COPY

U.S. Army Environmental Center

# FORT DEVENS FEASIBILITY STUDY FOR GROUP 1A SITES

## FINAL FEASIBILITY STUDY

## SHEPLEY'S HILL LANDFILL OPERABLE UNIT DATA ITEM A009

CONTRACT DAAA15-91-D-0008
DELIVERY ORDER NUMBER 0004

U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MARYLAND

FEBRUARY 1995

PRINTED ON RECYCLED PAPER

# FORT DEVENS FEASIBILITY STUDY FOR GROUP 1A SITES

## FINAL FEASIBILITY STUDY
## SHEPLEY'S HILL LANDFILL OPERABLE UNIT
## DATA ITEM A009

CONTRACT DAAA15-91-D-0008
DELIVERY ORDER NUMBER 0004

*Prepared for*:

U.S. Army Environmental Center
Aberdeen Proving Ground, Maryland

*Prepared by*:

ABB Environmental Services, Inc.
Portland, Maine
Project No. 07005-08

FEBRUARY 1995

FORT DEVENS FEASIBILITY STUDY FOR GROUP 1A SITES
SHEPLEY'S HILL LANDFILL OPERABLE UNIT

## TABLE OF CONTENTS

**TABLE OF CONTENTS**
(continued)

**TABLE OF CONTENTS**
(continued)

**TABLE OF CONTENTS**
(continued)

**TABLE OF CONTENTS**
(continued)

**TABLE OF CONTENTS**
(continued)

## LIST OF FIGURES

## LIST OF FIGURES
(continued)

## LIST OF FIGURES
(continued)

## LIST OF TABLES

**LIST OF TABLES**
(continued)

**LIST OF TABLES**
(continued)

# EXECUTIVE SUMMARY

The U.S. Army Environmental Center directed ABB Environmental Services, Inc. (ABB-ES), under Contract No. DAAA15-91-D-0008, to conduct a Feasibility Study to evaluate alternatives to reduce potential human health and ecological risks associated with contaminated groundwater at the Shepley's Hill Landfill Operable Unit at Fort Devens, Massachusetts. The Shepley's Hill Landfill Operable Unit consists of the sanitary landfill incinerator, Area of Contamination (AOC) 4; sanitary landfill No. 1 or Shepley's Hill Landfill, AOC 5; and the asbestos cell, AOC 18. Both AOC 4 and 18 are located within the bounds of the Shepley's Hill Landfill.

Landfill operations at Shepley's Hill Landfill began at least as early as 1917 and stopped as of July 1, 1992. The landfill received household and military refuse, and during its last few years of use, operated using the modified trench method. From 1941 until the late 1940s ash from the sanitary landfill incinerator was buried in the landfill.

In an effort to mitigate the potential for off-site contaminant migration, Fort Devens initiated the Sanitary Landfill Closure Plan in 1984 in accordance with Massachusetts regulations. A four-phase installation of an 84-acre polyvinyl chloride (PVC) geomembrane cap began in 1986 and was completed in early 1993 (Figure ES-1).

The Remedial Investigation Addendum Report evaluated potential human health and ecological risks associated with exposure to contaminants in surface soil and groundwater at the landfill, and surface water, sediments, and fish in nearby Plow Shop Pond, which is interpreted to have received the discharge of landfill contaminated groundwater (ABB-ES, 1993b). Human health risks exceeded the U.S. Environmental Protection Agency (USEPA) points of departure (i.e., risk management guidelines corresponding to cancer risks exceeding $1x10^{-6}$ and noncancer hazard index (HI) values exceeding 1) for the following risk scenarios:

- Residential use of groundwater under future land-use conditions (there is no exposure under current land-use conditions). The primary contributors to risk were the inorganics arsenic, manganese, chromium, lead, nickel, aluminum, iron, and sodium, and the organics 1,2-dichloroethane and dichlorobenzenes.

- Consumption of fish from Plow Shop Pond.
- Direct contact with Plow Shop Pond sediment.

The ecological risk assessment identified potential risks to aquatic and semi-aquatic receptors in Plow Shop Pond. The primary contributors to ecological risk were arsenic, chromium, lead, manganese, and mercury.

Based on the results of the risk assessments, the following remedial action objectives were developed for groundwater at the Shepley's Hill Landfill Operable Unit:

- Prevent potential residential exposure to groundwater containing chemicals in excess of the following site-specific Preliminary Remediation Goals (PRGs): dichlorobenzenes (5 micrograms per liter [μg/L]), 1,2-dichloroethane (5 μg/L), aluminum (6,870 μg/L), arsenic (50 μg/L), chromium (100 μg/L), iron (9,100 μg/L), lead (15 μg/L), manganese (291 μg/L), nickel (100 μg/L), and sodium (20,000 μg/L).
- Prevent off-site migration of groundwater containing chemicals in excess of the above concentrations.
- Prevent contaminated landfill groundwater from contributing to arsenic contamination of Plow Shop Pond sediments in excess of health- and risk-based Applicable or Relevant and Appropriate Requirements (ARARs).
- Meet location-specific and action-specific ARARs.

Because of unresolved issues concerning Plow Shop Pond, the U.S. Army, USEPA, and the Massachusetts Department of Environmental Protection mutually agreed that remedial alternatives to reduce potential risks associated with exposure to contaminated fish and sediments in Plow Shop Pond will be evaluated in an FS for the Plow Shop Pond Operable Unit.

Ten candidate remedial alternatives were developed and screened, and five were evaluated in detail for their ability to meet the remedial action objectives. The matrix shown below presents the major components of each alternative.

| Remedial Action | Alternatives | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SHL-1 | SHL-2 | SHL-3 | SHL-4 | SHL-5 | SHL-6 | SHL-7 | SHL-8 | SHL-9 | SHL-10 |
| Groundwater Monitoring | | X | X | X | X | X | X | X | X | X |
| Institutional Controls | | X | X | X | X | X | X | X | X | X |
| Groundwater Containment | | | X | X | | | | | | |
| Groundwater Barrier | | | | | X | X | X | X | X | |
| Install a RCRA Cap | | | | | | | | | | X |
| In-situ Oxidation | | | | X | | | | X | | |
| Groundwater Extraction | | | X | | X | X | X | | X | |
| Ion-Exchange Treatment | | | X or | | X | | | | | |
| Chemical Precipitation Treatment | | | X | | | X | | | | |
| Constructed Wetland Treatment | | | | | | | X | | | |
| Discharge to Nonacoicus Brook | | | X | | X | X | X | | | |
| Discharge to POTW | | | | | | | | | X | |

The candidate alternatives rely heavily on groundwater containment and groundwater barriers in the form of slurry walls, grout curtains, and drains to control and redirect groundwater flow. Because of this, a groundwater model based on the U.S.

Geological Survey modeling code MODFLOW played a major role in the screening of alternatives. The groundwater model indicated that the existing landfill cap will cause a major shift in groundwater flow direction. According to the model, (contaminated) groundwater flow that used to discharge to the cove along the western shore of Plow Shop Pond will turn to the north and leave the site beneath the extreme northern tip of the landfill. Based on this modeling, there would be no benefit from installation of the proposed groundwater containment and barriers. Furthermore, comparison of modeled groundwater elevations under the landfill cap with the ground surface elevation prior to landfilling (i.e., the interpreted lower limit of landfill waste) indicates that waste materials are above the water table. Therefore, Alternative SHL-3 was screened out because its long slurry wall groundwater containment system offered no advantage over the shorter groundwater barrier of Alternatives SHL-5 or SHL-6. The model also indicated that hydrogen peroxide injected into the aquifer as part of the two alternatives, SHL-4 and SHL-8, employing in-situ oxidation, would not mix with groundwater. Alternatives SHL-4 and SHL-8 were screened out because of predicted difficulties with injection and mixing of the in-situ oxidant.

Alternative SHL-6 was screened out because preliminary vendor information indicated that its chemical precipitation treatment system offered no advantages over the ion-exchange of Alternative SHL-5. Alternative SHL-7 was screened out because of concerns about the effectiveness of its constructed wetland treatment system. To maintain a range of candidate alternatives for detailed evaluation, Alternatives SHL-5 and SHL-9 were retained, but were modified by elimination of their slurry wall groundwater barrier. Alternative SHL-10 was retained.

Five candidate alternatives remained after screening. Alternative SHL-1, the No Action alternative, takes no action to reduce potential risks associated with future residential exposure to groundwater. Under this alternative, the U.S. Army would not perform any further closure or post-closure activities. Available groundwater monitoring data indicate that groundwater leaving the site along predicted contaminated water flow paths meets numerical PRGs contained in the remedial action objectives.

Alternative SHL-2, Limited Action, reduces potential risk from potential residential exposure to groundwater by implementing institutional controls in the form of zoning and deed restrictions to limit residential development and residential well placement at the landfill. Because there is no current residential groundwater exposure, and because the landfill and bordering land are owned by the U.S. Army, there is unique potential for Alternative SHL-2 to be protective of human health. A long-term groundwater monitoring program will monitor downgradient groundwater quality at the site. Available groundwater monitoring data indicate that groundwater leaving the site along predicted contaminated water flow paths meets numerical PRGs contained in the remedial action objectives.

Alternative SHL-5, Collection/Ion Exchange Treatment/Surface Water Discharge, reduces potential risk from groundwater exposure by extracting contaminated groundwater, treating it at an ion exchange treatment facility to be constructed on site, and discharging treated groundwater to Nonacoicus Brook. There are two variants of this alternative, SHL-5A and SHL-5B, that differ only in the location of the proposed extraction well. Under SHL-5A the extraction well would be located at the northern tip of the landfill. Under SHL-5B the extraction well would be located between the landfill and Plow Shop Pond. This latter extraction location would be used if final groundwater flow paths did not conform to groundwater model predictions. Although available groundwater monitoring data indicate that extraction and treatment of groundwater from the north end of the landfill is not needed at this time, inclusion of Alternative SHL-5A provides flexibility in evaluating and selecting an appropriate remedial response. Successful implementation of this alternative would require obtaining a National Pollutant Discharge Elimination System (NPDES) permit for the discharge of treated groundwater to Nonacoicus Brook.

Alternative SHL-9, Collection/Discharge to POTW, is similar to the collection/treatment/discharge approach of Alternative SHL-5. Alternative SHL-9, however, proposes discharge of extracted groundwater to the Town of Ayer Publicly Owned Treatment Works (POTW) for treatment and discharge. Available groundwater monitoring data indicates that extracted groundwater should be able to be discharged to the POTW without pretreatment. Preliminary conversations with POTW representatives indicate that the facility has capacity available to accept the extracted groundwater. Implementation of this alternative would require negotiation of a long-term discharge agreement between the Town of Ayer and the U.S. Army. Similar to Alternative SHL-5, this alternative has two variants SHL-9A and SHL-9B.

Alternative SHL-10, Installation of RCRA Cap, proposes installation of a composite cap consisting of a geomembrane and underlying geosynthetic clay liner on top of the existing cover. Institutional controls and long-term groundwater and landfill gas monitoring programs similar to those prepared for SHL-2 would also be implemented.

There are no implementation costs associated with Alternative SHL-1. The estimated present worth of Alternative SHL-2 is $2,219,000. The estimated present worth of Alternatives SHL-5A and SHL-5B is $9,126,000. Alternatives SHL-9A and SHL-9B have a present worth of $3,874,000. Alternative SHL-10 has a present worth of $20,936,000.

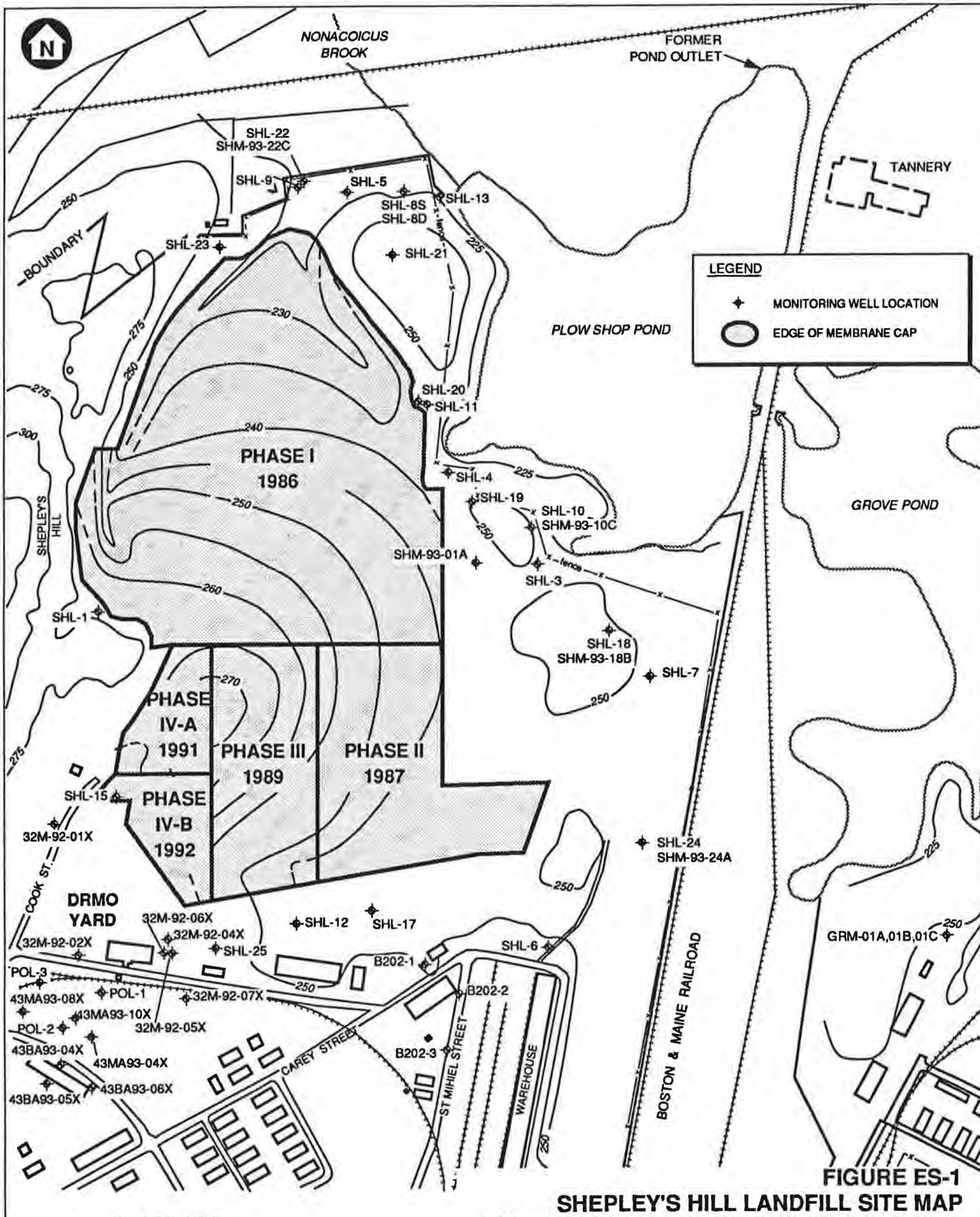



**FIGURE ES-1**
**SHEPLEY'S HILL LANDFILL SITE MAP**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403001D(G)1 34

# 1.0 INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES), prepared this Feasibility Study (FS) Report for the Shepley's Hill Landfill Operable Unit as part of the FS effort for Group 1A sites at Fort Devens, Massachusetts. This work was conducted in accordance with the U.S. Army Environmental Center (formerly U.S. Army Toxic and Hazardous Materials Agency) Contract DAAA15-91-D-0008, Delivery Order 0004. The Group 1A sites were identified for investigation in the Fort Devens Master Environmental Plan, and are subject to a Federal Facility Agreement (Interagency Agreement [IAG]) between the U.S. Department of the Army and the U.S. Environmental Protection Agency (USEPA) (USEPA, 1991c). Fort Devens was placed on the National Priorities List (NPL), effective December 21, 1989. This FS was prepared in accordance with USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988b).

The Group 1A sites consist of the sanitary landfill incinerator, Area of Contamination (AOC) 4; sanitary landfill No. 1 or Shepley's Hill Landfill, AOC 5; the asbestos cell, AOC 18; and Cold Spring Brook Landfill, AOC 40. AOCs 5 and 18 are located within the capped area at Shepley's Hill Landfill. The three AOCs are collectively referred to as Shepley's Hill Landfill in this FS report and are included in the Shepley's Hill Landfill Operable Unit. Figure 1-1 shows a Site Location Map for the Group 1A sites.

Fort Devens was identified for closure by the Base Realignment and Closure Act of 1991, and will cease to be an active Army installation on September 30, 1995. Although a small military presence will remain, a major portion of the post will be released for development.

The Administrative Record, which contains documents relating to the Group 1A sites, is available for public review at the Fort Devens Base Realignment and Closure Office and at the Ayer Town Hall.

## 1.1 Purpose and Organization of Report

The purpose of this FS Report for Shepley's Hill Landfill Operable Unit (AOCs 4, 5, and 18) within the Group 1A sites at Fort Devens, Massachusetts is to:

- establish response objectives, as appropriate, based on actual or potential risks to human health or the environment;
- identify the types of response actions necessary to accomplish response objectives;
- identify and screen specific remedial technologies that may be capable of attaining response objectives;
- develop and evaluate a range of remedial alternatives based on those technologies; and
- compare the alternatives in accordance with evaluation criteria recommended by USEPA.

It is based on information and data presented in the Remedial Investigation (RI) Report prepared by Ecology and Environment, Inc. (E&E, 1993) and the RI Addendum Report prepared by ABB-ES (ABB-ES, 1993b). This report also presents updated information from the Regulatory Draft Preliminary Remedial Technology Screening document (ABB-ES, 1992) and the Draft Alternatives Screening Report (ABB-ES, 1993a). Figure 1-2 is a schematic of the FS process. Alternatives to remediate sediment contamination in the Plow Shop Pond Operable Unit and Cold Spring Brook Landfill Operable Unit will be evaluated in separate documents.

This FS Report consists of six sections. Section 1 provides a brief description and history of the Shepley's Hill Landfill Operable Unit. In addition, it summarizes the nature and extent of contamination and the baseline risk assessment presented in the RI Addendum Report (ABB-ES, 1993b).

Section 2 discusses chemical-specific, location-specific, and action-specific Applicable or Relevant and Appropriate Requirements (ARARs) and their role in site remediation. Section 3 identifies remedial action objectives and identifies and screens potential remedial technologies.

Section 4 develops and screens potential remedial alternatives for the Shepley's Hill Landfill Operable Unit.

Section 5 contains the detailed analysis of alternatives and Section 6 contains the Comparative Analysis of Remedial Alternatives.

## 1.2 SITE DESCRIPTION AND HISTORY

The Shepley's Hill Landfill Operable Unit includes three AOCs: AOC 4, the sanitary landfill incinerator; AOC 5, sanitary landfill No. 1 or Shepley's Hill Landfill; and AOC 18, the asbestos cell. The sanitary landfill incinerator was located in former Building 38 near Cook Street within the area included in Phase 1 of the sanitary landfill closure. The incinerator was constructed in 1941. It burned household refuse and operated until the late 1940s. Ash from the incinerator was buried in the landfill. The incinerator was demolished and buried in the landfill in September 1967. The building foundation was removed and buried on site in 1976.

### 1.2.1 Surficial Geology

Shepley's Hill Landfill lies within the Ayer topographic quadrangle. The surficial geology of the Ayer quadrangle was mapped in 1941 by Jahns (Jahns, 1953). The soils in and around Shepley's Hill Landfill are predominantly unconsolidated, poorly graded fine to medium sands with gravel, cobbles and a silt content ranging between 1 and 15 percent. Soils in the landfill area are part of the Hinckley-Merrimack-Windsor Association and are associated with deposition in glacial Lake Nashua, which formed against the terminus of the Wisconsinan ice sheet. Depositional features include a kame terrace, a glacially deposited hill of stratified sands and gravels, with an elevation of 250 feet above sea level (ASL) located in the northeast corner of the landfill, and prominent cross beds in an exposed channel fill feature 100 feet west of well SHL-7. The uppermost portion of the unconsolidated deposits consists of fine aeolian deposited sand. Palustrine sediments, such as peat, are probably located below fill material in the central and north-central sections of the landfill between Shepley's Hill and the kame plateau.

