The above potential receptors have not been specifically identified by surveys, door-to-door interviews, and ecological assays. Only general knowledge and checking with appropriate agencies, game wardens, fish and wildlife officials, and available relevant records were used to define the human and ecological receptors. The potential receptors represent those whom the site would most likely affect in terms of acute and chronic toxicity, as well as biological health implications. It must be noted the available data indicate that only individuals using water from contaminated residential wells (without treatment) have been exposed to site contaminants.

6.3 Selection of the Critical Contaminants

In order to perform the risk assessment, there is a need to address the implications associated with the contaminants found during the RI and prior studies. To consider all of the pollutants that were detected would not measurably add to the

effectiveness of the evaluation. Therefore, addressing only the major contaminants will provide adequate input for the Feasibility Study (FS) and will result in a representative analysis of the present situation. Providing remediation of the critical contaminants will also correct for any impacts associated with other contaminants that were not highlighted.

The following criteria were used to select or exclude the critical contaminants from the risk assessment.

- If there were significant health consequences, based on toxicological potential or level of exposure, associated with an individual contaminant in site-specific circumstances, it was considered to be significant and included in the risk assessment. Conversely, if the opposite were true, the contaminant was not considered. Detected organic contaminants omitted for this reason were di-n-butyl phthalate, ethylbenzene, acetone, 2-butanone (methyl ethyl ketone [MEK]), 2-hexanone, 4-methyl-2-pentanone (methyl isobutyl ketone [MIBK], iron, manganese, and zinc.
- If there were less than two positive detections (in the analytical data) of a compound in any single media (air, soils, groundwater, surface water), the pollutant was not selected. These detections were considered to be unconfirmed. Many of the organic contaminants were found infrequently or in only one sample; consequently, they were not considered to be sufficiently prevalent for risk assessment purposes. Among these were 1,1-dichloroethane, 1,2-dichloropropane, chloroethane, o-xylene, and PCB-1254.
- Other analytical results were not tabulated or used in the risk assessment for the following reasons.
 - All reported detections below contract detection limits were not considered positive findings, but could be used qualitatively for description of contamination patterns.

- Tentatively identified compounds were not considered, mainly because of the lack of an adequate toxicology data base for evaluation and because the reported levels were only estimated.
- Inorganic contaminants (unless the major pollutant was known to be a site-specific toxic inorganic constituent) found in soils were not evaluated because of the inherent heterogeneity of the samples. Inorganic contaminants in groundwater were assessed in terms of their relevance to probable exposure of the receptors and in terms of pertinent water quality criteria.
- In some instances, there were some detected contaminants that were considered to be laboratory contaminants because they did not display a distribution pattern consistent with the other analytical data and have been associated in the past with laboratory contamination problems. Consequently, it has been difficult to ascertain their source. Among the reported contaminants falling in this category were chloroform and methylene chloride. Acetone may have been a contaminant, originating from its use as a decontamination fluid for the bailers used to-obtain the groundwater samples.

The remaining chemical substances found at and around the Heleva Landfill Site have been selected as the critical contaminants to be appraised in the risk assessment. Table 6-1 includes a list of these contaminants, the media in which they were detected, concentrations ranges, and the number of positive detections.

6.4 Potential Health Effects

Potential health impacts are used to evaluate the risk imposed on human receptors exposed to the hazardous constituents. These health effects are defined in terms of the exposure experienced, e.g., acute toxicity--chemical toxic effects after episodic (one time) or short-term exposures; or chronic toxicity--chemical toxic effects resulting from long-term, repeated exposure to low levels of the contaminant. Toxic biological effects include (1) carcinogenicity--the potential

TABLE 6-1
CRITICAL CONTAMINANTS
HELEVA LANDFILL SITE

<u>Contaminant</u>	<u>Media</u>	<u>Concentration Range*</u>	<u>Number of Samples In Which Detected*</u>
Trichloroethene (TCE)	Surface Water	1.7-41.0 µg/l	11
	Sediment	2.6 µg/kg	1
	Residential Wells	55-200 µg/l	4
	Monitoring Wells	1.8-15,000 µg/l	21
	Ambient Air	0.7-538.3 µg/m ³	2
Tetrachloroethene (PCE)	Monitoring Well	13-16 µg/l	4
	Residential Well	12 µg/l	1
	Ambient Air	1.9-3.8 µg/m ³	5
Vinyl Chloride	Surface Water	8.6-9.2 µg/l	3
	Monitoring Wells	10-5,700 µg/l	7
1,1,1-Trichloroethane	Sediment	10 mg/kg	1
	Monitoring Wells	6-1,100 µg/l	2
Toluene	Surface Water	1.1-282 µg/l	8
	Sediment	7.2-14 µg/kg	2
	Monitoring Well	17 µg/l	1
	Ambient Air	0.92-11.7 µg/m ³	5
1,2-trans- Dichloroethene	Surface Water	2.0-40.0 µg/l	11
	Residential Wells	9-31 µg/l	4
	Monitoring Wells	6.2-7,000 µg/l	19
	Ambient Air	3.1-4.8 µg/m ³	2

*Values are based on Remedial Investigation data only.

for causing some manifestation of cancer, based on epidemiological studies and/or animal test results; (2) tumorigenicity--where the chemical contaminant acts as a causal agent to produce tumors, which may be cancerous or benign; (3) mutagenicity --where there is a potential for affecting somal or germinal cells with mutation; and (4) reproductive effects based on animal studies.

Table 6-2 lists the chemical and biological toxicity parameters reported in the toxicology literature for each of the critical contaminants. Pertinent data include (a) acute chemical toxicity data; (b) allowable daily intakes (ADIs) for chronic toxicity evaluation; (c) carcinogenicity classifications and calculated potencies; (d) scope of mutagenicity data in terms of positive findings in multiple test systems; and (e) reported tumorigenicity and reproductive effects, based totally on animal tests. These toxicity parameters are mainly qualitative and must be used with care. The tabulated data is the best information available at this time.

Toxicity parameters, where available, used to gauge the health impacts in this risk assessment include, but are not limited to (a) acute toxicity--the most appropriate toxic effect (based on exposure route) listed in the latest issue (July 1984) of the "Registry of Toxic Effects of Chemical Substances." Where the most relevant dosage was not available, the oral-rat lethal dose, causing death in 50 percent of the test animals (LD₅₀), is used; (b) for chronic toxicity--an Allowable Daily Intake (ADI), calculated by the Environmental Criteria and Assessment Office (ECAO) of EPA, based on the lowest levels at which any effects were observed in animal tests; (c) carcinogenic classifications in the National Toxicology Program (NTP) report on carcinogens of substances or groups of substances that are known to be carcinogenic or that may reasonably be anticipated to be carcinogens. If the contaminant is not listed by the NTP, the International Agency for Research in Cancer (IARC) classification, based on animal test data, is used to define the disease potential; (D) reproductive effects, as listed in the latest Registry of Toxic Effects of Chemical Substances (RTECS).

TABLE 6-2
CRITICAL CONTAMINANTS - TOXICOLOGY DATA

Critical Contaminant	Chemical Toxicity Parameters				Health Advisory SNARLS (µg/L)(c)	Dermal Absorption and Toxicity (d)
	Observed Max. Conc.	Acute Tox. mg/kg (a)	Chronic Toxicity ADIs (mg/day)(b)			
1. Trichloroethene (TCE) CAS No. 79-01-6	15,000 µg/l mon. well	oral human LD ₅₀ -7,000 oral rat LD ₅₀ -7,913	---	---	1 day-2,020 10 day-200 long term-75	---
2. Tetrachloroethene (PCE) CAS Nos. 127-18-4	16 µg/l mon. well	oral rat LD ₅₀ -8,850	---	---	1 day-2,300 10 day-175 long term-20	---
3. Vinyl Chloride CAS No. 75-01-4	5,700 µg/l mon. well	oral rat LD ₅₀ -500	---	---	---	High penetration (gas), extreme and local potency (gas)
4. 1,1,1-Trichloroethane CAS No. 71-55-6	1,100 µg/l mon. well	oral human LD ₅₀ -670 oral rat LD ₅₀ -10,300	38	---	---	---
5. Toluene CAS No. 108-88-3	282 µg/l surf. water	oral rat LD ₅₀ -5,000	30	---	1 day-21,500 10 day-2,200 long term-340	Slight penetration, slight systemic and local potency
6. 1,2-trans-Dichloroethene CAS No. 127-18-4	7,000 µg/l mon. well	No apparent acute toxicity	---	---	1 day-2,700 10 day-270	---

Sources:

- U.S. Department of Health and Human Services (USDHHS), July 1984
- USEPA, 1984a
- USEPA, 1980a
- USEPA, 1980b

NOTES:

- The lack of available data does not imply that associated health impacts are not present.

TABLE 6-2
CRITICAL CONTAMINANTS - TOXICOLOGY DATA
PAGE TWO

Biological Toxicity Parameters

Critical Contaminant	Observed Max. Conc.	Carcinogenicity (e) (f)	Carcinogenic Potency Index (g)	Mutagenicity Bioassays (a)	Reported Reproductive Effects (a)	Reported Tumorigenic Activity (a)
1. Trichloroethene (TCE) CAS Nos. 79-01-6	15,000 µg/l mon. well	Animal suspected (f) human indefinite	2.5	Positive in <u>in vitro</u> bacterial, mammalian, and human cell bioassays. Positive in <u>in vivo</u> animal tests 3 species	5 inhalation studies, rats and mice; 1 oral-rat @ high dose 2688 mg/kg	3 animal studies via inhalation of 100 ppm-500 ppm for 6 months; 1 mouse study ingestion of 455-912 gm/kg
2. Tetrachloroethene (PCE) CAS No. 127-18-4	16 µg/l mon. well	Animal suspected (f)	6.0	Positive - <u>in vitro</u> bacterial (1), mammalian tissue (2), host-mediated (1). Positive - <u>in vivo</u> in rats via ingestion Sperm via inhalation.	4 inhalation studies of rats and mice. No oral tests showed effects. Inhalation, mouse	1 oral-mouse study, ingested 195-240 gm/kg
3. Vinyl Chloride CAS No. 75-01-4	5700 µg/l mon. well	Human definite (e)	1.0	Positive - <u>in vitro</u> bacterial and human cell bioassays, host-mediated-rat and mouse tests. Positive - <u>in vivo</u> animal and insect tests.	Only in inhalation studies of rats and mice. Reported in epidemiological study in man.	In rat and mouse studies by inhalation, 2 oral rat studies at very high dosage, 3.5 gm/kg for 1 year.

(a) USDHSS, July 1984
(e) USDHHS, September 1983
(f) IARC, 1979a
(g) USEPA, 1984(b)

TABLE 6-2
CRITICAL CONTAMINANTS - TOXICOLOGICAL DATA
PAGE THREE

Biological Toxicity Parameters (Continued)						
Critical Contaminant	Observed Max. Conc.	Carcino-genicity (e) (f)	Carc. Potency Index (g)	Mutagenicity Bioassays (a)	Reported Reproductive Effects (a)	Reported Tumorigenic Activity (a)
4. 1,1,1-Trichloroethane CAS No. 71-55-6	1,100 µg/l mon. well	Currently being tested (a)	0.2	Positive - in vitro bacterial (2), rat and hamster tissue.	2 rat inhalation studies @ 2,100 ppm. No oral route studies show positive results.	---
5. Toluene CAS No. 108-88-3	282 µg/l surf. water	Currently being tested (a)	---	Positive - in vitro bacterial (2) and rat liver cells. Positive in vitro rat via inhalation and subcutaneous inject at high doses.	Inhalation by man, Inhalation-rat and mouse studies at high conc., 500 ppm for 7 hours.	---
6. 1,2-trans-Dichloroethene CAS No. 127-18-4	7,000 µg/l mon. well	---	---	---	---	---

Sources:

- (a) USDHSS, July 1984
 (e) USDHHS, September 1983
 (f) IARC, 1979a
 (g) USEPA, 1984(b)

In order to clarify the limitations inherent in using animal test data for cancer risk assessment, the following direct quotation is given:

The risk--likelihood of developing cancer--depends on the intensity, route, and duration of exposure to a carcinogen. Individuals may respond differently to similar exposures, depending on host factors such as age, sex, nutritional status, overall health, and inherited characteristics. Only in a few instances, where studies of long-term human exposures and cancer incidence in restricted environments, can risk be estimated with confidence (USDHHS 1983).

