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Region V

Waste Management Division

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PUBLIC COMMENT
FEASIBILITY STUDY REPORT

FULTZ LANDFILL SITE
BYESVILLE, OHIO

EPA WA NO. 07-5LC6
CONTRACT NO. 68-W8-0084

JUNE 1991

ARCS V

Remedial Planning Activities at
Selected Uncontrolled
Hazardous Waste Sites – Region V

prc

PRC Environmental Management, Inc.

PUBLIC COMMENT
FEASIBILITY STUDY REPORT

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**EXECUTIVE SUMMARY
FULTZ LANDFILL SITE
FEASIBILITY STUDY REPORT**

This Executive Summary presents the major findings of the Feasibility Study (FS) for the Fultz Landfill Site in Byesville, Ohio.

The purpose of the FS is to develop and compare cost-effective remedial alternatives that meet established remedial objectives. The FS was performed in accordance with CERCLA, as amended, and followed OSWER Directive 9355.3-01, Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. The U.S. Environmental Protection Agency (EPA) selects the alternative to be implemented considering input from both the State (Ohio Environmental Protection Agency) and the general public.

To identify the alternatives that are technically feasible, reliable and protective of the public health, welfare and environment, the following activities were performed:

1. The nature and extent of contamination at the site were assessed based on the analytical results from surface and subsurface soil samples, leachate water and sediments, surface water from the site ponds, Wills Creek and Streams A & B, and groundwater from the shallow and coal mine aquifers collected during Phases I and II of the Remedial Investigation (RI). The site geology, hydrogeology, and contaminant migration pathways are also evaluated and reported in the RI Report.
2. The toxicity of the site contaminants and the public health and environmental risks associated with the contaminant concentrations were assessed and presented in the Baseline Risk Assessment portion of the RI Report.
3. Remedial Action Objectives were established based on the RI findings and public health and environmental risks. Remedial technologies were identified and were screened on the basis of implementability, effectiveness and cost in the FS.

SUMMARY OF REMEDIAL ACTION OBJECTIVES

Based of the public health and environmental risks associated with the Fultz Landfill Site, the following remedial action objectives were used as the basis for the development of remedial alternatives for the site.

1. Reduce the risks to human health associated with the ingestion of contaminated groundwater, or inhalation of volatilized chemicals from contaminated groundwater, by local residents using residential wells screened in either the shallow or coal mine aquifers.
2. Reduce risks to human health associated with the inhalation of airborne contaminants from the landfill area.
3. Reduce risks to human health associated with the ingestion of contaminated groundwater, or inhalation of volatilized chemicals from contaminated groundwater, by future users of groundwater from either the shallow or the coal mine aquifer.
4. Reduce risks to the environment associated with excessive manganese and aluminum concentrations in the on-site surface waters.

For remedial technology screening and assessment, the contaminated media at the Fultz Landfill Site were grouped into two broad categories, based on the remedial action objectives and results of the risk assessment: solids and waters. Contaminated solids include site surface soils, pond, stream and leachate seep sediments, and landfill waste. Contaminated waters include both shallow and coal mine aquifer groundwater, surface water and leachate. The technologies passing the screening process were then grouped into applicable remedial alternatives. These alternatives were examined with respect to requirements stipulated in the National Contingency Plan (NCP), 40 CFR Part 300, Section 300.430, paragraph (e)(9) and were evaluated for:

- Overall Protection of Human Health and the Environment,
- Compliance with ARARs,
- Long Term Effectiveness and Permanence,

- Reduction or Toxicity, Mobility and Volume Through Treatment,
- Short Term Effectiveness,
- Implementability,
- Cost,
- State Acceptance, and
- Community Acceptance.

DESCRIPTION OF ALTERNATIVES DEVELOPED AND SCREENED

A total of ten alternatives were developed to meet the remedial action objectives by combining the technologies that passed the technology screening process. Of the 10 alternatives developed, 4 were eliminated based on an evaluation against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. As a result of this screening an array of six alternatives were retained for detailed evaluation. A brief synopsis of the six alternatives follows.

ALTERNATIVE 1 - NO ACTION: With this alternative, the site will be left as is without taking any steps to reduce the risks of exposure to contamination. The risks were defined in detail in the public health risk assessment in the RI Report.

ALTERNATIVE 2 - INSTITUTIONAL ACTIONS AND MONITORING: The components of Alternative 2 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring

This alternative consists of restricting access to the contaminated areas of the site through physical and legislative means. A fence would be erected around the perimeter of the contaminated zone, and warning signs would be posted at regular intervals. Additionally, residences with wells that are affected by the site and are found to present an unacceptable risk will be connected to the municipal water supply. Long-term monitoring of air, surface water, leachate, groundwater, and sediments will be performed for a minimum of 30 years to evaluate the migration of contaminants from the landfill and to

monitor the effects of natural attenuation. The estimated present worth cost (30-years, 5% discount rate) of Alternative 2 is \$2,300,000.

ALTERNATIVE 3 - MULTI-LAYER RCRA CAP: The components of Alternative 3 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Subsurface Structural Supports
- Surface Water and Sediment Controls
- Multi-layer Cap
- Leachate Collection System
- Wetlands Replacement

This alternative adds a revised monitoring program and a RCRA-equivalent cap system to the institutional controls, fencing and alternative water supply of Alternative 2. Subsurface support will be provided for the mine voids under the landfill to prevent damage of the cap by subsequent mine subsidence and to reduce the potential for bedrock fracturing between the landfill and the coal mine aquifer. Additionally, part of Stream Valley A northeast of the existing landfill will be regraded to eliminate standing surface water, and divert runoff away from the landfill. A berm will be constructed of compacted clay along the northern side of the landfill to bring the toe of the cap up to elevation 835 feet MSL and reduce the overall slope of the cap to about 5-1/2%. Following the construction of the containment berm, a multi-layer cap will be installed over the entire 30 acres of the landfill. A leachate collection system will be installed along the northern side of the landfill to intercept groundwater leaving the landfill. Leachate will be collected and transported offsite for treatment. During the design and construction of Alternative 3, every effort will be made to minimize the disturbance of areas identified as wetlands. Upon completion of construction, the clean water diversion channel will be re-routed into the sediment pond, and the base water level of the sediment pond will be raised to provide pond surface area equal to the area lost by the elimination of Ponds 2, 2A, and 3. The estimated present worth cost of Alternative 3 is \$20,000,000.

ALTERNATIVE 4 - MULTI-LAYER CAP, GROUNDWATER EXTRACTION AND ON-SITE TREATMENT:

The components of Alternative 4 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Subsurface Structural Supports
- Surface Water and Sediment Controls
- Multi-layer Cap
- Leachate Collection System
- Extraction Well System
- On-site Water Treatment Plant
- Discharge of Treated Water To Surface Water
- Wetlands Replacement

This alternative adds to the previous alternative a groundwater extraction and on-site treatment system for the shallow aquifer groundwater and leachate. An array of extraction wells will be installed in the shallow aquifer to lower the water table in the landfill area, intercept groundwater migrating towards the deep-mine aquifer, and collect contaminated groundwater for treatment. Some of the extraction wells will be installed through the multi-layer cap and will have to be sealed to the liner against infiltration. In order to treat the water extracted from the shallow aquifer and the leachate produced by the existing landfill, an on-site water treatment plant will be installed which will reduce the contaminant levels sufficiently for discharge to surface water. The final treatment system selection will be based on samples from the extraction system, after it is constructed and functioning. Discharge of the treatment plant effluent will be to Stream A downstream of the sediment pond by way of a dedicated discharge pipeline. The present worth cost of Alternative 4 is estimated at \$21,000,000.

ALTERNATIVE 5 - ON-SITE LANDFILL: The components of Alternative 5 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply

- Monitoring
- Over-excavation of the Underground Mine
- Rock Underdrain
- Erosion and Sediment Controls
- Dewatering Facilities
- RCRA Equivalent On-site Landfill
- Wetlands Replacement

This alternative utilizes the institutional controls, site fencing and alternative water supply from the other alternatives and adds to it a revised monitoring program and an on-site landfill. Construction of a landfill on the eastern portion of the Fultz Landfill Site property will include some over excavation on the abandoned underground mine to remove the danger of subsidence. Stream Valley A will be regraded, and erosion and sediment controls will be installed, as will temporary dewatering facilities to eliminate the seepage of groundwater into the excavation. After over-excavation and backfilling of the coal mine, the RCRA-equivalent on-site landfill pit will be constructed and filled with the existing landfill waste. If hazardous materials are encountered in the existing landfill, they will be disposed of off-site. The estimated present worth cost of Alternative 5 is \$58,000,000.

ALTERNATIVE 6 - MULTI-LAYER CAP WITH SUBSURFACE BARRIER: The components of Alternative 6 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Subsurface Structural Supports
- Surface Water and Sediment Controls
- Multi-layer Cap
- Leachate Collection System
- Slurry Wall
- Wetlands Replacement

This alternative includes the institutional controls, site fencing, alternate water supply, monitoring program, subsurface structural support, surface water controls and the Alternative 3 multi-layer cap system over the existing

landfill and adds a subsurface groundwater flow barrier. A low-permeability, subsurface vertical barrier will be constructed around the west and north of the landfill to direct groundwater in the shallow aquifer around the landfill. The estimated present worth cost of Alternative 6 is \$21,000,000.

COMPARISON OF ALTERNATIVES

Each of the six alternatives was compared to the other alternatives to determine their relative value in meeting the evaluation criteria. Alternative 1 (No Action) did not address any of the remedial action objectives. The results of the comparison for seven of the nine criteria follows. Evaluation of State and community acceptance cannot be made prior to the formal public comment period.

Overall Protection of Human Health and the Environment: Since Alternative 1 is not protective, it is eliminated from further consideration. All of the remaining alternatives reduce the current and future risks associated with the contaminants at the Fultz Landfill Site to acceptable levels by the implementation of institutional controls. Alternatives 3, 4, 5, and 6, provide additional protection through engineering controls (containing the waste), and reduce risks by treating the landfill leachate and/or contaminated groundwater.

Compliance with ARARs: Alternatives 2 and 5 do not meet ARARs and, consequently, were omitted from further consideration. Alternative 2 would not result in groundwater meeting maximum contaminant levels (MCLs) and this alternative does not meet the solid waste closure ARARs. The Ohio Environmental Protection Agency indicated that Alternative 5 would not meet State of Ohio solid waste landfill siting requirements. Alternatives 3, 4, and 6 would meet all identified chemical-specific, action-specific, and location-specific ARARs.

Long Term Effectiveness and Permanence: Because of the size and heterogeneous nature of the waste in the existing landfill, no truly permanent (full treatment of all site waste) solution was determined to be cost effective for the Fultz Landfill Site. However, since Alternative 4 includes treatment of

both landfill leachate and contaminated groundwater, it reduces the magnitude of residual risk and offers a greater degree of reliability than Alternatives 3 and 6, which only call for collection and off-site treatment of the landfill leachate. Alternative 4, which incorporates an on-site water treatment system, would require management and off-site disposal of treatment residuals, such as spent activated carbon or sludges from the treatment system.

Reduction of Toxicity, Mobility and Volume (TMV) through Treatment:

Alternative 4 achieves the greatest degree of reduction in toxicity and volume of hazardous materials. Alternatives 3 and 6 reduce the TMV of contaminants to a lesser degree as they treat only landfill leachate, ^(off-site treatment) with no extraction and treatment of contaminated groundwater.

Short Term Effectiveness: Alternatives 3, 4, and 6 require similar times for construction (approximately 3 years). Construction of Alternative 4 would take about 6 months longer than Alternative 3 because of the construction of the extraction wells and water treatment plant. Alternative 4 attains all of the remedial response objectives in the shortest amount of time. Alternatives 3, 4, and 6 would require a similar approach for protection of on-site workers and the nearby community during the remedial action. A short-term environmental impact to the Pond 6 wetland area could occur during implementation of Alternatives 3, 4, or 6, since the stream which feeds Pond 6 must be diverted during construction activities.

Implementability: Alternatives 3, 4, and 6 present no great difficulty in implementation as they require the use of conventional equipment, materials, and technologies. The subsurface supports necessary for the deep mine roof can be constructed with reliable, established procedures and technologies. The need to excavate strip mine soil to construct a slurry wall would make implementation of Alternative 6 the most difficult of the three alternatives. Alternative 4 would be less difficult than Alternative 6, but more difficult than Alternative 3, because extraction well installation would require an extensive design investigation to determine optimum well placement and pumping rates. All the alternatives would require care during construction so that impact to the site wetlands is minimized.

Cost: Alternatives 3, 4, and 6, the three capping options, are similar in cost at approximately \$21,000,000. Alternative 4 requires the greatest amount of initial construction costs, but the on-site treatment system for leachate and contaminated groundwater results in lower annual operation and maintenance costs than Alternatives 3 and 6, which require leachate to be collected and transported off-site for treatment.

1.0 INTRODUCTION

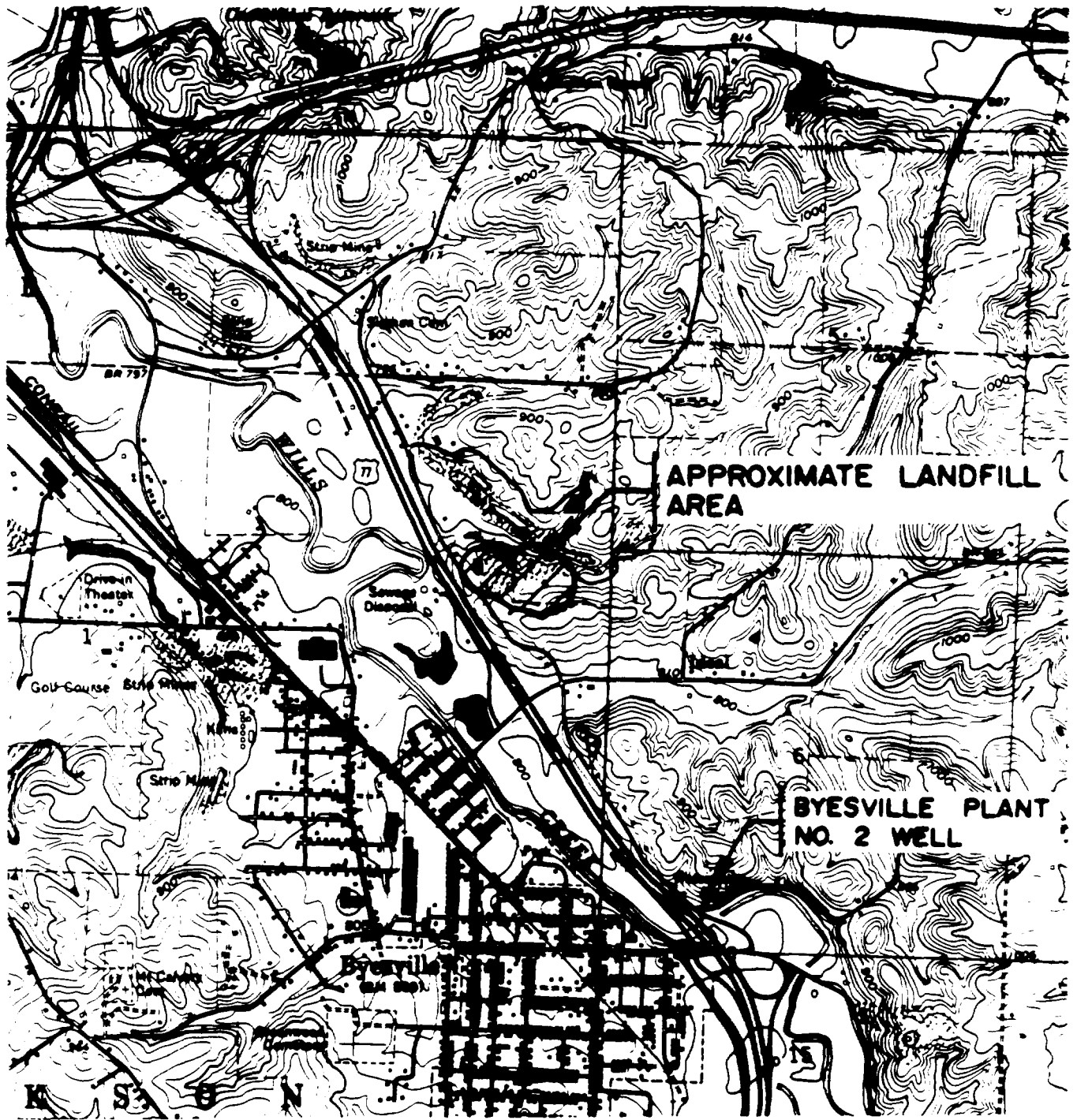
1.1 PURPOSE

In accordance with the National Contingency Plan (NCP), the appropriate extent of remedy is defined as a "cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health, welfare, and the environment" [40 CFR 300.68(1)]. This Feasibility Study is based on the information and data presented in the Final Remedial Investigation (RI) Report submitted by PRC Environmental Management, Inc. in April 1990. The purpose of this Feasibility Study (FS) Report is to summarize the process used in developing and evaluating remedial action alternatives for the Fultz Landfill Site.

The methodology used in the FS employs a step-by-step evaluation of technologies and alternatives. Initially, general qualitative information is used for the identification of applicable technologies. Subsequently, more refined and quantitative information is used to eliminate from consideration infeasible or otherwise unacceptable remedial actions. Remedial technologies that are not eliminated are then assembled into remedial alternatives. NCP methodology provides a systematic procedure for (1) identifying and evaluating remedial alternatives, (2) specifying criteria for determining the magnitude and importance of effects resulting from the implementation of an action, and (3) considering measures to mitigate adverse effects of the remedial actions.

1.2 SITE BACKGROUND AND DESCRIPTION

The Fultz Landfill Site is located in an agricultural and coal mining region of east-central Ohio, approximately 75 miles east of Columbus. Fultz Landfill Site is situated in Jackson Township in the northwest corner of Military Lot 5, Township 1 North, Range 3 West in Guernsey County, Ohio. The site is about one-half mile northeast of the corporate limits of Byesville, Ohio, and about one mile southeast of the interchange of Interstates 77 and 70, as illustrated on Figure 1-1.



REFERENCE:

U.S.G.S. 7.5' TOPOGRAPHIC MAPS, BYESVILLE QUADRANGLE, OHIO, DATED: 1961, PHOTOREVISED: 1972 AND 1975, CAMBRIDGE QUADRANGLE, OHIO, DATED: 1962, PHOTOREVISED: 1972 AND 1978, SCALE: 1" = 2000'



0 2000 4000



SCALE IN FEET



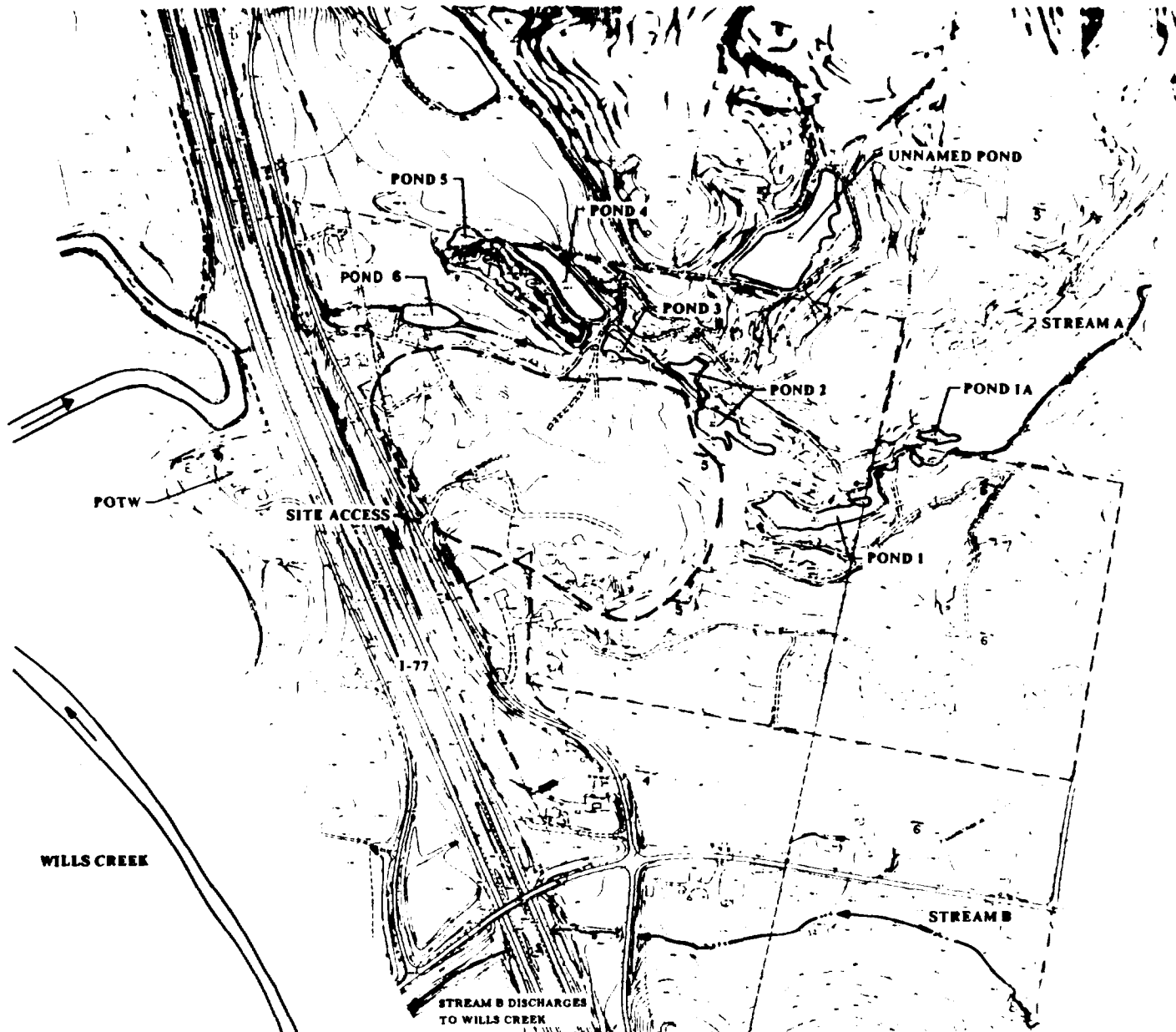
QUADRANGLE LOCATION

FIGURE 1-1
SITE LOCATION MAP
 FULTZ LANDFILL SITE, BYESVILLE, OHIO
 FEASIBILITY STUDY REPORT

The Fultz Landfill Site is a privately-owned sanitary landfill where it is alleged that hazardous industrial wastes were co-disposed with municipal waste. The landfill has been closed since 1985 and was one of two facilities that served the refuse-disposal needs of Guernsey County. The landfill, illustrated on Figure 1-2, occupies 30 acres of a 58-acre land tract. Prior to 1950, the property was part of a farm that comprised about 200 acres. Land use in the vicinity of the site is primarily wooded and pasture to the south, north and east. To the west, land has been developed for residential and light industrial use. Much of the property surrounding the Fultz Landfill Site has been mined for coal through both surface and underground mining methods.

The 30-acre landfill on the property was an open dump from 1958 through 1968. The site was first licensed by the Guernsey County District Board of Health in 1969, at which time the landfill was permitted to accept household, commercial and industrial solid wastes.

The landfill had a history of substandard compliance with state regulations during the 1970s, when the operator was repeatedly cited for inadequate daily celling of waste, open dumping, inadequate daily cover, receiving unauthorized waste, leachate runoff, and blowing debris. On April 14, 1983, the site was again brought to the attention of the authorities, when a bulldozer at the site rolled over a drum containing calsibar (a dry pyroforic powder mixture of calcium, silicon and barium) that ignited and burned. Local and state authorities received reports that the calsibar drum was accidentally discharged to the landfill. Soon after this incident, a landfill employee signed a statement confirming that industrial solvents were dumped and burned at the site in order to sell the empty drums. The landfill ceased waste disposal operations in December 1985, when the owner failed to renew the site's operating permit for 1986.



- LEGEND**
- APPROXIMATE LANDFILL AREA
 - PROPERTY BOUNDARY
 - POTW PUBLICLY OWNED TREATMENT WORKS FOR CITY OF BYESVILLE

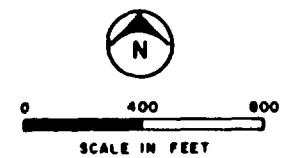


FIGURE 1-2
 SITE MAP
 FULTZ LANDFILL SITE, BYESVILLE, OHIO
 FEASIBILITY STUDY REPORT

1.3 SUMMARY OF ACTIVITIES DURING PHASE II OF THE RI

The RI field efforts began with a leachate seep reconnaissance performed on June 14, 1989, during a period of high surface flow conditions. Seventeen leachate seeps were identified, mostly along the northern slope and perimeter of the landfill. Leachate water and sediment sampling were performed at the site from June 27 through June 29, 1989. Eight leachate water samples and nine leachate sediment samples were obtained for analysis.

Surface water samples from Stream A and Wills Creek were obtained during the week of July 31, 1989, and pond surface water and sediment sampling occurred during the week of August 7, 1989.

A total of 15 surface soil samples were collected for analysis from the existing cover on the site on October 20, 25, and 26, 1989, to determine the nature and extent of the contaminants present, as well as the physical properties of the soil.

A total of 32 borings were drilled at the site for the investigation of site geology and installation of groundwater monitoring wells. Seven borings were drilled by the owner prior to Phase I of the RI, nine borings were drilled as part of Phase I of the RI performed during 1985 through 1987, and 18 borings were drilled during Phase II of the RI.

Eighteen monitoring wells were installed during Phase II of the RI to monitor groundwater contamination at the site. Monitoring well locations were selected to further define groundwater flow directions based on the data obtained during the Phase I investigations. Drilling and installation of all but two monitoring wells occurred from October 3, 1989 through November 3, 1989. The remaining two wells were installed from February 26 through March 2, 1990. Monitoring well locations are shown on Figure 1-3.

Aquifer permeability tests were performed on 10 Phase II wells installed between March 6 and March 9, 1990, using both rising head and falling head

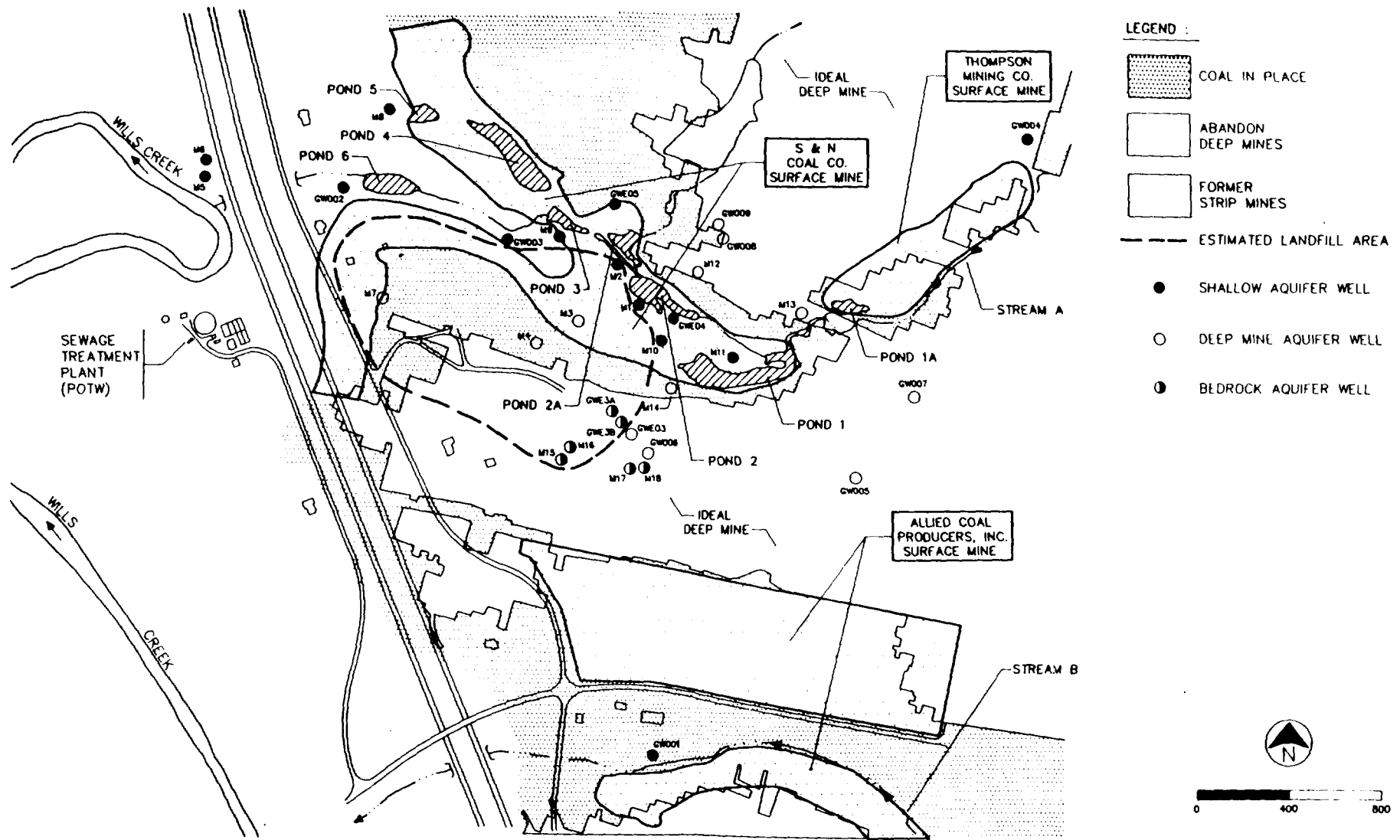


FIGURE 1-3
 POND AND MINE LOCATIONS
 FULTZ LANDFILL SITE, BYESVILLE, OHIO
 FEASIBILITY STUDY REPORT

methods. Two Phase II wells were packer-tested, to determine the permeability of the bedrock southeast of the landfill.

Groundwater sampling was performed during the weeks of November 13, 20, and 27, 1989 and on March 7, 1990. On October 16, 1989, personal air sampling was conducted while drilling through the landfill, as required by the February 1989 Health and Safety Plan.

1.4 MAJOR FINDINGS OF PHASE II OF THE RI

This section presents a summary of the major findings of Phase II of the Remedial Investigation. Section 1.4.1 describes the topography, geology, surface water hydrology, and hydrogeology of the Fultz Landfill Site. Section 1.4.2 summarizes of the extent of contamination.

1.4.1 PHYSICAL CONDITION OF THE FULTZ LANDFILL SITE

1.4.1.1 Topography

Topographic relief in Guernsey County varies by approximately 200 feet. Surface elevations at the Fultz Landfill Site vary from about 800 to 900 feet MSL. A high percentage of the land surface in the area slopes steeply, with natural slopes of 10% to 25% occurring in the vicinity of the site. Broad flat areas exist along the Wills Creek flood plain to the west of the site.

1.4.1.2 Surface Water Hydrology

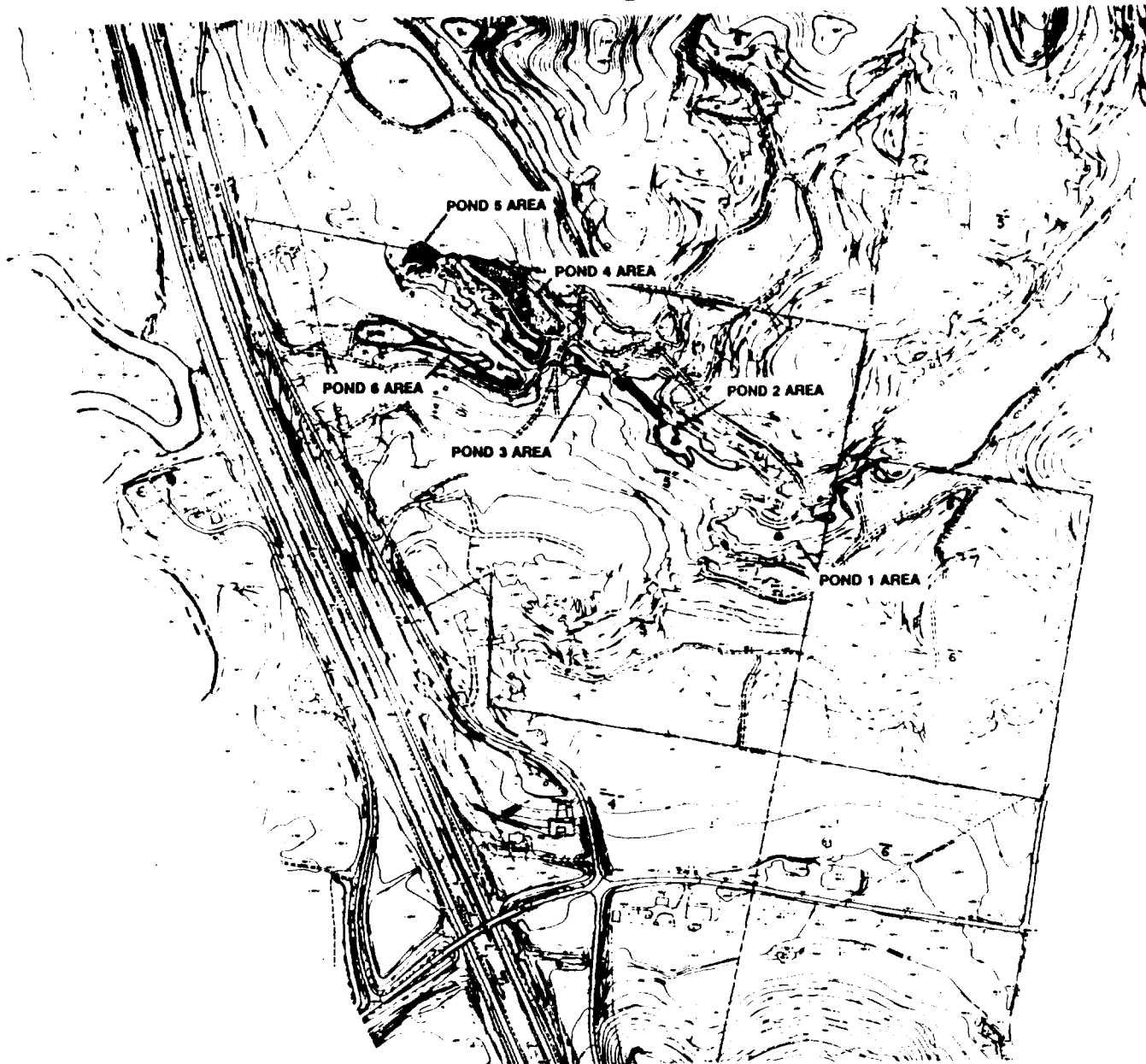
Major surface water features associated with the Fultz Landfill Site are Wills Creek, Stream A, a series of ponds resulting from surface mining, and south of the site, Stream B. Refer to Figures 1-2 and 1-3 for the identification of these features.

Stream A and the On-Site Ponds: The drainage course on the north edge of the landfill is designated Stream A which is an intermittent stream which enters

the site from the east. Prior to the development of the landfill, Stream A was interrupted by surface mining activities, and several ponds were left in the surface mining pits. The ponds are identified as Ponds 1 through 6, 1A, and 2A. Upon entering the site, Stream A flows directly into Pond 1, which then overflows into Ponds 2 and 2A. Surface water outflow from Pond 1 exceeds the inflow, indicating that Pond 1 also receives discharge from groundwater. Ponds 2 and 2A are separated from each other only during low water level conditions, and the ponds have never been observed to overflow. Ponds 3, 4, and 5 are located to the north of the landfill and are upgradient from the landfill relative to surface water and groundwater flow. These three ponds maintain water levels approximately 10 feet higher than the normal Pond 2/2A levels. Ponds 3 overflows only during periods of heavy precipitation, forming the lower section of Stream A, which appears to be a relatively undisturbed section of the original stream. Pond 6 was observed to be present only during high precipitation periods.

Stream A is routed through a 350-foot long, 8-foot diameter culvert beneath Route 77 and into Wills Creek, as shown in Figure 1-2 and Figure 1-3. Flow measurements upstream on Stream A have been consistently higher than downstream measurements, indicating that surface water inflow to the site exceeds the outflow.

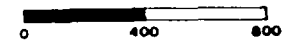
Stream A Wetland Areas: On October 9, 1990, U.S. Army Corps of Engineers performed a wetlands delineation at the Fultz Landfill Site. Pond 1 was classified as a deep water habitat, Ponds 2 through 6 were classified as wetlands, and the area of the landfill where leachate seeps emanate was determined to be a weeping hillside wetland. Figure 1-4 shows the approximate extent of the wetland areas associated with the site ponds. The weeping hillside wetland was only generally defined as the areas associated with certain leachate seeps on the north slope of the landfill, and are not indicated on Figure 1-4.



LEGEND



APPROXIMATE EXTENT OF WETLAND AREAS



SCALE IN FEET

FIGURE 1-4
WETLAND AREAS
FULTZ LANDFILL SITE, BYESVILLE, OHIO
FEASIBILITY STUDY REPORT

Stream B: Located south of the site Stream B drains a one square mile area consisting of farm land and reclaimed surface coal mines and discharges into Wills Creek. The discharge in this stream was not measured, because flow was completely absent during several periods, including the period of stream sampling.

1.4.1.3 Geology

Bedrock in the region consists of a thick sequence of Paleozoic Era sedimentary rock strata. In eastern Ohio, these strata dip gently southeast toward the Appalachian Basin. The rocks outcropping in the vicinity of the site belong to the Pennsylvanian age Conemaugh Group. Rock units in this group generally consist of sequences of interbedded shale, claystone, limestone, sandstone, and coal. Underlying the Conemaugh Group is the Allegheny Group, which has the Upper Freeport Coal as its uppermost member. The Upper Freeport Coal seam has been mined at the site. The regional dip of the seam is approximately 30 feet per mile to the southeast, with local variations due to smaller scale structures.

1.4.1.4 Hydrogeology

The hydrogeology of the Fultz Landfill Site area is complex due to the underground and surface (strip) coal mining on and adjacent to the site. The conceptual model of groundwater flow at the Fultz Landfill Site is a two-aquifer system: the shallow aquifer and the coal mine aquifer. The shallow aquifer system is a local water table aquifer generally limited to the unconsolidated valley sediments and strip mining spoils. The coal mine aquifer system is a confined to partially-confined aquifer that has formed in the abandoned Ideal Coal Mine due to the flooding of the interconnected underground mine workings of the Upper Freeport Coal. The City of Byesville uses the coal mine aquifer system as a source of municipal water. The withdrawal point is the Plant No.2 well approximately one mile south of the site. In addition to the shallow and coal mine aquifers, groundwater may also

seasonally occur above perching layers in intact bedrock above the mined Upper Freeport Coal Seam.

Stream A Shallow Aquifer: The Stream A shallow aquifer system is defined as groundwater at water table conditions located within the unconsolidated alluvial deposits and surface mine spoil in the Stream A valley. The shallow aquifer also includes bedrock adjacent to the unconsolidated valley sediments and strip mining spoils, where it has not been dewatered by the effects of underground coal mining. The overall groundwater flow direction in the Stream A valley is from east to west, with the exception of the region around Ponds 2 and 2A, where a depression in the water table between Ponds 1 and 2 causes the shallow aquifer to become divided into eastern and western systems. The depression in the water table forms a groundwater capture, defined as the "Pond 2 groundwater capture area." The Pond 2 groundwater capture area causes a groundwater divide, splitting the shallow aquifer into eastern and western systems. These two systems are discussed in further detail below.

Stream A Shallow Aquifer - Eastern System: Groundwater flow in the eastern system is dominated by radially inward gradients centered around Wells M3, M10, and GWE04, and the Pond 2 and 2A areas. The location of this groundwater depression appears to be related to the surface mine highwall in the eastern half of the old S&N Coal Company mine. The heads measured in the shallow aquifer generally range between 10 and 12 feet higher than heads in the coal mine aquifer. Thus, despite the depressed water table at the Pond 2 groundwater capture area, there remains a significant potential for groundwater flow from the eastern system of the shallow aquifer into the deep mine. The existence of the groundwater depression is conclusive evidence that mine passages and/or high permeability zones exist in the coal barrier that separates the deep mine and surface mine, and that groundwater flows from the eastern system of the shallow aquifer into the deep mine aquifer.

Stream A Shallow Aquifer - Western System: Groundwater flow in the western system of the shallow aquifer is generally west toward Wills Creek. The flow originates partly from the mine spoil areas on the north and south sides of

Stream A, and partly from the western half of the Fultz Landfill Site. The groundwater then flows west beneath I-77 and into Wills Creek.

Stream B Shallow Aquifer: The Stream B shallow aquifer is located in the alluvial sediments of Stream B in the valley south of the landfill. This aquifer includes groundwater in the spoil of the former Allied Coal Producers Inc. surface mines located on the north and south sides of Stream B (Figure 1-3). Well GW001 is the only well screened in the shallow aquifer of Stream B valley, and the groundwater level was observed to vary between 0.5 and 2 feet below the ground surface. The direction of groundwater flow in this area cannot be determined by available direct measurements of groundwater levels. The piezometric level of the Stream B shallow aquifer at GW001 has been approximately 1 to 3 feet higher than the head in the coal mine aquifer for all measurements except for a period in November of 1985. Precipitation during this month was 8 inches higher than normal at the Pittsburgh station. Based on a comparison between water levels in the deep mine verses water levels in GW001, groundwater would be expected to flow from the Stream B shallow aquifer to the coal mine aquifer under normal hydrologic conditions. Under unusually high precipitation conditions, the water level in the deep mine was observed to be up to 3 feet higher than the ground surface level at well GW001. During these high flow conditions, groundwater would be expected to temporarily reverse and flow from the coal mine aquifer to the Stream B shallow aquifer.

Groundwater in Bedrock: The Phase I water level measurements in owner-installed Wells GWE3A and GWE3B suggested that saturated conditions may have existed in the shales lying above the deep mine. These water levels formed the basis for the preliminary identification of a "bedrock aquifer" consisting of perched saturated zones in the shales and claystones overlying the Upper Freeport Coal. Well nests M15/M16 and M17/M18 were installed during Phase II of the RI to investigate the possibility of saturated conditions at other locations in the mine overburden.

During the installation of three of the four wells, there were strong indications of bedrock fracturing. Drilling water was lost at various depths during the drilling of Wells M16, M17 and M18, and pump-in packer testing indicated very high permeabilities in the lower sections of these wells.

None of the four Phase II bedrock wells had water in them when they were originally installed, although it was eventually observed that two of the wells, M15 and M17, accumulated water very slowly. The water level measured in both of these wells, however, are not considered indicative of true groundwater levels. In all, the data strongly suggests that saturated conditions generally do not exist in the bedrock beneath the fill, and that groundwater infiltrates vertically from the south half of the landfill to the underlying deep mine aquifer.

Coal Mine (Deep Mine) Aquifer: Beneath the shallow aquifer and underlying the bedrock is the coal mine aquifer (also referred to as the deep mine aquifer). The shallow aquifer is separated from the coal mine aquifer by in-place coal barriers left by the mining operations. The location of the coal barriers, indicated on Figure 1-3, is based on mine maps which may or may not be accurate, and the barriers may not be intact as shown.

The groundwater flow directions in the deep mine aquifer depend not only on the on the potentiometric gradient, but also on the degree of mine void interconnection or fractures between adjacent mine rooms and passages. Potentiometric readings from previous studies and the Phase II results indicate a very minimal potentiometric gradient going from the north to the south or southeast of the study area. This shows that the hydraulic connections within the coal mine aquifer system are almost unrestricted. Recharge to the system comes both indirectly from the northeast of the study area and from percolation through the overlying shallow aquifer.

Groundwater flow within the coal mine aquifer has been generally described in the literature (ODNR 1980) as through the mines in the unconfined areas of the aquifer, and upward through overlying rocks in the confined areas of the

aquifer, ultimately discharging to Wills Creek. In this context, Wills Creek refers to an approximately seven mile section of stream that parallels the deep mine complex in the Upper Freeport Coal south of the site. Discharge to in this section of Wills Creek refers to groundwater flow from the aquifer to the Wills Creek stream bed, and artesian discharges to the ground that ultimately flow to Wills Creek via surface water.

The potentiometric level of the deep mine aquifer is about 20 feet lower than the water table level in the shallow aquifer. Because of the significant head difference, a potential exists for groundwater seepage through fractures in the bedrock and coal seam barriers into the deep mine aquifer. Based on groundwater level observations, there is a possible seepage route on the northeast sides of Pond 2 and 2A, and from the shallow aquifer around the locations of Wells M3 and M10 to the south of the surface mine highwalls. Potentiometric level fluctuations within the coal mine aquifer exceeded 5 feet during a precipitation period. These fluctuations indicate that the aquifer responds relatively quickly to precipitation events and this is evidence of direct surface water routes to the deep mine.

Due to the highly preferential flow pathways caused by the room and pillar deep mining method, and the very high permeability in the deep mine, piezometric head data alone are not adequate to describe specific flow directions within the coal mine aquifer. Certain assumptions regarding the general groundwater flow directions are possible, however, using the following rationale. The Fultz landfill lies over a recharge area for the coal mine aquifer and the Byesville Plant No.2 well is a significant artesian discharge point located in a confined area of the mine near the Wills Creek flood plain. It is reasonable to assume that groundwater flow directions lead from the Fultz Landfill Site to the Byesville Plant No.2 well. The route from the landfill to the well would be a circuitous one approximately 1.6 miles long, mostly following the major mine entries surrounding the Stream B valley.

1.4.2 NATURE AND EXTENT OF CONTAMINATION

Table 1-1 presents a summary of the chemicals detected during the RIs at the Fultz Landfill Site and indicates which chemicals were site related. A description of the chemicals detected by location and media type follows.

1.4.2.1 Chemicals in the Background Environment

Fourteen polynuclear aromatic hydrocarbons (PAHs) were detected in the Phase II background soil, sediment, and water samples. PAHs can be associated with coal, coal tar or other coal distillation products, as well as coal and petroleum combustion products. Because they are common trace chemicals in the environment, PAHs were not attributed to the landfill based on the available background data and screening criteria. Aside from the typical metals normally associated with coal such as iron and manganese, several other heavy metals have been documented in the literature as being associated with coal pile leachate, including arsenic, antimony, and selenium. These metals are particularly significant because of their presence in on-site samples and importance in the assessment of health and environmental risks. Some of the chemicals in the background were determined to pose significant risks as shown in Phase II of the RI Appendix L.

1.4.2.2 Surface Soil Contamination

Five organic chemicals were detected in the on-site samples including acetone, di-n-butylphthalate, methylene chloride, tetrachloroethene and toluene. Selenium was the only inorganic chemical found in the on-site soil samples at concentrations above background.

1.4.2.3 Leachate and Leachate Sediment

Fifteen organic chemicals were detected in the leachate samples, including acetone, benzene, benzyl alcohol, bis(2-ethylhexyl)phthalate, chlorobenzene,

TABLE 1-1
 SUMMARY OF CHEMICALS DETECTED (3)
 Fultz Landfill Site, Evesville, Ohio
 Feasibility Study Report

CHEMICAL	Groundwater			Surface Water/Sediment										
	Shallow Aquifer	Deep Aquifer	Residential Wells (b)	Evesville Plant No. 2		Leachate Seeps		Ponds and Stream A		Wills Creek				
				Untreated	Treated	Water	Sediment	Water	Sediment	Water	Sediment	Soil	Air	
ORGANICS:														
Acetone	X	(X)		(X)			X	X		X			X	X
Benzene	X						X		(X)					X
Benzoic acid	X	X												
Benzyl alcohol							X							
Bis(2-ethylhexyl)phthalate	X	X					X	X		X				
Bromodichloromethane			(X)						X					
Bromoform									(X)					
2-Butanone	X	(X)												
Butylbenzylphthalate	X						X							
Carbon disulfide	X								(X)					X
Carbon tetrachloride				(X)										
Carcinogenic PAHs	X							X						
Chlorobenzene	X						X	X		X				
Chloroethane	X						X							
Chloroform										X				
Dibromochloromethane			(X)							(X)				
1,4-Dichlorobenzene								X						
3,3'-Dichlorobenzidene								X						
1,1-Dichloroethane										(X)				
1,1-Dichloroethene	X									(X)				
1,2-Dichloroethene (Total)	X	X								(X)				
1,2-Dichloropropane										(X)				
cis-1,3-Dichloropropene										(X)				
trans-1,3-Dichloropropene										(X)				
Diethylphthalate	X						X							

TABLE 1-1 (Continued)

CHEMICAL	Groundwater				Surface Water/Sediment											
	Shallow Aquifer	Deep Aquifer	Residential Wells (b)	Byeville Plant No. 2		Leachate Seeps		Ponds and Stream A		Wills Creek						
				Untreated	Treated	Water	Sediment	Water	Sediment	Water	Sediment	Soil	Air			
2,4-Dimethylphenol	X															
Di-n-butylphthalate		X							X							X
Di-n-octylphthalate	X						X									
Ethylbenzene	X	X				X	X		(X)							
4-Methyl-2-pentanone	X															
2-Methylphenol						X										
4-Methylphenol						X										
Methylene chloride	X						(X)								(X)	
N-nitrosodiphenylamine	X					X	X									
Monocarcinogenic PAHs	X	(X)				X	X			X						
Pentachlorophenol	X									X						
Phenol						X										
Styrene										(X)						
Tetrachloroethene										(X)					X	
Toluene	X	X				X	X			(X)	X			X	X	X
1,1,1-Trichloroethane											X					
1,1,2-Trichloroethane										(X)						
Trichloroethene										(X)	(X)					
Vinyl acetate										(X)						
Vinyl chloride	X	X														
Xylenes (total)	X	X				X	X				(X)					
INORGANICS:																
Aluminum	X	(X)									X					
Antimony	X	X											X			
Arsenic	X											X		X		X
Barium	X	X				X					X			X		
Beryllium	X	X														
Cadmium	X	X											X			

TABLE 1-1 (Continued)

CHEMICAL	Groundwater					Surface Water/Sediment						Soil	Air
	Shallow Aquifer	Deep Aquifer	Residential Wells (b)	Byesville Plant No.2		Leachate Seeps		Ponds and Stream A		Wills Creek			
				Untreated	Treated	Water	Sediment	Water	Sediment	Water	Sediment		
Calcium	X					X	X		X				
Chloride	X	X											
Chromium	X	X				X							
Cobalt	X	X						X			X		
Copper	X	X			(X)			X					
Iron	X	X	(X)				X				X		
Lead	X	X	(X)										
Magnesium	X	X				X							
Manganese	X	X	(X)			X		X	X		X		
Mercury	X								X				
Nickel	X	X						X			X		
Potassium	X					X							
Selenium	X						X		X			X	
Silver	X						X		X				
Sodium	X					X			X		(X)		
Sulfate													
Thallium	X						X		X				
Vanadium	X	X									X		
Zinc	X	X	(X)										
Cyanide							X		X				

Notes: (a) Chemicals determined to be site-related and/or chemicals of potential concern based on the RI results.
 X A chemical of potential concern in the risk assessment, and probably site-related.
 (X) A chemical of potential concern in the risk assessment, but probably not site-related. Site-related chemicals were determined based on a comparison of the onsite versus background concentrations for each media.
 (b) Some residential wells may be located in downgradient directions relative to the landfill.

1-18

chloroethane, diethylphthalate, ethylbenzene, 2-methylphenol, 4-methylphenol, n-nitrosodiphenylamine, naphthalene, phenol, toluene and xylenes. The concentrations ranged from 2 $\mu\text{g}/\text{l}$ for benzene, to 150 $\mu\text{g}/\text{l}$ for ethylbenzene. Seven inorganic chemicals were detected in the leachate water at levels above the background range including barium, calcium, chromium, magnesium, manganese, potassium and sodium.

Seventeen organic chemicals were detected in the leachate sediment samples including acetone, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, benzo(a)anthracene, chlorobenzene, 1,4-dichlorobenzene, 3,3-dichlorobenzidene, di-n-octylphthalate, ethylbenzene, dibenzofuran, fluoranthene, naphthalene, phenanthrene, methylene chloride, n-nitrosodiphenylamine, toluene and xylenes. Six inorganic chemicals were detected above background in the leachate sediment samples, including calcium, iron, silver, selenium, thallium and cyanide.

1.4.2.4 Pond Water and Sediment Contamination

Surface water and sediment samples were collected from two locations on Stream A, from six of the ponds, and from four locations on Wills Creek. The upgradient Stream A water and sediment samples were used as background to evaluate the water and sediment samples from downgradient Stream A and the site ponds, and the upstream Wills Creek samples were used as background to evaluate all other samples collected on Wills Creek.

Twenty-two organic chemicals, mostly VOCs, were detected in the sediment sample from off-site Pond 1A, more than in any other sediment sample collected. Several of the compounds detected in this sample were not detected in any other on-site or downgradient sample including bromoform, cis-1,3-dichloropropene, dibromochloromethane, 1,1-dichloroethane, 1,2-dichloropropane, trans-1,3-dichloropropene, and vinyl acetate. Because Pond 1A is located upgradient of the landfill, and because of the nature of the detections (none detected in the water and low levels in the sediment), it is

possible that the chemicals migrated to the sediments via the shallow groundwater from an off-site source to the east of the pond.

Trichloroethene was detected at a concentration of 1.75 $\mu\text{g}/\text{l}$ in Pond 1 and was the only organic chemical detected in the Phase II pond water samples.

Chlorobenzene, chloroform and 1,1,1-trichloroethane were detected in the sediments of all ponds and chloroform was detected in the background sediment sample. The detection of these volatile compounds in the sediment of Ponds 3, 4, and 5, is evidence that there may be sources of these compounds other than the landfill. The location of these sources cannot be determined, but possible source areas include the reclaimed surface mines east of Pond 1A and surface mines in the vicinity of Ponds 4 and 5. In addition to these compounds, phthalates were detected in the sediments of Ponds 1, 3, and 4. Manganese was the only inorganic chemical regularly detected in the pond water samples.

1.4.2.5 Downgradient Stream A Contamination

The water sample at the downstream location on Stream A contained one organic chemical, toluene detected at 3 $\mu\text{g}/\text{l}$, and the sediment sample at this location contained three volatile organic chemicals including acetone (350 $\mu\text{g}/\text{kg}$), chloroform (7 $\mu\text{g}/\text{kg}$) and toluene (10 $\mu\text{g}/\text{kg}$), as well as four noncarcinogenic PAHs. Arsenic (54.1 $\mu\text{g}/\text{kg}$), barium (460 $\mu\text{g}/\text{kg}$), cadmium (6.7 $\mu\text{g}/\text{kg}$), calcium (11,800 $\mu\text{g}/\text{kg}$), manganese (14,300 $\mu\text{g}/\text{kg}$), and silver (5.1 $\mu\text{g}/\text{kg}$) were found to exceed background levels in the stream sediments.

1.4.2.6 Wills Creek Contamination

No organics were detected in the downstream water samples in Wills Creek, and no inorganics were detected in the downstream water samples at levels above background.

Except for traces of chloroform and toluene, only PAHs were detected in the downstream sediment samples. In general, significantly fewer organics were detected in the downstream sediment samples than were found in the background sample. The concentrations of organics that were detected in the downgradient samples were generally an order of magnitude less than in the background sample. Overall, the concentrations of PAHs appeared to decrease with distances from the background sample location.

1.4.2.7 Shallow Aquifer Contamination

The eastern shallow aquifer within the influence of the groundwater capture contained relatively low concentrations of carbon disulfide, chloroethane, 1,2-dichloroethene, ethylbenzene, 4-methyl-2-pentanone and xylenes. The bis(2-ethylhexyl)phthalate found in the samples could also be site-related. All of the metals analyzed were detected above background concentrations, with barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese and vanadium present in concentrations greater than 5 times the background concentrations. Contaminants in the eastern shallow aquifer have a high potential of moving into the deep mine aquifer via the Pond 2 and coal barrier routes.

The western shallow aquifer contained low concentrations of 1,2-dichloroethene, ethylbenzene, toluene and xylenes, mostly in a well that was screened in the landfill. The bis(2-ethylhexyl)phthalate found in a well in this aquifer could also be site-related. Gradients in the western shallow aquifer indicate that groundwater flows from the western half of the landfill area to Wills Creek with the potential to flow into the deep mine aquifer near the western edge of the landfill.

Within the western shallow aquifer, several semi-volatile organic compounds were detected at low concentrations in off-site wells M5 and M6 screened in the sediments beneath Wills Creek, including benzoic acid, n-nitrosodiphenylamine, and di-n-octylphthalate. Although these compounds were detected in on-site leachate, sediment and groundwater samples, they were

found infrequently and at low concentration. The organic analyses of groundwater do not provide any conclusive indication that the groundwater at off-site wells M5 and M6 has been impacted by site-related contaminants. Many of the same metals detected at well nest M5/M6 were detected in on-site wells immediately downgradient from the landfill, with concentrations higher in the deeper well (Well M5) than in the shallow well (Well M6). Metals concentrations in Well M5 that were elevated above the GW004 background sample include arsenic (136 $\mu\text{g}/\text{l}$), barium (2120 $\mu\text{g}/\text{l}$), copper (277 $\mu\text{g}/\text{l}$), lead (150 $\mu\text{g}/\text{l}$), manganese (5,560 $\mu\text{g}/\text{l}$), mercury (0.4 $\mu\text{g}/\text{l}$) and vanadium (126 $\mu\text{g}/\text{l}$). Because groundwater gradients in the western shallow aquifer indicate that groundwater flows from the western half of the site to the sand and gravel aquifer under Wills Creek, it is possible that these metals detected in Well M5 are site-related.

Well M8 is located in the western shallow aquifer upgradient from the site and was intended to be a background well. However, the relatively high concentrations of total metals, including barium, beryllium, cadmium, chromium, cobalt, lead, nickel and vanadium, suggests a possible off-site source of inorganic contaminants upgradient of this well. One potential source area may be located the reclaimed surface mines to the north of the Fultz Landfill Site or property.

1.4.2.8 Deep Mine Aquifer Contamination

The deep mine aquifer groundwater near the Pond 2 migration route contained elevated concentrations of most of the metals found in the shallow aquifer, but did not contain any of the organics found in the shallow aquifer. This may indicate a significant source of metals in the northern region of the eastern shallow aquifer capture area, near Ponds 2 and 2A.

The deep mine aquifer groundwater near the coal barrier route was found to contain elevated concentrations of only a few metals, but also contained low concentrations of organics including vinyl chloride, 1,2-dichloroethene, and benzoic acid. The vinyl chloride could be a biodegradation by product of the

trichloroethene reportedly disposed of in the landfill and 1,1-dichloroethene seen in the shallow aquifer and may be indicative of contamination further from the source. The deep mine aquifer contaminants reflect the effects of contaminated groundwater moving from the shallow aquifer through the coal barrier route into the deep mine aquifer. The contaminants found in the deep mine aquifer at this location may also reflect the effects of contaminated groundwater moving from the bedrock via secondary permeability in the rocks underlying the southern half of the landfill.

1.4.2.9 Byesville Well Water Quality

The Fultz Landfill Site lies over a recharge area for the coal mine aquifer, and the Byesville Plant No.2 well is a significant artesian discharge point located in the confined area of the coal mine aquifer. Groundwater flow directions within the aquifer lead from the Fultz Landfill Site to the Byesville Plant No.2 well. The route from the landfill to the well would be a circuitous one approximately 1.6 miles long, mostly following the major mine entries surrounding the Stream B valley. Dispersion, dilution and flow upward into overlying rocks in the confined area of the aquifer would likely cause contaminants originating at the landfill, already relatively low in concentration, to become undetectable in the vicinity of the Byesville Municipal well.

1.5 MIGRATION PATHWAYS IDENTIFIED IN THE REMEDIAL INVESTIGATION

Potential contaminant migration pathways through three media were identified in the RI, namely through surface water, groundwater, and air. Of these, migration of contaminants through groundwater is, by far, the most significant.

1.5.1 MIGRATION THROUGH SURFACE WATER AND SEDIMENT

The most immediate surface release of contaminants present in the Fultz Landfill Site is through the leachate seeps around the base of the landfill.

Contamination in these seeps results from the infiltration of precipitation into the landfill surface, and subsequent percolation through the wastes. Leachate seeps on the eastern side of the landfill enter Pond 2, and the water in Pond 2 ultimately infiltrates into the groundwater system or evaporates. Leachate seeps on the western side of the landfill enter Stream A downgradient of the site, which in turn flows into Wills Creek.

While many of the contaminants in the leachate water and sediment are the same as those detected in groundwater, the concentrations of the contaminants are an order of magnitude higher in the seep samples. Lower contaminant levels are seen in the groundwater because the leachate is diluted when it mixes with the groundwater.

Leachate seeps on the western side of the landfill enters Stream A downgradient of the site, which in turn flows into Wills Creek. Downstream transport of a contaminant by this mechanism would be expected to result in significant dilution of contaminant concentrations.