Maps indicate that these areas were swamps prior to landfilling operations and may have been the result of a small kettle lake. Dense silt, 1 to 10 feet thick, was encountered at the overburden bedrock interface in borings SHL-1, SHL-4, SHL-16, SHL-25 (E&E, 1993), and SHM-93-01A. This silt may represent a till, and contained gravel-to cobble-size pieces of slightly weathered gneiss and phyllite. The unconsolidated overburden reaches a maximum observed thickness of 115 feet at both the northern and southern portions of the landfill. Across the central portion of the landfill the overburden thickness is estimated to range from 25 to 50 feet, dependent on landforms. The overburden over the entire landfill has the general trend of thinning to the west where it abuts the Shepley's Hill outcrop.

### 1.2.2 Bedrock Geology

The surficial soils at Shepley's Hill Landfill are underlain by low-grade phyllitic metasiltstones and biotite-rich gneiss. The metasiltstone is calcareous, with secondary quartz and sulfides along bedding planes and fractures. Extensive folding, banding, and foliation is also evident. The metasiltstones are only slightly weathered with small (0.1 to 0.5 inch) solution cavities. The bedrock core obtained from SHM-93-10C was moderately fractured in the uppermost 10 feet and became increasingly competent with depth. The fractures occurred chiefly along bedding planes, although some fractures were nearly perpendicular in bedding. The foliation was observed to be dipping at 45 to 50 degrees, but was nearly vertical in areas. The following boreholes encountered metasiltstone: SHL-10, SHL-24 (E&E, 1993), SHM-93-10C, and SHM-93-22C. The bedrock core from SHM-93-22C indicates that bedrock at this location is a low-grade gneiss. The metasiltstones below Shepley's Hill Landfill belong to the Silurian Berwick Formation.

The gneiss, which appears from outcrops to be nonintrusive, is characterized by its high biotite content, gneissic foliation, and elongated feldspathic porphyroblasts. The following boreholes encountered varying metamorphic grades of gneiss: SHL-1, SHL-2, SHL-3, SHL-4, SHL-5, SHL-8, SHL-11, SHL-14, SHL-20, and SHL-22 (E&E, 1993). The gneiss, which is associated with the Devens-Long Pond facies of the Ayer Granite (Upper Ordovician and Lower Silurian) is only slightly weathered. The gneiss directly underlies unconsolidated materials beneath most of the landfill outcropping to the west at Shepley's Hill and to the southwest near the Defense Reutilization and Marketing Office (DRMO) yard and adjacent to the Petroleum Oil and Lubricants (POL) yard. The 20 feet of gneiss core obtained from SHM-93-22C contained only three natural fractures, all within the uppermost 10 feet. Secondary quartz and quartzite occur throughout the rock along healed fractures. Both open and healed fractures were observed to be dipping at approximately 50 degrees. The Berwick Formation metasiltstone occurs only in the southeast corner of the landfill.

As interpreted in the RI Addendum Report, it appears that a bedrock ridge extends from SHL-1 eastward below Plow Shop Pond (ABB-ES, 1993b). The evidence supporting the existence of the ridge includes the bedrock elevation of 215.7 feet ASL at monitoring well SHM-93-01A. This is 5 feet higher than the bedrock elevation at well SHM-93-10C which is 250 feet to the northeast. This change in elevation would be consistent with the presence of a ridge aligned east-northeastward from Shepley's Hill to below Plow Shop Pond. The results of the seismic survey indicated a bedrock high between wells SHL-3 and SHL-11, with bedrock elevations rising above 200 feet ASL. The seismic survey data may be explained by a local, closed bedrock high not just the presence of a ridge. Exposed bedrock topography also supports the existence of a ridge; the gneiss that comprises Shepley's Hill juts out to the east near SHL-1 along the line of the axis of the inferred ridge. Furthermore, the prelandfill ground surface contours and the presence of a generally coincident topographic high with a superimposed shallow swampy depression suggests a shallow bedrock substrate.

The bedrock topography along the southern boundary of the landfill is characterized by a series of hills and valleys that appear to trend roughly north-south.

Bedrock along the northern end of the landfill is characterized by a deep valley increasing in depth toward Nonacoicus Brook.

### 1.2.3 Groundwater Hydrology

Groundwater present in the overburden represents the primary aquifer in the Shepley's Hill Landfill area. Groundwater also occurs in the underlying bedrock; however, there is little or no primary effective porosity. Groundwater flow can occur along bedrock fractures and solution cavities.

Groundwater in the area flows primarily from the west-southwest to the east and north (Figure 1-3). Discharge areas for groundwater around the landfill include Plow Shop Pond and the wetland north of West Main Street in Ayer. The presence of the dam in the northwest corner of Plow Shop Pond has raised the pond surface elevation in this area above the groundwater elevation, thereby locally reversing the gradient and causing water to discharge from Plow Shop Pond. The point where the gradient reverses varies seasonally depending on pond and groundwater elevation. Groundwater modeling discussed in Section 4 indicates that this transition occurs in the vicinity of well SHM-93-01A. Groundwater to the north of this point flows north, while groundwater to the south discharges to Plow Shop Pond.

Measured groundwater elevations indicate a groundwater divide exists to the southwest of the landfill below the DRMO yard. The divide occurs along a northwest-southeast trending line between monitoring well 32M-92-07X and Shepley's Hill. Groundwater to the northeast of this divide flows eastward and northeastward under the southern portion of the landfill, while groundwater to the southwest of the divide flows to the southwest away from the landfill. The overburden aquifer appears to be recharged at least in part, by groundwater discharging from the bedrock along the western border of the landfill. The relationship between the bedrock aquifer and the overburden aquifer in the center of the cap is unknown; however, it is possible that the bedrock aquifer may also discharge to the overburden in this area. Vertical hydraulic gradients between the bedrock aquifer and the overburden show an upward gradient of 0.05 feet per foot (ft/ft) between SHM-93-10C and SHL-10 and 0.026 ft/ft between SHL-24 and SHM-93-24A. An upward gradient of 0.004 ft/ft exists between the deep overburden well SHM-93-18B and the water table well SHL-18. A downward gradient of 0.13 ft/ft appears to occur in the northern section of the landfill between the bedrock well SHM-93-22C and the water table well SHL-22. No measurable vertical gradient occurs between SHL-8S and SHL-8D in the northeast corner of the landfill.

Upward vertical gradients are observed along the southeastern and eastern perimeters of Shepley's Hill Landfill as would be expected as groundwater discharges to Plow Shop Pond. A downward gradient and lack of vertical gradient are observed in the northern and northeastern portions of the landfill. This is consistent with Plow Shop Pond discharging to the overburden aquifer because of the presence of the dam. The groundwater ultimately discharges to the wetland north of West Main Street and to the Nashua River.

The landfill cap covers approximately 84 acres (Biang et al., 1992). The cap has reduced or eliminated infiltration from precipitation, and lowered the water table beneath it. The result of lowering the water table has been to impart a more northerly component of flow in the southern section of the landfill, as shown in Figure 1-3.

Permeability testing of Shepley's Hill Landfill monitoring wells produced hydraulic conductivity estimates ranging from $2x10^{-2}$ centimeters per second (cm/sec) to $5x10^{-4}$ cm/sec for the unconfined overburden aquifer and $3x10^{-5}$ cm/sec to $5x10^{-7}$ cm/sec for the bedrock aquifer (ABB-ES, 1993b).

### 1.2.4 Shepley's Hill Landfill History

Shepley's Hill Landfill encompasses approximately 84 acres in the northeast corner of the Main Post at Fort Devens. It is situated between the bedrock outcrop of Shepley's Hill on the west and Plow Shop Pond on the east (Figure 1-4). Nonacoicus Brook, which drains Plow Shop Pond, flows through a wooded wetland at the north end of the landfill. The southern end of the landfill borders the DRMO yard and a warehouse area. An area east of the landfill and south of Plow Shop Pond is the site of a former railroad roundhouse.

Review of the surficial geology map of the Ayer Quadrangle (Jahns, 1953) shows that in the early 1940s the active portion of the landfill consisted of approximately 5 acres near the end of Cook Street, near where monitoring well SHL-1 is located. The fill was elongated north-south along a preexisting small valley marked by at least two swamps (probably kettle holes) and lying between the bedrock outcrop of Shepley's Hill to the west and a flat-topped kame terrace to the east with an elevation of approximately 250 feet, adjacent to Plow Shop Pond (E&E, 1993). During the landfilling operation, the valley was obliterated, as was much of the kame terrace, which may have been used as cover material. Background information indicates the landfill formerly operated as an open burning site.

Landfill operations at Shepley's Hill Landfill began at least as early as 1917 and stopped as of July 1, 1992. During its last few years of use, the landfill received about 6,500 tons per year of household refuse, military refuse, and construction debris, and operated using the modified trench method (Biang, 1992). There is evidence that trenches in the northwest portion cut into previously used areas containing glass and spent shell casings. The glass dated from the mid-nineteenth century to as late as the 1920s. The approximate elevation of the bottom of the waste is estimated at 220 feet ASL at the north end of the landfill, and 225 feet ASL in the central and northeast portions of the landfill, based on pre-landfill surface contours. The maximum depth of the refuse is about 30 feet (DEH, 1985). The average thickness of waste is not documented; however, if the average thickness were 10 feet, the landfill volume would be over 1,300,000 cubic yards. Reports of flammable fluid disposal in the southeast portion of the landfill have not been substantiated by test pits or other research (Biang, 1992). The Army has no evidence that hazardous materials were disposed of in the landfill after November 19, 1980. No waste hot spots or hazardous waste disposal areas were identified during RI or supplemental RI activities (E&E, 1993, ABB-ES, 1993b).

In an effort to mitigate the potential for off-site contaminant migration, Fort Devens initiated the Fort Devens Sanitary Landfill Closure Plan in 1984, in accordance with Massachusetts regulations 310 CMR 19.000. The plan, written by Gale Engineering, was approved by the Massachusetts Department of Environmental Protection (MADEP) in 1985. The closure approval was consistent with 310 CMR 19.00 and contained the following requirements:

- grading the landfill surface to a minimum 2 percent slope in non-operational areas of the landfill and 3 percent in operational areas
- removing waste from selected areas within 100 feet of the 100-year floodplain
- installing a gas venting system
- installing an impermeable cap and covering the cap with sand, gravel, and loam, and seeding to provide cover vegetation and prevent erosion
- implementing a groundwater monitoring program based on sampling five existing monitoring wells every four months

The capping was completed in four phases in accordance with the plan (see Figure 1-4). In Phase I, 50 acres were capped in October 1986; in Phase II, 15 acres were capped in November 1987; and in Phase III, 9.2 acres were capped in March 1989. Phase IV closure of the last 10 acres was accomplished in two steps: Phase IV-A was closed in 1991, and Phase IV-B was closed as of July 1, 1992, although the geomembrane cap was not installed over Phase IV-B until May 1993.

Because of the large area and shallow surface slope of the existing landfill, early phases of the landfill closure were completed with a 2 or 3 percent slope. Slopes were increased to 5 percent in Phase IV-B. Phases I through IV-A were capped with a 30-mil polyvinyl chloride (PVC) geomembrane overlain with a 12-inch drainage layer and 6-inch topsoil layer. At the request of MADEP, the Phase IV-B cap design was modified to a 40-mil PVC geomembrane, a 6-inch drainage layer, and a 12-inch topsoil layer. A landfill gas collection system consisting of 3-inch gas-collection pipes bedded in a minimum 6-inch layer of $1x10^{-3}$ material was installed beneath the PVC geomembrane in all closure phases. Gas vents were installed through the PVC geomembrane at 400-foot centers. A minimum 6-inch cushion/protection layer was maintained beneath the geomembrane. As requested by USEPA and MADEP, four additional groundwater monitoring wells were installed in 1986 to supplement the five in the original groundwater monitoring program.

AOC 4, the sanitary landfill incinerator was located in former Building 38 near the end of Cook Street within the area included in Phase I of the sanitary landfill closure. The incinerator was constructed in 1941, and burned household refuse and operated until the late 1940s. Ash from the incinerator was buried in the landfill. The incinerator was demolished and buried in the landfill in September 1967. The building foundation was removed and buried on-site in 1976.

AOC 18, the asbestos cell, is located in the section of the landfill closed during Phase IV. An estimated 6.6 tons of asbestos construction debris were placed in the section closed during Phase IV-A between March 1982 and November 1985. A new asbestos cell was opened in 1990 in the section closed during Phase IV-B, and was used for disposal of small volumes of asbestos-containing material until July 1992.

### 1.2.5 Adjacent Areas

Plow Shop Pond is a shallow, 30-acre pond outside the installation boundary, northeast of the landfill. It is the furthest downstream of a chain of six ponds (Long Pond, Sandy Pond, Flannagan Pond, Balch Pond, Grove Pond, and Plow Shop Pond) in the Town of Ayer, and is downstream of Bare Hill Pond, Bowers Brook and Cold Spring Brook in the Town of Harvard. It receives drainage from approximately 17.7 square miles in the towns of Groton, Ayer, and Harvard. Based on comparison to the Nashua River at East Pepperell, the seven-day 10-year (7Q10) low flow in Nonacoicus Brook is approximately 2.6 cubic feet per second.

The eastern shore of Plow Shop Pond is formed by a railroad causeway constructed in the 1800s. A stone arch culvert under the causeway connects the pond with Grove Pond. Water elevation in Plow Shop Pond is controlled at approximately 216 feet ASL by a dam located at the northwest corner of the pond. The central portion of the pond is approximately eight feet deep. A maximum water depth of about 10 feet occurs in the northeast arm of the pond. The discharge from the dam forms Nonacoicus Brook, which flows about 1 mile northwest before its confluence with the Nashua River.

At one time, Plow Shop Pond discharged through a canal, now blocked, at a sawmill at the northeast corner of the pond near the present location of the G.V. Moore Lumber Co. During periods of relatively low stream flow, the Plow Shop Pond dam also controls the water elevation in Grove Pond. However, during periods of high stream flow, the culvert under the railroad causeway restricts flow to Plow Shop Pond, and the elevation of Grove Pond may be 2 feet or more above that of Plow Shop Pond.

The area south of Plow Shop Pond and east of Shepley's Hill Landfill was the site of a railroad roundhouse operated by the Boston and Maine Railroad between 1900 and 1935. Figure 1-5 shows the approximate extent of the former railroad facilities as indicated on a 1934 railroad drawing (B&MRR, 1934), as well as elevation contours at the landfill prior to landfilling. The property formerly occupied by the roundhouse facilities is now owned by the Army. Guilford Transportation Industries operates an extensive, active railyard adjacent to the former roundhouse facilities.

From 1854 through 1961, the area east of the railroad causeway at the northwest corner of Grove Pond was the site of a tannery (Wilson, 1961a,b). The tannery changed ownership several times and operated intermittently between 1900 and 1944. From December 1944, until destroyed by fire in June 1961, this was a successful cattlehide tannery with facilities that included a beam-house for hide unhairing and a tan-house for chrome-tanning.

The tannery is of interest because of its waste disposal practices and its potential as a source of contaminants, especially arsenic, chromium, lead, and mercury, to Grove and Plow Shop ponds. Before 1953, process wastewater from the tannery was discharged to Grove Pond with little or no treatment (Fay, 1993; Taylor, 1953; Power, 1957). In addition, a dump was located on tannery property between the tannery and Grove Pond (Fay, 1993; Fillibrown, 1993; Naparstek, 1993). The dump's specific location is suggested by the gradual filling-in of an embayment in Grove Pond as discernable in aerial photographs taken in 1943, 1952, and 1965 (Detrick, 1991, Figures 14, 15, and 16). As early as 1944, the Town of Ayer and the Commonwealth were concerned about contamination of Grove Pond by the tannery, and in 1949 the town began the process of borrowing funds to connect the tannery to the local wastewater treatment plant (Town of Ayer, 1950; Wilson, 1961a,b); the connection was completed on April 17, 1953 (Taylor, 1953).

Four wetland vegetative cover types were identified within the vicinity of Shepley's Hill Landfill. The wetland cover types and the areas they occupy are identified in Figure 1-6. These areas were identified during the RI by completion of New England Division Army Corps of Engineers Wetland Delineation Data Forms (E&E, 1993). Each wetland cover type meets the three criteria (i.e., hydrophytic vegetation, hydric soils, and wetland hydrology) necessary to be classified as jurisdictional wetland. The 222-feet contour shown in Figure 1-6 defines the edge of the 100 year floodplain. Except for the areas north of the landfill, the floodplain occupies approximately the same area as the delineated wetlands.

## 1.3 NATURE AND EXTENT OF CONTAMINATION

The RI and supplemental RI at the Group 1A sites assessed environmental contamination in the following media at Shepley's Hill Landfill:

| MEDIUM | INTERPRETED CONTAMINANT CLASSES |
|---|---|
| Source Area Soils | None |
| Source Area Groundwater | Volatile Organic Compounds (VOCs), Inorganics |
| Plow Shop Pond Sediments | Semivolatile Organic Compounds (SVOCs), Pesticides, Inorganics |
| Plow Shop Pond Surface Water | VOCs, Inorganics |

Sources: E&E, 1993; ABB-ES, 1993b

Soils. Three surface soil samples were collected from suspected seep areas in 1991 during the RI and analyzed for Target Compound List (TCL) organics, Target Analyte List (TAL) metals, and total organic carbon (TOC). Low concentrations of acetone and methylene chloride were reported in the samples; however, they were attributed to laboratory contamination. No other organics were detected. Concentrations of TAL metals were within the estimated background range, except for calcium, which was elevated slightly. This was not considered significant (E&E, 1993). Because soil contamination was not identified during the RI, soils were not sampled during the supplemental RI in 1992.

Groundwater. Groundwater quality was assessed through two rounds of sampling at 22 wells during the RI, and one confirming round at 27 wells plus a second round at five new wells during the supplemental RI. Target analyte groups for the two field programs are listed below.

| | FIELD PROGRAM | |
|---|---|---|
| ANALYTE GROUPS | RI | SUPPLEMENTAL RI |
| VOCs | X | X |
| SVOCs | X | |
| Pesticides and polychlorinated biphenyls (PCBs) | X | X |
| Explosives | X | X |
| Total Inorganics | X | X |
| Dissolved Inorganics | | X |
| Anions | X | |

Sources: E&E, 1993; ABB-ES, 1993b

The RI Report concluded that groundwater downgradient of the landfill was contaminated with VOCs and inorganics as well as low concentrations of explosives, pesticides, and PCBs in scattered wells. The presence of pesticides was not certain, however, because of apparent laboratory contamination of several method blanks. The PCB Aroclor-1260 was found at a low concentration in only one sample in one sampling round. The SVOC di-ethylphthalate was reported at 12 and 32 micrograms per liter ($\mu$g/L) in samples from two separate wells and was considered a sampling artifact (E&E, 1993).

The RI Addendum Report identified three groups of monitoring wells: a southern cross-gradient group, a downgradient group, and a northern cross-gradient group (Table 1-1). Mild exceedances of background concentrations for inorganics were noted in the cross-gradient wells, indicating that sources other than Shepley's Hill Landfill may have degraded groundwater quality in the area.

Downgradient wells exhibited contamination with several VOCs and inorganics. Groundwater analytes exceeding background concentrations are listed in Table 1-2. Organic compounds were reported most frequently and at the highest concentrations in wells SHL-10, SHL-11, SHL-20, and SHM-93-10C along the eastern edge of the landfill. Inorganics were also reported at the highest concentrations in these wells, especially SHL-10, SHL-11, and SHL-20. Of particular interest is the influence of total suspended solids (TSS) on inorganic concentrations. Review of analytical results in the RI Addendum Report shows that a significant portion of the total concentration of inorganics is typically associated with suspended material. However, in wells SHL-11, SHL-19, and SHL-20, high dissolved arsenic concentrations were associated with low oxidation potential (Eh) and/or high pH, indicating that these conditions may have mobilized the arsenic. Table 1-3 provides average and maximum concentrations of VOCs and inorganics in downgradient wells at Shepley's Hill Landfill.

No pesticides or PCBs were reported in the supplemental groundwater samples. This supports the RI Addendum Report reinterpretation of groundwater data presented in the final RI report. Although pesticides were reported at low concentrations in several RI samples, no well had a hit in both RI sampling rounds. In addition, Subsection 5.1.6.3 of the final RI report states that several pesticides including heptachlor, endrin, alpha- and beta-benzenehexachloride (BHC), 2,2-bis(para-chlorophenyl)-1,1,1-trichloroethane (DDT), and endosulfan sulfate were detected in method blank samples and that low concentrations of those compounds should be considered laboratory contamination. Analytical difficulties were noted for PCBs. Subsection 5.2.6.3 of the final RI report also indicates difficulties with the pesticides analysis. These considerations and the supplemental RI data support the conclusion that the landfill is not a source of pesticides or PCBs in groundwater.