The end-point of a mutational event may be cancer, tumors (benign and malignant), and various birth defects. Although the mutagenicity (ability to cause mutations) may be established by a tier of short-term bioassays of increasing complexity, there is no known link between exposure to a mutagenic contaminant and human health effects because human defense mechanisms are not included in the scope of the bioassay. Consequently, the finding that some of the critical contaminants have exhibited mutagenicity in some bioassays does not establish their carcinogenicity or ability to cause birth defects. However, the positive results in a three-tier test approach would indicate that prudence should be exercised with respect to exposure to these contaminants.

Probability of exposure, as determined by the site-specific hydrogeologic circumstances and extent of contamination, is the other major element used in assessing risk of health consequences and environmental impacts. This is, of necessity, a qualitative judgment that takes into account all of the pertinent factors. Environmental exposure criteria, where available, are used to gauge the health risks associated with the site contaminants. Table 6-3 is a compilation of those relevant criteria.

The selected contaminants are believed to adequately represent the chemical hazards most prevalent at the site. These compounds, therefore, are also representative of the major potential risks to be addressed by further remedial action at the site. Summary appraisals of each compound follow.

ORIGINAL
(Red)

TABLE 6-3
CRITICAL CONTAMINANTS - ENVIRONMENTAL CRITERIA

	Ingestion (Water)					Inhalation	Remarks	
	Critical Contaminant	Observed Max. Conc.	Recommended Maximum Contaminant Levels and		Allowable Daily Intakes µg/day (2)	Suggested Adjusted ADIs (1) * µg/L		Recommended Ambient Air Quality Guidelines µg/m ³ (ppm)
			PPCL (1) (3) µg/L					
1.	Trichloroethene (TCE) CAS No. 79-01-6	15,000 µg/L mon. well	0 (1.8)+			260	6,552 (1,200)	
2.	Tetrachloroethene (PCE) CAS No. 127-18-4	16 µg/L mon. well	0 (1.0)+			85	8,268 (1,200)	
3.	Vinyl Chloride CAS No. 75-01-4	5,700 µg/L mon. well	0 (2.0)+			60	6.24 (2.4)	
4.	1,1,1-Trichloroethane CAS No. 71-55-6	1,100 µg/L mon. well	0 (21.7)+	38,000**		1,000	---	ADI based on rat chronic oral lowest observed adverse effect level (loael) (reproduct. effects)
5.	Toluene CAS No. 108-88-3	282 µg/L surf. water	-(15,000)++	30,000**		---	---	ADI based on rat chronic oral loael

USEPA, 1984c
USEPA, 1984b
USEPA, 1984d
Philadelphia AMS, 1983

* Does not consider carcinogenicity and excludes contributions from air and food
** See Remarks for basis for ADIs
+ Preliminary Protection Concentration Limits (PPCL) based on unit cancer risk
++ PPCLS based on ADIs

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6.5 Evaluation of the Critical Contaminants

6.5.1 Trichloroethene (TCE)

Trichloroethene (TCE) is a volatile, common, frequently encountered solvent, used primarily in dry cleaning and metal degreasing. Human exposure can occur through inhalation (the most extensively studied mode), ingestion, or direct contact.

At the Heleva Landfill Site, TCE was detected in 21 monitoring well samples. The maximum concentration (15,000 $\mu\text{g/l}$) occurred in monitoring well B-7. The remaining concentrations are within the range of 1.8 to 410 $\mu\text{g/l}$. TCE was also found in five residential well samples (maximum concentration 200 $\mu\text{g/l}$), nine surface water samples (maximum concentration 41 $\mu\text{g/l}$), two leachate samples (maximum concentration 9.6 $\mu\text{g/l}$), and one sediment sample (2.6 $\mu\text{g/kg}$).

The major potential exposure to TCE in site-specific circumstances is by ingestion of contaminated drinking water due to groundwater contamination.

Exposure by direct contact is a secondary exposure scenario. There is some potential for dermal exposure to TCE by persons using the surface waters for recreational purposes, through dermal contact with contaminated surface water and ingestion of contaminated surface water.

There is a slight potential for chronic biological health impacts from exposure to TCE vapors at extremely low levels in ambient air, both inside and outside the residences, where groundwater has shown some contamination.

A measure of acute toxicity risks associated with TCE can be estimated by comparison with the reported lowest lethal dose (LD_{LO}) in humans of 7 gm/kg via oral exposure. The EPA's Health Advisory Suggested No Adverse Response Level (SNARL) (based on a 10 kg child who consumes 1 liter of water per day) for TCE sets the permissible exposure limit (for ingestion of water) at 2,020 $\mu\text{g/l}$ for a one-day exposure with no observed chemical toxic effects. At 15,000 $\mu\text{g/l}$ (monitoring well B-7), there are some potential acute toxicity risks associated with

the site, if the water is ingested. Although the residential well data do not indicate immediate acute health risks (maximum residential well TCE concentration: 200 µg/l), TCE levels could reach significantly higher concentrations at some time in the future.

With regard to chronic exposure to TCE in drinking water, the most relevant comparison criteria are the SNARLs [10 kg child, 1 liter of water per day of 200 µg/l (10 days) and 75 µg/l (long-term exposure)]. Three of the domestic well samples (Cincilla, Heleva, Heleva Duplicate) exceeded the long-term SNARL. There is a potential for chronic chemical toxic effects associated with long-term consumption of drinking water containing TCE at the observed concentrations in the residential wells.

Chronic health effects via inhalation of volatilized TCE when showering or bathing is not expected. However, there is a potential for biological health consequences from long-term exposure.

Mutation effects (heritable changes in genetic material) due to TCE exposure have been observed in mutagenic bioassays using a variety of tester organisms. All of the reported reproductive effects observed in animal tests are based on inhalation exposure (USDHHS 1984). Tumorigenic effects have been observed in mice fed high doses (455 gm/kg for 78 weeks) of TCE. At the TCE levels present in groundwater samples, tumorigenic effects would not be expected in any exposure scenario.

TCE is classified by the International Agency for Research on Cancer (IARC, 1980) as a "suspected animal carcinogen." At present, it is not included in the National Toxicology Program (NTP) list of known or suspected carcinogens. A comparison to the Preliminary Protective Concentration Limit (PPCL), based on an acceptable cancer risk of 10^{-6} , i.e., one additional case of cancer attributed to exposure to TCE at this level in a group of one million people, suggests that there may be potential carcinogenic risks associated with consumption of contaminated drinking water from the domestic wells. A comparison of the PPCL for TCE at 1.84 µg/l to

the maximum observed concentration of 200 $\mu\text{g/l}$ indicates a cancer risk if the water is ingested over a long time (i.e., chronic ingestion for 70 years).

TCE is rapidly absorbed through human skin upon dermal contact (U.S. EPA, 1980b). Therefore, there may be potential health risk to recreational users (swimmers) of contaminated surface waters. However, even if Todd Lake and Ranger Lake are used for swimming and boating, producing long-term (over 10-30 years), repeated dermal exposures to 7.0 $\mu\text{g/l}$ of TCE (found in Ranger Lake), the risks would be considered to be of a low order because of the low probability of the exposure mode required to produce the health effect, i.e., 10-30 years of repeated exposures over the entire year.

There is a slight potential of exposure to TCE by receptors consuming aquatic organisms from contaminated surface waters. Additionally, the maximum TCE concentration observed in surface waters (41 $\mu\text{g/l}$) is well below the Ambient Water Quality Criteria for ingestion of aquatic organisms (80.7 $\mu\text{g/l}$ - 10^{-6} carcinogen risk). Therefore, the probability of an individual developing adverse health effects from consuming fish obtained from the contaminated offsite surface waters is very low.

Multiple exposure, through inhalation of TCE-contaminated indoor air and dermal contact during bathing, may be associated with a low potential for consequent health impacts to the residents, where well contamination has occurred. There is no analytical data available to confirm the above conclusion.

Migration of TCE vapors from the "TCE Spill Area" with eventual exposure to human receptors in the vicinity of the site is not likely in the site-specific context. Attenuation of the maximum observed concentration (533 $\mu\text{g/m}^3$) would be reduced to background levels by the time the air reaches the receptor location, by dispersion from winds and diffusion into an infinite sink (the ambient air).

6.5.2 Tetrachloroethene (PCE)

Tetrachloroethene (PCE) is a volatile, frequently encountered solvent used primarily for dry cleaning or degreasing. It can be toxic by inhalation, ingestion, or skin absorption.

Tetrachloroethene was detected in two monitoring well samples (13-16 $\mu\text{g/l}$) and one domestic well sample at a concentration of 12 $\mu\text{g/l}$ (at the inlet side of a water softener only). PCE was not found above detection limits in any surface water or leachate, sediment, or soil samples.

In site-specific circumstances, ingestion via contaminated drinking water is the primary route of exposure to PCE. Inhalation and dermal exposure (volatilization during bathing, showering, etc.) or dermal contact/ingestion (recreational use of surface waters) are minor potential exposure modes.

Acute toxic effects from episodic or short-term exposure to PCE would not be expected in any reasonably conceivable exposure scenario. This conclusion is based on an oral-rat LD_{50} of 8,850 mg/kg of body weight and the EPA SNARL of 2,300 $\mu\text{g/l}$ (10 kg child consuming one liter of water per day).

ADIs or drinking water standards have not been established for PCE. The SNARLs (10 kg child ingesting one liter of water per day) for chronic exposure has been established at 175 $\mu\text{g/l}$ (10 day exposure) and 20 $\mu\text{g/l}$ (life time exposure). Based on these criteria, consumption of PCE at the observed concentrations in groundwater would pose a minimal chronic chemical toxicity risk, since the observed concentrations do not exceed any of the above criteria.

Mutation activity has been reported in several bioassay systems using various cell types, tester organisms, and tissues. All of the reported reproductive effects associated with PCE have been generated by animal test data, where the administered route has been inhalation. Inhalation would be an unlikely major route of exposure in site-specific circumstances. Some tumorigenicity (in animal tests) has been associated with the ingestion of PCE. However, the dosages needed

to generate tumors in mice have been at high levels, i.e., 195-240 mg/kg of test animal body weight.

PCE is classified by the International Agency for Research in Cancer (IARC) as a "suspected animal carcinogen." It is not included in the NTP list of known or suspected carcinogens. A comparison of the maximum observed concentration of 12 µg/l (before treatment in one residential well i.e., the Horwith Well) to the PPCL of 1.0 µg/l would indicate that the exposure level in that one residential well could pose an unacceptable health risk, if treatment were discontinued. It must be emphasized that the preceding PPCL is based on ingesting water, contaminated at this level for a 70-year period, at a rate of 2 liters per day. It should also be pointed out that present-day, state-of-the-art analytical methods can not detect 1.0 µg/l with any precision and that intake background levels of PCE in many water supplies exceed the PPCLs in some parts of the United States.

However, there is no data to indicate that receptors near the Heleva Landfill Site are being exposed to PCE via contaminated drinking water.

Given the absence of PCE in surface water samples, potential health risks to receptors using surface waters for swimming or fishing would be of a low order.

6.5.3 Vinyl Chloride

Vinyl chloride is a synthetic, chlorinated, organic chemical used in the manufacture of polyvinyl chloride (PVC) and other products used in the building and construction, automotive, and other industries. Vinyl chloride has been produced in large quantities over the past 40 years (5 billion pounds in the United States in 1978) and has been the backbone material for the production of plastics throughout the world. Its presence in site-specific circumstances may be attributable to breakdown of the halogenated aliphatic hydrocarbons TCE and PCE to vinyl chloride. It may also be an artifact resulting from the solvent extraction process during laboratory analysis.

Concern for human exposure to vinyl chloride stems mainly from its association with the production of liver cancer in workers exposed by inhalation during the production of vinyl chloride and vinyl chloride monomers. The International Agency for Research on Cancer (IARC) and the U.S. Department of Health and Human Services, through the auspices of the National Toxicology Program, consider vinyl chloride a human carcinogen.