While a few organics (chloroform, toluene, and PAHs) were detected in downstream Wills Creek sediment sample at low concentrations, none were found in the downstream water samples. Because so few of the numerous organic chemicals detected in leachate samples were found in either Wills Creek surface water or sediment, the possible association of the contaminants detected in the creek to the Fultz Landfill Site is uncertain. This uncertainty is increased because upstream concentrations of chloroform, toluene, and PAHs were at or above levels detected in the downstream samples.

1.5.2 MIGRATION WITHIN GROUNDWATER

Contaminant migration at the Fultz Landfill Site is primarily a function of groundwater flow. Figure 1-5 and Figure 1-6 show the principal groundwater migration pathways in plan and section drawings.

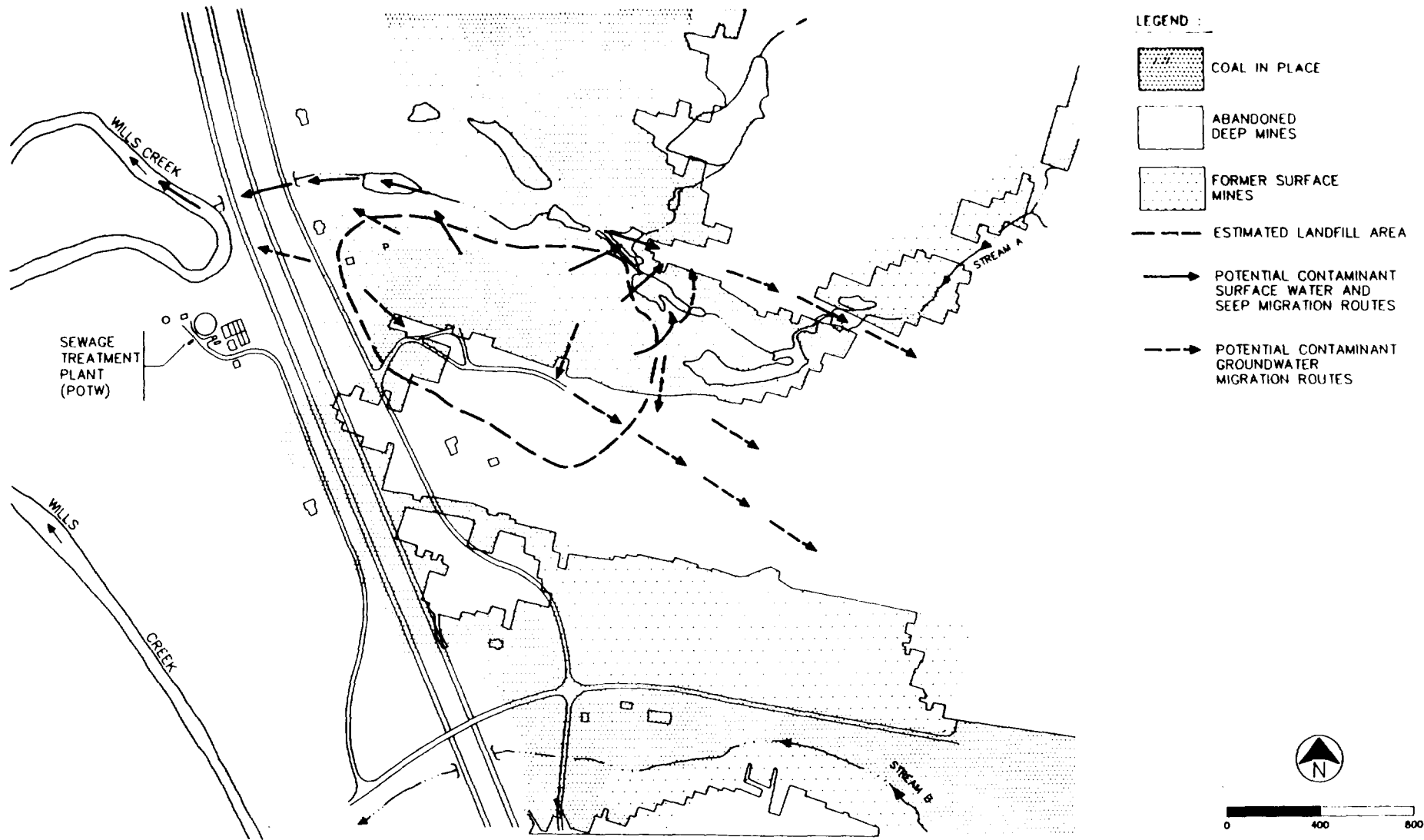


FIGURE 1-5
 POTENTIAL CONTAMINATION
 MIGRATION ROUTES
 FULTZ LANDFILL SITE, BYESVILLE, OHIO
 FEASIBILITY STUDY REPORT

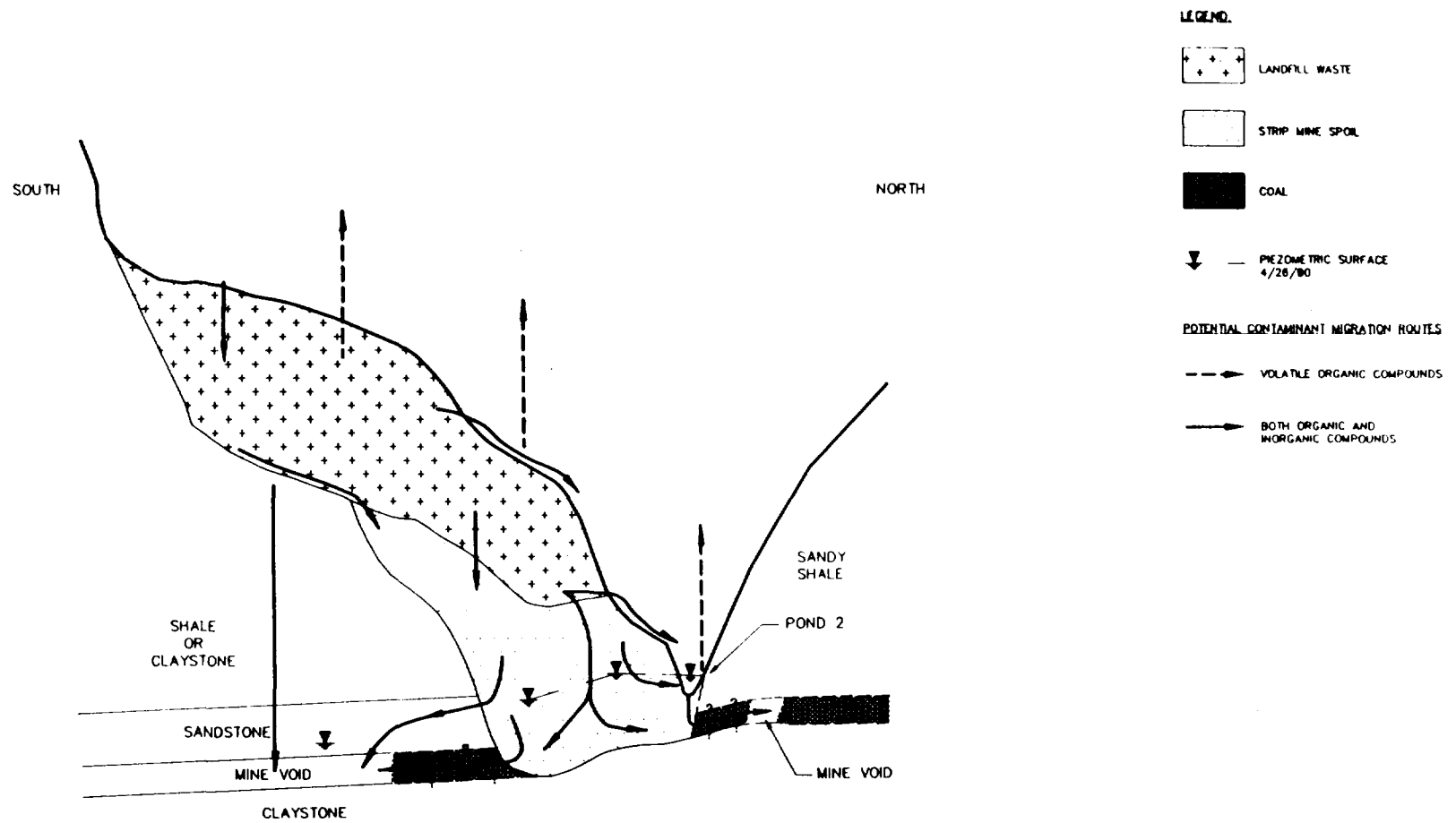


FIGURE 1-6
 POTENTIAL CONTAMINATION
 MIGRATION ROUTES - CROSS SECTION
 FULTZ LANDFILL SITE, BYESVILLE, OHIO
 FEASIBILITY STUDY REPORT

1.5.2.1 The Shallow Aquifer

The contaminated groundwater beneath the eastern half of the landfill flows to the deep mine aquifer by two main routes: (1) north through a pathway created by the intersection of the strip mine and deep mine near Ponds 2 and 2A, and (2) south through potential mining-related breaches or natural fractures in the coal barrier that separate the shallow and deep mine aquifers.

Groundwater from the western side of the landfill flows north towards the western end of Stream A and into Wills Creek. Groundwater infiltrating into the bedrock moves mostly via unsaturated flow into the deep mine. In areas where the bedrock is undermined, contamination may also be transported through subsidence fractures.

1.5.2.2 The Deep Mine Aquifer

Groundwater flow directions within the deep mine aquifer indicate flow in the direction of the Byesville Municipal well. The route from the landfill to the well would be a circuitous one, approximately 1.6 miles long, mostly following the major mine entries that surround the Stream B valley. Dispersion, dilution, and flow upward into overlying rocks along the migration route would likely cause contaminants originating at the landfill, already relatively low in concentration, to become undetectable in the vicinity of the Byesville Municipal well.

Review of the organics detected in both the shallow and deep mine aquifers demonstrates a connection between the two aquifers. Alkylbenzenes, chlorinated aliphatics, ketones, PAHs and phthalates were detected in both aquifers although fewer total compounds were detected and at lower frequencies in the deep mine aquifer. Concentrations were similarly low in both aquifers, although PAHs appear to be higher in the shallow aquifer.

1.5.3 MIGRATION INTO AND THROUGH AIR

Volatile compounds can migrate from the soil, leachate, and/or surface water into the air. Of the several volatile organic compounds which were found in the soil, leachate, or surface water, only benzene, toluene, and acetone were detected during the air monitoring survey.

1.6 PUBLIC HEALTH/ENVIRONMENTAL ASSESSMENT

The baseline risk assessment developed for the Fultz Landfill Site (presented as Section 6 of the RI report) identified several potential risks which currently exist above baseline levels, or may develop in the future as a result of future site development. Evaluation of the following exposure routes resulted in identification of potential risks to human health exceeding 1×10^{-6} and/or hazard indices greater than 1.0:

- Ingestion of groundwater and inhalation of vapors by nearby residents while showering with water from residential wells (excess lifetime carcinogenic risks ranged from 3×10^{-6} to 6×10^{-4} , non-carcinogenic hazard indices ranged from 0.003 to 1.0).
- Ingestion of untreated water from the Byesville water supply by residents (excess cancer risk of 3×10^{-3}).
- Inhalation of airborne contaminants by the nearby residents (excess cancer risk of 1×10^{-4}).
- Ingestion of groundwater and inhalation of vapors while showering with water from the shallow aquifer by future residents (excess cancer risk of 1×10^{-3} , hazard index of 7).
- Ingestion of groundwater and inhalation of vapors while showering with water from the deep mine aquifer by future residents (excess cancer risk of 1×10^{-3} , hazard index of 11).

1.6.1 SUMMATION OF ESTIMATED RISKS UNDER CURRENT LAND-USE SCENARIOS

Table 1-2 summarizes the potential human health risks exposure under current land-use scenarios that have an upper-bound excess lifetime cancer risk $\geq 10^{-6}$ or a hazard index ≥ 1.0 for a given exposure pathway. This table also identifies the chemicals of concern contributing to the overall risks associated with each exposure scenario. Six off-site residential wells were sampled during Phase I of the RI. One of these wells (RW006) was actually the Byesville well. Of the remaining five wells, three exhibit potential carcinogenic risks exceeding 1×10^{-6} , and one of these three had a hazard index greater than one. The risks associated with the residential wells are driven by arsenic and bromodichloromethane. It is not clear whether these contaminants are site related. Bromodichloromethane was not detected in on-site groundwater during the RI, and arsenic is a naturally occurring chemical related to coal and may not be site related. The residential wells will be addressed in the FS due to the potential for site related contaminants to migrate to downgradient areas.

Risk assessment analysis of the data associated with the untreated water sample collected at the Byesville well resulted in a cancer risk of 3×10^{-5} . This risk is driven by the presence of carbon tetrachloride. There exists some doubt as to the value of this deduction as carbon tetrachloride was not detected in any other groundwater samples, and was only detected in one of two duplicate Byesville well water samples. Furthermore, there were no excessive risks associated with the treated water sample collected at the Byesville water supply. For purposes of the FS, the Byesville water will not be considered to present a risk for the current use scenario. The current risk associated with the inhalation of airborne contaminants is primarily driven by benzene detected in the air at the existing landfill. Airborne contamination at the Fultz Landfill Site will also be addressed in the FS.

TABLE 1-2

SUMMARY OF POTENTIAL HUMAN HEALTH RISKS
 UPPER-BOUND CANCER RISKS $\geq 10^{-6}$, HAZARD INDEX ≥ 1.0
 CURRENT LAND USE
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT

Exposure Pathway	Upper-Bound Excess Lifetime Cancer Risk	Hazard Index	Major Chemicals Contributing to:	
			Maximum Cancer Risks $\geq 10^{-6}$	Hazard Indexes ≥ 1.0
Byesville Water Supply				
Untreated	3E-05	<1	Carbon tetrachloride (1E-05)	--
Offsite Residential Wells				
RW001 (Davis)	1E-04	<1	Arsenic (1E-04)	--
RW002 (Hanes)	2E-03	<1	Bromodichloromethane (2E-06)	--
RW003 (Minarchek)	3E-06	1	Arsenic (6E-04)	Arsenic Barium Manganese Zinc
Inhalation of Airborne Contaminants by Nearby Residents				
	1E-04	<1	Benzene (1E-04)	--

1-30

1.6.2 SUMMATION OF ESTIMATED RISKS UNDER FUTURE LAND-USE SCENARIOS

Table 1-3 summarizes the potential human health risk exposure under future land-use scenarios that have an upper-bound excess lifetime cancer risk $\geq 10^{-6}$ or a hazard index ≥ 1.0 for a given exposure pathway and also identifies the chemicals of concern contributing to the overall risks associated with each exposure scenario. The carcinogenic risks associated with the potential future ingestion of groundwater from the shallow aquifer are primarily driven by the presence of 1,1-dichloroethene, carcinogenic PAHs, vinyl chloride, arsenic, beryllium, and bis(2-ethylhexyl)phthalate (BEHP). The hazard index is driven primarily by the presence of antimony and thallium. The carcinogenic risks associated with the potential future ingestion of groundwater from the coal mine aquifer are primarily driven by the presence of vinyl chloride, beryllium, and BEHP. The hazard index is driven primarily by the presence of antimony, barium, beryllium, and zinc. Risk to human health from future ingestion of water from the shallow aquifer will be considered in the FS. Because of the migration path between the shallow aquifer and the deep mine aquifer, the possibility that the Byesville well may present a risk to human health at some time in the future is discussed in Section 1.8.3.

1.6.3 ENVIRONMENTAL CONCERNS

In addition to the human health assessment, the baseline risk assessment also qualitatively addressed potential environmental concerns. The concentration of manganese detected in Ponds 1, 1A, 2, 3, 4, and 5, and downstream of Pond 5, potential water sources for the local deer and wildlife population, exceeded the recommended dietary level for livestock. In addition, the concentrations of aluminum detected in Ponds 1 and 1A exceeded federal chronic AWQC for aluminum. The highest concentration of manganese in surface water exceeded the recommended dietary level for livestock by a factor of 30.

TABLE 1-3

SUMMARY OF POTENTIAL HUMAN HEALTH RISKS
 UPPER-BOUND CANCER RISKS $\geq 10^{-6}$, HAZARD INDEX ≥ 1.0
 FUTURE LAND USE
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT

Exposure Pathway	Upper-Bound Excess Lifetime Cancer Risk	Hazard Index	Major Chemicals Contributing to:	
			Maximum Cancer Risk ($\geq 10^{-6}$)	Hazard Index (≥ 1.0)
Ingestion of Groundwater and Inhalation of Vapor While Showering:				
Shallow Aquifer	1E-03	7	1,1-Dichloroethene (2E-05) BEHP Carcinogenic PAHs (5E-04) Vinyl chloride (1E-04) Arsenic (5E-04) Beryllium (3E-04)	Noncarcinogenic PAHs Arsenic Antimony Barium Cadmium Chromium Manganese Mercury Nickel Thallium Vandaium
Deep Mine Aquifer	1E-03	11	BEHP Vinyl chloride (2E-04) Beryllium (9E-04)	BEHP Antimony Barium Beryllium Cadmium Chromium Copper Manganese Nickel Vandaium Zinc

Notes:

BEHP = Bis(2-ethylhexyl)phthalate

1.7 CONTAMINATION TO BE ADDRESSED IN THE FEASIBILITY STUDY

The analytical data collected during the RI and the baseline risk assessment indicate the presence of contaminants in various media at levels that may present a risk to human health and the environment. Additionally, promulgated groundwater protection standards also appear to be exceeded at some sampling locations. Section 2.3 presents the remedial response objectives that were developed in the RI to address the risks identified in the baseline risk assessment. In summary, the primary concerns will be the groundwater in the shallow and deep mine aquifers, the airborne contaminants near the existing landfill, and the on-site surface waters. In addition to these objectives, the FS will take into consideration the historical data that identified the existing landfill as having received hazardous wastes in the past, and as a result, is likely to be a source of contamination.

1.8 SITE-SPECIFIC CONDITIONS AFFECTING POTENTIAL REMEDIAL ACTIONS

Unique conditions at the Fultz Landfill Site preclude the formulation of some of the remedial action alternatives requested by the published guidance. The implementation of other remedial actions, such as those that would leave the existing landfill in place is complicated by the possibility of subsidence in former underground mine under much of the site, the unique groundwater migration pathways, and the presence of wetlands.

1.8.1 WETLANDS

Section 1.4.1 described areas of the Fultz Landfill Site that have been classified as wetlands by the U.S. Army Corps of Engineers. Remedial actions proposed in this feasibility study must consider their potential impact on wetlands. Remedial actions that would be prudent from an engineering standpoint must be eliminated or modified because of potential harmful impact on the wetlands at the Fultz Landfill Site. Sections 2.5 and 2.6 describe the identification and screening of remedial technologies, and Section 3.0 describes the development of remedial alternatives. Remedial actions such as

deep subsurface drains, or elimination of surface water, that control contaminant migration by making major modifications in the surface and groundwater hydrology of the site could not be used at the Fultz Landfill Site without eliminating a substantial portion of the wetland habitat. Where it is impossible to avoid some impact on wetlands, additional technologies must be added to the alternatives to mitigate the impact on the wetlands.

1.8.2 THE POTENTIAL FOR MINE SUBSIDENCE

About 40% of the existing landfill on the Fultz Landfill Site is underlain by former room-and-pillar coal mines. Phase I of the RI indicated that the mine roof was deteriorated and had collapsed in places. Borings into the mine during Phase II of the RI showed fairly clean voids, indicating that significant parts of the mine, especially in the vicinity of the existing landfill, have not collapsed. The likelihood and potential effects of future subsidence has a significant bearing on the identification of remedial technologies and the development of remedial alternatives. Appendix B presents a discussion on the likelihood of subsidence at the Fultz Landfill Site, the consequences of mine subsidence on remedial actions that would involve leaving the existing landfill in-place, and the measures that can be taken to prevent subsidence at the Fultz Landfill Site.

1.8.3 EFFECT OF CONTAMINANT MIGRATION ON THE BYESVILLE WATER SUPPLY

The RI established that there is a likely migration path from the Fultz Landfill Site to the deep mine aquifer from which the City of Byesville draws its water supply. Thirteen inorganic chemicals were found in samples of untreated water from the Byesville Plant No.2 well; however all but sodium and chloride were below background levels. Two organic compounds (acetone, and carbon tetrachloride) were also found in samples from the Byesville well, but their relation to the landfill was considered doubtful. The RI did not quantitatively investigate the potential for contaminant transport between the Fultz Landfill and the Byesville well. Because contamination appears to enter the deep mine aquifer at points beneath the existing landfill, it would be

reasonable to suppose that this contamination would find its way over time to the Byesville water supply. The gradient in the deep mine aquifer is predominantly north to south, but water velocity and flow path are difficult to determine because the flow is through mine workings whose configuration is uncertain. In addition, contamination entering the deep mine aquifer from the existing landfill will be diluted by groundwater entering the mine from the north, resulting in concentrations at the Byesville well, potentially below detection limits. Diffusion of contaminants throughout the mine and into the bedrock above it would also tend to reduce their concentration at the Byesville well.

A solute transport model for the deep mine aquifer was developed in order to evaluate the potential effects of contaminant migration of the Byesville Plant No.2 well using the U. S. Geological Survey two-dimensional solute transport and dispersion model by Konikow and Bredehoeft (1978). Details of the model are presented in Appendix C. The model attempted to determine the time it would take for contaminants migrating from the Fultz Landfill Site to the Byesville Well to reach steady-state concentrations at the well, and about what percent of the source concentration would appear at the well under steady state conditions. The effect of dispersivity on the model results was also tested.

The results of the model showed that following a release from the landfill maximum concentrations at the Byesville well were reached within 13 years of the release. The steady-state concentrations at the Byesville well (about 6% of the concentration in the aquifer at the source) should be below detection limits based on current concentrations in the shallow aquifer. It was also determined that the dispersivity of the contaminants within the mine did not have a major effect on the model results. Should additional uncontrolled releases occur, the potential exists for the contamination of the Byesville water supply.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 INTRODUCTION

The identification and screening of potentially applicable technologies is the first step toward assembling site-specific remedial alternatives. Remedial action objectives developed from the RI serve to focus the identification of technologies and the development of alternatives on site-specific priorities. Remedial action objectives consist of media-specific or site specific goals for protecting human health and the environment. They are based upon chemical and site-specific ARARs, the baseline risk assessment, and site-specific characteristics. Once the remedial action objectives have been developed for the site, the areas and volumes of material requiring evaluation in the FS can be estimated. Technologies are identified that are potentially applicable to the type and quantity of contaminated material, and that promote the goals of the remedial action objectives. These potentially applicable technologies and their process options are screened for effectiveness, implementability, and relative cost. Those technologies and process options best suited for the site are assembled into remedial alternatives for site remediation.

The results of the baseline risk assessment were presented in Section 1.0. The first part of Section 2.0 is devoted to the identification of ARARs and the development of the remedial action objectives. The remainder of the Section 2.0 presents the identification and screening of technologies. Alternative development is presented in Section 3.0.

2.2 SITE-SPECIFIC APPLICABLE OR RELEVANT AND APPROPRIATE REGULATIONS (ARARS)

Section 121(d) of SARA and the NCP (40 CFR Part 300; March 8, 1990) require that CERCLA, (as amended) remedial actions comply with all federal and state ARARs. ARARs are used to determine the appropriate extent of site cleanup, to scope and formulate remedial action alternatives, and to govern the implementation and operation of the selected action. According to SARA, requirements may be waived by EPA under six specific conditions, provided that protection of human health and the environment is still assured:

- The selected remedial action is an interim remedy or portion of a total remedy which will attain the standard when complete.
- Compliance with such requirements will result in greater risk to human health and the environment than alternative options.
- Compliance with such requirements is technically impracticable from an engineering perspective.
- The selected remedial action will provide an equivalent standard of performance using another approach.
- The requirement is a state requirement that has not been consistently applied.
- The alternative will not provide a balance between the public health and environmental welfare and the availability of funds to respond to existing or potential threats at other sites, taking into account the relative immediacy of the threats.

In this section, the approach to identifying ARARs for the Fultz Landfill Site is discussed and ARARs for potential site-specific conditions are tentatively identified.

2.2.1 DEFINITION OF ARARS

A requirement under CERCLA, as amended may be either "applicable" or "relevant and appropriate" to a site-specific remedial action.

Applicable Requirements: "Applicable requirements" refer to those federal and state requirements that would be legally applicable, whether directly or incorporated by a federally-authorized state program, if the response actions were not undertaken pursuant to CERCLA 104 or 106, as amended. An example of an applicable requirement would be maximum contaminant levels (MCLs) for a site that causes contamination of a public water supply system which provides water service to 15 or more service entrances or to 25 or more people.

Relevant and Appropriate Requirements: "Relevant and appropriate requirements" are federal and state standards, criteria, or limitations that are not legally applicable to the site, yet they address problems sufficiently similar to those found on site that their use is well suited to the particular site. For example, while Resource Conservation and Recovery Act (RCRA) regulations are not applicable to closing undisturbed hazardous waste in place, the RCRA regulation for closure by capping may be deemed relevant and appropriate. During the FS evaluation process, relevant and appropriate requirements are intended to have the same weight and consideration as applicable requirements.

Other Requirements to be Considered: Federal and state guidance documents or criteria that are not generally enforceable, but are advisory, do not have the requirement evaluation status of potential ARARs. Where no specific ARARs exist for a chemical or situation, or where such ARARs are not sufficient to be protective, guidance documents or advisories may be considered in determining the necessary level of cleanup for protection of human health or the environment.

2.2.2 TYPES OF ARARS

The ARAR requirements that Superfund actions may have to comply with are generally classified into three functional groups:

- Location-specific (i.e., requirements that restrict remedial actions based on the location or characteristics of the site or its immediate environs).
- Action-specific (i.e., requirements that set controls or restrictions on the design, implementation, and performance levels of activities related to the management of hazardous substance, pollutants, or contaminants).

- Chemical-specific (i.e., requirements that set protective cleanup levels for the chemicals of concern, or indicate an acceptable limit of discharge associated with a remedial action).

Location-specific requirements set restrictions on the types of remedial activities that can be performed based on site-specific characteristics or site location. Remedial action alternatives may be restricted or precluded based on federal or state siting laws for hazardous waste facilities, proximity of the site to wetlands or floodplains, or to manmade features such as existing landfills, disposal areas, or local historic buildings. These ARARs provide a basis for assessing restrictions during the formulation and evaluation of potential site-specific remedies. Table 2-1 lists and evaluates potential location-specific ARARs for the site.

Action-specific requirements are triggered by the particular remedial activities that are selected to accomplish the cleanup. After remedial alternatives are developed, action-specific ARARS that specify performance levels, actions, or technologies, as well as specific levels for discharge of residual chemicals provide a basis for assessing the feasibility and effectiveness of the remedies. These action-specific ARARs may include, for example, hazardous waste transportation and handling requirements, air emission and water discharge standards, and the RCRA and TSCA landfilling and treatment requirements. Table 2-2 presents an evaluation of potential action-specific ARARs for the site.

Chemical-specific requirements set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances. These requirements provide protective site cleanup levels or a basis for calculating cleanup levels for the chemicals of concern in the designated media. Chemical-specific ARARs are also used to indicate acceptable discharge concentrations to determine treatment and disposal requirements, and to assess the effectiveness of the remedial alternative. If a chemical has more than

TABLE 2-1
 LOCATION-SPECIFIC ARARs AND CRITERIA, ADVISORIES, AND GUIDANCE
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT

Potential ARAR	Issues & Requirements	ARAR STATUS		Consideration in the RI/FS
		Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS				
FLOODPLAINS/SURFACE WATER BODIES				
Fish and Wildlife Coordination Act (16 USC 661); CWA (Section 404) 40 CFR 6.302(b)	Any activity that proposes to modify a body of water or potentially affect fish and wildlife services is addressed under CWA Section 404 requirements.	Potentially	Potentially	If a remedial alternative modifies a body of water or potentially affects fish or wildlife then the US Fish and Wildlife Services must be consulted.
RCRA Location Standards 40 CFR 264.18(b)	Construction, operation and maintenance regulations for a RCRA facility on a 100-yr floodplain so as to avoid washout.	No		May be necessary to comply with unless waste may be removed safely before floodwater can reach the facility or no adverse effects on human health and the environment would result.
Executive Order 11988 Protection of Floodplains 40 CFR 6, Appendix A	Actions to avoid adverse effects, minimize potential harm, restore and preserve the natural and beneficial values of floodplains.	No		Floodplains protection consideration may be incorporated into the planning and decision-making of remedial alternatives.
HISTORY				
National Historic Preservation Act (16 USC Section 469); 36 CFR 65 40 CFR 6.301(b)	Action to recover and preserve artifacts if in an area where action may cause irreparable harm, loss or destruction of significant artifacts.	Potentially	Potentially	May be necessary to consult with the National Register of the Department of Interior since indians once freely roamed these lands.
HABITAT/WILDLIFE				
Endangered Species Act of 1973 (16 USC 1531) 50 CFR 200, 402 Fish and Wildlife Coordination Act (16 USC 661) 33 CFR 320-330	Action to conserve endangered species or threatened species if action may be critical or threatens the habitat upon which species depend.	Potentially	Potentially	May be necessary to consult the Department of Interior since it is apparent that the area supports plants and wildlife.

2-5

Table 2-1 (Continued)

Potential ARAR	Issues & Requirements	ARAR STATUS		Consideration in the RI/FS
		Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS				
CWA (Section 404) 40 CFR 230.30-230.32	Consideration of impacts on biological characteristics of the Aquatic Ecosystem when complying with guidelines of disposal sites for dredged or fill material.	Potentially	Potentially	May need to consider when planning and deciding remedial alternative for ponds on site.
UNDERGROUND MINE				
RCRA Location Standards 40 CFR 264.16 (c)	Prohibits the placement of non-containerized or bulk liquid hazardous wastes, in certain locations.	Yes	Yes	Since the site is located on and near a deep mine, may need to be considered when planning and deciding the remedial alternatives.
WETLANDS				
CWA (Section 404) 40 CFR 230.41	Consideration of impacts on wetlands when complying with guidelines of disposal sites for dredged or fill material.	Potentially	Potentially	May need to be considered when planning and deciding remedial alternatives for ponds on site.
Executive Order 1990 40 CFR 6, Appendix A	Avoid whenever possible adversely affecting wetlands and evaluate potential effects of actions in these designated areas.	Potentially	Potentially	May be considered when planning and deciding the remedial alternatives.
CWA (section 404) 40 CFR 6.302 (a)	No activity that adversely affects a wetlands shall be permitted if a practicable alternative with lesser effects is available.	Potentially	--	May be considered when planning and deciding the remedial alternative

TABLE 2-2
 REVIEW OF POTENTIAL ACTION-SPECIFIC ARARS
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT

Potential ARAR	Issues	Requirements	ARAR STATUS		Consideration in the RI/FS
			Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS					
Resource Conservation and Recovery Act (RCRA)					
40 CFR 261; Definition and identification of hazardous waste	RCRA (part 261) establishes basic definitions of solid and hazardous wastes. Waste material and contaminated media are present at the site. Remedial actions may produce potentially hazardous residuals. Need to identify whether these materials are potentially subject to requirements under RCRA.	Waste is subject to regulations under RCRA if: 1. Waste exhibits one of four characteristics (ignitability, corrosivity, reactivity, or EP toxicity); 2. Wastes are listed as hazardous; 3. Wastes are mixtures of wastes listed as hazardous by RCRA regulations.	Potentially	Potentially	Offsite Actions - Treatment of residuals will have to be analyzed for the appropriateness of a hazardous designation. Onsite Actions - As any action is part of a CERCLA activity, hazardous designation is not appropriate.
40 CFR 262; Standards for generators of hazardous waste	RCRA (part 262) establishes regulations covering activities of generators of hazardous waste. Need to identify whether generator requirements extend to CERCLA actions hazardous waste.	Generator requirements include identification of waste generation activity, obtaining EPA ICF number, record keeping, and use of uniform national manifest.	Potentially	Potentially	Offsite Action - As remedial actions could result in treatment residue deemed hazardous, these requirements would be applicable. Onsite Actions - If wastes are managed onsite as part of a CERCLA action, these requirements would not be appropriate.
40 CFR 263; Standards for transport of hazardous waste	RCRA (part 263) establishes regulations covering the transport of hazardous waste. Need to identify whether these apply to offsite actions.	The transport of hazardous waste is subject to requirements including DOT regulations, manifesting, record keeping, and discharge cleanup.	Yes	--	If materials categorized hazardous under RCRA are taken offsite their transport will be subject to requirements.
40 CFR 264; Standards for treatment of hazardous waste	RCRA (part 264) establishes regulations covering the treatment, storage, and disposal of hazardous waste. Need to identify how these apply to remedial actions at this site.	RCRA requirements for treatment apply if the waste is a RCRA waste and the activity constitutes treatment as defined by RCRA.	Potentially	Potentially	The groundwater contamination at the site may have resulted from the improper handling of materials that could have been RCRA hazardous wastes. If it is determined that these wastes were in fact RCRA wastes, these requirements might be applicable. Otherwise, they would be relevant and appropriate.

Table 2-2 (Continued)

Potential ARAR	Issues	Requirements	ARAR STATUS		Consideration in the RI/FS
			Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS					
40 CFR 264 Standards for treatment of hazardous waste (Continued)	Contaminated groundwater would be collected and treated prior to discharge. Need to determine if constitutes RCRA treatment.	See previous page.	Potentially	Potentially	See previous page.
	Groundwater monitoring would be performed. Need to determine if plan should be for compliance monitoring.	Provides specific requirements for a groundwater monitoring and protection program.	Potentially	Potentially	Groundwater monitoring must conform to the requirements of this section.
40 CFR 268; Land Disposal Restrictions ("Land Ban")	Treatment residuals resulting from onsite water treatment would be considered to be a RCRA-listed waste and would be subject to the requirements of this section.	After 11/90, placement of CERCLA wastes, which are also RCRA hazardous waste, on or in land outside unit boundary or area of contamination will trigger land disposal requirements and restrictions. Requires treatment by Best Demonstrated Available Technology (BDAT) before placement.	Yes	--	Land disposal of treated residuals must meet treatment standards set forth in this section.
40 CFR 122, 125 National Pollutant Discharge Elimination Systems (NPDES)	This section of the CWA regulates the discharge of water into surface water bodies. The remedial alternatives may include the discharge of treated or untreated groundwater to Wills Creek.	The State of Ohio has authorization to administer NPDES in Ohio. Refer to the state ARAR section for specific requirements.	Yes	--	NPDES discharge requirements are applicable and substantive discharge requirements will have to be met.
40 CFR 403 Effluent Guidelines and Standards; Pretreatment Standards	This section establishes pretreatment standards (both general and categorical) for the control of pollutants discharges into POTWs. The remedial alternatives may include the discharge of treated or untreated groundwater to the local POTW.	Discharge to POTW must not cause pass-through interference, violation of specific prohibitions, or violations of local limitations or ordinances. POTW should either have an EPA-approved pretreatment program or have sufficient mechanisms to meet the requirements of the national pretreatment program in accepting CERCLA waste.	Yes	--	Pretreatment requirements will have to be met for discharge to POTW.

Table 2-2 (Continued)

Potential ARAR	Issues	Requirements	ARAR STATUS		Consideration in the RI/FS
			Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS					
40 CFR 230 Dredge and Fill Requirements	Regulates the discharge of dredged or fill material into the waters of the U. S. Authority under Section 404 of the CWA extends authority to include activities affecting wetlands/flood plains.	Dredged or fill material should not be discharged into the aquatic ecosystem unless it can be demonstrated that it will not have an unacceptable adverse impact.	Potentially	--	These requirements may need to be considered if the remedial actions for the contaminated sediments and water in the ponds require that they be dredged and filled.
Safe Drinking Water Act (SDWA)					
40 CFR 144 Underground Injection Control Program	Controls the underground injection of wastes and treated waste water.	Defines standards and procedures for the underground injection of fluids.	Yes	Yes	Since aquifer is not currently used as a drinking water source, this requirement is not applicable. It is, however, relevant and appropriate.
U. S. EPA Ground Water Protection Strategy					
	The protection strategy does not involve potential ARARs but does contain policy statements to be considered. The strategy includes classification of aquifers. Need to determine if the groundwater protection strategy will cause groundwater restoration to be considered.	The strategy includes guidelines on classifying groundwater for EPA decisions affecting groundwater protection and corrective actions. Criteria includes ecological importance, replaceability, and vulnerability considerations.	No	To be considered	Groundwater in Ohio is not classified but is generally considered a potential source of drinking water unless some site specific problem makes it unusable.
Clean Air Act (CAA)					
CAA Section 109 and 40 CFR 50 National Ambient Air Quality Standards	Sets national ambient air quality standards to attain and maintain primary and secondary standards to protect public health and the environment. Need to determine how aspects apply to remedial actions. Remedial actions which may result in new sources of air emissions including drilling activities.	Pre-Construction Review	No	Potentially	Purpose of this review is to obtain construction permit. CERCLA 121(e) exempts onsite activities from obtaining permits. However, this review would meet requirements to fulfill substantive requirements and conditions of the permitting process.

Table 2-2 (Continued)

Potential ARAR	Issues	Requirements	ARAR STATUS		Consideration in the RI/FS
			Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS					
CAA Section 109 and 40 CFR 50 National Ambient Air Quality Standards (continued)		Major source permit PSD permit. Non-attainment area permit. Visibility permit.	No	Potentially	Not anticipated that emissions for the CERCLA activities would qualify as major sources. If not, a major source would be exempt from substantive requirements of major source permits, PSD review, non-attainment review, or visibility permit. Therefore, these requirements are relevant but not appropriate.
CAA Section III New Source Performance Standards	Promulgates standards for new sources of air emissions. Need to determine if apply to potential	Requirements are source-specific.	No	No	Not applicable because NSPS are for specific source types, however, may be relevant and appropriate if the emission and the technology employed during cleanup are sufficiently similar to the pollutant and the source. Would not be relevant and appropriate for drilling activities, because source is not similar.
Occupational Safety and Health Act					
29 CFR 1900 ET SEQ Standards for worker protection.	Provide a safe workplace.	General requirements in OSHA to provide a workplace free of harm.	Yes		Applies to all workplaces.
29 CFR 1910. 120 Regulations for workers involved in hazardous waste operations.	Hazardous waste operation:	Regulate training, protective equipment, proper handling of wastes, monitoring of employee health, site information, and emergency procedures for workers at hazardous waste operations.	Yes		Applies to all workers involved in construction and operation of remedial actions.
Hazardous Materials Transportation Act					
49 CFR Parts 100 through 199 Transportation of hazardous materials.	Regulates the transport of hazardous materials. Need to determine how this applies to remedial actions.	Specific DOT requirements for labelling, packaging, shipping papers/manifesting, and transport by rail, aircraft, vessel, and highway.	Potentially		If the remedial action involves the offsite transport of waste, RCRA requires that the transportation of wastes be consistent with DOT regulations and therefore would be applicable.

2-10

Table 2-2 (Continued)

Potential ARAR	Issues	Requirements	ARAR STATUS		Consideration in the RI/FS
			Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS					
National Environmental Policy Act					
Section 102(2)(c)	The evaluation of the environmental impact of federal actions. Need to determine the applicability of NEPA to the site remedial actions.	A statement of environmental impact.	No	No	CERCLA actions are exempted from the NEPA requirement because EPA's decision-making process in selecting a remedial action alternative is the functional equivalent of the NEPA analysis.
Intergovernmental Review of Federal Programs Executive Order 12372					
40 CFR 29	State and local coordination and review of proposed EPA assisted projects.	EPA administrator is required to communicate with state and local officials to explain the project, consult with other involved federal agencies, and provide a comment period for state review.	Yes	--	Project requires intergovernmental review since project will use federal funds.

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Table 2-2 (Continued)

Potential ARAR	Issues & Requirements	ARAR STATUS		Consideration in the RI/FS
		Applicable	Relevant & Appropriate	
STATE REQUIREMENTS				
Ohio Revised Code (ORC) 3734.02 (B)	This regulation prohibits excavation and construction activities without authorization from the Ohio Director of Environmental Protection.	Potentially	Potentially	Remediation may include relocation of some or all of the existing landfill.
Ohio Revised Code 3734.05 (C)	This regulation defines criteria and requirements that need to be included in a hazardous waste facility operating permit.	Yes	--	Regulation applies to residuals generated by treatment processes.
OHIO SOLID WASTE DISPOSAL REGULATIONS				
Ohio Administrative Code (OAC) 3745-27-02	This regulations states that no provision of 3745-27 or 3745-37 shall exempt parties from compliance with any federal regulation or any section of the Ohio Revised Code.	Yes	--	Regulation applies to residuals generated by treatment processes, and/or to possible relocation of wastes on-site.
Ohio Administrative Code 3745-27-05	This regulation specifies that solid waste in Ohio must be managed by landfilling, incineration, compositing, or approved methods not prohibited by OAC 3745-27.	Yes	--	Regulation applies to residuals generated by treatment processes and/or to alternatives which involve relocation of wastes on-site.
Ohio Administrative Code 3745-27-06	This regulation requires that the plans for new solid waste disposal facilities specify the design features for on-site solid waste disposal activities.	Potentially	Potentially	May apply if on-site landfill is the chosen alternative.
Ohio Administrative Code 3745-27-07	These regulations require that the operator incinerate waste materials as soon as possible and that incinerator operations comply with chapters 3704 and 6111.	No	--	Incineration not an alternative.
Ohio Administrative Code 3745-27-08	These regulations establish the general performance requirements for the operation of solid waste disposal facilities.	Potentially	Potentially	During remediation, the operation and filling of a landfill would be governed by these regulations.
Ohio Administrative Code 3745-27-10	These regulations establish performance requirements for the closure of sanitary landfills. These requirements are relevant and appropriate to alternatives that involve disposal of nonhazardous waste on-site and subsequent closure of the on-site sanitary landfill.	Yes	--	Closure would be required for an on-site landfill. Most of the waste is non-hazardous sanitary waste.
OHIO HAZARDOUS WASTE MANAGEMENT REGULATIONS				
Ohio Administrative Code 3745-50 through 3745-69	These regulation closely parallel the federal regulation described in 40 CFR 264 and establish minimum standards for the acceptable management of hazardous wastes.	Potentially	Potentially	If waste would be handled on-site, these regulations apply.

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Table 2-2 (continued)

Potential ARAR	Issues & Requirements	ARAR STATUS		Consideration in the RI/FS
		Applicable	Relevant & Appropriate	
STATE REQUIREMENTS				
OHIO WATER QUALITY STANDARDS				
Ohio Administrative Code 3745-01 (-03, -04, -05, and -07)	These regulations establish performance standards for the collection of samples and maintenance of existing surface water. They prohibit nuisance discharges and define water use and criteria that should be maintained.	Potentially	--	If discharge of treated water to Will's Creek is chosen, these regulations would apply.
OHIO AIR POLLUTION REGULATIONS				
Ohio Administrative Code 3745-15-07	This regulation prohibits air pollution nuisance emissions not regulated under 3745-17, 3745-18, 3745-21 or 3745-31. The substantive requirements of these regulations are applicable to alternatives that would produce air emissions.	Yes	--	Air emissions have been measured at the site, and excavation of wastes may generate additional emissions.
Ohio Administrative Code 3745-15-16	This regulation establishes stack height guidelines for point sources of air emissions.	No	No	On-site incineration is not considered an option.
Ohio Administrative Code 3745-17 (-02, -05, -07, and -09)	These standards specify maximum ambient air particulate levels and establishes emission limits for opacity and capacity.	No	No	This type of an emission is not a problem at the site.
Ohio Administrative Code 3745-18 (-02, -04, and -06)	These establish standards, methods of measurement, and allowable emission rates for sulfur dioxide.	No	No	This type of an emission is not a problem at the site.
Ohio Administrative Code 3745-21 (-02, -03, and -05)	These regulations set ambient air quality standards, establish acceptable methods for the measurement of ambient air quality, and prohibit the degradation of ambient air quality set in 3745-21-02.	No	No	This type of an emission is not a problem at the site.
Ohio Administrative Code 3745-21-07	These regulation establish rules to control the emission of organic materials from new stationary sources.	Potentially	Potentially	Some water treatment materials may generate air emissions.

one such requirement, compliance with the more stringent ARAR should be performed. Table 2-3 lists potential chemical-specific ARARs tentatively identified for the Fultz Landfill Site, along with an evaluation of each potential ARAR. Table 2-4 presents a summary of numerical values for the chemical-specific ARARs identified for the site.

2.2.3 SUMMARY OF ARARs

ARARs apply to on-site and off-site actions or conditions. On-site actions implemented by the EPA under CERCLA, as amended, however, are exempt from having to obtain federal, state, or local permits as long as the substantive requirements of the permits are met. Off-site actions are subject to the full requirements of the applicable standards or regulations, including obtaining the necessary permits.

Based on the statutory requirements outlined above, the remedial actions developed in this FS will be analyzed for compliance with federal and state environmental and public health requirements. This process involves the initial identification of potential requirements, the detailed evaluation of the potential requirements for applicability or relevance and appropriateness, and finally a determination of the ability of the remedial alternatives to achieve the ARARs.

The determination of whether an ARAR will be met by a specific remedial alternative will be presented in the detailed evaluation of alternatives in Section 4.0.

2.3 REMEDIAL ACTION OBJECTIVES

As stated in the NCP: "The appropriate extent of remedy shall be determined by the lead agency's selection of a cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health and welfare and the environment." (40 CFR 300.68(i)). Additionally, SARA requires that:

TABLE 2-3
 CHEMICAL-SPECIFIC ARARs AND CRITERIA, ADVISORIES, AND GUIDANCE
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT

Potential ARAR	Issues & Requirements	ARAR STATUS		Consideration in the RI/FS
		Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS				
GROUNDWATER/SURFACE WATER				
RCRA Protection Standards 40 CFR 264.94	Cleanup to background or drinking water standards or set a level that is protective to public health or the environment.	Potentially	Yes	Since groundwater at the site is contaminated, it poses a threat to the public health and environment and therefore must be considered.
SDWA Maximum Contaminant Levels 40 CFR 141.11-141.16	Enforceable standards for public water systems. These standards could be applied as a cleanup level for the shallow aquifer.	Yes	--	Groundwater is currently a drinking water source.
SDWA Maximum Contaminant Levels Goals 40 CFR 141.50 - 141.51	Non-enforceable health goals for public water systems. Need to determine if these standards should be applied as a cleanup level for the shallow aquifer.	Yes	--	Groundwater is currently a drinking water source.
CWA, National Pollutant Discharge Elimination Systems (NPDES) 40 CFR 122, 125	Regulates the discharge of water to surface water bodies.	Yes	--	The remedial alternatives may include discharge of untreated or treated groundwater to Wills Creek, therefore, numerical discharge requirements may have to be met.
CWA, Effluent guidelines and Standards 40 CFR 403	Pretreatment Standards established for the control of pollutants discharged into POTW's.	Yes	--	Pretreatment requirements may have to be met if remedial alternatives include discharge of treated groundwater to POTW.
GROUNDWATER/SURFACE WATER				
EPA Risk Reference Doses (RfDs)	Dose levels developed and considered unlikely to cause significant adverse health effects.	To be considered	To be considered	Used to characterize risks due to noncarcinogens in groundwater.
EPA Carcinogen Assessments Group Potency Factors	Most up-to-date information on cancer risks derived from EPA's cancer assessment group (CAG)	To be considered	To be considered	Used to compute the individual incremental cancer risk resulting from exposure to certain compounds.

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Table 2-3 (Continued)

Potential ARAR	Issues & Requirements	ARAR STATUS		Consideration in the RI/FS
		Applicable	Relevant & Appropriate	
FEDERAL REQUIREMENTS				
EPA Drinking Water Health Advisories	Non-regulatory health advisories of contaminant concentrations in drinking water at which adverse health effects would not be anticipated to occur.	To be considered	To be considered	Criteria may be used as guidance in determining appropriate groundwater cleanup levels.
Ambient Water Quality Criteria	Health-based criteria developed for 95 carcinogenic and non-carcinogenic compounds and are used in conjunction with designated use for the stream to establish water quality standards.	To be considered	To be considered	Criteria may be applicable for determining compliance since the remedial alternatives may include the discharge of treated groundwater to Wills Creek.

TABLE 2-4
 CHEMICAL-SPECIFIC ARARS FOR THE FULTZ LANDFILL SITE ($\mu\text{g}/\text{l}$)
 FEASIBILITY STUDY REPORT

	Wills Creek Surface Water Criteria 30 Day Average***		Maximum Contaminant Level (MCL)		Maximum Contaminant Level Goals (MCLG's)		Drinking Water Health Advisory for Lifetime Exposure		Secondary Drinking Water Standards		Byesville Waste Water Treatment Plant Influent Levels
	Aquatic Life Habitat	Agricultural Water Supply									
VOLATILE ORGANIC COMPOUNDS											
Vinyl Chloride	5,250.0	--	2	(a)	0	(a)	--		--		--
Chloroethane	--	--	--		--	--	--		--		--
Methylene Chloride	430.0	--	5	(P,aa)	0	(P,aa)	--		--		--
Acetone	78.0	--	--		--		--		--		--
Carbon Disulfide	--	--	--		--		--		--		--
1,1-Dichloroethene	78.0	--	7	(a)	7	(a)	7	(e)	--		--
1,2-Dichloroethene (total)	--	--	--		70	(P,b)	70	(e)	--		--
2-Butanone	7.1	--	--		--		170	(e)	--		--
Benzene	560.0	--	5	(a)	0	(a)	--		--		--
4-Methyl-2-Pentanone	--	--	--		--		--		--		--
Toluene	1,700.0	--	2,000	(P,b)	2,000	(P,b)	2,420	(e)	40	(P,b)	--
Chlorobenzene	26.0	--	100	(P,b)	100	(P,b)	300	(e)	--		--
Ethylbenzene	62.0	--	700	(P,b)	700	(P,b)	680	(a)	30	(P,b)	--
Xylenes (total)	--	--	10,000	(P,b)	10,000	(P,b)	400	(e)	20	(P,b)	--
SEMI-VOLATILE ORGANIC COMPOUNDS											
2,4-Dimethylphenol	--	--	--		--		--		--		--
Benzoic Acid	--	--	--		--		--		--		--
Naphthalene	--	--	--		--		--		--		--
2-Methylnaphthalene	--	--	--		--		20	(am)	--		--
Dibenzofuran	--	--	--		--		--		--		--
Diethylphthalate	120.0	--	--		--		--		--		--
Fluorene	--	--	--		--		--		--		--
N-Nitrosodiphenylamine	--	--	--		--		--		--		--
Pentachlorophenol	8.6 **	8.6 **	200	(P,b)	200	(P,b)	220	(e)	30	(P,b)	--
Phenanthrene	--	--	--		--		--		--		--
Anthracene	--	--	--		--		--		--		--
Fluoranthene	--	--	--		--		--		--		--
Pyrene	--	--	--		--		--		--		--
Butylbenzylphthalate	49.0	--	--		--		--		--		--
Chrysene	--	--	--		--		--		--		--
Di-n-butylphthate	190.0	--	--		--		--		--		--
Bis(2-ethylhexyl)phthalate	8.4	--	--		--		--		--		--
Di-n-octylphthalate	--	--	--		--		--		--		--
Benzyl alcohol	--	--	--		--		--		--		--
2-Methylphenol	22.0	--	--		--		--		--		--
4-Methylphenol	6.2	--	--		--		--		--		--
N nitrosodiphenylamine	--	--	--		--		--		--		--
Phenol	370.0	--	--		--		--		--		1000

TABLE 2-4 (Continued)

INORGANICS												
Aluminum	--	--	--	10:5	(P, aa, ab)	3	(P, aa)	--	--	50	(P, b)	--
Antimony	--	--	100.0	50	(a)	50	(P, c)	--	--	--	--	--
Arsenic	190.0	--	1,000	1,000	(a)	5,000	(P, b)	1,500	(e)	--	--	--
Barium	--	--	6,100.0 *	1	(P, aa)	0	(P, a)	--	--	--	--	--
Beryllium	6,100.0 *	--	37.0 *	10	(a)	5	(P, b)	5	(e)	--	--	3000
Cadmium	37.0 *	--	--	--	--	--	--	--	--	--	--	--
Calcium	--	--	11.0	50	(a)	100	(P, b)	120	(e)	--	--	3000
Chromium	--	--	--	--	--	--	--	--	--	--	--	--
Cobalt	--	--	110.0 *	1,300	(P, k)	1,300	(P, k)	--	--	1,000	(1)	1000
Copper	1.0	--	5.0	50	(a)	0	(P, k)	--	--	300	(b)	15000
Iron	1,100.0 *	--	--	--	--	--	--	--	--	--	--	500
Lead	--	--	10.0	2	(a)	2	(P, b)	1.1	(e)	--	--	--
Magnesium	0.2	--	450.0 *	100	(P, aa)	100	(P, aa)	150	(e)	--	--	2000
Mercury	450.0 *	--	50.0	10	(a)	50	(P, b)	--	--	--	--	--
Nickel	5.0	--	--	50	(a)	--	--	--	--	90	(P, b)	--
Potassium	--	--	--	--	--	--	--	--	--	--	--	--
Selenium	--	--	2:1	0.5	(P, aa, ad)	--	--	--	--	--	--	--
Silver	16.0	--	--	--	--	--	--	--	--	--	--	--
Sodium	--	--	--	--	--	--	--	--	--	--	--	--
Thallium	--	--	270.0 *	270.0 *	--	--	--	--	--	5,000	(1)	3000
Vanadium	270.0 *	--	--	--	--	--	--	--	--	--	--	--
Zinc	--	--	--	--	--	--	--	--	--	--	--	--

SAS ANALYSIS Chloride (mg/l) Sulfate (mg/l)

NOTES: * Concentration dependent upon the groundwater water hardness

** Concentration dependent upon the pH of the groundwater

*** Ohio Administrative Code 3745-1 Ohio Water Quality Standards. Effective May, 1990.

-- Standard not developed for this chemical

- (P) Proposed
- (a) 40 CFR, Part 141 - National Primary Drinking Water Regulations. 526-533, 585-587
- (b) Environmental Protection Agency (EPA). National Primary and Secondary Drinking Water Regulations; Proposed Rule. Federal Register. Vol. 54, No. 97, Monday, May 22, 1989 22062-22160
- (c) Environmental Protection Agency (EPA). National Primary Drinking Water Regulations. Synthetic Organic Chemicals, Inorganic Chemicals and Microorganisms. Proposed Rule. Federal Register, vol. 50, No. 219, Wednesday, November 13, 1985. 46935-47025
- (e) Environmental Protection Agency (EPA). Health Advisories. Office of Drinking Water. Washington, D.C., March 31, 1987.
- (k) Environmental Protection Agency (EPA). Drinking Water regulations; Maximum Contaminant Level Goal and National Primary Drinking Water Regulations for Lead and copper; Proposed. Federal Register, vol. 53, No. 160, 31513-31578, Thursday, August 19, 1988.
- (aa) Environmental Protection Agency (EPA). National Primary and Secondary Drinking Water Regulations; Synthetic Organic Chemicals and Inorganic Chemicals. Proposed Rule. Federal Register, vol. 53 No. 143, Wednesday, July 25, 1990
- (ad) EPA proposes MCLs of 2ug/l and 1 ug/l for thallium based on proposed practical quantitation levels (PQLs).
- (am) Environmental Protection Agency (EPA) 1990. Health Advisory for Naphthalene. Office of Drinking Water. Washington D.C. March, 1990.

- Preferred remedial actions are those "...in which treatment that permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants is a principal element..." (Section 121(b)). SARA also requires that if a permanent solution using treatment or recovery technologies is not selected, an explanation must be provided.

- General objectives for the level of remedial action cleanup be developed such that remedial actions "...shall attain a degree of cleanup of hazardous substances, pollutants, and contaminants released into the environment and of control of further releases at a minimum which assures protection of human health and the environment" (Section 121 (d)).

- The selected remedy must comply with or attain the level of any promulgated "standard, requirement, criteria, or limitation under a state environmental or facility siting law that is more stringent than any federal standard, requirement, criteria, or limitation" (Section 121(d)(2)(A))

In general, these are the statutory requirements of all CERCLA, as amended, remedial actions. Considering the human health and environmental risks presented for the Fultz Landfill Site, the following remedial action objectives are considered appropriate:

1. Reduce risks to human health associated with ingestion of contaminated groundwater or inhalation of volatilized chemicals from contaminated groundwater by local residents using residential wells screened in either the shallow or coal mine aquifers.

2. Reduce risks to human health associated with the inhalation of airborne contaminants from the landfill area.

3. Reduce risks to human health associated with the future use of groundwater from either the shallow or the coal mine aquifer.

4. Reduce risks to the environment associated with excessive manganese and aluminum concentrations in the on-site surface waters.

Based on the results of the risk assessment, and consistent with the remedial action objectives, the contaminated media at the site will be grouped into two broad categories: solids and waters. Contaminated solids will include site surface soils, pond, stream and leachate seep sediments, and waste (landfill contents). Contaminated waters will include both shallow and coal mine aquifer groundwater, surface water, and leachate.

Addressing risks associated with site surface soils over the 30 acre landfill, and the waste landfill solids (730,000 cubic yards) would directly contribute to the satisfaction of remedial action objective 2, and would indirectly contribute to the satisfaction of remedial action objectives 3 and 4 by a reduction of chemical migration from the source. Addressing sediments would indirectly contribute to the satisfaction of remedial action objectives 3 and 4, since the contaminated sediments, while not posing an excessive risk, may be acting as a source of contamination to either the groundwater or the surface water.

Addressing risks associated with the groundwater would directly contribute to the satisfaction of remedial action objectives 1 and 3. The volume of contaminated groundwater in the shallow aquifer is estimated to be 2.9 million cubic feet. Addressing the risks associated with surface waters would directly contribute to the satisfaction of remedial action objective 4. Addressing the leachate risks would indirectly contribute to the satisfaction of remedial action objectives 3 and 4, as continued migration of leachate at an estimated rate of 2 to 4 gallons per minute may adversely affect both the site surface waters and groundwater underlying the site.

2.4 GENERAL RESPONSE ACTIONS

General response actions are broad categories of remedial actions capable of addressing contamination problems at the site and which contribute to the satisfaction of the goals of the remedial action objectives. Some response

actions are sufficiently broad in effect that they are capable of meeting the remedial response objectives alone. However, in most cases, combinations of response actions are required to be effective in meeting all of the remedial goals and objectives. Response actions for the Fultz Landfill Site were based on information presented in the RI Report, including the baseline risk assessment. The general response actions to be considered for the site are as follows:

- No Action
- Institutional Actions and Monitoring
- Containment
- Removal
- Collection/Extraction
- Treatment
- Discharge
- Disposal

A general discussion of the types of technologies that are associated with each response action follows.

No Action: NCP regulations and CERCLA, as amended, require the evaluation of a no-action alternative as the basis for comparison with other proposed remedial alternatives. The baseline risk assessment evaluates the risks associated with the no-action alternative because it assumes that no remedial activities have taken place at the site when the future risks associated with the site are calculated.

Institutional Actions: Institutional actions seek to reduce risks associated with the site and meet the remedial action objectives by reducing the potential frequency of receptor exposure. They are comprised of institutional controls, access restrictions, and environmental monitoring. Institutional controls include the passage of governmental regulations or deed amendments restricting future uses of the site property or the local groundwater. Control of site access may include site fencing and public education programs. Environmental monitoring technologies are implemented to provide a data base and evaluate changes in site conditions over time. Because these technologies

do not treat contaminated materials to reduce contaminant toxicity, mobility, or volume, they result in waste remaining untreated on-site. CERCLA, as amended, requires a review of the site conditions every five years whenever untreated materials are left on-site. Monitoring of the site would provide a substantial amount of information that will be required to adequately perform the five-year site review.

Containment: Containment technologies control potential hazards by eliminating routes of exposure or reducing the rate of exposure through isolation of the contaminated material (source). Containment technologies do not treat contaminated materials, however, they do reduce the mobility of the chemicals associated with the contaminated media. These technologies require continual monitoring to determine whether the remedial measures are performing successfully. As with the institutional actions, because untreated waste remains on-site, a five-year interval review of the site conditions is required.

Removal: Removal technologies are physical processes used to separate contaminated areas from those that are relatively uncontaminated. Removal basically refers to methods used to excavate and handle soils, wastes, and other solid materials. Technologies in this group provide no treatment, but must be used prior to the implementation of treatment or disposal technologies (with the exception of in-situ treatments) to remove the targeted materials from the designated areas.

Collection/Extraction: Collection technologies generally refer to the collection/extraction of groundwater, surface water, and leachate so that they may be treated or disposed in some manner. Collection technologies generally do not decrease the toxicity of the chemicals present; however, they do typically reduce the chemical volume and mobility.

Treatment: Treatment technologies reduce the toxicity, mobility, or volume of contaminants by physical, chemical, biological, or thermal processes. Treatment to reduce toxicity includes methods that destroy chemicals or modify their properties to such an extent as to render it less harmful. Treatment to

reduce chemical mobility may include methods to modify the physical or chemical properties of the contaminated matrix. Treatment to reduce volume includes extraction procedures to concentrate chemicals. Treatment technologies may be implemented in situ, on-site following removal or collection, or off-site following removal or collection. CERCLA as amended favors use of treatment technologies to achieve remedial response objectives, unless site conditions limit their application.