The explosive nitroglycerine was reported in one monitoring well, the water table well SHM-93-24A, at 80.8 $\mu g/L$. This well is considered cross-gradient of the landfill and the source of the nitroglycerine is not known. The landfill is not considered a source of nitroglycerine. The explosives 1,3,5-trinitrobenzene, 1,3-dinitrobenzene and tetryl were reported inconsistently and at low concentrations in RI samples, they were not detected in the supplemental RI samples. SVOCs were not identified as groundwater contaminants in the RI report or targeted as analytes during the supplemental field program. They are not considered groundwater contaminants at Shepley's Hill Landfill.

Plow Shop Pond Sediments. Plow Shop Pond is believed to have been an historical discharge area for groundwater passing beneath Shepley's Hill Landfill and to have received contamination from the landfill. The characterization of Plow Shop Pond sediments was accomplished during both the RI and supplemental RI. RI sampling involved collection and analysis of shallow (0 to 6-inch depth) samples for TCL organics, TAL metals, and TOC. The RI Report concluded that pond sediments were contaminated with high concentrations of TAL metals and low concentrations of several polynuclear aromatic hydrocarbons (PAHs). The VOCs acetone, methylene chloride, and 2-butanone were reported in several samples, as were low concentrations of 2,2-bis(para-chlorophenyl)-1,1-dichloroethene (DDE) and heptachlor (E&E, 1993). The presence of acetone, methylene chloride, and heptachlor is attributed to laboratory contamination.

During the supplemental RI, sediment samples (0 to 1-foot depth) were collected at 28 locations and analyzed for Project Analyte List (PAL) pesticides, PCBs, and inorganics. The RI Addendum Report concluded that sediments were contaminated with arsenic, barium, copper, chromium, iron, lead, manganese, mercury, nickel, and zinc. Based on manufacturing process chemicals, waste disposal practices, and chemical distribution patterns in Grove and Plow Shop Ponds, the tannery located on Grove Pond was identified as the major source of arsenic, chromium, lead, and mercury. Shepley's Hill Landfill was identified as a primary source of barium, iron, manganese, and nickel and a secondary source of arsenic, chromium, and lead. Additional data are needed to define the source of copper. The supplemental sampling confirmed the presence of 2,2-bis(para-chlorophenyl)-1,1-dichloroethane (DDD), DDE, and DDT at low concentrations in pond sediments. The chemicals exceeding Ontario Ministry of the Environment sediment guidelines (Persaud, 1992) are listed in Table 1-2. The RI Addendum Report did not identify the landfill as a source of the pesticides. Potential remedial actions for Plow Shop Pond sediment contamination will be evaluated in a separate FS for the Plow Shop Pond Operable Unit.

Surface Water. During the RI, samples were collected from 13 locations along the Plow Shop Pond shoreline to characterize surface water quality. Target analytes included TCL organics and TAL metals. The VOCs chloroform and methylene chloride were reported in several samples, and the pesticide endrin detection was reported at a low concentration in one sample. Methylene chloride was considered a laboratory contaminant and the endrin detection was not considered significant in the RI Report. The presence of chloroform, considered an improbable surface water contaminant in the RI Report, could not be explained. The inorganics copper, silver, and zinc exceeded Ambient Water Quality Criteria (AWQC) for the protection of aquatic life throughout the pond, and iron and zinc exceeded AWQC in the wetlands area north of the pond (E&E, 1993) (see Table 1-2).

Nonacoicus Brook Wetland. Two surface water/sediment pair samples were collected from Nonacoicus Brook and the wetland area immediately north of the Shepley's Hill Landfill during the RI and analyzed for TCL organics, TAL inorganics, and general analytical parameters (E&E, 1993). In surface water the only reported organics were alpha-benzenehexachloride and methylene chloride; however, the alpha-benezenehexachloride was not confirmed and the methylene chloride was attributed to laboratory contamination. The RI report concluded that concentrations of TAL inorganics in the two samples were generally similar to average concentrations in Plow Shop Pond surface water, although concentrations of barium, iron, and manganese were somewhat greater. The only organic compound reported in the two sediment samples was methylene chloride and it was attributed to laboratory contamination (E&E, 1993). The RI report did not note unusual or high concentrations of TAL inorganics in the two sediment samples.

During supplemental RI activities, surface soil and shallow groundwater samples were collected from four shallow, hand-dug pits in the area immediately north of the landfill (ABB-ES, 1993b). All the samples were analyzed for PAL VOCs, pesticides, PCBs, explosives, and inorganics as well as several general analytical parameters. No PAL organics were reported in the water samples. Concentrations of 14 inorganics in unfiltered groundwater samples exceeded background concentrations; however, the RI Addendum Report concluded that the high concentrations resulted from high TSS concentrations in the samples and that the dissolved contaminant load was low. Barium, calcium, potassium, manganese, lead, and zinc were considered contaminants in shallow groundwater.

No PAL VOCs, PCBs, or explosives were reported in the soil samples. Low concentrations of the pesticides DDE and DDT were reported in two of the total of eight soil samples. A total of 20 PAL inorganics were detected in the soil samples, and concentrations of 16 exceeded background concentrations at least once. After consideration of detection frequency and reported concentration, chromium, mercury, beryllium, silver, copper, and zinc were considered contaminants in the soil samples. Concentrations of chromium and mercury were highest in the samples collected near Nonacoicus Brook and their presence was attributed to historical brook overflows. The influence of Shepley's Hill Landfill on inorganic concentrations in soil was not clear. The RI Addendum Report concluded that the sampled area was not a major discharge area for contaminated groundwater (ABB-ES, 1993b).

## 1.4 Summary of Human Health Risk Assessment

A supplemental risk assessment was performed for Shepley's Hill Landfill in the RI Addendum Report (ABB-ES, 1993b) to update the RI Risk Assessment completed in April 1993 (E&E, 1993). Figures 1-7 through 1-10 present risk estimates produced in the Supplemental Risk Assessment relative to USEPA risk management guidelines corresponding to cancer risks exceeding $1x10^{-6}$ and noncancer Hazard Index (HI) values exceeding 1. The risk estimates shown in Figures 1-9 and 1-10 for residential groundwater use are updated from those contained in the Supplemental Risk Assessment (ABB-ES, 1993b). The spreadsheets included in Appendix K of the Final RI Addendum Report erroneously contained a factor for shower exposure time (ET). Figures 1-9 and 1-10 show risk estimates that do not include the factor ET.

Actual fish tissue analyses obtained through the October 1992 fish sampling program measured Chemical of Potential Concern (COPC) levels in fish. (The RI Risk Assessment estimated concentrations of COPCs in fish tissue by multiplying measured sediment concentrations by bioaccumulation factors.) The health risks faced by a recreational fisherman or family member who consumes fish from Plow Shop Pond ranged from $3x10^{-6}$ to $4x10^{-4}$. Arsenic in the fish accounts for approximately 96 to 99 percent of the total risk. Mercury, a COPC not considered to be landfill-related, presented noncancer risks above the regulatory guideline of one (hazard quotients [HQs] range from 2 to 7). Detected concentrations of mercury in the bullhead and bass fillets in Plow Shop Pond also exceeded the U.S. Food and Drug Administration (USFDA) action level for mercury of 1 part per million (ppm). One additional COPC not related to the landfill, DDE, presented a cancer risk of $2x10^{-6}$, which represents only 0.4 to 4 percent of the total risk.

While the risk estimates associated with arsenic in Plow Shop Pond fish do exceed the USEPA points of departure, the risk estimates are thought to overestimate the true risks. Arsenic in fish exists largely as organic forms that possess minimal inherent toxicity and are believed to possess no mutagenic or carcinogenic potential. For the risk calculations of the RI Addendum Report, all of the arsenic in Plow Shop Pond fish was assumed to be inorganic; the analytical methods for inorganics used in the Supplemental RI did not distinguish between the organic and inorganic forms of a metal. Furthermore, the cancer slope factor for inorganic arsenic is thought by many to overestimate the true risk. The USEPA Integrated Risk Information System (IRIS) file (December 1993) on inorganic arsenic states that "the uncertainties associated with ingested arsenic are such that estimates could be modified downwards as much as an order of magnitude, relative to risk estimates associated with most other carcinogens." If a modifying factor of 10 were applied to the unmodified risk estimates for the fish ingestion pathway, modified cancer risk estimates would range from $3x10^{-7}$ to $4x10^{-5}$ -- risks within or below the Superfund target risk range of $1x10^{-6}$ to $1x10^{-4}$. Because the true risks associated with arsenic in Plow Shop Pond are thought to be significantly lower than initially calculated, it appears that the major health risk associated with Plow Shop Pond fish is due to mercury contamination.

In the Supplemental Risk Assessment, ingestion of and direct contact with sediment presented average and Reasonable Maximum Exposure (RME) cancer risks (unmodified to account for the uncertainty associated with arsenic) ranging from $2x10^{-5}$ to $2x10^{-4}$, respectively, under current land use, and $9x10^{-5}$ to $6x10^{-4}$, respectively, under future land use. Arsenic is responsible for essentially 100 percent of the risk. These risks are above the USEPA point of departure of $1x10^{-6}$ but, under average exposure conditions, within the Superfund target risk range of $1x10^{-6}$ to $1x10^{-4}$. Only under RME conditions does the cancer risk exceed the upper end of the target risk range (at $2x10^{-4}$ and $6x10^{-4}$). If the modifying factor of 10 were applied to the cancer risk estimates for arsenic, cancer risk estimates would range from $2x10^{-6}$ to $2x10^{-5}$ (under current land use) and $9x10^{-6}$ to $6x10^{-5}$ (under future land use); these risks are within the Superfund target risk range.

Cadmium was reported in the RI Risk Assessment to present an assumed health risk of potential concern in Plow Shop Pond fish. However, cadmium was not detected in the bluegills or bullhead and bass fillets in Plow Shop Pond that were evaluated in the Supplemental Risk Assessment and was not a COPC in fish tissue.

The health risks from lead in Plow Shop Pond fish or sediment could not be estimated quantitatively in the Supplemental Risk Assessment because of the lack of a USEPA-approved dose/response value for lead. Lead was detected in one of five bluegills in Plow Shop Pond, but not in the bullhead or bass fillets. The concentrations of lead in sediment were evaluated using the USEPA interim soil cleanup level for lead for residential settings of 500 micrograms per gram ($\mu g/g$). Although the maximum detected concentration of lead in Plow Shop Pond (632 $\mu g/g$) sediment was above this soil lead cleanup level, the average concentration of lead in Plow Shop Pond was 125 $\mu g/g$. Exposure to lead in sediment at Plow Shop Pond was also predicted to be much less than in a residential setting. Therefore, lead was not predicted to pose a significant health risk in Plow Shop Pond sediment.

Groundwater sampling data from the March and June 1993 sampling rounds (reported in the RI Addendum Report) confirmed the RI Risk Assessment conclusion that the health risks associated with residential use of the groundwater exceed the USEPA points of departure and Superfund target risk range. The cancer risks (unmodified to account for the uncertainty associated with arsenic) from groundwater consumption (from Well Group 1) range from $4x10^{-4}$ to $8x10^{-3}$. Most of the risk was due to the presence of arsenic. The HQs for manganese at average (2,400 $\mu g/L$) and maximum (9,650 $\mu g/L$) exposure concentrations exceed one; they ranged from 12 to 55. The two organic analytes, 1,2-dichloroethane and dichlorobenzenes, presented cancer risks of $1x10^{-5}$ and $6x10^{-6}$, respectively -- within the Superfund target risk range. If the downward modifying factor of 10 were applied to the unmodified cancer risk estimates for arsenic, the modified risks would range from $4x10^{-5}$ to $8x10^{-4}$. It should be noted that even when the concentration of arsenic in groundwater is assumed to be at the federal Maximum Contaminant Level (MCL) of 50 $\mu g/L$, the cancer risk associated with the MCL ($1x10^{-3}$) exceeds the Superfund target risk range and its HQ (of 5) exceeds one.

In the Supplemental Risk Assessment, using the latest groundwater samples (from the two Supplemental RI sampling rounds) and a landfill well grouping slightly different from the RI well group, three compounds besides arsenic contribute to the total risk at risk levels above the USEPA points of departure - 1,2-dichloroethane, dichlorobenzenes, and manganese. Although benzene was detected in the Supplemental RI sampling (in 3 of 14 samples), it does not present a cancer risk above the USEPA point of departure. Chloroform was detected, but considered an artifact of decontamination procedures. Chloroform was not a COPC in the Supplemental Risk Assessment.

In comparing the March and June 1993 sampling results to drinking water standards, for Well Group 1, the maximum detected concentrations of several analytes in unfiltered groundwater exceeded a primary (or health-based) federal or state drinking water standard. These included: 1,2-dichloroethane, dichlorobenzenes, arsenic, chromium, lead, and nickel. Based on filtered samples, however, the maximum concentration of lead was below the federal Safe Drinking Water Act action level. Neither chromium nor nickel were detected in filtered samples. Dichlorobenzenes (isomers unidentified) were detected in one of 14 samples; while the maximum detection exceeded the Commonwealth of Massachusetts drinking water guideline for p-dichlorobenzene (the isomer with the lowest guideline), the average concentration (5.4 $\mu g/L$) approximated the guideline (5 $\mu g/L$). While the maximum detected concentration of 1,2-dichloroethane (9.9 $\mu g/L$) exceeded the federal MCL of 5 $\mu g/L$, the average concentration of 0.97 $\mu g/L$ did not exceed the MCL. Secondary Maximum Contaminant Levels (SMCLs), standards developed to protect against unacceptable aesthetic effects (such as appliance or clothes staining, or taste), were exceeded for aluminum, iron, and manganese. The federal and Commonwealth guidelines for sodium in drinking water were also exceeded. Sodium guidelines have been set for people on sodium-restricted diets.

In summary, the Supplemental Human Health Risk Assessment identified the following potential human health risks:

- Consumption of fish from Plow Shop Pond contaminated with mercury and, to a much lesser degree, with arsenic
- Direct contact with arsenic in Plow Shop Pond sediment
- Future residential use of unfiltered groundwater interpreted to be under the influence of the landfill and contaminated with several inorganics (arsenic, manganese, chromium, lead, nickel, and sodium) and 1,2-dichloroethane and dichlorobenzenes

A human health Preliminary Risk Evaluation (PRE) was performed for the Nonacoicus Brook Wetland area north of Shepley's Hill Landfill, and is contained in Appendix X of the RI Addendum Report (ABB-ES, 1993b).

The human health PRE compared detected concentrations to conservative standards and concluded that they did not present significant public health risk. Although four inorganics detected in shallow groundwater exceeded their respective drinking water guidelines (aluminum, iron, lead, and manganese), only the drinking water guideline for lead and the MCLG for manganese were based on health-protective endpoints. Analyte concentration exceedances of aluminum and iron guidelines, which are derived for aesthetic or economic reasons, may not be indicative of a health risk. In addition, because the groundwater was obtained from test pits at two-to-three foot depths, it was not considered representative of groundwater that would be used for drinking water, thereby making drinking water guidelines conservative standards for comparison.

Arsenic and beryllium both exceeded Region III risk-based soil concentrations; however, arsenic did not exceed the MADEP S-1/GW-1 standard and beryllium, which was detected in only one sample, only slightly exceeded the S-1/GW-1 standard. These standards are for a residential setting with soil frequently being contacted by sensitive receptors. It is likely that the Nonacoicus Brook forested wetland area will not be used for residential (or commercial) purposes.

## 1.5 Summary of Ecological Risk Assessment

A Supplemental risk assessment was performed at the Shepley's Hill Landfill to update the ecological risk assessment of the RI Report (E&E, 1993). The supplemental ecological risk assessment integrated information gathered from several phases of investigation at the Group 1A Sites in order to determine whether environmental contaminants may pose a risk to ecological receptors. Specifically, the supplemental risk assessment evaluated sediment and fish tissue analytical data that were unavailable when the RI Report was produced. Available surface water analytical data and macroinvertebrate community data were used to characterize risk to aquatic and semi-aquatic receptors. No additional evaluation of surface soils or groundwater was included in the supplemental ecological risk assessment.

The risk assessment of the RI Report indicated that sediment contamination from landfill-derived inorganic analytes in Plow Shop Pond may pose a risk to ecological receptors (E&E, 1993). Arsenic was found to be the primary risk contributor to aquatic and semi-aquatic biota. Risks to aquatic biota were also predicted from cadmium.

In order to further evaluate ecological risk from the Shepley's Hill Landfill, analytical chemistry data from 41 shallow sediment samples and 15 individual whole fish (representing 3 species) were evaluated in the supplemental risk assessment. Appendix E contains a Wetlands Functional Assessment report (updated from the RI Addendum Report) that characterizes the habitat at Plow Shop Pond.

Average and maximum Plow Shop Pond fish tissue analyte concentrations were compared to regional and national data-bases by trophic level for landfill analytes (as assessed in the Final RI Addendum Report) and other analytes.

The average fish tissue concentration from Plow Shop Pond exceeded regional averages for the following analytes: DDE, aluminum, mercury, and zinc, and the landfill related analytes iron and manganese. The mean whole body concentrations of aluminum, iron, manganese, and zinc in Plow Shop Pond fish were significantly greater ($P < 0.05$) than mean concentrations from the regional database. The maximum Plow Shop Pond whole fish tissue concentrations of cadmium, copper, mercury, and the landfill related analyte arsenic exceeded their respective National Contaminant Biomonitoring Programs (NCBMP) 85th percentile concentrations. Fish body weight (and concomitantly trophic status) appears to be a good predictor of mercury contaminant burden in Plow Shop Pond, with higher trophic level fish species having accumulated higher concentrations of this analyte.

A total of 193 fish representing seven families and 12 species were collected in Plow Shop Pond. Top predators, including the largemouth bass and chain pickerel, represented more than 10% of the total numbers of animals collected. Omnivores and insectivores were also well represented in Plow Shop Pond. Based on the data collected in this study, the species composition and taxa richness of Plow Shop Pond is typical of a southern New England warm water fish community. A gross pathological examination of fish from Plow Shop Pond suggests that the individuals from the population examined are healthy. No tumors, lesions, or other significant abnormalities were observed in any fish examined.

The macroinvertebrate sampling program at Shepley's Hill Landfill was designed to provide baseline information regarding the biota associated with aquatic habitats in Plow Shop Pond. Although some uncertainty was associated with the use of New Cranberry Pond as a reference pond, the macroinvertebrate community data suggest that Plow Shop Pond may be slightly impacted relative to New Cranberry Pond. In particular, the macroinvertebrate statistical analysis indicates that Plow Shop Pond may have a significantly lower taxa richness than New Cranberry Pond, the reference site. The study also indicated that New Cranberry Pond may have more pollution-intolerant species than Plow Shop Pond; Plow Shop Pond had a significantly higher percentage of pollution-tolerant dominant taxa in the vegetated substrate. Lastly, the macroinvertebrate sampling station farthest from the landfill at Plow Shop Pond appeared to have greater macroinvertebrate biodiversity than stations closer to the landfill.

Water quality parameters did not appear to be influencing factors in the differences observed between the macroinvertebrate communities at the two ponds or at the different stations within a pond. A statistical analysis between sediment chemistry data and macroinvertebrate abundance was generally inconclusive. However, the analysis did suggest that a group of approximately 15 inorganic COPCs may collectively impact the macroinvertebrate community adversely, with arsenic, cobalt, iron, manganese, and mercury being the COPCs of greatest concern.

This information suggests that the macroinvertebrate community in Plow Shop Pond, particularly in the vicinity of the landfill, may be slightly impaired relative to that of New Cranberry Pond. However, as discussed in the Final RI Addendum Report (ABB-ES, 1993b), considerable uncertainty is associated with the interpretation of the results of the Group 1A macroinvertebrate study. Limited numbers of samples, uncertainties associated with the selected reference pond, differences in habitat types between ponds, and natural environmental stochasticity make it difficult to draw conclusions from this portion of the supplemental risk assessment.