Mutagenicity of vinyl chloride has been demonstrated in laboratory study systems. Biotransformation to an active electrophilic species, causing nonrepairable damage to DNA, resulting in a mutagenic effect, is probably one of many factors associated in vinyl chloride's carcinogenicity. Detrimental reproductive effects have also been demonstrated in laboratory studies involving rodents. Reports of congenital defects have been cited (U.S. EPA 1978); however, the results of these studies are not completely unequivocal.

Chronic exposure to vinyl chloride through inhalation has been associated with liver toxicity, fatty deposition in particular. Its toxicity, from an acute standpoint, is a reversible narcosis similar to alcohol intoxication. Chronic effects, while possible, are minor in contrast to vinyl chloride's carcinogenic potential. It is unlikely that acute effects would be observed at the concentrations and exposure scenarios expected.

Environmental sampling and analysis at the Heleva Landfill Site revealed vinyl chloride in leachate streams on the east side of the landfill (8.6 $\mu\text{g/l}$, 8.9 $\mu\text{g/l}$, and 9.6 $\mu\text{g/l}$). If allowed to follow the runoff pattern, the vinyl chloride in these streams would most likely be deposited in the retention pond; however, none of the data gathered indicate that this has occurred. Considering the very high Henry's Constant ($H=8.2 \times 10^3$) of vinyl chlorides, volatilization to the atmosphere probably occurs before deposition in the pond.

Therefore, the individuals at risk for exposure to vinyl chloride in the leachate streams would be remedial investigation workers or persons trespassing on the site, who may encounter vaporous vinyl chloride. A conservative estimate of the maximum exposure concentration to an individual in the immediate vicinity of a

leachate stream at the concentrations observed is $78.9 \mu\text{g}/\text{m}^3$ (31 ppb) at the interface between the leachate and ambient air. Dilution of this concentration would occur rapidly, as distance from the source (the stream) increases. Hence, in all probability, an inhalation exposure, such as the one described, would be of a much lower concentration and of brief duration.

Vinyl chloride was also observed in seven samples from five separate monitoring wells. Two of the wells (10B, three observations: $62 \mu\text{g}/\text{l}$, $69 \mu\text{g}/\text{l}$, and $50 \mu\text{g}/\text{l}$; and 9A, one observation, $10 \mu\text{g}/\text{l}$) were south and east of the site and in the general site contaminant migration plume. A third affected well (13B, one observation, $50 \mu\text{g}/\text{l}$) is located on the northern edge of the site. Two of the Nassaux-Hemsley Wells contained vinyl chloride at concentrations much higher than those observed in any other environmental samples. These observations were NHB-7, $560 \mu\text{g}/\text{l}$ and NHB-8, $5,700 \mu\text{g}/\text{l}$. None of the residential wells sampled have been contaminated with vinyl chloride. Although vinyl chloride exposure by ingestion of domestic water is not occurring, ingestion and concomitant inhalation is possible if vinyl chloride migrates to the wells of groundwater users.

All concentrations of vinyl chloride observed in the monitoring wells are in excess of the Preliminary Protective Concentration Limit (PPCL) of $2.0 \mu\text{g}/\text{l}$, which is based upon Unit Cancer Risk (UCR). Hence, should groundwater contaminated with vinyl chloride, at the levels observed in the investigation, be ingested, those exposed would incur an increased risk of cancer greater than the 10^{-6} (one in a million) level.

6.5.4 1,1,1-Trichloroethane

1,1,1-Trichloroethane (methyl chloroform) is a colorless, synthetic chemical, widely used as a degreasing and dry cleaning solvent. It is often found as a component of solvent mixtures. It is commonly found in the workplace and at low concentrations in the environment.

Human exposure to methyl chloroform can occur via inhalation, ingestion, or direct contact.

Methyl chloroform was found in groundwater in two monitoring well samples (6-1100 µg/l) and one sediment sample (10 µg/kg). It was not found above detection limits in surface water, soil, or domestic water samples.

Ingestion of contaminated drinking water is the primary exposure mode for methyl chloroform in site-specific circumstances. Exposure via inhalation is also a potential exposure scenario.

Exposure of an episodic nature (single-time) to methyl chloroform in drinking water does not have any associated health effects at the reported levels. The most relevant criterion for comparison are the human, oral, lowest reported Toxic Dose Level (TDL) of 670 µg/kg of body weight and an oral rat LD₅₀ of 10,300 mg/kg of body weight. Thus, there are no known acute toxicity effects associated with this contaminant at the concentrations detected in the groundwater.

The ADI for methyl chloroform is 38 µg/day. This figure is based on a rat chronic Lowest Observed Adverse Effect Level (LOAEL) associated with toxic effects in a number of organ systems. Assuming a 2 liter consumption of water per day or 19 µg/l, all of the samples detected would be below the established ADI. All detected concentrations were also below the ADI-derived Preliminary Protective Concentration Limit (PPCL) of 19,000 µg/l. Therefore, potential chronic toxic effects from the ingestion of methyl chloroform contaminated water would not be expected.

Mutation effects have been reported by the Registry of Toxic Effects of Chemical Substances (RTECS) for methyl chloroform. Reproductive effects associated with methyl chloroform have been reported by RTECS (RTECS, 1980) as a result of inhalation studies in animals. However, under present site-specific circumstances, exposure via the inhalation route would be of a low order.

Methyl chloroform is classified by IARC as an indefinite animal carcinogen. It is not included in the NTP list of known or suspected carcinogens. A comparison to the Unit Cancer Risk (UCR) derived PPCL (10^{-6} carcinogenic risk) of 21.9 µg/l, would indicate a potential carcinogenic risk associated with methyl chloroform at

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this site, if domestic water would become contaminated and be used for drinking purposes over a lifetime. However, at present, there is no evidence to indicate that human exposure to methyl chloroform is occurring.

Given the absence of methyl chloroform in surface water samples, potential health risks to receptors using surface waters for recreational purposes would not be present.

6.5.5 Toluene

Toluene is a common solvent used in the production of many organic compounds. Human exposure can occur through ingestion, inhalation, and to a lesser extent, through skin contact. The primary site-specific route of exposure to toluene is ingestion of drinking water and dermal exposure by users of contaminated surface waters. Inhalation is a minor mode of exposure.

At Heleva, toluene was found in one monitoring well sample (17 $\mu\text{g/l}$), 2 leachate samples (85-282 $\mu\text{g/l}$), 6 surface water samples (maximum concentration 51 $\mu\text{g/l}$), and one sediment sample (14 $\mu\text{g/kg}$). Toluene was not found above detection limits in any of the residential well samples.

Acute toxic effects via the ingestion of toluene-contaminated drinking water would not be expected in any reasonably conceivable exposure scenario. This assessment is based on the maximum observed concentration (17 $\mu\text{g/l}$ -monitoring well, 51 $\mu\text{g/l}$ -surface water) compared to an oral-rat LD_{50} of 5,000 mg/kg of body weight and a SNARL (based on a 10 kg child consuming 1 liter of water per day) of 21,500 $\mu\text{g/l}$ for a one day exposure.

A comparison to the ADI for toluene of 30 mg/day (based on a rat NOAEL) would indicate that ingestion of 2 liters of contaminated groundwater would not exceed this criteria. Potential chronic health effects of exposure to toluene in drinking water would not be a consideration.

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Mutations (inheritable changes in genetic material) have been reported in some bioassay systems. Toluene is presently classified as provisionally non-mutagenic.

Reproductive effects were observed in one test animal where toluene was administered orally to mice (6-15 days pregnant) in large doses. The lowest reported toxic concentration (TC_{LO}) was 15-30 g/kg of body weight.

Toluene is currently being tested (as of June 1983) by the NTP for carcinogenicity. There are no available data to indicate that toluene is a human or animal carcinogen.

Toluene in the liquid form exhibits a slight degree of dermal and a slight degree of systemic and local potency. Under site-specific circumstances, there is a low potential for health effects from dermal contact to contaminated surface or groundwater.

A comparison to the ambient water quality criteria of 424 mg/l for the protection of human health from chemical toxic properties of toluene, by ingesting aquatic organisms from contaminated water, suggests that potential health effects from this exposure mode would be unlikely.

6.5.6 1,2-trans-Dichloroethene

Both the trans and cis isomers of 1,2-dichloroethene have been used as solvents and chemical intermediates. Because of their flammability and subsequent limited usage, toxicological data is scant. All of the reported toxicological effects associated with 1,2-trans-dichloroethene have been generated by animal test data in which the administration route has been inhalation or intraperitoneal injection (RTECS, 1980).

At Heleva, 1,2-trans-dichloroethene was found in 19 monitoring wells at a concentration range of 6.2 to 7000 µg/l, the maximum concentration occurring at monitoring well B-7. The remaining concentrations are in the range of 6.2 to 730 µg/l. 1,2-trans-dichloroethene was also detected in eleven surface

water/leachate samples (maximum concentration 40 $\mu\text{g/l}$) and 4 residential well samples (maximum concentration 31 $\mu\text{g/l}$). 000001
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At the Heleva Landfill Site, ingestion of contaminated drinking water is the primary exposure mode to 1,2-trans-dichloroethene. Inhalation and dermal contacts are also potential routes of exposure.

Acute toxic effects from short-term exposure to 1,2-trans-dichloroethene at the maximum reported concentration (7000 $\mu\text{g/l}$) in groundwater would be unlikely under site-specific circumstances. Data indicate a low to moderate oral toxicity for 1,2-trans-dichloroethene (PATTY, 1981). In comparison to the oral-rat LD_{50} (60:40 cis-trans isomer mixture) of 2000 mg/kg of body weight, acute toxic effects would be unlikely in any reasonably expected exposure scenario (PATTY, 1981).

No ADI, drinking water standard, or SNARLs have been established for 1,2-trans-dichloroethene. The possible chronic health effects from exposure to 1,2-trans-dichloroethene in drinking water would be minimal because of the low toxicity character of this contaminant.

6.6 Environmental Effects

The presence of TCE and 1,2-trans-dichloroethene in the surface waters (Quarry, Coplay Creek, and Ranger Lake) south and south-east of the site raises the concern of possible effects on aquatic flora and fauna. The ecological impacts have one primary component, i.e., toxic effects on the fish and plant life in surface waters from exposure to TCE and 1,2-trans-dichloroethene. Data regarding acute and chronic toxicity to aquatic life are shown in Table 6-4.

In comparison to the maximum observed concentrations of TCE and 1,2-trans-dichloroethene in surface waters (41 and 40.8 $\mu\text{g/l}$ respectively, both observed in the Quarry), potential acute or chronic toxic effects would be unlikely.

Toxic effects could occur at lower or higher concentrations in species that exhibit greater or lesser sensitivity than those tested.

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TABLE 6-4
AQUATIC TOXICITY DATA
HELEVA LANDFILL SITE

	<u>Maximum Observed Concentration</u>	<u>Ambient Water Quality Criteria Acute Toxicity</u>	<u>Ambient Water Quality Criteria Chronic Toxicity</u>
Trichloroethene ¹	41 µg/l	45,000 µg/l	21,000 µg/l ²
1,2-trans- ¹ Dichloroethene	40.8 µg/l	118,000 µg/l	20,000 µg/l

¹ Both observations at the Quarry near the spring

² Based on behavioral effects

6.7 Conclusions

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A summary of the health and environmental risks associated with the Heleva Landfill Site is presented to focus the evaluation. The risks are based on comparisons with relevant environmental criteria and the conclusions derived from the contamination patterns, opportunities for exposure, and the chemical and biological toxicity of the contaminants.

- The primary exposure path, along with concomitant health risks, is ingestion of contaminated groundwater (with TCE) found in two residential wells. TCE concentrations exceed the 10^{-6} cancer risk* level. Acute and chronic chemical toxicity resulting in health deterioration effects would not be expected at this site.

However, if the concentrations of TCE, PCE, and vinyl chloride in the residential wells increased to levels found in the monitoring wells, users of the water would be exposed to chronic chemical toxicity risks.