Discharge: Discharge technologies are those associated with the final release of collected groundwater, surface water and leachate from the Fultz Landfill Site. Collected waters may be discharged after treatment or, untreated (direct discharge).

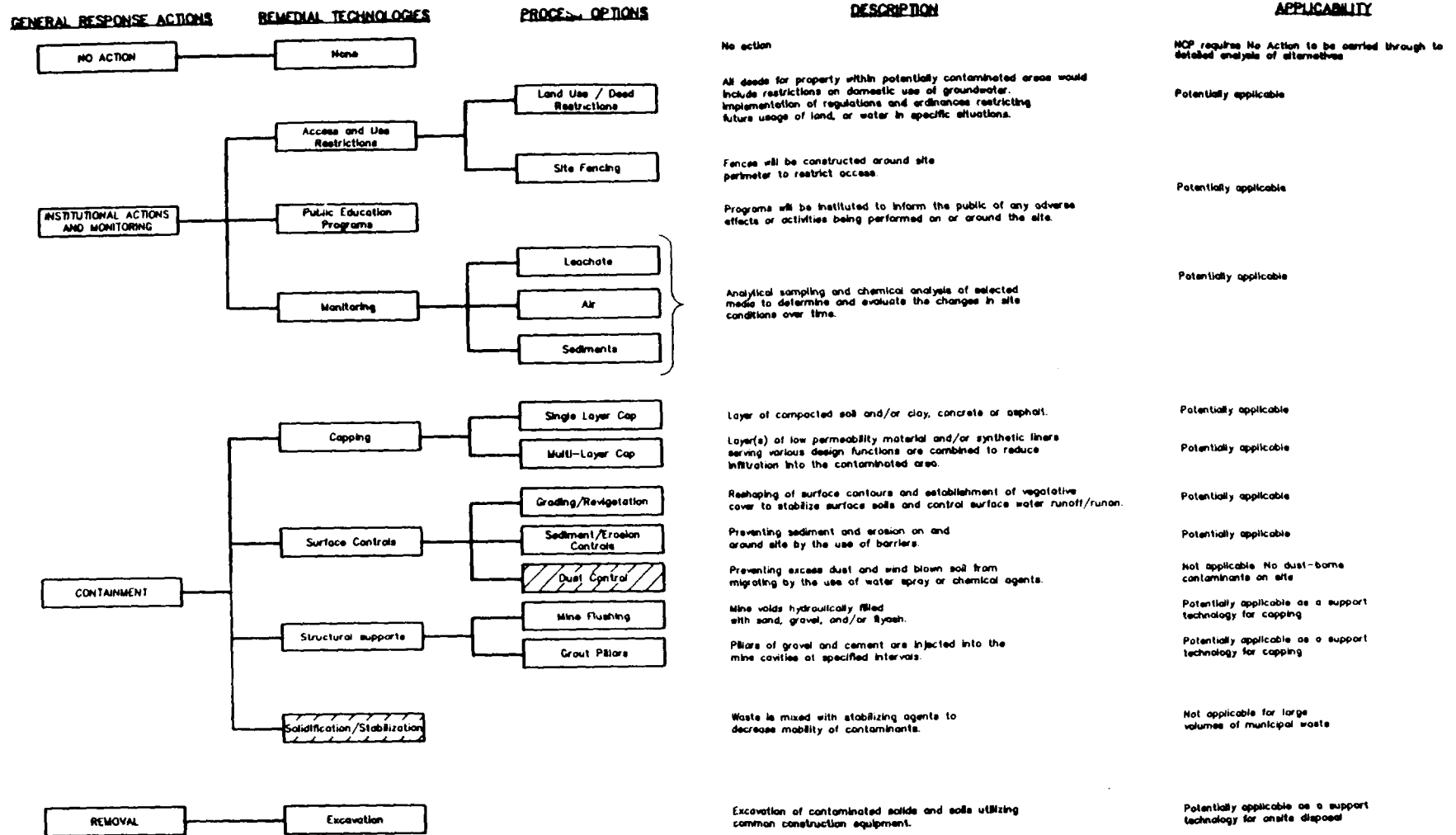
Disposal: Disposal technologies are those associated with the placement of waste materials in designated facilities that have been designed and are operated for such purposes. Disposal technologies typically refer to the disposal of contaminated solids.

2.5 IDENTIFICATION OF TECHNOLOGIES

During the RI, site-related chemicals were found in a number of media. In order to identify the technologies that are potentially applicable to the remediation of The Fultz Landfill Site the affected media are grouped into two operable units: solids, including landfill solids, sediments and soils; and water, including groundwater surface water, and leachate.

2.5.1 LANDFILL SOLIDS AND SOILS TECHNOLOGIES

This section identifies technologies and process options within the general response action categories that may potentially apply to the remediation of the contaminated landfill solids, soils, and sediments at the Fultz Landfill Site. Figure 2-1 summarizes the technologies that were identified for the remediation of soils and solids.



 Response action, technology or process option judged to be not applicable to site conditions.

FIGURE 2-1 (1 OF 2)
 IDENTIFICATION OF APPLICABLE REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
 LANDFILL SOLIDS AND ASSOCIATED SOILS
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

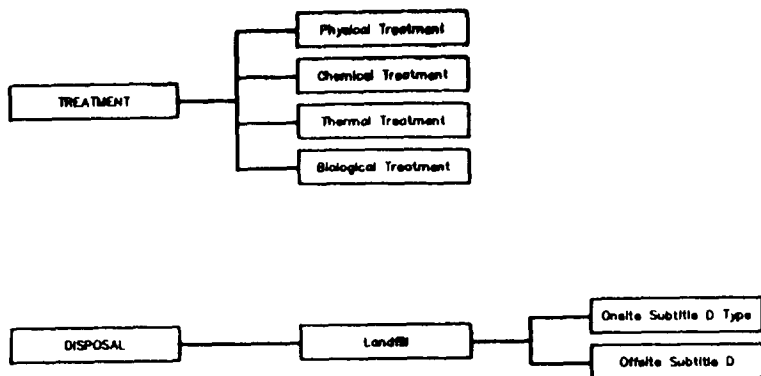
GENERAL RESPONSE ACTIONS

REMEDIAL TECHNOLOGIES

PROCESS OPTIONS

DESCRIPTION

APPLICABILITY



Commercially available treatment technologies which can concentrate, destroy or immobilize contaminants in solids and soils.

Potentially applicable

Contaminated solids and soils are excavated and disposed of in an onsite landfill constructed in accordance with the Code of Federal Regulations, (CFR) Section 257.
 Contaminated solids and soils are excavated and transported to an offsite landfill constructed and permitted in accordance with 40 CFR 257.

Potentially applicable

Potentially applicable



Response action, technology or process option judged to be not applicable to site conditions.

FIGURE 2-1 (2 OF 2)
 IDENTIFICATION OF APPLICABLE REMEDIAL
 TECHNOLOGIES AND PROCESS OPTIONS
 LANDFILL SOLIDS AND ASSOCIATED SOILS
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

2.5.1.1 Institutional Actions and Monitoring

Deed restrictions may be used to restrict future land uses or activities (such as excavation or drinking-water well drilling) that may result in increased contact with contaminated soils and solids or groundwater and leachate. Deed restrictions may be used alone or with other technologies to reduce the potential for human exposure. Institutional actions can be easily executed by local and state governments. Local ordinances, such as those restricting future land use and development of the Fultz Landfill Site, could achieve the remedial response objectives by reducing the potential for human contact with contaminated media.

Site fencing consists of the installation of a site perimeter fence, typically 6 feet high chain link, to prevent access to the landfill area. The fence would be posted at regular intervals with warning signs. Fencing would restrict site access and reduce human exposure to potential contact hazards posed by contaminated soils and wastes. Site fencing could also be used to control access during implementation of remedial actions.

Monitoring would consist of the periodic sampling and chemical analysis of various environmental media. The specific media that might be monitored at the Fultz Landfill Site include: surface soil, sediment, surface water, groundwater, leachate, and air. Monitoring could be used to track contaminant migration, identify changes in contaminant concentrations, identify combustible gas emanating from the landfill and track contaminant concentrations where the groundwater discharges into Stream A or Wills Creek.

Public education programs can also be easily implemented. These programs would keep the public informed of current and future activities proposed for the Fultz Landfill Site.

2.5.1.2 Containment

Containment of contaminants by the construction of caps or covers made of a low permeability material (clay), a synthetic liner material (flexible

2.5.1.1 Institutional Actions and Monitoring

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Public education programs can also be easily implemented. These programs would keep the public informed of current and future activities proposed for the Fultz Landfill Site.

2.5.1.2 Containment

Containment of contaminants by the construction of caps or covers made of a low permeability material (clay), a synthetic liner material (flexible

membrane liners), or some combination of the two have been used at numerous sites to isolate contaminated solids. Caps minimize the potential for direct contact with surface and subsurface contaminants and reduce the infiltration of precipitation through the landfill, thus reducing leachate generation and the migration of contaminants to the groundwater system.

Surface controls consist of physical measures implemented to change the character of the existing ground surface. Regrading could be performed to eliminate depressions that collect water, and to construct suitable grades with adequate ground cover that promote runoff, but minimize erosion. In this way, migration of contaminated solids by transport in surface water is reduced. Revegetation consists of the establishment of suitable vegetative cover to reduce erosion and increase evapotranspiration. Dust control is accomplished by the surface application of various materials to suppress wind-borne dusts. Dust control is not applicable to the Fultz Landfill Site, however, because there are no dust-born contaminants of concern at the site.

The Fultz Landfill Site is partly underlain by an abandoned room-and-pillar coal mine that consists of alternating pillars of coal, and rooms from which the coal has been removed. The abandoned mine complicates the containment options because of the possibility of mine subsidence increasing the permeability of the soil and rock between the waste and the mine, and creating additional migration routes that other containment options would not address. Structural supports, such as grout pillars or mine flushing, may be required to reduce the danger of subsidence.

2.5.1.3 Removal

The general response action for removal of landfill solids and contaminated soils involves excavation prior to treatment or disposal of the materials. Excavation could be performed using common construction equipment and would be treated as a support technology for on-site or off-site disposal response actions.

2.5.1.4 Treatment

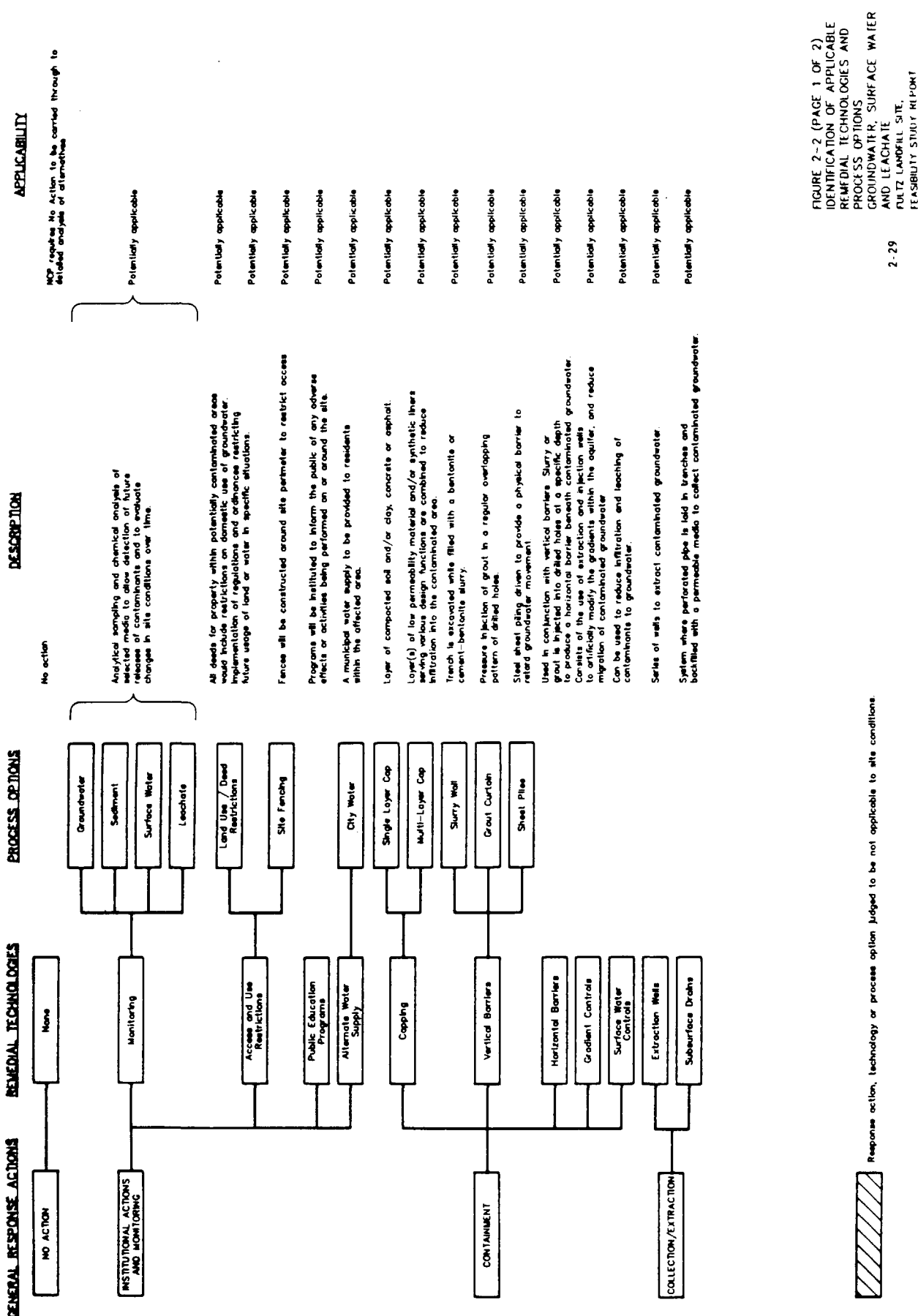
Thermal and chemical treatment are evaluated as remedial technologies for treating the landfill solids and soils at the site. Thermal treatment processes are capable of destroying contaminants in the waste, but have to be evaluated to see if they are feasible for the physical properties of the solids and the chemical properties of the contaminants. Surface soil analytical results indicate that on-site soils are primarily contaminated with inorganic elements at low to moderate concentrations. Surface soil samples also show some semi-volatile, volatile, and inorganic chemicals at concentrations higher than background. Some chemical treatment processes are also capable of destroying contaminants in the waste. The chemical treatments that are evaluated in this FS are soil washing, in-situ soil flushing, stabilization/solidification, and chemical reduction/oxidation. All of these treatment technologies will be evaluated for effectiveness and implementability at the site.

2.5.1.5 Disposal

Disposal technologies involve the containment and complete encapsulation of the landfill solids and soils in a properly constructed solid waste disposal facility. The facility would have such safeguards as multiple liner systems, leachate collection and detection, and a multi-layer cap. The disposal facility could be either a permitted facility at an off-site location, or it could be constructed on-site to meet applicable regulations.

2.5.2 GROUNDWATER, SURFACE WATER, AND LEACHATE TECHNOLOGIES

This section identifies technologies within general response action categories that may potentially apply to the remediation of contaminated groundwater, surface water, and leachate at the Fultz Landfill Site. Figure 2-2 summarizes the technologies that were identified for the remediation of groundwater, surface water, and leachate.

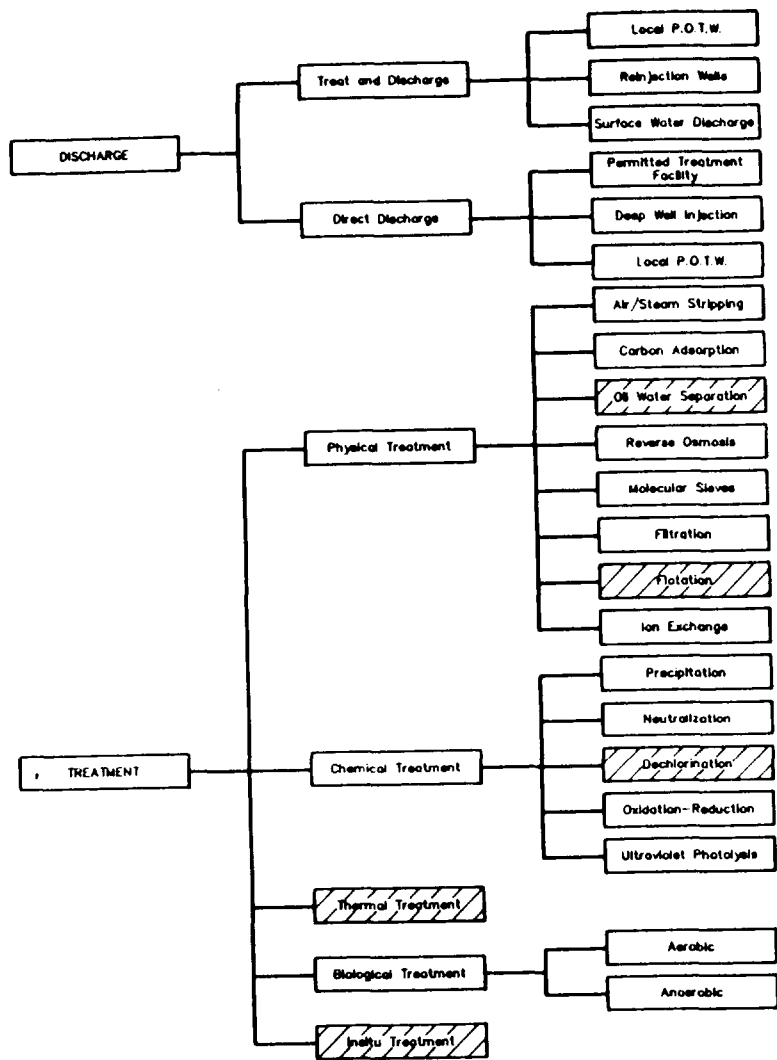


Response action, technology or process option judged to be not applicable to site conditions



FIGURE 2-2 (PAGE 1 OF 2)
IDENTIFICATION OF APPLICABLE
REMEDIAL TECHNOLOGIES AND
PROCESS OPTIONS
GROUNDWATER, SURFACE WATER
AND LEACHATE
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGIES PROCESS OPTIONS DESCRIPTION APPLICABILITY



Offsite discharge of treated groundwater to a local P.O.T.W. Potentially applicable

Reinjection of treated groundwater to aquifer using a series of reinjection wells. Potentially applicable

Discharge of treated groundwater to Mills Creek. Potentially applicable

Contaminated groundwater is extracted and discharged to a permitted facility for treatment and disposal. Potentially applicable

Contaminated groundwater is extracted and then discharged untreated to a regulated deep well injection system. Potentially applicable

Contaminated groundwater is extracted and discharged to the local P.O.T.W. for treatment and disposal. Potentially applicable

Mixing of large volumes of air with water in a packed column, or through diffused aeration, or by injecting steam into stripping column to add heat to promote transfer of VOC's to air. Potentially applicable

Passage of contaminated water over column of activated carbon where contaminants absorb on surface of carbon. Potentially applicable

Utilizes density differences of oils and water in the separation process. Not applicable. No oil contamination present at site

Use of high pressure to force clean water through a membrane, leaving contaminants behind. Potentially applicable

Synthetically produced compounds designed to absorb contaminants in groundwater, as well as other gases and liquids. Potentially applicable

Contaminated groundwater is passed through a bed of granular material resulting in the removal of suspended solids. Potentially applicable

Emulsified oils and suspended solids are separated from wastewater by attaching to gas bubbles introduced into the system and floating to water surface where they are skimmed off. Not applicable. No oil contamination present at site

Contaminated water is passed through a bed of resin material where exchange of ions occurs between the bed and the water. Potentially applicable

Alteration of chemical equilibria to reduce the solubility of a constituent. Potentially applicable

The interaction of an acid or base to adjust the pH of a contaminant solution to a normal range. Potentially applicable

Chlorine is chemically removed from chlorinated contaminants. Not applicable for waste type

Use of an oxidizing or reducing agent to chemically transform contaminants, thereby reducing or destroying their toxicity. Potentially applicable

Use of ultraviolet light and hydrogen peroxide to chemically oxidize organic compounds in water. Potentially applicable

Thermal destruction of contaminants in a liquid phase using a variety of methods, with incineration being the most prominent. Not applicable for treating groundwater with low levels of contamination

Use of micro-organisms in an aerobic environment to biodegrade organics. Potentially applicable

Use of micro-organisms in an anaerobic environment to biodegrade organics. Potentially applicable

Treatment of contaminated groundwater by physical chemical, or biological method without removing it from its existing location beneath the ground surface. Not applicable due to complex hydrology of the site

Response action, technology or process option judged to be not applicable to site conditions.

2.5.2.1 Institutional Actions and Monitoring

Essentially the same response actions that apply for the solids and sediments would also address waters at the site. Administrative or institutional actions such as deed restrictions on future groundwater and surface water use would reduce potential hazards associated with exposure to each of the contaminated media but do not reduce volume, mobility, or toxicity of the identified hazards. Current and future human health risks associated with residential drinking-water wells in the vicinity of the Fultz Landfill Site could be addressed effectively and inexpensively by substituting municipal water for private water well that are affected by the Fultz Landfill Site. Human health risks that were based on projected future use could also be reduced by other administrative controls such as local ordinances restricting development of the Fultz Landfill Site or the use of groundwater from the shallow and coal mine aquifers.

2.5.2.2 Containment

Containment technologies confine the potential hazards and may reduce the mobility of the contaminants, but do not reduce the toxicity and volume of the contaminants. Surface water controls such as diversion channels can be used to direct runoff away from contaminated areas reducing the spread of contamination to surface and groundwater. Subsurface containment barriers constructed of low permeability material have been used on many sites to control groundwater movement. Vertical and horizontal subsurface barriers isolate groundwater and surface water from the contaminant source by restricting movement across the barrier. Surface capping could be used with or without vertical barriers to restrict infiltration through the source area into the groundwater system. Subsurface structural supports (discussed more fully under technology screening for solids), such as grout pillars or mine flushing, could be installed in the underground mine cavities under the existing landfill to prevent mine subsidence from opening additional migration pathways into the coal mine aquifer. Gradient controls prevent groundwater inflow to the contaminated zone, thereby reducing further migration and concentration of contaminants. These containment controls can aid in

attaining site response objectives, however, they require continual monitoring to determine whether remedial measures are performing successfully. Under CERCLA, as amended, re-evaluation of containment options is required every five years.

2.5.2.3 Collection/Extraction

Subsurface collection trenches and/or extraction wells may be used to control groundwater movement or intercept contaminated groundwater at the site for collection and treatment. Recharge trenches and wells may be used to reintroduce treated water into the groundwater system for disposal or to control migration of contaminated groundwater during the extraction period. These technologies generally reduce the mobility of contaminants but not the toxicity or volume of contaminants.

2.5.2.4 Treatment

Groundwater, surface water, and leachate at the Fultz Landfill Site are contaminated with metals, volatile and semi-volatile organic compounds, where some of the organic compounds are chlorinated. These contaminants are not difficult to treat, but may require the application of multiple treatment technologies to reduce contaminant concentrations to the required discharge levels. A number of potential technologies can be used to remove VOCs. These include air/steam stripping, carbon adsorption, biological treatment, ultraviolet (UV)/oxidation, and thermal treatment. Technologies potentially applicable to removing metals include chemical precipitation, ion exchange, and oxidation-reduction. Chlorinated organic compounds may be treated by applicable technologies such as reverse osmosis. Depending on the applied technology, neutralization and/or filtration may be necessary for post- or pre-treatment of the waste streams.

2.5.2.5 Discharge

Several discharge options are potentially applicable to the site remediation actions. These options are primarily designed to reduce the mobility of

contaminants, but not the volume or toxicity of contaminants. Untreated groundwater could be pumped or hauled to a permitted commercial facility for treatment. Treated water could be discharged to the nearby surface water, Wills Creek, Stream A, or the ponds, or re-injected into groundwater. Discharge to groundwater would entail pumping treated water back into the aquifer. This could be accomplished using either injection wells or a recharge field.

2.6 SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

During the identification of technologies, those technologies which were obviously not applicable to the site were eliminated. The goal of screening is to select remedial technologies and process options that can be effectively implemented, and may be considered as part of a reliable and safe remedial action alternative for the site. The following criteria are used in screening remedial technologies and process options:

Effectiveness Criteria: Specific remedial technologies and process options are evaluated by their effectiveness in achieving the intended goal of the technology or process option. Technologies or process options may also be evaluated by their overall effectiveness in achieving CERCLA, as amended, goals, which include: (1) providing protectiveness to human health and the environment, (2) complying with ARARs as established by federal and state standards, and (3) being part of a remedy that uses permanent solutions or treatment technologies to permanently and significantly reduce the mobility, toxicity, or volume of hazardous substances.

In summary, the following concepts are considered in evaluating the effectiveness of a technology or process option:

- Effectiveness in achieving the intended goals of the remedial action objectives.
- Reliability and proven performance.

- Effectiveness in protecting human health and the environment, both during and after implementation.
- Effectiveness as a permanent solution.
- Effectiveness in complying with chemical-specific ARARs.

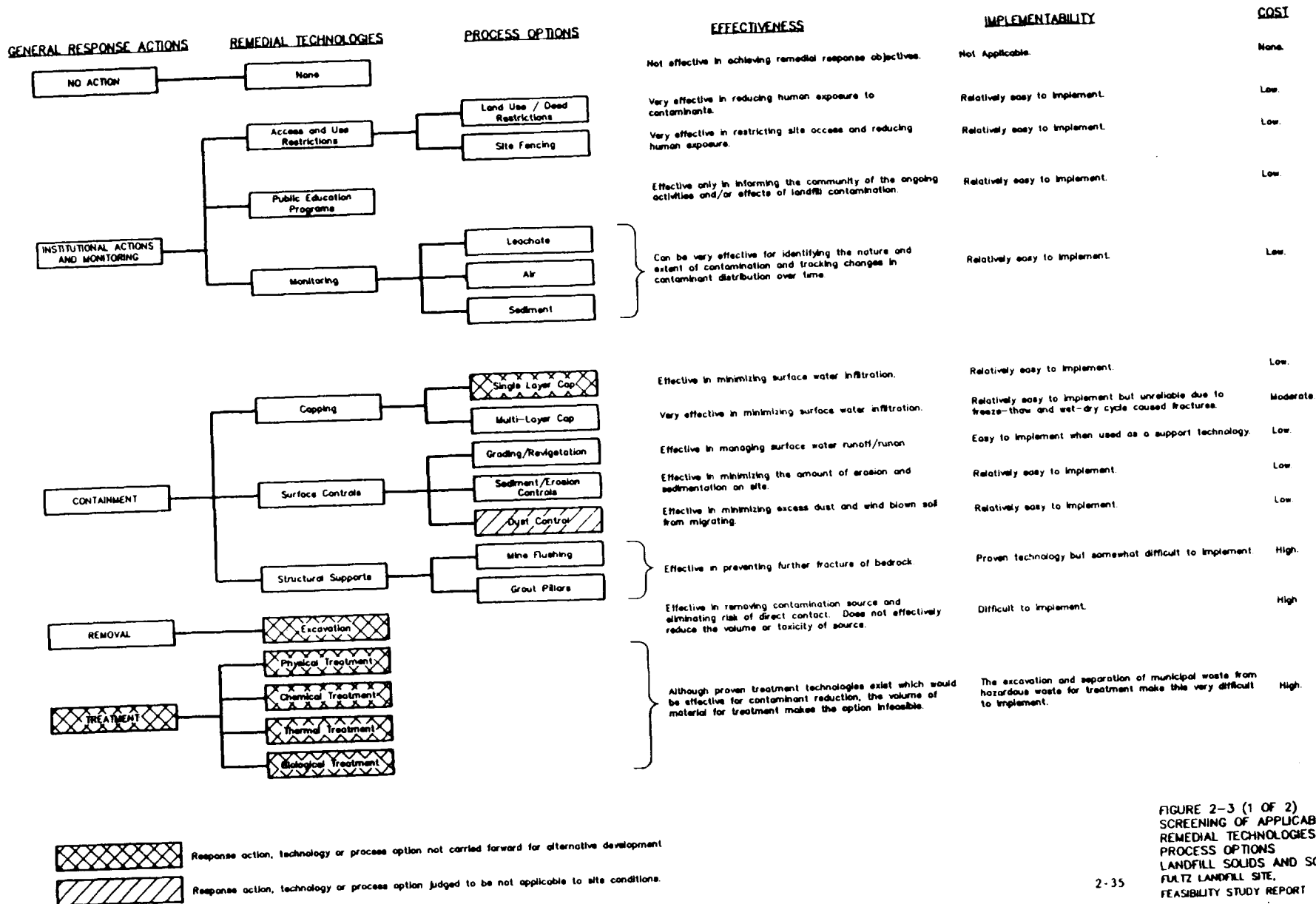
Implementability Criteria: Specific technologies and process options are also evaluated with respect to the technical and institutional considerations required for implementation of the technology. The following concepts are considered in evaluating the implementability of a technology or process option:

- Site conditions which make the technology technically difficult to implement.
- Availability of necessary equipment and services required to implement the technology.
- Ability to obtain necessary approvals from government agencies.
- Compliance with location and action-specific ARARs.

Cost Considerations: Cost plays a secondary role in the screening of technologies and process options. Relative capital and operation and maintenance (O&M) costs are considered, rather than detailed cost estimates. The costs are evaluated in terms of being low, moderate, or high relative to other process options within the same technology type.

2.6.1 TECHNOLOGY SCREENING FOR LANDFILL SOLIDS AND SOILS

This section describes the screening of technologies and process options using the above criteria with respect to the remediation of the contaminated landfill solids, soils, and sediments at the Fultz Landfill Site. Figure 2-3 summarizes the screening of technologies for the remediation of soils and solids.





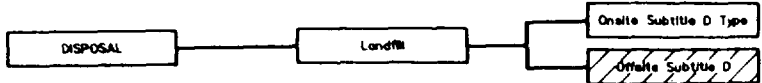
 Response action, technology or process option not carried forward for alternative development
 Response action, technology or process option judged to be not applicable to site conditions.

FIGURE 2-3 (1 OF 2)
 SCREENING OF APPLICABLE
 REMEDIAL TECHNOLOGIES AND
 PROCESS OPTIONS
 LANDFILL SOLIDS AND SOILS
 FAUZZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

GENERAL RESPONSE ACTIONS

REMEDIAL TECHNOLOGIES

PROCESS OPTIONS



EFFECTIVENESS

Effective in reducing contaminant mobility and eliminating infiltration of water through contaminated materials.

Effective but inappropriate for the site because of the impracticality of moving a large volume of contaminated solids and soils from an existing landfill to another facility.

IMPLEMENTABILITY

Difficult to implement due to require multiple handling of landfill material during construction.

Difficult to implement due to the handling and separation of large volumes municipal and hazardous material during excavation.

COST

High.

High.



Response action, technology or process option not carried forward for alternative development.



Response action, technology or process option judged to be not applicable to site conditions.

FIGURE 2-3 (2 OF 2)
 SCREENING OF APPLICABLE
 REMEDIAL TECHNOLOGIES AND
 PROCESS OPTIONS
 LANDFILL SOLIDS AND SOILS
 FULTZ LANDFILL SITE.
 FEASIBILITY STUDY REPORT

2.6.1.1 Institutional Actions and Monitoring

Land Use and Deed Restrictions: Deed restrictions can be implemented which restrict future use and development of the landfill property, and place regulatory controls on excavation or other activities including well drilling, that may result in contact with contaminated solids. Deed restrictions can be very effective in reducing human exposure to contaminants if they are properly enforced. Deed restrictions would best be enforced at the local level, perhaps by the local municipal authority. The implementation of deed restrictions on future use does not seem unreasonable and could likely be implemented with little or no public opposition. The implementation cost is relatively small. Deed restrictions will be carried forward as a potential technology to be used in the development of remedial alternatives. Other land use restrictions could include such items as zoning ordinances restricting construction, excavation, well drilling or other activities that would bring the public in contact with contaminated soils and sediments. Land use and deed restrictions can be very effective in reducing the risks associated with exposure to contaminated media, but their effectiveness is dependent on enforcement over time. They can be implemented with little difficulty and at a low cost under most circumstances. Land use and deed restrictions will be carried forward as a potential technology to be used in the development of remedial alternatives.

Site Fencing: This technology would involve installation of site perimeter fencing to prevent access to the landfill area. The fence would be posted at regular intervals with warning signs. Fencing would restrict site access and reduce human exposure to potential contact hazards posed by contaminated soils and wastes. It could also be used to control access during implementation of remedial actions. Site fencing is highly effective and reliable in restricting site access and reducing human exposure if the fence is properly maintained. Fencing is easy to implement, and installation costs are low. Periodic inspections and repairs would be required, however, to maintain the physical integrity of the fence. Site fencing will be carried forward as a potential technology to be used in the development of remedial alternatives, possibly to be combined with other technologies.

Public Education Programs: Public education programs could be implemented to inform the public about any on-going activities that are, or will, be performed on or near the site. The effectiveness of such programs depends on the individual community and the perceived dangers involved. Public education programs are usually used to enhance the effectiveness of other remedial technologies. These programs are easily implemented and should have the local communities' support. The cost of public education programs is low. Public education programs will be carried forward as a potential technology to be used in the development of remedial alternatives combined with other institutional actions.

Monitoring: Monitoring technologies detect any changes in the distribution and extent of contaminants in various media and identify contaminant releases from the site. The releases can be to groundwater, surface water, soil, sediment, air or a combination of these. At specified time intervals, soil, water, sediment, and air samples are collected from predetermined sampling locations, and analyzed for site related chemicals. Analytical data would be used to track contaminant levels over time and would form the basis for future recommendations on additional remedial actions.

Monitoring is very effective for identifying the nature and extent of contamination and a complete multi-media monitoring program can be highly effective in tracking changes in contaminant distribution over time. Monitoring does not, however, reduce toxicity, mobility, or volume, nor does it reduce the potential for human exposure to occur. Therefore, it is not protective of human health. This technology is easy to implement using standard sampling equipment and routine analytical procedures. The cost of monitoring depends on the particular monitoring program chosen, but in general, is low compared with removal and treatment technologies.

The monitoring technologies for a multi-media sampling plan will be carried forward as a potential technology to be used in the development of remedial alternatives.

2.6.1.2. Containment

Single Layer Cap: A single layer cap is a low permeability barrier constructed of one type of material, the most common materials being clay, asphalt or concrete. The cap would be constructed over the landfill area, usually after a layer of imported fill is placed to provide a proper subgrade and satisfactory slope.

A single layer cap is effective in reducing infiltration of surface water into the landfill, and would reduce leachate generation caused by percolation of water through the waste mass. It would prevent the release of contaminants either by wind or water erosion, and direct contact with surface and sub-surface contaminants by site intruders. However, a single layer cap material would be susceptible to cracking from freeze/thaw cycles, leakage, settlement, and soil desiccation. A single layer cap is relatively easy to implement, with some cleaning, grubbing, and regrading of the existing cover before placement. Common construction equipment can be used to transport, spread and compact the cap material. The cost of a single-layer cap would be moderate for the Fultz site but less expensive than multi-layer caps or treatment technologies. Because it is much less reliable, less durable and requires more maintenance than a multi-layer cap system, and because a single-layer cap would not meet ARARs since historical information indicates that hazardous waste was disposed of at the Fultz Landfill Site, a single-layer cap will not be considered for the development of remedial alternatives.

Multi-Layer Cap: A multi-layer cap consists of a combination of layers constructed of different materials, with each layer performing a specific function. From the bottom up, a multi-layer cap would typically consist of a gas collection layer to vent landfill gases; a clay layer to retard infiltration and provide a physical barrier; a synthetic membrane, also to retard infiltration; a drainage collection layer to collect infiltration and convey it off of the cap; and a vegetative support layer to protect the underlying components and provide a layer of soil to be revegetated. The multi-layer cap functions in a manner similar to a single layer cap in that it reduces infiltration, prevents erosion, and reduces public health risks

resulting from direct contact with ingestion of and/or inhalation of contaminated materials. It is effective in protecting human health for the same reasons discussed for single layer caps.

Unlike a single layer cap, however, the low-permeable barrier layer and drainage layer retard surface infiltration more effectively and direct it away from the landfill. Multi-layer caps can generally withstand greater settlement and harsher conditions, due to their flexibility and the greater amount of soil cover. Implementation of a multi-layer cap is more difficult than a single layer cap because there are many more construction steps necessary to properly construct its multiple layers. Installation of the synthetic membrane would also require special care to ensure proper seam installation and to prevent damage to it during subsequent construction operations. The cost of a multi-layer cap is also much higher than a single layer cap.

Minimizing infiltration of surface water through the cap to the groundwater is a critical issue to be addressed at this site, as is the construction of a physical barrier over the landfill cells. The collection and venting of gases is also required because of the methane gas usually produced by the putrescible waste in a decomposing landfill. Such gas could accumulate beneath the low-permeability barrier causing the cap to crack, or the gas itself may migrate off-site in a lateral direction. The multi-layer cap technology with a gas venting system will be carried forward in the development of remedial alternatives.

Grading and Revegetation: These two process options reshape surface contours and establish a vegetative cover to control surface water runoff and runoff in order to stabilize surface soils. Both are effective in managing surface water, easy to implement, and inexpensive when used as support technologies. They will be carried forward in the development of remedial alternatives.

Sediment and Erosion Controls: Sediment and erosion controls, such as diversion channels, silt fences, sedimentation ponds, and other barriers, could be used as support technologies to minimize sedimentation and erosion

on and around the site. They contribute to the effectiveness of other technologies and are relatively easy and inexpensive to implement. These technologies will be carried forward in the development of remedial alternatives.

Subsurface Structural Supports: Subsurface supports installed in the mined-out areas beneath the landfill would be effective in preventing subsidence, and improving the performance of any capping technology. Two types of supports, grout pillars and mine flushing are currently used to provide structural support for buildings constructed over mine cavities. Both technologies are fairly easy to implement, and reliable in providing long-term subsurface support, but are somewhat expensive. Subsurface support technologies will be retained for consideration for use with capping options in the development of alternatives.

2.6.1.3 Removal

Excavation: Excavation provides no treatment, but must be performed prior to any treatment or transport of the source material. This option is effective in that it removes the contaminated source, and eliminates the risk of direct contact; however, the volume or toxicity of the contamination is not reduced. Excavation is relatively easy to implement, and common construction equipment can be used in the excavation process. It could result in a temporary increase in exposure potential through volatilization of some organic compounds, and direct contact during construction. The large volume of material at the Fultz Landfill Site could result in some logistical problems such as stockpiling and storage of the material. Volatile emissions and contaminated surface water runoff from the storage pile will need to be controlled during excavation. The number and quantity of seeps from the landfill are indications that much of the excavated material might be saturated and require dewatering. All of these operations are costly but feasible. Therefore, excavation will be retained as a support technology to be used in conjunction with disposal.

2.6.1.4 Treatment of Soils and Landfill Solids

Except for in-situ treatment, the implementation of a treatment response action would involve the excavation, handling, and treatment of over 770,000 cubic yards of municipal refuse. With any municipal landfill, it is difficult to identify zones of hazardous waste or "hot spots" within the landfill. Despite extensive investigations at the Fultz Landfill Site neither Phase I nor Phase II of the remedial investigation revealed an area of concentrated contamination. Thermal treatment processes, for example, are capable of destroying whatever hazardous contaminants might be found in the waste, but it is not feasible to excavate and separate municipal waste from hazardous contaminants in order to thermally destroy them. The same is true of other treatment processes such as soil washing, stabilization/solidification, and chemical reduction/oxidation. Because of the difficulties in implementation, no technology that requires the excavation, and treatment of the landfill solids will be carried forward for the development of alternatives.

In-situ treatment of solids also has limitations. In-situ thermal treatment would not be feasible because of the danger of an underground fire starting within the landfill and possibly spreading to the abandoned mine below. Other forms of in-situ treatment, such as biological treatment, soil gas extraction, and vitrification are infeasible because of the depth of the landfill, the low level of contamination found, soil type, and the commingling of waste and soils in the landfill. Therefore, treatment of landfill solids and soils at the Fultz Landfill Site is not considered appropriate, and will not be considered in this FS.

2.6.1.5 Disposal

On-site Landfill: An on-site landfill utilizing an underlying double liner system and a multi-layer cap could be constructed in a designated area within the property boundaries for the disposal of contaminated soils and solids excavated from the existing landfill. On-site landfiling does not provide any treatment, but it is protective because it is an effective and reliable method to contain wastes and eliminate existing exposure routes. Construction

of an on-site landfill would provide total encapsulation of the waste materials and would be effective in reducing the off-site migration of contaminants from the source material. The waste is isolated from the groundwater exposure route by a double liner and leachate collection system, and from exposure via air and surface water routes by a multi-layer cap. Although it eliminates the need to move contaminated materials off-site, implementing an on-site landfill would be difficult from both technical and administrative perspectives. In addition to the direct exposure of workers during excavation, there will be additional risks to workers if stockpiling of wastes is needed while the landfill cell is being constructed. Dewatering or treatment of saturated materials would probably be necessary before placing them in the landfill liner. Implementation of an on-site landfill would be feasible, but difficult. Although equipment and services are readily available, meeting landfill siting requirements would be difficult because of the Stream A channel and underground mine beneath the site. The cost of an on-site landfill would also be very high compared with some other technologies, but since it would be the most protective of the feasible technologies, it will be retained for alternative development.

Off-site Landfill: Disposal of the wastes from the Fultz Landfill Site in an off-site landfill would require that the contaminated solids and soils be excavated and transported in accordance with current regulations. Off-site landfilling would be effective in meeting the remedial response objectives for the Fultz Landfill Site because the source of contamination would be removed from the site. It would be protective of human health and the environment for the site itself after implementation, but during implementation, off-site disposal of large volumes of contaminated solids carries all of the disadvantages of the on-site landfill, and adds the problem of safe transport to a new location. Transporting the large volume of waste using highway-sized trucks would make the implementation time excessive, and pose excessive risk to populations in route. Excavation and off-site disposal of hazardous waste could require treatment of the hazardous waste in order to meet criteria under the Resource Conservation and Recovery Act (RCRA) Land disposal restrictions prior to land disposal. The cost would most likely be higher than for on-site disposal because of the transportation costs. For

these reasons, off-site disposal is not practical and will no longer be considered for alternative development.

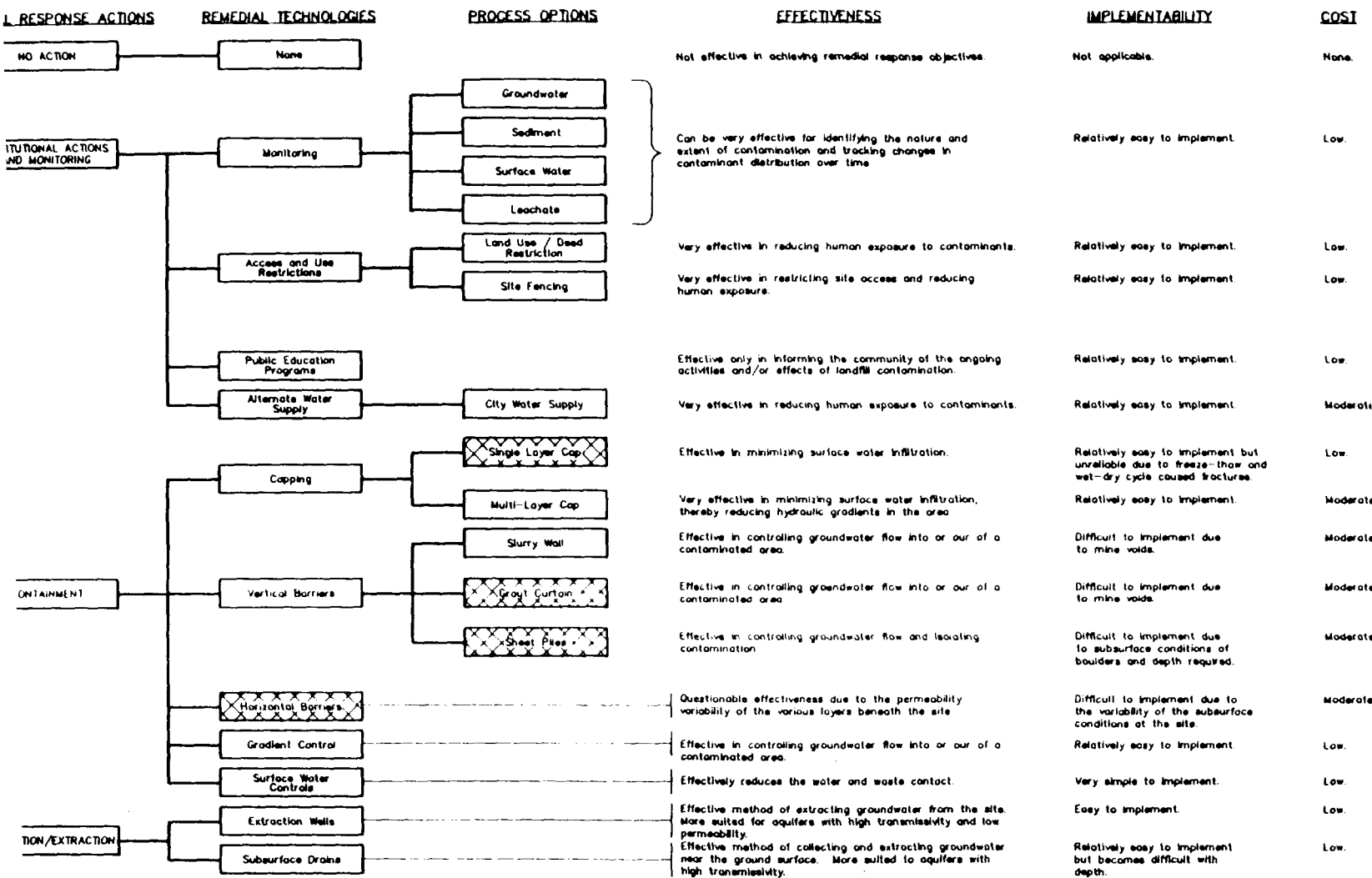
2.6.2 TECHNOLOGY SCREENING FOR GROUNDWATER, SURFACE WATER, AND LEACHATE


This section describes the screening of technologies and process options using the above criteria with respect to the remediation of the contaminated surface water, groundwater, and leachate at the Fultz Landfill Site. Figure 2-4 summarizes the screening of technologies for the remediation of surface water, groundwater, and leachate.

2.6.2.1 Institutional Actions and Monitoring

Monitoring: Monitoring will provide a data base that will be periodically reviewed in order to evaluate changes in conditions at the Fultz Landfill Site. Monitoring is effective as a basis for determining the need to implement other technologies, to determine the potential for human exposure, or to identify the need to remediate the problem. Implementation would be easy because surface water and leachate sampling points are easily accessible, and monitoring wells are already installed. If additional monitoring wells are required they would be easy to install. The cost of monitoring would be low, but monitoring activities would be conducted for many years and would require long-term data management efforts. Monitoring will be included in alternatives where contaminated materials remain on site, and therefore will be carried forward.

Access and Use Restrictions: As with soils and solids, institutional actions can be very effective in reducing the risks associated with exposure to contaminated surface water, groundwater and leachate. Risk reduction is achieved by restricting activities which could result in the exposure of humans to contaminated water, such as the installation of drinking water wells or the use of surface water. The effectiveness of institutional actions is dependent upon their successful implementation and enforcement. Although their effectiveness is subject to changes in political jurisdictions, legal



 Response action, technology or process option judged to be not applicable to site conditions.


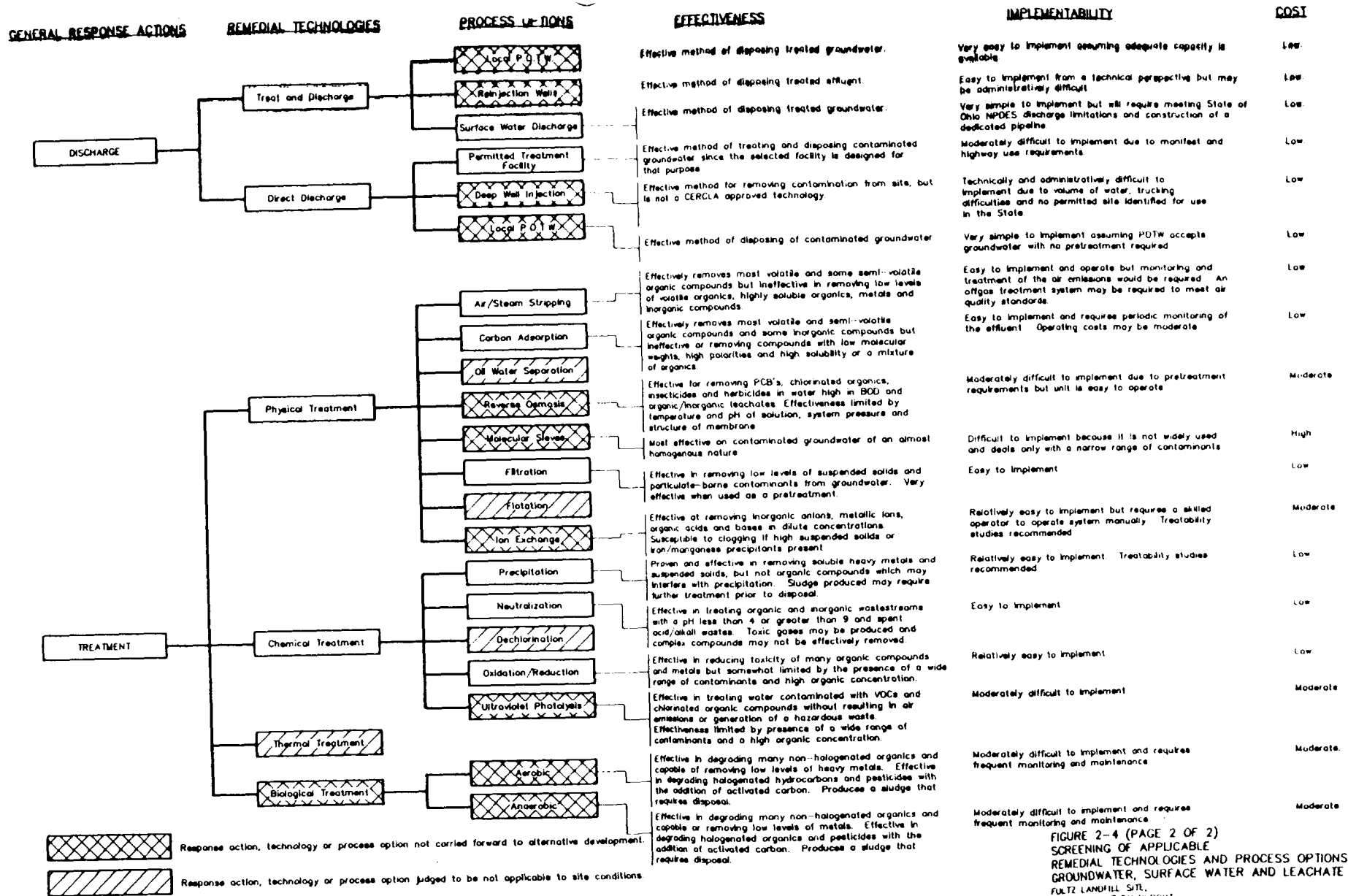
 Response action, technology or process option not carried forward to alternative development.

FIGURE 2-4 (PAGE 2-45)
 SCREENING OF APl
 REMEDIAL TECHNOLOGIES
 PROCESS OPTIONS
 GROUNDWATER, SURFACE
 AND LEACHATE
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT







 Response action, technology or process option not carried forward to alternative development.
 Response action, technology or process option judged to be not applicable to site conditions

FIGURE 2-4 (PAGE 2 OF 2)
 SCREENING OF APPLICABLE
 REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
 GROUNDWATER, SURFACE WATER AND LEACHATE
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

interpretations, and regulatory enforcement, they can be implemented with little difficulty and at a low cost under most circumstances. These actions will be carried forward as a potential technology to be used in the development of remedial alternatives.

Site Fencing: Site fencing is a highly effective and reliable technology for restricting site access and reducing human exposure to surface water and leachate. Implementation is easy, and the capital cost is low, but periodic inspections and fence maintenance is required to maintain the physical integrity of the fence. It will be carried forward into the assembly of remedial alternatives.

Public Education Programs: Public education programs could be implemented to inform the public about any on-going activities that are, or will, be performed on or near the site. The effectiveness of such programs depends on the individual community and the perceived dangers involved. Public education programs are usually used to enhance the effectiveness of other remedial technologies. These programs are easily implemented and should have the local communities' support. The cost of public education programs is low. Public education programs will be carried forward as a potential technology to be used in the development of remedial alternatives combined with other institutional actions.

Alternate Water Supply: Residents who live nearby the Fultz Landfill Site and who use well water from either of the contaminated aquifers would be connected to the Byesville municipal water supply. Supplying municipal water is an effective way to eliminate exposure from ingestion of contaminated groundwater. Because water mains are near the residents most likely to be affected, connecting them to city water would be easy and relatively inexpensive. Alternate water supply will be retained in the FS for inclusion in the remedial alternatives.

2.6.2.2 Containment

Single Layer Cap: A single layer cap is effective in reducing the infiltration of surface water into the landfill, as well as subsequent leachate generation caused by percolation of water through the waste mass. As long as the cap remained intact, it would be protective of human health by reducing contaminant migration into the groundwater and surface water; however, a single layer cap is susceptible to cracking and leakage due to natural freeze/thaw cycles, settlement and/or soil desiccation. These environmental conditions have a detrimental effect on the performance of the cap layer and frequent maintenance is generally necessary. Although the single layer cap is relatively easy to implement, and fairly low in cost, it is unreliable and generally possesses poor durability. In addition, a single-layer cap would not meet ARARs since historical information indicates that hazardous waste was disposed of at the Fultz Landfill Site. Therefore, the single-layer cap will be eliminated from further consideration in the FS.

Multi-Layer Cap: A multi-layer cap is described in the screening of technologies for remediation of soils and solids. The multi-layer cap is effective in reducing infiltration of precipitation into the waste mass, and thus reduces the migration of contaminants to groundwater. It also prevents contamination of surface water from erosion of cover soils. Because multi-layer caps are thicker and more flexible than single layer caps they are better able to withstand settlement of the landfill and harsh weather. As a result they are more protective of human health than single-layer caps. The materials and technology are readily available, and the conditions at the Fultz Landfill Site would require only minor regrading of the existing landfill before capping. Although the cost of a multi-layer cap is much higher than a single-layer cap, its increased reliability and decreased need for maintenance make it more advantageous for reducing groundwater contamination. Therefore, the multi-layer cap will be carried forward in the development of remedial alternatives.

Slurry Wall: This technology consists of the construction of a vertical subsurface soil-bentonite or cement-bentonite barrier of low permeability

(10^{-7} to 10^{-6}) to minimize groundwater migration above a pre-existing natural confining layer. The wall is constructed by trenching down to the confining layer of bedrock or claystone, and keying the excavation into it. Bentonite slurry is used to fill the trench and maintain the stability of the sidewalls. Soil is subsequently added to the trench and mixed with the slurry to form a permanent vertical barrier. Slurry walls are often used in conjunction with caps and/or drainage systems to minimize infiltration, control subsurface drainage, and reduce the off-site migration of contaminants in groundwater.

Slurry walls can be an effective and reliable method to control groundwater flow. They are easy to implement and are one of the most commonly used methods to hydraulically isolate sources of contamination. The site is underlain by a formation of competent rock that will enable a slurry wall to isolate the waste from Valley A to the north of the landfill. Because the groundwater migration routes include the coal mine to the south of the landfill, part of a slurry wall would have to intercept groundwater flowing through the mine at a depth of over 100 feet from the surface. Slurry walls have been routinely constructed to this depth with little difficulty; however, implementation becomes more difficult as depth increases. Additionally, it is not feasible to construct a slurry wall within mine voids. A slurry wall may be useful along the northern and eastern sides of the existing landfill to isolate the waste from the groundwater flowing through Stream Valley A. This technology will be carried forward in the development of remedial alternatives.

Grout Curtain: Grouting is the act of pressure-injecting a slurry of cement or clay into the void space of earth materials to reduce or eliminate their permeability or to consolidate and strengthen them. Grout curtains can be an effective method to control groundwater flow and to hydraulically isolate large sources of contamination.

Unlike slurry walls, it is not necessary to key into a confining layer with grout curtains; however, it is difficult to construct a continuous wall, and leakage may occur. Because this technology provides no advantages over a

slurry wall and is less reliable, it will not be carried forward in the development of remedial alternatives.

Sheet Piles: This technology involves the driving of steel sheet pilings into the ground to provide a physical barrier to retard groundwater flow. Usually the piles are driven to bedrock or to a depth at which groundwater does not readily flow around the pilings. Sheet pilings are effective in controlling groundwater flow and isolating contamination, but are more suitable for shallow excavations or where soil deformation can be tolerated because of its flexibility. Implementation of this technology is limited by depth, type of soil, and obstructions such as boulders. Similarly to grout curtains, it is difficult to ensure the integrity of the wall, and leakage may occur around the joints. At the Fultz Landfill Site, the candidate area for driving the pilings is comprised of mine spoil and alluvium. Because mine spoil frequently contains large boulders, installation may be very difficult. The cost of installation is moderate under ideal conditions, but increases substantially as depth and difficulty of installation increases. Because there are other options which are more effective and reliable in the control of groundwater, this technology will be eliminated from further consideration.

Horizontal Barriers: Horizontal barriers function in a similar manner to vertical barriers (sheet piles, grout curtains, slurry walls, etc.) in that they restrict movement of groundwater in the direction perpendicular to the barrier. Horizontal barriers are much more difficult to install, however. Properly installed horizontal barriers are effective in preventing the vertical migration of contaminants. They are moderately expensive to install, and involve no operating cost, but it is difficult to monitor the integrity of the barrier. Horizontal barriers are not applicable to the Fultz Landfill Site because the depth to the bottom of the existing landfill is highly variable, and there is a low permeability bedrock formation beneath the coal mine aquifer. Horizontal barriers will, therefore, not be carried forward for the development of alternatives.

Gradient Controls: Gradient controls consist of a series of extraction and injection wells that are strategically placed and used to artificially modify

the groundwater flow gradients in the aquifer. It can also be used to reduce migration of contaminants by lowering the water table in order to reduce contact with contaminated soils, and/or to direct clean groundwater around contaminants. This is an effective technology for controlling the flow patterns in an aquifer. It is well-developed, reliable, and simple to implement. The installation cost is moderately low, but application of this technology would require long-term operations. Gradient controls will be carried forward in the development of alternatives since it would aid in the remedial objectives.

Surface Water Controls: Surface water controls such as grading, diversion channels, sedimentation ponds, silt fences and revegetation reshape surface contours and establish a vegetative cover to control surface water runoff. By controlling surface water runoff they also control migration of contaminants into surface water bodies. They are effective in managing surface water, easy to implement, and inexpensive when used as support technologies. They will be carried forward in the development of remedial alternatives.

2.6.2.3 Collection/Extraction

Extraction Wells: An extraction well system consists of either a series of well points or radial collector wells installed into a strata to remove contaminated groundwater. This method of removal is generally well-suited for aquifers with low permeability and high transmissivity. The extraction well is effective in removing soluble contaminants from an aquifer, but is not effective in removing hydrophobic, low solubility contaminants such as PCBs. The extracted water would require treatment and/or disposal. A scheme of varying flow rates can be used to optimize the removal from a specific zone of contamination. It is a well developed technology, simple to implement, and moderate in cost. Since most of the contaminants that have been identified at the Fultz Landfill Site are soluble, and the permeability of the shallow aquifer is moderate, extraction wells would be effective and implementable. Wells could extract water from the coal mine aquifer, but it would be difficult to predict the effect of groundwater extraction from this aquifer on contaminants within the aquifer. Pumping tests performed in a similar aquifer

to the south of the former Ideal Mine generated a uniform decline in piezometric head over the entire aquifer. Under these conditions, it is impossible to predict flow paths within the aquifer or assess the effect of the extraction wells on contaminant migration within the aquifer. Lowering the piezometric head within the coal mine aquifer would increase the gradient between the coal mine aquifer and the shallow aquifer thus promoting the migration of contaminants to the coal mine. Since there would be no way to determine if wells in the coal mine aquifer could capture the contaminants, extraction of groundwater from the coal mine aquifer is inappropriate. Therefore, extraction wells for the coal mine aquifer will not be carried forward for the development of remedial alternatives. On the other hand, extraction wells for the shallow aquifer will be carried forward in the development of remedial alternatives.

Subsurface Drains: Subsurface drain collection systems consist of perforated pipes installed in trenches, and backfilled with a permeable media such as gravel. The water collected by the drains flows by gravity to a wet well and is then pumped to either a holding tank, a treatment facility, or otherwise discharged. This type of system is most appropriate for use in formations with low transmissivity and when flows need to be controlled over a large area.