Concentrations of all five landfill-related analytes (arsenic, barium, iron, manganese, and nickel), as assessed in the Final RI Addendum Report, exceeded the available sediment quality criteria or guidelines. The average exposure HQ for arsenic was 14.2, whereas the RME HQ for this analyte was 97. Average exposure and RME HQs for the other landfill analytes ranged from 1.5 to 128. Other non-landfill related COPCs in Plow Shop Pond sediments were also present in concentrations in excess of their Reference Toxicity Values (RTVs). HQs ranged from slightly higher than 1 to an RME HQ of 867, for mercury. The RME HQs for cobalt, cadmium, chromium, copper, lead, and zinc were also greater than 1, and ranged from 1.1 (cobalt) to 125 (chromium). For aquatic receptors, approximately 15% of the average exposure HI for Plow Shop Pond is attributable to landfill analytes in sediments. The remaining 85% of the average exposure HI is due to parameters from sources other than the Shepley's Hill Landfill, with mercury being the primary risk contributor.

Neither average nor maximum surface water concentrations of landfill-related analytes, as assessed in the Final RI Addendum Report, exceeded chronic or acute AWQC. Average concentrations of copper and silver exceeded their respective chronic AWQC. Maximum surface water concentrations of copper, silver, and zinc exceeded their respective acute AWQC. HQs ranged from 1.2 (zinc RME) to 7.4 (copper RME).

For semi-aquatic wildlife, exposure to RME concentrations of arsenic in Plow Shop Pond sediment and fish tissue resulted in HQs greater than 1 for four of the eight receptor species evaluated in the food web model, including the mallard duck, painted turtle, green frog, and muskrat. Only the mallard duck was at risk from the average scenario. One other landfill contaminant (manganese) had an HQ in excess of 1; RME to manganese resulted in an HQ of 5 for the mink. Average and RME exposure to mercury and chromium, both non-landfill-related COPCs in Plow Shop Pond sediments, were also presumed to result in risks to semi-aquatic receptors, with HQs greater than 1 for the great blue heron, muskrat, mallard, mink, painted turtle, and green frog.

These findings suggest that contaminants in Plow Shop Pond may be posing a risk to aquatic and semi-aquatic receptors. Analytes from Shepley's Hill Landfill and from sources other than the Shepley's Hill Landfill are ecological risk contributors to aquatic and semi-aquatic receptors in Plow Shop Pond. Primary risk contributors in Plow Shop Pond include arsenic, chromium, lead, manganese, and mercury.

Additionally, although not quantitatively evaluated, possible impacts to vegetation at Plow Shop Pond were observed during a 1993 site visit. Limited qualitative evidence suggests that aquatic plant life in the northern cove, and to a lesser extent in the southern cove, is sparse relative to the rest of Plow Shop Pond. It is unknown whether these potential differences are due to contaminant exposure.

A ecological PRE performed for the Nonacoicus Brook wetland area north of Shepley's Hill Landfill concluded that there was not a significant ecological risk in that area (ABB-ES, 1993b).

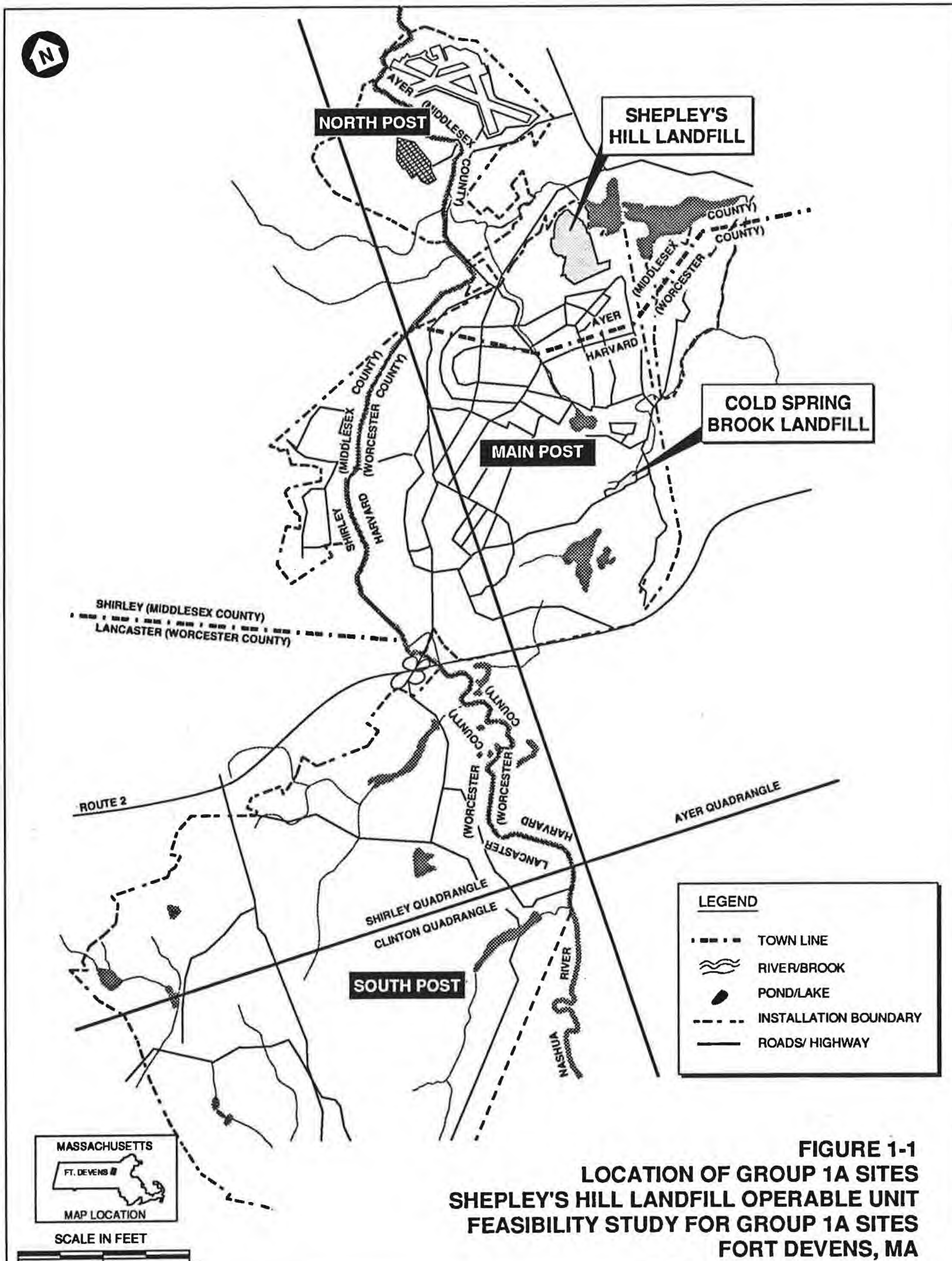



**FIGURE 1-1**
**LOCATION OF GROUP 1A SITES**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

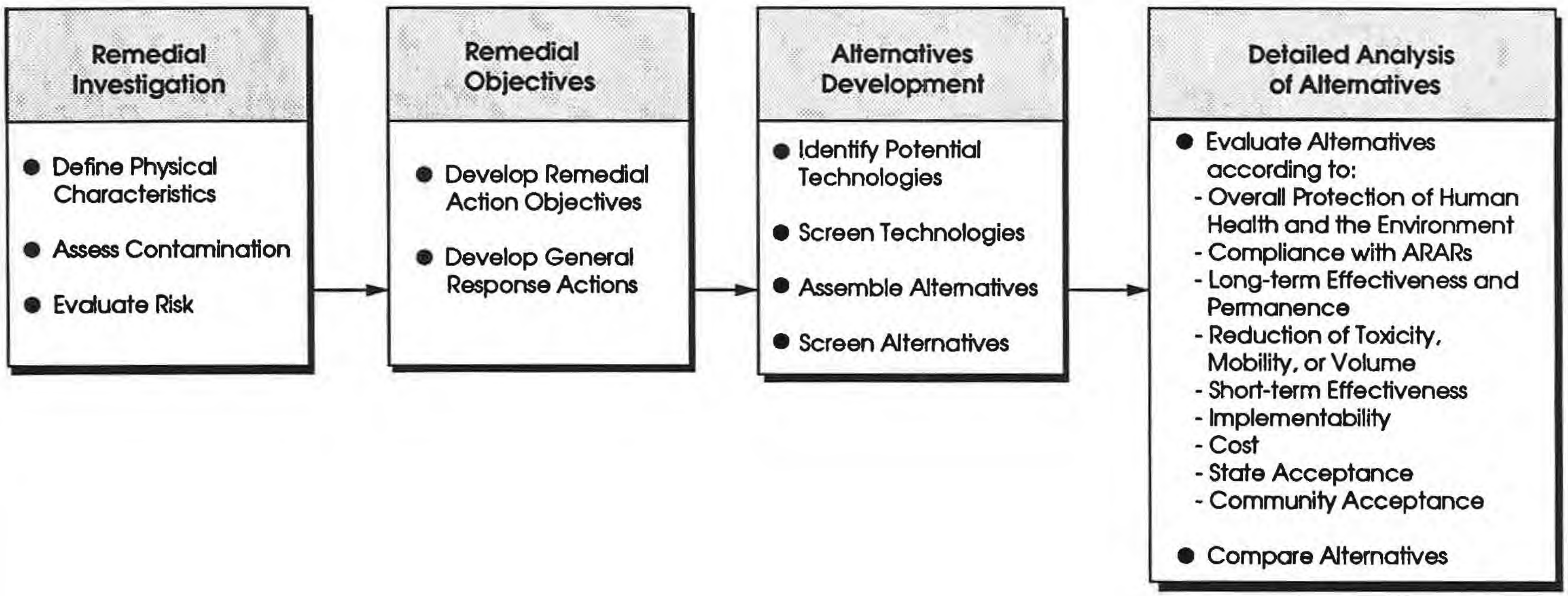



**FIGURE 1-2**
**FEASIBILITY STUDY PROCESS**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

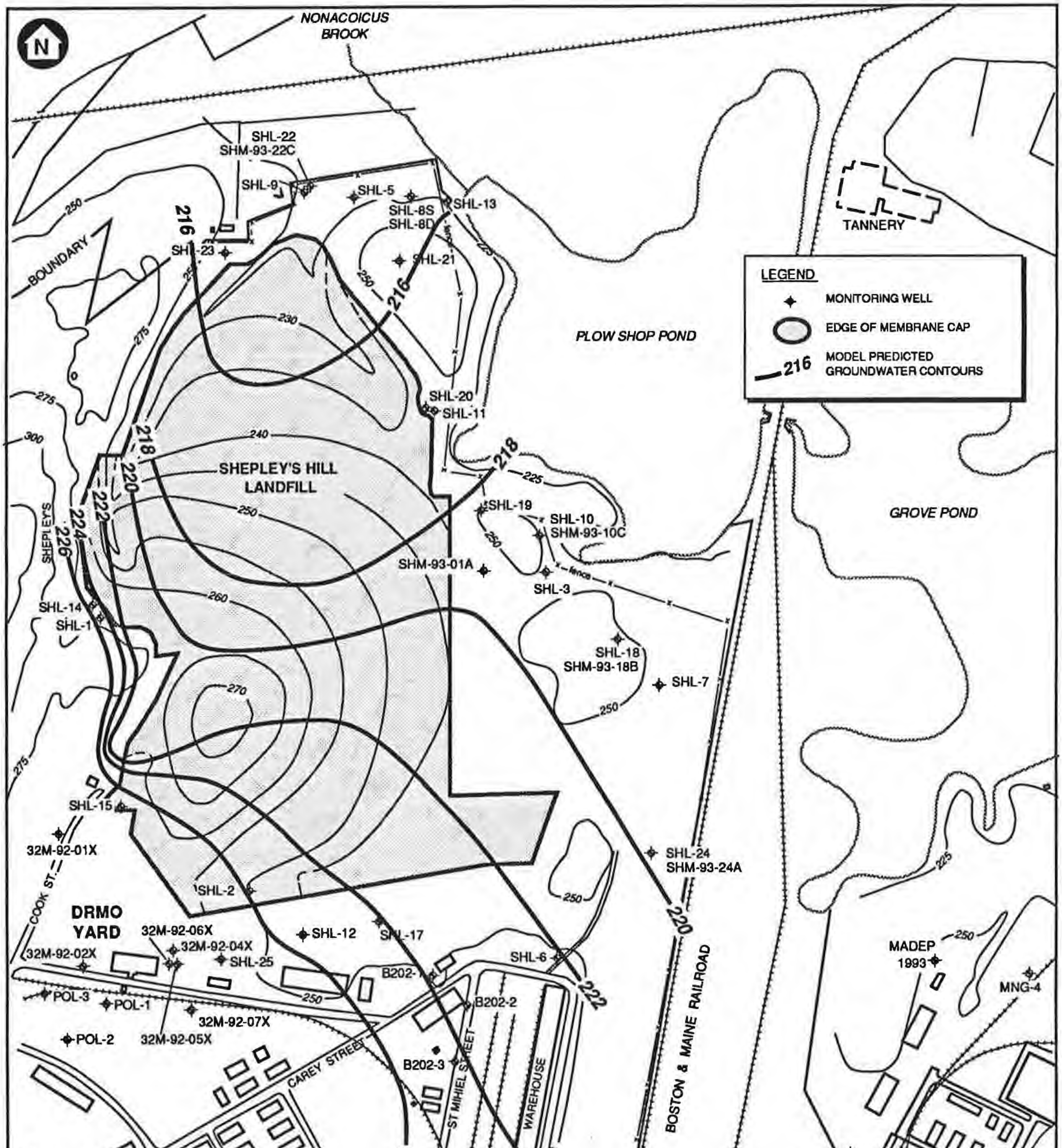



**FIGURE 1-3**
**MODEL PREDICTED GROUNDWATER CONTOURS**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9402037D 1 S6 PQ

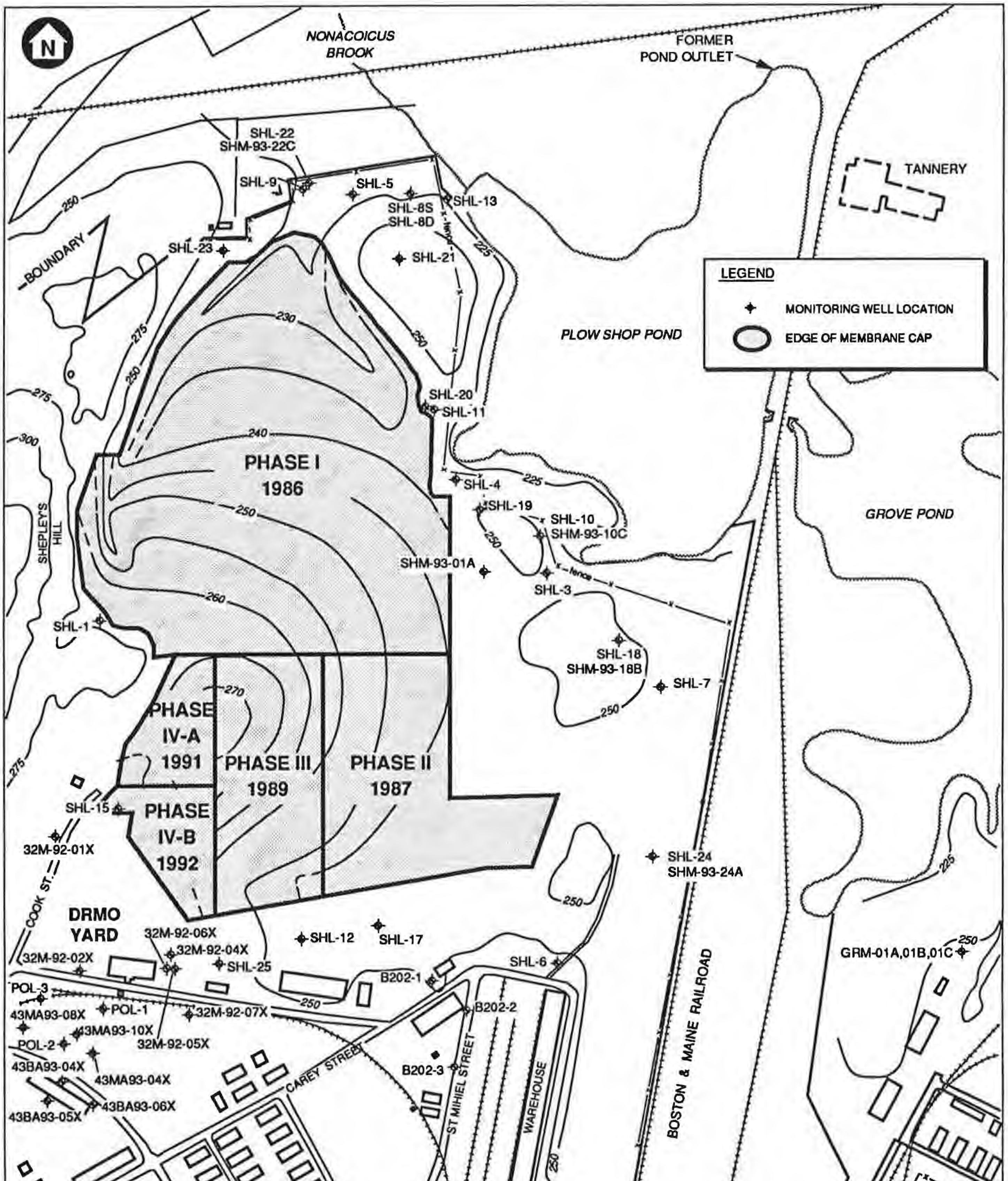
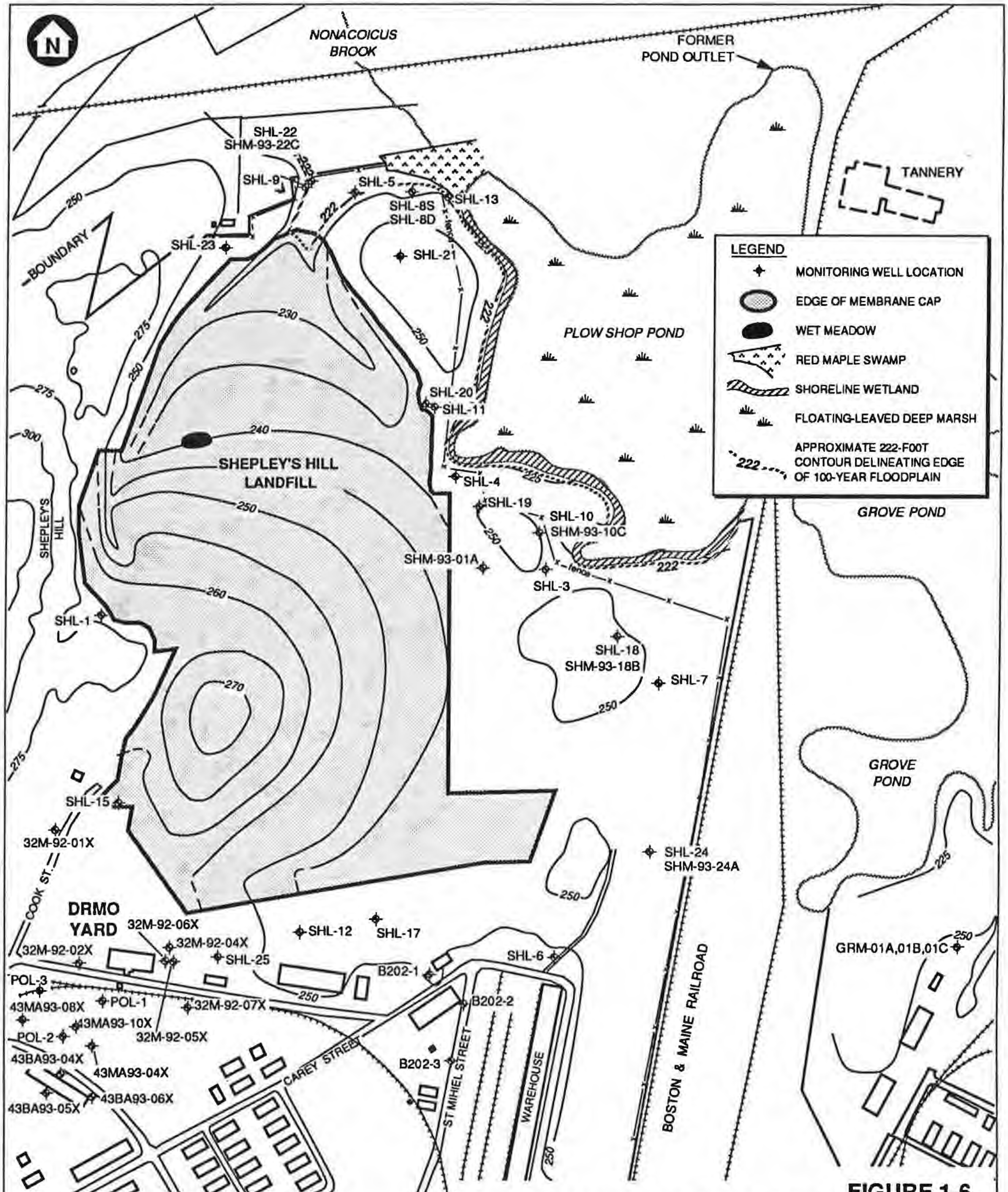