- Another possible exposure mode for the TCE-contaminated groundwater is bathing (dermal exposure and inhalation of accumulated organic vapors in ambient air in the homes using the water. There is no available data to determine what the exposure levels are or whether exposure is occurring. Inhalation of TCE would be of greatest concern. Because of the intermittent nature of the exposure, this mode may not pose any health risks.
- Recreational use of the surface waters containing TCE may pose a risk. However, the intermittent, seasonal and short-time nature of the exposure would preclude any potential health risks associated with this exposure mode.

* 10^{-6} cancer risk is defined as the concentration (of that particular chemical) at which it is estimated one additional cancer case would be expected to occur in an exposed population of one million people.

- Ingestion of any of the volatile organic contaminants in the food chain is not considered to be an exposure path of consequence. The comparatively low bioaccumulation factors (10.6, TCE; 30.6, PCE; and 1.17, vinyl chloride), combined with the low probability of consumption of aquatic food animals from the lakes and the absence of commercial fishing, would indicate a minimal contribution of these contaminants to the body burden. This pathway, although it may be real, is not considered to be of any consequence.
- At the observed concentration of contaminants in surface water, considering the absence of any mechanisms causing an increase to significant levels, aquatic toxicity effects would not be expected.

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7.0 SCREENING OF REMEDIAL ACTION TECHNOLOGIES

A two-phased process is used for the selection of the most appropriate remedial approach for a given site. First, an initial screening of feasible technologies is required to eliminate obviously infeasible, inappropriate, or environmentally unacceptable alternatives. The second phase of remedial action selection involves a detailed analysis of a limited number of remedial alternatives, based on technologies that have passed the initial screening stage.

Numerous technologies are available for use at the Heleva Landfill Site. Although many are applicable, it is apparent that a number of technologies can be removed from further consideration, based on the information obtained about the site during the Remedial Action Master Plan (RAMP) and the Remedial Investigation (RI).

Screening began during the RI, as information on the site conditions was obtained. Following the assessment and evaluation of the data collected at the Heleva Landfill Site during the RI, a list of preliminary, applicable technologies was developed. This list consists of actions that address the significant site problems and pathways of contamination identified during the RI:

- No action
- Monitoring
- Alternative water supply
- Surface capping
- Groundwater barriers
- Surface regrading and revegetation
- Surface water diversion
- Leachate collection
- Gas collection and venting or treatment
- Groundwater collection
- Source reduction
- Treatment technologies

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- Contaminated soil/sediment removal
- Excavation
- Disposal technologies

These actions can be grouped as shown on Table 7-1.

Each technology has been studied and reviewed in accordance with the following four categories of criteria:

- Technical Considerations
- Public Health and Environmental Considerations
- Institutional Considerations
- Cost Considerations

During initial screening, the investigation team and other personnel, with experience in an applicable discipline, reviewed and evaluated the results and conclusions of the RI. The technologies identified during the RI, as well as technologies encompassing treatment or disposal, which were thought to be of importance, were discussed and evaluated. In the following narratives, each technology is reviewed and discussed separately under each category. If the technology is rejected for use at the Heleva Landfill Site under a particular category, it is eliminated from further consideration.

In some cases, there are several technologies that are similar to each other, such as the various technologies used for leachate collection or water supply. In these cases, an evaluation was performed to determine which technology was most appropriate for the Heleva Landfill Site.

7.1 Technical Considerations

7.1.1 No-Action Technologies

The purpose of reviewing the no-action alternative is to estimate the effect of not performing additional remedial actions at the site.

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TABLE 7-1

GENERAL RESPONSE ACTIONS AND
ASSOCIATED REMEDIAL TECHNOLOGIES
HELEVA LANDFILL SITE

<u>General Response Action</u>	<u>Associated Remedial Technologies</u>
No Action	No Action Monitoring
Alternative Water Supply	Public Water Extension New Well and Distribution Bottled Water Individual Well Treatment
Containment	Capping Groundwater Barriers
Diversion	Regrading and Revegetation Diversion Ditches and Berms
Collection	Leachate Collection Gas Collection and Venting or Treatment
Groundwater Contamination Reduction	Groundwater Collection Source Reduction
Onsite Treatment	Leachate Treatment

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TABLE 7-1
GENERAL RESPONSE ACTIONS AND
ASSOCIATED REMEDIAL TECHNOLOGIES
HELEVA LANDFILL SITE
PAGE TWO

<u>General Response Action</u>	<u>Associated Remedial Technologies</u>
Offsite Treatment	Leachate Treatment
Complete Removal	Soils and Sediments Landfill Waste Material
Offsite Disposal	Landfill Incineration
Onsite Disposal	Landfill Incineration

7.1.1.1 No Action

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This alternative assumes that no remedial activities will be taken at the Heleva Landfill Site. The identified contamination in the groundwater will continue, with the possibility of either increasing or decreasing without anyone's being aware of those changes or being able to take steps to deal with them. The landfill cover will continue to erode, a factor that will lead to increased exposure of wastes to the environment.

7.1.1.2 No Action - Monitoring

Under a no-action alternative, additional remedial activities would not be performed. However, a long-term monitoring program can be established to provide information, so that possible adverse public health or environmental impacts that may arise can be addressed. At the Heleva Landfill Site, this would include monitoring the groundwater and surface waters, at a minimum. This technology will be considered further.

7.1.2 Alternative Water Supply

Alternative water supply systems are designed to provide residences and other facilities with potable water. Currently, some residences are experiencing contamination of their water supplies from contaminated groundwater. The following water supply system alternative actions have potential applications at the Heleva Landfill Site.

- Extend the water supply lines
- Install, in the affected area, two upgradient wells with a storage and distribution system
- Provide bottled water
- Install individual treatment units on the present wells

These alternative actions do not alleviate problems that arise from the landfill leachate and plume but rather provide protection to the receptors.

7.1.2.1 Extension of Municipal Water

Water lines can be extended from the Northampton Municipal Authority's 12-inch-diameter water main to the affected area. This main will provide potable water, along with fire protection, and must be the minimum size (12-inch) that the authority will allow. This alternative is the most complete and reliable of the water supply system alternative actions considered.

7.1.2.2 Installation of Community Wells

Installation of two upgradient wells with water being pumped to a reservoir and then to the affected area by a water distribution system is a feasible solution to the problem. The water main used for distribution purposes would only be required to be 6 inches in diameter and would provide adequate protection for the residences or facilities in the affected area. Although this would be a complete system, it would require modifications if new residences or facilities were to connect to it. Also, without treatment of the water supply, there would always be a possibility of groundwater contamination from other sources. This will lead to a continuous, long-term monitoring program for the system to ensure its quality.

7.1.2.3 Bottled Water

Providing bottled water is a short-term solution to the problem. Extended usage of bottled water is an inconvenience to the residents and does not provide protection from dermal exposure. Since the time for any improvement of the groundwater is expected to be several years, even with source reduction, this technology will be eliminated from further consideration.

7.1.2.4 Individual Treatment Units

Installation of individual treatment units on the present wells involves designing an adequate treatment system to remove contaminants found in the groundwater, followed by continuous monitoring of the systems over an extended time.

Treatment systems proposed for the Heleva Landfill Site are carbon filter units to remove the volatile organics and water softening units to remove high zinc, iron, and manganese levels, primarily for aesthetic reasons. Although these systems would alleviate the problem of nonpotable drinking water, they would not provide fire protection and are subject to upkeep and maintenance. Improper upkeep of these systems could lead to failure and possible future contamination. Routine sampling would be required to ensure that a unit is operating properly. Since residential well sampling has shown a wide variation in contaminant concentrations, this monitoring would have to be done frequently.

7.1.2.5 Conclusions

A summary of the technology screening for alternative water supply systems is presented in Table 7-2.

A detailed discussion of the alternative water supply technologies can be found in Appendix F. After evaluation of these technologies, extension of the public water lines will be retained, while individual treatment units and new upgradient wells will not be considered further. The water line extension is a standard, reliable technology that will require little or no monitoring. Individual treatment units would require frequent monitoring, particularly in light of the high fluctuation in contaminant concentrations. They will also have to be continually maintained and are not as reliable as the municipal water supply. The upgradient well option has several drawbacks. First, groundwater movement is controlled by fractures. In order for a well to yield sufficient quantities of water, it must intersect one of the fractures. Several attempts may be needed before a productive well is drilled. Second, there is no way to prevent a well from intersecting with a fracture that leads to a pollution source. Routine monitoring will be needed to assure the quality of the water being produced from the well. Third, a small facility, such as is proposed here, is more vulnerable to accidents than a much larger system, which normally has backup equipment. A pump failure, electrical outage, or similar problem can result in inadequately treated water, or no water, for the consumers. Fourth, a separate water supply will have to duplicate services already provided by the municipal water authority. These services include the routine testing, certified

TABLE 7-2

TECHNICAL SCREENING
ALTERNATIVE WATER SUPPLY TECHNOLOGY
HELEVA LANDFILL SITE

<u>Technology</u>	<u>Costs (in \$ thousands)</u>	<u>Retained for Further Evaluation</u>	<u>Comments</u>
Extend present water lines	388.0	Yes	Most complete and reliable; no monitoring required.
Install logradient wells with storage and distribution system	529.5	No	Little excess capacity; continuous monitoring required.
Provide bottled water	20.2	No	Short-term solution; not appropriate.
Install individual treatment units on existing wells	314.3	No	Requires extensive monitoring and maintenance.

operators, proper maintenance, and proper, quick response to service requests. For these reasons, the extension of the municipal water supply is the only technology that will be recommended for provision of an alternative water supply system.

7.1.3 Surface Capping

Capping techniques are designed to minimize leachate generation by reducing or eliminating infiltration and to reduce offsite transport of covered materials and exposed refuse. Capping is normally performed in conjunction with site closure and in preparation for potential reuse of the area.

This technology involves installation of a highly impermeable barrier over the soil cover, with topsoil and vegetation then covering the barrier. Regrading of the cover material will be required in preparation for capping.

Possible capping materials include

- Synthetic membranes
- Clay
- Sprayed bituminous membranes
- Polyurethane foam
- Resins
- Soil additives and cements

Synthetic membranes and clay have been used extensively as capping materials. However, material availability, costs, and extended exposure/deterioration of some synthetic materials might be disadvantageous.

Sprayed bituminous membranes such as asphalt are susceptible to cracking. This tendency reduces the effectiveness of the cap by increasing the potential for infiltration. Special handling and application are also required, factors which increase the costs for this type of cap.

Cap materials such as polyurethane foam and resins have not had widely practiced, site-specific applications. Therefore, they are not applicable at this site.

Soil additives and cements are applicable at this site. The cover soil available on site is a homogeneous mixture of mine spoil material that is already relatively clayey. Bentonite clay can be added to sufficiently lower the permeability to meet the RCRA requirements. Caps of these materials are susceptible to cracking and deterioration, but these factors can be controlled by a good topsoil cover and proper maintenance.

A cap conforming to the requirements of the Resource Conservation and Recovery Act (a RCRA cap) must be less permeable than the material that comprises the bottom of the landfill. Since the Heleva Landfill has no impermeable liner on the bottom, an acceptable cap would be constructed of 2 feet of clay, with a 1-foot drainage layer, a geotextile filter fabric, and a protective soil cover 4 feet thick above it.

A summary of surface capping technology screening is presented in Table 7-3.

7.1.4 Groundwater Barriers

Groundwater barriers are installed vertically to (1) decrease the possibility of groundwater migration from the site or (2) divert groundwater so that contact with the waste materials is reduced. Groundwater barriers at this site might be constructed upgradient of the landfill to divert groundwater or could be constructed to completely surround the landfill.

Various methods and materials that can be used to construct impermeable groundwater barriers include

- Slurry walls
 - Soil/bentonite
 - Cement/bentonite
- Sheet piling

TABLE 7-3

TECHNICAL SCREENING
SURFACE CAPPING TECHNOLOGIES
HELEVA LANDFILL SITE

<u>Surface Capping Technology</u>	<u>Retained for Further Evaluation</u>	<u>Comments</u>
Synthetic Membrane	Yes	
Clay	Yes	
Sprayed Bituminous Membrane	No	Susceptible to cracking
Polyurethane Foam	No	Not fully demonstrated
Resins	No	Not fully demonstrated
Soil Additives and Cements	Yes	Use onsite material

- Gel injection
- Grout curtain
- Vibrating beam/asphalt

Construction of groundwater barriers is a relatively specialized technology practiced by only a few firms.