Subsurface drains would be an effective method of collecting groundwater and leachate from the shallow aquifer. The depth and at which subsurface drains are placed are critical to their effectiveness. Deep subsurface drains, extending from the surface to the confining stratum beneath the shallow aquifer, might be used to intercept contaminated groundwater across a contaminant migration path and collect the water for treatment. Use of deep subsurface drains at the Fultz Landfill Site to collect groundwater for treatment presents several problems. The most effective location for the drains to intercept contaminant migration into the coal mine aquifer would be under the landfill along the interface between the fill and the in-place coal of the coal mine aquifer. Installation would require excavation through the center of the landfill. Installation of subsurface drains would disturb the landfill, risk the spread of contamination, and would be difficult to

implement because of the mix of trash, municipal waste, and hazardous waste within the landfill. It would not be implementable with a multi-layer cap since deep drain through the landfill would be difficult to monitor and impossible to repair. If a drain were to fail in one section, preventing contaminated water from being pumped out, it would serve as a conduit for contamination instead of a barrier. A subsurface drain extending through mine spoil and alluvium on the northern side of the landfill to intercept flow is technically feasible but would collect mostly surface water that would filter down from Ponds 1, 2, 2A, and 3. For these reasons, deep subsurface drains are not carried forward for alternative development.

On the other hand, shallow subsurface drains would be ideal for the collection of leachate and groundwater in the shallow aquifer around the perimeter of a landfill cap. Leachate collection systems that are installed with landfill caps exemplify this subsurface drain technology. This type of leachate collection system would extend a few feet below the bottom of the waste in the existing landfill to about elevation 795, and would prevent landfill leachate from flowing into the Stream Valley A aquifer north of the landfill. Shallow subsurface drains could also be used upgradient of the existing landfill to divert shallow groundwater from the hill overlooking the landfill to the south away from the waste area. Excavated to bedrock, and combined with a liner on the downgradient side, a subsurface drain would provide protection from groundwater intrusion into the existing landfill.

Shallow subsurface drains are a well developed technology and simple to implement. The cost of installation is moderate, but since they are passive collection systems, operation costs are low. Therefore, shallow subsurface drains will be carried forward in the development of remedial alternatives.

2.6.2.4 Discharge

Treated Discharge to Local POTW: In this technology, the contaminated water that has been treated in an on-site treatment plant would be discharged to a local publicly operated treatment works (POTW). Discharge to a local POTW would be a very simple and effective method of disposing treated water at this

site since the public sewer line is only half a mile from the site. Permission from the POTW would be required, and a permit must be obtained. It is probable that permission will be granted since the contaminated water extracted from the site must satisfy the POTW pretreatment standards after the on-site treatment. Because discharge to the POTW would require the construction of a new sewer line under an interstate highway, and the Byesville Sewage Treatment Plant is already receiving sewage near its capacity of 400,000 GPD. This option will not be carried forward.

Treated Discharge to ReInjection Wells: This technology would consist of the use of newly constructed on-site injection wells to reinject treatment plant effluent into the shallow aquifer on site. The use of reinjection wells would be an effective method to dispose of high quality treatment-plant effluent, using standard well construction technologies. This option is easy to implement from a technical standpoint but not from an administrative one. Administratively, it will require compliance with the Underground Injection Control (UIC) Program. This option will not be carried forward in the development of remedial technologies since there are other technologies as effective and more easily implemented.

Treated Discharge to Surface Water: In this technology, treated groundwater and leachate would be discharged to Wills Creek, to Stream A, or possibly to the ponds. Discharge into the local surface drainage would be a very simple and effective method of disposing the treated groundwater and leachate at this site. The receiving stream(s) are located within close proximity to the site. It would be easy to implement, but would require the establishment of NPDES discharge limits from the Ohio Environmental Protection Agency. It will also require the construction of dedicated discharge pipeline. It is inexpensive and less difficult to implement from an administrative standpoint than is the use of reinjection wells. Therefore, it will be carried forward as a potential technology to be used in the development of remedial alternatives.

Untreated Discharge to Permitted Treatment Facility: Untreated groundwater, surface water, or leachate collected from the site would be transported by tankers to a permitted treatment facility. Treating the groundwater at a

permitted facility would be a highly effective method of treating the contaminated water from the Fultz Landfill Site, since the facility would, by definition, be a facility licensed to treat liquid wastes to appropriate standards. Since there is a facility in Cleveland that would be capable of receiving the waste from the Fultz Landfill Site off-site disposal would be easy to implement for small discharges. Manifest tracking documents would be required when the contaminated water is removed from the site. This technology would be more difficult to implement if the volume of water requiring treatment was large enough to result in heavy truck traffic that would be unacceptable to the community. There are no capital costs associated with this treatment option. However, the transportation and treatment costs for implementing this technology would be high. This technology will be carried forward for inclusion in alternatives where the volume of fluids to be treated would be low.

Untreated Discharge to Deep Well Injection: In this technology, the extracted groundwater, surface water and leachate would not be treated, but injected into a deep aquifer at a regulated deep well disposal site. This technology may be effective in removing the contamination from the site and placing it in a zone where it would not likely be accessible for domestic water use. However, this technology does not follow the CERCLA guidance which favors technologies that provide a permanent solution through treatment and reduce the toxicity, mobility, and volume of contamination. Implementation would be fairly difficult due to the volume of water required for disposal, number of trucks required to transport the water, and the distance to a potential site. No permitted deep well injection facilities that accept waste from off-site locations could be identified in the State of Ohio. The technology is inexpensive to operate once the injection wells are installed, but administrative difficulties may be encountered. This technology will not be carried forward as a potential technology since there are other disposal options which are easier to implement.

Untreated Discharge to Local POTW: In this technology, untreated groundwater, surface water, and leachate collected from the site would discharge to a local POTW. The nearest sewer line is located approximately one-half mile west of

the site but would require the construction of a new sewer line under an interstate highway. Analysis of the groundwater and leachate during the RI determined that all inorganic compounds, except iron, were below influent limitations for the Byesville Sewage Treatment Plant. Limitations on discharge of organic compounds could not be provided by the plant manager. At present, however, the Byesville Sewage Treatment Plant is already receiving sewage near its capacity of 400,000 GPD. For this reason, discharge to the POTW will not be carried forward for alternative development.

2.6.2.5 Treatment

Air/Steam Stripping: In this technology, large volumes of air are mixed with contaminated water in either a packed tower system or basin arrangement system, or steam is injected to promote transfer of volatile organic compounds from the liquid phase to the gas phase. It is effective in removing VOCs and semi-VOCs from aqueous wastes where the organic concentration is less than one percent. It is not effective in removing low VOCs (Henry's law constant $< 10^{-3}$), highly soluble compounds, metals, or inorganic. Treated waste water would require further treatment if non-VOCs and metals are present. If not removed by pretreatment, metals and carbonates may precipitate out and reduce the packing efficiency of the tower by channelling. Monitoring and treatment of air emissions (ie, vapor phase carbon or catalytic convertor) may be necessary, and enclosures may be required. Residuals produced from the stripping process would consist of collected particulates which would have to go to a RCRA facility. This technology is commercially available, inexpensive, and easy to implement and operate. It will be carried forward as a support technology for the development of remedial alternatives.

Carbon Adsorption: In this technology, soluble molecules are removed from solution as they pass through a bed of activated carbon and bond onto the carbon surface. The activated carbon selectively adsorbs the contaminants by a surface attraction process in which molecules are attracted to the internal pores of the carbon granules. The contaminated stream is forced through the carbon using either pressurized tanks or gravity tanks.

Carbon adsorption is effective in removing organic liquids with metals or nitrogen, chelated metals, and VOCs from aqueous or gaseous wastes. However, the adsorption capacity is limited for low molecular weight compounds, compounds with high polarities and/or high solubility, and certain mixtures of organics. Waste streams with high suspended solids, soluble inorganic, or unassociated metals require pretreatment. Spent carbon and a small amount of sludge produced must be treated/recycled or disposed. This technology is commercially available, easy to implement, and requires periodic monitoring of effluent. The capital cost is low, but the operating costs may be moderate, depending on the type and concentration of contaminants in the input stream. Since it applies to the remedial objectives, it will be carried forward in the development of alternatives.

Reverse Osmosis: In this technology, solutes are separated from liquids when a pressure greater than the osmotic pressure of the system (approximately 300 - 1000 psi) is applied and forces the liquid through a semi-permeable membrane which functions by selectively rejecting contaminants based on pore size, ion valence, or co-precipitation.

It is effective in removing PCB's, chlorinated organics, insecticides and herbicides in groundwater, water high in BOD, and organic and inorganic leachates. This process is limited by temperature and pH of solution, pressure of the system, and chemical/physical structure of the membrane. The membrane is susceptible to plugging due to the presence of suspended solids, and oils, and to deterioration/destruction due to chemical reactions; therefore, pretreatment and prechlorination may be required. Further treatment of the waste stream is usually necessary, because a concentrated output waste stream equivalent to 10-20% of the feed volume is produced. Therefore, this technology is best used to polish low flow streams containing highly toxic contaminants. It is commercially available, and moderate in cost, but moderately difficult to implement even though the unit itself is easy to operate. This technology will not be carried forward in the development of alternatives since there are other options that would be more effective and easier to implement.

Molecular Sieves: In this treatment technology, contaminated water is passed over synthetically-produced anhydrous metal-alumina-silicates, and the soluble molecules in the water bond onto the surface of the activated aluminosilicate. This technology is effective for waste streams of an almost homogeneous nature because of the precise size and molecular dimensions of the sieve; therefore, it is not applicable for treatment of heterogeneous waste streams. It requires the utilization of numerous waste-specific molecular sieves, and as a result would be fairly expensive for the Fultz Landfill Site. It is not a widely used technology and is difficult to implement. This technology will be eliminated from further consideration, because it would not be effective for the heterogeneous waste to be treated from the Fultz Landfill Site.

Filtration: With this treatment technology, suspended solids are removed from a fluid by passing the fluid through a bed of granular material such as sand or a combination of sand and carbon. An underdrain system allows the filtered water to be drawn off while leaving the granular material in place. It is effective in removing suspended solids and particulate-borne contaminants. Spent material may require treatment and disposal. Filtration is often used as a pretreatment process or in conjunction with other treatment processes such as precipitation to remove suspended solids. Sampling during Phase II of the RI indicated that surface water and shallow groundwater at the Fultz Landfill Site contains a significant level of suspended solids. The risks associated with the contaminants are not reduced, however, and further treatment would be required. This technology is commercially available, inexpensive and easy to implement and operate. Hence, it will be carried forward as a support technology in the development of a remedial alternative.

Ion Exchange: In this technology, dissolved cations and anions in dilute aqueous waste can be removed from solution by electrostatically attaching to a solid resin material. This process yields a large volume of purified product (water) and a small volume of solution (spent regenerant) containing a high concentration of the extracted species. It is effective in removing all metallic anions and cations, inorganic anions, and organic acids and bases, but only for dilute concentrations. By placing cationic and anionic exchange columns in series, both types of dissolved ions can be effectively removed.

The resins are able to withstand a wide range of temperatures and pH, and capable of selecting for a specific ion. The resin bed is susceptible to clogging if high suspended solids or iron/manganese precipitants are present in the waste stream, therefore, pretreatment may be required. Oxidants in the waste stream should be avoided because they foul the system. It is recommended to perform a treatability test on the aqueous waste. Spent resin and concentrated toxic backwash stream produced require further treatment and disposal. This technology is commercially available and easy to implement. It can be operated manually or automatically; however, it requires a skilled operator to operate it manually. This technology will be eliminated from further consideration because there are other treatment processes that are more applicable for the type of waste.

Precipitation: This technology is a process by which the chemical equilibrium of a waste stream is altered to reduce the solubility of dissolved inorganic compounds. The process involves the addition of a coagulant or the alteration of the solution's temperature to decrease the solubility, mechanical mixing to aid in the precipitation, and time to allow the large particles to settle as sludge to be removed. It is effective for detoxifying aqueous solutions containing metals and suspended solids, but is not effective for organic compounds that may interfere in precipitation. Cyanide ions and other ions may also interfere in precipitation. The sludge produced will require further treatment prior to disposal. Treatability testing is recommended to determine appropriate coagulants and dosage. This process is commercially available, inexpensive and easy to implement. Hence, this technology will be carried forward in the development of remedial alternatives.

Neutralization: This process involves the addition of an acid or base to adjust the pH of a contaminated solution. Neutralization can be used as a final waste treatment process, or as a pretreatment process to prepare a waste stream for further treatment. Neutralization is used in many commercial applications and has a wide range of applicability to waste treatment. It is effective in treating organic and inorganic waste streams and spent acid/alkali wastes. The required dosage is affected by the buffer capacity and the waste concentration. Wastes with a pH between 4 and 9 may not be

effectively treated. Toxic gases may be produced and complex compounds may not be effectively removed. Depending on the waste characterization, a sludge may be produced that will require further treatment prior to disposal. This technology is commercially available, inexpensive and easy to implement. Used alone neutralization may not be an effective technology, but could be used effectively in combination with other treatment technologies and, therefore, will be carried forward as a support technology in the development of remedial alternatives.

Oxidation/Reduction: This process involves a chemical transformation of contaminants by the addition of an oxidizing or reducing agent which raises or lowers the oxidation state of the contaminants while the agent is reduced or oxidized. It is effective in reducing the toxicity of many organics and metals, but is limited by the presence of a wide range of contaminants and of high organic concentrations. The treatment process usually requires pH adjustment of the waste stream, followed by oxidizing agent addition, mixing, and some type of settling or precipitation procedure. This technology is commercially available, inexpensive and easy to implement. Used alone oxidation/reduction may not be an effective technology, but could be used effectively in combination with other treatment technologies and, therefore, will be carried forward as a support technology in the development of remedial alternatives.

Ultraviolet Photolysis: With this treatment technology, the chemical bonds of an organic contaminant are broken using a combination of ultraviolet light and hydrogen peroxide. Ultraviolet light sources would include sunlight, florescent lamps, or mercury arcs. UV photolysis is effective in treating water contaminated with VOCs and chlorinated organic compounds without resulting in air emissions or generation of hazardous waste. When combined with hydrogen peroxide, ultraviolet photolysis significantly enhances chemical degradation rates for certain organic compounds; however, it is moderately expensive and not geared towards large scale groundwater treatment. This process will not be retained for further consideration since there are other options that are as effective and widely used.

Biological Treatment: This technology utilizes micro-organisms to biodegrade specific organic contaminants under aerobic (presence of oxygen) or anaerobic (absence of oxygen) conditions. Biological treatment is effective in treating many non-halogenated organics and capable of removing low levels of heavy metals. It can be effective in treating pesticide, herbicides, halogenated hydrocarbons and solvents with the addition of activated carbon. The micro-organisms are adaptable to the contaminants and the ease at which biodegradation occurs is contaminant-specific. The micro-organisms perform at an optimal pH (7) and temperature (50-60 F) and require proper nutrients, therefore, this process requires frequent monitoring and maintenance. This treatment process can be more effective if combined with another technologies such as precipitation and filtration. The reliability of this process can be adversely affected by "shock" loads of contaminants, by start-up, and by detention time. Depending on the waste characterization, the sludge produced may require further treatment prior to disposal. It is commercially available, but is moderately expensive and moderately difficult to implement. This process option will be eliminated from further consideration, because the expected biological oxygen demand (BOD) of the combined groundwater and leachate that would be treated may be too low, and there are other options as effective.

3.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

3.1 INTRODUCTION

In this section, potential remedial alternatives are developed using the remedial technologies that passed the technology screening in Section 2 (see Figures 2-3 and 2-4). Surviving technologies that would be used to implement these response actions are summarized in Table 3-1. Many of the surviving technologies are feasible at the Fultz Landfill Site for limited applications or as support technologies. Applications for each technology are also presented in Table 3-1. Easily implemented actions such as site fencing, deed restrictions, public information programs, and institutional actions are combined under the general title "Institutional Controls."

Most of the technologies that survived screening address both the solid and water operable units. Because of this, the distinction between solids and waters will not be used in the development of alternatives. Rather, the remaining technologies are grouped into alternatives that would remediate the site as a whole.

The alternative development process is governed by regulatory and published guidance, as well as by site specific characteristics. A discussion of alternative development criteria and guidelines is presented in Section 3.2, the development of alternative is presented in Section 3.3, and alternative screening is presented in Section 3.4.

3.2 REMEDIAL ALTERNATIVE DEVELOPMENT CRITERIA

Development of alternatives must conform to requirements identified in CERCLA, as amended, and to the extent possible, the National Contingency Plan (NCP). Section 300.68 of the NCP specifically refers to ARARs in the Development of Alternatives. CERCLA Section 121(d) requires that Superfund remedial actions attain ARARs or other Federal statutes. Superfund remedial actions must also

TABLE 3-1
 SURVIVING TECHNOLOGIES AND APPLICATIONS
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT

TECHNOLOGY	PROCESS OPTION	APPLICATION/LIMITATIONS
LANDFILL SOLIDS, SEDIMENTS, AND SOILS		
Monitoring	Leachate, Air, Sediments	Combine with other actions.
Institutional Controls	All	Combine with other actions.
Capping	Multi-layer Cap	Used to close the existing landfill. The minimum attainable slope would be 5.5%
Surface Controls	Grading and Revegetation	Use in the implementation of alternatives with a cap and on-site landfill.
	Sediment and Erosion Controls	Required for construction of cap and on-site landfill.
Structural Supports	Mine Flushing	Use with capping options.
	Grout Pillars	Use with capping options.
Excavation		Use in the construction of an on-site landfill, and in the relocation of pond sediments.
Landfill	On-site Subtitle D Type	Relocate wastes to a lined landfill on the eastern end of the site.
GROUNDWATER, SURFACE WATER, AND LEACHATE		
Monitoring	Air, Surface Water, Groundwater, Leachate, Sediment	Combine with other actions.
Institutional Controls	All	Combine with other actions.
Alternate Water Supply	City Water	Combine with other actions.
Vertical Barriers	Slurry Wall	Use for groundwater diversion only.
Gradient Controls		Would result from operation of extraction wells, or the construction of a slurry wall.
Extraction Wells		To intercept groundwater driven contaminant migration in conjunction with other actions.
Subsurface Drains		Used as elements in cap and/or on-site landfill to divert groundwater and collect leachate.
Treat and Discharge	Surface Water Discharge	Discharge after Treatment
Water Treatment Technologies	See Section 3.4.4.3	Used to treat leachate, groundwater, etc. as part of other options.
Direct Discharge	Permitted Treatment Facility	Disposal of untreated landfill leachate at a permitted facility.

attain state requirements that are more stringent than Federal requirements to the extent they are also applicable or relevant and appropriate and are identified to EPA in a timely manner.

CERCLA, Section 121(b) identifies the following statutory preferences when developing and evaluating remedial alternatives:

- Remedial actions that involve treatments that permanently and significantly reduce the volume, toxicity, or mobility of the contaminants or hazardous substances are preferred over remedial actions not involving such treatment.
- Off-site transport and disposal of hazardous substances or contaminated materials without treatment is considered the least-favored remedial action when practical treatment technologies are available.
- Remedial actions using permanent solutions, alternative treatment technologies, or resource recovery technologies shall be assessed.

Considering CERCLA statutory preferences and site-specific response objectives, remedial alternatives developed herein are designed to meet the following criteria to the maximum extent practicable:

- The remedial alternative is protective of human health and the environment.
- The remedial alternative attains chemical-specific ARARs and can be implemented in a fashion consistent with location-and action-specific ARARs.
- The remedial alternative reduces the volume, toxicity, or mobility of site contaminants.
- The remedial alternative uses permanent solutions and alternative treatment technologies to the maximum extent practicable.
- The alternatives developed are capable of achieving a remedy in a cost-effective manner.

OSWER Directive 9355.3-01, "Guidance for Conducting RI/FS Under CERCLA," Interim Final, October, 1988, indicates that a range of source control alternatives should be developed that include:

- A no-action alternative
- One or more alternatives that utilize containment with little or no treatment, but protect human health and the environment by preventing exposure.
- A number of treatment alternatives that range from one that would eliminate, to the extent possible, the need for long-term site management, to one which uses treatment as a principal component to mitigate major threats at the site.

Relative to management of migration alternatives for groundwater, OSWER Directive 9283.1-2, "Guidance on Remedial Actions for Contaminated Groundwater at Superfund Site," December, 1988, indicates that . . .

"Several types of remedial action alternatives that span a range of technologies and restoration time frames should be developed early in the FS process. Potential response approaches include the following:

- An active restoration alternative that reduces contaminant levels to required cleanup levels in the minimal time feasible
- Additional active restoration alternative that achieve cleanup levels over longer time frames
- A plume containment alternative that prevents expansion of the plume
- A natural attenuation alternative that includes institutional controls and monitoring
- An alternative involving wellhead treatment or provision of an alternative water supply and institutional controls when active restoration is not practicable."

3.3 DEVELOPMENT OF ALTERNATIVES

In developing remedial alternatives, consideration has been given to the guidance presented in Section 3.2, the remedial action objectives presented in Section 2.3, and the limitations caused by the physical conditions at the Fultz Landfill Site. Significant site conditions such as the complicated contaminant migration routes, the former underground mine under most of the site, the need to minimize impacts on the potential wetlands in Stream Valley

A, and the infeasibility of treating landfill solids severely limit the range of alternatives that can be developed. Another limitation on the development of alternatives is the lack of options that would vary aquifer restoration times. This is because the only feasible technology to attempt aquifer restoration would be a series of extraction wells to intercept one or more of the migration paths and extract groundwater from the shallow aquifer for treatment. Since the source material would remain in place, there is little that can be done to vary the cleanup time of the shallow aquifer. One alternative includes groundwater extraction and treatment. As previously discussed, alternatives that entail treatment of the contaminated source material have not been developed, as they have been determined to be not feasible. Source containment is also limited to capping the existing landfill, with or without restricting the flow of groundwater underneath the landfill.

The alternatives developed from combining the technologies and process options that survived screening steps, considering prior discussions as well, are as follows:

- | | |
|---------------------|---|
| Alternative No. 1: | No Action |
| Alternative No. 2: | Institutional Controls and Monitoring |
| Alternative No. 3: | Multi-layer Cap |
| Alternative No. 4: | Multi-layer Cap with Groundwater Extraction and Treatment |
| Alternative No. 5: | On-site RCRA Landfill |
| Alternative No. 6: | Multi-layer Cap with Subsurface Barrier |
| Alternative No. 7: | Groundwater Extraction (without cap) |
| Alternative No. 8: | Cap with Upgrade of the Byesville Water Treatment Plant. |
| Alternative No. 9: | On-site Landfill with Groundwater Extraction |
| Alternative No. 10: | Coal mine aquifer cut-off barrier. |

The remedial action objectives are summarized as follows:

1. Reduce risks to human health associated with the present use of contaminated groundwater from either the shallow or coal mine aquifers.
2. Reduce risks to human health associated with the inhalation of airborne contaminants from the landfill area.
3. Reduce risks to human health associated with the future use of groundwater from either the shallow or the deep aquifer.
4. Reduce risks to the environment associated with excessive manganese and aluminum concentrations in the on-site surface waters.

3.3.1 ALTERNATIVE 1: NO ACTION

The site will be left as is without taking any steps to reduce the risks of exposure to contamination. The risks were defined in detail in the public health risk assessment in Phase II of the RI.

3.3.2 ALTERNATIVE 2: INSTITUTIONAL ACTIONS AND MONITORING

This alternative attempts to meet the remedial action objectives 1, 2, and 4 by restricting access to the site thereby preventing human exposure. Remedial action objective 4 is addressed also by restrictions on future use of the site for water supplies and habitation.

The components of Alternative 2 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring

3.3.2.1 Institutional Controls

Institutional controls will be implemented to reduce exposure to site contaminants by legally restricting access to the site. These will include

deed restrictions on land and water use, a public information program to advise nearby residents of the nature of the problem at the site, zoning ordinances that will forbid future uses of the site that will expose humans to contamination, and local ordinances restricting the drilling of wells and the use of groundwater and surface water. The intent of these restrictions will be two-fold: first, to eliminate groundwater usage as a potential exposure route, and second, to restrict future on-site voluntary activities, such as excavation, that would result in increased exposure to contaminants. Deed restrictions will be enforced at the local level, perhaps by local officials or the local municipal authority. The extent of the restrictions will be determined by the results of the monitoring program outlined below. The public education program will serve to increase public awareness of the hazards associated with the contaminated landfill solids and soils and groundwater from the site. This program will be designed by the U.S. EPA or the State of Ohio, in cooperation with the local governing authorities. Potential components of the public education program could include presentations at public meetings, mailing information to individual residents, and meeting with the local authorities who will be implementing the deed restriction program and land use ordinances.

3.3.2.2 Site Fence

Prior to the commencement of any work on the Fultz Landfill Site and immediately following initial mobilization, an equipment staging/site admittance area will be constructed. A 6-foot high chain-link fence approximately 10,000 feet in length, as shown in Figure 3-1, will be installed around the entire Fultz Landfill Site to restrict access and reduce direct exposure to surface contamination. The fence will be topped with barbed wire and equipped with warning signs posted at 100-foot intervals along the fence. Periodic inspection and maintenance of the fence will also be required. Locked gates will be installed to permit controlled access to the site for monitoring and maintenance.

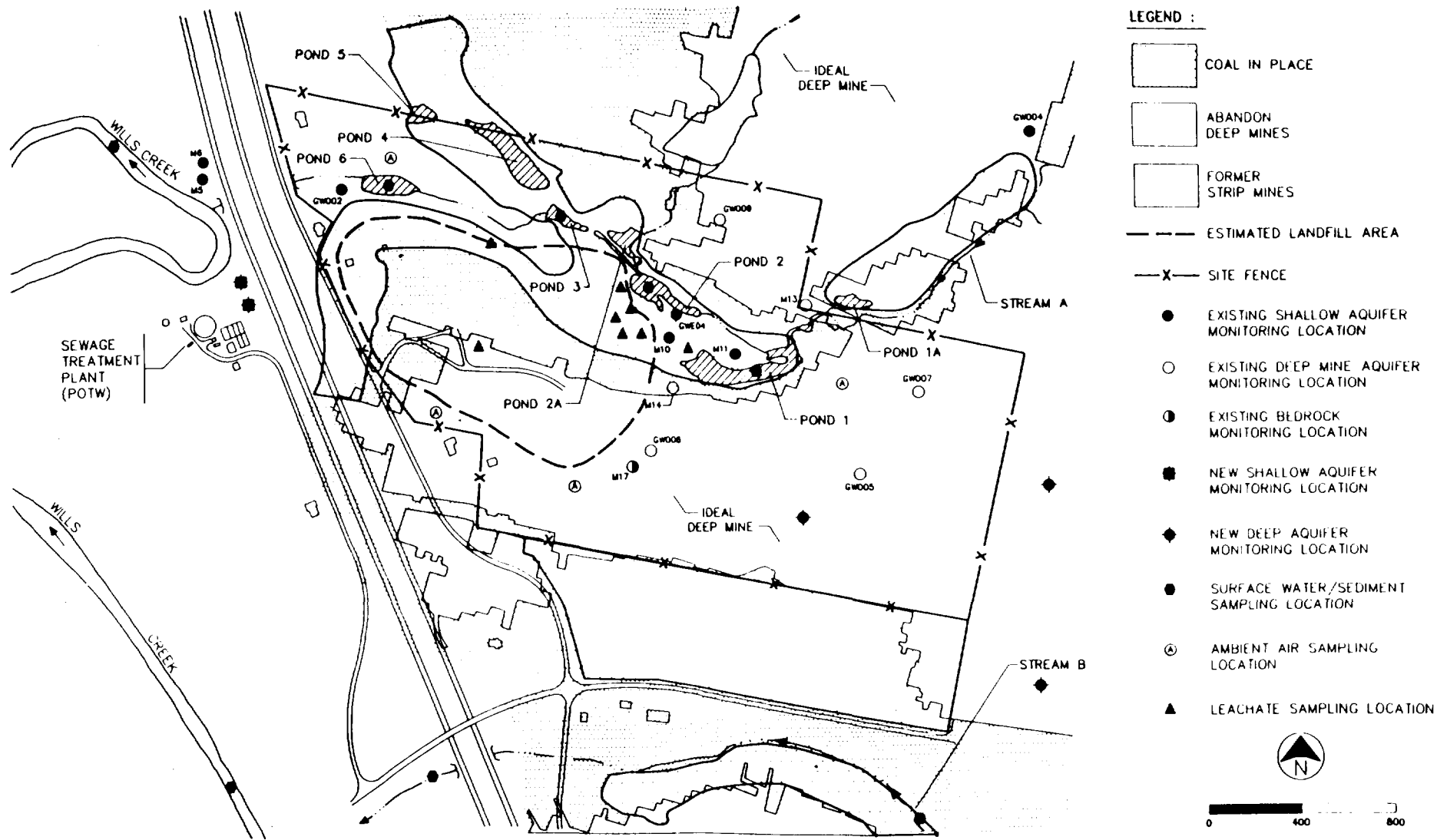


FIGURE 3-1
 ALTERNATIVE 2
 INSTITUTIONAL ACTIONS
 AND MONITORING
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

3.3.2.3 Alternate Water Supply

A water supply inventory will be conducted to identify all residential wells that are downgradient and within a one-mile radius of the Fultz Landfill Site. The depth of each well will be ascertained to determine if it is screened in one of the potentially contaminated aquifers. A sample will be taken from each well and analyzed using analytical methods appropriate to characterize water intended for drinking for the full CLP Target Compounds List for organic contaminants (TCL) and the Target Analyte List for inorganic contaminants (TAL). Residences with wells that are found to present an unacceptable risk will be connected to the municipal water supply. The number of wells that will be sampled will also be identified during the water supply inventory. Phase I of the RI estimated that there are 100 drinking-water wells within a one-mile radius of the Fultz Landfill Site. For the purpose of estimating the cost of this remedial action, it is assumed that 50 residential wells will be sampled, and one-half of these will need to be connected to the municipal water supply.

3.3.2.4 Monitoring

Long-term monitoring of air, surface water, leachate, groundwater, and sediments will be performed in accordance with Ohio Administrative Code 3745-54-90 through 99 and other applicable regulations for a minimum of 30 years to evaluate the migration of contaminants from the landfill and to monitor the effects of natural attenuation. Potential sampling locations are presented on Figure 3-1. The actual monitoring plan will be determined during remedial design. One possible monitoring plan could be as follows:

Ambient air monitoring will be performed quarterly at a minimum. Four samples obtained from the vicinity of the landfill (1 upwind and 3 downwind) will be analyzed for volatile contaminants.

This monitoring will be performed in an effort to identify any increases in the levels of volatile organic compounds in the ambient air over time.

Combustible gas monitoring must also be performed in accordance with existing regulations (Ohio Administrative Code 3745-27-12).

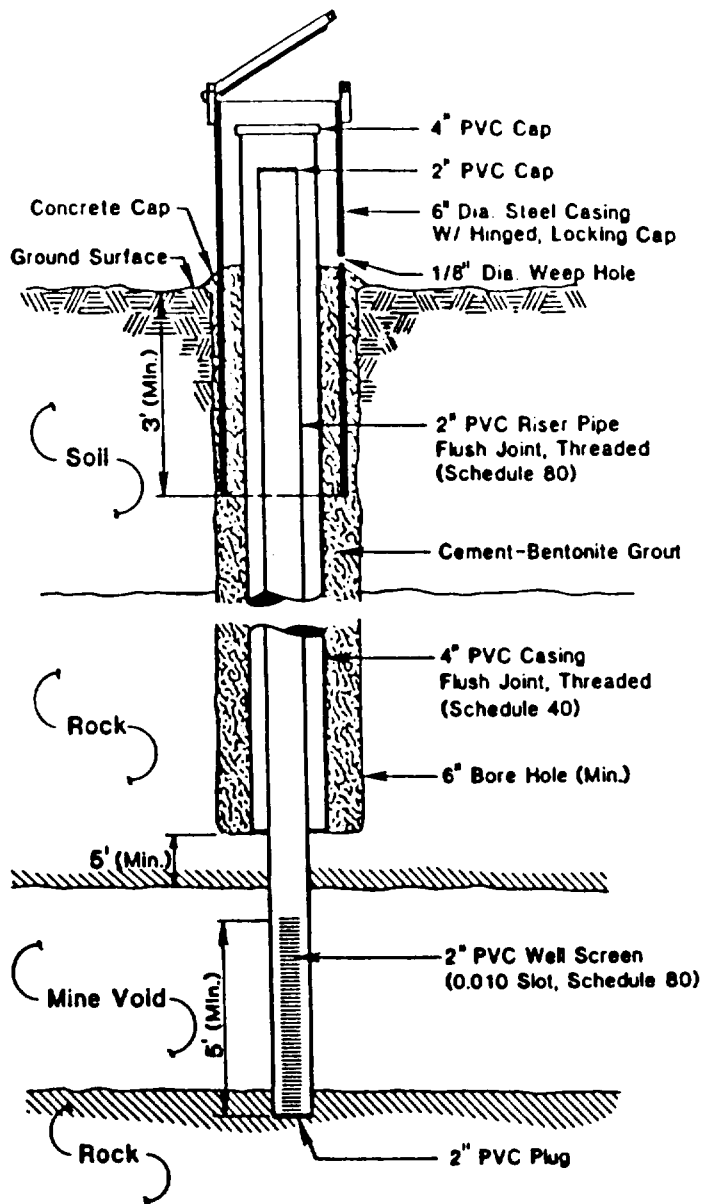
Quarterly monitoring of surface water and sediment will be performed at 2 locations in Wills Creek, two locations in Stream B, and one location in each of Ponds 1, 2, 3, and 6. Chemical analysis will consist of the full Target Compounds List for organic contaminants (TCL) and Target Analyte List for inorganic contaminants (TAL). The purpose of this sampling and analysis will be to monitor the levels of various contaminants in Valley A, Valley B, and Wills Creek resulting from the discharge of the shallow and coal mine aquifers, or leachate from the landfill, to the ponds or streams.

Quarterly sampling of leachate at 8 locations will be performed as well. The purpose of these samples will be to monitor any changes in the level of contamination in the leachate over time. Leachate will be analyzed for the same parameters as surface water/sediment.

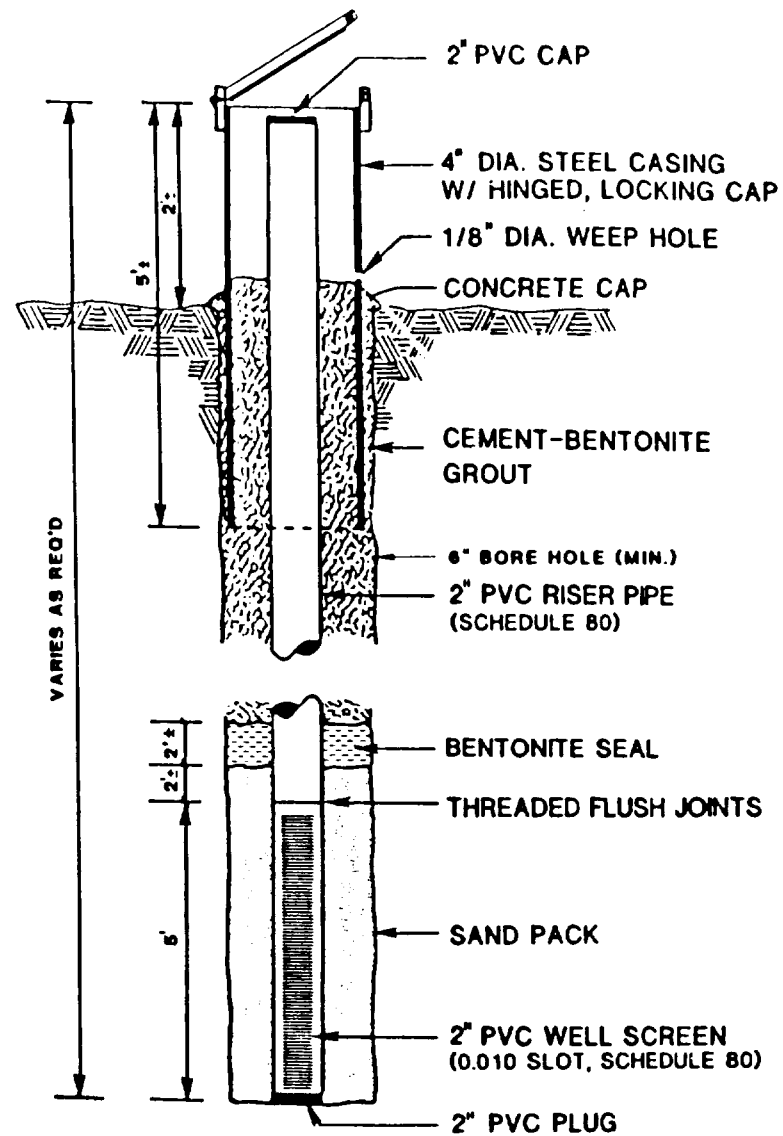
For groundwater monitoring, existing regulations (Ohio Administrative Code 3745-27-10 and Ohio Administrative Code 3745-65-91) call for a minimum of one upgradient well and three downgradient wells. Because of the size and complexity of the Fultz Landfill Site, additional monitoring should be performed. Details of typical monitoring wells are presented in Figure 3-2. One potential groundwater monitoring plan would be as follows:

- Shallow Aquifer: 10 points (8 existing wells, 2 new)
- Coal mine Aquifer: 9 points (6 existing wells, 3 new)

Two new wells in the shallow aquifer will be needed to fill a data gap that exists downgradient of the existing landfill to the west. The wells will be installed at depths similar to M5 and M6. Three new coal mine aquifer wells will be needed downgradient of the existing landfill to the southeast to supplement GW005 and GW006 in detecting possible migration of contaminants towards the Byesville municipal well. One of the new coal mine aquifer wells will be installed southeast of the existing landfill in an area where the mine



CONSTRUCTION DETAIL OF MINE MONITORING WELL



CONSTRUCTION DETAIL OF SHALLOW MONITORING WELL

FIGURE 3-2
 TYPICAL MONITORING WELLS
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

is constricted because contamination that might not be detected in other wells would be more likely to be dictated in this area.

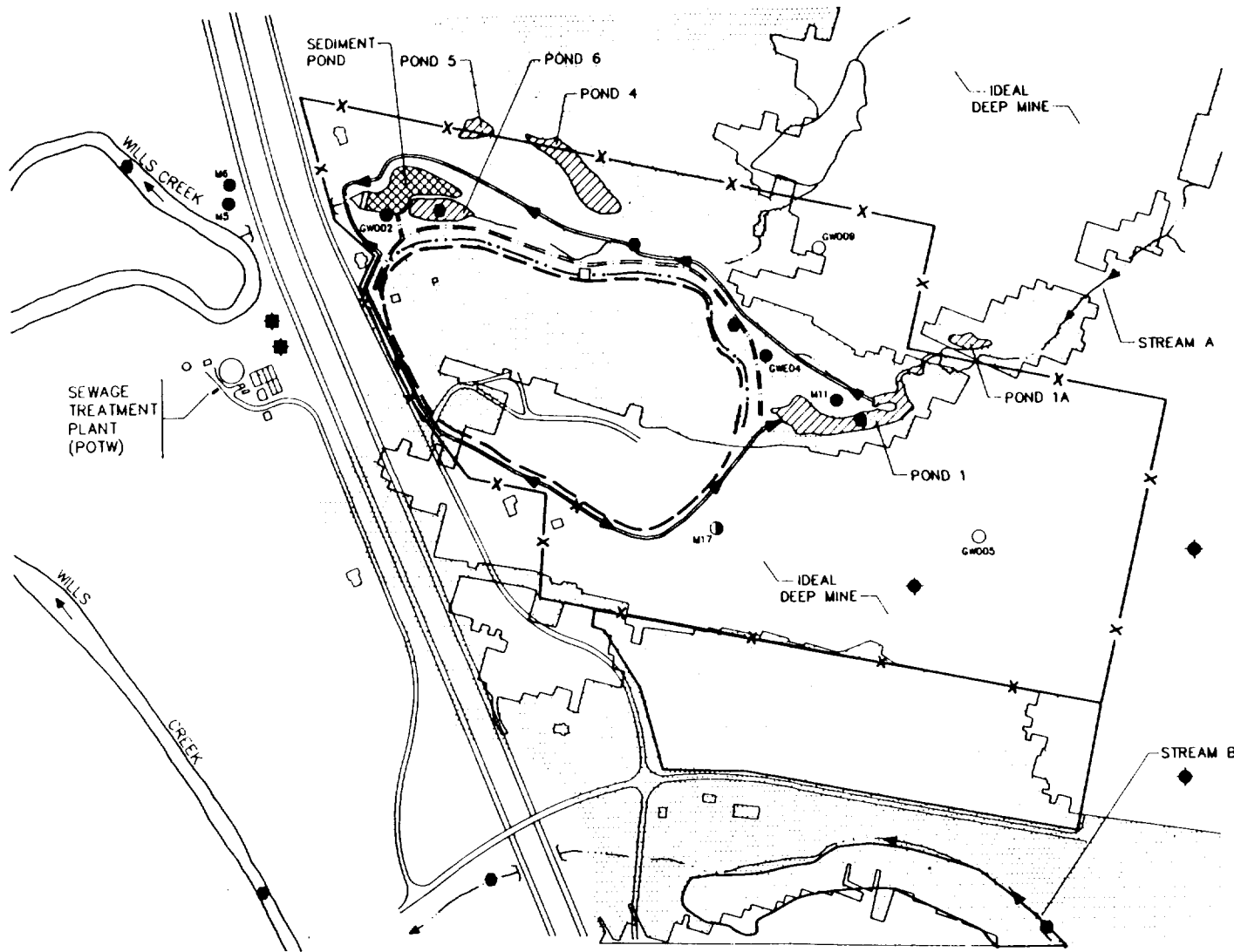
Groundwater sampling will be performed semi-annually at a minimum. The above-referenced monitoring program should be sufficient to monitor contaminant migration both horizontally and vertically. Chemical analysis will consist of the full TCL and TAL. Five-year reviews will be instituted in order to re-evaluate the site conditions on a periodic basis. The reviews will include a detailed analysis of the long-term monitoring data, a temporal and spatial evaluation of contaminant migration and attenuation in various media, an assessment of current residual health risks, an evaluation of the effectiveness of the institutional controls, response to public comments or complaints received during the five-year period, and an evaluation of what additional remedial measures, if any, should be implemented based on the reviewed site conditions.

3.3.3 ALTERNATIVE 3: MULTI-LAYER RCRA CAP















Closure of the existing landfill will be performed by installation of a cap, gas venting system, and leachate collection system. The cap will meet the remedial action objectives 1, 3, and 4 by reducing the migration of contamination from the landfill into the shallow and coal mine aquifers and the production of leachate. A cap will meet remedial action objective 2 by preventing exposure through direct inhalation of airborne contamination. The cap will be designed to meet Ohio landfill closure requirements. A plan view of the location of the major components of Alternative 3 is presented in Figure 3-3.

The components of Alternative 3 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Subsurface Structural Supports



LEGEND :

-  COAL IN PLACE
-  ABANDON DEEP MINES
-  FORMER STRIP MINES
-  ESTIMATED LANDFILL AREA AND MULTI-LAYER CAP
-  SITE FENCE
-  CLEAN WATER DIVERSION DITCH
-  TEMPORARY SEDIMENT CONTROL DITCH
-  SUBDRAIN SUMP AND PUMP LOCATION FOR LEACHATE COLLECTION
-  EXISTING SHALLOW AQUIFER MONITORING LOCATION
-  EXISTING DEEP MINE AQUIFER MONITORING LOCATION
-  EXISTING BEDROCK MONITORING LOCATION
-  NEW SHALLOW AQUIFER MONITORING LOCATION
-  NEW DEEP AQUIFER MONITORING LOCATION
-  SURFACE WATER/SEDIMENT SAMPLING LOCATION

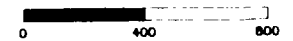


FIGURE 3-3
ALTERNATIVE 3
MULTI-LAYER CAP
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

- Surface Water and Sediment Controls
- Multi-layer Cap
- Leachate Collection System
- Wetlands Replacement

3.3.3.1 Institutional Controls, Site Fence and Alternate Water Supply

Items 3.3.2.1 through 3.3.2.3 of Alternative 2 will be performed.

3.3.3.2 Monitoring

Because the landfill will be capped with this alternative, and the leachate collected for off-site disposal, no leachate samples will be collected for analysis. Long-term monitoring of surface water, groundwater, combustible gas, and sediments will be performed in accordance with Ohio Administrative Code 3745-54-90 through 99 and other applicable regulations for a minimum of 30 years to evaluate the migration of contaminants from the landfill and to monitor the effects of natural attenuation.

Semi-annual monitoring of surface water and sediment will be performed in a total of 8 locations, namely, at 2 locations in Wills Creek, two locations in Stream B, one each in Ponds 1 and 6, and two locations in the diversion channel between ponds 1 and 6. Chemical analysis will consist of the full TCL and TAL. The purpose of this sampling and analysis would be to monitor the levels of various contaminants in Valley A, Valley B, and Wills Creek resulting from the discharge of the shallow and coal mine aquifers, or leachate from the landfill, to the ponds or streams.

For groundwater monitoring, existing regulations (Ohio Administrative Code 3745-27-10 and Ohio Administrative Code 3745-65-91) call for a minimum of one upgradient well and three downgradient wells. Because of the size and complexity of the Fultz Landfill Site, additional monitoring should be performed. One potential groundwater monitoring plan is as follows:

Shallow Aquifer: 10 points (8 existing wells, 2 new)
Coal mine Aquifer: 9 points (6 existing wells, 3 new)

Two new wells in the shallow aquifer will be needed to fill a data gap that exists downgradient of the existing landfill to the west. The wells will be installed at depths similar to M5 and M6. Three new coal mine aquifer wells will be needed downgradient of the existing landfill to the southeast to supplement GW005 and GW006 in detecting possible migration of contaminants towards the Byesville municipal well. One of the new coal mine aquifer wells will be installed southeast of the existing landfill in an area where the mine is thought to be constricted because contamination that might not show up in other wells would be more likely to show up in this area.

Groundwater sampling will be performed on a semi-annual basis at a minimum. The above monitoring program should be sufficient to monitor contaminant migration both horizontally and vertically. Chemical analysis will consist of the full TCL and TAL.

Five-year reviews will be instituted in order to re-evaluate the site conditions on a periodic basis. The reviews will include a detailed analysis of the long-term monitoring data, a temporal and spatial evaluation of contaminant migration in various media and the extent of natural attenuation, and an assessment of residual health risks. The review will also include an evaluation of the effectiveness of the institutional controls, responses to public comments or complaints received during the five-year period, and an evaluation of what additional remedial measures, if any, should be implemented based on the reviewed site conditions.

3.3.3.3 Subsurface Structural Supports

Subsurface support will be provided for the mine voids under the landfill to prevent damage of the cap by subsequent mine subsidence and to reduce the potential for bedrock fracturing between the landfill and the coal mine aquifer. There are two standard approaches to providing subsidence supports, namely, grout pillars and mine flushing.

The grout-pillar approach provides roof support by drilling into a mine cavity and installing wide pillars made of material similar to concrete. The pillars

are installed so that they achieve a minimum contact area (generally six feet in diameter) with the roof of the mine. The pillars are built up in layers to prevent the concrete from slumping away. In areas where the mine is flooded, special admixtures are added to the mix to compensate for the water in the mine.

Mine flushing attempts to fill entire mine voids with a lower cost mixture, usually consisting of fly ash, cement, sand, and water. Sometimes coarser aggregate is used in sloping or flooded mines. The mix is pumped down a borehole into the mine with a large quantity of water. As the mix flows through the mined-out rooms, the solids settle out of the mix and the water flows through. After a time the solids build up from the mine floor to the roof providing support.

Grout pillars use a small volume of relatively costly material and rely on good design and placement to achieve the desired support of the mine roof. Mine flushing uses large quantities of less costly materials but the design and placement of the borings are less important. In the case of the Fultz Landfill Site, the cost of grout pillars would be about half the cost of mine flushing for the same area. For the purpose of the feasibility study, mine flushing has been selected as the representative process option because the design less complicated and the technology is more reliable. A cost estimate for the installation of grout pillars is included as an optional element. Mine flushing appears to fall under the Underground Injection Control (UIC) Program (40 CFR 144). The full impact of UIC restrictions will be determined during remedial design. At a minimum, mine flushing materials would require testing to assure that the operation would have no detrimental impact on the coal mine aquifer as a source of drinking water.

3.3.3.4 Surface Water and Sediment Controls

Part of Stream Valley A northeast of the existing landfill will be regraded to eliminate standing surface water, and divert runoff away from the landfill. This will include filling in Ponds 2, 2A, and 3 and constructing a clean water diversion channel in the approximate location of Stream A from the western end

of Pond 1 to the culvert downstream of Pond 6 to divert runoff away from the landfill. In order to provide sediment control for earth disturbances resulting from capping the landfill, a sediment control pond will be constructed in an area to the northwest of Pond 6. The size of the sediment pond at maximum pool level will be equal to or greater than the combined area of Ponds 2, 2A, and 3. A sediment control ditch will be constructed at the base of the existing landfill to channel runoff from the landfill to the sediment control pond. The northern part of Valley A along the border of the existing landfill will be filled and graded to elevation 820 feet MSL to remove standing surface water from that part of the valley. Ponds 2, 2A, and 3 will be breached and filled in to avoid interference with the leachate collection system. The outlet elevation of Pond 1 will be reduced from elevation 814 feet MSL to elevation 808 feet MSL for the same purpose. This will cause an estimated 20% reduction in the size of the pond, while significantly reducing the potential for groundwater flow from Pond 1 to the leachate collection system.

3.3.3.5 Multi-layer Cap

A berm will be constructed of compacted clay along the northern side of the landfill to bring the toe of the cap up to elevation 835 feet MSL and reduce the overall slope of the cap to about 5-1/2%. Following the construction of the containment berm, a multi-layer cap will be installed over the entire landfill. A detail schematic of the multi-layer cap is presented in Figure 3-4. Cap layers will include (from the bottom up):

- Random earth fill required in places to grade off the existing landfill and establish an even slope of 5-1/2%;
- A synthetic drainage layer for gas collection with filter fabric above and below;
- A 24-inch thick compacted clay layer (10^{-7} cm/s permeability);
- A 40-mil HDPE synthetic liner;
- A synthetic drainage layer for infiltration with filter fabric above;
- A 30-inch thick random earth fill;
- A 6-inch thick topsoil layer.

3-18

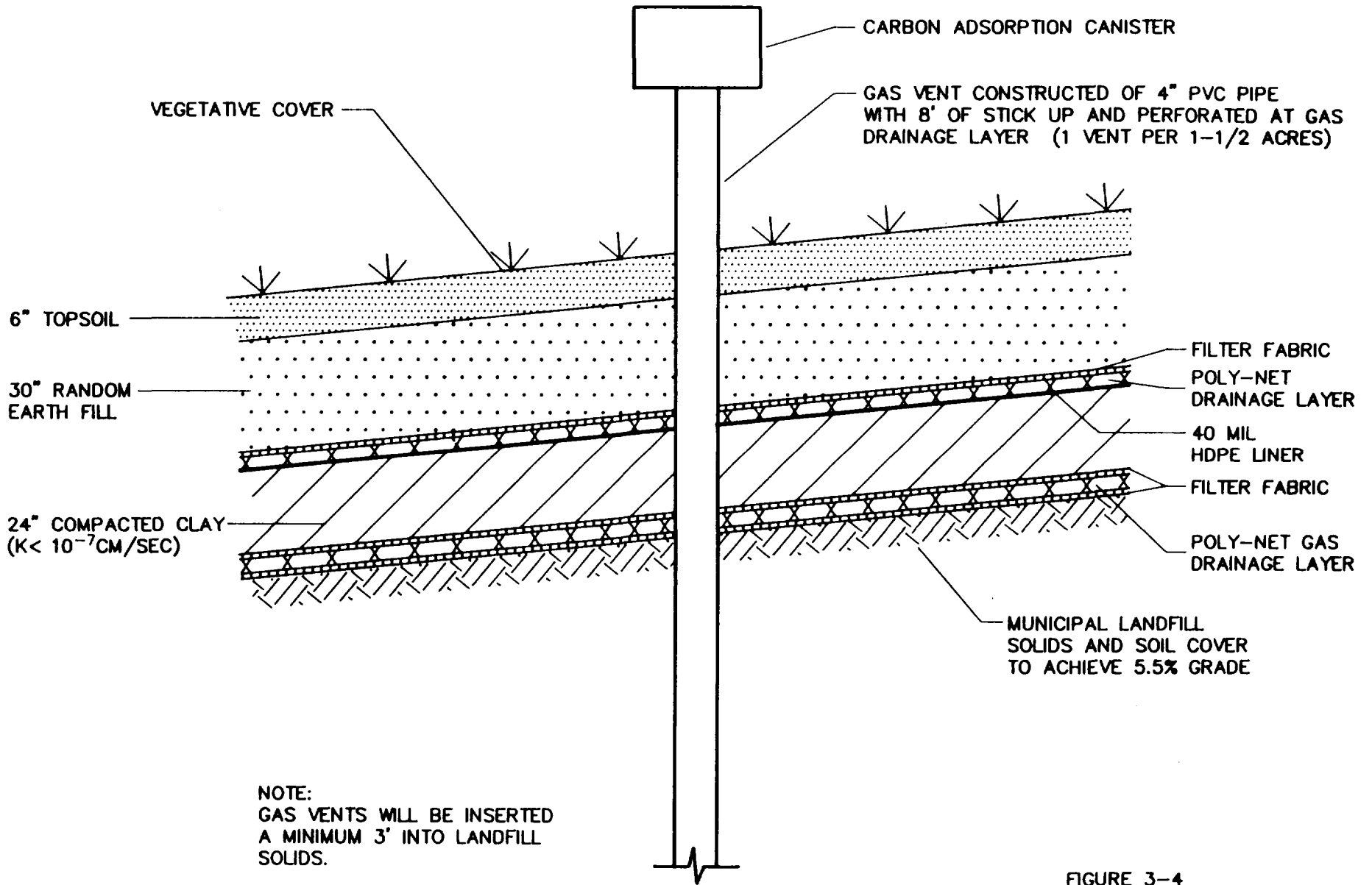


FIGURE 3-4
ALTERNATIVE 3
MULTI-LAYER CAP DETAIL
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

Since the existing landfill is constructed on a series of benches on the side of a hill, it must be protected from infiltration by groundwater and surface-water run-off from the hill above. Extending the cap to the crest of the hill would require a very large quantity of fill on the southern side of the landfill to bring it up to grade. When finished, the slope of the cap would exceed 12% from the top of the hill to Stream Valley A, and the size of the cap would be about 15% larger than the area of the existing landfill. Construction would require the relocation of one local resident. For these reasons, it is preferable to use surface and subsurface diversion drains at the top of the landfill to collect and divert any water which might flow towards the landfill.

The subsurface drain will consist of a channel excavated to bedrock, with an HDPE liner on the downgradient side filled with crushed rock or gravel. A perforated collection pipe will be embedded in the gravel at a slope that will allow the groundwater to drain freely around the landfill into Pond 1 on the eastern side and Stream A on the western side. The uppermost two feet will be backfilled with earth and topsoil over a layer of filter fabric. The surface water diversion will consist of a grouted rip-rap lined channel along the base of the hill overlooking the landfill. Grouted rip-rap will be needed because of the steep slopes leading away from the landfill. The channel will be sized to carry at least a 100-year 24-hour storm with adequate freeboard to prevent over-topping. Figure 3-5 shows details for both the subsurface and surface water diversions.

3.3.3.6 Leachate Collection System

The quantity of leachate that will be produced by the landfill once it is capped was estimated using the U.S.G.S. HELP model. The current rate of infiltration predicted by the HELP model is 4.2 inches per year or about 4.88 gallons per minute (GPM). This prediction corresponds well with the field estimates of the volume of seeps from the landfill as 2 to 4 GPM. After capping, the steady-state infiltration is predicted to be 0.02 inches per year or 0.02 GPM. Observations of the leachate seeping out of the landfill during the remedial investigation indicate that the moisture in the landfill may be

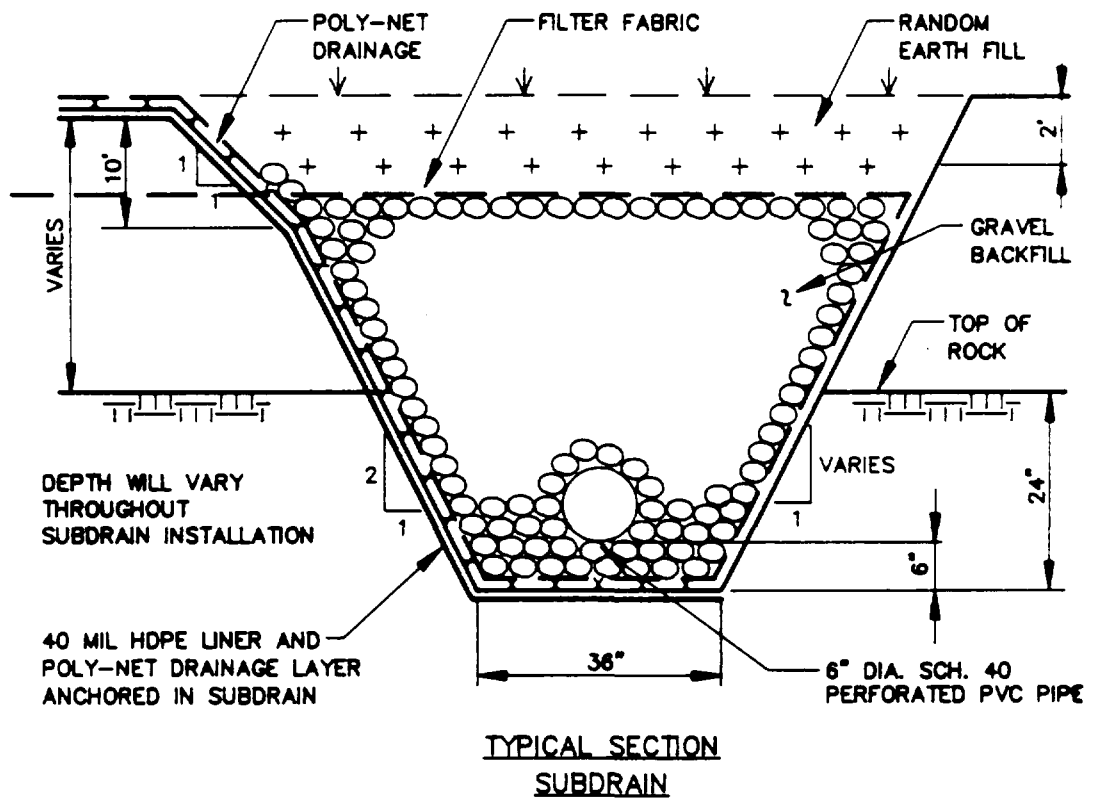
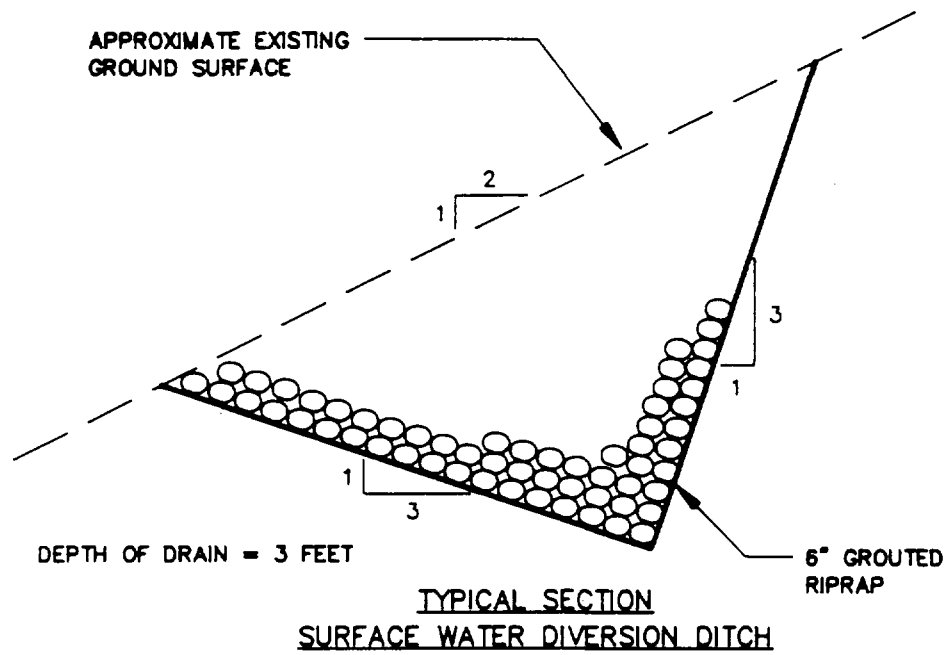


FIGURE 3-5
ALTERNATIVE 3
DIVERSION DITCH DETAIL,
SUBDRAIN DETAIL
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

much higher than under steady state capped conditions. This means that the existing landfill may continue to drain for many years after it is capped. Therefore, the HELP model was run for the capped landfill starting with initial moisture conditions matching the final conditions of the existing landfill model. Running the model over a 25-year period indicated that moisture will continue to flow out of the landfill for more than 25 years at rates that range from 1.13 GPM over the first five years declining to 0.32 GPM for the final 5 years. The 30 year average flow is predicted to be 0.68 GPM. For the purpose of designing a treatment system or estimating disposal costs, a conservative maximum flow of 2 GPM will be assumed. This conservative rate makes allowance for some additional infiltration that might occur from Pond 1 and/or the shallow aquifer in Stream Valley A under high flow conditions.