**FIGURE 1-4**
**SHEPLEY'S HILL LANDFILL SITE MAP**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403001D(G)1 34


FIGURE 1-5
LOCATION OF FORMER RAILROAD
ROUNDHOUSE FACILITY
SHEPLEY'S HILL LANDFILL OPERABLE UNI
FEASIBILITY STUDY FOR GROUP 1A SITE
FORT DEVENS, M
ABB Environmental Services,

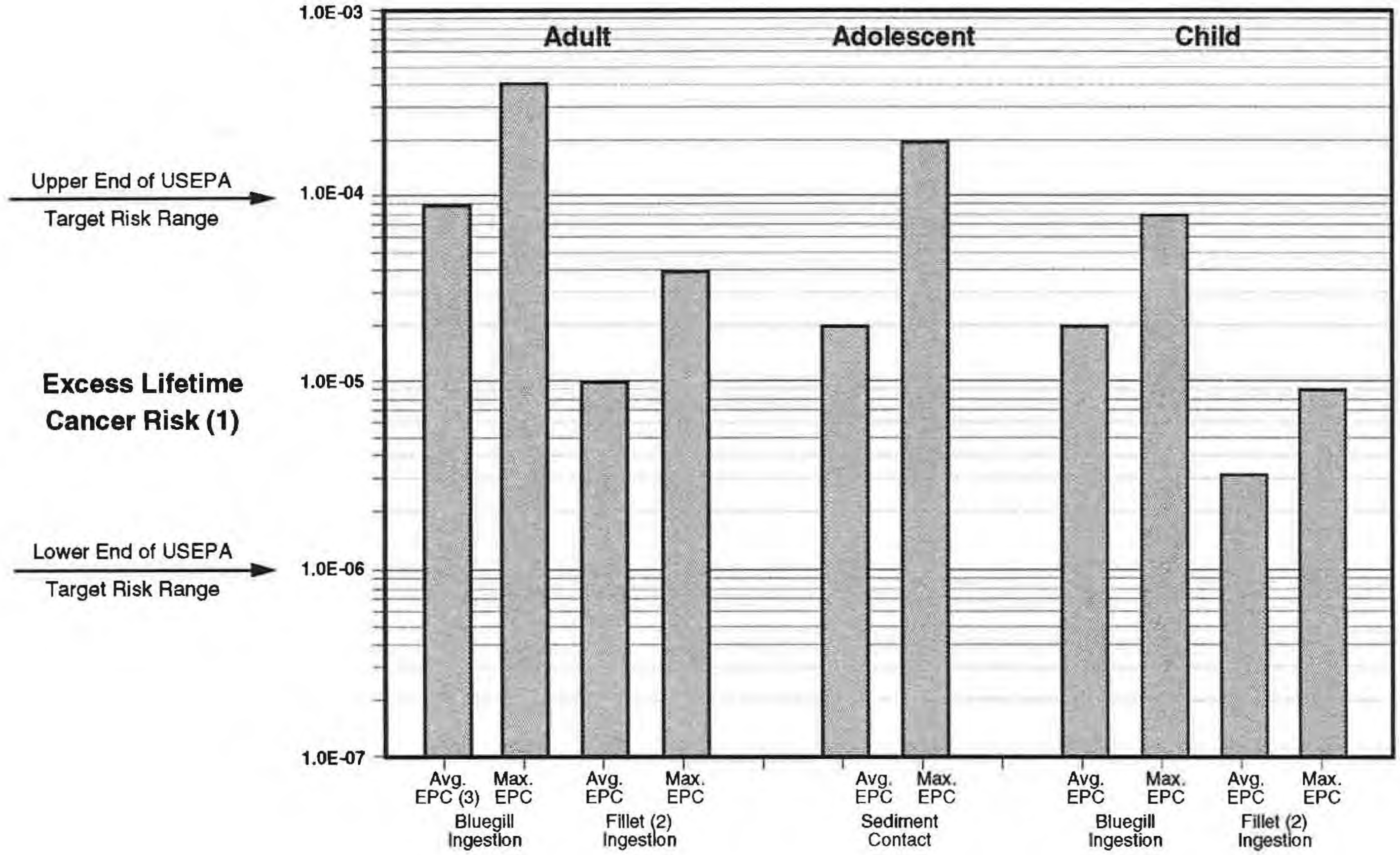



SOURCE: ECOLOGY AND ENVIRONMENT, INC., 1993.

**FIGURE 1-6**
**INTERPRETED WETLAND DELINEATION**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403001D 1 3 67




**NOTE:**

(1) Landfill-related COPCs account for between 96 and 100% of the total risk.

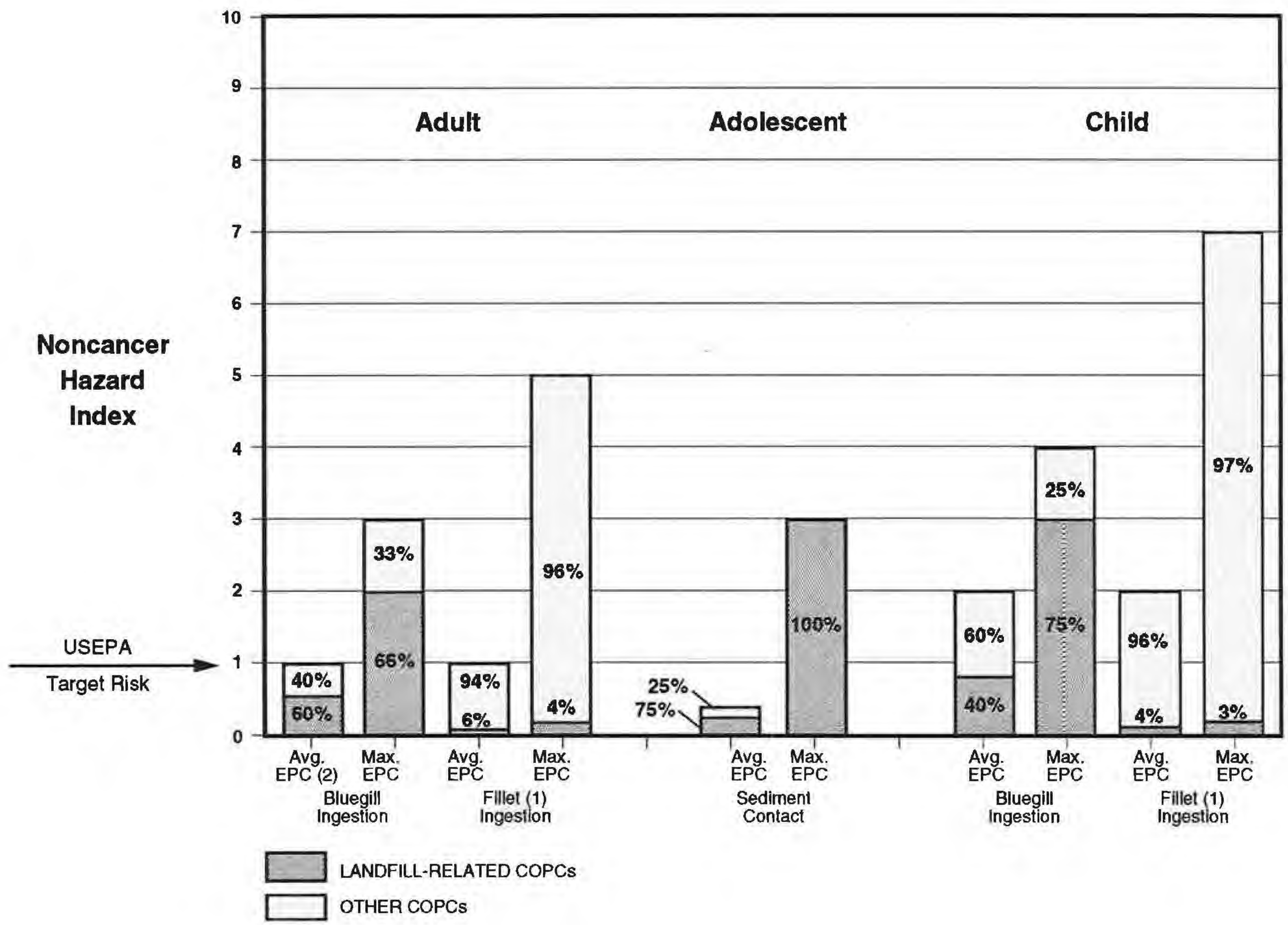
(2) Fillets include bullheads and largemouth bass.

(3) Avg. EPC = average exposure point concentration.
Max. EPC = maximum exposure point concentration.

**FIGURE 1-7**
**SUMMARY OF CANCER RISK ESTIMATES**
**CURRENT LAND USE**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403001D(B)




**NOTE:**

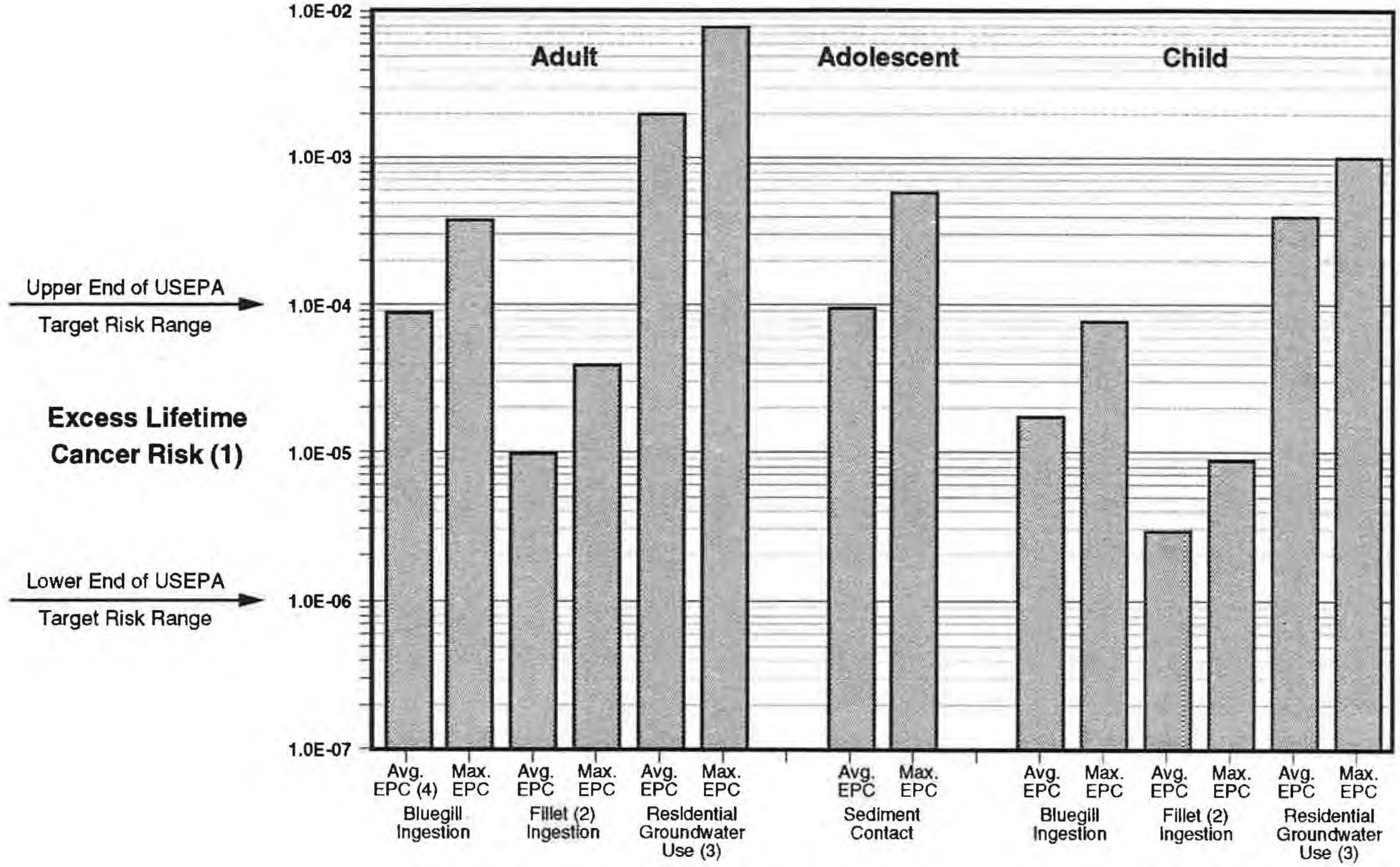
(1) Fillets include bullheads and largemouth bass.

(2) Avg. EPC = average exposure point concentration.
Max. EPC = maximum exposure point concentration.

**FIGURE 1-8**
**SUMMARY OF NONCANCER RISK ESTIMATES**
**CURRENT LAND USE**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403001D(D)




**NOTE:**

(1) Landfill-related COPCs account for between 96 and 100% of the total risk.

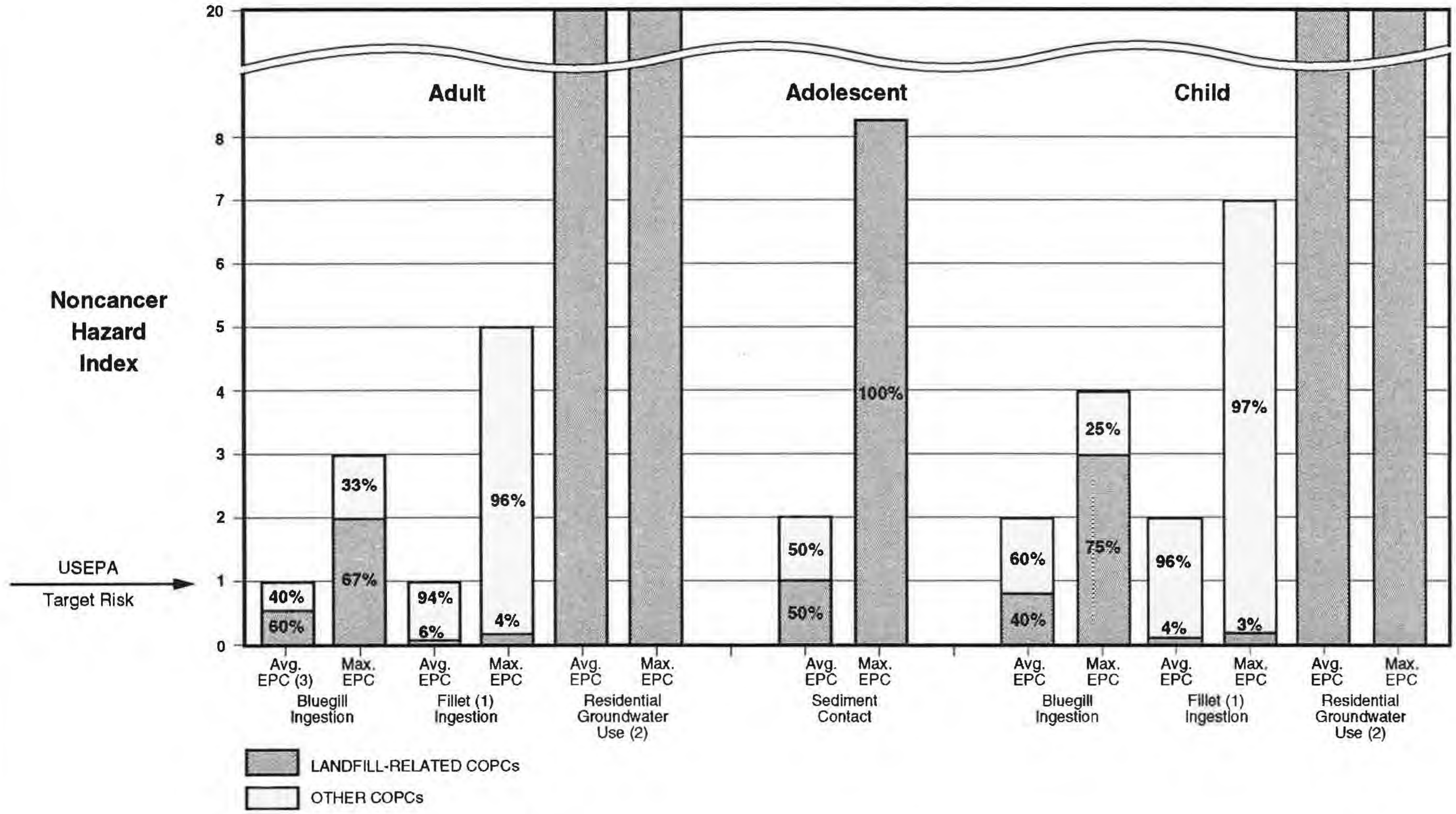
(2) Fillets include bullheads and largemouth bass.

(3) Groundwater estimates are based on unfiltered Supplemental RI samples.

(4) Avg. EPC = average exposure point concentration.
Max. EPC = maximum exposure point concentration.

**FIGURE 1-9**
**SUMMARY OF CANCER RISK ESTIMATES**
**FUTURE LAND USE**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.




**NOTE:**

(1) Fillets include bullheads and largemouth bass.

(2) Groundwater estimates are based on unfiltered Supplemental RI samples.

(3) Avg. EPC = average exposure point concentration.
Max. EPC = maximum exposure point concentration.

**FIGURE 1-10**
**SUMMARY OF NONCANCER RISK ESTIMATES**
**FUTURE LAND USE**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

## TABLE 1-1
## MONITORING WELL GROUPS AT SHEPLEY'S HILL LANDFILL

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| Southern Cross-gradient Wells | Well Group 1 Downgradient Wells | Northern Cross-gradient |
|---|---|---|
| SHL-6 | SHL-3 | SHL-8S |
| SHL-7 | SHL-4 | SHL-8D |
| SHL-12 | SHL-5 | SHL-13 |
| SHL-17 | SHL-9 | SHL-21 |
| SHL-24 | SHL-10 | |
| SHL-25 | SHL-11 | |
| SHM-93-24A | SHL-18 | |
| | SHL-19 | |
| | SHL-20 | |
| | SHL-22 | |
| | SHM-93-01A | |
| | SHM-93-10C | |
| | SHM-93-18B | |
| | SHM-93-22C | |

**Note:**

Wells SHL-1, SHL-15, and SHL-23 are upgradient wells

**TABLE 1–2**
**CHEMICALS EXCEEDING EVALUATION CRITERIA**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| CHEMICAL | GROUNDWATER WELL GROUP 1 | PLOW SHOP POND SEDIMENT | PLOW SHOP POND SURFACE WATER H.H. AWQC | PLOW SHOP POND SURFACE WATER Eco. AWQC |
|---|---|---|---|---|
| **VOLATILE ORGANIC COMPOUNDS** | | | | |
| Benzene | X | | | |
| Chloroethane | X | | | |
| 1,1–dichloroethane | X | | | |
| 1,2–dichloroethane | X | | | |
| 1,2–dichloroethylenes | X | | | |
| 1,2–dichloropropane | X | | | |
| Dichlorobenzenes | X | | | |
| Toluene | X | | | |
| **SEMIVOLATILE ORGANIC COMPOUNDS** | | | | |
| Benzo(a)anthracene | | X | | |
| Chrysene | | X | | |
| Fluoranthene | | X | | |
| Naphthalene | | X | | |
| Phenanthrene | | X | | |
| Pyrene | | X | | |
| **PESTICIDES/PCBs** | | | | |
| DDD | | X | | |
| DDE | | X | | |
| DDT | | X | | |
| **INORGANICS** | | | | |
| Aluminum | X | n.a. | | |
| Antimony | X | n.a. | | |
| Arsenic | X | X* | X | |
| Barium | X | X* | | |
| Beryllium | | n.a. | | |
| Calcium | X | n.a. | | |
| Chromium | X | X | | |
| Cobalt | X | n.a. | | |
| Copper | X | X | | X |
| Iron | X | X* | X | X |
| Lead | X | X | | |
| Magnesium | X | n.a. | | |
| Manganese | X | X* | X | |
| Mercury | | X | | |
| Nickel | X | X* | X | |
| Potassium | X | n.a. | | |
| Selenium | | n.a. | | |
| Silver | | n.a. | | X |
| Sodium | X | n.a. | | |
| Vanadium | X | n.a. | | |
| Zinc | X | X | | X |

Notes:
There are no interpreted contaminants in surface soil at Shepley's Hill Landfill (E&E, 1993).
* = Arsenic, barium, iron, manganese, and nickel in sediment are considered landfill related.
H.H. AWQC = Ambient Water Quality Criteria for protection of human health.
Eco. AWQC = Ambient Water Quality Criteria for protection of aquatic life.
n.a. = Sediment evaluation criteria not available.