Groundwater barrier control involves a thorough hydrogeologic and geotechnical investigation prior to design. Variables affecting the long-term effectiveness of this technology include

- Depth to bedrock
- Degree of fracturing of the bedrock
- Permeability of surrounding soils
- Aquifer transmissivity
- Hydraulic conductivity
- Soils classification
- Hydraulic gradient
- Compatibility with contaminants

At the Heleva Landfill Site, bedrock is highly fractured, and groundwater barriers would not effectively exclude or contain groundwater. Since this technology would be ineffective, it will not be considered further.

7.1.5 Surface Regrading and Revegetation

This technology involves regrading the site to reduce surface water infiltration and to control erosion. Grading is often performed as a part of surface-sealing activities because of its inherent aesthetic and soil transport control aspects. Revegetation involves preparing the soil surface, seeding, fertilizing, and mulching to establish a good growth of vegetation. This action should decrease the amount of erosion caused by wind and water.

Grading and revegetation involve the use of standard construction procedures; however, substantial quantities of local soil may be required to modify the slopes. Also, periodic regrading and future site maintenance may be necessary to repair depressions formed through differential settlement or to repair slopes that have slumped or become badly eroded.

ORIGINAL
(Red)

At the Heleva Landfill Site, simple grading and revegetation had been implemented with little success. The present cover material is barren, because of its low fertility, and is eroding, a process that will result in exposure of the landfilled refuse to the atmosphere. For this reason, surface grading and revegetation, as described above, will not be studied further for use at the Heleva Landfill Site. Grading will be used, where appropriate, to prepare the surface for other remedial actions such as capping.

7.1.6 Surface Water Diversion

This methodology involves constructing surface water diversion structures, such as dikes, berms, or ditches to control surface water flow on and around the site. Surface water from uphill would be intercepted and routed around the landfill. Surface water running off the landfill would be managed, so that its velocity will stay low, and erosion would not occur. This technology is effective, and it will be considered further.

7.1.7 Leachate Collection

Leachate control systems are designed to collect and control surface seeps prior to entering the groundwater or surface water.

This technology addresses surface water contamination, although evidence indicates that contamination via surface water migrating off site is not significant at this time. Some leachate is generated in response to rain at the Heleva Landfill Site, and this leachate would be collected. The following leachate collection technologies have potential applications at the Heleva Landfill Site:

- French drain
- Tile drain
- Pipe drain

French drains are constructed by excavating a trench, lining the trench with filter fabric, and backfilling with gravel. Leachate that is intercepted then flows along the trench to a sump, tank, or appropriate collection point. The French drain is not as efficient as tile and pipe drains for conveying leachate because of lower hydraulic conductivity.

Tile drains are similar to French drains, but have vitrified clay pipe placed along the bottom of the trench in the gravel to provide a more effective conduit for leachate removal. Leachate seeps in joints between each length of pipe. The joints are, however, susceptible to clogging and the pipe is susceptible to crushing.

Pipe drains are similar to tile drains, except that the clay pipe is replaced with perforated plastic pipe, which is installed with sealed joints. The design eliminates the potential for clogging, and plastic pipe has more resistance to crushing than clay pipe. Thus, pipe drains are the preferable method of shallow leachate collection.

A summary of the screening of leachate collection technologies is presented in Table 7-4.

Leachate collection systems are normally followed by treatment. Because the chemical consistency and quantity of leachate varies, the treatment system should be based on a treatability study program. The leachate quality may also change with the age of the landfill.

7.1.8 Gas Collection and Venting or Treatment

The decomposition of wastes in a landfill generates methane, which normally rises and mixes with the atmosphere without causing any problems. However, when the landfill is capped, this gas must be collected and managed so that it does not build high internal pressures or migrate underground to nearby homes.

TABLE 7-4
 TECHNICAL SCREENING
 LEACHATE COLLECTION TECHNOLOGIES
 HELEVA LANDFILL SITE

<u>Leachate Collection Technology</u>	<u>Retained for Further Evaluation</u>	<u>Comments</u>
French Drain	No	Less efficient leachate removal because of low hydraulic conductivity
Tile Drain	No	Tile drain susceptible to clogging and crushing.
Pipe Drain	Yes	

Several types of active and passive gas collection and venting systems are available. Active systems draw or force the gas out of the landfill. Passive systems allow the gases to move along gravel channels or through vertical pipes, which are installed vertically to the base of the landfill. The gases rise via naturally occurring pressure gradients to vent pipes, which extend through the cover material and into the atmosphere. Perforated pipe is often used within the gravel channels to assist in conveying the gases, but this feature adds to the expense. Gas channels and vents are used in conjunction with the clay or synthetic covers, which act as a confining layer, to prevent cracking of the cover or unwanted and random escape of the gases.

The discharge from the gas collection system could include compounds that may pose a public health risk. If a public health risk is created by this discharge from the gas collection system, the discharge will need to be treated. Gas treatment can include carbon adsorption or thermal oxidation. Carbon adsorption involves sending the gas through activated carbon, with the contaminants being adsorbed by the carbon. Thermal oxidation involves flaring or burning the gas. If the amount of treatment by the flares is insufficient, afterburners may be needed to incinerate the gas stream and destroy the contaminants.

Gas collection and treatment is an established, technologically feasible, and acceptable engineering practice, and it will be retained for further consideration.

7.1.9 Groundwater Collection

This technology involves removal of the contaminated plume by pumping downgradient wells. As determined by the Remedial Investigation, there is TCE contamination southeast of the landfill in the groundwater, the quarries, and Coplay Creek. Historic information indicates that the contaminants move very quickly through the fractures in the bedrock. TCE contamination was observed in the Ormrod Well (1500 feet downgradient) in less than 3 years of landfill operation.

Evidence to date indicates that TCE is flowing through the highly fractured and structurally complex bedrock at the site. To capture the plume, the pumping rates

may be as great as 1000 gallons per minute (gpm), as evidenced by pumping rates in the Whitehall quarry when it was active. Lower pumping rates could cause a reversal of groundwater gradients; however, site-specific, large-scale pump tests have been performed to quantify the value of pumping these downgradient wells.

The extraction of water at this high rate will have an adverse effect on other wells in the area. Also, a treatment facility with a high capacity would be required to remove the contaminants from the extracted groundwater. The possibility of capturing all of the groundwater would be small because of the numerous fractures that are not interconnected. The success of constructing collection wells would be low owing to the difficulty of intersecting open rock fractures in the zone where the TCE pollutant may be located.

Finally, if the plume removal option were used, it would be necessary to implement this option for a very long time if the source were not removed. If the source were reduced or controlled, the groundwater flow would help cleanse the aquifer and reduce contaminants to even lower levels than observed to date.

In summary, the collection of groundwater and treatment from beneath the site is judged not practical nor effective. Since this technology would not be effective, it will not be considered further.

7.1.10 Source Reduction

Assuming that a "hot spot" or high concentration of TCE is at the bottom of the landfill, an appropriate remedial technology could include the removal of this source to decrease future groundwater degradation. Since TCE was present in the percent concentrations in the 1978 Nassaux-Hemsley analyses, it might still be present in a separate phase owing to the solubility of TCE in water ($\sim$ 1000 ppm). Even if not present in a separate phase, much higher concentrations would be expected at the bottom of the landfill, owing to the high density of TCE. With these assumptions, a recovery system designed only to recover liquids from the bottom of the landfill would be beneficial in reducing the groundwater contamination problem.

The exact extent of the TCE is unknown; therefore, numerous assumptions on recovery are needed. The cost developed will be a yearly value and can be projected for actual needs. A system was developed to remove the TCE or TCE-contaminated liquid. The system includes the installation of twelve 4-inch-diameter wells on 200-foot centers across the landfill. These wells could be as deep as 100 feet. The wells are designed to pump up to 5 gpm each of liquid for an 8-hour period, then rest for 16 hours to allow for recovery. This timing procedure is based on a 24-hour pump test performed on the Heleva B-7 well, in which the TCE concentration dropped from 152,000 $\mu\text{g/l}$ to 22 $\mu\text{g/l}$ after 12 hours of pumping. Contaminated water that is pumped from the wells is expected to be very similar to leachate and will be treated to appropriate permit limits and discharged to Coplay Creek.

This technology has had limited application; however, the principles are similar to monitoring well and municipal well installations, and it should work effectively. This technology will be retained for further study.

7.1.11 Leachate Treatment Technologies

For the treatment of contaminated water or leachate streams at hazardous waste sites, there are a number of possible treatment unit processes that may be used singly or in combination to meet the objectives of site remediation. Some of the processes are used as pretreatment steps, whereas others can provide a sufficient degree of treatment to allow discharge of the effluent to the appropriate receiving stream.

The following unit treatment processes have been considered.

- Flow Equalization

The primary objective of flow equalization is to dampen flow and concentration fluctuations. Both biological and physico/chemical processes operate more effectively if composition and volume are fairly constant. Because of the high variability in leachate, equalization basins

will almost invariably be required to increase the stability and effectiveness of biological and physico/chemical unit treatment processes.

Equalization basins can be designed for either sideline equalization, where water in excess of the daily flow is stored (equalized), or for in-line operation, where the entire daily flow is equalized. Because of large fluctuations in the concentrations of contaminants, leachate treatment will require in-line equalization.

Equalization basins can dramatically increase the stability of sensitive treatment processes such as activated carbon adsorption, biological treatment, precipitation, and ion exchange. The only disadvantage is that an equalization basin may require a considerable amount of land area to accommodate peak flows.

- Precipitation, Flocculation, and Sedimentation

Precipitation, flocculation, and sedimentation are well-developed processes that have been used to treat various municipal and industrial wastewaters containing particulates (i.e., suspended solids) and/or soluble heavy metals.

Precipitation removes a substance from solution and transforms it into a solid particle. Flocculation promotes particle growth of the solids so that they can be more easily removed from the bulk liquid. Sedimentation removes the suspended solids from the liquid.

These processes are applicable treatment methods whenever it is necessary to remove soluble substances and/or suspended solids. The most common applications for hazardous waste sites include

- Removal of suspended solids from surface water runoff
- Removal of soluble and insoluble toxic metals

- Removal of soluble inorganics from groundwater supplies
- Removal of certain colloidal organics from leachate streams and surface water runoff

There is no upper limit on the concentrations that can be treated by these processes. The lower limit for the removal of soluble species, however, is generally governed by the solubility product of the particular ion of concern, although, using the solubility product for predicting removal efficiency is not reliable.

The most common precipitation reaction applicable to leachate treatment is the addition of a chemical to the contaminated solution that will chemically react with the hazardous chemical solute ion to form a sparingly soluble compound. A second reaction is the addition of either an acid or an alkali to adjust the solution pH to a point where a soluble compound becomes insoluble and precipitates. The addition of lime is the most widely used method for precipitation of heavy metals in leachate streams.

Coagulation/flocculation reactions are intended to overcome the repulsion force of individual particles and thus cause them to agglomerate into larger particles, which can be removed from solutions by gravitational and/or inertial forces.

Sedimentation may be carried out in a separate operation (i.e., basin) from precipitation and coagulation or in combination. In the first case, a conventional in-line, continuous flow, treatment scheme can be used; the second case could be an intermittent batch treatment process.

- **Filtration**

Filtration is an operation to separate suspended matter from water or wastewater by passing it through a filter bed composed of granular material, with or without the addition of chemicals. Complex removal

mechanisms, such as straining, interception, impaction, sedimentation, and adsorption can occur in the filtering material. The dominant removal mechanisms depend on the physico/chemical characteristics of the suspension and the medium of the filter, the rate of filtration, and the chemical characteristics of the influent wastewater. The end of the filtration run is usually indicated by the increase of suspended solids in the effluent or the increase of the hydraulic head from the filter. A complete filtration operation involves two phases, i.e., filtration and backwashing.