A leachate collection system will be installed along the northern side of the landfill to intercept groundwater leaving the landfill. It will consist of a subdrain similar to the upgradient groundwater diversion drain extending below the lowest elevation of landfill waste or about elevation 795 feet MSL. The rock drain will be sloped to a central sump from which the accumulated leachate can be pumped for off-site treatment or disposal (Figure 3-3).

3.3.3.7 Wetlands Replacement

During the design and construction of Alternative 3, every effort will be made to minimize the disturbance of areas identified as wetlands. When the destruction of wetland environment is anticipated from proposed remedial activities a study will be performed to delineate the extent of wetlands and develop a plan for remediation. At a minimum, the wetlands replacement plan would include replacement or restoration of the ponds and surrounding habitat. Upon completion of construction, the clean water diversion channel will be re-routed into the sediment pond, and the base water level of the sediment pond will be raised to provide pond surface area equal to the area lost by the elimination of Ponds 2, 2A, 3 and the lowering of the pool level of Pond 1.

3.3.4 ALTERNATIVE 4: MULTI-LAYER CAP,, GROUNDWATER EXTRACTION AND ON-SITE TREATMENT

This alternative will attempt to meet the remedial action objectives in the same way as Alternative 3, with the added advantage that contaminated groundwater will be removed from the shallow aquifer and treated. The groundwater extraction and treatment system attempts to improve the effectiveness of Alternative 3 by directly intercepting a groundwater contaminant migration route and removing leachate directly from the existing landfill.

The components of Alternative 4 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Subsurface Structural Supports
- Surface Water and Sediment Controls
- Multi-layer Cap
- Leachate Collection System
- Extraction Well System
- On-site Water Treatment Plant
- Discharge of Treated Water To Surface Water
- Wetlands Replacement

3.3.4.1 Components Similar To Alternative 3

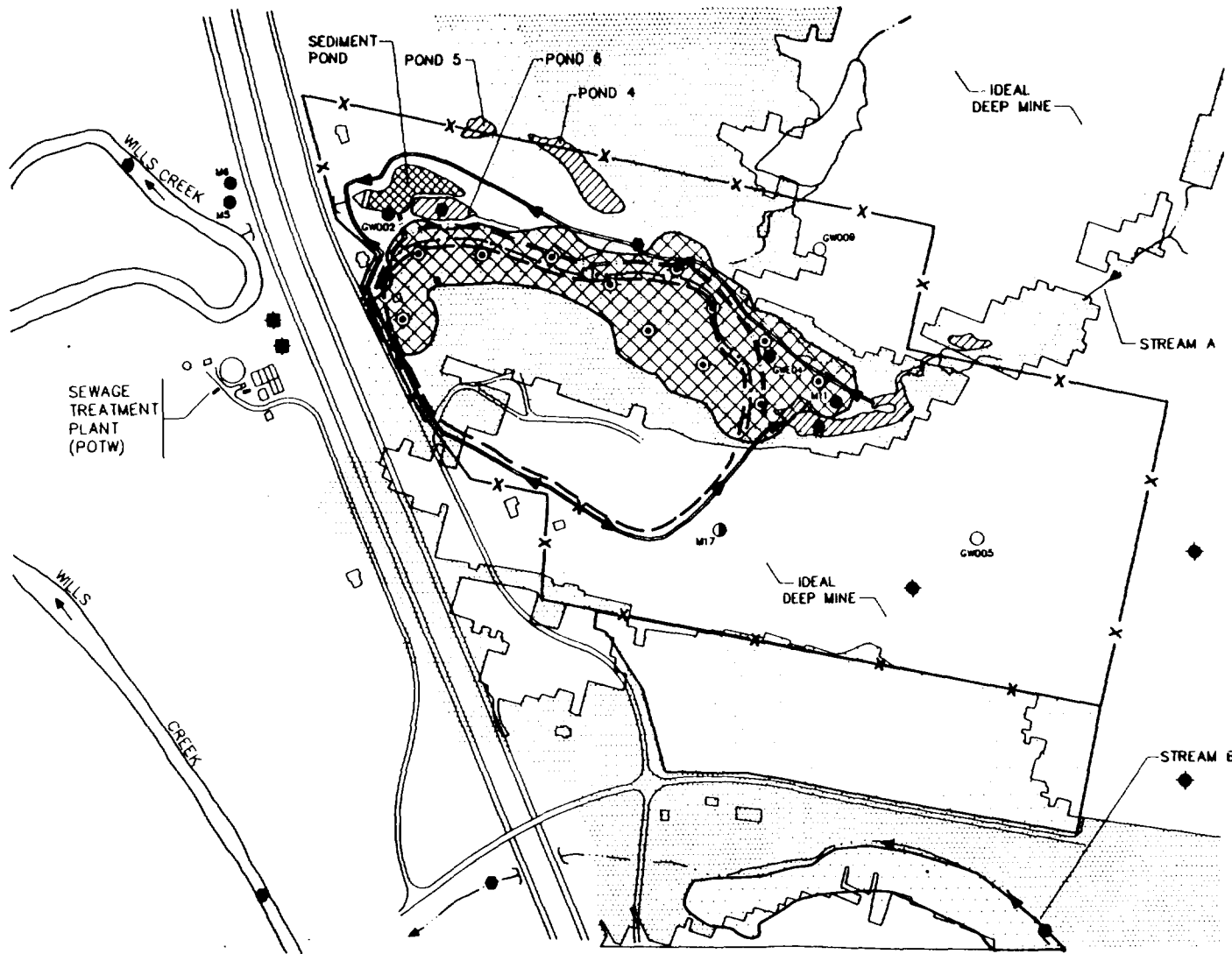
With Alternative 4, Items 3.3.3.1 through 3.3.3.6 of Alternative 3 will be performed, with the exception that leachate will be discharged to an on-site treatment system rather than hauled off-site. Since an on-site treatment system will be needed to economically treat the volume of groundwater extracted from the shallow aquifer, it will be most cost-effective to treat the leachate in the same system rather than haul it off-site.

3.3.4.2 Extraction Well System


















An array of extraction wells will be installed in the shallow aquifer to lower the water table in the landfill area, intercept groundwater migrating towards the deep-mine aquifer, and collect contaminated groundwater for treatment. The extraction well system is shown in Figure 3-6, and a typical extraction well is detailed in Figure 3-7. Some of the extraction wells will be installed through the multi-layer cap and will have to be sealed to the liner against infiltration.

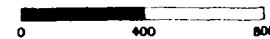
The conceptual design of the groundwater extraction system is based on available slug test and aquifer characteristic data. Slug tests were performed on 6 monitoring wells in the alluvium and mine spoil in the vicinity of the landfill. Hydraulic conductivity measurements in the shallow aquifer ranged from 4×10^{-4} to 2×10^{-3} cm/sec. The value of 5×10^{-4} cm/sec, that is, the geometric mean of the observed values from the shallow aquifer tests, was chosen as representative of the shallow aquifer. Shallow aquifer thickness varies somewhat in Stream Valley A, ranging from less than 8 feet upstream of Pond 1A to over 29 feet to the west of Pond 3. In the central area of the valley, under the northern portion of the landfill and near Ponds 2 and 2A, the shallow aquifer is about 15 feet thick. The specific capacity of a typical well was calculated to be 0.105 gpm/ft using the Jacob equation and the following assumptions: (1) average hydraulic conductivity of 5×10^{-4} cm/sec, (2) a typical storage coefficient for unconfined aquifers of 0.20, (3) a well radius of 0.5 feet, (4) aquifer thickness of 15 feet. More complete calculations are presented in Appendix A.

At a drawdown of 4 feet, and a pumping rate of 0.4 GPM, the steady state radius of influence will be approximately 157 feet. At this rate, an array of 12 wells will cover most of the area around the landfill where contamination has been identified. Assuming drawdowns of 20% to 25% of the aquifer thickness, and taking into account variable yields for different parts of the shallow aquifer, the total estimated production of the entire system will be slightly greater than 10 GPM. Because of the complex hydrogeology in Stream Valley A, the exact production rate and zone of influence of each extraction



LEGEND :

-  COAL IN PLACE
-  ABANDON DEEP MINES
-  FORMER STRIP MINES
-  ESTIMATED LANDFILL AREA AND MULTI-LAYER CAP
-  CLEAN WATER DIVERSION CHANNEL
-  SITE FENCE
-  SEDIMENT CONTROL DITCH
-  LEACHATE COLLECTION SUBDRAIN
-  ESTIMATED CAPTURE ZONE
-  SUBDRAIN SUMP AND PUMP LOCATION FOR LEACHATE COLLECTION
-  EXISTING SHALLOW AQUIFER MONITORING LOCATION
-  EXISTING DEEP MINE AQUIFER MONITORING LOCATION
-  EXISTING BEDROCK MONITORING LOCATION
-  NEW SHALLOW AQUIFER MONITORING LOCATION
-  NEW DEEP AQUIFER MONITORING LOCATION
-  SURFACE WATER/SEDIMENT SAMPLING LOCATION
-  EXTRACTION WELL



3-24

FIGURE 3-6
ALTERNATIVE 4
MULTI-LAYER CAP WITH
GROUNDWATER EXTRACTION
AND TREATMENT
FUZZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

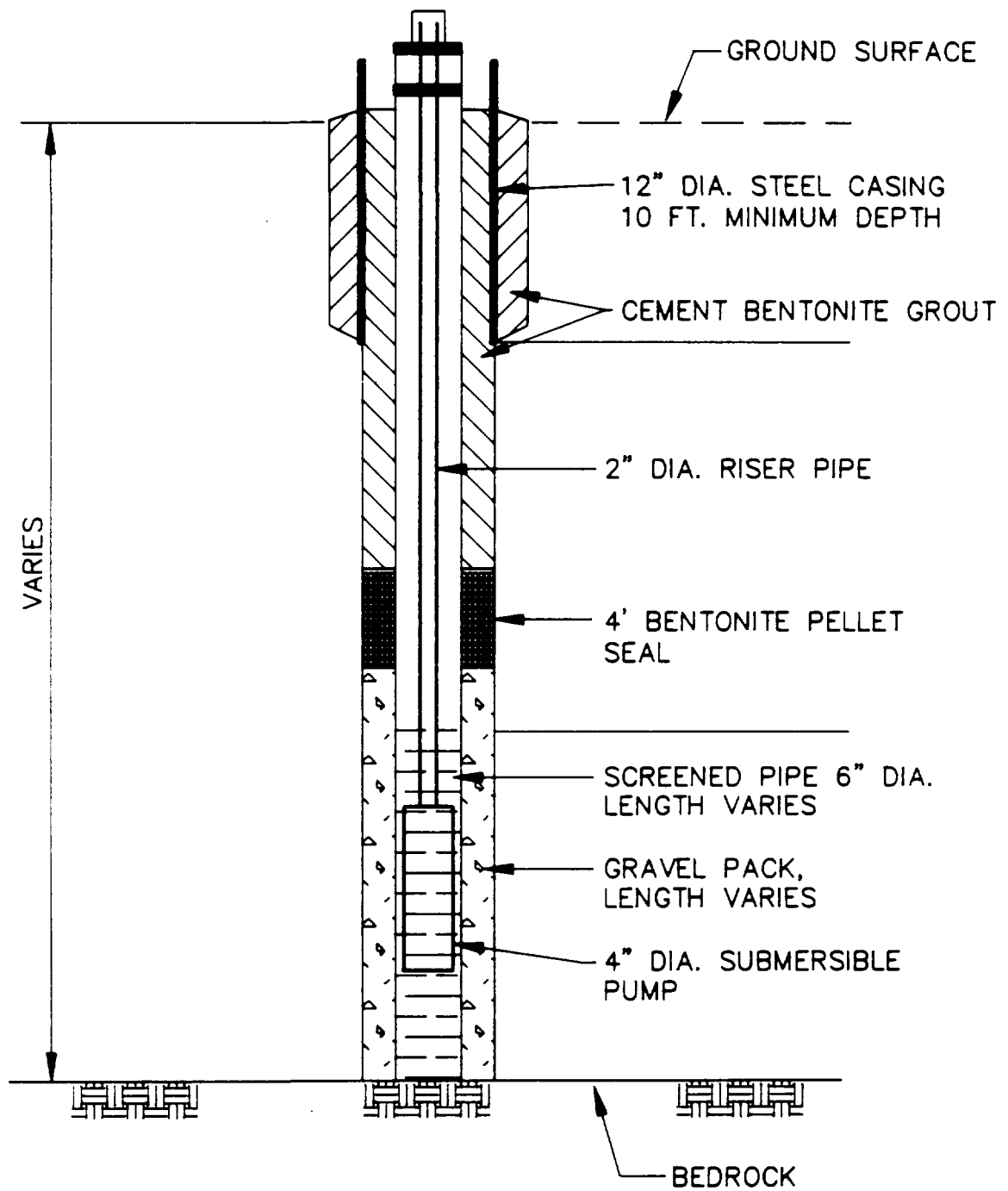


FIGURE 3-7
TYPICAL EXTRACTION WELL
ALTERNATIVE 4
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

well array are impossible to determine without pump tests. Figure 3-6 shows the minimum coverage that will be expected by overlapping estimated minimum cones of influence of the individual wells.

3.3.4.3 On-site Water Treatment Plant

The process options for treatment that survived the technology screening step in Section 2.6.1 consist of the following:

- Oxidation
- Precipitation
- Filtration
- Carbon Adsorption
- Neutralization
- Air Stripping

In order to treat the water extracted from the shallow aquifer and the leachate produced by the existing landfill, an on-site water treatment plant will be installed which will reduce the contaminant levels sufficiently for discharge to surface water. Water quality criteria for Wills Creek are presented in Table 2-4. These criteria are not strictly effluent (i.e., end of pipe) limitations, but the more conservative long-term average stream quality criteria.

Because of the low concentrations of volatile organic compounds, and the inclusion of an aqueous phase carbon filter, an air stripper will not be needed for removing volatile organic compounds. Even though air stripping survived the technology screening of Section 2.6.1, it is not included in the treatment system. The remaining processes can be combined into a treatment train capable of treating the compounds identified in leachate and groundwater at the Fultz Landfill Site. It is currently estimated that the treatment system for the site must be capable of operating at rates of at least 15 gpm, that is, about 10 GPM from the extraction wells, 2 GPM from the leachate collection system, and 3 GPM excess capacity as a factor of safety (see Appendix A for more detail).

The proposed treatment system is only one of a number of different types that could be used at the Fultz Landfill Site. For the purposes of this study, only one system was carried through the cost estimate, although many different configurations could be equally effective. The final treatment system selection will be based on samples from the extraction system, after it is constructed and functioning.

A problem noted with the existing chemical analysis data base is the erratic distribution of potential contaminants of concern, which makes it difficult to estimate influent concentrations. In the groundwater extraction system, water will be drawn from different areas of the site, but principally from the mine spoil and alluvium to the north of the present landfill. The expected influent to the treatment system will be a mixture of groundwater from areas with different contaminants, and the mixing will serve to dilute some contaminants. Mixing of groundwater with leachate, which has a different chemical profile, will dilute some contaminants and increase others. Therefore, anticipated influent concentrations were based on weighted averages of the detected concentrations found in the areas targeted for extraction wells and maximum contaminant levels found in the leachate samples. Prior to the full-scale design of the treatment system, pump test and treatability studies should be performed to better define the range of contaminant concentrations, optimum treatment processes, the most appropriate well configuration, and the actual operational requirements.

The water treatment system used at the Fultz Landfill Site must be capable of detoxifying or removing a number of inorganic compounds, volatile organic compounds, and semi-volatile organic compounds. Table 3-2 shows the maximum compound concentrations detected in the shallow aquifer, and leachate, as well as the weighted average concentrations based on expected flows from each source. The treatment system will be capable of removing, at a minimum, all chemicals that contribute to the carcinogenic risk above 10^{-6} and non-carcinogenic risk factors greater than 1 as defined in RI Chapter 6. In addition, the effluent from the treatment system must meet all limitations established by the State of Ohio. For the purpose of a conceptual design of the treatment system we have considered Federal MCLs, MCLGs, Drinking Water

TABLE 3-2
SUMMARY OF ANTICIPATED CONTAMINANT CONCENTRATIONS OF THE
INFLUENT TO THE PROPOSED WATER TREATMENT SYSTEM (µg/l)
FULTZ LANDFILL SITE
FEASIBILITY STUDY REPORT

	Groundwater Concentration Shallow Aquifer		Leachate Concentration	Weighted Average Groundwater & Leachate
	Maximum	Average	Maximum	
VOLATILE ORGANIC COMPOUNDS				
Vinyl Chloride	5.0	0.00	--	0.00
Chloroethane	7.0	0.08	130.0	23.49
Methylene Chloride	1.0	0.03	--	0.02
Acetone	8.0	1.28	52.0	10.42
Carbon Disulfide	5.0	0.28	--	0.23
1,1-Dichloroethene	5.0	0.00	--	0.00
1,2-Dichloroethene (total)	5.0	0.31	--	0.25
2-Butanone	8.5	1.12	--	0.91
Benzene	1.0	0.00	6.0	1.08
4-Methyl-2-Pentanone	17.0	0.44	--	0.36
Toluene	3.0	0.29	87.0	15.91
Chlorobenzene	3.0	0.00	130.0	23.42
Ethylbenzene	2.0	0.23	150.0	27.22
Xylenes (total)	12.0	1.08	47.0	9.35
SEMI-VOLATILE ORGANIC COMPOUNDS				
2,4-Dimethylphenol	35.0	0.90	--	0.74
Benzoic Acid	100.0	0.08	--	0.06
Naphthalene	250.0	7.03	5.0	6.66
2-Methylnaphthalene	380.0	12.43	--	10.19
Dibenzofuran	77.0	2.59	--	2.12
Diethylphthalate	24.0	0.00	3.0	0.54
Fluorene	12.0	0.31	--	0.25
N-Nitrosodiphenylamine	2.0	0.15	--	0.13
Pentachlorophenol	3.0	0.00	--	0.00
Phenanthrene	69.0	1.78	--	1.46
Anthracene	5.0	0.13	--	0.11
Fluoranthene	14.0	0.36	--	0.29
Pyrene	10.0	0.26	--	0.21
Butylbenzylphthalate	2.0	0.00	--	0.00
Chrysene	2.0	0.05	--	0.04
Di-n-butylphthalate	0.0	0.00	--	0.00
Bis(2-ethylhexyl)phthalate	100.0	4.79	6.0	5.01
Di-n-octylphthalate	13.5	0.54	--	0.44
Benzyl alcohol	0.0	--	15.0	2.70
2-Methylphenol	0.0	--	45.0	8.11
4-Methylphenol	0.0	--	25.0	4.50
N-nitrosodiphenylamine	0.0	--	6.5	1.17
Phenol	0.0	--	21.5	3.87

TABLE 3-2 (Continued)
SUMMARY OF ANTICIPATED CONTAMINANT CONCENTRATIONS OF THE
INFLUENT TO THE PROPOSED WATER TREATMENT SYSTEM (µg/l)
FULTZ LANDFILL SITE
FEASIBILITY STUDY REPORT

	Groundwater Concentration Shallow Aquifer		Leachate Concentration	Weighted Average Groundwater & Leachate
	Maximum	Average	Maximum	
INORGANICS				
Aluminum	911,000	99,964	782	48,036
Antimony	146	31	--	15
Arsenic	427	37	6.5	21
Barium	6,000	1,302	2,155	1,748
Beryllium	68	8	--	4
Cadmium	78	9	--	4
Calcium	432,000	173,298	282,000	230,210
Chromium	1,580	201	900	567
Cobalt	806	116	14	63
Copper	1,340	227	32	125
Iron	1,860,000	225,338	79,800	149,140
Lead	1,530	145	15	77
Magnesium	217,000	94,004	282,000	192,431
Manganese	25,100	6,128	9,070	7,668
Mercury	1	1	--	0
Nickel	1,630	220	674	457
Potassium	97,600	19,565	90,100	56,494
Selenium	10	5	--	2
Silver	28	5	--	2
Sodium	721,000	74,943	386,000	237,800
Thallium	10	4	--	2
Vanadium	1,610	208	53	127
Zinc	4,890	745	364	546
SAS ANALYSIS				
Chloride (mg/l)	387	90	--	--
Sulfate (mg/l)	379	115	--	--
-- Concentration Below Detection Limit				

Standards, and Ohio State Water Quality Standards for Wills Creek. Table 2-4 provides a comparison of the various water quality standards. Table 3-3 shows the principal contaminants of concern in the design of the water treatment system.

The major inorganic contaminants to be treated by the system include antimony, arsenic, barium, beryllium, cadmium, chromium, iron, lead, mercury, manganese, nickel, thallium, vanadium, and zinc. High iron concentrations can lead to fouling of some equipment and must be removed in an initial treatment step. Major organics that must be treated include 1,1-DCE, benzene, methylene chloride, 2-methylnaphthylene, bis(2-ethylhexyl)phthalate, and n-nitrosodiphenylamine. Vinyl chloride appeared at a very low concentration, and it volatilizes so rapidly that it is unlikely that it will show up in the treatment stream. Therefore, no special treatment step has been included for vinyl chloride, though it might be required based upon the results of pre-design sampling.

The proposed treatment process will begin with the addition of an oxidizing agent, such as hydrogen peroxide, to oxidize the iron, arsenic, and other metals. This step will decrease the solubility of these compounds, making them easier to remove. A precipitant will then be mixed with the solution, which will be discharged to a clarifier where most of the solids will precipitate out, and be removed as a sludge. The sludge will be discharged to a filter press that removes moisture, increasing its solids content to about 30%. The clarified water will pass through a granular carbon filter to remove the remaining suspended solids. These steps should be capable of removing the inorganic contaminants in the collected water to such a degree that appropriate discharge standards are achieved. Following those steps, the effluent will be passed through a bed of granular activated carbon (GAC) as a polishing step to remove any remaining organic compounds. At periodic intervals, the spent carbon must be replaced with fresh carbon, and the used carbon either regenerated or disposed.

**TABLE 3-3
 CHEMICALS OF CONCERN FOR WATER TREATMENT SYSTEM INFLUENT
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT**

ORGANICS	Risk Factor	Exceeds MCL's	Exceeds MCLG's	Exceeds SWS	Exceeds DWHA
Vinyl Chloride	•				
1,1-Dichloroethene	•				
Methylene Chloride			•		
Benzene	•		•		
2-Methylnaphthalene					•
Bis(2-ethylhexyl)phthalate	•			•	
N-nitrosodiphenylamine	•				
INORGANICS	Risk Factor	Exceeds MCL's	Exceeds MCLG's	Exceeds SWS	Exceeds DWHA
Antimony	•	•	•		
Arsenic	•				
Barium		•	•		
Beryllium	•	•	•		
Cadmium			•		
Chromium	•				
Iron				•	•
Lead		•	•		
Mercury	•				
Manganese	•				
Nickel		•	•	•	
Thallium	•	•	•		
Vanadium	•				
Zinc	•				

3.3.4.4 Discharge of Treated Water To Surface Water

Discharge of the treatment plant effluent will be to Stream A downstream of the sediment pond by way of a dedicated discharge pipeline. Figure 3-8 presents a schematic of the proposed treatment system.

3.3.4.5 Wetlands Replacement

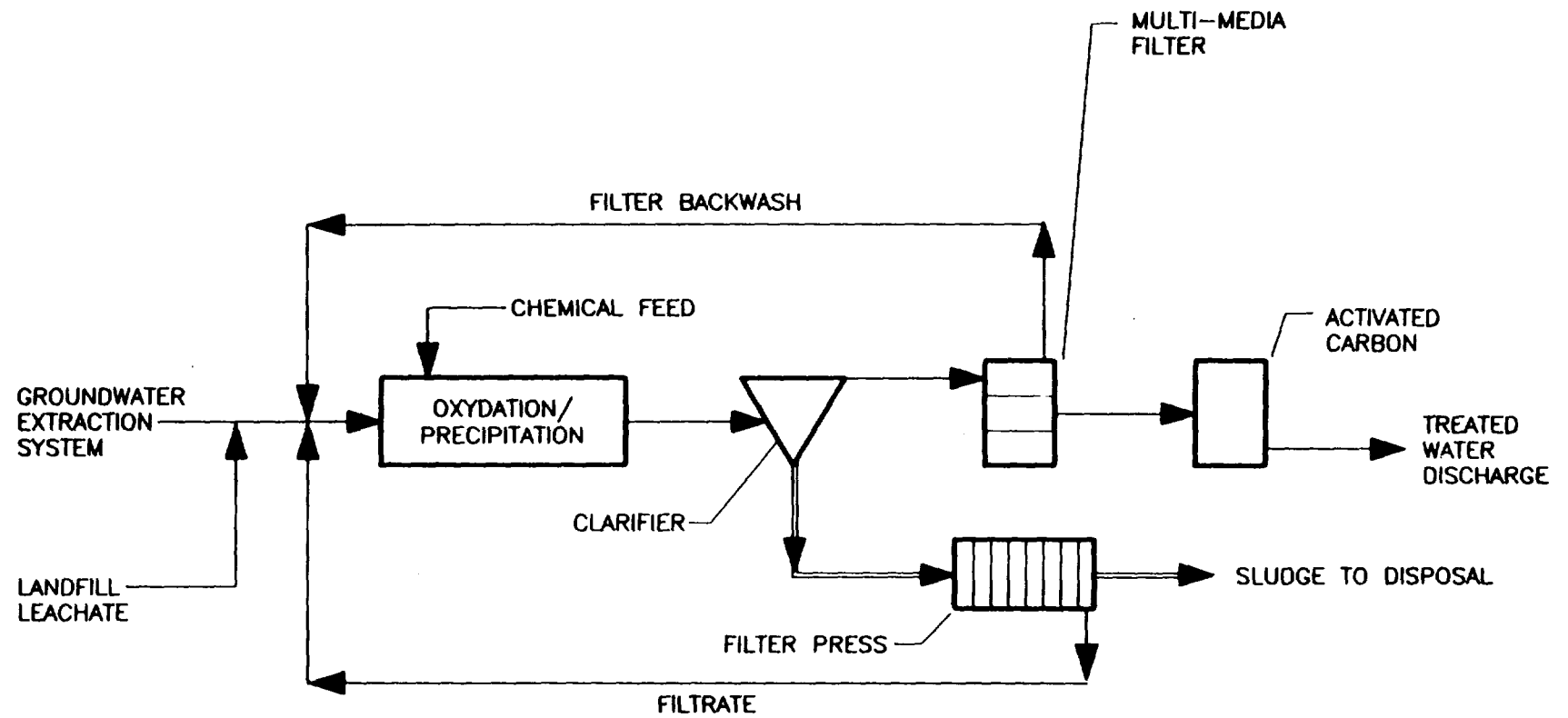
The same actions performed under Alternative 3, Section 3.3.3.7, will be performed under Alternative 4.

3.3.5 ALTERNATIVE 5: ON-SITE LANDFILL

The purpose of an on-site landfill is to remove the contaminated municipal waste from its existing location and deposit it in a secure double-lined RCRA equivalent landfill, which will prevent the lateral and vertical movement of contaminants from bringing them in contact with humans or the environment. The Fultz Landfill Site property is large enough to permit the construction of a landfill in a side valley adjacent to Stream Valley A to the east of the existing landfill (Figure 3-9). The area is partially underlain by intact coal, and partially by the former Ideal Mine some 40 to 120 feet below the existing ground surface. The hillside to the east and south of the proposed location will provide two natural sides to contain the landfill. Berms of compacted clay will be constructed on the western and southern sides so that the landfill cap will have a uniform slope of about 12% from south to north. Figure 3-10 shows a typical landfill section.

The components of Alternative 5 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Over-excavation of the Underground Mine



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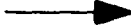
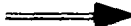
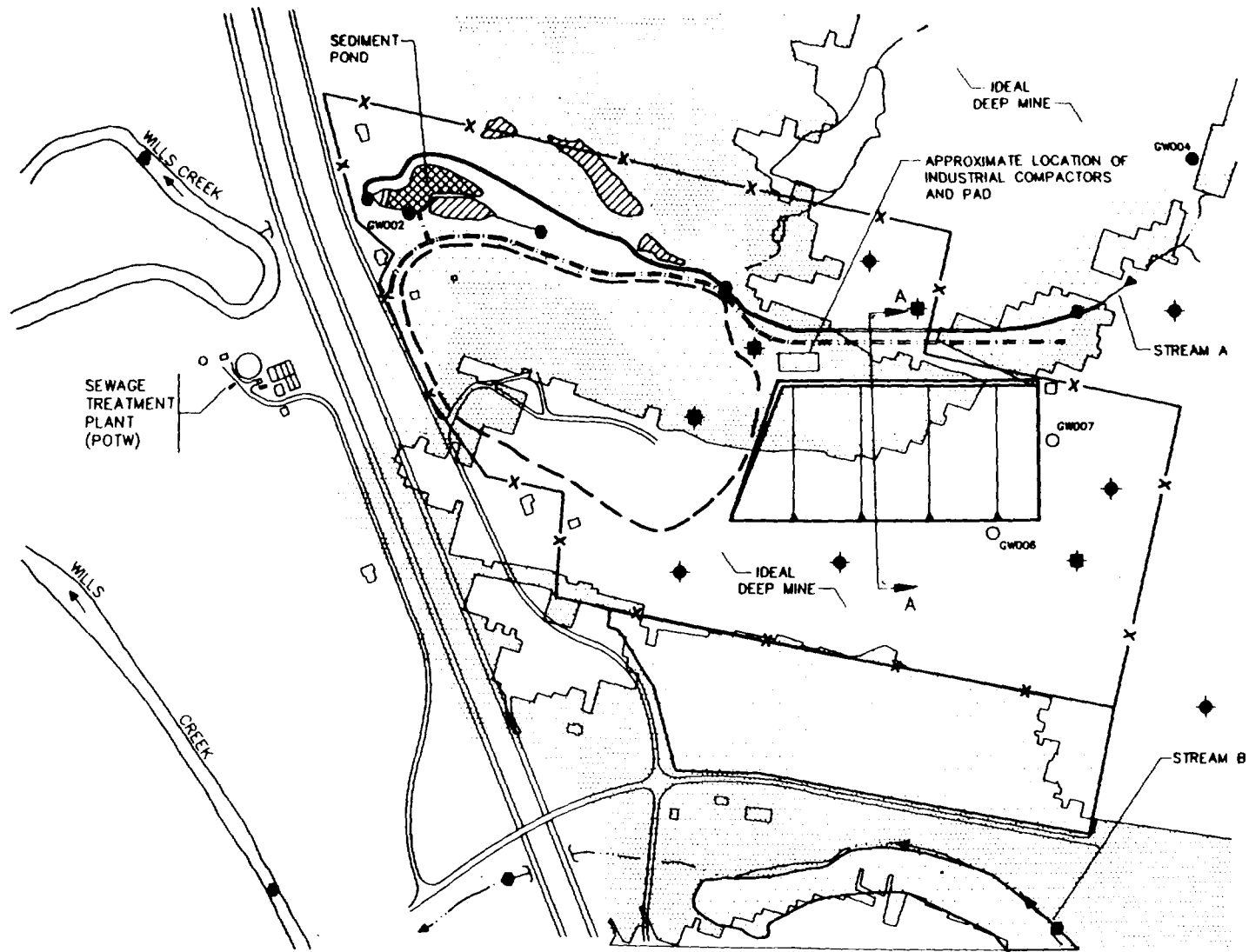
-  LIQUIDS
-  SOLIDS

FIGURE 3-8
ALTERNATIVE 4
WATER TREATMENT SCHEMATIC
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT



LEGEND





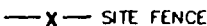
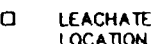


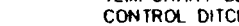
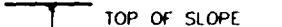





-  COAL IN PLACE
-  ABANDON DEEP MINES
-  FORMER STRIP MINES
-  ESTIMATED LANDFILL AREA
-  SITE FENCE
-  LEACHATE SUMP AND PUMP LOCATION
-  CLEAN WATER DIVERSION CHANNEL
-  TEMPORARY SEDIMENT CONTROL DITCH
-  TOP OF SLOPE
-  BOTTOM OF SLOPE
-  EXISTING SHALLOW AQUIFER MONITORING LOCATION
-  EXISTING DEEP AQUIFER MONITORING LOCATION
-  NEW SHALLOW AQUIFER MONITORING LOCATION
-  NEW DEEP AQUIFER MONITORING LOCATION
-  SURFACE WATER/SEDIMENT MONITORING LOCATION



FIGURE 3-9
 ALTERNATIVE 5
 ONSITE LANDFILL
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

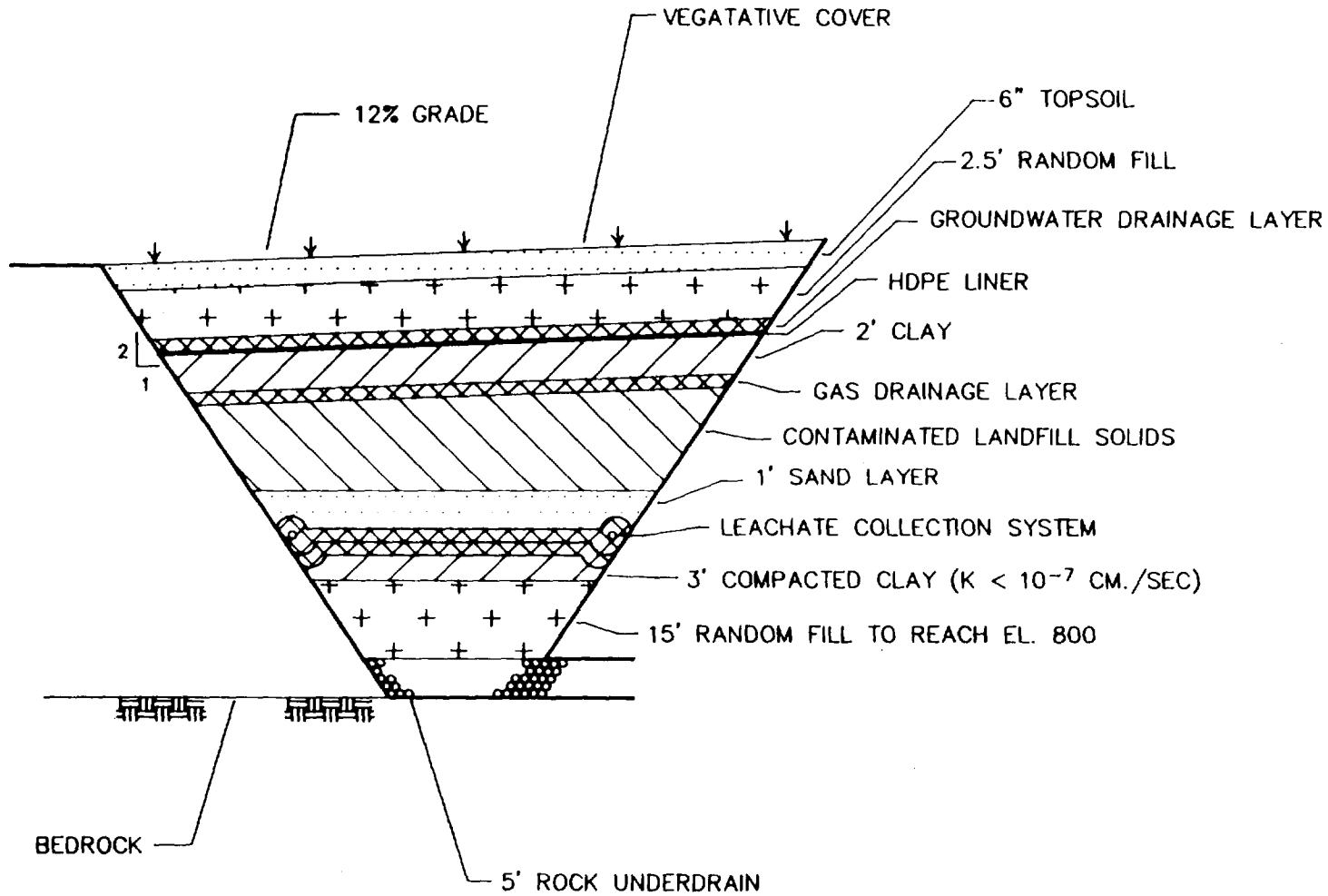


FIGURE 3-10
ALTERNATIVE 5
TYPICAL LANDFILL SECTION
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

- Rock Underdrain
- Erosion and Sediment Controls
- Dewatering Facilities
- RCRA Equivalent On-site Landfill
- Wetlands Replacement

3.3.5.1 Institutional Controls, Site Fence and Alternate Water Supply

Items 3.3.2.1 through 3.3.2.3 of Alternative 2 will be performed.

3.3.5.2 Monitoring

Because the new landfill will be lined and capped, and the leachate will be collected for off-site disposal, leachate samples will be taken. Long-term monitoring of surface water, groundwater, sediments and combustible gas will be performed in accordance with all applicable regulations for a minimum of 30 years to evaluate the migration of contaminants from the landfill and to monitor the effects of natural attenuation. The actual monitoring plan will be determined during remedial design. One possible monitoring plan could be as follows:

Semi-annual monitoring of surface water and sediment will be performed in a total of 8 locations, namely, at 2 locations in Wills Creek, two locations in Stream B, two locations in the clean water diversion channel, one location at the entrance to the sedimentation pond, and one at the outfall of the sedimentation pond. Chemical analysis will consist of the full TCL and TAL. The purpose of this sampling and analysis will be to monitor Stream Valley A, Stream Valley B, and Wills Creek for the expected attenuation of contaminant concentration with time after the source of contamination is isolated.

For groundwater monitoring, existing regulations (Ohio Administrative Code 3745-27-10 and Ohio Administrative Code 3745-65-91) call for a minimum of one upgradient well and three downgradient wells. Because of the size and complexity of the Fultz Landfill Site, additional monitoring should be performed. One possible groundwater monitoring plan could be as follows:

Shallow Aquifer: 8 points (4 existing wells, 4 new)

Coal mine Aquifer: 7 points (2 existing wells, 5 new)

Since the new on-site landfill will be located over 1000 feet to the east of the existing landfill, most of the existing wells are not in suitable locations to monitor groundwater near the new facility. Four new wells (one upgradient and three downgradient) will be needed to assure adequate monitoring of the shallow aquifer. One new background well will be installed in the soil zone on the hill above the new landfill to the south. Three downgradient wells will be installed in the strip spoil or alluvium in Stream Valley A to the north and west of the new landfill. Five new wells will be needed in the coal mine aquifer to fill data gaps around the new landfill as shown in Figure 3-9. One of the new coal mine aquifer wells will be installed southeast of the new landfill in an area where the mine is thought to be constricted since contamination that might not be detected in other wells would be more likely to be detected in this area.

Groundwater sampling will be performed on a semi-annual basis at a minimum. The above monitoring program should be sufficient to monitor contaminant migration both horizontally and vertically. Chemical analysis will consist of the full TCL and TAL.

Five-year reviews will be instituted in order to re-evaluate the site conditions on a periodic basis. The reviews will include a detailed analysis of the long-term monitoring data, a temporal and spatial evaluation of contaminant migration in various media and the extent of natural attenuation, and an assessment of residual health risks. The review will also include an evaluation of the effectiveness of the institutional controls, responses to public comments or complaints received during the five-year period, and an evaluation of what additional remedial measures, if any, should be implemented based on the reviewed site conditions.

3.3.5.3 Over-excavation of the Underground Mine

Construction of a landfill on the eastern portion of the Fultz Landfill Site property will require some treatment of the abandoned underground mine to remove the danger of subsidence. The same mine flushing procedure of Alternative 3 could be used to provide adequate support, but in the case of a new landfill where a disposal pit must be excavated for the installation of liners, leachate collection system, and waste disposal, it will be more cost-effective to continue the excavation down to the mine floor to eliminate the mine cavities and in-place coal. Over-excavation will be more reliable than mine flushing since the mine itself will be eliminated. The cost of excavation will also be partly offset by the sale of extracted coal pillars. During the excavation, topsoil will be removed and stockpiled in a level area on the hill above the new landfill site to the east. Materials will be segregated for later use in construction of the landfill. Materials which can be used for backfilling the over-excavation can be stockpiled on the existing landfill. Some material can be used to construct the berm around the northern and western sides of the new landfill. The remaining materials will be stockpiled in Stream Valley A to be used for regrading the existing landfill area once the waste is removed.

3.3.5.4 Rock Underdrain

As part of the procedure eliminating the mine the excavation will be backfilled with a 5-foot thick rock underdrain, and 15 additional feet of low permeability granular fill approved by the OEPA in an effort to maintain the water table at least 15 feet below the bottom of the landfill (Figure 3-11). The drainage of shallow groundwater into the rock fill, and from there into the coal mine aquifer, will follow the existing groundwater flow pattern in the area. After filling the excavation to about elevation 800 feet MSL the sides of the pit will be backfilled and graded to a 2 horizontal:1 vertical slope.

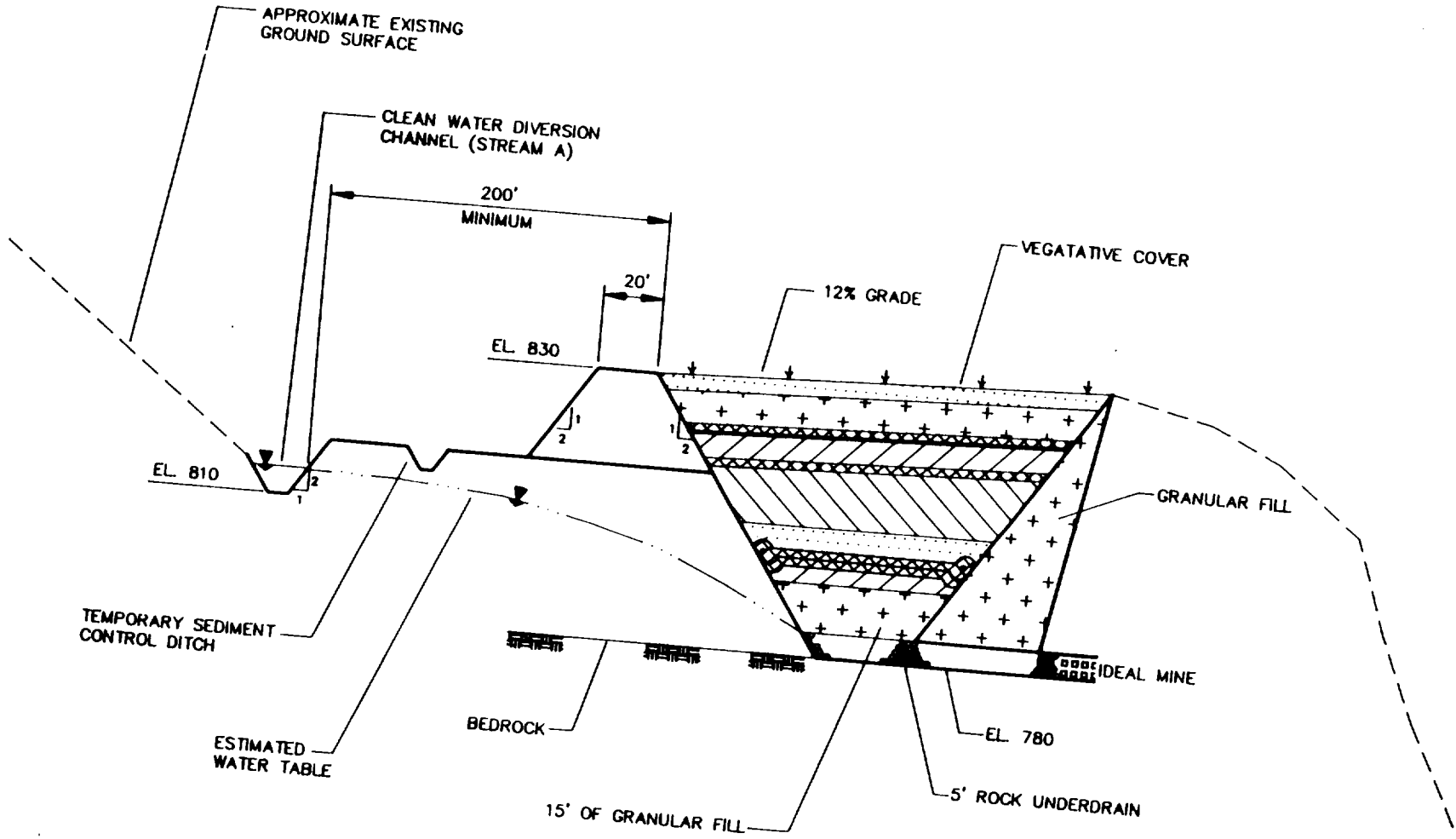


FIGURE 3-11
ALTERNATIVE 5
ON-SITE LANDFILL SECTION A-A
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

3.3.5.5 Erosion and Sediment Controls

Prior to commencing any excavation for the new landfill, Stream Valley A will be regraded, and erosion and sediment controls will be installed. First, ponds 1, 2, and 2A will be drained and the sediments removed to a stockpile on the existing landfill. Ponds 2 and 2A will be backfilled and a clean water diversion channel constructed along the north side of Stream Valley A as shown in Figure 3-9. This channel will effectively replace Stream A, and most of the channel will remain after construction. A sediment control pond will be excavated in an area to the west and north of Pond 6, and a temporary sediment control ditch constructed just south of the clean water diversion channel.

The sediment pond will remain after construction to replace pond water habitat eliminated by the filling of ponds 1, 2, and 2A, and the clean water diversion will be re-routed into the sediment pond after revegetation of all disturbed areas. Temporary erosion controls, such as silt fences and hay bail barriers, will be installed as needed during the excavation.

3.3.5.6 Dewatering Facilities

Temporary dewatering facilities consisting of well points and sump pumps will probably be required during the excavation of the landfill pit to eliminate the seepage of groundwater into the excavation. A line of well points will be installed along the northern edge of the proposed pit to lower the water table as needed during excavation. Any water that seeps into the excavation from the south will be removed with sump pumps. The groundwater in this area should be similar in quality to the upgradient background well GW004 and will be discharged into the sediment control ditch and pond. The discharge of this water could require meeting the substantive requirements of Ohio's NPDES. After the rock underdrain is installed, groundwater will drain under the backfill and the dewatering equipment will not be needed.

3.3.5.7 RCRA-Equivalent On-site Landfill

The landfill pit will be prepared as shown on Figure 3-9 and Figure 3-11. After over-excavation and backfilling of the coal mine, the sides of the pit will be graded to the proper slope and a thirty-six inch thick layer of clay compacted to achieve a permeability of 10^{-7} cm/s will be installed. A synthetic double liner with leachate collection and leak detection systems using synthetic drainage netting will be installed as detailed on Figure 3-12. A layer of filter fabric and a 12-inch-thick layer of sand will be placed on top of the uppermost drainage netting. The solid waste from the existing landfill will be placed on top of the sand layer.

Prior to excavation of the existing landfill, the existing cover area will be cleared, grubbed, and stripped. Temporary haul roads will be constructed as needed between the two landfills. Existing cover soil will be removed and stockpiled as the excavation proceeds, so that it can be re-used as cover in the new landfill or as backfill for the existing landfill. Chemical waste was reported to have been dumped at the existing landfill, but the quantity and location of the contamination was never identified. If these wastes are indeed present in the existing landfill, they will be uncovered during the excavation, tested to determine if they are considered hazardous, stabilized, and disposed of off-site, if necessary. For cost estimation purposes it was assumed that approximately 20,000 cubic yards of hazardous waste will be disposed-of off-site.

Before placement in the new landfill, solids from the existing landfill will be excavated and compacted to reduce the volume of the waste that must be stored, and to reduce the potential for settlement within the new landfill. Front-end loaders will be used to excavate the existing waste. Three industrial compactors, working in parallel and mounted on concrete pads between the existing and new landfills, will reduce the volume of the waste about 10% to 20% and dewater any refuse that contains excessive moisture. Any water which is generated by the compaction process will be tested, and, if necessary, disposed off-site at a permitted facility. After compaction, the waste will be placed in the new landfill.

3.3.5.5 Erosion and Sediment Controls

Prior to commencing any excavation for the new landfill, Stream Valley A will be regraded, and erosion and sediment controls will be installed. First, ponds 1, 2, and 2A will be drained and the sediments removed to a stockpile on the existing landfill. Ponds 2 and 2A will be backfilled and a clean water diversion channel constructed along the north side of Stream Valley A as shown in Figure 3-9. This channel will effectively replace Stream A, and most of the channel will remain after construction. A sediment control pond will be excavated in an area to the west and north of Pond 6, and a temporary sediment control ditch constructed just south of the clean water diversion channel.

The sediment pond will remain after construction to replace pond water habitat eliminated by the filling of ponds 1, 2, and 2A, and the clean water diversion will be re-routed into the sediment pond after revegetation of all disturbed areas. Temporary erosion controls, such as silt fences and hay bail barriers, will be installed as needed during the excavation.

3.3.5.6 Dewatering Facilities

Temporary dewatering facilities consisting of well points and sump pumps will probably be required during the excavation of the landfill pit to eliminate the seepage of groundwater into the excavation. A line of well points will be installed along the northern edge of the proposed pit to lower the water table as needed during excavation. Any water that seeps into the excavation from the south will be removed with sump pumps. The groundwater in this area should be similar in quality to the upgradient background well GW004 and will be discharged into the sediment control ditch and pond. The discharge of this water could require meeting the substantive requirements of Ohio's NPDES. After the rock underdrain is installed, groundwater will drain under the backfill and the dewatering equipment will not be needed.

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Prior to excavation of the existing landfill, the existing cover area will be cleared, grubbed, and stripped. Temporary haul roads will be constructed as needed between the two landfills. Existing cover soil will be removed and stockpiled as the excavation proceeds, so that it can be re-used as cover in the new landfill or as backfill for the existing landfill. Chemical waste was reported to have been dumped at the existing landfill, but the quantity and location of the contamination was never identified. If these wastes are indeed present in the existing landfill, they will be uncovered during the excavation, tested to determine if they are considered hazardous, stabilized, and disposed of off-site, if necessary. For cost estimation purposes it was assumed that approximately 20,000 cubic yards of hazardous waste will be disposed-of off-site.

Before placement in the new landfill, solids from the existing landfill will be excavated and compacted to reduce the volume of the waste that must be stored, and to reduce the potential for settlement within the new landfill. Front-end loaders will be used to excavate the existing waste. Three industrial compactors, working in parallel and mounted on concrete pads between the existing and new landfills, will reduce the volume of the waste about 10% to 20% and dewater any refuse that contains excessive moisture. Any water which is generated by the compaction process will be tested, and, if necessary, disposed off-site at a permitted facility. After compaction, the waste will be placed in the new landfill.

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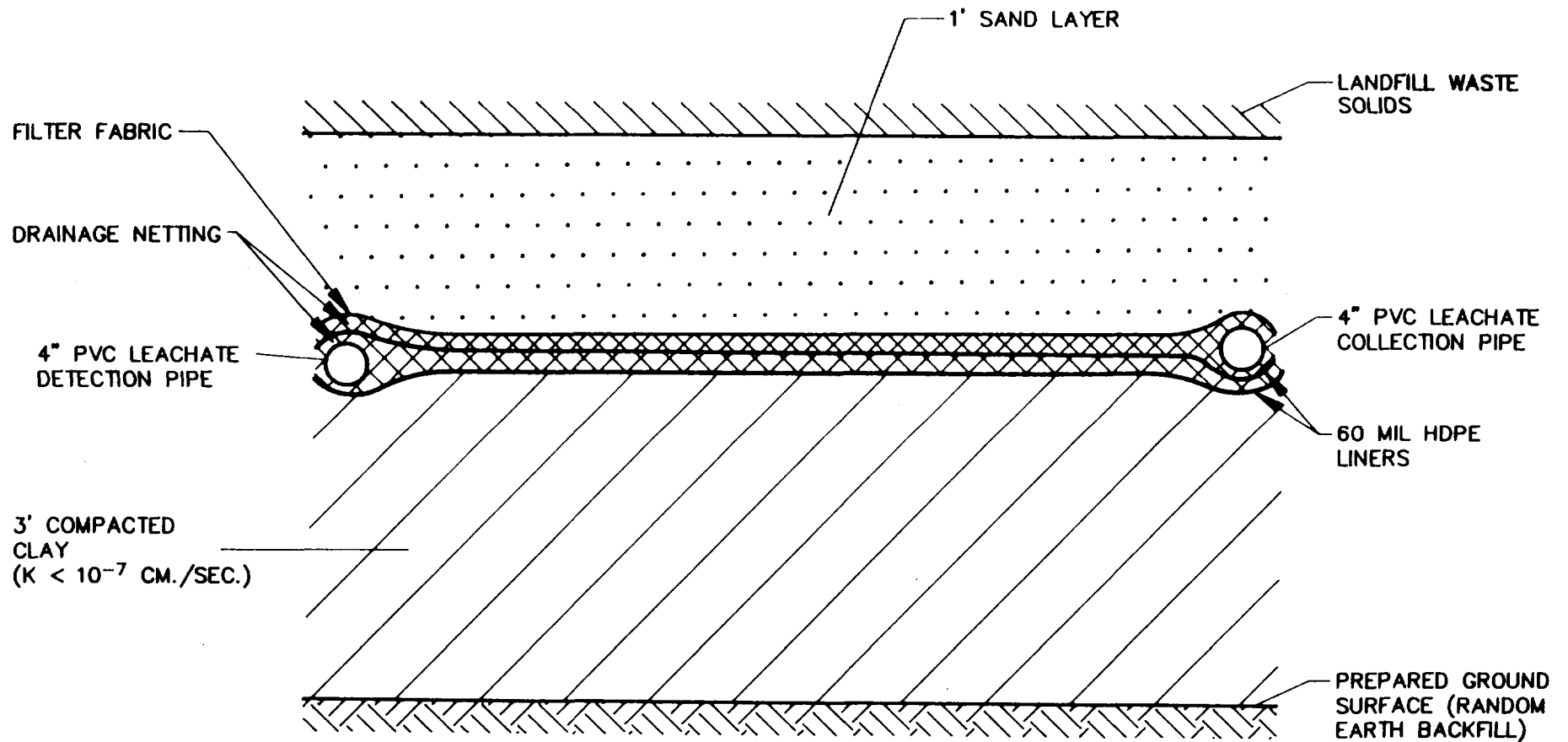


FIGURE 3-12
ALTERNATIVE 5
RCRA LANDFILL DOUBLE LINER
ON-SITE LANDFILL
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

Following placement of the waste, a multi-layer cap similar to the cap of Alternative 3 will be placed on the landfill. Because the incremental cost of providing a Subtitle C cap would not be significantly higher than the cost of a Subtitle D cap, and the Subtitle C cap would be more protective, a Subtitle C cap will be used. The exact slope of the cap will be determined during remedial design. A slope of approximately 12% from the top of the landfill on the southern to the top of the containment berm on the northern side would be suitable given the terrain surrounding the proposed landfill location.

3.3.5.8 Wetlands Replacement

During the design and construction of Alternative 5, every effort will be made to minimize the disturbance of areas identified as wetlands. When the destruction of wetland environment is anticipated from proposed remedial activities a study will be performed to delineate the extent of wetlands and develop a plan for remediation. At a minimum, the wetlands replacement plan would include replacement or restoration of the ponds and surrounding habitat. Upon completion of construction, the clean water diversion channel will be re-routed into the sediment pond, and the base water level of the sediment pond will be raised to provide a pond area large enough to replace some of the area lost by eliminating of Ponds 1, 2, and 2A. After the existing landfill is removed, instead of backfilling the entire excavation, an area just to the south of Pond 6 may also used provide an additional wetland environment.

3.3.6 ALTERNATIVE 6: MULTI-LAYER CAP WITH SUBSURFACE BARRIER

The purpose of this alternative is to isolate the landfill from infiltration, including lateral infiltration from the groundwater flowing through Stream Valley A and vertical infiltration through the ground surface. The cap will prevent infiltration of precipitation from the landfill surface and shallow groundwater from the south. At the same time the cap will lower the water table under the landfill by an estimated 3 to 7 feet. This will increase the potential for groundwater in the eastern side of the shallow aquifer to flow under the landfill transporting contaminants southward into the coal mine aquifer. A subsurface barrier around the west and north of the landfill will

minimize the transport of contaminants by preventing groundwater from Stream Valley A from flowing under the landfill.

The components of Alternative 6 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Subsurface Structural Supports
- Surface Water and Sediment Controls
- Multi-layer Cap
- Leachate Collection System
- Slurry Wall
- Wetlands Replacement

3.3.6.1 Components Similar to Alternative 3

Items 3.3.3.1 through 3.3.3.6 of Alternative 3 will be performed with the exception that Pond 3 will not be removed.

3.3.6.2 Slurry Wall

A low-permeability, subsurface vertical barrier will be constructed around the eastern and northern sides of the existing landfill to divert groundwater in the shallow aquifer around the landfill as illustrated on Figure 3-13. Although many types of barriers will accomplish the same purpose, a soil-bentonite slurry wall will work best in the mine spoil and alluvium encountered in Stream Valley A. After Stream Valley A is regraded, and the multi-layer cap with leachate collection is installed, the slurry wall will be constructed from the ground surface to the top of competent bedrock. Bedrock in Stream Valley A is a sandy shale of the Allegheny Group, which also forms the floor of the Ideal Mine. After regrading, the depth to bedrock will vary from about 45 below the surface at the western end of valley to about 30 feet in the area between Pond 1 and the landfill. Along the eastern side of the landfill the slurry wall will run north to south and will tie into the former

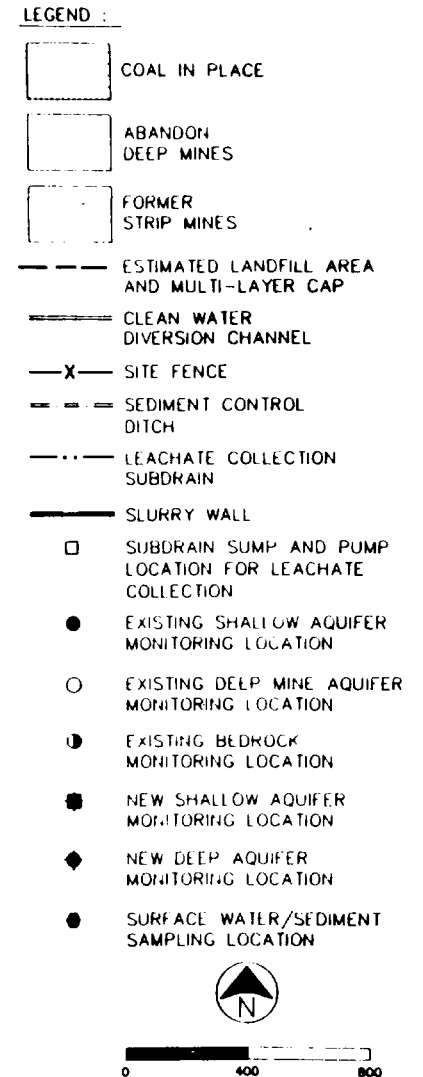
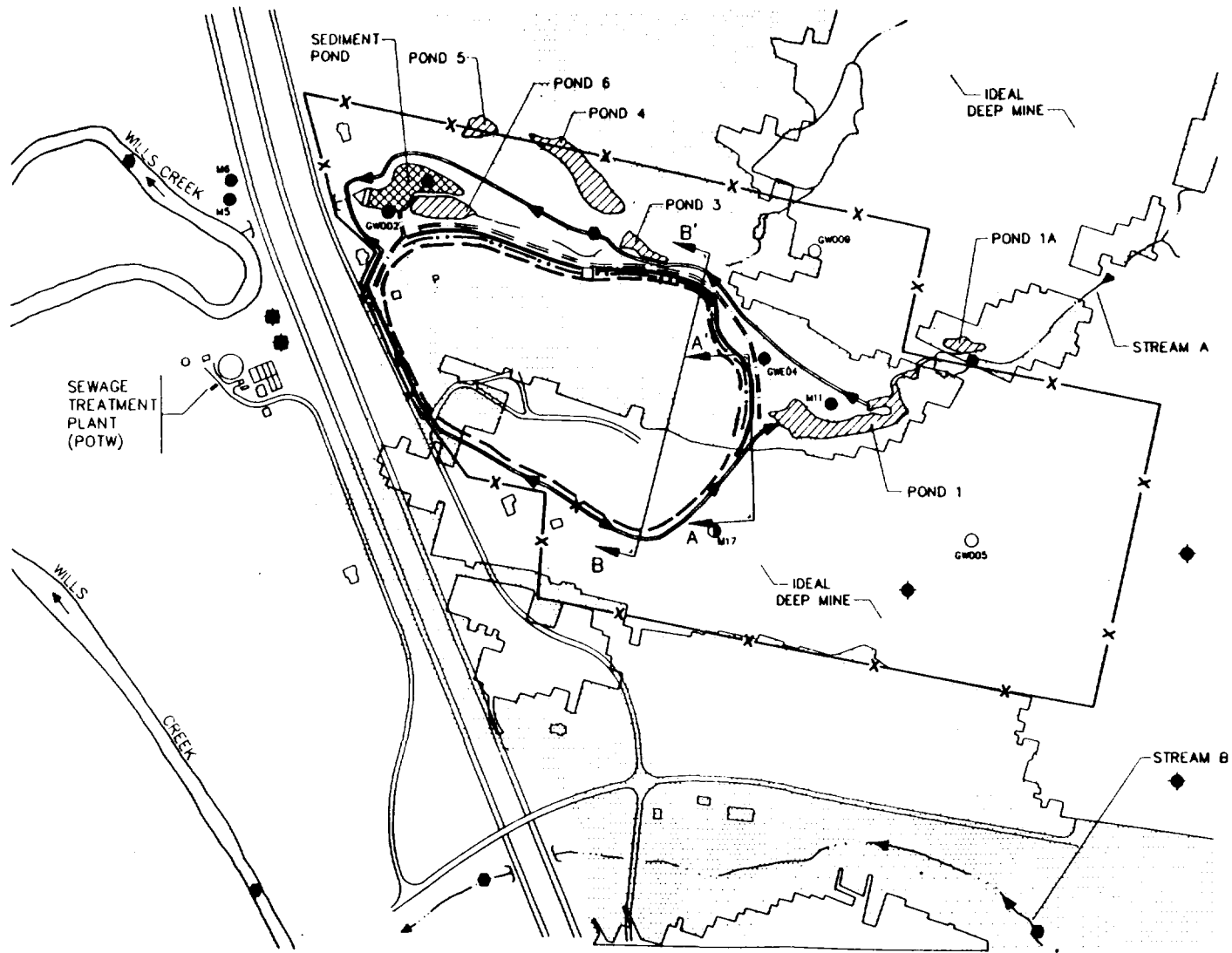


FIGURE 3-13
 ALTERNATIVE 6
 MULTI-LAYER CAP WITH
 SUBSURFACE BARRIER
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

face of the strip mine excavation where it will continue up along the sandstone and claystone that overlies the in-place coal (Figure 3-14). The overall average depth of the slurry wall will be about 40 feet.