## TABLE 1-3
## CHEMICAL CONCENTRATIONS IN DOWNGRADIENT WELLS AT SHEPLEY'S HILL LANDFILL

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| | Unfiltered Samples | | | Filtered Samples | | |
|---|---|---|---|---|---|---|
| Chemical | Frequency of Detection | Average Concentration mg/L | Maximum Concentration mg/L | Frequency of Detection | Average Concentration mg/L | Maximum Concentration mg/L |
| 1,1-Dichloroethane | 4/14 | 0.00086 | 0.0044 | NA | NA | NA |
| 1,2-Dichloroethane | 5/14 | 0.00097 | 0.0099 | NA | NA | NA |
| 1,2-Dichloropropane | 1/14 | 0.00027 | 0.00052 | NA | NA | NA |
| 1,2-Dichloroethene (total) | 6/14 | 0.0014 | 0.007 | NA | NA | NA |
| Benzene | 3/14 | 0.00051 | 0.0017 | NA | NA | NA |
| Chloroethane | 1/14 | 0.0013 | 0.0055 | NA | NA | NA |
| Dichlorobenzenes | 1/14 | 0.0054 | 0.011 | NA | NA | NA |
| Toluene | 1/14 | 0.0003 | 0.0006 | NA | NA | NA |
| Aluminum | 13/14 | 4.3 | 75.5 | 1/10 | 0.150 | 0.236 |
| Antimony | 2/14 | 0.0017 | 0.0033 | 1/10 | 0.002 | 0.003 |
| Arsenic | 12/14 | 0.10 | 0.39 | 6/10 | 0.071 | 0.27 |
| Barium | 13/14 | 0.048 | 0.35 | 10/10 | 0.030 | 0.117 |
| Calcium | 14/14 | 54 | 219 | 10/10 | 37 | 175 |
| Chromium | 5/14 | 0.009 | 0.115 | 0/10 | NC | NC |
| Cobalt | 1/14 | 0.014 | 0.0546 | 0/10 | NC | NC |
| Copper | 4/14 | 0.0086 | 0.0922 | 0/10 | NC | NC |

continued

# TABLE 1-3
## CHEMICAL CONCENTRATIONS IN DOWNGRADIENT WELLS AT SHEPLEY'S HILL LANDFILL

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| | | UNFILTERED SAMPLES | | FILTERED SAMPLES | | |
|---|---|---|---|---|---|---|
| CHEMICAL | FREQUENCY OF DETECTION | AVERAGE CONCENTRATION mg/L | MAXIMUM CONCENTRATION mg/L | FREQUENCY OF DETECTION | AVERAGE CONCENTRATION mg/L | MAXIMUM CONCENTRATION mg/L |
| Iron | 14/14 | 17.6 | 97.4 | 7/10 | 14 | 91.6 |
| Potassium | 13/14 | 7.1 | 31.8 | 9/10 | 4.1 | 10.6 |
| Magnesium | 14/14 | 7.6 | 24 | 9/10 | 4.7 | 19.9 |
| Manganese | 14/14 | 2.4 | 9.65 | 10/10 | 1.8 | 9.54 |
| Sodium | 14/14 | 21 | 67.3 | 10/10 | 17 | 64.6 |
| Nickel | 1/14 | 0.023 | 0.177 | 0/10 | NC | NC |
| Lead | 10/14 | 0.0052 | 0.0668 | 0/10 | NC | NC |
| Vanadium | 3/14 | 0.094 | 0.0791 | 0/10 | NC | NC |
| Zinc | 3/14 | 0.029 | 0.22 | 1/10 | 0.011 | 0.025 |

**Notes:**

Averages based on one-half the sample quantitation limit for nondetected analytes.

NA = not analyzed
NC = not calculated

# 2.0 ASSESSMENT OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Compliance with ARARs is one of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) criteria to be evaluated for each of the alternatives screened for detailed analysis in Section 5. CERCLA was passed by Congress and signed into law on December 11, 1980 (Public Law 96-510). This act was intended to provide for "liability, compensation, cleanup, and emergency response for hazardous substances released into the environment and cleanup of inactive waste disposal sites." The Superfund Amendments and Reauthorization Act, adopted on October 17, 1986 (Public Law 99-499), did not substantially alter the original structure of CERCLA, but provided extensive amendments to it.

In particular, § 121 of CERCLA specifies that remedial actions for cleanup of hazardous substances must comply with requirements or standards under federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances or circumstances at a site. Inherent in the interpretation of ARARs is the assumption that protection of human health and the environment is ensured.

## 2.1 TERMS AND DEFINITIONS

The following is an explanation of the terms used throughout this ARARs discussion:

**Applicable requirements** are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site" (*52 FR 32496*, August 27, 1987).

**Relevant and appropriate requirements** are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (*52 FR 32496*).

Requirements under federal or state law may be either applicable or relevant and appropriate to CERCLA cleanup actions, but not both. However, requirements must be both relevant and appropriate for compliance to be necessary. In the case where both a federal and a state ARAR are available, or where two potential ARARs address the same issue, the more stringent regulation must be selected. However, CERCLA §121(d)(4) provides several ARAR waiver options that may be invoked, providing that the basic premise of protection of human health and the environment is not ignored. A waiver is available for state standards that have not been uniformly applied in similar circumstances across the state. In addition, CERCLA §121(d)(2)(C) forbids state standards that effectively prohibit land disposal of hazardous substances.

CERCLA on-site remedial response actions must only comply with the substantive requirements of a regulation and not the administrative requirements to obtain federal, state, or local permits [CERCLA §121(e)]. As noted in the ARARs guidance (USEPA, 1988a):

> The CERCLA program has its own set of administrative procedures which assure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion.

**Substantive requirements** pertain directly to the actions or conditions at a site, while **administrative requirements** facilitate their implementation. In order to ensure that CERCLA response actions proceed as rapidly as possible, the USEPA has reaffirmed this position in the final National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (*55 FR 8756*, March 8, 1990). The NCP defines on-site as "the areal extent of contamination and all areas in very close proximity to the contamination necessary for implementation of the response action." The IAG provides additional guidance on the applicability of permitting requirements to response actions at Fort Devens (USEPA, 1991c). The USEPA recognizes that certain of the administrative requirements, such as consultation with state agencies, and reporting, are accomplished through the state involvement and public participation requirements of the NCP.

The Army's interpretation of the applicability of the Massachusetts Contingency Plan (MCP) to the Shepley's Hill Landfill Operable Unit parallels guidance provided by USEPA in comments dated February 28, 1994 on the Draft Proposed Plan and Final Feasibility Study for AOCs 44 and 52 at Fort Devens (USEPA, 1994). In its comments USEPA references the following sentences from the *CERCLA Compliance with Other Laws Manual* 310 CMR 40.0111(1)(a) provides:

> The CERCLA program has its own set of administrative procedures which assure proper implementation of CERCLA. The application of additional or conflicting administrative requirements could result in delay or confusion.

Further reference is made to the MCP at 310 CMR 40.0111 which contains a specific provision for deferring application of the MCP at CERCLA sites. 310 CMR 40.0111(1)(a) provides that response actions at CERCLA sites shall be deemed adequately regulated for purposes of compliance with the MCP, provided the MADEP concurs in the CERCLA record of decision.

In the absence of federal- or state-promulgated regulations, there are many criteria, advisories, guidance values, and proposed standards that are not legally binding, but may serve as useful guidance for remedial actions. These are not potential ARARs but are "to-be-considered" (TBC) guidance. These guidelines may be addressed as deemed appropriate.

ARARs are divided into the three categories listed below.

- **Location-specific ARARs** "set restrictions upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations" (*53 FR 51394*). In determining the use of location-specific ARARs for selected remedial actions at CERCLA sites, one must investigate the jurisdictional prerequisites of each of the regulations. Basic definitions and exemptions, must be analyzed on a site-specific basis to confirm the correct application of the requirements.

- **Chemical-specific ARARs** are usually health- or risk-based standards that limit the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels, or the basis for calculating such levels. For example, groundwater MCLs may provide the necessary cleanup goals for sites with contaminated groundwater. There are no direct chemical-specific ARARs for soils. Chemical-specific ARARs for the site may also be used to indicate acceptable levels of discharge in determining treatment and disposal requirements, and to assess the effectiveness of future remedial alternatives.

- **Action-specific ARARs** set controls or restrictions on particular kinds of activities related to the management of hazardous waste (53 *FR* 51437). Selection of a particular remedial action at a site will invoke the appropriate action-specific ARARs that may specify particular performance standards or technologies, as well as specific environmental levels for discharged or residual chemicals. Action-specific ARARs are established under the Resource Conservation and Recovery Act (RCRA), the Clean Air Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act, and other laws.

Many regulations can fall into more than one category. For example, many location-specific ARARs are also action-specific because they are triggered if remedial activities affect site features. Likewise, many chemical-specific ARARs are also location-specific.

The Occupational Safety and Health Administration (OSHA) has promulgated standards for protection of workers at hazardous waste operations at RCRA or CERCLA sites (29 CFR Part 1910). These regulations are designed to protect workers who would be exposed to hazardous waste. Federal construction activities involving no potential for hazardous substance exposure are covered by the OSHA standards found at 29 CFR Part 1926. USEPA requires compliance with the OSHA standards in the NCP (40 CFR 300.150), not through the ARAR process. Therefore, the OSHA standards are not considered as ARARs. They are discussed in the site-specific Health and Safety Plan.

Section 5 contains an alternative-specific discussion of ARARs.

## 2.2 REGULATIONS PERTAINING TO LANDFILL CLOSURE

This subsection discusses potential closure regulations for Shepley's Hill Landfill. Each of the identified regulations includes requirements for installing a landfill cover as part of landfill closure. All of the discussed regulations contain performance standards for cover systems, and the Massachusetts Solid Waste Management regulations and the USEPA Municipal Solid Waste Landfill (MSWLF) regulations contain specific design and component standards. In addition, the regulations contain requirements for post-closure care such as facility maintenance and groundwater and landfill gas monitoring. The identification of regulations relating to landfill closure is particularly important because of the high cost associated with constructing and installing a landfill cover. Other regulations are discussed in Section 5.

Landfill closure regulations appropriate for consideration relative to Shepley's Hill Landfill include the following:

- Massachusetts Solid Waste Management Regulations at 310 CMR 19.000
- USEPA Regulations for Owners and Operators of Permitted Hazardous Waste Facilities at 40 CFR Part 264
- USEPA Criteria for Municipal Solid Waste Landfills at 40 CFR Part 258
- Massachusetts Hazardous Waste Management Rules at 310 CMR 30.000

Massachusetts Solid Waste Management Regulations at 310 CMR 19.000 regulate the storage, transfer, processing, treatment, disposal, use, and reuse of solid waste in Massachusetts. The regulations apply to all solid waste management facilities, including landfills. They are considered applicable to the closure of Shepley's Hill Landfill. The regulations were adopted effective July 1, 1990 and contain provisions for facilities already in existence at that time. Specifically, 310 CMR 19.021 states that after July 1, 1990 and until July 1, 1992 existing facilities may continue to operate in accordance with a approved plan issued by the MADEP on or before December 17, 1987 pursuant to Massachusetts Regulations for The

Disposal of Solid Wastes by Sanitary Landfill, April 1971, 310 CMR 19.00). The requirements for closure at Shepley's Hill Landfill are contained in the May 30, 1985 plan approval letter and are consistent with 310 CMR 19.00. The approved closure plan included:

- grading the landfill surface to a minimum 2 percent slope in non-operational areas of the landfill and 3 percent in operational areas
- removing waste from selected areas within 100 feet of the 100-year floodplain
- installing a gas venting system
- installing an impermeable 30-mil PVC membrane cap and covering the cap with sand, gravel, and loam, and seeding to provide cover vegetation and prevent erosion
- implementing a groundwater monitoring program

The Solid Waste Management Regulations (319 CMR 19.000) that replaced the sanitary landfill regulations of 1971 provide general performance standards and general design standards for cover systems as well as technical standards for final cover system components. These standards are summarized below.

General Performance Standards

- minimize the percolation of water through the final cover system into the landfill to the greatest extent practicable
- promote proper drainage of precipitation
- minimize erosion of the cover
- facilitate the venting and control of landfill gas
- ensure isolation of landfill wastes from the environment

- accommodate settling and subsidence of the landfill such that the above performance standards will continue to be met

General Design Standards

- minimum top slope of 5 percent, maximum side slope of 3 horizontal to 1 vertical
- be constructed of materials compatible with expected landfill gases
- be constructed to minimize erosion
- be constructed to protect the low permeability layer from adverse effects of frost
- be constructed to maintain slope stability

Component Standards (from bottom to top)

- Landfill gas venting layer: Minimum thickness of six inches. Hydraulic conductivity of at least $1x10^{-3}$ cm/sec
- Low permeability layer: Eighteen inches of natural or amended soil with a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec or a flexible membrane liner
- Drainage layer: A minimum of six inches of soil with a hydraulic conductivity of at least $1x10^{-3}$ cm/sec or an approved geosynthetic
- Vegetative layer: At least 12 inches of soil capable of supporting the selected vegetation
- There shall be at least 18 inches of soil material in the drainage and vegetative support layers above the low permeability layer

The adequacy of landfill closure measures undertaken pursuant to 310 CMR 19.000 is assessed by evaluation of environmental monitoring data collected during the post-closure period. If monitoring data exceed established criteria or indicate potential adverse impacts to public health, safety, or the environment, corrective action may be required.

USEPA regulations at 40 CFR Part 264 for owners and operators of permitted hazardous waste facilities were promulgated pursuant to RCRA Subtitle C. Subpart N (40 CFR 264.300 through 264.317) pertains specifically to hazardous waste landfills and contains requirements for closure and post-closure care. RCRA Subtitle C requirements for the treatment, storage, and disposal of hazardous wastes are applicable for a Superfund remedial action if the following conditions are met:

The waste is a RCRA hazardous waste, and either:

1) The waste was initially treated, stored, or disposed of after November 19, 1980, the effective date of Subtitle C regulations, or

2) The activity at the CERCLA site constitutes treatment, storage, or disposal.

At Shepley's Hill Landfill wastes were disposed of through June 1992; however, they have not been identified as hazardous wastes. In addition, the grading of wastes within Shepley's Hill Landfill during capping activities does not constitute treatment, storage, or disposal. Therefore, Subtitle C regulations are not considered applicable. However, Subtitle C is considered relevant and appropriate to the closure of Shepley's Hill Landfill. If Subtitle C were considered applicable, USEPA could require installation of a Subtitle C cap on the landfill. Because Subtitle C is considered relevant and appropriate, USEPA can allow the current cap to remain in place as part of a hybrid closure that includes long-term cover management, groundwater monitoring, and institutional controls USEPA, 1991b).

RCRA regulations at 40 CFR 264.310 state that at final closure of a hazardous waste landfill the owner or operator must cover the landfill with a final cover designed and constructed to meet the following five performance criteria:

1) provide long-term minimization of migration of liquids through the closed landfill;

2) function with minimum maintenance;

3) promote drainage and minimize erosion or abrasion of the cover;

4) accommodate settling and subsidence so that the cover's integrity is maintained; and

5) have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present.

The USEPA publication *Design and Construction of RCRA/CERCLA Final Covers* recommends the following design for a Subtitle C cover (USEPA, 1991b):

1) A Low Hydraulic Conductivity Geomembrane/Soil Layer. A 60-cm (24-inch) layer of compacted natural or amended soil with a hydraulic conductivity of $1x10^{-7}$ cm/sec in intimate contact with a minimum 0.5-mm (20-mil) geomembrane liner.

2) A Drainage Layer. A minimum 30-cm (12-inch) soil layer having a minimum hydraulic conductivity of $1x10^{-2}$ cm/sec, or a layer of geosynthetic material having the same characteristics.

3) A Top, Vegetative/Soil Layer. A top layer with vegetation (or an armored top surface) and a minimum of 60 cm (24-inch) of soil graded at a slope between 3 and 5 percent.

Groundwater monitoring is used to assess whether the facility closure achieves compliance with established groundwater protection standards, and whether corrective action is to be implemented to meet standards and protect human health and the environment.

USEPA regulations at 40 CFR Part 258 establish minimum national criteria under RCRA for MSWLF units. However, because Shepley's Hill Landfill is already regulated under Massachusetts regulations (i.e., 310 CMR 19.000), 40 CFR 258 is considered relevant and appropriate, but not applicable. The USEPA regulations specify at 40 CFR 258.1(d)(4) that MSWLF units that received waste after October 9, 1991, but stopped receiving waste before April 9, 1994 and do not meet other specific criteria, are exempt from all the requirements of 40 CFR Part

258 except the final cover requirements of 40 CFR 258.60(a). The final cover system must be designed and constructed to:

- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than $1x10^{-5}$ cm/sec, whichever is less

- Minimize infiltration through the closed MSWLF by use of an infiltration layer that contains a minimum of 18-inches of earthen material

- Minimize erosion of the final cover by use of an erosion control layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth

Massachusetts Hazardous Waste Management Regulations at 310 CMR 30.000 regulate the generation, storage, collection, transport, treatment, disposal, use, reuse, and recycling of hazardous materials in Massachusetts. Because wastes at Shepley's Hill Landfill have not been identified as hazardous, 310 CMR 30.000 is not considered applicable. It is considered relevant and appropriate, however.

The regulations specify that at final closure a landfill will be covered with a final cover designed and constructed to:

- Provide long term minimization of migration of liquids through the closed landfill

- Function with minimum maintenance

- Promote drainage and minimize erosion and abrasion of the cover

- Accommodate settling and subsidence so that cover integrity is maintained

- Have a permeability less than or equal to the permeability of the bottom liner system

Groundwater monitoring conducted as part of stipulated post-closure activities is used to assess if regulated hazardous waste management units are in compliance with established groundwater standards and whether corrective action is to be implemented to achieve compliance.

In conclusion, Massachusetts Solid Waste Management Regulations at 310 CMR 19.000 are considered applicable at the Shepley's Hill landfill Operable Unit, while the capping requirements of Massachusetts Hazardous Waste Management Regulations, and RCRA Subtitle C, and RCRA Subtitle D regulations are considered relevant and appropriate.

# 3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

Response and remedial action objectives form the basis for identifying remedial technologies and developing remedial alternatives. This section identifies response and remedial action objectives, and potential general response actions to meet those objectives. Remedial technologies considered implementable, and which also address the remedial action objectives and general response actions, are identified. Candidate remedial technologies are then screened based on their applicability to site and waste characteristics. The purpose of the screening is to produce an inventory of suitable technologies that can be assembled into remedial alternatives capable of mitigating actual or potential risks at the Shepley's Hill Landfill Operable Unit.

The Shepley's Hill Landfill Operable Unit includes all media and contamination of concern at Shepley's Hill Landfill except surface water and sediment in Plow Shop Pond. Technologies and alternatives to remediate sediment contamination in Plow Shop Pond will be evaluated in a separate document for the Plow Shop Pond Operable Unit.

## 3.1 IDENTIFICATION OF RESPONSE OBJECTIVES

Response objectives are site-specific, qualitative cleanup objectives based on the nature and extent of contamination, the resources currently or potentially threatened, and the potential for human and environmental exposure. For the Shepley's Hill Landfill Operable Unit, response objectives were formulated based on environmental concerns defined in the human health and ecological risk assessments. Response objectives are used to develop remedial action objectives and appropriate remedial alternatives.

Based on the human health and ecological risk assessments in the RI and RI Addendum Reports, the following response objectives were identified for the Shepley's Hill Landfill Operable Unit:

- Protect potential residential receptors from exposure to contaminated groundwater migrating from the landfill having chemicals in excess of MCLs and health-based ARARs.