During the filtration cycle, suspended solids and/or colloidal material accumulate within the interstices of the filter media. As the holding capacity of the filter media bed is approached, as evidenced by a "breakthrough" of either turbidity or suspended solids, the filtration cycle is reversed and the unit is placed in a backwash mode. Clean water at a relatively high rate is allowed to flow through the filter bed, in such a manner as to physically agitate the media and dislodge the accumulated solids. The effluent from the backwash operation is discharged to an additional treatment device, where the solids are removed by either gravity sedimentation and/or sludge filtration. Clean backwash water from the secondary treatment in the context of this application is discharged to the receiving stream.

- Biological Treatment

Most organic chemicals are biodegradable, although the relative ease of biodegradation varies widely, requiring properly acclimated microbial populations, adequate detention time, and flow equalization to ensure adequate treatment. Biological treatment can be used to treat a wide variety of organic chemical contaminants. There is considerable flexibility in biological treatment because there are a variety of available processes and microorganisms are remarkably flexible.

Important biological treatment unit processes include the following.

- Activated sludge

The activated sludge process is capable of converting most organic wastes to more stable inorganic forms or to cellular biomass. In this process, much of the soluble and colloidal organic material is metabolized to carbon dioxide and water (in an aeration tank) by a diverse group of microorganisms. At the same time, a sizeable fraction is converted to a cellular mass that can be separated from the waste flow by gravity sedimentation.

To produce a high quality effluent, the biomass (after removing the organic material from the wastewater) must be separated from the liquid stream. This is accomplished in a sedimentation device (clarifier) and is only effective if the biomass will readily agglomerate.

After separating the liquid from the solid biomass, the biomass is returned to the aeration tank. A relatively constant mass of microorganisms is maintained in the system by wasting excess biomass from the system when needed. An optimum food-to-microorganism (i.e., contaminant-to-biomass) ratio must be maintained unique to the waste treated and to the settling characteristics of the biomass generated.

This process has been proven effective in the treatment of industrial and municipal wastewaters. Special considerations, such as waste strength and the inhibition or toxicity of waste constituents, must be considered in order to apply this technology.

- Trickling Filter

A trickling filter is an attached biological growth system that requires the presence of some type of medium to support the biological mass. The name trickling filter is somewhat misleading, as the primary

mechanism for organic removal is not by a filtering action of the fine pores of the support media but rather by diffusion and microbial assimilation.

Trickling filtration consists of uniformly distributing wastewater over a bed of support media (stone or synthetic) by a flow distributor. The wastewater forms a thin layer as it flows over the biological growth attached to the surface of the media.

As the contaminants in the wastewater are utilized by the microorganisms, the thickness of the microbial film will increase. After a period of time, the film will reach a thickness such that the organisms at the base of the film lose the ability to cling to the support media and are therefore washed out of the filter. This phenomenon is known as "sloughing." The waste stream containing the "sloughed" solids is sent to a sedimentation tank where the solids are removed from the bulk liquid.

Organic and hydraulic loadings are the major factors affecting the performance of the trickling filter. Trickling filters decompose organics, as does the activated sludge process. However, the percentage removal of organics is not as complete as in activated sludge because of the relatively shorter residence time. Trickling filters have been used satisfactorily to decompose such chemicals as acetaldehyde, acetone acid, acetone, acrolein, alcohols, benzene, butadiene, chlorinated hydrocarbons, cyanides, formaldehyde, ketones, and propylene dichloride. Trickling filters can better handle shock loading of organic wastes than activated sludge and are less inhibited by metal concentrations.

- Rotating Biological Contactors

Rotating Biological Contactors (RBC) consist of a series of closely spaced plastic disks. They are partially submerged in the wastewater

and rotated slowly through it. Similar to the trickling filter, the biological growths of RBC attach to the surfaces of the disks and form a slime layer over the surface of the disk. As the disk rotates, a film of waste adheres to the surface of the disk, and the microorganisms (using oxygen from the air) utilize the organic material in the waste stream as food. Similar to trickling filters, both hydraulic and organic loading rates can affect the sizes of the unit. RBCs can handle hydraulic and organic surges and short circuiting because of their large amount of biological mass and the plug-flow design.

- Anaerobic, Aerobic, and Facultative Lagoons

Lagoons or waste stabilization ponds are large shallow basins that rely on long retention times and natural aeration to biologically decompose the waste. The aerated (i.e., aerobic) lagoon is a variation in which the wastes are mechanically aerated with diffused air or mechanical aerators. Lagoons differ from activated sludge processes in that there is no sludge biomass recycle with lagoons.

Waste stabilization ponds without mechanical aeration utilize a combination of aerobic, facultative, and anaerobic bacteria to decompose organic wastes. However, these ponds are more sensitive to high concentrations of waste contaminants and suspended solids than other biological methods. Since there is no mixing, the suspended solids will settle out and create an excessive load that inhibits benthic microorganisms and produces a sludge blanket. The end result is disruption of the pond ecosystem.

In anaerobic stabilization ponds, since the active biomass does not require oxygen from the air, the metabolic process requires significantly less surface area. Also, the anaerobic bacteria can handle higher organic loads and certain organic contaminants that are

not easily metabolized by aerobic or facultative bacteria. A major drawback with anaerobic ponds is odor generation, most notably hydrogen sulfide.

- Carbon Adsorption

The process of carbon adsorption involves contacting a waste stream with granular activated carbon, which selectively adsorbs hazardous organic materials by physical and/or chemical forces. When the carbon reaches its ultimate capacity for adsorption, it is removed from its containment vessel for disposal, destruction, or regeneration.

The suitability of carbon adsorption for the treatment of wastewater depends upon the contaminant characteristics, the extent of pretreatment, and the required effluent quality. Contaminant characteristics, such as molecular weight, structure, and solubility, are critical considerations.

Activated carbon has been proven effective in the removal of a variety of chlorinated hydrocarbons, organic phosphorus, PCBs, phenols, and aromatic hydrocarbons. Activated carbon has not been shown suitable for treatment of municipal landfill leachate from "young" landfills, since carbon shows poor adsorptivity for fatty organic acids, which are prevalent in these leachates.

- Air Stripping

Air stripping consists of entraining the gases or volatile materials dissolved in water by means of a current of air passing in the opposite direction through the liquid mass to be purified.

Plate towers and packing towers filled with a contact mass (plastic rings, coke, etc.) are generally used. This technology is used for deodorization,

removal of ammoniacal or sulfurous compounds, phenols, and a variety of volatile organic hydrocarbons, such as TCE, PCE, etc.

Problems associated with air stripping are reduced efficiency from cold weather and ice formation. Also of concern is the possibility of exceeding ambient air standards for certain stripped constituents.

All of the treatment technologies reviewed are appropriate for use at the Heleva Landfill Site. Their use will depend upon the characteristics of the wastewater or leachate to be treated, the degree of removal of contaminants required for discharge, and the results of treatability tests run on the wastewater.

7.1.12 Contaminated Soil/Sediment Removal

This technology involves physically removing the contamination and reduces or eliminates further need for monitoring or maintenance. Removed material may be disposed at an approved offsite facility or in onsite areas that must be constructed and closed in an environmentally safe manner that satisfies the requirements of RCRA.

This technology is considered separate from excavation, as soils and sediments are generally surface materials requiring shallow scraping (2 or 3 feet maximum depth) of the material, as opposed to deep excavation.

This technology has been frequently applied at similar sites using standard engineering practices. At the Heleva Landfill Site, levels of contamination in sediments washed from the site are very low and present no health or environmental hazards. Therefore, this technology will not be considered further.

7.1.13 Excavation

This technology involves the physical removal of the wastes by using common excavation practices. At the Heleva Landfill Site, some of the waste is below the water table continuously. Other parts may be below the seasonal high water table.

Excavation of the landfill could be sequenced so that excavation of the lower portions of the fill would be accomplished in the dry months. However, two areas, old quarry pits, will have to be excavated below the water table. Excavation of these pits can best be accomplished by using a crane with a dragline bucket to remove refuse and place it on a dewatering pad. Trash will be dewatered by compacting it on a dewatering pad, then removing it for appropriate disposal. After excavation, the site will be backfilled, regraded, and revegetated.

Excavation is a commonly used and well-established technique, which involves standard engineering practices. Therefore, it will be retained for further consideration.

7.1.14 Disposal Technologies

Onsite disposal proposes the construction of a secure hazardous waste landfill on site. Elements of such a site must meet the applicable RCRA and PADER requirements and regulations. Thus, the landfill would be designed to provide a lined base and sides, a leachate and runoff collection system, and a final cover to reduce rainfall infiltration. This technology is applicable at the Heleva Landfill Site.

Offsite disposal involves excavation of the contaminated wastes and soils and transport of the materials to the nearest approved hazardous waste disposal facility that complies with current RCRA requirements. All aspects of offsite disposal are based on standard engineering practice, provided an approved hazardous waste landfill is used as the disposal site. This technology is applicable for use at the Heleva Landfill Site.

Incineration is a process that uses thermal oxidation to convert organic substances to a less bulky inorganic material. Generally, only organic and organic/inorganic wastes are considered for incineration. This process can reduce the waste volume and destroy the toxic compounds by a number of methods presently available on the market. The total destruction of organic contaminants can be obtained by the use of incinerators that operate at temperatures in excess of 1000°C. At present, there are only a few commercial facilities permitted under an interim RCRA

status. Any number of incineration types could be used on site; however, they must be constructed to meet permit standards. The incinerator types considered for use on the wastes found on site are as follows:

- Rotary kiln
- Fluid bed
- Multiple hearth
- Cement kiln

Rotary kiln is generally the most appropriate type of incinerator for refuse such as would be found at the Heleva Landfill Site. Other types will not be considered.

7.2 Public Health and Environmental Considerations

7.2.1 No Action Technologies

7.2.1.1 No Action

The no-action alternative does not address the remediation of the site nor the potential threat to the environment or public via the contamination pathways. Public reaction may be unfavorable, since onsite and offsite contamination will not be mitigated. At the Heleva Landfill Site, the no-action alternative allows the continued contamination of the two nearest residential wells and its resulting health impact to continue without any method of determining the amount of contamination; thus, it will be dropped from further consideration.

7.2.1.2 No Action - Monitoring

While this alternative does not address the contamination, it does provide a mechanism for identifying future problems.

7.2.2 Alternative Water Supply

Provision of an alternative water supply will address the current health hazards presented by consumption of contaminated drinking water. It will not affect any current or future environmental impacts caused by the site contaminants.

7.2.3 Surface Capping

A cap that meets RCRA requirements provides a protective cover to limit erosion and acts as a barrier to vertical gas migration. It isolates and contains wastes from contact with the atmosphere and the public. Capping has been scientifically and historically proven to minimize surface infiltration and prevent subsequent leachate formation. Thus capping reduces public health and environmental impacts.

Other caps can be relatively effective in minimizing infiltration but are not quite as effective as a RCRA cap. If no impermeable material is used in the cap, some leachate may still be generated and the leachate will have to be treated.

7.2.4 Surface Water Diversion

Surface waters are diverted to reduce or eliminate water running onto the landfill and consequently reduce the amount of leachate generated. This technology is also used to manage water on the site, to prevent erosion of any cap, and to prevent the subsequent exposure of waste materials. It does not cause any health or environmental hazards on its own.

7.2.5 Leachate Collection

Collection of leachate precludes migration offsite and allows treatment to be performed to reduce excessive levels of contamination. While it minimizes public health and environmental impacts by controlling leachate flow, the collected flow must be treated to prevent impacts.

7.2.6 Gas Collection and Venting or Treatment

Gas collection and treatment minimizes public health and environmental impacts by preventing undesirable and possibly dangerous levels of methane and/or toxic vapors from migrating or escaping in an uncontrolled manner.

7.2.7 Source Reduction

Source reduction will reduce the site's public health and environmental impacts by reducing the quantity of contaminants that may enter the groundwater, and thus will permit a shorter time for flushing the aquifer.

7.2.8 Treatment Technologies

By reducing excessive levels of contaminants in the leachate, discharge of treated effluent to receiving streams minimizes adverse toxic effects on human or wildlife by direct or indirect contact. Some technologies could result in the release or disposal of air emissions or sludge residues.

Incineration of the contaminated material in an onsite or offsite facility will significantly reduce the threat of public exposure or environmental contamination. Air pollution control devices required under RCRA will reduce the release of contaminants into the atmosphere.