3.3.6.3 Wetlands Replacement

During the design and construction of Alternative 6, every effort will be made to minimize the disturbance of areas identified as wetlands. When the destruction of wetland environment is anticipated from proposed remedial activities a study will be performed to delineate the extent of wetlands and develop a plan for remediation. At a minimum, the wetlands replacement plan would include replacement or restoration of the ponds and surrounding habitat. Upon completion of construction, the clean water diversion channel will be re-routed into the sediment pond, and the base water level of the sediment pond will be raised to provide pond area equal to the area lost by the elimination of Ponds 2 and 2A and the lowering of the pool level of Pond 1.

3.3.7 ALTERNATIVE NO. 7: GROUNDWATER EXTRACTION AND ON-SITE TREATMENT

This alternative is the same as Alternative 4, Multi-layer Cap, Groundwater Extraction and On-site Treatment, shown on Figure 3-6 except that a multi-layer cap and leachate collection system will not be installed. As with Alternative 2, Alternative 7 attempts to meet the remedial action objectives through institutional actions and monitoring with the added advantage of treating groundwater from the shallow aquifer.

The components of Alternative 7 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Surface Water and Sediment Controls
- Extraction Well System
- On-site Water Treatment Plant

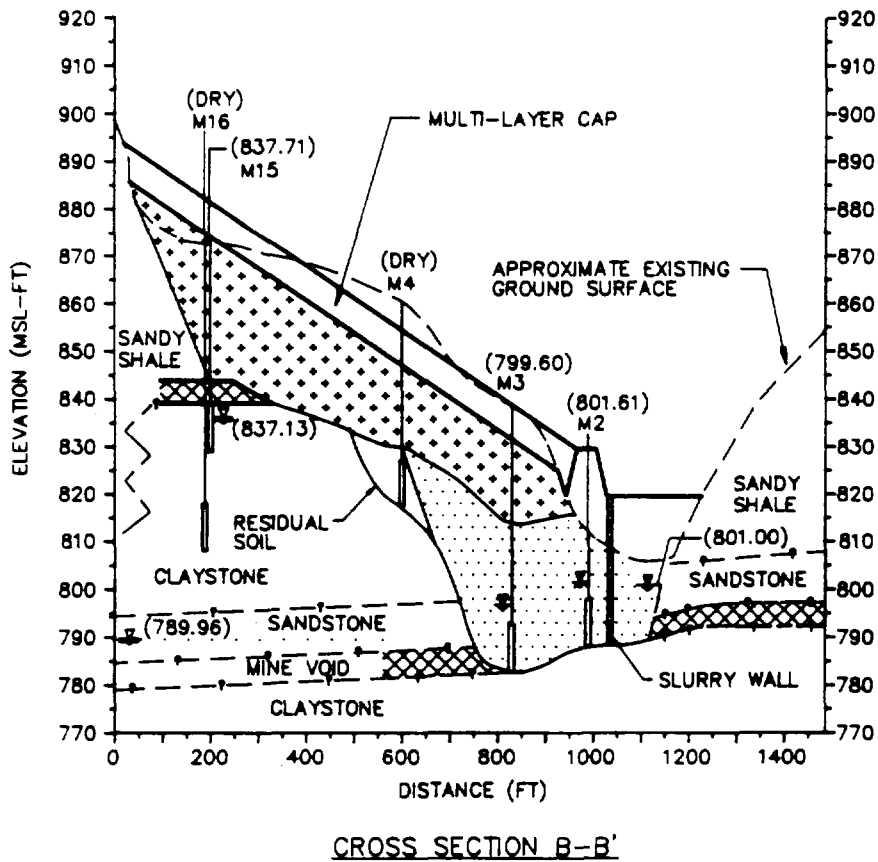
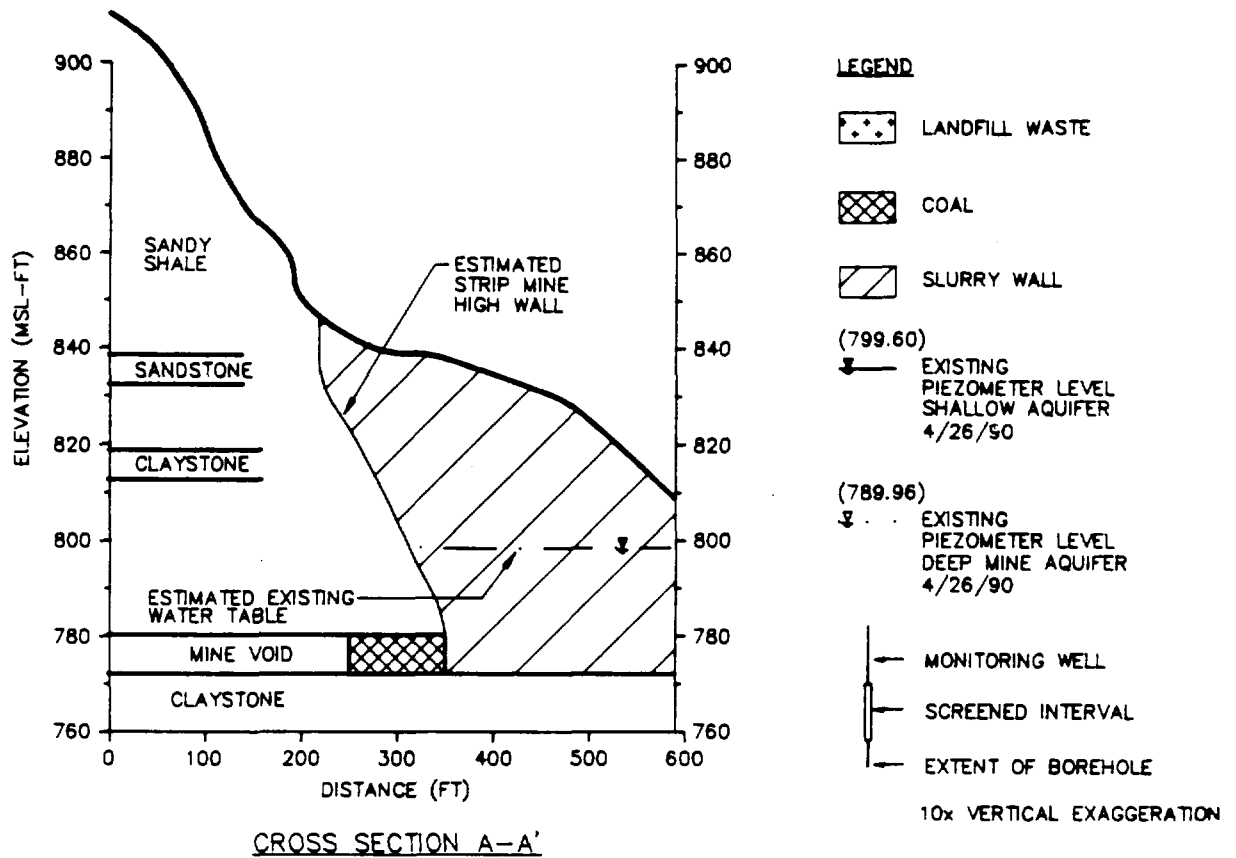


FIGURE 3-14
 ALTERNATIVE 6
 CROSS SECTIONS A-A' AND
 B-B'
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

- Discharge of Treated Water To Surface Water
- Wetlands Replacement

3.3.8 ALTERNATIVE NO. 8: MULTI-LAYER RCRA CAP WITH UPGRADE OF THE BYESVILLE WATER TREATMENT PLANT.

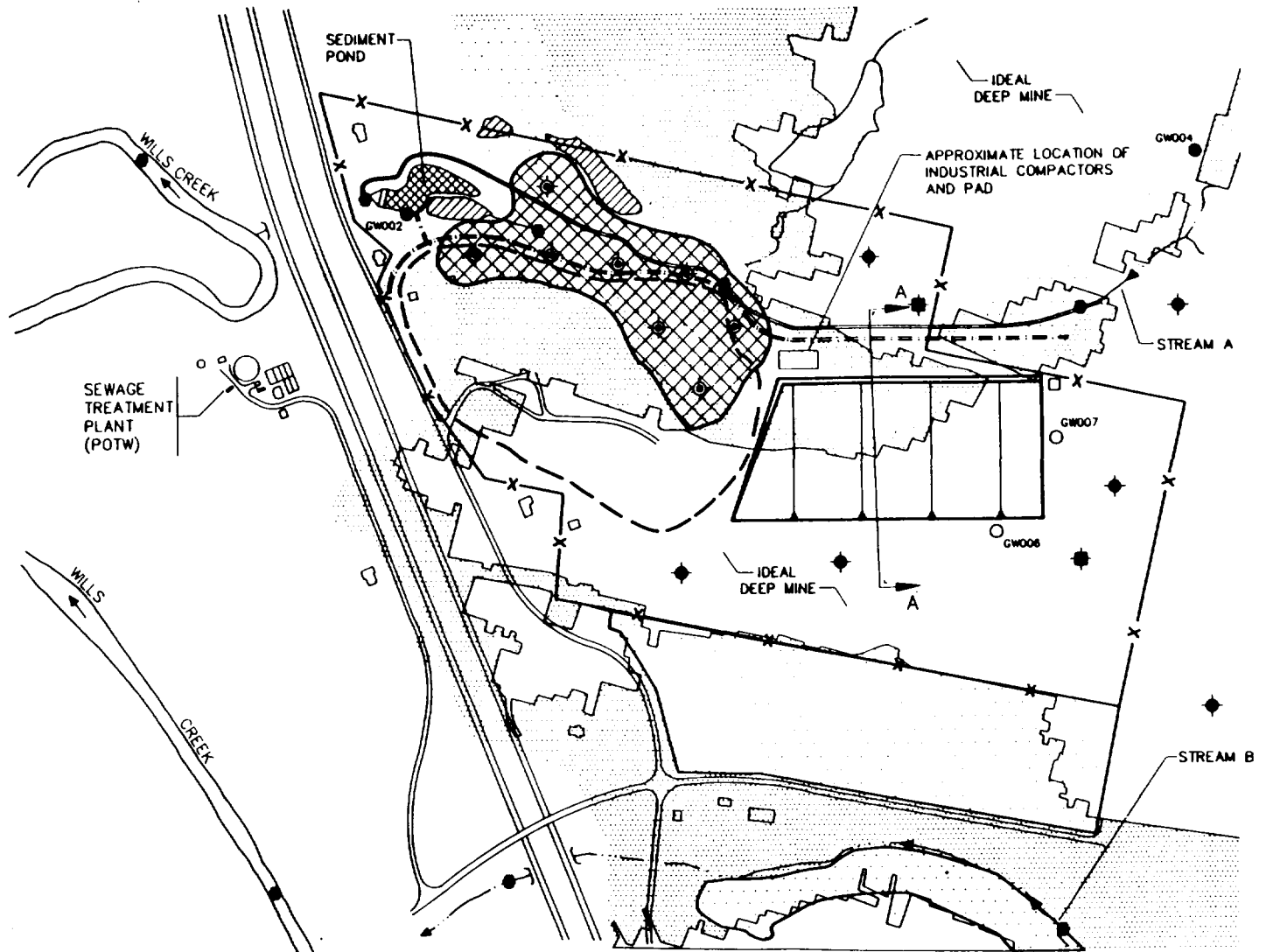
Alternative 8 is the same as Alternative 3, Multi-layer RCRA Cap, with the addition of an upgrade to the Byesville Water Treatment Plant to prevent any contamination from the Fultz Landfill Site that might migrate to the Byesville Plant No. 2 from entering the public drinking water supply. This Alternative achieves the remedial action objectives both by institutional controls and by insuring a safe drinking water supply regardless of increases in contaminant concentrations in the coal mine aquifer.

The components of Alternative 8 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Subsurface Structural Supports
- Surface Water and Sediment Controls
- Multi-layer Cap
- Leachate Collection System
- Upgrade of the Byesville Water Treatment Plant
- Wetlands Replacement

3.3.9 ALTERNATIVE NO. 9: ON-SITE LANDFILL WITH GROUNDWATER EXTRACTION AND TREATMENT

Alternative 9 is a combination of Alternative 5, On-site RCRA Landfill with the groundwater extraction and the on-site treatment system of Alternative 4. As shown on Figure 3-15, the array of groundwater extraction wells consists of 8 wells instead of the 12 wells used in Alternative 4. Only 8 wells will be used because the wells in Alternative 4 that were intended to cut off the migration of contaminants from the existing landfill to the coal mine aquifer will not be needed once the landfill waste is relocated. Alternative 9 meets






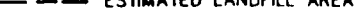













- LEGEND :**
-  COAL IN PLACE
 -  ABANDON DEEP MINES
 -  FORMER STRIP MINES
 -  ESTIMATED LANDFILL AREA
 -  SITE FENCE
 -  LEACHATE SUMP AND PUMP LOCATION
 -  CLEAN WATER DIVERSION CHANNEL
 -  TEMPORARY SEDIMENT CONTROL DITCH
 -  TOP OF SLOPE
 -  BOTTOM OF SLOPE
 -  ESTIMATED CAPTURE ZONE
 -  EXISTING SHALLOW AQUIFER MONITORING LOCATION
 -  EXISTING DEEP AQUIFER MONITORING LOCATION
 -  NEW SHALLOW AQUIFER MONITORING LOCATION
 -  NEW DEEP AQUIFER MONITORING LOCATION
 -  SURFACE WATER/SEDIMENT MONITORING LOCATION
 -  PROPOSED EXTRACTION WELL

FIGURE 3-15
 ALTERNATIVE 9
 ONSITE LANDFILL WITH GROUNDWATER
 EXTRACTION AND TREATMENT
 FULTZ LANDFILL SITE,
 FEASIBILITY STUDY REPORT

the remedial action objectives in the same manner as Alternative 5 with the added benefit of extracting contaminated groundwater from the shallow aquifer for treatment.

The components of Alternative 9 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Surface Water Controls
- Over-excavation of the Underground Mine
- Rock Underdrain
- Erosion and Sediment Controls
- Dewatering Facilities
- RCRA Equivalent On-site Landfill
- Extraction Well System
- On-site Water Treatment Plant
- Discharge of Treated Water To Surface Water
- Wetlands Replacement

3.3.10 ALTERNATIVE NO. 10: COAL MINE AQUIFER CUT-OFF BARRIER

Alternative 10 meets the remedial action objectives by a combination of the institutional actions of Alternative 2, and the installation of a low permeability barrier within the coal mine aquifer, as shown on Figure 3-16. The cut-off barrier would effectively prevent the migration of contaminants from the existing landfill and shallow aquifer into the coal mine aquifer.

The components of Alternative 10 are as follows:

- Institutional Controls
- Site Fence
- Alternate Water Supply
- Monitoring
- Erosion and Sediment Controls
- Dewatering Facilities

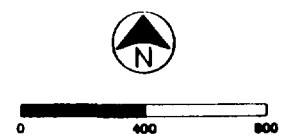
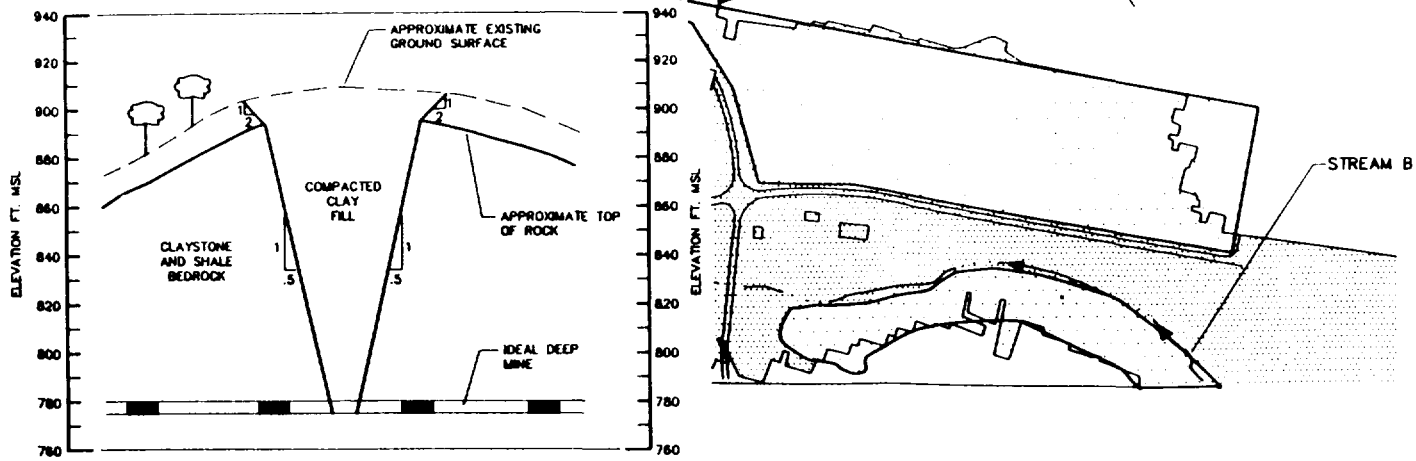
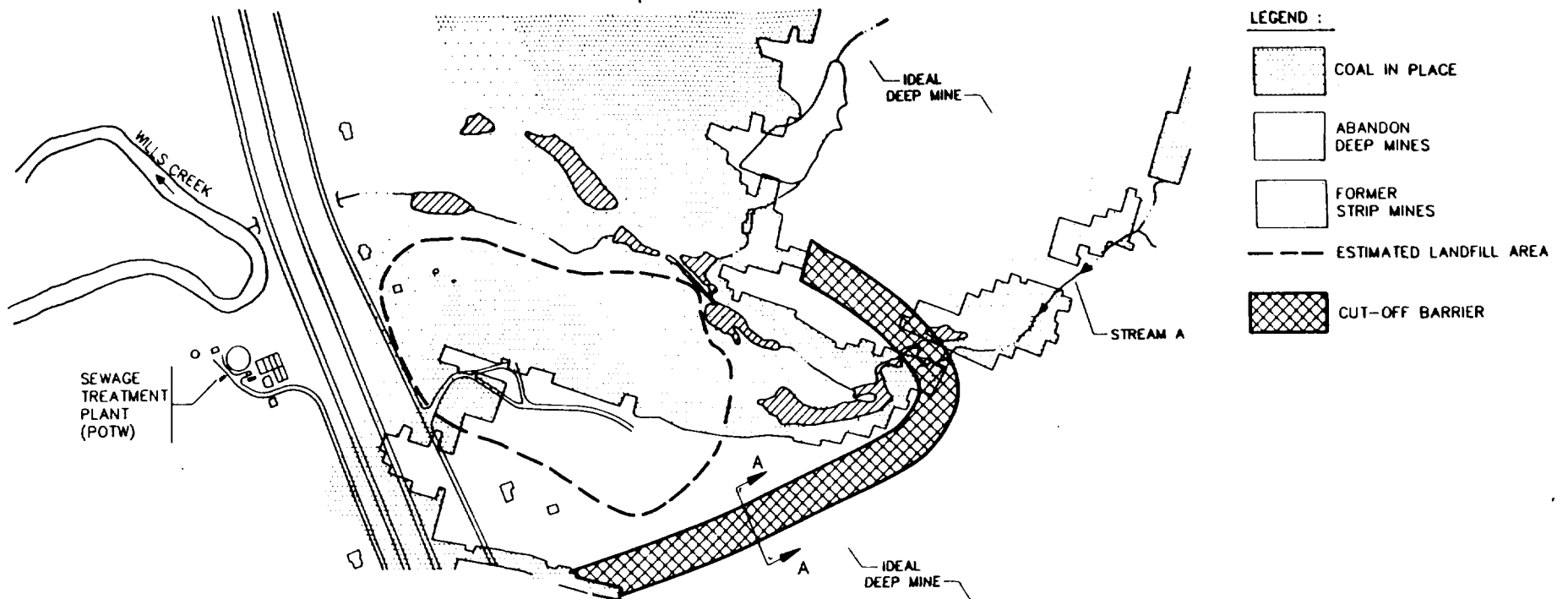


FIGURE 3-16
ALTERNATIVE 10
COAL MINE AQUIFER,
CUT-OFF BARRIER,
FULTZ LANDFILL SITE
3-51 FEASIBILITY STUDY REPORT

- Low Permeability Compacted Clay Cut-off Barrier
- Surface Water Control
- Wetlands Restoration

3.3.10.1 Institutional Controls, Site Fence, Alternate Water Supply, and Monitoring

Items 3.3.2.1 through 3.3.2.4 of Alternative 2 will be performed.

3.3.10.2 Erosion and Sediment Controls

Temporary erosion and sedimentation controls such as silt fences, hay-bail siltation barriers and small diversion channels will be installed as needed to prevent erosion during the construction of the cut-off barrier. Because the excavation and construction of the barrier can be staged to proceed from one end to the other, no permanent diversion channels or sediment ponds will be needed.

3.3.10.3 Dewatering Facilities

Temporary dewatering facilities consisting of well points and sump pumps will probably be required during the excavation of the trench for the cut-off barrier to control the seepage of groundwater into the excavation. A line of well points will be installed along sides of the excavation to lower the water table as needed during construction. Water that seeps into the excavation from the coal mine aquifer will be removed with sump pumps. Temporary facilities meeting all applicable Federal and State requirements will be built to hold the extracted water for testing and treatment or disposal.

3.3.10.4 Low Permeability Compacted Clay Cut-off Barrier

Construction of 2,400-foot long cut-off barrier in the coal mine aquifer will begin with the excavation of a trench from the ground surface to the floor of the coal mine. The trench will be 20-foot wide at the bottom and from 50 to 180 feet wide at the ground surface. It will extend from the intact coal to

the north of Stream Valley A through the former Ideal Mine, Stream Valley A between Pond 1A and Pond 1, through the former Ideal Mine west and south of the existing landfill to the intact coal on the northern side of Stream Valley B. The approximate location of the barrier is shown on Figure 3-16. The depth of the trench will vary from 36 feet near Stream A to 115 feet at the crest of the hill south of Pond 1. The average depth will be about 80 feet and will require the removal of an estimated 610,000 cubic yards of material approximately 60% of which will be rock. The trench will be filled with compacted clay to achieve a permeability of less than 10^{-7} cm/sec. The clay backfill will extend to within 3 feet of the original ground surface. The uppermost 3 feet of the excavation will be backfilled with random fill and covered with sufficient topsoil to permit revegetation of the disturbed area.

3.3.10.5 Surface Water Control

Part of the cut-off barrier will intersect Stream Valley A between Pond 1A and Pond 1. During the excavation and backfilling of the cut-off trench, Stream A will have to be temporarily re-routed around the excavation. To accomplish, the excavation will proceed in stages to allow Stream A to be diverted through a series of channels circumventing the excavation area.

3.3.10.6 Wetlands Restoration

During the design and construction of Alternative 10, every effort will be made to minimize the disturbance of areas identified as wetlands. The only area where wetlands are likely to be disturbed is in the vicinity of Stream A between Pond 1A and Pond 1 comprising approximately 8,000 square feet. Before construction commences, a study will be performed to delineate the extent of wetlands and develop a plan for remediation. At a minimum, the wetlands replacement plan would include restoration of the wetlands area temporarily disturbed by the barrier installation.

3.4 SCREENING OF ALTERNATIVES

In this section, defined alternatives are evaluated against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. The alternatives are evaluated more generally in this section than in the detailed analysis of alternatives in Section 4. It is important to note that comparisons between alternatives during screening are made between similar alternatives with the most promising carried forward for further evaluation; whereas, comparisons made during the detailed analysis will differentiate across the entire range of the alternatives. The criteria used during screening are roughly the same as the criteria presented for the screening of technologies (Section 2.6) except that the criteria are applied to the alternative as a whole.

Of the 10 alternatives that were developed to meet the remedial action objectives, 4 were eliminated based on the screening criteria discussed above. The following sections present the rationale for screening out Alternatives 7 through 10.

3.4.1 ALTERNATIVE 7: GROUNDWATER EXTRACTION (WITHOUT CAP)

Alternative 7 was not carried forward for detailed analysis because, without the installation of a cap, it did not provide adequate closure of the existing landfill. It would be less effective in preventing the spread of contamination because it would not address the vertical migration of contaminants through the bedrock layer between the existing landfill and the coal mine aquifer. Although the cost would be much lower than Alternatives 3 through 6, the groundwater extraction system would need to be operated indefinitely because there would be no reduction in contaminant transport by infiltration of precipitation through the existing landfill.

3.4.2 ALTERNATIVE 8: CAP WITH UPGRADE OF THE BYESVILLE WATER TREATMENT PLANT.

Alternative 8 was not carried forward for detailed analysis because the analysis of contaminant transport from the Fultz Landfill Site to the coal mine aquifer utilizing a two dimensional solute model (Appendix C) indicated that the effects of the Fultz Landfill Site on the Byesville water supply well are minimal at present.

Comparison of the results of analysis of treated and untreated samples from the Byesville Water Treatment Plant during the RI indicates that the present treatment system is capable of treating the water adequately to protect human health and the environment. As a result, no additional effectiveness would be added to Alternative 3 by upgrading the Byesville Water Treatment Plant.

3.4.3 ALTERNATIVE 9: ON-SITE LANDFILL WITH GROUNDWATER EXTRACTION

Alternative 9 was not carried forward for detailed analysis because it was judged no more effective in protecting human health and the environment than Alternative 5. At the same time, the cost of groundwater extraction and treatment would make Alternative 9 substantially higher than Alternative 5. Although the cleanup time for the shallow aquifer would potentially be shorter with groundwater extraction and treatment, the contaminant concentrations in the shallow aquifer groundwater would be reduced over time (estimated at 14 to 46 years) by natural attenuation once the wastes are contained. Therefore, the additional expense of an extraction and treatment system is not justified.

3.4.4 ALTERNATIVE 10: COAL MINE AQUIFER CUT-OFF BARRIER.

Alternative 10 would be the most effective alternative for preventing the off-site migration of contaminants from the Fultz Landfill Site through the coal mine aquifer. However, the highest risks that were identified in the BRA were attributed to future use of on-site groundwater. Alternative 10 would address risks from use of the on-site groundwater with site access and use restrictions only, making it no more effective than Alternative 2 at reducing the highest risks. Although the technologies used to implement Alternative 10

are common and readily available, an excavation of this size involving the movement of 700,000 cubic yards of earth and rock and the importation of a near equal quantity of clay would be an enormous task. Controlling the infiltration of groundwater from the coal mine aquifer might also prove very difficult. Because it is not more effective in reducing the major risks at the Fultz Landfill Site, would be costly and difficult to implement, and without the installation of a cap would not provide adequate closure of the existing landfill, Alternative 10 was not carried forward for detailed analysis.

4.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

4.1 INTRODUCTION

In this section, each of the remedial alternatives and options assembled in Section 3.0 are evaluated in detail. An overview of the criteria used in the evaluation is provided in Section 4.2. Table 4-1 provides a summary of the principal elements contained in each alternative. The alternatives were described in detail in Section 3.0. The detailed evaluation of each remedial alternative considering effectiveness, implementability, and cost of the remedial alternative, emphasizing the factors outlined in the proposed NCP Final Rule (March, 1990) is presented in Table 4-2. Appendix D provides a complete cost breakdown of the capital and operation and maintenance costs of the individual elements of each alternative. The level of detail in the conceptual design is focused on providing cost estimates with an accuracy in the range of +50% / -30%, based on the scope of work developed herein. Actual contractor bids may exceed this range due to the final design and bidding conditions that exist at the time of the bid. Section 4.3 provides a comparison of the relative value of each alternative in meeting each of the nine criteria.

4.2 EVALUATION CRITERIA

Following their description, the remedial alternatives are examined with respect to requirements stipulated in the proposed NCP, 40 CFR Part 300, Section 300.430, paragraph (e)(9). A total of nine criteria are used in alternative evaluation:

- Overall Protection of Human Health and the Environment;
- Compliance with ARARs;
- Long Term Effectiveness and Permanence;
- Reduction of Toxicity, Mobility, and Volume Through Treatment;
- Short Term Effectiveness;
- Implementability;
- Cost;

**TABLE 4-1
KEY COMPONENTS OF REMEDIAL ACTION ALTERNATIVES
FULTZ LANDFILL SITE
FEASIBILITY STUDY REPORT**

REMEDIAL TECHNOLOGY OR ACTION	Alternative					
	No Action	Institutional Actions and Monitoring	Capping	Capping and Ground- water Extraction	Onsite Landfill	Capping and Slurry Wall
Monitoring		■	■	■	■	■
Institutional Controls		■	■	■	■	■
Alternate Water Supply		■	■	■	■	■
Multi-layer Cap			■	■	■	■
Grading and Revegetation			■	■	■	■
Sediment and Erosion Controls			■	■	■	■
Wetlands Replacement			■	■	■	■
Excavation (Removal)					■	
Onsite Landfill					■	
Subsurface Supports			■	■		■
Slurry Wall						■
Extraction Wells				■		
Subsurface Drains			■	■	■	■
Onsite Water Treatment				■		
Offsite Leachate Disposal			■		■	■
Discharge To Surface Water				■		

TA
DETAILED EVALUATION
FULTZ LAA
FEASIBILITY

EVALUATION CRITERIA	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS	ALTERNATIVE 3 MULTI-LAYER CAP	ALTERNATIVE 4 MULTI-LAYER CAP WITH GROUNDWATER EXTRACTION AND TREATMENT	ALTERNATIVE 5 BEN OF-SITE LANDFILL	ALTERNATIVE 6 MULTI-LAYER CAP AND SUBSURFACE BARRIER
Overall Protection of Human Health and the Environment.	Risks will continue at current levels. 1. cancer risks of 2×10^{-5} to 10^{-6} for off-site residential wells, 10^{-4} for inhalation of airborne contaminants by nearby residents, and 10^{-3} for ingestion of on-site shallow groundwater, and mine aquifer water by future residents.	Risks will be significantly reduced by site access and site use restrictions if strictly enforced. A potential risk from airborne contamination will remain, but is not anticipated to be significant outside of the site fence.	Risks from both groundwater and air will be significantly reduced, provided that the cap remains intact, and institutional controls are strictly enforced. The contaminants would remain on-site, but their mobility would be reduced by the cap, and they would be collected on-site by the leachate collection system.	Risks from groundwater and air would be significantly reduced provided that the cap remains intact and site access and use restrictions are strictly enforced. The bulk of the contamination source would remain on-site, but their mobility would be reduced by the cap, leachate collection system, and active groundwater extraction from the shallow aquifer.	Risks to human health would be reduced to the current risk levels associated with background levels of contaminants, provided that the new landfill liners and cap remain intact.	Risks from groundwater and air would be significantly reduced, provided that the cap remains intact and site access and use restrictions are strictly enforced. Contaminants would remain on-site but their mobility would be reduced by the cap, leachate collection system, and subsurface barrier.
Compliance with ARARs	Ohio standards for landfill construction and closure would not be met. NCLs for groundwater would not be met. There would be no impact by remediation on existing wetlands.	Ohio standards for landfill closure would not be met. NCLs for groundwater quality would not be met. There would be no impact by remediation on existing wetlands.	Ohio standards for landfill closure would be met provided that justification can be made for cap with a slope greater than 5%. Ponds 2 and 3 would and the weeping hillside wetland would be eliminated. Replacement would be provided for Ponds 2, 3 and the wetlands lost from lowering Pond 1.	Ohio standards for landfill closure would be met provided that justification can be made for cap with a slope greater than 5%. Ponds 2 and 3 and the weeping hillside wetland would be eliminated. Replacement wetlands would be provided for Ponds 2, 3 and the wetlands lost from lowering Pond 1.	Ohio siting criteria for construction of a solid waste landfill would not be met. Ponds 1 and 2 would and the weeping hillside wetland would be eliminated. Replacement wetlands would be provided for Ponds 1 and 2.	Ohio standards for landfill closure would be met provided that justification can be made for cap with a slope greater than 5%. Ponds 2 and the weeping hillside wetland would be eliminated. Replacement wetlands would be provided for Pond 2 and the wetlands lost from lowering Pond 1.
Long Term Effectiveness and Permanence						
Magnitude of residual risk	Groundwater quality would be expected to remain as it exists now indefinitely. Since no specific concentrated source was identified, it is not possible to estimate the length of time that the groundwater would be affected. Risks identified in the Remedial Investigation would remain at current levels indefinitely.	Estimated average annual infiltration of precipitation through the landfill is 6.3 inches or about 18,360 GPD which would continue to move contaminants into the shallow and coal mine aquifers, and surface water. Reduction in risks would depend on the effectiveness of enforcement of the institutional controls.	Infiltration through the landfill would be reduced to about 0.02 inches per year (about 32 GPD). Assuming that most of the infiltration would drain into the leachate collection system as indicated by the HELP model (see Appendix A), the contaminant loading to the shallow aquifer would be negligible. Risks from ingestion of water from the shallow aquifer would be significantly reduced by institutional controls. Infiltration and percolation of rain and snow water currently provides one complete groundwater change to the shallow aquifer every 13 years. Assuming no additional contaminant loading groundwater in the shallow aquifer would attain NCLs within 13 to 46 years.	Infiltration through the landfill cap would be reduced to about 0.02 inches per year. Nearly all of this, however, would be intercepted by the groundwater extraction wells. Leachate that is not collected by the leachate collection system would be removed by the extraction wells. Estimated time to meet NCLs for the shallow aquifer is 4 to 14 years.	Since the source of contamination will be removed when the waste is placed in the new landfill, groundwater quality is expected to improve to background concentrations over time. Estimated time to meet NCLs by dilution in the shallow aquifer is 13 to 46 years, assuming no additional contaminant loading after the existing source is removed.	Infiltration through the landfill would be reduced to about 0.02 inches per year (about 32 GPD). As with Alternative 3, the contaminant loading to the shallow aquifer would be negligible. Migration of contaminants from the shallow to coal mine aquifer would be reduced even further by the subsurface barrier. Risks from ingestion of water from the shallow aquifer would be significantly reduced by institutional actions. Assuming no additional contaminant loading from outside the landfill, groundwater would attain NCLs within 13 to 46 years.
Adequacy and reliability of controls.	Continued erosion of the landfill surface is likely. Leachate seeps from the landfill will continue to transport contamination slowly to the surface waters to the north and west of the landfill. Vertical migration of contaminants into the coal mine aquifer will also continue.	Institutional controls will require strict enforcement by state and local officials in order to be effective. Site fence will require periodic maintenance. There is no guarantee that contaminant transport off-site will not increase over time. The existing landfill surface will continue to erode possible exposing the buried waste.	Fence and cap will require periodic maintenance but should be reliable over the 30 year life of the alternative. Leachate collection system will need to be emptied every 2 days in the first few years after capping, declining to once a week at the end of the 30 year period. Cap will require replacement at some time in the future, beyond the 30 year period.	As in Alternative 3, the fence and cap will require periodic maintenance, and would be very reliable in reducing infiltration over the 30 year life of the alternative. Groundwater extraction and treatment system requires considerable more maintenance, and frequent replacement of equipment, but it is also very reliable for cleaning up the shallow aquifer.	Assuming the integrity of the liner and cap, exposure to site-related contaminants would be reduced to near zero. Because the contaminant source within the existing landfill will be removed and treated off-site, and the remaining solid waste will be isolated in a double lined and capped landfill, this remedial action will be very reliable in the source of contaminant release.	As in Alternative 3, the fence and cap will require periodic maintenance but should be reliable over the 30 year life of the alternative. The slurry wall would be adequate to reduce migration of contaminants to the coal mine aquifer. Although occasionally, slurry walls fail they are generally reliable without maintenance over long periods of time. Cap and slurry wall will require replacement at some time in the future beyond the 30-year period.

TABLE 4-2 (Continued)
 DETAILED EVALUATION OF ALTERNATIVES
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT

EVALUATION CRITERIA	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 INSTITUTIONAL CONTROLS	ALTERNATIVE 3 MULTI-LAYER CAP	ALTERNATIVE 4 MULTI-LAYER CAP WITH GROUNDWATER EXTRACTION AND TREATMENT	ALTERNATIVE 5 NEW ON-SITE LANDFILL	ALTERNATIVE 6 MULTI-LAYER CAP AND GROUNDSPACE BARRIER
Reduction of Toxicity, Mobility, and Volume Through Treatment.	No treatment process used.	No treatment process used.	ALTERNATIVE 3 MULTI-LAYER CAP Toxicity and volume of contaminants would be reduced because an estimated annual average of 525,000 gallons per year of leachate would be collected and removed for off-site treatment. However, whatever hazardous materials that are currently believed to be present in the landfill would be expected to remain there indefinitely, and a small quantity of leachate may continue to infiltrate vertically from the existing landfill into the coal mine aquifer. Off-site treatment of leachate would produce sludges. Mobility of contaminants would be reduced. Infiltration and percolation through the waste would be reduced. Leachate collection system would significantly reduce the amount of leachate entering the shallow and coal mine aquifers.	ALTERNATIVE 4 MULTI-LAYER CAP WITH GROUNDWATER EXTRACTION AND TREATMENT Alternative 4 would achieve the same reduction in mobility and toxicity that would occur in Alternative 3 plus an additional 5 million gallons of contaminated groundwater would be extracted and treated. The on-site treatment plant is expected to produce 30 tons per year of sludge which will have to be treated and/or landfilled off-site.	ALTERNATIVE 5 NEW ON-SITE LANDFILL Hazardous materials, if encountered during excavation, would be stabilized and treated off-site. The quantity of material for treatment is unknown. About 130,000 gallons of leachate per year from the new on-site landfill would have to be treated off-site.	ALTERNATIVE 6 MULTI-LAYER CAP AND GROUNDSPACE BARRIER An estimated annual average of 525,000 gallons per year of leachate would be collected and removed for off-site treatment. Mobility of contaminants would be reduced because the cap would cut off infiltration into the landfill, and the leachate collection system would prevent most of the leachate from entering the shallow and coal mine aquifers. The slurry wall would virtually eliminate migration of contaminants from the existing landfill into the coal mine aquifer.
Short-term Effectiveness	No action, therefore, no short-term increase in risk level.	The only on-site activity is the installation of a site fence. There would be no intrusive action in the waste area, and as a result no short-term increase in risk to the public from the implementation of Alternative 2.	Construction of the cap would involve moving a maximum of 82,000 cubic yards of waste during regrading of the existing landfill and construction of the leachate collection system. Controls would be needed to limit the increased potential risk from the release of volatiles during the construction process.	Controls would be required to limit the risk from VOC air emissions, that would primarily be during regrading of the existing landfill and construction of the leachate collection system. Noise and dust from the regrading of the landfill area and the construction of the cap would be a nuisance for nearby residents without proper controls.	The excavation of 1 million cubic yards of soil for the new landfill and the relocation of existing waste would be a nuisance for nearby residents without proper controls. Blasting may be required during excavation. Some VOC air emissions would occur during excavation of the waste.	As with Alternative 3, some increased VOC air emissions would probably occur during construction of the slurry wall, and leachate collection system. Noise and dust during construction would be a nuisance for nearby residents without proper controls. Surface water quality would be potentially affected during the installation of the slurry wall, but sediment controls should mitigate this effect.
Protection of workers during remedial action.	No risk to workers associated with no action.	The installation of the site fence would expose workers to some VOC vapors, but since the duration of the work is short and low, the additional short-term risk would be minimal. Dermal and respiratory protection may be required. Fugitive dust emissions during construction would require controls as per OMC 3745-17-06.	Regarding the landfill and construction of the lower layers of the cap will require workers to breathe VOC vapors and dusts directly with potentially contaminated soils. Use of Personal Protection Equipment, Level 'C', may be required to reduce the short-term risk below acceptable limits. Protection level D would suffice for the construction of the cap. Fugitive dust emissions during construction would require controls as per OMC 3745-17-06.	Regarding the landfill and construction of the lower layers of the cap will require workers to breathe VOC vapors and dusts directly with potentially contaminated soils. Use of Personal Protection Equipment, Level 'C', may be required to reduce the short-term risk below acceptable limits. Protection level D would suffice for the construction of the cap and the installation of monitoring wells. Fugitive dust emissions during construction would require controls as per OMC 3745-17-06.	Level C and/or level B health and safety protection and safety required during excavation and regrading of waste. If hazardous materials are found within the landfill, protection level B or A may be required. There is some additional danger from the lack of knowledge about the location of hazardous or industrial wastes suspected to have been dumped in the landfill. Fugitive dust emissions during construction would require controls as per OMC 3745-17-06.	Level C health and safety protection may be required during excavation of the landfill, and the installation of the slurry wall, collection system and slurry wall. Level B protection would suffice for the construction of the cap and the installation of monitoring wells. Fugitive dust emissions during construction would require controls as per OMC 3745-17-06.
Time until remedial actions are achieved.	No remedial action.	Estimated time to completion depends on speed with which institutional controls can be put into effect. This should be less than one year.	Capping the landfill should take about 3 years, following the completion and approval of the remedial design.	Construction of the cap would take about 4 years. Alternative 3 would take about 3 years to complete the cap, the pit, and move the existing waste, and another 1.5 years to cap the new landfill for a total construction time of 7.5 years following approval of the remedial design.	Excavation of the new landfill would take about 3 years with an additional 3 years to close the pit, and move the existing waste, and another 1.5 years to cap the new landfill for a total construction time of 7.5 years following approval of the remedial design.	Because the slurry wall can be constructed concurrently with the landfill cap the total construction time would be the same as Alternative 3, that is, 3 years following approval of the remedial design.

TABLE 4-2 (Continued)
 DETAILED EVALUATION OF ALTERNATIVES
 FULTZ LANDFILL SITE
 FEASIBILITY STUDY REPORT

EVALUATION CRITERIA	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 ENVIRONMENTAL CONTROLS	ALTERNATIVE 3 MULTI-LAYER CAP	ALTERNATIVE 4 MULTI-LAYER CAP WITH GROUNDWATER EXTRACTION AND TREATMENT	ALTERNATIVE 5 NEW ON-SITE LANDFILL	ALTERNATIVE 6 MULTI-LAYER CAP AND SURFACE BARRIERS
Environmental Impacts	Continued release of contaminants to groundwater, surface water, and air.	Continued release of contaminants to groundwater, surface water, and air.	Disturbance of about 40 acres of ground surface will result in some additional sedimentation and contamination of surface water, which will be minimized by sedimentation controls. Wildlife in Ponds 2 and 3, and in the existing landfill area will be displaced.	The environmental impacts would be similar to those of Alternative 3. Disturbance of about 40 acres of ground with potentially some additional contamination of surface water. Wildlife in Ponds 2 and 3, and in the existing landfill area will be displaced.	Disturbance of about 52 acres of ground surface will result in some additional sedimentation and contamination of surface water, which will be minimized by sedimentation controls. Wildlife in Ponds 1 and 2, the existing landfill area, and the proposed landfill area will be displaced. Some additional contaminated water from the eastern end of the shallow aquifer would flow into the coal mine during construction.	The environmental impacts would be similar to those of Alternative 3. Disturbance of about 40 acres of ground and potentially some additional contamination of surface water. Wildlife in Pond 2, and in the existing landfill area would be displaced.
Implementability						
Technical Feasibility	No action taken.	All actions are easily implemented using established methods.	All technologies are easily implemented using established methods.	All actions are easily implemented using established methods.	Although construction would use standard methods, control of groundwater during over-excavation of the coal mine may be difficult. The movement and stockpiling of such a large quantity of earth and rock will also be somewhat difficult.	All actions are easily implemented using established methods.
Availability of services and Materials	No action taken.	All services are readily available.	All technologies employed use readily available materials most of which are available locally.	All technologies employed use readily available services and materials.	All technologies employed use readily available services and materials.	All technologies employed use readily available services and materials.
Administrative Feasibility	No action taken.	Administrative problems are not expected.	Permission for the relocation of wetlands will be required. The substantive requirements of an NPDES permit will have to be met for onsite discharge.	Replacement of wetlands will require approval from state and federal agencies. The substantive requirements of an NPDES permit will have to be met for onsite discharge.	Permit equivalencies may be required to remove the coal mine and construct the landfill. Although it is feasible to meet siting requirements, it will be difficult to design and construct the landfill with minimal impact to wetlands and other environments. State approval for a new landfill may be difficult to obtain because of the uncertainty of the quantity and location of hazardous materials in the existing landfill. The substantive requirements of an NPDES permit will have to be met for onsite discharge.	Replacement of wetlands will require approval from state and federal agencies. The substantive requirements of an NPDES permit will have to be met for onsite discharge.
Cost						
Capitol Cost*	None	\$520,000	\$16,000,000	\$17,000,000	\$54,000,000	\$17,000,000
Annual Operation and Maintenance	None	\$110,000	\$240,000	\$220,000	\$130,000	\$240,000
Present Worth (6.5% discount rate over 30 years)	None	\$2,300,000	\$21,000,000	\$21,000,000	\$57,000,000	\$21,000,000

* Capitol costs including permitting, contingency and design costs.

- State Acceptance;
- Community Acceptance.

The first two criteria are threshold criteria which must be met by each alternative considered. The next five criteria are the primary balancing criteria upon which the analysis is based. The final two criteria are modifying criteria and are applied following the public comment period to evaluate state and community acceptance. They are evaluated following comment on the RI/FS report and the proposed plan and are addressed once a final decision is being made and the Record of Decision (ROD) is being prepared.

Each of the nine evaluation criteria are assessed by evaluating specific factors to allow a thorough and consistent analysis of the alternatives. These factors are presented in Table 4-2 and briefly discussed in the order they are performed in the detailed analysis in the following subsections.

4.2.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This evaluation criterion provides an overall assessment of protection based on whether the alternative can adequately protect human health and the environment from unacceptable risks posed by hazardous substances present at the site. It draws on other factors such as long-term and short-term effectiveness and compliance with ARARs. Evaluations of the overall protectiveness address:

- How a specific site remedial action achieves protection over time;
- How site risks are reduced; and,
- How each source of contamination is to be eliminated, reduced, or controlled for each remedial action.

4.2.2 COMPLIANCE WITH ARARS

This evaluation criterion is used to determine how each remedial action complies with applicable or relevant and appropriate Federal and State requirements. Each alternative is evaluated in detail for:

- Compliance with chemical-specific ARARs,
- Compliance with action-specific ARARs,
- Compliance with location-specific ARARs, and
- Compliance with appropriate criteria, advisories, and guidance (i.e., "To Be Considered") material.

4.2.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

This evaluation criterion addresses the results of the remedial action in terms of the risk remaining after the response objectives have been met. Of particular interest is the effectiveness of the controls that will be applied to manage the risks posed by the residuals of the treatment process and/or untreated source. The components of this criterion include the magnitude of the remaining risks measured by numerical standards such as cancer risk levels; the adequacy and suitability of controls used to manage treatment residuals or untreated wastes; and the long-term reliability of management controls for providing continued protection from residuals, i.e., the assessment of potential failure of the technical components.

4.2.4 REDUCTION OF TOXICITY, MOBILITY OR VOLUME

This evaluation criterion addresses the statutory preference that treatment is used to reduce the principal threats of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. Factors of this criterion to be evaluated include the treatment process employed; the amount of hazardous material destroyed or treated; the degree of reduction in toxicity, mobility, or volume expected; and the type and quantity of treatment residuals.

4.2.5 SHORT-TERM EFFECTIVENESS

This evaluation criterion addresses the impacts of the action on public health and the environment during the construction and implementation phase until the remedial response objectives are met. Factors to be evaluated include protection of workers during the remedial actions, environmental impacts resulting from the implementation of the remedial actions, and the time required to achieve protection.

4.2.6 IMPLEMENTABILITY

This criterion addresses the technical and administrative feasibility of implementing a remedial action and the availability of various services and materials required during its implementation. Factors of technical feasibility include construction and operational difficulties, reliability of technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy. The administrative feasibility includes the ability and time required for permit approval, property access, and for activities needed to coordinate with applicable State and local agencies. Factors to evaluate the availability of services and materials include availability of treatment, storage, and disposal services with required capacities; availability of equipment and specialists; and availability of prospective technologies for competitive bid.

4.2.7 COST

The cost evaluation criteria addresses: capital costs, operation and maintenance (O&M) costs, costs of five-year reviews, where required, present value of capital and O&M costs, and potential future remedial action costs. Capital costs consist of direct and indirect costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install remedial actions. Indirect costs include expenditures for engineering, financial, and other services required to complete the application of remedial alternatives. Annual O&M costs include auxiliary materials and energy, disposal of residues, purchased services, administrative costs, insurance,

taxes, license costs, maintenance reserve and contingency funds, rehabilitation costs, and costs for periodic site reviews.

There are six contingency factors that are applied to the construction subtotal costs; health and safety, bid, scope, permitting and legal, services during construction, and engineering and design. These contingencies represent the uncertainties involved in the project costing, and are intended to provide the additional costs that may be required to complete the project. These six contingency factors are discussed in greater detail below:

- Health and Safety: This contingency is intended to reflect the additional costs incurred by the health and safety program that will be required to be implemented at the site. Costs cover medical monitoring of all on-site workers, health and safety equipment and monitoring devices, and oversight by trained health and safety officers.

- Bid: Bid contingencies may cover unknown costs associated with construction, such as adverse weather conditions, strikes by material suppliers, geotechnical unknowns, and unfavorable market conditions.

- Scope: Scope contingencies cover scope changes that invariably occur during final design and implementation. At this stage, the design concept is not developed fully enough to identify all the project components and ancillary costs. The scope contingency provides a reserve for change orders, inaccuracies in defining unit quantities and volumes, and the lack of performance history for hazardous chemical remediation projects.

- Permitting and Legal: Expenses may include legal fees and fees for technical personnel necessary to obtain licenses and permits. This contingency covers the cost for preparing permit applications and obtaining permits, as well as the cost of obtaining legal advice for negotiating construction and operating contracts.

- Services During Construction: This contingency is intended to cover the anticipated costs incurred during the actual implementation of the remedial alternative. It includes construction management and on site observation, submittal review and office services, additional design work required during remediation, and the production of any required operation and maintenance manuals.
- Engineering and Design: Engineering and design contingencies include the design and process development, preparation of specifications and bid documents, drafting, and additional monitoring and testing that may be required.

4.2.8 STATE ACCEPTANCE

This assessment evaluates the technical and administrative issues and concerns the State of Ohio may have regarding each of the remedial actions. The factors to be evaluated include features of the actions that the State supports, the State has reservations over, or the State opposes. Since the State can not provide formal comments concerning the alternatives until it can review the Draft FS, evaluation of the "State Acceptance" criterion can not realistically be addressed in this draft report. The State Acceptance criterion will be addressed in the Record of Decision (ROD), issued following receipt of comments from the State. The State will also be involved as a mediator for receipt of public comments concerning the site, and the proposed alternatives at the site.

4.2.9 COMMUNITY ACCEPTANCE

This assessment incorporates public input into the analysis of the remedial actions. Factors of community acceptance to be discussed include features of the support, reservations and opposition of the community. Since the public has not been provided with a formal opportunity to review the detailed analysis of the remedial actions, evaluation of the "Community Acceptance" criterion can not realistically be addressed in this report. Public comments and concerns will be incorporated into the Record of Decision (ROD) following

a public meeting and the receipt of comments from the public. The State and Community Acceptance criterion will not be addressed further in this report. Therefore, only the first seven evaluation criteria were used to evaluate the remedial alternatives.

4.3 COMPARISON OF ALTERNATIVES

In this section the six alternatives are compared in order to highlight the differences between the alternatives, and determine their relative value in meeting seven of the nine criteria for the detailed evaluation of alternatives. Since Alternative 1 (No Action) does not address any of the remedial action objectives, it is considered only briefly in this comparison.

4.3.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

With the exception of Alternative 1, all of the alternatives reduce the current and future potential risks associated with the Fultz Landfill Site to acceptable levels by the implementation of institutional actions. Since Alternative 1 fails to meet this threshold criterion it will be dropped from further consideration. All the other alternatives will be carried forward in this comparison.

4.3.2 COMPLIANCE WITH ARARS

Alternative 2, Institutional Actions and Monitoring, does not meet ARARs for the Fultz Landfill Site. Closure of the existing landfill according to state standards would not be performed, and the pattern of contaminant migration would continue. Chemical specific ARARs would not be met in the shallow or deep mine aquifers. Maximum leachate concentrations would continue to exceed surface water criteria for discharges to Wills Creek for at least four organic compounds and four inorganics. Surface water sampling during the RI indicated that the leachate becomes diluted before reaching Wills Creek. Iron was the only chemical that exceeded the surface water standards for discharge to Wills Creek. Alternative 5 will not meet all ARARs because it does not meet State

of Ohio solid waste landfill siting criteria. Therefore it will be eliminated from further consideration. Alternatives 3, 4 and 6 would meet ARARs. Since Alternative 1 and 5 failed to meet this threshold criterion they will be dropped from further consideration. Alternative 3, 4 and 6 will be carried forward in the comparison.

4.3.3 LONG TERM EFFECTIVENESS AND PERMANENCE

Because of the size and heterogeneous nature of the existing landfill, no truly permanent solution was determined to be cost effective for the Fultz Landfill Site. With all of the alternatives, some form of waste remain on-site, and therefore, the site would require continued monitoring for the foreseeable future. The reduction in risk with all of the alternatives depends in part on the enforcement of institutional controls. Alternative 4, provides an advantage over Alternatives 3 and 6 because contaminated groundwater is extracted and treated. Alternative 4 also provides hydraulic control migration of contaminants from the existing landfill. Alternative 6 provides a partial barrier to contaminant migration. Alternative 3 provides only control over infiltration induced migration of contaminants. Listed in the order of overall long-term effectiveness from the most effective to the least effective; they are:

Most Effective

- Alternative No. 4: Multi-layer Cap with Groundwater Treatment
- Alternative No. 6: Multi-layer Cap with Subsurface Barrier
- Alternative No. 3: Multi-layer Cap

Least Effective

4.3.4 REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT

Alternative 4 provides the greatest reduction in toxicity and volume of hazardous materials. Alternative 4 addresses the principal threat at the site by treating over 6 million gallons of contaminated groundwater per year.

Listed in the order of overall reduction of toxicity, mobility and volume through treatment from the greatest reduction to the least reduction, they are:

Greatest reduction

- Alternative No. 4: Multi-layer Cap with Groundwater Treatment
- Alternative No. 6: Multi-layer Cap with Subsurface Barrier
- Alternative No. 3: Multi-layer Cap

Least Reduction

4.3.5 SHORT TERM EFFECTIVENESS

Alternative 4 achieves remedial action goals in the least amount of time although it requires a somewhat longer time for construction. Alternative 6 poses the greatest risk to workers during construction because of the excavation of the slurry wall. Alternatives 3 and 6 pose a greater risk to the community because leachate will be hauled offsite. Listed in the order of short-term effectiveness in achieving remedial action goals from the most effective to the least effective, they are:

Most effective in the short term

- Alternative No. 4: Multi-layer Cap with Groundwater Treatment
- Alternative No. 3: Multi-layer Cap
- Alternative No. 6: Multi-layer Cap with Subsurface Barrier

Least effective in the short term

4.3.6 IMPLEMENTABILITY

All of the alternatives are relatively easy to implement, use widely available equipment and materials, and well established reliable methods. Installation of the slurry wall of Alternative 6 in the strip mine spoil of Stream Valley A may be difficult because of the nature of strip mine spoil. A detailed design investigation would have to be performed to assure that a slurry wall will be

cost effective and practical to implement. Alternative 4 would be less difficult than Alternative 6, but would be more difficult to implement than Alternative 3 because well installation would require a detailed design investigation in order to determine the optimum well placement and pumping rates. Alternative 4 will require the offsite disposal of water treatment residuals. Based on the above discussion, Alternative 3 would be the easiest to implement. Listed in the order of overall ease of implementation from the easiest to implement to the most difficult to implement, they are:

Easiest to implement

- Alternative No. 3: Multi-layer Cap
- Alternative No. 4: Multi-layer Cap with Groundwater Treatment
- Alternative No. 6: Multi-layer Cap with Subsurface Barrier

Most difficult to implement

4.3.7 COST

All of the remaining alternatives have about the same total implementation overall cost. Alternative 3 has the lowest capital cost but project operating costs are higher than alternative 4 due to the cost of offsite leachate disposal.

Least costly

- Alternative No. 3: Multi-layer Cap
- Alternative No. 4: Multi-layer Cap with Groundwater Treatment
- Alternative No. 6: Multi-layer Cap with Subsurface Barrier

Most costly

APPENDIX A

INFILTRATION, GROUNDWATER COLLECTION, AND LEACHATE CALCULATIONS

APPENDIX A
INFILTRATION, GROUNDWATER COLLECTION, AND LEACHATE CALCULATIONS

Cap Performance

Objective:

Estimate of the performance of a conceptual multi-layer cap design at the Fultz landfill site.

Method:

Version 2.05 of Hydrologic Evaluation of Landfill Performance (HELP) model, U. S. Army Corps Of Engineers Waterways Experiment Station, Vicksburg, MS.

Approach:

First, estimate the infiltration of the existing landfill using a three-layer model consisting of the following layers, from the top down:

1. Vertical percolation layer of municipal waste to simulate groundwater percolation through the landfill waste. Thickness = 30 feet, porosity = .52, initial water content = .29, saturated hydraulic conductivity = 0.0005 cm/sec. Surface consists of "Poor Grass".
2. A lateral drainage layer five feet thick, at a slope of 5.5%, and of similar material to layer 1 but with higher hydraulic conductivity (0.0016 cm/sec.) to simulate the anisotropy of the waste layer, and a lower porosity (.4057) to simulate additional compaction at the base of the waste layer.
3. A barrier layer of much lower permeability to simulate the bedrock which partially restricts vertical flow from the existing landfill. Thickness = 20 feet, porosity = .43, initial water content = .43, saturated hydraulic conductivity = 10^{-7} cm/sec.

Second, estimate the infiltration through a seven-layer cap consisting of 6 inches of topsoil, 30 inches of random fill, a synthetic drainage layer, a synthetic liner with a 24-inch soil liner, and the three layers above that are used to simulate the existing landfill. The gas collection system was ignored since it would neither promote nor impede the movement of water through the system.

The model layers are as follows, from the top down:

1. A vertical percolation layer to simulate the topsoil with vegetative cover. Thickness = 6 inches, porosity = .46, initial water content = .23, saturated hydraulic conductivity = 1.5×10^{-3} cm/sec.
2. A vertical percolation layer to simulate the random earth fill layer. Thickness = 2.5 feet, porosity = .33, initial water content = .21, saturated hydraulic conductivity = 6×10^{-5} cm/sec.