- Prevent contaminated landfill groundwater from contributing to the contamination of Plow Shop Pond sediments in excess of human health and ecological risk-based concentrations.

Response objectives were not identified for surface soil, landfill gas, or leachate. The risk assessments did not identify potential risks from exposure to surface soil, and ambient air monitoring during the RI did not identify airborne contaminants. Liquid leachate was not identified during either RI or supplemental RI activities.

### 3.2 Preliminary Remediation Goals

Preliminary Remediation Goals (PRGs) are numerical goals for site cleanup that are intended to be protective and to comply with ARARs. PRGs are based both on risk assessment and on ARARs. PRGs for the Shepley's Hill Landfill Operable Unit were developed following the USEPA guidance document entitled, *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)*, Interim, December 1991 (RAGS Part B) (USEPA, 1991d) and OSWER Directive 9355.0-30, *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions* (USEPA, 1991e). The first step in developing human health PRGs is to identify those environmental media that in the baseline risk assessment present either a cumulative current or future cancer risk greater than $1x10^{-4}$ or a cumulative noncarcinogenic HI greater than 1, based on RME assumptions. The next step is to identify COPCs within the medium that present cancer risks greater than $1x10^{-6}$ or an HQ greater than 1. Following identification of media of concern and COPCs, PRGs are developed and refined by considering the following:

- ARARs
- exposure factors
- technical factors, and
- uncertainty factors

Because groundwater was the only medium at the Shepley's Hill Landfill Operable Unit with potential risks that exceeded USEPA criteria, only the groundwater exposure pathway in the baseline human health risk assessment was reviewed for the development of PRGs. Exposure to groundwater represents a potential exposure pathway under assumptions of future land use. Groundwater as an exposure medium was not evaluated in the baseline risk assessment under conditions of current land use. Tables 3-1 and 3-2 have been extracted from the baseline risk assessment and summarize the risk estimates associated with Shepley's Hill Landfill, including potential future residential groundwater use.

The risk estimates in Tables 3-1 and 3-2 for residential groundwater use have been modified since the baseline risk assessment (ABB-ES, 1993b). This is because the spreadsheets (Appendix K of ABB-ES, 1993b) used to calculate the intake from ingestion of groundwater inadvertently included the factor "ET" for shower exposure time in the numerator of the ingestion intake equation for groundwater. This factor has been removed, and Tables 3-1 and 3-2 contain corrected values.

As seen in Tables 3-1 and 3-2, the risk estimates associated with residential groundwater use exceed the USEPA risk management criteria of a $1x10^{-4}$ cancer risk and a HI of one. Chemicals of concern in the groundwater whose risks exceed a $1x10^{-6}$ cancer risk or a HI of one include arsenic, 1,2-dichloroethane, dichlorobenzenes, and manganese. In addition, the baseline risk assessment identified the following chemicals as exceeding their respective drinking water standard or guideline: aluminum, chromium, iron, lead, nickel, and sodium.

Table 3-3 contains federal and Commonwealth drinking water standards and guidelines for these chemicals of concern. It also lists the basewide background concentrations of inorganics in unfiltered groundwater samples at Fort Devens and the average and maximum exposure point concentrations (EPCs) in Well Group 1 groundwater. The estimation of background concentrations is discussed in Section 4 of the RI Addendum Report (ABB-ES, 1993b). The EPCs were reported in the baseline risk assessment (ABB-ES, 1993b). PRGs are proposed as either the lowest drinking water standard or guideline, or as the background concentration, whichever is highest. As seen in Table 3-3, ARARs-based PRGs are proposed for arsenic, chromium, dichlorobenzenes, 1,2-dichloroethane, lead, nickel, and sodium. PRGs are proposed at background concentrations for aluminum, iron, and manganese. Risk-based PRGs were not developed for the Shepley's Hill Landfill Operable Unit.

### 3.3 Remedial Action Objectives

Remedial action objectives are medium- or operable unit-specific, quantitative goals defining the extent of cleanup required to achieve response objectives. They specify contaminants of concern, exposure routes and receptors, and PRGs. In the case of groundwater, they also include a restoration time frame. Remedial action objectives are used as the framework for developing remedial alternatives. Table 3-4 lists remedial action objectives for the Shepley's Hill Landfill Operable Unit. The remedial action objectives are formulated to achieve the overall goal of USEPA of protecting human health and the environment.

### 3.4 General Response Actions

General response actions describe categories of remedial actions that may be employed to satisfy remedial action objectives. General response actions provide the basis for identifying specific remedial technologies.

Applicable general response actions are listed in Tables 3-5 and 3-6. General response actions for groundwater at the Shepley's Hill Landfill Operable Unit include the following: No Action, Limited Action, Containment, Collection, Treatment, and Discharge. These general response actions are in accordance with recommendations made in USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988b).

### 3.5 Technology Identification

Categories of remedial technologies and specific process options were identified based on a review of literature, vendor information, performance data, and experience in developing other FSs under CERCLA. Of these process options, 28 were selected as being potentially applicable to attaining the remedial response objectives. Applicable remedial technologies and associated process options are identified for each of the six possible general response actions (i.e., No Action, Limited Action, Containment, Collection, Treatment, and Discharge) as shown in Table 3-5. Table 3-6 provides descriptions for the groundwater process options.

### 3.6 TECHNOLOGY SCREENING

The technology screening process reduces the number of potentially applicable technologies and process options by evaluating factors that may influence process option effectiveness and implementability. This overall screening is consistent with the guidance for conducting FSs under CERCLA (USEPA, 1988b).

The screening process assesses each technology or process option for its probable effectiveness and implementability with regard to site-specific conditions, known and suspected contaminants, and affected environmental media. The effectiveness evaluation focuses on: (1) whether the technology is capable of handling the estimated areas or volumes of media and meeting the contaminant reduction goals identified in the remedial action objectives; (2) the effectiveness of the technology in protecting human health during the construction and implementation phase; and (3) how proven and reliable the technology is with respect to the contaminants and conditions at the site. Implementability encompasses both the technical and institutional feasibility of implementing a technology. Effectiveness and implementability are incorporated into two screening criteria: waste- and site-limiting characteristics.

Waste-limiting characteristics largely establish the effectiveness and performance of a technology; site-limiting characteristics affect implementability of a technology. Waste-limiting characteristics consider the suitability of a technology based on contaminant types, individual compound properties (e.g., volatility, solubility, specific gravity, adsorption potential, and biodegradability), and interactions that may occur between mixtures of compounds (e.g., reactions and increased solubility). Site-limiting characteristics consider the effect of site-specific physical features, including topography, buildings, underground utilities, available space, and proximity to sensitive operations, on the implementability of a technology. Technology screening based on waste- and site-limiting characteristics serves a two-fold purpose of screening out technologies whose applicability is limited by site-specific waste or site considerations, while retaining as many potentially applicable technologies as possible.

Table 3-7 summarizes the technology screening phase for the Shepley's Hill Landfill Operable Unit at Fort Devens. Technologies and process options judged ineffective or not implementable were eliminated from further consideration.

Table 3-8 summarizes the groundwater technologies retained for further consideration. The technologies retained following screening represent an inventory of technologies considered most suitable for groundwater at the Shepley's Hill Landfill Operable Unit. Technologies retained in this section may be used to develop remedial alternatives. Treatability studies may be required prior to final technology selection to confirm the effectiveness of a given technology.

TABLE 3-1
SUMMARY OF CANCER RISK ESTIMATES[1]
FUTURE LAND USE

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| EXPOSURE SCENARIO | ADULT AVERAGE EPC | ADULT MAXIMUM EPC | ADOLESCENT AVERAGE EPC | ADOLESCENT MAXIMUM EPC | CHILD AVERAGE EPC | CHILD MAXIMUM EPC | RISK CONTRIBUTIONS (BY CHEMICAL) |
|---|---|---|---|---|---|---|---|
| **Ingestion of Bluegills** | | | | | | | |
| Landfill-related COPCs | 9E-05 | 4E-04 | NA | NA | 2E-05 | 8E-05 | Arsenic (99 %) |
| Total Risk- All COPCs | 9E-05 | 4E-04 | NA | NA | 2E-05 | 8E-05 | |
| **Ingestion of Fillets (bullhead and bass)** | | | | | | | |
| Landfill-related COPCs | 1E-05 | 4E-05 | NA | NA | 3E-06 | 9E-06 | Arsenic (96 %) |
| Total Risk- All COPCs | 1E-05 | 4E-05 | NA | NA | 3E-06 | 1E-05 | |
| **Sediment Contact** | | | | | | | |
| Landfill-related COPCs | NA | NA | 9E-05 | 6E-04 | NA | NA | Arsenic (96 %) |
| Total Risk- All COPCs | NA | NA | 9E-05 | 6E-04 | NA | NA | |
| **Residential Groundwater Use (Well Group 1)** | | | | | | | |
| Unfiltered | 2E-03 | 8E-03 | NA | NA | 4E-04 | 1E-03 | Arsenic (99 %)[2] |
| Filtered | 1E-03 | 6E-03 | NA | NA | 3E-04 | 1E-03 | Arsenic (100 %) |
| **Total Risk[3]** | | | | | | | |
| Unfiltered | 2E-03 | 9E-03 | NA | NA | 4E-04 | 1E-03 | |
| Filtered | 1E-03 | 7E-03 | NA | NA | 3E-04 | 1E-03 | |

Notes:

[1]As reported in the Fort Devens Group 1A Sites Final Remedial Investigation Addendum Report (December 1993).

[2]Two additional COPCs, 1,2-dichloroethane ($1x10^{-5}$) and dichlorobenzenes ($6x10^{-6}$), present cancer risks above the USEPA point of departure of $1x10^{-6}$, but account for less than 1% of the total risk.

[3]Total risk is calculated for adults who consume COPCs in fillets, contact sediment, and use the groundwater from Well Group 1 for domestic purposes. Total risk is calculated for children who consume fillets and use the groundwater from Well Group 1 for domestic purposes.

EPC= Exposure Point Concentration

NA= Not Applicable

Note: Shaded risk estimates represent updated values, different from those reported in the Final RI Addendum Report (December 1993); an error existed in the December 1993 risk spreadsheets and the shaded risk estimates are corrected values.

TABLE 3-2
SUMMARY OF NONCANCER RISK ESTIMATES[1]
FUTURE LAND USE

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| | ADULT | | ADOLESCENT | | CHILD | | RISK CONTRIBUTIONS[2] |
|---|---|---|---|---|---|---|---|
| EXPOSURE SCENARIO | AVERAGE EPC | MAXIMUM EPC | AVERAGE EPC | MAXIMUM EPC | AVERAGE EPC | MAXIMUM EPC | (BY CHEMICAL) |
| **Ingestion of Bluegills** | | | | | | | |
| Landfill-related COPCs | 0.6 | 2 | NA | NA | 0.8 | 3 | |
| Total Risk- All COPCs | 1 | 3 | NA | NA | 2 | 4 | Arsenic (0.5,2; skin) |
| **Ingestion of Fillets (bullhead and bass)** | | | | | | | |
| Landfill-related COPCs | 0.06 | 0.2 | NA | NA | 0.08 | 0.2 | |
| Total Risk- All COPCs | 1 | 5 | NA | NA | 2 | 7 | Mercury (2,7; kidney) |
| **Sediment Contact** | | | | | | | |
| Landfill-related COPCs | NA | NA | 1 | 10 | NA | NA | |
| Total Risk- All COPCs | NA | NA | 2 | 10 | NA | NA | Arsenic (1,8), Manganese (0.06,1; CNS effect |
| **Residential Groundwater Use (Well Group 1)** | | | | | | | |
| Unfiltered | 20 | 90 | NA | NA | 20 | 100 | Arsenic (9, 36), Manganese (12, 55)[3] |
| Filtered | 20 | 80 | NA | NA | 20 | 90 | Arsenic (7,25), Manganese (10,55) |
| **Total Risk[4]** | | | | | | | |
| Landfill-related COPCs: | | | | | | | |
| Unfiltered | 20 | 90 | NA | NA | 20 | 100 | |
| Filtered | 20 | 80 | NA | NA | 20 | 90 | |
| All COPCs: | | | | | | | |
| Unfiltered | 21 | 95 | NA | NA | 22 | 107 | |
| Filtered | 21 | 85 | NA | NA | 22 | 97 | |

Notes:

[1]As reported in the Fort Devens Group 1A Sites Final Remedial Investigation Addendum Report (December 1993).

[2]Hazard quotients for individual chemicals shown in parentheses, at average and maximum EPCs, respectively, for receptor showing greatest risk. Toxicity endpoint of dose-response value also shown in parentheses.

[3]At maximum concentrations, the hazard quotients for six other COPCs were 0.1 or greater: benzene (0.4), vanadium (0.3), antimony (0.3), barium (0.1), chromium (0.6), and nickel (0.3).

[4]Total risk is calculated for adults and children who consume COPCs in fillets and use the groundwater from Well Group 1 for domestic purposes.

EPC= Exposure Point Concentration

NA= Not Applicable

Note: Shaded risk estimates represent updated values, different from those reported in the Final RI Addendum Report (December 1993); an error existed in the December 1993 risk spreadsheets and the shaded risk estimates are corrected values.

**TABLE 3-3**
**PROPOSED PRELIMINARY REMEDIATION GOALS**
**FOR GROUNDWATER**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| CHEMICAL OF CONCERN | WELL GROUP 1 AVERAGE EPC (µg/L) UNFILTERED | WELL GROUP 1 AVERAGE EPC (µg/L) FILTERED | WELL GROUP 1 MAXIMUM EPC (µg/L) UNFILTERED | WELL GROUP 1 MAXIMUM EPC (µg/L) FILTERED | BACKGROUND CONCENTRATION (µg/L) | DRINKING WATER STANDARDS AND GUIDELINES: MCL (µg/L) | SMCL (µg/L) | MCLG (µg/L) | HA (µg/L) | MMCL (µg/L) | SMCL (µg/L) | ORSG (µg/L) | PROPOSED PRG (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 4,259 | NA | 75,500 | 236 | 6,870 | – | 50 – 200 | – | – | – | 50 – 200 | – | 6,870 |
| Arsenic | 101 | 71 | 390 | 270 | 10.5 | 50 | – | – | – | 50 | – | – | 50 |
| Chromium | 9 | ND | 115 | ND | 14.7 | 100 | – | 100 | 100 | 100 | – | – | 100 |
| Dichlorobenzenes | 5.4 | NA | 11 | NA | NA | 75[3] | – | 75 | 75 | 5[3] | – | – | 5 |
| 1,2-Dichloroethane | 0.97 | NA | 9.9 | NA | NA | 5 | – | 0 | – | 5 | – | – | 5 |
| Iron | 17,608 | 14,427 | 97,400 | 91,600 | 9,100 | – | 300 | – | – | – | 300 | – | 9,100 |
| Lead | 5.2 | NA | 66.8 | 1.52 | 4.25 | 15[4] | – | 0 | – | 15 | – | – | 15 |
| Manganese | 2045 | 1812 | 9650 | 9540 | 291 | – | 50 | – | – | – | 50 | – | 291 |
| Nickel | 22.9 | ND | 177 | ND | 34.3 | 100 | – | 100 | 100 | 100 | – | – | 100 |
| Sodium | 20,749 | 16,934 | 67,300 | 64,600 | 10,800 | – | – | – | 20,000 | – | – | 28,000 | 20,000 |

Notes:
[1]"Drinking Water Regulations and Health Advisories", December 1993, USEPA Office of Water
[2]"Drinking Water Standards & Guidelines for Chemicals in Massachusetts Drinking Waters", Spring 1993, Massachusetts Department of Environmental Protection
[3]Value for p-dichlorobenzene, the lowest of the three isomers. The MCL & MMCL for O-Dichlorobenzene are both 600 µg/L.
[4]Action level[1]
EPC = Exposure Point Concentration
ND = Not detected
NA = Not appropriate
MCL = Maximum Contaminant Level[1]
SMCL = Secondary MCL[1]
MCLG = Maximum Contaminant Level Goal[1]
HA = Health Advisory[1]
MMCL = Massachusetts MCL[2]
ORSG = Massachusetts Department of Environmental Protection Office of Research and Standards Guideline[2]

**TABLE 3-4**
**REMEDIAL ACTION OBJECTIVES FOR SHEPLEY'S HILL LANDFILL**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| SHEPLEY'S HILL LANDFILL GROUNDWATER | |
|---|---|
| • | Prevent potential residential exposure to groundwater containing chemicals in excess of the following site-specific PRGs: dichlorobenzenes (5 $\mu$g/L)*, 1,2-dichloroethane (5 $\mu$g/L), aluminum (6,870 $\mu$g/L), arsenic (50 $\mu$g/L), chromium (100 $\mu$g/L), iron (9,100 $\mu$g/L), lead (15 $\mu$g/L), manganese (291 $\mu$g/L), nickel (100 $\mu$g/L), and sodium (20,000 $\mu$g/L). |
| • | Prevent off-site migration of groundwater containing chemicals in excess of the above concentrations. |
| • | Prevent contaminated landfill groundwater from contributing to arsenic contamination of Plow Shop Pond sediments in excess of health- and risk-based ARARs. |
| • | Meet location-specific and action-specific ARARs. |

**Notes:**

*The value of 5 $\mu$g/L pertains to 1,4-dichlorobenzene. The PRG for 1,2-dichlorobenzene would be 600 $\mu$g/L.

## TABLE 3-5
## POTENTIAL REMEDIAL TECHNOLOGIES FOR GROUNDWATER

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTION |
|---|---|---|
| NO ACTION | None | Not Applicable |
| MINIMAL ACTION | Institutional Controls | Zoning Restrictions |
| | | Deed Restrictions |
| | Environmental Monitoring | Groundwater Monitoring |
| | Landfill Cap Maintenance | As Applicable |
| CONTAINMENT | Capping | Composite Barrier |
| | Hydraulic Barriers | Slurry Wall |
| | | Grout Curtain |
| | | Sheet Piling |
| COLLECTION | Extraction | Interceptor Trenches |
| | | Extraction Wells |
| TREATMENT | Physical/Chemical | Aeration (Precipitation) |
| | | Filtration |
| | | Chemical Precipitation |
| | | Air Stripping |
| | | UV Oxidation |
| | | Activated Carbon |
| | | Ion Exchange |
| | | Fixation (In situ) |
| | | Air Sparging (In situ)* |
| | | Electrolytic Sep. (In situ)* |
| | Biological | Constructed Wetland |
| | | Bioremediation (In situ)* |
| | | Fort Devens WWTP |
| | | Ayer POTW |
| DISCHARGE | On Site | Fort Devens WWTP |
| | | To Groundwater |
| | Off Site | Ayer POTW |
| | | Plow Shop Pond |
| | | Nonacoicus Brook |

**Notes:**

*Innovative technology listed in USEPA VISITT Database.
WWTP = wastewater treatment plant
POTW = publicly owned treatment works
USEPA = U.S. Environmental Protection Agency

**TABLE 3-6**
**DESCRIPTION OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/TECHNOLOGY | DESCRIPTION OF PROCESS OPTIONS |
|---|---|
| No Action | |
| None | No action taken to reduce risk. |
| Minimal Action | |
| Institutional Controls | Zoning Restrictions. Through administrative controls, zone land around Shepley's Hill Landfill to prohibit residential development.<br><br>Deed Restrictions. Place deed restrictions on transferred land to prohibit future installation of drinking water wells. |
| Environmental Monitoring | Groundwater Monitoring. Perform water quality analyses to monitor contaminant concentrations and assess future environmental impacts. |
| Landfill Cap Maintenance | Landfill Cap System Maintenance. Continue to maintain existing landfill cap, complete any necessary repairs, and consider surface drainage improvements. |
| Containment | |
| Capping | Composite Barrier. A hydraulic barrier consisting of a flexible membrane liner in intimate contact with a low-permeability soil layer and covered with soil is installed over the landfill. |
| Hydraulic Barriers | Slurry Wall. Excavate a trench in overburden and fill with impervious backfill to provide a low-permeability cutoff wall.<br><br>Grout Curtain. Drill boreholes in overburden or bedrock at a designed spacing and fill with high pressure grout to provide a low-permeability cutoff wall.<br><br>Sheet Piling. Drive steel sheet piles into the overburden to provide a low-permeability cutoff wall. |
| Collection | |
| Extraction | Interceptor Trenches. Trenches, drains and piping used to passively collect (by gravity flow) groundwater. Trench installation is typically limited to a depth of approximately 40 feet, and cannot be used below the bedrock surface. |