7.2.9 Excavation

This technology removes the wastes from the site and eliminates further contamination and its resultant impact. There is the potential for a significant impact during excavation through volatilization of the TCE from the exposed wastes.

7.2.10 Disposal Technologies

Disposal, whether onsite or offsite, has an unknown, long-term effect. Short-term impacts would be less severe.

7.3 Institutional Considerations

7.3.1 No - Action - Monitoring

This technology can be implemented easily once an agency has been selected to perform it.

7.3.2 Alternative Water Supply

This technology can be implemented easily, based on standard industry practices and the local water purveyor's requirements.

7.3.3 Surface Capping

There are RCRA design standards for surface capping. EPA has published various Technical Resource Documents identifying the various types of capping procedures and materials that will meet the standards.

7.3.4 Surface Water Diversion

Federal and State requirements under RCRA clearly prohibit surface water run on. Numerous methods are available for determining design characteristics necessary to meet required performance levels.

7.3.5 Leachate Collection

No design requirements specifically applicable to collection of surface leachate seeps are known. Various guidance documents are available for design and construction of such systems.

7.3.6 Gas Collection and Venting or Treatment

Same comment as for leachate collection. Treatment processes for air pollutants are well established. Treatment systems will have to be operated and maintained.

7.3.7 Source Reduction

Any system set up will require operation and maintenance. It will also require routine monitoring to determine its effectiveness.

7.3.8 Treatment Technologies

Leachate treatment and discharge onsite will require meeting specific standards, depending on the receiving stream. An NPDES and a State water quality permit will be required, and the treatment facilities must comply with the technical requirements of RCRA. Coordination with other agencies will be required, depending on the technology chosen. Facilities will require operation, maintenance, and monitoring.

7.3.9 Excavation

Implementation will have a local impact because of noise and traffic congestion. Transporting of wastes resulting from excavation must meet Department of Transportation (D.O.T.) and State/Federal shipping and manifesting regulations.

7.3.10 Disposal Technologies

Construction of onsite facility for disposal has many and varied design and construction requirements under RCRA and State regulations. Permitting criteria depend on these requirements being met and are themselves extensive. RCRA design and permitting standards are contained in Subpart C, 40 CRR, Parts 264 and 123. There are various guidance documents regarding siting, design, construction, and permitting of such facilities. Construction of a landfill will restrict future uses of that land.

Commercial disposal facilities must meet stringent analytical, RCRA, and State permitting and compliance standards. Using offsite facilities also necessitates meeting D.O.T. requirements for hazardous waste transport.

Offsite incineration of contaminated materials must be completed in a RCRA-permitted facility. Onsite incineration would also be regulated under RCRA. In addition to RCRA requirements, a Hazardous Waste Management Facility Permit may be required, as well as any applicable State permits. An emissions--air or water--monitoring program would also be a mandatory part of the incineration process.

7.4 Cost

7.4.1 No Action - Monitoring

This technology has little or no capital costs and low O & M costs.

7.4.2 Alternative Water Supply

This technology has a low capital cost and nominal O & M costs.

7.4.3 Surface Capping

Unit costs of materials differ widely, depending on availability. Also, costs must reflect site-specific characteristics, such as design parameters. O&M costs involve inspection, maintenance, and groundwater monitoring expenditures (well construction and chemical analyses). Generally, cost is most affected by cap materials and dimensional variations. If a soil cap is used, leachate treatment costs will be added to the other costs.

7.4.4 Surface Water Diversion

Capital costs for this technology are generally given on a "dollar per linear foot" basis, and they are relatively low. Cost components include channel dimension

(depth and length) or volume of soil removed, and lining materials, if required. O&M costs are proportionately higher for this technology, as maintenance and repair are required frequently to maintain satisfactory performance.

7.4.5 Leachate Collection

Design parameters, which directly affect the amount of materials required, strongly influence costs. Trench depth (and the subsequent volumes of excavation and backfilling) is the most cost influencing factor.

O&M costs include sampling and replacement expenditures. When used with a properly constructed cap, reduced infiltration and subsequent leachate generation will gradually subside over a period of years. If onsite storage is anticipated, relevant costs must be included and may be significant, depending on expected leachate volume.

7.4.6 Gas Collection and Venting or Treatment

Costs for gas collection are similar to leachate collection in the components and materials required. However, this technology may employ either active or passive elements in collection and will not require equalization. Active elements include fans, blowers, etc., which add considerably to capital and O&M costs. These elements are maintenance intensive and will eventually require replacement. If treatment is needed, additional capital and O & M costs will be incurred.

7.4.7 Source Reduction

Costs for well installation are similar to monitoring well installations. Special pumps and control panels will be needed. O & M costs are anticipated to be low.

7.4.8 Treatment Technologies

Costs for treatment technologies will vary depending on the process used. Most will require a moderate capital cost and low to moderate O & M costs. All will require routine operation and maintenance in order to operate effectively.

7.4.9 Excavation

Costs are given in "dollars per cubic yard" as the standard soil excavation measure. A cubic yard is assumed to weight $\pm$ one ton. Transportation and disposal costs must be included as part of the overall cost.

Factors most affecting excavation costs include

- Depth (volume)
- Health and safety requirements
- Physical state of materials

Backfilling after removal was included to prevent large open areas, which would trap rain and run-on.

7.4.10 Disposal Technologies

Disposal costs for both onsite and offsite landfill scenarios were included with excavation, since similar factors affect the costs.

Onsite disposal assumed construction of a RCRA permitted facility, utilizing adjacent farmlands. Offsite transportation and disposal costs assumed a destination that was 300 miles from the waste site. Factors which affect offsite disposal costs include the distance to the disposal facility and the disposal fees.

Costs for offsite incineration are largely determined by the waste type. The cost for liquid incineration is significantly different than that for solids. Also, costs for low BTU waste destruction differs from that for medium and high BTU wastes. Transportation costs are also a major factor in the cost of offsite incineration.

Onsite incineration costs include construction or lease (mobile unit) costs, permitting and testing costs, and operation and maintenance costs. Also included are the costs for contaminated ash disposal and process water treatment.

7.5 Remedial Action Alternative Development

This section identifies the most promising technologies and reviews the methods used to develop the candidate alternatives.

The technologies remaining after the initial screening (see Table 7-5) will be combined to develop the alternatives that would meet the site-specific remedial action objectives and the criteria for evaluation of alternatives. The combined technologies were screened with respect to the remedial objectives, as outlined in the text that follows:

- To maintain public health and safety.
- To maintain the quality of local surface water.
- To maintain the local land use by decreasing the risk of the migration of contaminants.
- To ensure technical feasibility, public acceptability, and cost-effectiveness of the remedial actions.

In addition, the following were used to eliminate many of the permutations obtained from the combining of technologies.

TABLE 7-5
POTENTIAL REMEDIAL ACTION TECHNOLOGIES
HELEVA LANDFILL SITE

<u>Technology</u>	<u>Retained For Further Evaluation?</u>
Site Remediation:	
No Remedial Action	no
No Remedial Action-Monitoring	yes
Alternative Water Supply	yes
Surface Capping	yes
Groundwater Barriers	no
Regrading and Revegetation	no
Surface Water Diversion	yes
Leachate Collection	yes
Gas Collection and Venting or Treatment	yes
Groundwater Pumping	no
Source Reduction	yes
Contaminated Soil/Sediment Removal	no
Excavation	yes
Treatment and Disposal:	
Filtration	yes
Precipitation	yes
Neutralization	yes
Carbon Adsorption	yes
Air Stripping	yes
Incineration	yes
Biological Treatment	yes
Offsite Disposal	yes
Onsite Disposal	yes

- Based upon the results of the Remedial Investigation, potential movement of contaminated groundwater is a problem at this site.
- Controlling the flow of the surface water across the site is a universal requirement of the remediation. Pennsylvania Department of Environmental Resources (PADER) regulations require that clean water be diverted away from or around a contaminated location. Therefore, diversion of surface water must be included in a chosen alternative.
- Decreasing the amount of erosion of surface materials, through grading and revegetation of the site, is a requirement of the remediation and must be included in a chosen alternative.

The NCP specifies that remedial alternatives, besides falling each of the categories, should be classified either as source control (40 CFR 300.68(e)(2)) or offsite (management of migration) remedial actions (40 CFR 300.68(e)(3)). Source control remedial actions address situations in which hazardous substances remain at or near the areas in which they were originally located and are not adequately contained to prevent migration into the environment. Management of migration remedial actions address situations in which the hazardous substances have largely migrated from their original locations. Alternatives developed may fall solely in either classification or may involve a combination of source control and management of migration measures, as determined by the specific-site problems addressed. Table 7-6 displays the source control and management of migration alternatives that have been developed for the Heleva Landfill Site.

The cost-effective alternative is defined as the lowest cost alternative that is technologically feasible and reliable, effectively mitigates or minimizes damage, and provides adequate protection of public health, welfare, and the environment (National Contingency Plan). Alternatives were developed by applying the technologies to the site singly or in combination, based on the previously developed remedial objectives.

TABLE 7-6
SOURCE CONTROL AND MANAGEMENT OF MIGRATION TRADEOFF MATRIX
FOR HELEVA LANDFILL SITE

Alternative	Cost (\$1,000)	Present Capital Worth	Public Health Concerns	Environmental Concerns	Technical Concerns	Institutional Concerns	Other
1. Source Control 1. No-action - monitoring		538	Unacceptable exposure to TCE through continued release to surface water, air, and groundwater. Could potentially cause a 10 ⁻⁶ to 10 ⁻⁵ cancer risk (ingestion of contaminated water)	Continued migration to the groundwater and release to air and surface water.	---	Unacceptable	---
2. Landfill capping, gas collection, surface water diversions.		4,962	Exposure through groundwater will continue. Surface leachate seeps and uncovering of landfill will be stopped.	Same	---	Unacceptable	---
3. Landfill capping, gas collection, surface water diversion, source reduction, and treatment.		9,144	Groundwater contamination will be reduced at an unknown rate. Length of time of unacceptable exposure cannot be determined.	Migration to groundwater and release to air and surface water will be reduced at an unknown rate.	Conditions at base of landfill are unknown.		
4. Excavation and disposal in a RCRA landfill onsite.		40,735	Same. In addition, excavation will result in increased release to air. Removal of source should speed groundwater cleansing.	Same. In addition, excavation will result in increased air release. Removal of source should hasten groundwater cleansing.	Quantity of waste is unknown.		
5. Excavation, incineration, and disposal.		61,624	Same	Same			

TABLE 7-6
SOURCE CONTROL AND MANAGEMENT OF MIGRATION TRADEOFF MATRIX
FOR HELEVA LANDFILL SITE
PAGE TWO

Alternative	Cost (\$1,000)		Public Health Concerns	Environmental Concerns	Technical Concerns	Institutional Concerns	Other
	Present	Capital Worth					
7. Excavation and disposal in an offsite RCRA landfill.	96.604		Same as for 6, plus additional exposure via truck travel.	Same as for 6.			
II. Management of Migration							
1. No-action - monitoring	538.0		Same as for source control.	Same as for source control.	---	Unacceptable	---
2. Alternative water supply	878.0		Eliminates public health risk.	Environmental impacts continue.			

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8.0 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

Those technologies that have passed the technology screening process are used to form remedial alternatives for the Heleva Landfill Site. Remedial alternatives are developed using best engineering judgment to select a technology or groups of technologies that best address the problems at the site. In addition, objectives for the Feasibility Study (FS) were identified and used to guide alternative development. Those objectives are listed in Section 7.5.

In order to study a range of responses, NUS has developed site remediation alternatives that fall into one of five categories. These categories are described below.

- No action: No-action alternatives could include monitoring activities.
- Alternatives that meet the CERCLA goals of preventing or minimizing present or future migration of hazardous substances and protect human health and the environment but do not attain all of the applicable or relevant standards. (This category may include an alternative that closely approaches but does not meet the level of protection provided by the applicable or relevant standards.)
- Alternatives that meet the CERCLA goals and attain all applicable or relevant Federal public health and environmental standards, guidance, and advisories.
- Alternatives that exceed all applicable or relevant Federal public health and environmental standards, guidance, and advisories.
- Alternatives specifying offsite storage, destruction, treatment, or secure disposal of hazardous substances at a facility approved under the Resource Conservation and Recovery Act (RCRA). Such a facility must also be in compliance with all other applicable Environmental Protection Agency (EPA) standards.