3. A lateral drainage layer to simulate the drainage netting.
Thickness = .5 inches, porosity = .7, initial water content = .09,
saturated hydraulic conductivity = 1×10^{-1} cm/sec, slope = 5.5%.
4. A barrier soil liner to simulate the combined liner and clay barrier.
Thickness = 2 feet, porosity = .43, initial water content = .43,
saturated hydraulic conductivity = 1×10^{-7} cm/sec.
- 5, 6, 7 The same as layers 1, 2, 3 in the uncapped model.

Results:

Summary outputs from the HELP program are presented on pages A-3 through A-6. A comparison of the output with and without the cap layers shows that capping significantly reduces the infiltration of water through the landfill from about 5 inches without a cap to about 0.0001 inches with the cap. The total annual lateral seepage estimated by the model is about 341,190 cubic feet per year or about 4.88 gallons per minute. This corresponds well to the field estimate of 2 to 4 gallons per minute for all the seeps together.

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EXISTING LANDFILL WITHOUT CAP
9/14/90

POOR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	-	360.00 INCHES
POROSITY	-	0.5200 VOL/VOL
FIELD CAPACITY	-	0.2942 VOL/VOL
WILTING POINT	-	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000500000024 CM/SEC

LAYER 2

LATERAL DRAINAGE LAYER

THICKNESS	-	60.00 INCHES
POROSITY	-	0.4057 VOL/VOL
FIELD CAPACITY	-	0.3089 VOL/VOL
WILTING POINT	-	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.3089 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.001600000076 CM/SEC
SLOPE	-	5.50 PERCENT
DRAINAGE LENGTH	-	500.0 FEET

LAYER 3

BARRIER SOIL LINER

THICKNESS - 240.00 INCHES
 POROSITY - 0.4300 VOL/VOL
 FIELD CAPACITY - 0.3663 VOL/VOL
 WILTING POINT - 0.2802 VOL/VOL
 INITIAL SOIL WATER CONTENT - 0.4300 VOL/VOL
 SATURATED HYDRAULIC CONDUCTIVITY - 0.000000100000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER - 83.99
 TOTAL AREA OF COVER - 970000. SQ FT
 EVAPORATIVE ZONE DEPTH - 21.00 INCHES
 UPPER LIMIT VEG. STORAGE - 10.9200 INCHES
 INITIAL VEG. STORAGE - 6.9189 INCHES
 INITIAL SNOW WATER CONTENT - 0.0000 INCHES
 INITIAL TOTAL WATER STORAGE IN
 SOIL AND WASTE LAYERS - 227.6460 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
 SOLAR RADIATION FOR COLUMBUS OHIO

MAXIMUM LEAF AREA INDEX - 3.30
 START OF GROWING SEASON (JULIAN DATE) - 121
 END OF GROWING SEASON (JULIAN DATE) - 286

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
-----	-----	-----	-----	-----	-----
27.10	29.80	40.00	51.40	61.40	70.20
73.80	72.40	65.80	53.90	42.10	32.10

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

PRECIPITATION						

TOTALS	3.23 2.67	1.83 4.76	3.50 3.16	2.77 2.48	2.56 1.96	4.05 3.12
STD. DEVIATIONS	1.60 1.56	1.20 0.23	0.91 1.61	0.93 0.63	1.41 1.09	0.69 1.48
RUNOFF						

TOTALS	0.156 0.042	0.082 0.118	0.078 0.025	0.019 0.003	0.031 0.000	0.019 0.074
STD. DEVIATIONS	0.348 0.093	0.159 0.143	0.125 0.053	0.043 0.004	0.068 0.001	0.025 0.126
EVAPOTRANSPIRATION						

TOTALS	0.696 3.098	1.260 3.634	2.215 3.608	2.987 1.904	2.811 1.305	4.989 0.669
STD. DEVIATIONS	0.204 1.516	0.294 0.658	0.297 0.706	0.656 0.245	1.015 0.140	1.235 0.109
LATERAL DRAINAGE FROM LAYER 2						

TOTALS	0.3144 0.3819	0.2929 0.3816	0.3355 0.3656	0.3408 0.3712	0.3675 0.3510	0.3653 0.3533
STD. DEVIATIONS	0.0823 0.0701	0.0744 0.0694	0.0738 0.0661	0.0707 0.0669	0.0716 0.0630	0.0684 0.0624
PERCOLATION FROM LAYER 3						

TOTALS	0.1144 0.1167	0.1043 0.1166	0.1151 0.1128	0.1119 0.1163	0.1162 0.1123	0.1128 0.1157
STD. DEVIATIONS	0.0028 0.0023	0.0038 0.0023	0.0025 0.0022	0.0024 0.0022	0.0024 0.0021	0.0023 0.0021

 AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	36.09 (2.628)	2917598.	100.00
RUNOFF	0.646 (0.264)	52187.	1.79
EVAPOTRANSPIRATION	29.177 (1.032)	2358457.	80.84
LATERAL DRAINAGE FROM LAYER 2	4.2209 (0.7413)	341190.	11.69
PERCOLATION FROM LAYER 3	1.3650 (0.0259)	110335.	3.78
CHANGE IN WATER STORAGE	0.686 (3.293)	55429.	1.90

PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.32	187533.3
RUNOFF	0.682	55121.2
LATERAL DRAINAGE FROM LAYER 2	0.0147	1185.0
PERCOLATION FROM LAYER 3	0.0038	310.4
HEAD ON LAYER 3	31.0	
SNOW WATER	1.50	120932.1
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4125	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1397	

 FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	110.14	0.3059
2	20.97	0.3494
3	103.20	0.4300

SNOW WATER 0.00

Leachate Output From the Capped Landfill

Objective:

Estimate the maximum probable leachate production from the existing after capping.

Method:

Version 2.05 of Hydrologic Evaluation of Landfill Performance (HELP) model, U. S. Army Corps Of Engineers Waterways Experiment Station, Vicksburg, MS.

Approach:

Assume that the moisture conditions in the landfill resemble those at the end of the five year HELP model simulation. Use the ending moisture contents for the three layers of the uncapped simulation as the starting moisture conditions for the corresponding layers in the capped simulation. Run the model for a series of five-year periods using the ending conditions of the previous period for the starting conditions for the subsequent periods. The change in moisture multiplied by the volume of each layer will give the maximum amount of leachate that would be expected over the given period (see Table A-1 and Figure A-1).

Results:

Sample runs for the first and fifth periods are presented on pages A-10 through A-21. Figure A-1 presents a plot of the average five-year change in moisture content over time. Running the model for five periods shows a clear trend of slowly declining leachate production as the existing landfill dewateres. This is a conservative, that is high estimate because it counts the total moisture change without taking into account the moisture lost through migration into the mine beneath the landfill. Analysis of the cap performance itself suggests that this may be as much as 25% of the total.

Table A-1
Leachate Volume vs. Time
Existing Landfill After Capping
Fultz Landfill Site - Feasibility Study Report

Area of Landfill:	970,000 Sq Ft		
Existing Landfill Layers:		Thickness	Volume
		Feet	Cubic Feet
Waste Layer (Vertical Infiltration): Wv		30	29,100,000
Waste Layer (Horizontal Drainage): Wh		5	4,850,000
Confining Layer: Cl		20	19,400,000

	Moisture Content vol/vol			Leachate Production		
	Wv	Wh	Cl	Total Year Change	Average Annual Cu. Ft.	Average Annual GPM

Moisture Content						
Before Capping	0.2742	0.3089	0.43			
Total Volume	7,979,220	1,498,165	8,342,000			
After 5 years	0.2605	0.309	0.43			
Moisture Change	-0.0137	0.0001	0			
Volume Change	-398,670	485	0	-398,185	-79,637	
-1.13						
After 10 Years	0.2486	0.3089	0.43			
Moisture Change	-0.0119	-0.0001	0			
Volume Change	-346,290	-2,910	0	-349,200	-69,840	
-0.99						
After 15 Years	0.2415	0.3089	0.43			
Moisture Change	-0.0071	0	0			
Volume Change	-206610	0	0	-206,610	-41,322	
-0.59						
After 20 Years	0.2365	0.3089	0.43			
Moisture Change	-0.005	0	0			
Volume Change	-145500	0	0	-145,500	-29,100	
-0.41						
After 25 Years	0.2326	0.3089	0.43			
Moisture Change	-0.0039	0	0			
Volume Change	-113490	0	0	-113,490	-22,698	
-0.32						
+++++						
30 year average						
At Equilibrium	0.1849	0.3161	0.43			
Moisture Change	-0.0566	0.0072	0			
Volume Change	-1,647,060	209,520	0	-1,437,540	-47,918	
-0.68						

ICF KAISER ENGINEERS

PROJECT FUITZ FS PROJECT NO. 30430

LEACHING - PRODUCTION ESTIMATES

PAGE _____ OF _____

FROM HELP. MODEL

MADE BY DAG DATE 23 Sep. '70 CHECKED BY _____ DATE _____

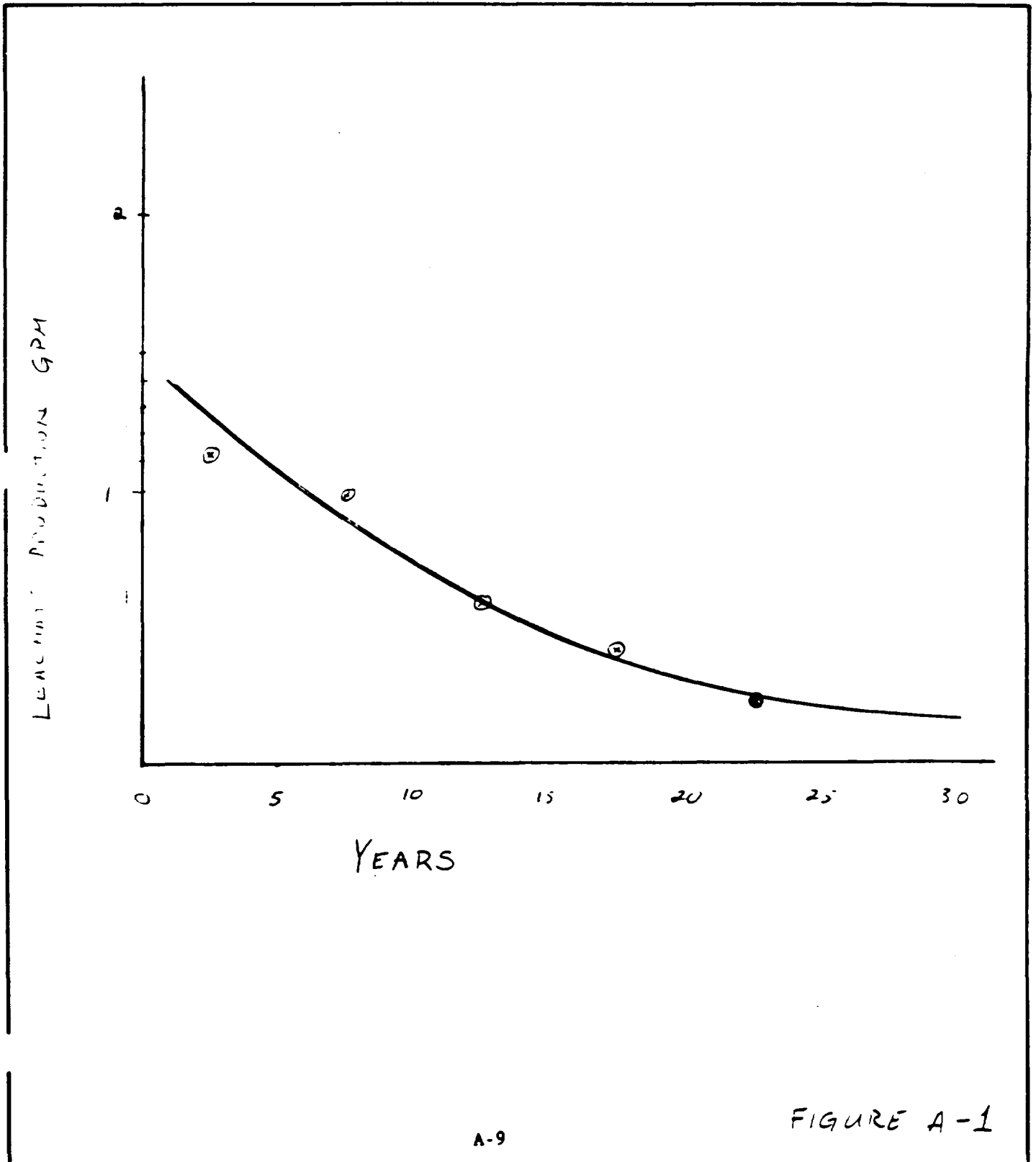


FIGURE A-1

FULTZ LANDFILL SITE - FEASIBILITY STUDY
EXISTING LANDFILL CAPPED - YEARS 1 THROUGH 5
9/14/90

GOOD GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	-	6.00 INCHES
POROSITY	-	0.4630 VOL/VOL
FIELD CAPACITY	-	0.2320 VOL/VOL
WILTING POINT	-	0.1157 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2320 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.001553999959 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	-	30.00 INCHES
POROSITY	-	0.3325 VOL/VOL
FIELD CAPACITY	-	0.2173 VOL/VOL
WILTING POINT	-	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2173 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000059999998 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	-	0.50 INCHES
POROSITY	-	0.7000 VOL/VOL
FIELD CAPACITY	-	0.0400 VOL/VOL
WILTING POINT	-	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.0906 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.100000001490 CM/SEC
SLOPE	-	5.50 PERCENT
DRAINAGE LENGTH	-	500.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	-	24.00 INCHES
POROSITY	-	0.4300 VOL/VOL
FIELD CAPACITY	-	0.3663 VOL/VOL
WILTING POINT	-	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	-	0.01000000

LAYER 5

VERTICAL PERCOLATION LAYER

THICKNESS	-	360.00 INCHES
POROSITY	-	0.5200 VOL/VOL
FIELD CAPACITY	-	0.2942 VOL/VOL
WILTING POINT	-	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000500000024 CM/SEC

LAYER 6

LATERAL DRAINAGE LAYER

THICKNESS	-	60.00 INCHES
POROSITY	-	0.4057 VOL/VOL
FIELD CAPACITY	-	0.3089 VOL/VOL
WILTING POINT	-	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.3089 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.001600000076 CM/SEC
SLOPE	-	5.50 PERCENT
DRAINAGE LENGTH	-	500.0 FEET

LAYER 7

BARRIER SOIL LINER

THICKNESS	-	240.00 INCHES
POROSITY	-	0.4300 VOL/VOL
FIELD CAPACITY	-	0.3663 VOL/VOL
WILTING POINT	-	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000000100000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER - 72.00
 TOTAL AREA OF COVER - 970000. SQ FT
 EVAPORATIVE ZONE DEPTH - 21.00 INCHES
 UPPER LIMIT VEG. STORAGE - 7.7655 INCHES
 INITIAL VEG. STORAGE - 4.6515 INCHES
 INITIAL SNOW WATER CONTENT - 0.0000 INCHES
 INITIAL TOTAL WATER STORAGE IN
 SOIL AND WASTE LAYERS - 245.9223 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
 SOLAR RADIATION FOR COLUMBUS OHIO

MAXIMUM LEAF AREA INDEX - 3.30
 START OF GROWING SEASON (JULIAN DATE) - 121
 END OF GROWING SEASON (JULIAN DATE) - 286

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
27.10	29.80	40.00	51.40	61.40	70.20
73.80	72.40	65.80	53.90	42.10	32.10

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.23	1.83	3.50	2.77	2.56	4.05
	2.67	4.76	3.16	2.48	1.96	3.12
STD. DEVIATIONS	1.60	1.20	0.91	0.93	1.41	0.69
	1.56	0.23	1.61	0.63	1.09	1.48

Public Comment Feasibility Study
 Fultz Landfill Site
 June 1991

RUNOFF

TOTALS	0.776	0.301	0.281	0.000	0.003	0.000
	0.000	0.001	0.000	0.000	0.000	0.005
STD. DEVIATIONS	1.735	0.672	0.619	0.000	0.006	0.000
	0.000	0.002	0.000	0.000	0.000	0.011

EVAPOTRANSPIRATION

TOTALS	0.708	1.288	2.222	2.835	2.706	5.339
	3.104	3.777	3.636	1.911	1.343	0.693
STD. DEVIATIONS	0.201	0.290	0.297	0.770	0.868	1.610
	1.508	0.790	0.722	0.236	0.129	0.119

LATERAL DRAINAGE FROM LAYER 3

TOTALS	0.3358	0.3906	0.4591	0.4747	0.4920	0.5019
	0.6073	0.6095	0.2462	0.1488	0.0964	0.2720
STD. DEVIATIONS	0.2585	0.2053	0.1291	0.0109	0.0115	0.0214
	0.0809	0.1673	0.1265	0.1157	0.0787	0.1710

PERCOLATION FROM LAYER 4

TOTALS	0.0017	0.0018	0.0020	0.0021	0.0020	0.0017
	0.0015	0.0012	0.0010	0.0011	0.0010	0.0013
STD. DEVIATIONS	0.0007	0.0006	0.0006	0.0002	0.0002	0.0002
	0.0001	0.0001	0.0000	0.0000	0.0000	0.0004

LATERAL DRAINAGE FROM LAYER 6

TOTALS	0.0971	0.0984	0.1137	0.1050	0.1008	0.0966
	0.0983	0.0963	0.0909	0.0912	0.0970	0.0933
STD. DEVIATIONS	0.0744	0.0633	0.0778	0.0743	0.0723	0.0729
	0.0780	0.0799	0.0786	0.0819	0.0924	0.0899

PERCOLATION FROM LAYER 7

TOTALS	0.1070	0.0977	0.1075	0.1040	0.1075	0.1041
	0.1075	0.1075	0.1040	0.1074	0.1039	0.1072
STD. DEVIATIONS	0.0021	0.0022	0.0017	0.0017	0.0019	0.0019
	0.0020	0.0021	0.0020	0.0021	0.0020	0.0020

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	36.09 (2.628)	2917598.	100.00
RUNOFF	1.367 (1.894)	110470.	3.79
EVAPOTRANSPIRATION	29.563 (1.237)	2389660.	81.91
LATERAL DRAINAGE FROM LAYER 3	4.6343 (0.6870)	374607.	12.84
PERCOLATION FROM LAYER 4	0.0185 (0.0023)	1498.	0.05
LATERAL DRAINAGE FROM LAYER 6	1.1785 (0.8889)	95264.	3.27
PERCOLATION FROM LAYER 7	1.2652 (0.0205)	102273.	3.51
CHANGE IN WATER STORAGE	-1.914 (3.278)	-154676.	-5.30

PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.32	187533.3
RUNOFF	2.000	161698.7
LATERAL DRAINAGE FROM LAYER 3	0.0313	2530.0
PERCOLATION FROM LAYER 4	0.0001	6.9
HEAD ON LAYER 4	36.6	
LATERAL DRAINAGE FROM LAYER 6	0.0071	577.5
PERCOLATION FROM LAYER 7	0.0036	288.0
HEAD ON LAYER 7	11.4	
SNOW WATER	1.50	120932.1
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3698	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1302	

FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.50	0.2499
2	8.67	0.2889
3	0.35	0.7000
4	10.32	0.4300
5	93.78	0.2605
6	18.54	0.3090
7	103.20	0.4300
SNOW WATER	0.00	

FULTZ LANDFILL SITE FEASIBILITY STUDY
EXISTING LANDFILL CAPPED - YEARS 21 THROUGH 25
9/24/90

GOOD GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	-	6.00 INCHES
POROSITY	-	0.4630 VOL/VOL
FIELD CAPACITY	-	0.2320 VOL/VOL
WILTING POINT	-	0.1157 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2499 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.001553999959 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	-	30.00 INCHES
POROSITY	-	0.3325 VOL/VOL
FIELD CAPACITY	-	0.2173 VOL/VOL
WILTING POINT	-	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2889 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000059999998 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	-	0.50 INCHES
POROSITY	-	0.7000 VOL/VOL
FIELD CAPACITY	-	0.0400 VOL/VOL
WILTING POINT	-	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.7000 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.10000001490 CM/SEC
SLOPE	-	5.50 PERCENT
DRAINAGE LENGTH	-	500.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	-	24.00 INCHES
POROSITY	-	0.4300 VOL/VOL
FIELD CAPACITY	-	0.3663 VOL/VOL
WILTING POINT	-	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	-	0.01000000

LAYER 5

VERTICAL PERCOLATION LAYER

THICKNESS	-	360.00 INCHES
POROSITY	-	0.5200 VOL/VOL
FIELD CAPACITY	-	0.2942 VOL/VOL
WILTING POINT	-	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2365 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000500000024 CM/SEC

LAYER 6

LATERAL DRAINAGE LAYER

THICKNESS	-	60.00 INCHES
POROSITY	-	0.3089 VOL/VOL
FIELD CAPACITY	-	0.3089 VOL/VOL
WILTING POINT	-	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.3089 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.001600000076 CM/SEC
SLOPE	-	5.50 PERCENT
DRAINAGE LENGTH	-	500.0 FEET

LAYER 7

BARRIER SOIL LINER

THICKNESS	-	240.00 INCHES
POROSITY	-	0.4300 VOL/VOL
FIELD CAPACITY	-	0.3663 VOL/VOL
WILTING POINT	-	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000000100000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER - 72.00
 TOTAL AREA OF COVER - 970000. SQ FT
 EVAPORATIVE ZONE DEPTH - 21.00 INCHES
 UPPER LIMIT VEG. STORAGE - 7.7655 INCHES
 INITIAL VEG. STORAGE - 5.8329 INCHES
 INITIAL SNOW WATER CONTENT - 0.0000 INCHES
 INITIAL TOTAL WATER STORAGE IN
 SOIL AND WASTE LAYERS - 227.7104 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
 SOLAR RADIATION FOR COLUMBUS OHIO

MAXIMUM LEAF AREA INDEX - 3.30
 START OF GROWING SEASON (JULIAN DATE) - 121
 END OF GROWING SEASON (JULIAN DATE) - 286

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
27.10	29.80	40.00	51.40	61.40	70.20
73.80	72.40	65.00	53.90	42.10	32.10

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.23	1.83	3.50	2.77	2.56	4.05
	2.67	4.76	3.16	2.48	1.96	3.12
STD. DEVIATIONS	1.60	1.20	0.91	0.93	1.41	0.69
	1.56	0.23	1.61	0.63	1.09	1.48

Public Comment Feasibility Study
 Fultz Landfill Site
 June 1991

RUNOFF

TOTALS	0.777	0.303	0.375	0.108	0.003	0.000
	0.000	0.001	0.000	0.000	0.000	0.005
STD. DEVIATIONS	1.736	0.678	0.605	0.242	0.006	0.000
	0.000	0.002	0.000	0.000	0.000	0.011

EVAPOTRANSPIRATION

TOTALS	0.707	1.288	2.221	2.835	2.706	5.449
	3.182	3.777	3.634	1.909	1.342	0.693
STD. DEVIATIONS	0.201	0.290	0.298	0.770	0.868	1.666
	1.436	0.790	0.722	0.238	0.128	0.119

LATERAL DRAINAGE FROM LAYER 3

TOTALS	0.4229	0.3768	0.4491	0.4819	0.4903	0.4974
	0.6007	0.6067	0.2950	0.1601	0.0999	0.2780
STD. DEVIATIONS	0.2181	0.1961	0.1223	0.0148	0.0126	0.0242
	0.0864	0.1649	0.1621	0.1154	0.0781	0.1756

PERCOLATION FROM LAYER 4

TOTALS	0.0018	0.0020	0.0022	0.0022	0.0021	0.0018
	0.0015	0.0012	0.0010	0.0011	0.0010	0.0013
STD. DEVIATIONS	0.0006	0.0006	0.0006	0.0003	0.0002	0.0002
	0.0002	0.0002	0.0000	0.0000	0.0000	0.0004

LATERAL DRAINAGE FROM LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION FROM LAYER 7

TOTALS	0.0258	0.0234	0.0256	0.0247	0.0254	0.0245
	0.0252	0.0252	0.0242	0.0250	0.0241	0.0248
STD. DEVIATIONS	0.0018	0.0017	0.0018	0.0018	0.0018	0.0017
	0.0018	0.0018	0.0017	0.0017	0.0017	0.0017

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	36.09 (2.628)	2917598.	100.00
RUNOFF	1.572 (1.768)	127047.	4.35
EVAPOTRANSPIRATION	29.744 (1.403)	2404326.	82.41
LATERAL DRAINAGE FROM LAYER 3	4.7590 (0.7484)	384683.	13.18
PERCOLATION FROM LAYER 4	0.0193 (0.0021)	1559.	0.05
LATERAL DRAINAGE FROM LAYER 6	0.0001 (0.0000)	7.	0.00
PERCOLATION FROM LAYER 7	0.2979 (0.0210)	24084.	0.83
CHANGE IN WATER STORAGE	-0.279 (3.064)	-22548.	-0.77

PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.32	187533.3
RUNOFF	2.000	161695.4
LATERAL DRAINAGE FROM LAYER 3	0.0313	2530.0
PERCOLATION FROM LAYER 4	0.0001	6.9
HEAD ON LAYER 4	36.7	
LATERAL DRAINAGE FROM LAYER 6	0.0000	0.0
PERCOLATION FROM LAYER 7	0.0009	73.8
HEAD ON LAYER 7	0.0	
SNOW WATER	1.50	120932.1
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3698	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1302	

FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.50	0.2499
2	8.67	0.2889
3	0.35	0.7000
4	10.32	0.4300
5	83.75	0.2326
6	18.53	0.3089
7	103.20	0.4300
SNOW WATER	0.00	

Leachate Output from a New On-site RCRA-Type Landfill

Objective:

Estimate the leachate that would be produced by a new RCRA-type double-lined onsite landfill over the 30-year life of Alternative 5.

Method:

Version 2.05 of Hydrologic Evaluation of Landfill Performance (HELP) model, U. S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Approach:

A ten layer model is used to simulate the double-lined landfill and the rock underdrain under the landfill. The upper five layers simulate the cap and waste, and are the same as those used in the multi-layer cap simulation. The remaining layers are as follows:

6. A vertical percolation layer, to simulate the protective sand layer which is placed over the synthetic liner and drainage material. Thickness = 1 foot, porosity = .33, saturated hydraulic conductivity = 2.9×10^{-4} cm/sec.
7. A lateral drainage layer to simulate the synthetic drainage netting. Thickness = 1 foot, porosity = .7, saturated hydraulic conductivity = 1×10^{-1} cm/sec. Collection pipes would be installed every 50 feet, so that the drainage length would be 25 feet. The drainage slope would be controlled at 4%.
8. A barrier soil liner to simulate the combined liner and clay barrier. Thickness = 3 feet, porosity = .4, saturated hydraulic conductivity = 1×10^{-8} cm/sec. A leakage factor of 0.01 is used in order to be conservative.
9. A vertical percolation layer is used to simulate the fill and the rock drain under the landfill. Thickness = 15 feet, porosity = .33, saturated hydraulic conductivity = 5×10^{-6} cm/sec.
10. A barrier soil liner to simulate the bedrock under the rock drain. Thickness = 20 feet, porosity = .43, saturated hydraulic conductivity = 1×10^{-8} cm/sec.

Since the object is to determine steady state leachate production over the life of the landfill, and the waste will be compacted and drained before placement, An initial model run used default moisture conditions for the types of soil under used. Additional runs were made using the final moisture conditions from the previous run as the starting moisture conditions, iterating until there was little change in moisture storage within a model run.

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Results:

The final iteration of the HELP model is presented on pages A-24 through A-30. Lateral drainage from layer 7 represents the leachate that will drain out of the waste and other layers within the landfill cell. The model estimates that we should expect 20,339 cubic feet per year, .04 GPM, on average.

FULTZ LANDFILL SITE - FEASIBILITY STUDY
ALTERNATIVE 5 - ON-SITE LANDFILL
14 NOVEMBER 1990 (Final Iteration)

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	-	6.00 INCHES
POROSITY	-	0.4630 VOL/VOL
FIELD CAPACITY	-	0.2320 VOL/VOL
WILTING POINT	-	0.1157 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2555 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.001554000075 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	-	30.00 INCHES
POROSITY	-	0.3325 VOL/VOL
FIELD CAPACITY	-	0.2173 VOL/VOL
WILTING POINT	-	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2909 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000006000000 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	-	0.50 INCHES
POROSITY	-	0.7000 VOL/VOL
FIELD CAPACITY	-	0.0400 VOL/VOL
WILTING POINT	-	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.1045 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.100000001490 CM/SEC
SLOPE	-	12.00 PERCENT
DRAINAGE LENGTH	-	100.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	-	24.00 INCHES
POROSITY	-	0.4300 VOL/VOL
FIELD CAPACITY	-	0.3663 VOL/VOL
WILTING POINT	-	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	-	0.01000000

LAYER 5

VERTICAL PERCOLATION LAYER

THICKNESS	-	360.00 INCHES
POROSITY	-	0.4200 VOL/VOL
FIELD CAPACITY	-	0.2942 VOL/VOL
WILTING POINT	-	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2154 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000199999995 CM/SEC

LAYER 6

VERTICAL PERCOLATION LAYER

THICKNESS	-	12.00 INCHES
POROSITY	-	0.3339 VOL/VOL
FIELD CAPACITY	-	0.0529 VOL/VOL
WILTING POINT	-	0.0245 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.1041 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000289999996 CM/SEC

LAYER 7

LATERAL DRAINAGE LAYER

THICKNESS	-	12.00 INCHES
POROSITY	-	0.7000 VOL/VOL
FIELD CAPACITY	-	0.0400 VOL/VOL
WILTING POINT	-	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.0401 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.100000001490 CM/SEC
SLOPE	-	4.00 PERCENT
DRAINAGE LENGTH	-	25.0 FEET

LAYER 8

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	-	36.00 INCHES
POROSITY	-	0.4000 VOL/VOL
FIELD CAPACITY	-	0.3560 VOL/VOL
WILTING POINT	-	0.2899 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.4000 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000000010000 CM/SEC
LINER LEAKAGE FRACTION	-	0.01000000

LAYER 9

VERTICAL PERCOLATION LAYER

THICKNESS	-	180.00 INCHES
POROSITY	-	0.3325 VOL/VOL
FIELD CAPACITY	-	0.2173 VOL/VOL
WILTING POINT	-	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2173 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000005000000 CM/SEC

LAYER 10

BARRIER SOIL LINER

THICKNESS	-	240.00 INCHES
POROSITY	-	0.4300 VOL/VOL
FIELD CAPACITY	-	0.3663 VOL/VOL
WILTING POINT	-	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000000010000 CM/SEC

H1
 PORO

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	-	0.01
TOTAL AREA OF COVER	-	600000. SQ FT
EVAPORATIVE ZONE DEPTH	-	21.00 INCHES
UPPER LIMIT VEG. STORAGE	-	7.7655 INCHES
INITIAL VEG. STORAGE	-	5.8965 INCHES
INITIAL SNOW WATER CONTENT	-	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	-	256.6207 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
 SOLAR RADIATION FOR COLUMBUS OHIO

MAXIMUM LEAF AREA INDEX - 3.30
 START OF GROWING SEASON (JULIAN DATE) - 121
 END OF GROWING SEASON (JULIAN DATE) - 286

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
27.10	29.80	40.00	51.40	61.40	70.20
73.80	72.40	65.80	53.90	42.10	32.10

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.23	1.83	3.50	2.77	2.56	4.05
	2.67	4.76	3.16	2.48	1.96	3.12
STD. DEVIATIONS	1.60	1.20	0.91	0.93	1.41	0.69
	1.56	0.23	1.61	0.63	1.09	1.48
RUNOFF						
TOTALS	0.292	0.061	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.079
STD. DEVIATIONS	0.654	0.136	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.176
EVAPOTRANSPIRATION						
TOTALS	0.703	1.273	2.238	2.882	2.787	4.957
	3.036	3.790	3.640	1.910	1.320	0.678
STD. DEVIATIONS	0.205	0.300	0.291	0.737	0.905	1.284
	1.520	0.817	0.728	0.260	0.132	0.113

LATERAL DRAINAGE FROM LAYER 3

 TOTALS 1.6006 1.4295 1.0484 1.0076 0.2728 0.1301
 0.0823 0.0585 0.0439 0.0378 0.0337 0.6908

STD. DEVIATIONS 1.0264 0.8680 1.2786 0.7989 0.1249 0.0340
 0.0142 0.0075 0.0045 0.0040 0.0090 1.1075

PERCOLATION FROM LAYER 4

 TOTALS 0.0011 0.0010 0.0011 0.0010 0.0011 0.0010
 0.0011 0.0011 0.0010 0.0011 0.0010 0.0011

STD. DEVIATIONS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

LATERAL DRAINAGE FROM LAYER 7

 TOTALS 0.0357 0.0323 0.0353 0.0339 0.0348 0.0335
 0.0344 0.0342 0.0329 0.0338 0.0325 0.0334

STD. DEVIATIONS 0.0042 0.0037 0.0040 0.0038 0.0039 0.0037
 0.0038 0.0038 0.0036 0.0037 0.0035 0.0036

PERCOLATION FROM LAYER 8

 TOTALS 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001
 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001

STD. DEVIATIONS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

PERCOLATION FROM LAYER 10

 TOTALS 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001
 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001

STD. DEVIATIONS 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

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 June 1991

 AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)	PERCENT
	-----	-----	-----
PRECIPITATION	36.09 (2.628)	1804700.	100.00
RUNOFF	0.432 (0.807)	21593.	1.20
EVAPOTRANSPIRATION	29.214 (0.987)	1460690.	80.94
LATERAL DRAINAGE FROM LAYER 3	6.4359 (1.4482)	321796.	17.83
PERCOLATION FROM LAYER 4	0.0124 (0.0000)	622.	0.03
LATERAL DRAINAGE FROM LAYER 7	0.4068 (0.0453)	20339.	1.13
PERCOLATION FROM LAYER 8	0.0012 (0.0000)	62.	0.00
PERCOLATION FROM LAYER 10	0.0012 (0.0000)	62.	0.00
CHANGE IN WATER STORAGE	-0.396 (2.338)	-19781.	-1.10

PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
	-----	-----
PRECIPITATION	2.32	116000.0
RUNOFF	1.462	73076.0
LATERAL DRAINAGE FROM LAYER 3	0.1901	9504.9
PERCOLATION FROM LAYER 4	0.0000	1.7
HEAD ON LAYER 4	0.3	
LATERAL DRAINAGE FROM LAYER 7	0.0015	77.2
PERCOLATION FROM LAYER 8	0.0000	0.2
HEAD ON LAYER 8	0.0	
PERCOLATION FROM LAYER 10	0.0000	0.2
HEAD ON LAYER 10	0.0	
SNOW WATER	1.50	74803.3
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3612	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1302	

FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.53	0.2555
2	8.73	0.2909
3	0.05	0.1045
4	10.32	0.4300
5	75.62	0.2100
6	1.20	0.0998
7	0.48	0.0401
8	14.40	0.4000
9	39.11	0.2173
10	103.20	0.4300
SNOW WATER	0.00	

Estimated Shallow Aquifer Cleanup Time

Objective:

Estimate the cleanup time for the shallow aquifer from natural dilution and from groundwater extraction.

Method:

Assume a closed, continuously-mixed system model consisting of a portion of the shallow aquifer to the north of the Fultz Landfill Site. Inputs into the system include infiltration of precipitation and lateral flow of groundwater from the upstream area of Valley A. Outflows from the system consist of groundwater flow into the Deep Mine Aquifer, Wills Creek Valley, and discharge from extraction wells. We assume that no chemical or physical reactions take place that would lengthen or shorten the flushing process.

Procedure:

Volume of Water in the Shallow Aquifer

Map Scale: 400 Ft. per Inch
 Porosity: 0.2

Zone	Thickness Feet	Area Sq In	Volume Sq Ft	Water Volume CF
I	29	0.712	3,303,680	660,736
II	25	0.814	3,256,000	651,200
III	22	0.860	3,027,200	605,440
IV	14	0.636	1,424,640	284,928
V	20	1.050	3,360,000	672,000
Total		4.072		2,874,304

Using a first order decay equation to calculate the effect of mixing clean water with the chemically affected water in the shallow aquifer:

$$C(t) = C_0 * \exp(-\alpha * t)$$

Where:

- alpha = $Q/V + k$
- t = Time from the start of the model (years)
- Q = the net flow of clean water into the system
- V = the volume of the system
- C_0 = the starting concentration in the system
- k = the reaction rate within the system = 0

With Natural Recharge Only, we assume that most of lateral flow down Valley A seeps into the Deep Mine Aquifer without affecting the contaminated area near the landfill, that is, the net input to the shallow aquifer in the area of the existing landfill is equal to infiltration from the surface.

Natural Infiltration Rate: 4 Inches/Year
 Annual Infiltration Volume: 217,173 Cubic Feet
 Years to Exchange One Volume: 13.24 Years = V/Q
 Q/V - Number of exchanges per year = 0.076

Using the maximum observed values of several representative chemicals compared with cleanup levels based on MCLs or other standards we calculate the change in chemical concentration with time:

		Chemical			
		Arsenic	Chromium	Lead	Bis(2-ethylhexyl) phthalate
	TCL* ug/l	50	50	50	8.4
	C ₀ ug/l	427	1580	1530	100
t=	1	395.93	1465.02	1418.66	92.72
	10	200.58	742.19	718.71	46.97
	20	94.22	348.64	337.61	22.07
	30	44.26	163.77	158.59	10.37
	34	32.72	121.06	117.22	7.66
	40	20.79	76.93	74.50	4.87
	45	14.25	52.73	51.06	3.34
	46	13.21	48.89	47.34	3.09

Maximum cleanup time without extraction wells would be about 46 years.

Maximum cleanup time without extraction wells would be about 13 years.

With Extraction Wells, we use the estimated extraction rates previously calculated and assume that the water table will be depressed sufficiently so that the additional flow will be added to the natural infiltration by lateral groundwater flow from upstream in Valley A.

With Extraction Wells:

Extraction Rate: 10 GPM
 Years to remove one volume 4.09 Years
 Q/V - Number of exchanges per year = 0.244 Exchanges

		Chemical			
		Arsenic	Chromium	Lead	Bis(2-ethylhexyl) phthalate
TCL $\mu\text{g}/\text{l}^*$		50	50	50	8.4
CO $\mu\text{g}/\text{l}$		427	1580	1530	100
t(years)	1	334.39	1237.33	1198.18	78.31
	10	37.04	137.07	132.73	8.68
	13	17.79	65.83	63.75	4.17
	14	13.93	51.55	49.92	3.26
	15	10.91	40.37	39.10	2.56
	20	3.21	11.89	11.52	0.75
	30	0.28	1.03	1.00	0.07

Maximum cleanup time with extraction wells would be about 14 years.

Minimum cleanup time with extraction wells would be about 4 years.

* Target Compound Limit based on the lowest of MCLs, MCLGs, surface water standards, etc., as in Table 2-4.

INFILTRATION INTO EXISTING LANDFILL

MADE BY DAG DATE 17 SEP 90 CHECKED BY JHW DATE 10/5/90

DISTANCE r FROM THE CENTER OF THE LANDFILL TO THE EDGE OF THE MINE 570' \approx 250 feet

RESOLVING WITH $r = 250'$

$$1/2 \times 77.77 \times \left\{ .53 - \left(\frac{1}{2}\right)^2 + 1776 \right\} = 84.51 = (h^2 - h_0^2)$$

$$h - h_0 = \sqrt{196 + 84.51} - 14 = 2.7'$$

$$10/2 \times 77.77 \times \left\{ 2.47 - \left(\frac{1}{2}\right)^2 + \frac{1}{.053} (1 - e^{-.053}) \right\} = 248.49$$

$$h - h_0 = \sqrt{196 + 248.49} - 14 = 7.08'$$

THE ABOVE CALCULATIONS ARE ONLY VALID FOR A HOMOGENEOUS ISOTROPIC AQUIFER WHERE THE WATER TABLE IS RELATIVELY FLAT AND THE INCREASE IN HEAD DUE TO INFILTRATION IS SMALL WITH RESPECT TO THE TOTAL AQUIFER THICKNESS. IN OUR CASE, THE WATER TABLE IS SLOPING AT UP TO A 0.06 GRADIENT AND IS ONLY 3 TO 20 FEET THICK UNDER VARIOUS PARTS OF THE LANDFILL. THE ABOVE MAXIMUMS, 7.5 feet and 7.08 feet WOULD BE UPPER BOUNDS ON THE POTENTIAL RISE.

Table 8.1 Values of $W(u)$ for Various Values of u

u	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
$\times 1$	0.219	0.049	0.013	0.0038	0.0011	0.00036	0.00012	0.000038	0.000012
$\times 10^{-1}$	1.82	1.22	0.91	0.70	0.56	0.45	0.37	0.31	0.26
$\times 10^{-2}$	4.04	3.35	2.96	2.68	2.47	2.30	2.15	2.03	1.92
$\times 10^{-3}$	6.33	5.64	5.23	4.95	4.73	4.54	4.39	4.26	4.14
$\times 10^{-4}$	8.63	7.94	7.53	7.25	7.02	6.84	6.69	6.55	6.44
$\times 10^{-5}$	10.94	10.24	9.84	9.55	9.33	9.14	8.99	8.86	8.74
$\times 10^{-6}$	13.24	12.55	12.14	11.85	11.63	11.45	11.29	11.16	11.04
$\times 10^{-7}$	15.54	14.85	14.44	14.15	13.93	13.75	13.60	13.46	13.34
$\times 10^{-8}$	17.84	17.15	16.74	16.46	16.23	16.05	15.90	15.76	15.65
$\times 10^{-9}$	20.15	19.45	19.05	18.76	18.54	18.35	18.20	18.07	17.95
$\times 10^{-10}$	22.45	21.76	21.35	21.06	20.84	20.66	20.50	20.37	20.25
$\times 10^{-11}$	24.75	24.06	23.65	23.36	23.14	22.96	22.81	22.67	22.55
$\times 10^{-12}$	27.05	26.36	25.96	25.67	25.44	25.26	25.11	24.97	24.86
$\times 10^{-13}$	29.36	28.66	28.26	27.97	27.75	27.56	27.41	27.28	27.16
$\times 10^{-14}$	31.66	30.97	30.56	30.27	30.05	29.87	29.71	29.58	29.46
$\times 10^{-15}$	33.96	33.27	32.86	32.58	32.35	32.17	32.02	31.88	31.76

SOURCE: Wenzel, 1942.

$h_0 - h$ from Eq. (8.7). Figure 8.5(b) shows a calculated plot of $h_0 - h$ versus t for the specific set of parameters noted on the figure. A set of field measurements of drawdown versus time measured in a piezometer that is set in an ideal confined aquifer with these properties would show this type of record.

The shape of the function $h_0 - h$ versus t , when plotted on log-log paper as in Figure 8.5(b), has the same form as the plot of $W(u)$ versus $1/u$ shown in Figure 8.5(a). This is a direct consequence of the relations embodied in Eqs. (8.6) and (8.7), where it can be seen that $h_0 - h$ and $W(u)$, and t and $1/u$, are related to one another through a constant term.

It is also possible to calculate values of $h_0 - h$ at various values of r at a given time t . Such a calculation leads to a plot of the *cone of depression* (or *drawdown cone*) in the potentiometric surface around a pumping well. Figure 8.4 provides a schematic example. The steepening of the slope of the cone near the well is reflected in the solution, Eq. (8.7). The physical explanation is clear if one carries out the simple flow-net construction shown in the plan view of Figure 8.4 and then carries the hydraulic head values down onto the section.

For a given aquifer the cone of depression increases in depth and extent with increasing time. Drawdown at any point at a given time is directly proportional to the pumping rate and inversely proportional to aquifer transmissivity and aquifer storativity. As shown in Figure 8.6, aquifers of low transmissivity develop tight, deep drawdown cones, whereas aquifers of high transmissivity develop shallow cones of wide extent. Transmissivity exerts a greater influence on drawdown than does storativity.

In that geologic configurations are seldom as ideal as that outlined above, the time-drawdown response of aquifers under pumpage often deviates from the

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COMPARISON OF LEACHATE SEEP FIELD

PAGE 1 OF 1

ESTIMATES WITH H.E.L.P. MODEL RESULTS

MADE BY DAG DATE 17 SEPT CHECKED BY JAW DATE 1/8/90

FIELD ESTIMATES.

<u>LOCATION</u>	<u>DESCRIPTION</u>	<u>Q GPM</u>
LS-16	TOWARDS POND 1	0.5
LS-15.16	" "	< 1.0
LS-3 + LS17	TOWARDS DOWN GRADIENT STREAM A	< 1.2
TOTAL ALL SEEPS		2-4

FROM HELP MODEL

"LATERAL DRAINAGE FROM LAYER 2" - WASTE LAYER ABOVE THE BEDROCK

$$341,190 \frac{\text{ft}^3}{\text{yr}} \times \frac{7.48 \text{ GAL}}{\text{ft}^3} \times \frac{1 \text{ DAY}}{24 \text{ HR}} \times \frac{60 \text{ MIN}}{\text{HR}} = 4.88 \text{ GAL}/\text{MIN}$$

"PERCOLATION THROUGH LAYER 3" - BEDROCK

$$102,000 \frac{\text{CF}}{\text{yr}} \times 1.423 \times 10^{-5} = 1.45 \text{ GAL}/\text{MIN}$$

PROJECT F.L.T.Z. F.S.

PROJECT NO. 70340-410

EXTRACTION WELL CONCEPTUAL DESIGN

PAGE _____ OF _____

MADE BY D.S. DATE _____ CHECKED BY _____ DATE _____

ESTIMATE THE NUMBER OF WELLS AND PUMPING RATES
NEEDED TO EXTRACT CONTAMINATED GROUNDWATER FROM
THE SHALLOW AQUIFER NEAR THE F.L.T.Z. LANDFILL

ICF KAISER ENGINEERS
1000 AVENUE OF THE STARS
SUIT 1000
ARLINGTON, VA 22202
TEL: 703/440-1400
FAX: 703/440-1401

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PROJECT FULTZ ES

PROJECT NO. 30430

EXTRACTION WELL CONCEPTUAL DESIGN

PAGE _____ OF _____

MADE BY DAG

DATE 20 SEPT '90

CHECKED BY SAW

DATE 1/8/91

TYPICAL WELL IN VALLEY A NORTH OF THE EXISTING LANDFILL

ESTIMATE THE SPECIFIC CAPACITY OF A TYPICAL WELL IN THE SHALLOW AQUIFER. USING JACOB'S EQUATION:

$$\frac{Q}{S} = \frac{T}{264 L \cdot \frac{0.3 T}{r^2 S}}$$

Q IN GPM

S IN FEET

ASSUMING A SPECIFIC YIELD OF: $S = 0.2$

$K_b = .007 \text{ GPM/ft} \times 24 \times 60 \times 15 \text{ ft} = 151.2 \text{ GPM/ft}$

$K = 5 \times 10^{-4} \text{ cm/s} \approx 0.007 \text{ GPM/ft}$

$b = b_{avg} = 15'$

r = RADIUS OF THE WELL - ASSUME 0.5 ft

t = DRAWDOWN TIME - ASSUME 1 YEAR ~~PER YEAR~~ 365 DAYS

JACOB'S EQUATION

ASSUMES THAT

$u = \frac{1.87 r^2 S}{T t}$ is small

checking $u = \frac{1.87 (.5 \text{ ft})^2 \cdot 0.2}{2100 \text{ day} \times 360 \text{ day}}$

$u = 1.48 \times 10^{-5}$

$\frac{Q}{S} = \frac{151.2}{264 \log \left(\frac{0.3 (151.2) + 300}{(0.5 \text{ ft})^2 \cdot 0.2} \right)} = 0.105 \text{ GPM/ft of drawdown}$

VALUES OF Q (EXTRACTION RATE)
FOR VARIOUS S (DRAWDOWN)

b = 15 FEET

b (ft)	Q (GPM)
2	0.21
3	0.32
4	0.42
5	0.53
6	0.63
7	0.74
8	0.84

EXTRACTION WELL CONCEPTUAL DESIGN

MADE BY DAG DATE 20 Sept '90 CHECKED BY JAW DATE 1/8/91

IF WE KEEP THE DRAWDOWN TO ABOUT 4' WE WOULD EXPECT THE WELL TO YIELD 0.4 GPM

CALCULATING AN IDEAL RADIUS OF INFLUENCE ASSUMING MINIMAL INFLUENCE FROM EXISTING GROUNDWATER FLOW:

USING THE STEADY-STATE EQUATION:

$$Q = \pi K \frac{(h_0^2 - h_w^2)}{\ln(r_0/r_w)}$$

$$\ln(r_0/r_w) = \frac{\pi K (h_0^2 - h_w^2)}{Q}$$

$$r_0 = r_w \left\{ e^{\frac{\pi K (h_0^2 - h_w^2)}{Q}} \right\} = .5 \left\{ e^{\frac{\pi (.007 \text{ GPM/ft}) (15^2 - 11^2)}{0.4 \text{ GPM}}} \right\}$$

$$r_0 = 0.5 e^{5.717} = 152 \text{ feet} \therefore \text{Diameter} \approx 300'$$

THE FRONT ALONG THE FACE OF THE DEEP MINE AQUIFER IS ABOUT 1700 FEET. WE WILL NEED A MINIMUM OF

$$\frac{1700}{300} \text{ OR } 6 \text{ WELLS}$$

OVERLAPPING THE WELLS BY 20% OR 30' TO ASSURE COVERAGE WOULD REQUIRE

$$\frac{1700}{240} = 8 \text{ WELLS}$$

ADDITIONAL WELLS COULD BE ADDED TO THE NORTH OF THIS LINE TO COVER THE AREA OF THE SHALLOW AQUIFER KNOWN TO BE CONTAMINATED (SEE FOLLOWING FIGURE)

ICF KAISER ENGINEERS

Fultz Landfill Site

Project No.

30340

Hydrologic Calculations

Made by: DAG

Date: 30-Nov-90

Checked by: Date:

=====

ESTIMATED WELL DISCHARGE IN GALLONS PER MINUTE FOR DIFFERENT AQUIFER THICKNESSES AND WELL DRAWDOWNS

s	b =					
	14	18	20	22	25	29
2	0.20	0.25	0.28	0.31	0.35	0.41
3	0.30	0.38	0.42	0.46	0.53	0.61
4	0.39	0.51	0.56	0.62	0.70	0.81
5	0.49	0.63	0.70	0.77	0.88	1.02
6	0.59	0.76	0.84	0.93	1.05	1.22
7	0.69	0.89	0.98	1.08	1.23	1.43
8	0.79	1.01	1.12	1.24	1.41	1.63

Estimated Extraction Well Discharges

Well Number	Aquifer Thickness	Drawdown Feet	Discharge GPM
E-1	20	5	0.70
E-2	20	5	0.70
E-3	18	4	0.51
E-4	14	4	0.39
E-5	14	4	0.39
E-6	22	6	0.93
E-7	22	6	0.93
E-8	22	6	0.93
E-9	25	6	1.05
E-10	25	6	1.05
E-11	29	7	1.43
E-12	29	7	1.43
TOTAL			10.44

MADE BY DAG

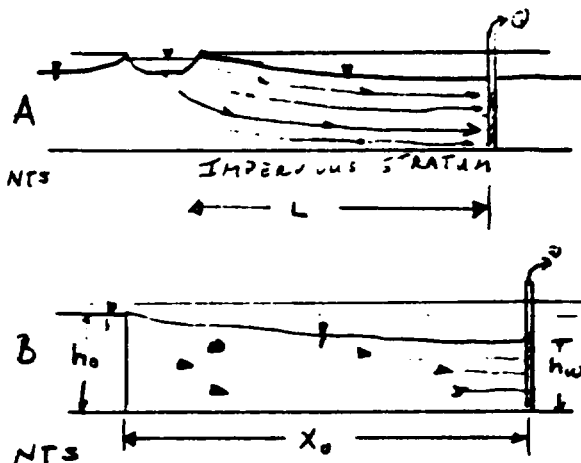
DATE 20 SEPT '90

CHECKED BY SAW

DATE

1/8/90

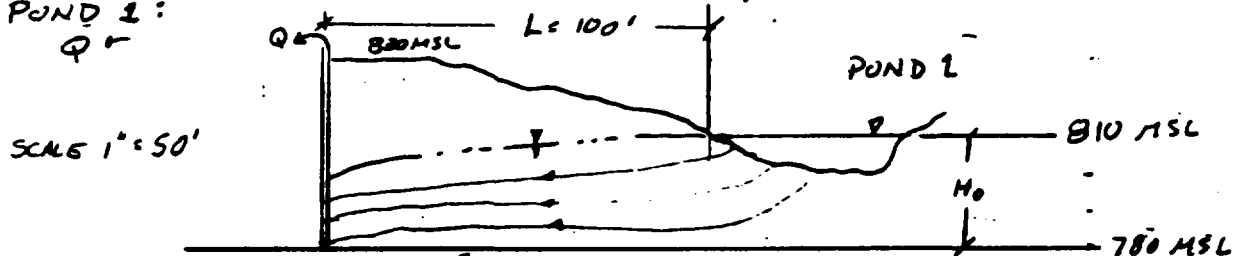
SEVERAL WELLS WOULD BE LOCATED NEAR PONDS OR STREAMS AND WOULD BE EFFECTED BY INFILTRATION FROM THE WATER IN THE STREAM



CASE B FOR A WELL NEAR A CONSTANT HEAD BOUNDARY CAN BE USED TO APPROXIMATE THE ACTUAL CASE A IF DISTANCE L IS REPLACED WITH AN EFFECTIVE DISTANCE $x_0 > L$ TO SIMULATE THE EFFECT OF THE PARTIAL PENETRATION OF THE CONSTANT HEAD BOUNDARY

x_0 IS USUALLY DETERMINED BY PUMP TESTS FOR EACH CASE BUT CAN BE APPROXIMATED BY THE LENGTH OF A CENTRAL FLOW LINE BETWEEN THE STREAM/LAKE AND THE WELL

FOR A TYPICAL WELL NEAR POND 1:



SINCE L IS LARGE COMPARED TO h_0 , WE TAKE $x_0 \approx L$

USING THE STEADY STATE EQUATION $Q = \pi r_w^2 K \frac{h_0^2 - h_w^2}{\ln(2L/r_w)}$

$L = 100'$

$h_0^2 = (20')^2 = 400 \text{ sf}$

$r_w = .5'$

$h_w^2 = (15')^2 = 225 \text{ sf}$

$K = .007 \text{ GPM/sf}$

$175 \text{ sf} = h_0^2 - h_w^2$

$Q = \pi (.007 \text{ GPM/sf}) \frac{175 \text{ sf}}{\ln(400)} = 0.642 \text{ GPM}$

SINCE WE PREVIOUSLY CALCULATED THAT .4 GPM WOULD BE EXPECTED WITHOUT THE INFLUENCE OF POND 1 WE CAN SAY THAT THIS = .24 GPM SHOULD BE ADDED TO THE DISCHARGE FOR EACH WELL IN THE VICINITY OF POND 1

ICF KAISER ENGINEERS

PROJECT FULTZ FS PROJECT NO. 30430

EXTRACTION WELL CONCEPT - DESIGN PAGE _____ OF _____

MADE BY DAG DATE 29 Sept 91 CHECKED BY JAW DATE 1/8/90

FOR WELLS NEAR PONDS 1, 2, 2A, 3 THE FOLLOWING TABLE PRESENTS THE RELATION BETWEEN DISTANCE AND ESTIMATED DISCHARGE. HW ASSUMES A DRAWDOWN OF ABOUT 0.25 HQ.

Discharge of a well near a stream.

Hydraulic Conductivity 0.007 GPM/ft
 Radius of the well 0.5

Location:	Pond 1	Pond 1	Pond 2	Pond 3
Elev.	808	808	801	810
H0	20	22	14	22
Hw	15	16	10	16

X0 Extraction Rate in GPM

X0				
20	0.88	1.14	0.48	1.14
40	0.76	0.99	0.42	0.99
60	0.70	0.91	0.39	0.91
80	0.67	0.87	0.37	0.87
100	0.64	0.84	0.36	0.84
125	0.62	0.81	0.34	0.81
150	0.60	0.78	0.33	0.78
175	0.59	0.77	0.32	0.77
200	0.58	0.75	0.32	0.75
250	0.56	0.73	0.31	0.73
300	0.54	0.71	0.30	0.71
350	0.53	0.69	0.29	0.69

NOTES

POND 3 WOULD ADD A SIGNIFICANT QUANTITY OF WATER TO WELLS AS FAR AWAY AS 250' AWAY

POND 1 WOULD ADD A MODERATE AMOUNT OF FLOW TO THE EXTRACTION WELLS CLOSER THAN 150', VERY LITTLE WATER TO WELLS OVER 200' AWAY.

MADE BY DAG

DATE 21 SEP '70

CHECKED BY DMW

DATE 10/5/89 ^{SMW}

VOLUME OF GROUNDWATER IN VALLEY A THAT WOULD BE CAPTURED BY THE GROUND WATER EXTRACTION SYSTEM EQUALS THE CAPTURE AREA THE SATURATED THICKNESS OF THE AQUIFER TIMES THE POROSITY

AREA FROM FIGURE _____ =

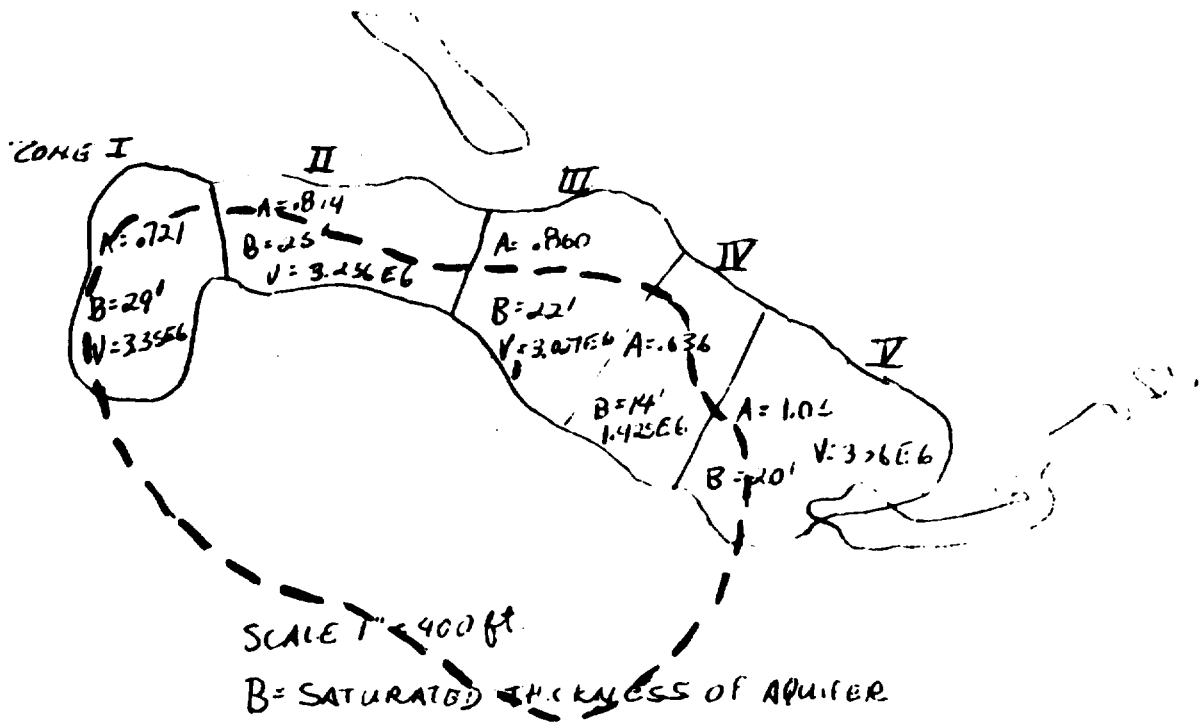
THE THICKNESS OF THE WATER TABLE VARIES FROM 29 FEET IN THE WESTERN END TO 14' IN THE POND 2 AREA 5 AVERAGE THICKNESS ZONES ARE USED FOR THE CALCULATION

Volume of Water in the Shallow Aquifer

Map Scale: 400 Ft. per Inch
 Porosity: 0.2
 Extraction Rate: 6 GPM

Zone	Thickness Feet	Area Sq In	Volume Sq Ft	Water Volume C Ft
I	29	0.712	3303680	660736
II	25	0.814	3256000	651200
III	22	0.86	3027200	605440
IV	14	0.636	1424640	284928
V	20	1.05	3360000	672000
Total				2874304

Years to remove one volume 6.82



APPENDIX B

EVALUATION OF MINE SUBSIDENCE

POTENTIAL

APPENDIX B
EVALUATION OF MINE SUBSIDENCE POTENTIAL

Introduction

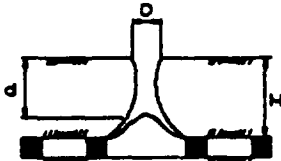
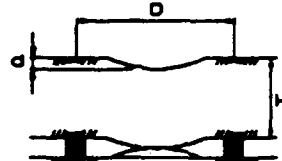
About 40% of the Fultz Site is underlain by former room-and-pillar coal mines. Although the Phase I RI indicated that some of the mine roof was deteriorated and had collapsed, borings into the mine during the Phase II RI showed fairly clean voids that indicate that significant parts of the mine, especially in the vicinity of the existing landfill have not collapsed. Open voids beneath the ground surface raise the issue of the possibility of future subsidence. The potential effects and likelihood of future subsidence has a significant bearing on the screening of technologies and the development of remedial alternatives. Certain remedial technologies are inappropriate for an undermined site. Others are feasible, but their effectiveness would be impaired if there was a significant danger of future subsidence. This evaluation of the potential for mine subsidence at the Fultz Landfill Site determines whether or not the open subsurface cavities left by the former underground mine threaten the effectiveness of remedial measures that might be employed at the Fultz Landfill Site.