Each category should have at least one alternative and may have more. If an alternative is not developed for a category, the reasons should be documented.

In addition, the remedial alternatives should be classified as source control remedial actions, offsite remedial actions (now known as management of migration), or a combination of the two. Source control remedial actions are used to prevent or minimize the migration of hazardous substances from the site. Management of migration remedial actions are used when the hazardous substances cannot be kept on the site or have already migrated away from the site.

After preliminary remedial alternatives are developed within general response categories, they are subjected to another round of screening. This screening looks at non-cost criteria, such as public health and environmental factors. Alternatives that do not meet the criteria are dropped, although one alternative should be left in each category. The remaining alternatives are then put through an "order of magnitude" cost screening, where alternatives are dropped if they have a cost that is an order of magnitude greater than other alternatives having equivalent public and environmental health benefits. The remaining alternatives are then presented for use by the decision-making agencies.

8.1 Development of Alternatives

Brief descriptions of the alternatives generated for each category can be found in the following sections.

8.1.1 No-Action - Monitoring

This is a baseline alternative that will be used for comparison against other alternatives in which remedial actions will be taken.

8.1.2 Alternatives that Meet CERCLA Goals

Two alternatives have been developed that provide different levels of remediation. The first alternative is for installation of an alternative water supply

and continued monitoring. This alternative will address the direct health threat that results from residential consumption of contaminated water, but will not reduce the low-level contamination identified in the downgradient surface waters.

The second alternative in this category provides for an alternative water supply, installation of a landfill cap with gas collection and treatment, and monitoring. Implementation of this alternative will provide better protection for the landfill and will control the onsite leachate. It will not address the groundwater problem.

8.1.3 Alternatives that Satisfy All Applicable Standards

One alternative has been developed for this category. This alternative provides an alternative water supply, installation of a landfill cap with gas collection and treatment, implementation of an onsite source reduction program, and monitoring. This alternative will be designed to meet all applicable standards.

8.1.4 Alternatives that Exceed All Applicable Standards

The first alternative developed for this category includes excavation of the wastes from the landfill, disposal in a RCRA-approved landfill built next to the existing landfill, backfilling and grading as needed, provision of an alternative water supply, and monitoring.

The second alternative developed for this category includes excavation of the wastes from the landfill; decontamination of the wastes by incineration on site; disposal of decontaminated material in an onsite, secure landfill; disposal of fly ash off site in a secure, RCRA landfill; backfilling and grading the excavation, as needed; provision of an alternative water supply; and monitoring.

8.1.5 Alternatives that Specify Offsite Disposal

Under this alternative, the wastes would be excavated and transported to an off-site, RCRA-approved landfill. The site excavation would be backfilled, graded, and revegetated. An alternative water supply would be provided, and a monitoring program would be implemented.

8.2 Criteria Used for Evaluation

In this section, each alternative will be described in detail and then evaluated against both non-cost and cost criteria. Non-cost criteria include technical, public health, environmental, and institutional considerations. Cost criteria include capital costs, and operation and maintenance costs. Detailed information on costs can be found in Appendix G.

8.2.1 Technical Evaluation

Each alternative will be evaluated for technical feasibility using the following criteria:

- Performance
- Implementability
- Reliability

The technical evaluation will assess the appropriateness of the alternative relative to site conditions. The performance of alternatives will be evaluated in terms of the ability to perform the intended function, as well as the estimated useful life of the alternative. Reliability of alternatives will be evaluated in terms of operation and maintenance requirements and demonstrated performance under similar conditions. Evaluation of the implementability of alternatives will consider factors such as the ability to actually construct each alternative relative to site conditions and the time needed to implement each alternative. The safety of the nearby residents and remedial action personnel will also be considered.

8.2.2 Public Health Evaluation

Remedial action alternatives will be evaluated for public health impacts both during and after implementation. Each alternative will be assessed in terms of the extent to which it is expected to effectively mitigate and minimize damage to public health and welfare.

8.2.3 Environmental Evaluation

Remedial action alternatives will also be evaluated for environmental impacts during and after implementation. Each alternative will be assessed in terms of the extent to which it is expected to effectively mitigate and minimize damage to the environment.

8.2.4 Institutional Evaluation

The impact of Federal, State, and local public health and environmental standards, regulations, guidance, advisories, and ordinances will be evaluated for each alternative as part of the institutional criteria evaluation. Community impacts will also be considered as part of this evaluation.

8.2.5 Cost Evaluation

The cost of each alternative will be presented. Capital and operation and maintenance costs, where applicable, will be estimated and converted to present-worth values for comparison. A detailed listing of costing components for consideration is included in Appendix G. A sensitivity analysis of the cost components of an alternative will be performed to evaluate the effects of variations in specific assumptions associated with the design, implementation, operation, and effective life on the estimated present-worth cost of the alternative.

8.3 Evaluation of the No-Action Alternative (No-Action - Monitoring)

8.3.1 Description

Under a no-action alternative, additional remedial activities would not be performed. However, a long-term monitoring program would be established to provide information on contaminant movement and on exposure to humans, sensitive and important nonhuman species, and the environment. Through the use of a comprehensive monitoring program, future environmental impacts could be observed and then addressed.

The primary contaminants found at the Heleva Landfill Site are trichloroethene (TCE) and 1,2 trans-dichloroethene. These chemicals are both volatile organics, and the objectives of the monitoring program can be met by analyzing for volatile organics only.

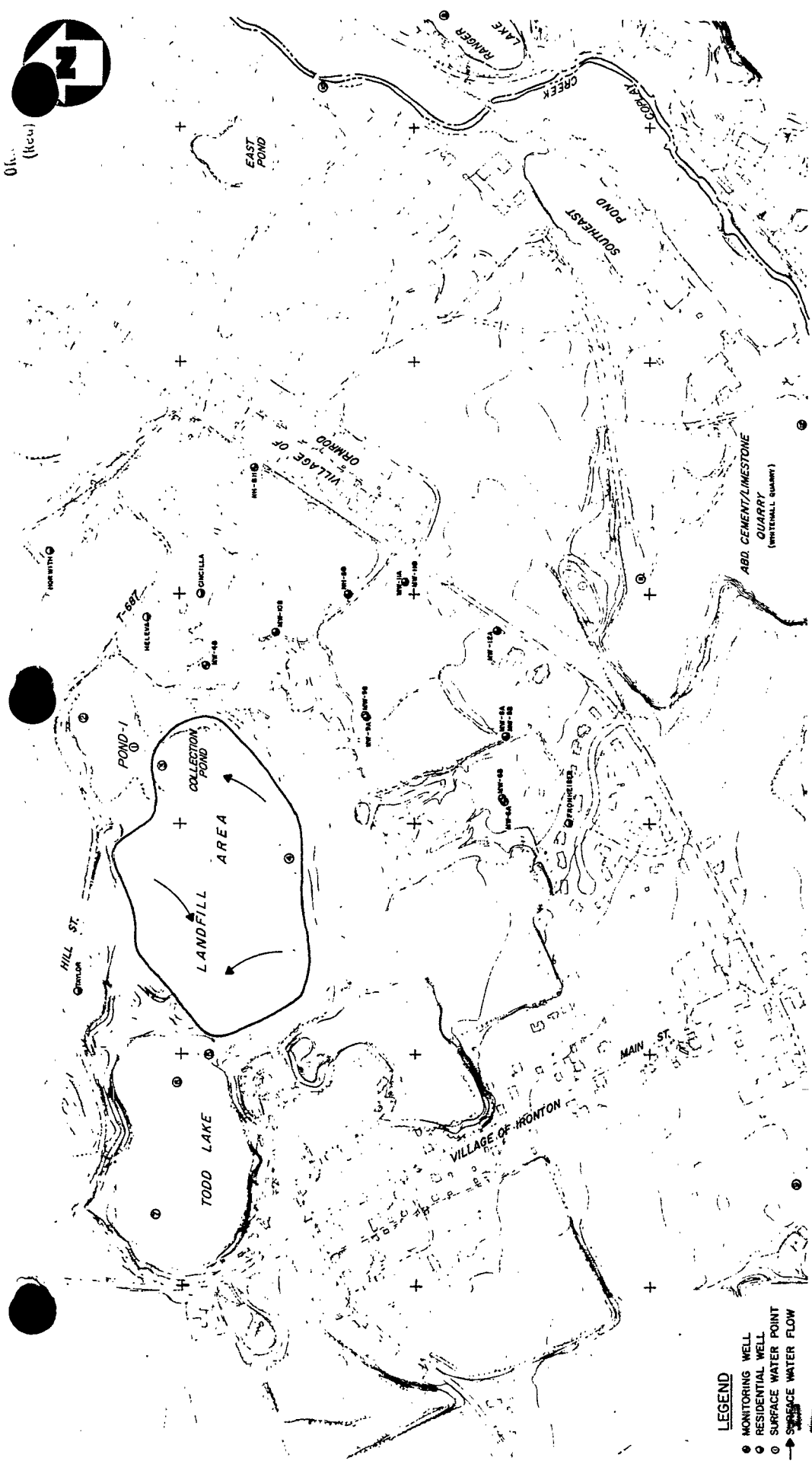
The three sources of water samples at the Heleva Landfill Site are residential wells, monitoring wells, and surface water points. Monitoring of the residential wells would be essential, since the water is used for human consumption. Those residential wells previously identified as contaminated, as well as those which could become contaminated, would be sampled. The residential wells recommended for monitoring are Taylor, Horwith, Heleva, Cincilla, and Fronheiser; these wells are shown on Figure 8-1.

Since fractures in the geologic formations can provide a pathway for migration of contaminants, it is necessary to monitor the groundwater. Monitoring wells constructed during the RI phase of this study (shown on Figure 8-1) could be used for monitoring contaminants that migrate downgradient from the site. Table 8-1 has the proposed monitoring well locations.

Surface waters are potential receptors for leachate that seeps from the deposited wastes. Also, groundwater may be contaminating some of the nearby surface waters. Surface waters may be used for bathing, irrigation, lawn watering, and



0 ft. (100)



- LEGEND**
- MONITORING WELL
 - RESIDENTIAL WELL
 - SURFACE WATER POINT
 - SURFACE WATER FLOW

R300367

PROPOSED MONITORING STATIONS
HELEVA LANDFILL SITE, NORTH WHITEHALL TWP., PA
 SCALE: 1" = 400'



8-7

FIGURE 8-1



TABLE 8-1
MONITORING WELLS PROPOSED FOR SAMPLING
HELEVA LANDFILL SITE

<u>Well Identification</u>	<u>Well Depth (Ft)</u>
4B	121
10B	71
9A	50
9B	68
11A	40
11B	52
12A	46
8A	38
8B	76
6A	54
6B	89
B-8	200
B-11	165

recreational uses, as well as providing a habitat for aquatic organisms. Figure 8-1 shows proposed locations for these sampling points, and Table 8-2 provides descriptions.

Because of seasonal variations, sampling and analyses should be conducted once per quarter, at a minimum. For costing purposes it was assumed that this program would be continued for 30 years.

8.3.2 Technical Evaluation

- Performance

This alternative will not reduce or eliminate any of the impacts resulting from the site contaminants. It will be effective in providing information about the movement of the contaminants, so that future remedial actions can be taken if necessary. This alternative can be implemented almost immediately.

- Implementability

This alternative can be implemented without difficulty at the Heleva Landfill Site.

- Reliability

This is a labor-intensive alternative that uses workers skilled in taking representative environmental samples from several environmental media. Such workers are readily available. Historically, monitoring has been proven to be reliable.

TABLE 8-2

DESCRIPTION OF SURFACE WATER SAMPLING POINTS
HELEVA LANDFILL SITE

<u>Location</u>	<u>Description</u>
1	Pond 1
2	Pond-1 background
3	Collection pond
4	Seep from TCE spill area
5	Leachate stream to Todd Lake
6	Todd Lake
7	Todd Lake background
8	Ranger Lake
9	Coplay Creek (upstream)
10	Coplay Creek (downstream)
11	Quarry where spring enters
12	Quarry background