Factors Affecting the Likelihood of Subsidence

From the point of view of the surface effects of mine subsidence, there are two basic manifestations, sinkholes and troughs. A sinkhole is a depression in the ground surface that occurs from the collapse of the overburden into a mine opening. Boundaries between the ground surface and the walls of the sinkhole are often abrupt, and the diameter generally increases with depth. Sinkholes generally develop where cover is thin, normally 3 to 10 times the height of the extracted seam (see Table B-1). A trough is a shallow, often broad, dish-shaped depression that develops when the overburden sags downward into the mine opening. [B]

Several failure mechanisms contribute to the collapse of abandoned mines. Roof beds spanning adjacent pillars may collapse due to shear failure or flexural failure. Pillar failure may cause trough like subsidences, generally in deeper overburden, at a considerable time after mining. Pillar failure is

TABLE B-1
CHARACTERISTICS OF SUBSIDENCE FEATURES
ASSOCIATED WITH ABANDONED MINES IN THE PITTSBURGH
COAL REGION*

	<u>Sinkholes</u>	<u>Troughs</u>
1. Mode of Development	Roof collapse	Roof collapse, Pillar crushing, Pillar punching
2. Geometry		
a. Characteristic Profile:		
b. Diameter, D:		
Range	1.5 - 45 ft*	30 - 1600 ft**
Mean	9 ft [170]+	300 ft [15]
80%	< 12 ft	< 300 ft
c. Depth, d:		
Range	1.5 - 45 ft	0.2 - 3 ft
Mean	14 ft [170]	< 3 ft [15]
80%	< 18 ft	< 3 ft
3. Occurrence		
a. Overburden thickness, H:		
Range	2.5 - 150 ft	35 - 450 ft
Mean	45 ft [212]	120 ft [15]
80%	< 70 ft	< 150 ft
b. Distance from outcrop	75% of occurrences within 50 ft ^x	No apparent relationship

* Height of typical mine opening is 5.5 to 6 feet

+ Number in brackets denotes size of sample

° Sinkholes are roughly circular in plan, i.e., $D_{max} = D_{min}$

** Nominal trough diameter $D = (D_{max} + D_{min})/2$.
 D_{max}/D_{min} : Range = 1 - 3.2; Mean = 1.45 [15]

Relationship of trough diameter D to overburden thickness H,
 D/H : Range = 0.4 - 4.7; Mean = 2.0 [15]; 80% lie between 0.5 and 2.5; and 50% between 1 and 2.

^x hillslope inclinations commonly range between 10 and 20 degrees.

frequently caused by additional loads from foundations or fills placed over the mine being transferred to the pillars. Squeezes or crushes, where pillars punch into floor or roof slabs, occur when floors or roofs have been weakened from the action of water or other weathering. An underclay mine floor, high pillar stresses, and flooded mine conditions all favor squeezes and crushes.

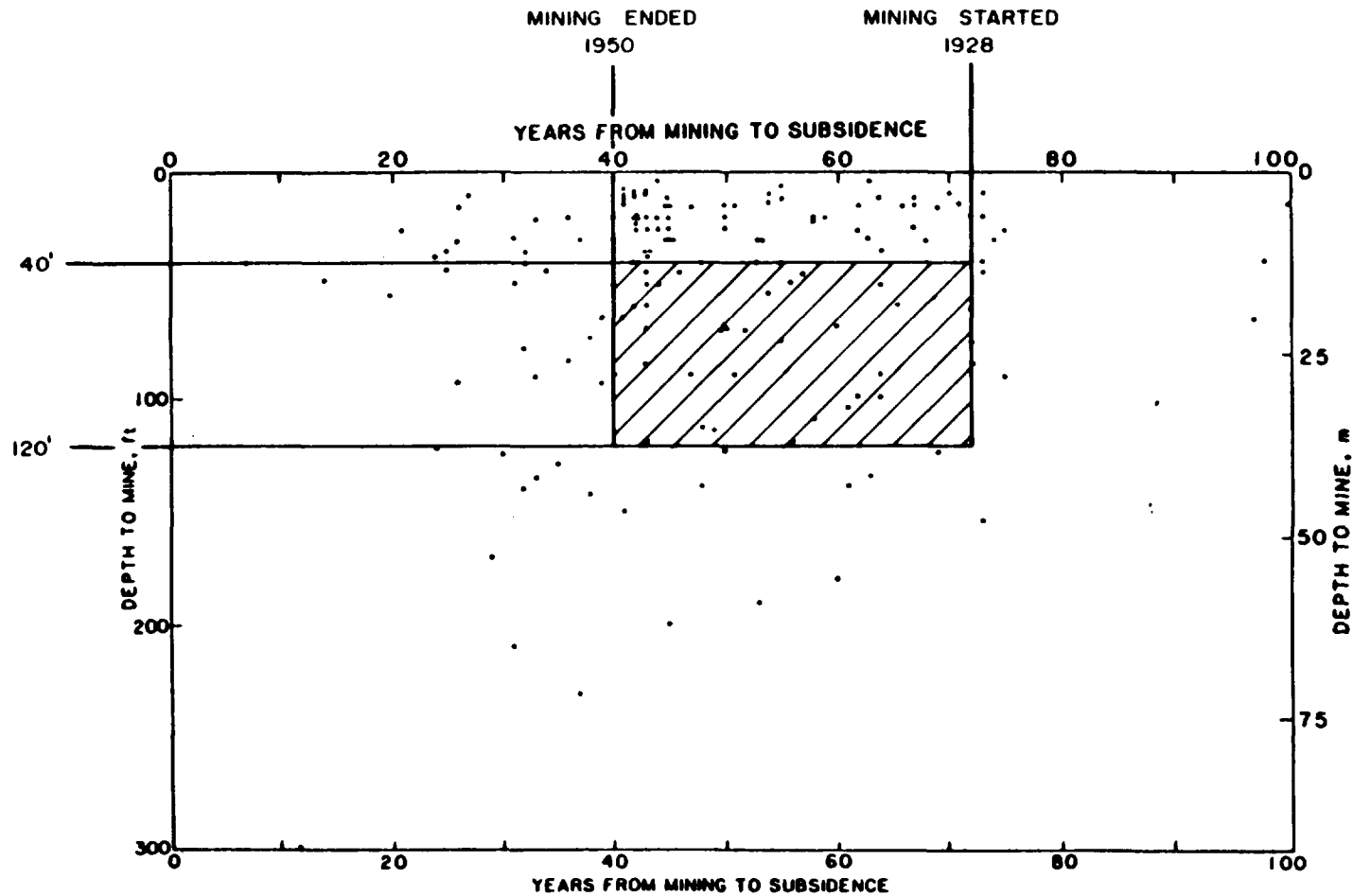
The height to which the collapse can take place is a function of the type of subsidence, volume of the original mine opening or room, the bulking factor of the strata material, and the location and thickness of the overlying competent strata. Table B-1 presents common ranges of surface effects for both sinkholes and troughs. In general, sinkholes are deeper, but include a smaller area than troughs.

The time of the onset and completion of the subsidence process varies widely with different combinations of the following factors: depth of working, mine geometry, strength and deformation characteristics of roof, pillar, and floor, type of roof control, overburden character, presence of old workings, state of stress, water and humidity fluctuations, non-mining factors, including mine fires, earthquakes, tectonic movements, and surface precipitation. Figure B-1 relates historical subsidence events with ages and depths of mining. Attempts to relate depth of mining to the time period of subsidence met with limited success, as exemplified by Figure B-1. It seems fairly certain on the basis of reported data, however, that subsidence events will continue to occur over room-and-pillar mines abandoned over 100 years ago. [A] Note also that the Fultz Landfill Site falls within the zone where past subsidence events have occurred most frequently.

Danger of Subsidence at the Fultz Landfill Site

Several conditions exist in the mine under the Fultz Landfill Site that increase the likelihood of subsidence in the future. Borings made into the mine near the existing landfill during the Phase II RI revealed that the mine contained open mine voids, or in-place coal in the vicinity of the existing landfill. Surface features, such as sinkholes and troughs, that would reflect mine collapse were not noticed in the study area. This indicates that the

B-4



Plot of the duration of subsidence as a function of mining depth for the Pittsburgh coal region (data from Gray et al, 1977).

 RANGE OF CONDITIONS AT THE FULTZ LANDFILL

FIGURE B-1
HISTORICAL MINE
SUBSIDENCE DATA
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

mine beneath the existing landfill has probably not collapsed to date. The rock overburden forming the roof of the mine is a relatively thin shale and claystone, about 40 to 60 feet thick, which is weathered or fissile over much of its thickness. It is overlain by a substantial layer of unconsolidated mine spoil and municipal waste which adds stress to the roof material without providing support. In the mine cavity, the western half of the mine workings is entirely above water, while the eastern half is submerged. The water elevation, and consequently the moisture conditions in the mine, fluctuates over time. Changing moisture conditions in a mine are known to contribute to the deterioration of mine pillars. If subsidence has already begun at the Fultz Landfill Site, the periodic regrading of the landfill during filling operations would have hidden any depressions that might have been caused by subsidence. Conditions within the mine are such that the likelihood of subsidence is increasing over time, so that even if past subsidence has not been observed, future subsidence can not be ruled out. Closure of the landfill will probably require regrading and the installation of some kind of landfill cap. A multi-layer cap that would add additional stress to the roof and pillars of the mine increasing the likelihood of collapse. A thin lightweight cap would allow additional moisture to migrate downward through the landfill weakening the roof and pillars, and also increasing the likelihood of collapse. In either case, closure of the existing landfill by capping would not help to prevent subsidence. To date, there is no certain way to obtain a numerical probability of subsidence at any one location over a fixed period of time, except to say that where room-and-pillar mines exist, the probability of subsidence some time in the future is 100%. Prudent engineering judgment aims to avoid deleterious events that have been observed to happen in similar situations in the past. Because the age and condition of the Ideal Mine favor continued subsidence far into the future, remedial alternatives must take into consideration potential effects of mine subsidence.

Potential Effects of Subsidence on a Multi-Layer Cap

We can conclude from the condition of the mine and its overburden that both

types of subsidence (sink holes and troughs) would be equally likely to occur at some time in the future. Sinkholes would have the most disastrous effect on a RCRA-type cap because, as the underlying support is removed from the cap, it would be likely to rupture leaving a deep hole in the cap surface. Rain water would collect in the sinkhole further eroding the cap, wash through the subsided waste, and carry contamination directly into the deep mine aquifer. Repair of the cap would be possible, but would be complicated by the need to provide vertical support for the waste to prevent the cap repair operations from moving additional waste into the mine cavity. When part of the mine roof collapses, fractures may form in the mine roof adjacent to the sink hole making additional roof failures more likely. As groundwater in the mine is forced to flow around the subsided area, the deterioration of mine pillars will be promoted by the redirected flow.

Subsidence troughs caused by squeezes, pillar failure, or overburden collapse may also form in the cap. The depth of these troughs, calculated using a method proposed by Peng and Cheng [C], would be about 60% of the height of the mine cavity, or about three feet. It is unlikely that the synthetic membrane would remain intact under these conditions. At a minimum, the integrity of the clay layer would be destroyed. Rain water would begin to pond on top of the cap within the troughs and surface cracks around the edges of the troughs would provide an opportunity for cap erosion to begin.

Hydrologic Consequences of Subsidence

The potential hydrologic consequences of subsidence at the Fultz Landfill Site are even more serious than the surface effects on the cap. At present, the contamination within the landfill is partially constrained from vertical migration into the deep mine aquifer by the shale and claystone bedrock that forms the roof on the mine. Even if the cap were to remain intact after a subsidence event, fractures would open in the bedrock creating low permeability zones beneath the landfill. In the case of troughs, these fractures would be very difficult to isolate and fill, even if the cap were repaired. In the case of a sinkhole, the hole could be filled, and the loose material around the sinkhole itself could be pressure-grouted to seal off the

migration route. During the interval between the event and the repair, contamination would migrate directly into the mine aquifer. Analysis using the HELP model showed that after the cap is in place, the landfill will continue to drain for the entire 30-year life of the alternative. With each subsidence event, additional pathways would be opened for leachate to drain into the mine aquifer.

Cost of Cap Repair and Replacement Compared with Subsurface Supports.

The initial cost of providing subsurface supports to prevent mine subsidence depends on the method chosen. Grout pillar supports would cost about \$900,000 to install, while mine flushing would cost about \$1.9 million. Both systems are well-developed technologies with an extensive history in preventing damage to surface structures where even small movements in foundations would show up later in the buildings. Both subsurface support systems have a high degree of success and provide long term stability without additional maintenance. In comparison, the repairs that could be performed on the cap, if damaged, would depend on the type and extent of future subsidence. Repairing a single small sinkhole would cost about \$50,000. Repairing a single subsidence trough of average size would cost \$175,000. Leaving sinkholes and troughs unrepaired would compromise the integrity of the cap, providing ready pathways for contaminant migration for the water within the capped area to enter the deep mine aquifer. Replacing the entire cap would cost \$3.9 million. One cap replacement would be twice the cost of the most expensive method for providing subsurface supports.

Conclusions

Because leachate production may continue for some time after the landfill is closed, mine subsidence would over time open migration paths for contamination to move from the landfill into the coal mine aquifer. If subsurface supports were not provided, frequent inspections of the cap would be required to detect and repair subsidence as soon as possible after each subsidence event so that the spread of contamination would be minimized. The cost of repairing eleven trough subsidences exceeds the cost of flushing the entire mine under the

APPENDIX C

EVALUATION OF THE POTENTIAL EFFECTS OF THE FULTZ LANDFILL SITE ON THE BYESVILLE WATER SUPPLY

APPENDIX C

EVALUATION OF THE POTENTIAL EFFECTS OF THE FULTZ LANDFILL SITE ON THE BYESVILLE WATER SUPPLY WELL

Introduction

The RI established that there is a potential migration pathway from the Fultz Landfill Site to the coal mine aquifer from which the City of Byesville draws its water supply. Thirteen inorganic chemicals were found in samples of untreated water from the Byesville well, but all except sodium and chloride were below background levels. Two organic compounds (acetone, and carbon tetrachloride) were also found in samples from the Byesville well, but their relation to the Fultz Landfill Site was considered doubtful. The RI did not perform a quantitative investigation of the potential for contaminant transport between the Fultz Landfill Site and the Byesville well. Because contamination appears to enter the coal mine aquifer at several points beneath the Fultz Landfill Site, it would be reasonable to suppose that this contamination would eventually find its way to the Byesville water supply.

General Approach to the Problem

The gradient in the coal mine aquifer is predominantly north to south, but water velocity is cannot be calculated because the hydraulic conductivity of the room and pillar mine is unknown. In addition, the dilution of the contamination by water entering the mine from the north would tend to lower the concentration at the Byesville well, possibly below detection limits. Diffusion of contaminants throughout the mine would also tend to reduce their concentration at the Byesville well.

In order to evaluate the potential effects of the contamination on the Byesville water supply, a solute transport model for the coal mine aquifer was developed using the U. S Geological Survey two-dimensional solute transport and dispersion model by Konikow and Bredehoeft (1978). Given a certain steady-state contaminant concentration in the landfill, the model attempts to show the arrival time, change in concentration over time, and time to steady state at the Byesville well.

Model Background

The Konikow and Bredehoeft model, also known as the Method of Characteristics (MOC) model, is applicable to one or two-dimensional problems involving steady-state or transient flow. The model computes the changes in chemical concentration over time caused by the processes of convective transport, hydrodynamic dispersion, and mixing (or dilution) from fluid sources. MOC utilizes a rectangular, uniformly spaced, block-centered, finite-difference grid, in which nodes are defined at the centers of the rectangular cells. A solution is obtained by coupling the groundwater flow equation with the solute transport equation. The solution is performed by a computer program that uses an alternating-direction implicit procedure to solve the finite-difference approximation to the groundwater flow equation, and method of characteristics to solve the solute transport equation.

The applicability and reliability of the model results are based on the following set of assumptions (Konikow and Bredehoeft, 1978):

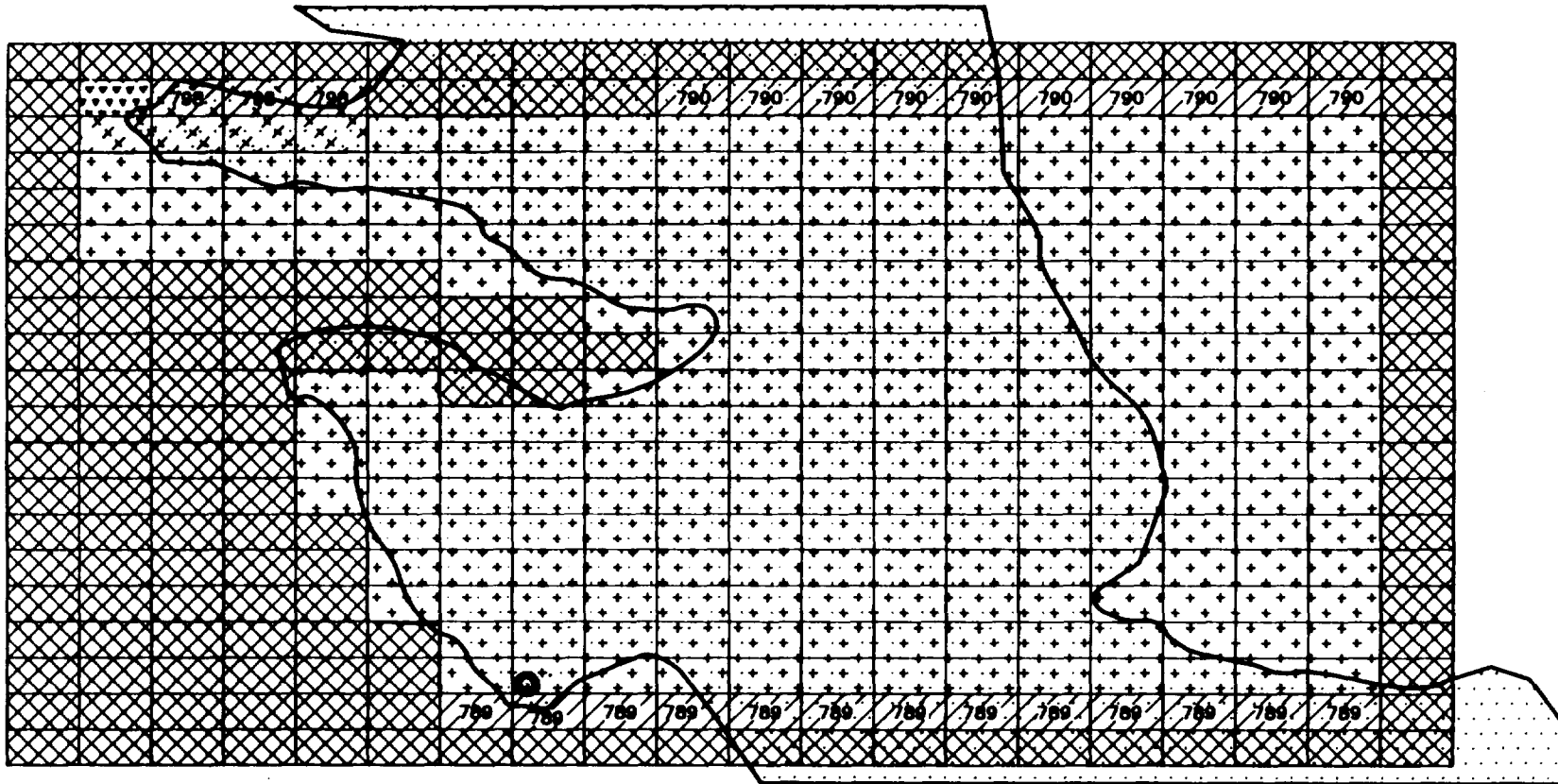
1. Darcy's law is valid and hydraulic-head gradients are the only significant driving mechanism for fluid flow.
2. The porosity and hydraulic conductivity of the aquifer are constant with time, and porosity is uniform in space.
3. Gradients of fluid density, viscosity, and temperature do not affect the velocity distribution.
4. No chemical reactions occur that affect the concentration of the solute, the fluid properties, or the aquifer properties.
5. Ionic and molecular diffusion are negligible contributors to the total dispersion flux.
6. Vertical variation in head and concentration are negligible.

7. The aquifer is homogeneous and isotropic with respect to the coefficients of longitudinal and transverse dispersivity.

Model Set-up and Calibration

A uniform 20 x 20 grid is used to represent the area of concern shown in Figure C-1. Rectangles within the grid measure 300 feet north to south by 600 feet east to west. The coal mine aquifer is simulated as a confined aquifer with a uniform thickness of 5 feet. The part of the Fultz Landfill Site where contaminant migration is suspected is delineated by the active nodes, that is, nodes where the flow of solute and water is permitted by the model. Parts of the Fultz Landfill Site where contaminant migration is unlikely are represented by inactive, or no-flow, nodes. The inactive nodes are zero transmissivity nodes, which assume that there is no flow of water or dissolved chemicals across the boundaries of the cell containing that node. Since a north to south gradient in has been observed in the mine, constant heads are placed across the northern and southern boundaries to simulate the observed gradient and the assumed overall groundwater flow through the aquifer system. Head difference between the two boundaries is set at 1 foot (elevation 790 to elevation 789), to simulate the observed head differential across the aquifer.

The existing landfill area is designated by a constant-head node with contamination level at 100 percent. This single node represents the driving head in the shallow aquifer which is approximately 798 feet MSL near the existing landfill. A low transmissivity unit surrounds the landfill area to simulate the resistance to flow provided by the alluvium, mine spoil, and coal barrier, all of which have lower significantly transmissivities than the coal mine aquifer. The transmissivity of the unit between the landfill and the mine aquifer is calibrated so that the heads in wells GW006 and GW007 in the mine aquifer correspond to observed values. Transmissivity of the coal mine aquifer is calibrated by estimated total flow in the mine aquifer. This is estimated to be between 800 GPM (the amount discharging from the Byesville well) and 1500 GPM, which has been estimated as the aquifer capacity in a report by State of Ohio Department of Natural Resources, 1980.



APPROXIMATE LIMITS OF THE IDEAL MINE



SOURCE CELL



NO-FLOW CELLS



TRANSMISSMITY = 1.6×10^{-3} FT.²/SEC



CONSTANT HEAD CELLS



TRANSMISSMITY = 1.6 FT.²/SEC



OBSERVATION POINT (BYESVILLE WELL)

FIGURE C-1
CONTAMINANT TRANSPORT MODEL
DEEP MINE AQUIFER
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

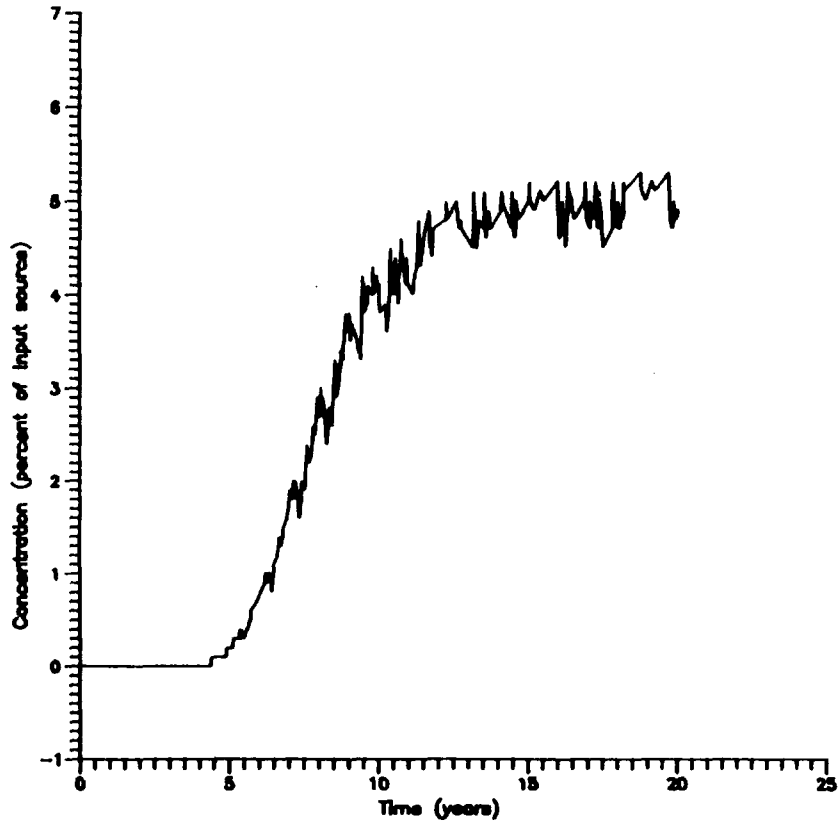
Other parameters of concern associated with the model are estimated as follows:

1. Effective porosity of the coal mine aquifer = 0.65: Based on the 65% extraction in most of the mine, the remaining 35% would be voids. Comparatively, the voids in soil and surrounding rock would represent only a small portion of the porosity.
2. Characteristic length: Longitudinal dispersivity of 50 and 5 feet were chosen to observe the sensitivity of this parameter. Dispersivity is expected to be low as it is a function of mechanical mixing factors in the aquifer.
3. Ratio of transverse to longitudinal dispersivity = 1 : A ratio of one was chosen since the aquifer unit is mainly mine voids and pillars, and the transverse dispersivity which is the mixing normal to the pathway of fluid flow is assumed to be the same as the mixing along the streamline of the fluid flow.

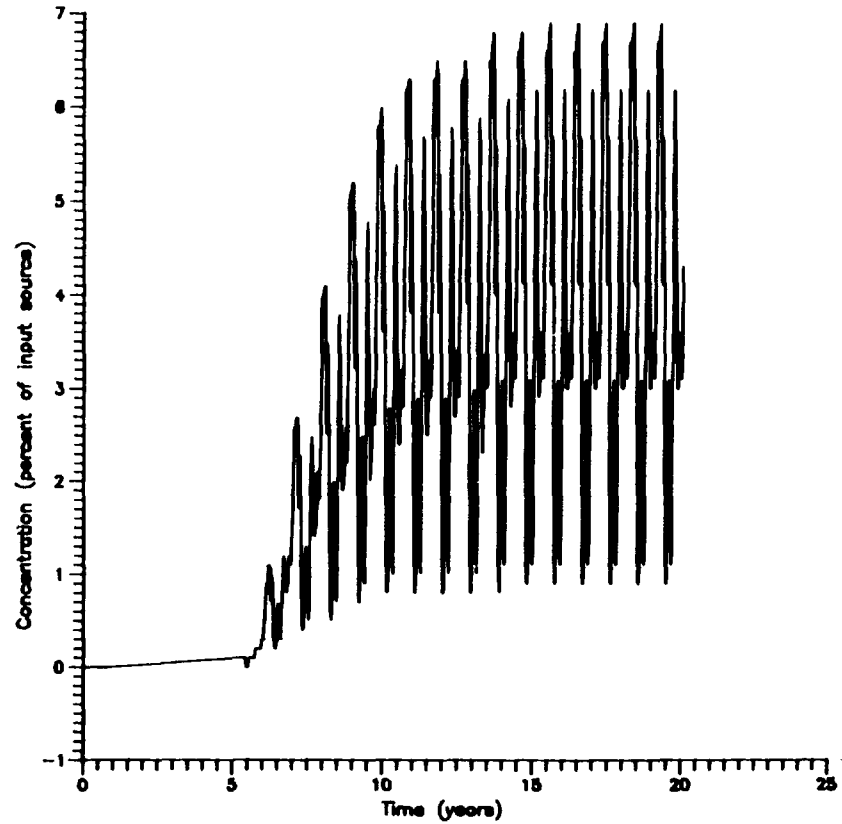
Model Results

Since the parameter of least certainty is the characteristic length (β), different model runs were performed with a wide range of lengths to test the sensitivity of the results to this parameter. The time period was made sufficiently large for the concentration observed at the Byesville well to reach steady state. At steady state, the value of the characteristic length has only a minor effect on the total concentration observed at the Byesville well. The results of the model based on steady-state groundwater flows over a 20-year period, and characteristic lengths of 5 and 50 feet are shown in Figures C-2 and C-3.

Both the results show that the migration of the contamination to the Byesville Plant will reach a maximum limit after about 13 years. At $\beta = 50$ feet, the maximum concentration level will reach about 5% of the concentration level at

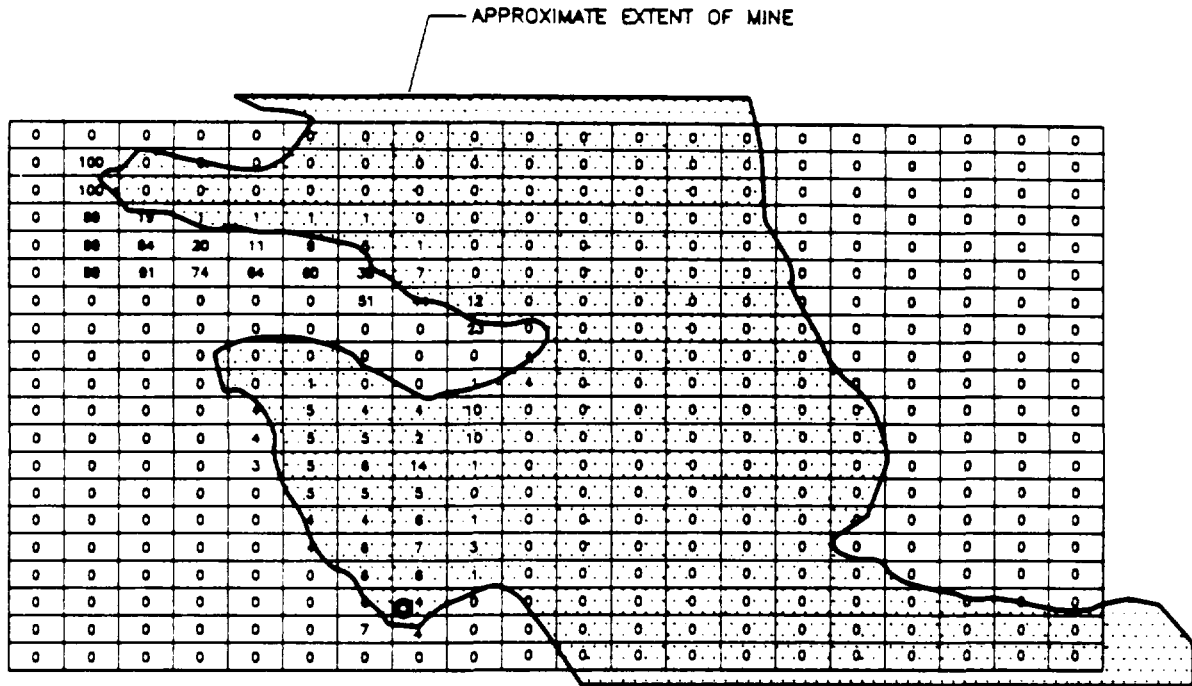


CHARACTERISTIC LENGTH AT 50 FEET

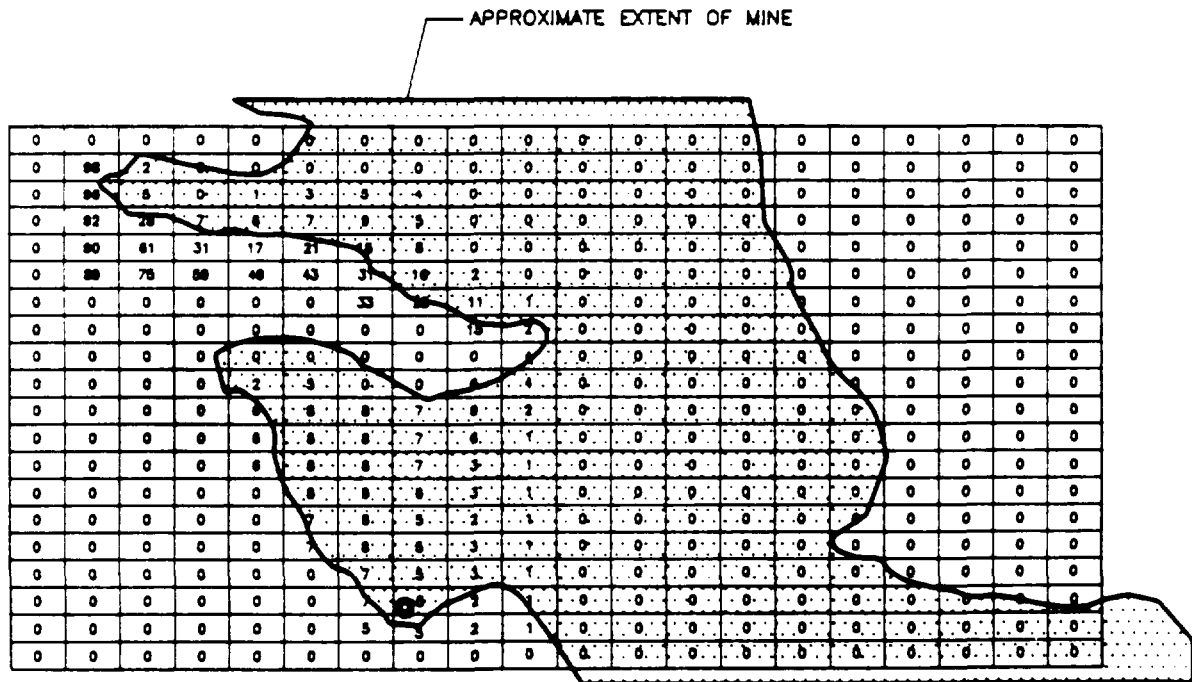


CHARACTERISTIC LENGTH AT 5 FEET

FIGURE C-2
MINE AQUIFER MODEL RESULTS
AT THE BYESVILLE WELL
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT



CHARACTERISTIC LENGTH = 5 FEET



CHARACTERISTIC LENGTH = 50 FEET

FIGURE C-3
MINE AQUIFER MODEL RESULTS
CONCENTRATION PROFILES
(% OF SOURCE)
FULTZ LANDFILL SITE,
FEASIBILITY STUDY REPORT

the source. Therefore, if the detected concentration level at the source is 20 $\mu\text{g}/\text{l}$, then the value at the 5% level will be 1.0 $\mu\text{g}/\text{l}$ which in most cases, depending on the type of chemical compound, will be less than the laboratory detection limits.

The graph of concentration versus time for $\beta = 5$ ft, Figure C-2, shows a very strong fluctuation in the concentration at the Byesville well over time. The fluctuation is due to the higher chemical mass balance error with the shorter characteristic length of 5 feet. The lower characteristic length, however, does not influence the time to steady state, nor does it significantly influence the steady state concentration at the Byesville well. A higher maximum concentration level is expected for a lower dispersivity value and in this case it is observed to be less than 7%. Figure C-3 shows the contamination migration path at 20 years for the respective characteristic lengths.

Conclusion

Historical records indicate that industrial chemical wastes were dumped at the Fultz landfill from 1969 to 1980. Since the time to steady state is less than the time that has elapsed since contaminants were reportedly dumped at the Fultz Landfill Site, the model results support the conclusion that chemical compounds at their present concentrations in the shallow aquifer have a relatively small impact on the Byesville water treatment Plant at present. The concentrations that would be expected at the Byesville well (about 6% of the source) should be below detection limits for the compounds found at the landfill. Since the present treatment system is capable of removing the existing contamination, additions to the Byesville system are not needed to maintain protection of human health. If however, additional uncontrolled releases from the landfill should occur, the potential exists for significant contamination of the Byesville water supply.

APPENDIX D

COST ESTIMATE TABLES

TABLE D-1
 COST ESTIMATE SUMMARY
 ALTERNATIVE 2 - INSTITUTIONAL ACTIONS AND MONITORING
 FULTZ LANDFILL SITE - FEASIBILITY STUDY REPORT

ITEM	Quantity	Capital Cost	Annual O & M	Present Worth O&M/Replacement	
				30 years, 5%	30 years, 10%
I. INSTITUTIONAL ACTIONS					
1. Deed Restrictions	NA	\$10,000			
2. Public Education Program	NA	\$20,000			
3. Institutional Controls	NA	\$20,000			
4. Alternate Water Supply	25	\$117,000			
Subtotal:		\$167,000			
II. GENERAL ACTIONS/SITE PREPARATION					
1. Site Fencing	10000 FT	\$160,000	\$8,000	\$123,000	\$75,000
2. Mobilization, Decon, Staging Area	NA	\$10,000			
Subtotal:		\$170,000	\$9,400	\$145,000	\$89,000
III. LONG-TERM MONITORING AND REVIEWS					
1. Monitoring Well Installation	5 wells	\$40,000		\$1,537,000	\$943,000
2. Environmental Sampling	*		\$100,000	\$83,000	\$47,000
3. 5 Year Reviews	6 Reviews **				
Subtotal:		\$40,000	\$100,000	\$1,620,000	\$990,000
CONSTRUCTION SUBTOTAL		\$377,000	\$109,400	\$1,765,000	\$1,079,000
Health and Safety	5%	\$18,850			
Bid Contingency	10%	\$37,700			
Scope Contingency	10%	\$37,700			
CONSTRUCTION TOTAL		\$471,300			
Permitting & Legal	5%	\$23,565			
Services During Construction	0%	\$0			
TOTAL IMPLEMENTATION COST		\$494,900			
Engineering & Design	5%	\$24,745			
TOTAL CAPITAL COSTS		\$519,600			
TOTAL PRESENT WORTH				\$2,284,600	\$1,598,600

NA: NOT APPLICABLE

- * Monitoring period of 30 years. Environmental sampling includes: ambient air, surface water, leachate, sediment, and groundwater, all of which are sampled semi-annually.
- ** Present worth value of reviews based on current cost of \$15,000/review. Reviews at t=5 yr, 10 yr, 15 yr, 20 yr, 25 yr, and 30 yr.

TABLE D-2
 COST ESTIMATE SUMMARY
 ALTERNATIVE 3 - MULTI-LAYER CAP
 FULTZ LANDFILL SITE - FEASIBILITY STUDY REPORT

ITEM	Quantity	Capital Cost	Annual O & M	Present Worth O&M/Replacement	
				30 years, 5%	30 years, 10%
I. INSTITUTIONAL ACTIONS					
1. Deed Restrictions	NA	\$10,000			
2. Public Education Program	NA	\$20,000			
3. Institutional Controls	NA	\$20,000			
4. Alternate Water Supply	25	\$117,000			
Subtotal:		\$167,000			
II. GENERAL ACTIONS/SITE PREPARATION					
1. Site Fencing	10000 FT	\$160,000	\$8,000	\$123,000	\$75,000
2. Mobilization, Decon, Staging Area	NA	\$130,000			
Subtotal:		\$290,000	\$8,000	\$123,000	\$75,000
III. MULTI-LAYER CAP					
1. Multi-Layer Cap Installation	22 acres	\$5,771,000		\$332,000	\$173,000
2. Leachate Collection System	2000 LF	\$402,000			
3. Mine Flushing	9 acres	\$2,026,000			
4. Leachate Disposal	NA		\$152,000	\$2,337,000	\$1,433,000
Subtotal:		\$8,199,000	\$152,000	\$2,669,000	\$1,606,000
IV. WATER CONTROL					
1. Subsurface Diversion Ditch	1600 LF	\$978,000			
2. Surface Water Diversion Ditch	1600 LF	\$10,000			
3. Pond Excavations		\$495,000			
4. Erosion & Sediment Controls		\$174,000			
5. Wetlands Replacement		\$250,000			
Subtotal:		\$1,907,000			
V. LONG-TERM MONITORING AND REVIEWS					
1. Monitoring Well Installation	5 wells	\$40,000		\$1,307,000	\$801,000
2. Environmental Sampling	*		\$85,000	\$83,000	\$46,000
3. 5 Year Reviews	6 Reviews **				
Subtotal:		\$40,000	\$85,000	\$1,390,000	\$847,000
CONSTRUCTION SUBTOTAL		\$10,603,000	\$245,000	\$4,182,000	\$2,528,000
Health and Safety	5%	\$530,150			
Bid Contingency	10%	\$1,060,300			
Scope Contingency	10%	\$1,060,300			
CONSTRUCTION TOTAL		\$13,253,800			
Permitting & Legal	5%	\$662,690			
Services During Construction	8%	\$1,060,304			
TOTAL IMPLEMENTATION COST		\$14,976,800			
Engineering & Design	10%	\$1,497,680			
TOTAL CAPITAL COSTS		\$16,474,500			
TOTAL PRESENT WORTH				\$20,656,500	\$19,002,500

NA: NOT APPLICABLE

* Monitoring period of 30 years. Environmental sampling includes: surface water, leachate, sediment, and groundwater, all of which are sampled semi-annually.

** Present worth value of reviews based on current cost of \$15,000/review. Reviews at t=5 yr, 10 yr, 15 yr, 20 yr, 25 yr, and 30 yr.

TABLE D-2-A
 COST ESTIMATE SUMMARY
 ALTERNATIVE 3-A - MULTI-LAYER CAP (With Grout Pillars)
 FULTZ LANDFILL SITE - FEASIBILITY STUDY REPORT

ITEM	Quantity	Capital Cost	Annual O & M	Present Worth O&M/Replacement	
				30 years, 5%	30 years, 10%
I. INSTITUTIONAL ACTIONS					
1. Deed Restrictions	NA	\$10,000			
2. Public Education Program	NA	\$20,000			
3. Institutional Controls	NA	\$20,000			
4. Alternate Water Supply	25	\$117,000			
Subtotal:		\$167,000			
II. GENERAL ACTIONS/SITE PREPARATION					
1. Site Fencing	10000 FT	\$160,000	\$8,000	\$123,000	\$75,000
2. Mobilization, Decon, Staging Area	NA	\$130,000			
Subtotal:		\$290,000	\$8,000	\$123,000	\$75,000
III. MULTI-LAYER CAP					
1. Multi-Layer Cap Installation	22 acres	\$5,771,000		\$332,000	\$173,000
2. Leachate Collection System	2000 LF	\$402,000			
3. Grout Pillars	NA	\$900,000			
4. Leachate Disposal	NA		\$152,000	\$2,337,000	\$1,433,000
Subtotal:		\$7,073,000	\$152,000	\$2,669,000	\$1,606,000
IV. WATER CONTROL					
1. Subsurface Diversion Ditch	1600 LF	\$978,000			
2. Surface Water Diversion Ditch	1600 LF	\$10,000			
3. Pond Excavations		\$495,000			
4. Erosion & Sediment Controls		\$174,000			
5. Wetlands Replacement		\$250,000			
Subtotal:		\$1,907,000			
V. LONG-TERM MONITORING AND REVIEWS					
1. Monitoring Well Installation	5 wells	\$40,000		\$1,307,000	\$801,000
2. Environmental Sampling	*		\$85,000	\$83,000	\$46,000
3. 5 Year Reviews	6 Reviews **				
Subtotal:		\$40,000	\$85,000	\$1,390,000	\$847,000
CONSTRUCTION SUBTOTAL		\$9,477,000	\$245,000	\$4,182,000	\$2,528,000
Health and Safety	5%	\$473,850			
Bid Contingency	10%	\$947,700			
Scope Contingency	10%	\$947,700			
CONSTRUCTION TOTAL		\$11,846,300			
Permitting & Legal	5%	\$592,315			
Services During Construction	8%	\$947,704			
TOTAL IMPLEMENTATION COST		\$13,386,300			
Engineering & Design	10%	\$1,338,630			
TOTAL CAPITAL COSTS		\$14,724,900			
TOTAL PRESENT WORTH				\$18,906,900	\$17,252,900

NA: NOT APPLICABLE

- * Monitoring period of 30 years. Environmental sampling includes: surface water, leachate, sediment, and groundwater, all of which are sampled semi-annually.
- ** Present worth value of reviews based on current cost of \$15,000/review. Reviews at t=5 yr, 10 yr, 15 yr, 20 yr, 25 yr, and 30 yr.

TABLE D-3
COST ESTIMATE SUMMARY
ALTERNATIVE 4 - MULTI-LAYER CAP, GROUNDWATER EXTRACTION AND TREATMENT
FULTZ LANDFILL SITE - FEASIBILITY STUDY REPORT

ITEM	Quantity	Capital Cost	Annual O & M	Present Worth O&M/Replacement		
				30 years, 5%	30 years, 10%	
I. INSTITUTIONAL ACTIONS						
1. Deed Restrictions	NA	\$10,000				
2. Public Education Program	NA	\$20,000				
3. Institutional Controls	NA	\$20,000				
4. Alternate Water Supply	25	\$117,000				
Subtotal:		\$167,000				
II. GENERAL ACTIONS/SITE PREPARATION						
1. Site Fencing	10000 FT	\$160,000	\$8,000	\$123,000	\$75,000	
2. Mobilization, Decon, Staging Area	NA	\$131,000				
Subtotal:		\$291,000	\$8,000	\$123,000	\$75,000	
III. MULTI-LAYER CAP						
1. Multi-Layer Cap Installation	22 acres	\$5,771,000		\$332,000	\$173,000	
2. Leachate Collection System	NA	\$402,000				
3. Mine Flushing	9 acres	\$2,026,000				
Subtotal:		\$8,199,000		\$286,000	\$150,000	
IV. WATER CONTROL						
1. Subsurface Diversion Ditch	1600 FT	\$978,000				
2. Surface Water Diversion Ditch	1600 FT	\$10,000				
3. Pond Excavations	NA	\$495,000				
4. Erosion & Sediment Controls	NA	\$174,000				
5. Wetlands Replacement	NA	\$250,000				
Subtotal:		\$1,907,000				
V. EXTRACTION AND ONSITE WATER TREATMENT						
1. Extraction Wells	12 Wells	\$150,000	\$15,000	\$231,000	\$141,000	
2. Treatment Plant Building	NA	\$350,000				
3. Treatment System	NA	\$165,000	\$103,000	\$1,583,000	\$971,000	
4. Residual Disposal	NA		\$7,000	\$108,000	\$66,000	
Subtotal:		\$665,000	\$125,000	\$1,922,000	\$1,178,000	
VI. LONG-TERM MONITORING AND REVIEWS						
1. Monitoring Well Installation	5 wells	\$40,000		\$1,307,000	\$801,000	
2. Environmental Sampling	*		\$85,000	\$83,000	\$46,000	
3. 5 Year Review	6 Reviews **					
Subtotal:		\$40,000	\$85,000	\$1,390,000	\$847,000	
CONSTRUCTION SUBTOTAL			\$11,269,000	\$218,000	\$3,721,000	\$2,250,000
Health and Safety	5%		\$563,450			
Bid Contingency	10%		\$1,126,900			
Scope Contingency	10%		\$1,126,900			
CONSTRUCTION TOTAL			\$14,086,300			
Permitting & Legal	5%		\$704,315			
Services During Construction	8%		\$1,126,904			
TOTAL IMPLEMENTATION COST			\$15,917,500			
Engineering & Design	10%		\$1,591,750			
TOTAL CAPITAL COSTS			\$17,509,300			
TOTAL PRESENT WORTH				\$21,230,300	\$19,759,300	

NA: NOT APPLICABLE

* Monitoring period of 30 years. Environmental sampling includes: surface water, leachate, sediment, and groundwater, all of which are sampled semi-annually.

** Present worth value of reviews based on current cost of \$15,000/review. Reviews at t=5 yr, 10 yr, 15 yr, 20 yr, 25 yr, and 30 yr.

TABLE D-3-A
 COST ESTIMATE SUMMARY
 ALTERNATIVE 4-A - MULTI-LAYER CAP, GROUNDWATER EXTRACTION AND TREATMENT
 (With Grout Pillars)
 PULIZ LANDFILL SITE - FEASIBILITY STUDY REPORT

ITEM	Quantity	Capital Cost	Annual O & M	Present Worth 30 years, 5% OM/Replacement	30 years, 10% OM/Replacement
I. INSTITUTIONAL ACTIONS					
1. Dead Restrictions	NA	\$10,000			
2. Public Education Program	NA	\$20,000			
3. Institutional Controls	NA	\$20,000			
4. Alternate Water Supply	\$25	\$117,000			
Subtotal:					
		\$167,000			
II. GENERAL ACTIONS/SITE PREPARATION					
1. Site Fencing	10000 FT	\$160,000	\$8,000	\$123,000	\$75,000
2. Mobilization, Decon, Staging Area	NA	\$131,000			
Subtotal:					
		\$291,000	\$8,000	\$123,000	\$75,000
III. MULTI-LAYER CAP					
1. Multi-Layer Cap Installation	22 acres	\$5,771,000		\$332,000	\$173,000
2. Leachate Collection System	NA	\$402,000			
3. Grout Pillars	NA	\$900,000			
Subtotal:					
		\$7,073,000		\$286,000	\$150,000
IV. WATER CONTROL					
1. Subsurface Diversion Ditch	1600 FT	\$978,000			
2. Surface Water Diversion Ditch	1600 FT	\$10,000			
3. Pond Excavations	NA	\$495,000			
4. Erosion & Sediment Controls	NA	\$176,000			
5. Wetlands Replacement	NA	\$250,000			
Subtotal:					
		\$1,907,000			
V. EXTRACTION AND ONSITE WATER TREATMENT					
1. Extraction Wells	12 Wells	\$150,000	\$15,000	\$231,000	\$141,000
2. Treatment Plant Building	NA	\$350,000		\$1,563,000	\$971,000
3. Treatment System	NA	\$165,000		\$1,583,000	\$971,000
4. Residual Disposal	NA	\$7,000		\$108,000	\$66,000
Subtotal:					
		\$665,000	\$125,000	\$1,922,000	\$1,178,000
V. LONG-TERM MONITORING AND REVIEWS					
1. Monitoring Well Installation	5 Wells	\$40,000		\$1,307,000	\$801,000
2. Environmental Sampling	6 Reviews **			\$83,000	\$46,000
3. 5 Year Reviews				\$1,390,000	\$847,000
Subtotal:					
		\$40,000	\$85,000	\$1,390,000	\$847,000
CONSTRUCTION SUBTOTAL					
		\$10,143,000	\$218,000	\$3,721,000	\$2,250,000
Health and Safety	5%	\$507,150			
Bid Contingency	10%	\$1,014,300			
Scope Contingency	10%	\$1,014,300			
CONSTRUCTION TOTAL					
		\$12,678,800			
Permitting & Legal	5%	\$633,940			
Services During Construction	8%	\$1,014,304			
TOTAL IMPLEMENTATION COST					
		\$14,327,000			
Engineering & Design	10%	\$1,432,700			
TOTAL CAPITAL COSTS					
		\$15,759,700			
TOTAL PRESENT WORTH					
		\$19,480,700		\$18,009,700	

NA: NOT APPLICABLE
 * Monitoring period of 30 years. Environmental sampling includes: surface water, leachate, sediment, and groundwater, all of which are sampled semi-annually.
 ** Present worth value of reviews based on current cost of \$15,000/review.
 Revisions at 5 yr, 10 yr, 15 yr, 20 yr, 25 yr, and 30 yr.

TABLE D-4
 COST ESTIMATE SUMMARY
 ALTERNATIVE 5 - ON-SITE LANDFILL
 FULLTZ LANDFILL SITE - FEASIBILITY STUDY REPORT

ITEM	Quantity	Capital Cost	Annual O & M	Present Worth 30 years, 5% O&M/Replacement 30 years, 10%
I. INSTITUTIONAL ACTIONS	NA NA NA NA	\$10,000 \$20,000 \$20,000 \$20,000		
1. Dead Restrictions				
2. Public Education Program				
3. Institutional Controls				
4. Alternate Water Supply	25	\$117,000		
Subtotal:		\$167,000		
II. GENERAL ACTIONS/SITE PREPARATION	10000 FT	\$160,000	\$8,000	\$123,000
1. Site Fencing				
2. Mobilization, Decom, Staging Area				
Subtotal:		\$424,000	\$8,000	\$123,000
III. WATER CONTROL	NA NA NA NA	\$591,000 \$212,000 \$756,000 \$250,000		
1. Pond Excavations				
2. Erosion & Sediment Controls				
3. Dewatering				
4. Wetlands Replacement				
Subtotal:		\$1,809,000		
IV. ON-SITE LANDFILL	NA 12 acres 150,000 GPY	\$20,850,000 \$2,570,000	\$46,000	\$117,000
1. Excavation and Construction				
2. Multi-Layer Cap				
3. Leachate Disposal				
Subtotal:		\$23,420,000	\$46,000	\$926,000
V. DRUM/HAZARDOUS MATERIAL DISPOSAL	3000 drums 20000 CY	\$3,123,000 \$6,000,000		
1. Drum Disposal				
2. Contaminated Soil Disposal				
Subtotal:		\$9,123,000		
V. LONG-TERM MONITORING AND REVIEWS	9 wells 6 Reviews **	\$72,000	\$80,000	\$754,000
1. Monitoring Well Installation				
2. Environmental Sampling				
3. 5 Year Reviews				
Subtotal:		\$72,000	\$80,000	\$754,000
CONSTRUCTION SUBTOTAL		\$35,015,000	\$134,000	\$2,362,000
Health and Safety	5%	\$1,750,750		
Bid Contingency	10%	\$3,501,500		
Scope Contingency	10%	\$3,501,500		
CONSTRUCTION TOTAL		\$43,768,800		
Permitting & Legal	5%	\$2,188,440		
Services During Construction	8%	\$3,501,504		
TOTAL IMPLEMENTATION COST		\$49,458,700		
Engineering & Design	10%	\$4,945,870		
TOTAL CAPITAL COSTS		\$54,404,600		
TOTAL PRESENT WORTH			\$56,766,600	\$55,830,600

NA: NOT APPLICABLE
 Monitoring period of 30 years. Environmental sampling includes: surface water, sediment, and groundwater, all of which are sampled semi-annually.
 Present worth value of reviews based on current cost of \$15,000/review.
 Reviews at 5 yr, 10 yr, 15 yr, 20 yr, 25 yr, and 30 yr.

**TABLE D-5
COST ESTIMATE SUMMARY
ALTERNATIVE 6 - MULTI-LAYER CAP AND SUBSURFACE BARRIER
FULTZ LANDFILL SITE - FEASIBILITY STUDY REPORT**

ITEM	Quantity	Capital Cost	Annual O & M	Present Worth O&M/Replacement	
				30 years, 5%	30 years, 10%
I. INSTITUTIONAL ACTIONS					
1. Deed Restrictions	NA	\$10,000			
2. Public Education Program	NA	\$20,000			
3. Institutional Controls	NA	\$20,000			
4. Alternate Water Supply	25	\$117,000			
Subtotal:		\$167,000			
II. GENERAL ACTIONS/SITE PREPARATION					
1. Site Fencing	10000 FT	\$160,000	\$8,000	\$123,000	\$75,000
2. Mobilization, Decon, Staging Area	NA	\$159,000			
Subtotal:		\$319,000	\$8,000	\$123,000	\$75,000
III. MULTI-LAYER CAP					
1. Multi-Layer Cap Installation	22 acres	\$5,771,000		\$332,000	\$173,000
2. Leachate Collection System	NA	\$402,000			
3. Mine Flushing	9 acres	\$2,026,000			
4. Leachate Disposal	NA		\$152,000	\$2,337,000	\$1,433,000
Subtotal:		\$8,199,000	\$152,000	\$2,669,000	\$1,606,000
IV. WATER CONTROL					
1. Subsurface Diversion Ditch	1600 FT	\$978,000			
2. Surface Water Diversion Ditch	1600 FT	\$10,000			
3. Pond Excavations	NA	\$420,000			
4. Erosion & Sediment Controls	NA	\$174,000			
5. Slurry Wall	76000 SF	\$760,000			
6. Wetlands Replacement	NA	\$200,000			
Subtotal:		\$2,342,000			
V. LONG-TERM MONITORING AND REVIEWS					
1. Monitoring Well Installation	5 wells	\$40,000		\$1,307,000	\$801,000
2. Environmental Sampling	*		\$85,000	\$83,000	\$46,000
3. 5 Year Review	6 Reviews **				
Subtotal:		\$40,000	\$85,000	\$1,390,000	\$847,000
CONSTRUCTION SUBTOTAL		\$11,067,000	\$245,000	\$4,182,000	\$2,528,000
Health and Safety	5%	\$553,350			
Bid Contingency	10%	\$1,106,700			
Scope Contingency	10%	\$1,106,700			
CONSTRUCTION TOTAL		\$13,833,800			
Permitting & Legal	5%	\$691,690			
Services During Construction	8%	\$1,106,704			
TOTAL IMPLEMENTATION COST		\$15,632,200			
Engineering & Design	10%	\$1,563,220			
TOTAL CAPITAL COSTS		\$17,195,400			
				\$21,377,400	\$19,723,400

NA: NOT APPLICABLE

* Monitoring period of 30 years. Environmental sampling includes: surface water, leachate, sediment, and groundwater, all of which are sampled semi-annually.
 ** Present worth value of reviews based on current cost of \$15,000/review. Reviews at t=5 yr, 10 yr, 15 yr, 20 yr, 25 yr, and 30 yr.

TABLE D-5-A
 COST ESTIMATE SUMMARY
 ALTERNATIVE 6-A - MULTI-LAYER CAP AND SUBSURFACE BARRIER
 (With Grout Pillars)
 FULTZ LANDFILL SITE - FEASIBILITY STUDY REPORT

ITEM	Quantity	Capital Cost	Annual O & M	Present Worth O&M/Replacement	
				30 years, 5%	30 years, 10%
I. INSTITUTIONAL ACTIONS					
1. Deed Restrictions	NA	\$10,000			
2. Public Education Program	NA	\$20,000			
3. Institutional Controls	NA	\$20,000			
4. Alternate Water Supply	\$25	\$117,000			
Subtotal:		\$167,000			
II. GENERAL ACTIONS/SITE PREPARATION					
1. Site Fencing	10000 FT	\$160,000	\$8,000	\$123,000	\$75,000
2. Mobilization, Decon, Staging Area	NA	\$159,000			
Subtotal:		\$319,000	\$8,000	\$123,000	\$75,000
III. MULTI-LAYER CAP					
1. Multi-Layer Cap Installation	22 acres	\$5,771,000		\$332,000	\$173,000
2. Leachate Collection System	NA	\$402,000			
3. Grout Pillars	NA	\$900,000			
4. Leachate Disposal	NA		\$152,000	\$2,337,000	\$1,433,000
Subtotal:		\$7,073,000	\$152,000	\$2,669,000	\$1,606,000
IV. WATER CONTROL					
1. Subsurface Diversion Ditch	1600 FT	\$978,000			
2. Surface Water Diversion Ditch	1600 FT	\$10,000			
3. Pond Excavations	NA	\$420,000			
4. Erosion & Sediment Controls	NA	\$174,000			
5. Slurry Wall	76000 SF	\$760,000			
6. Wetlands Replacement	NA	\$200,000			
Subtotal:		\$2,342,000			
V. LONG-TERM MONITORING AND REVIEWS					
1. Monitoring Well Installation	5 wells	\$40,000	\$85,000	\$1,307,000	\$801,000
2. Environmental Sampling	6 Reviews **			\$83,000	\$46,000
3. 5 Year Reviews					
Subtotal:		\$40,000	\$85,000	\$1,390,000	\$847,000
CONSTRUCTION SUBTOTAL		\$9,941,000	\$245,000	\$4,182,000	\$2,528,000
Health and Safety	5%	\$497,050			
Bid Contingency	10%	\$994,100			
Scope Contingency	10%	\$994,100			
CONSTRUCTION TOTAL		\$12,426,300			
Permitting & Legal	5%	\$621,315			
Services During Construction	8%	\$994,104			
TOTAL IMPLEMENTATION COST		\$14,041,700			
Engineering & Design	10%	\$1,404,170			
TOTAL CAPITAL COSTS		\$15,445,900			
TOTAL PRESENT WORTH				\$19,627,900	\$17,973,900

NA: NOT APPLICABLE

** Monitoring period of 30 years. Environmental sampling includes: surface water, leachate, sediment, and groundwater, all of which are sampled semi-annually.
 Present worth value of reviews based on current cost of \$15,000/review.
 Reviews at t=5 yr, 10 yr, 15 yr, 20 yr, 25 yr, and 30 yr.