**TABLE 3-6**
**DESCRIPTION OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/TECHNOLOGY | DESCRIPTION OF PROCESS OPTIONS |
|---|---|
| | Extraction Wells. Install extraction wells to collect groundwater. Wells are typically installed using augers in unconsolidated soils, and coring for bedrock wells. Wells are usually completed by placing a well screen to the desired depth and placing sandpack between well screen and aquifer materials. Well screens are chosen based on the characteristics of the aquifer material in which the well is placed. |
| Treatment | |
| Physical/Chemical | Aeration (Precipitation). Aerate the extracted groundwater to oxidize and precipitate inorganic compounds (i.e., arsenic and iron). Precipitated compounds are removed by settling in a clarifier and/or filtration.<br><br>Filtration. Use of a filter to remove total suspended solids and precipitated floc.<br><br>Chemical Precipitation. Chemical precipitation removes dissolved metals from aqueous wastes by chemically converting the metals to an insoluble form. The process produces a metal precipitate sludge and a treated effluent. The insoluble precipitate is typically removed by settling in a clarifier and/or filtration.<br><br>The most common precipitation processes are hydroxide, carbonate, and sulfide precipitation, and potassium permanganate oxidation/precipitation. Flocculation agents can be added to precipitation processes to encourage small suspended particles to agglomerate into larger particles that settle faster.<br><br>Air Stripping. Air stripping removes VOCs from extracted groundwater by contacting contaminated water with large volumes of air. Contaminants are transferred from the liquid phase to the gas phase, and carried off with effluent air.<br><br>UV Oxidation. UV oxidation involves the simultaneous application of UV radiation and chemical oxidants to degrade low concentrations of aqueous organics. Ozone and hydrogen peroxide have been documented as chemical oxidants. |

**TABLE 3-6**
**DESCRIPTION OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/TECHNOLOGY | DESCRIPTION OF PROCESS OPTIONS |
|---|---|
| | Activated Carbon. Activated carbon adsorption is a physical separation process in which organic and inorganic materials are removed from wastewater by sorption (i.e., the attraction and accumulation of one substance on another). Contaminants are removed by sorption onto available granular-activated carbon sites. |
| | Ion Exchange. Metal ions are removed from solution by exchange with ions electrostatically attached to a solid resin material. |
| | Fixation (In situ). Injection of chemicals into the groundwater to change the redox potential and render contaminants immobile. |
| | Air Sparging (In situ). In situ air sparging removes VOCs from groundwater by forcing air into the saturated zone. Contaminants dissolved in the groundwater volatilize into the air stream, and are transported to the vadose zone where they can be collected by a soil vapor extraction system. |
| | Electrolytic Separation (In situ). A d.c. electric field is imposed across electrode pairs placed in the ground. Metal ions migrate toward the cathode where they concentrate. The concentrated solution of contaminants is removed with groundwater from extraction wells. |
| Biological | Constructed Wetland. Passive flow of contaminated groundwater through a constructed wetland. Inorganics can be removed from the groundwater by several natural wetland processes including filtration and uptake by plant roots, adsorption of contaminants onto inorganic soil, neutralization and precipitation of contaminants. |
| | Bioremediation (In situ). Introduces microorganisms, nutrients, and oxygen into the groundwater using a matrix of injection wells and recirculation techniques.<br><br>Destroys organics through biodegradation, acclimation, degradation, or chemical conversion of organic wastes by either aerobic or anaerobic biological treatment processes. |

**TABLE 3-6**
**DESCRIPTION OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/TECHNOLOGY | DESCRIPTION OF PROCESS OPTIONS |
|---|---|
| | Fort Devens WWTP. Transport untreated groundwater to Fort Devens WWTP for treatment. This plant is a primary wastewater treatment facility located on North Post. |
| | Ayer POTW. Transport untreated groundwater to Ayer POTW for treatment. This plant is an activated sludge facility. |
| Discharge | |
| On Site | Fort Devens WWTP. Transport treated groundwater to Fort Devens WWTP. |
| | To Groundwater. Reinject treated groundwater meeting Massachusetts discharge limits outside limits of contamination. |
| Off Site | Ayer POTW. Transport treated groundwater to Ayer POTW. |
| | Plow Shop Pond. Discharge of treated groundwater meeting Massachusetts discharge limits to Plow Shop Pond. |
| | Nonacoicus Brook. Discharge of treated groundwater meeting Massachusetts discharge limits to Nonacoicus Brook. |

**Notes:**

VOCs = volatile organic compounds
UV = ultraviolet
WWTP = waste water treatment plant
POTW = publicly owned treatment works

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO: SITE-LIMITING CHARACTERISTICS | APPLICABILITY TO: WASTE-LIMITING CHARACTERISTICS | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| <u>No Action</u> | | | | |
| None | None.<br><br>Easily implementable. | None. | Retained. | Required for consideration by NCP.<br><br>Does not achieve remedial action objectives. |
| <u>Minimal Action</u> | | | | |
| Zoning Restrictions | Can only be implemented on property transferred by the Army. Would prohibit residential development within restricted area. | None.<br><br>Prevents future residential development. | Retained. | Retained for implementation on Army property.<br><br>Does not prevent off-site migration of contaminated groundwater. |
| Deed Restrictions | Can only be implemented on property transferred by the Army. Would prohibit installation of residential wells within restricted area. | None.<br><br>Prevents future residential ingestion of groundwater. | Retained. | Retained for implementation on Army property.<br><br>Does not prevent off-site migration of contaminated groundwater. |
| Groundwater Monitoring | None.<br><br>Easily implementable. Groundwater monitoring wells currently exist on site and may be used in a groundwater monitoring program. | None.<br><br>Would enable assessment of changes in contaminant concentrations over time. | Retained. | Would be considered in conjunction with other technologies. |

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| Landfill Cover System Maintenance | None.<br><br>Easily implementable. Conventional construction activities. | None.<br><br>Will continue to reduce groundwater contamination, which will minimize off-site migration of contamination. | Retained. | Would be considered in conjunction with other technologies. |
| Containment | | | | |
| Composite Barrier | None. | None. | Retained. | Would be considered in conjunction with other technologies. |

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| Slurry Wall | None.<br><br>Implementable. Barriers have been used successfully at other sites. Generally used in conjunction with capping which has already been performed at SHL. | Barrier design would require consideration of groundwater contaminants that may degrade barrier over time.<br><br>May reduce mobility of chemicals in groundwater. Could be used in conjunction with collection and treatment/disposal technologies to meet response objectives. Would minimize contaminated groundwater discharge to Plow Shop Pond. | Retained. | |
| Grout Curtain | Implementable. Compared to slurry wall, less controlled installation, and less likely to achieve an extensive low permeability seal in overburden. Effective at sealing fractures in bedrock. | Similar effectiveness as slurry wall. | Retained | Retained for use in bedrock only. |

continued

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| Sheet Piling | Implementable. Compared to slurry wall, less controlled installation, less likely to achieve low permeability seal due to poor connections between the steel sheets. | Similar effectiveness as slurry wall. | Eliminated. | Not applicable to bedrock; inappropriate for deep overburden. |
| Collection | | | | |
| Interceptor Trenches | Not implementable at SHL. Construction only practical to a depth of approximately 40 feet. Contaminated ground-water is deeper than 40 feet at several locations. Fine sands may create construction difficulties. | Effective technology to passively collect contaminated groundwater. Would prevent migration of contaminated groundwater. | Eliminated. | |
| Extraction Wells | None.<br><br>Implementable. Commonly used technology. Produces very little contaminated soil requiring disposal. | None.<br><br>Effective mechanism to collect contaminated groundwater. Would prevent migration of contaminated groundwater. | Retained. | Several wells would have to be strategically located so that the cones of depression intersect and capture all contaminated groundwater. |

continued

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO SITE-LIMITING CHARACTERISTICS | APPLICABILITY TO WASTE-LIMITING CHARACTERISTICS | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| Treatment | | | | |
| Aeration | None.<br><br>Easily implementable for extracted groundwater.<br><br>Precipitated sludge may require disposal at a RCRA TSD facility. | None.<br><br>Effective method for oxidation and precipitation of arsenic and iron.<br><br>Requires chemical oxidant to be effective for manganese. Groundwater may require additional treatment to achieve Maximum Contaminant Levels (MCLs). | Retained. | |
| Filtration | None.<br><br>Easily implementable for extracted groundwater.<br><br>Filtered solids may require disposal at a RCRA TSD Facility | None.<br><br>Effective for removal of total suspended solids and precipitated floc. | Retained | |

continued

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| Chemical Precipitation | None.<br><br>Easily implementable for extracted groundwater.<br><br>Precipitated heavy metal sludge would require treatment/disposal. | None.<br><br>Effective treatment for removing the groundwater contaminants (As, Fe, Mn). Precipitation may also remove low levels of a few organics in groundwater.<br><br>Groundwater may require additional treatment to achieve MCLs. | Retained. | |
| Air Stripping | None.<br><br>Easily implementable commonly used technology. | Does not provide effective treatment for the primary groundwater contaminants (As, Fe, Mn). | Eliminated. | |
| UV Oxidation | None.<br><br>Implementable. Commonly used technology. Self-contained and mobile units available. | Does not provide effective treatment for the primary groundwater contaminants (As, Fe, Mn). | Eliminated. | |

continued

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| Activated Carbon | None.<br><br>Implementable. Commonly used technology. Self contained and mobile units available.<br>Waste carbon considerably more toxic than influent water, special disposal, regeneration or destruction is required. | Primarily a treatment for organic contaminants. Not proven effective for inorganics. | Retained | Retained as a pretreatment step to improve ion exchange system performance. Will also provide treatment for 1,2-dichloroethane and dichlorobenzenes |
| Ion Exchange | None.<br><br>Implementable. Self-contained, mobile units available. High technical feasibility and demonstrated performance. | None.<br><br>Effectively removes As, Mn, Fe, and inorganics from groundwater. | Retained. | |

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| | Resin regeneration brine is considerably more toxic than influent water; special disposal or destruction is required. | Resins are often selective, and may be susceptible to fouling by high concentrations of TSS, and precipitated inorganics. Filtration prior to treatment may be required. | | |
| Fixation (In situ) | Shallow groundwater in several locations at SHL may limit injection capacity.<br>Wells may become plugged by precipitation of minerals caused by chemical reactions of soil/aquifer constituents with injected nutrients.<br>Does not require groundwater extraction. | None.<br>Hydrogen peroxide has been shown to effectively oxidize Fe. As has been shown to co-precipitate with Fe. | Retained. | |
| Air Sparging (In situ) | Could impact integrity of cap at SHL.<br>Would not meet remedial response objectives.<br>Does not require groundwater extraction. | Not effective treatment for inorganics. | Eliminated. | |

**Table 3-7**
**Screening of Groundwater Technologies**

**Shepley's Hill Landfill Operable Unit**
**Feasibility Study for Group 1A Sites**
**Fort Devens, MA**

| General Response Action/ Process Option | Applicability to: Site-Limiting Characteristics | Applicability to: Waste-Limiting Characteristics | Screening Status | Comments |
|---|---|---|---|---|
| Electrolytic Separation (In situ) | Large power requirements.<br><br>Does not require groundwater extraction | Has been demonstrated effective for removal of ionized inorganics at bench scale. Innovative technology. Not proven at full scale. | Eliminated. | |
| Constructed Wetland | None. Low maintenance. Large spatial require-ments to ensure low flow rates, and minimal depth of water in wetland. | Natural and constructed wetlands have been proven effective at removing some inorganics (i.e., Fe, Mn) from groundwater through natural processes. Effectiveness for removal of arsenic is not proven. Inorganics would be concentrated in wetland soil and organic material. | Retained. | |
| Bio-remediation (In situ) | Wells may become plugged by precipitation of minerals caused by chemical reactions of soil/aquifer constituents with injected nutrients. | Biological treatment will not remove arsenic, iron or manganese, the primary groundwater contaminants. | Eliminated. | |

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| | Does not require groundwater extraction. | | | |
| Fort Devens WWTP | Would require piping groundwater to existing Fort Devens sewer system. | Fort Devens has a primary wastewater treatment facility, not designed to treat inorganics. | Eliminated. | |
| Ayer POTW | Would require piping groundwater to Ayer sewer system. | None. It is estimated that hydraulic capacity exists, and that untreated groundwater would meet pre-treatment standards for Ayer POTW. | Retained. | Preliminary discussions with the POTW indicate a willingness to consider accepting extracted groundwater if pretreatment requirements are met. |
| Discharge<br>Fort Devens WWTP | Would require piping groundwater to existing Fort Devens sewer system.<br>Facility currently has a notice of non-compliance. | Fort Devens has a primary wastewater treatment facility not designed to treat inorganics. | Eliminated. | |

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| To Groundwater | Limited by recharge/ permeability rates of soils and availability of suitable nearby discharge site. On-site discharge of treated groundwater would reduce administrative burden of obtaining discharge permit. | None, as long as water has been treated to acceptable discharge standards (most likely MCLs). | Eliminated. | Only available discharge location is north of SHL. Water table is approximately 5 feet bgs and mounding could result in runoff into Nonacoicus Brook. |
| Ayer POTW | Would require piping groundwater to Ayer sewer system. | None. It is estimated that hydraulic capacity exists and treated groundwater would meet pretreatment standards for Ayer POTW. | Retained. | Preliminary discussions with the POTW indicate a willingness to consider accepting extracted groundwater if pretreat-ment requirements are met. |
| Plow Shop Pond | Negative public perception may exist for discharge to Plow Shop Pond. | None. If contaminants are treated to acceptable limits. | Eliminated. | |

**TABLE 3-7**
**SCREENING OF GROUNDWATER TECHNOLOGIES**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| GENERAL RESPONSE ACTION/ PROCESS OPTION | APPLICABILITY TO | | SCREENING STATUS | COMMENTS |
|---|---|---|---|---|
| | SITE-LIMITING CHARACTERISTICS | WASTE-LIMITING CHARACTERISTICS | | |
| Nonacoicus Brook | NPDES permit required for off-site discharge to Nonacoicus Brook. Estimated 60 dilutions available in brook at 7Q10 flow. | None. If contaminants are treated to acceptable limits. | Retained. | Nonacoicus Brook provides greater opportunity for discharge mixing than does Plow Shop Pond. |

**Notes:**

| | | |
|---|---|---|
| NCP | = | National Contingency Plan |
| MCLs | = | maximum contaminant levels |
| As | = | Arsenic |
| Mn | = | Manganese |
| Fe | = | Iron |
| TDS | = | total dissolved solids |
| WWTP | = | waste water treatment plant |
| POTW | = | publicly owned treatment works |
| BOD | = | biological oxygen demand |
| SHL | = | Shepley's Hill Landfill |
| CSBL | = | Cold Spring Brook Landfill |
| NPDES | = | National Pollutant Discharge Elimination System |
| RCRA | = | Resource Conservation and Recovery Act |
| TSD | = | treatment, storage and disposal |
| UV | = | ultraviolet |
| TSS | = | total suspended solids |
| bgs | = | below ground surface |
| 7Q10 | = | Average 7-day 10-year low flow |

## TABLE 3-8
## SCREENING SUMMARY OF TECHNOLOGIES

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| GENERAL RESPONSE ACTION/PROCESS OPTION | RETAINED | ELIMINATED |
|---|---|---|
| **GROUNDWATER** | | |
| No Action | | |
| None | X | |
| Minimal Action | | |
| Zoning Restrictions | X | |
| Deed Restrictions | X | |
| Groundwater Monitoring | X | |
| Landfill Cover System Maintenance | X | |
| Containment | | |
| Composite Barrier | X | |
| Slurry Wall | X | |
| Grout Curtain | X | X |
| Sheet Piling | | |
| Collection | | |
| Interceptor Trench | | X |
| Extraction Wells | X | |
| Treatment | | |
| Aeration | X | |
| Filtration | X | |
| Chemical Precipitation | X | |
| Air Stripping | | X |
| UV Oxidation | | X |
| Activated Carbon | X | |
| Ion Exchange | X | |
| Fixation (In situ) | X | |
| Air Sparging (In situ) | | X |
| Electrolytic Separation (In situ) | | X |
| Constructed Wetland | X | |
| Bioremediation (In situ) | | X |
| Fort Devens WWTP | | X |
| Ayer POTW | X | |
| Discharge | | |
| Fort Devens WWTP | | X |
| Groundwater | | X |
| Ayer POTW | X | |
| Plow Shop Pond | | X |
| Nonacoicus Brook | X | |

**Notes:**

UV = ultraviolet
WWTP = wastewater treatment plant
POTW = publicly owned treatment works
RCRA = Resource Conservation and Recovery Act
TSD = treatment, storage and disposal

W0029436T2.080/1

# 4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, technically feasible process options retained following the screening described in Section 3 are combined to form remedial action alternatives. Alternatives are developed to attain the remedial action objectives discussed in Section 3, using the following General Response Actions: (1) No Action; (2) Limited Action; (3) Containment; (4) Collection/Treatment/ Discharge; and (5) Collection/Discharge.

The developed remedial alternatives are then screened with respect to the criteria of effectiveness, implementability, and cost to meet the requirements of CERCLA and the NCP. The objective of this screening step is to eliminate impractical alternatives or higher cost alternatives (i.e., order of magnitude cost differences) that provide little or no improvement in effectiveness or implementability over their lower cost counterparts.

## 4.1 DEVELOPMENT OF ALTERNATIVES FOR SHEPLEY'S HILL LANDFILL OPERABLE UNIT

As discussed in Section 3, this FS Report evaluates only the Shepley's Hill Landfill Operable Unit. Potential remedial actions to address risks associated with exposure to Plow Shop Pond sediments will be evaluated in an FS for the Plow Shop Pond Operable Unit.

Ten remedial alternatives were developed for the Shepley's Hill Landfill Operable Unit to address remedial action objectives presented in Section 3. In assembling these alternatives, general response actions and process options chosen to represent the various technology types for the medium of concern are combined to form alternatives for the site as a whole (USEPA, 1988b). Alternatives were developed to provide a range of options consistent with USEPA RI/FS guidance (USEPA, 1988b).

These alternatives include:

- Alternative SHL-1: No Action

- Alternative SHL-2: Limited Action
- Alternative SHL-3: Containment/Collection/Short-term Ex Situ Treatment/Surface Water Discharge
- Alternative SHL-4: Containment/In Situ Oxidation
- Alternative SHL-5: Collection/Ion Exchange Treatment/Surface Water Discharge
- Alternative SHL-6: Collection/Chemical Precipitation Treatment/ Surface Water Discharge
- Alternative SHL-7: Collection/Constructed Wetland Treatment/Surface Water Discharge
- Alternative SHL-8: Groundwater Barrier/In Situ Oxidation
- Alternative SHL-9: Collection/Discharge to POTW
- Alternative SHL-10: Installation of RCRA Cap

### 4.1.1 Alternative SHL-1: No Action

The No Action alternative does not include any additional remedial action components to reduce or control potential risks at the Shepley's Hill Landfill Operable Unit. In addition, existing post-closure activities such as monitoring and maintenance would be discontinued. The No Action alternative will not be evaluated according to screening criteria; it will pass through screening to be evaluated during the detailed analysis as a baseline for the other retained alternatives (USEPA, 1988b).

### 4.1.2 Alternative SHL-2: Limited Action

The Limited Action alternative would include institutional controls, groundwater monitoring, maintenance of the existing Shepley's Hill Landfill cover system, and storm water drainage improvements. Institutional controls in the form of zoning and deed restrictions would be implemented with Alternative SHL-2, so at the time of property transfer from the U.S. Army to the new owner, this land could not be developed for residential use. Deed restrictions would also be implemented to prohibit placement of drinking water wells in this area. Residential development within this area is unlikely because of the proximity of the landfill and the railroad.

Alternative SHL-2 would rely primarily on the effectiveness of the existing cover system and includes cap repairs and surface drainage improvements to maximize runoff from the cap and minimize off-site contaminant migration. Long-term groundwater and landfill gas monitoring programs with five-year site reviews are proposed for the Limited Action alternative. The five-year reviews would be conducted to evaluate whether the Limited Action alternative continues to protect human health and the environment.

### 4.1.3 Alternative SHL-3: Containment/Collection/Short-term Ex Situ Treatment/Surface Water Discharge

This alternative includes containment of the groundwater within the landfill area, and reduction of inflow of groundwater under the landfill. At present, the areas south and west of the landfill are upgradient areas from which groundwater in the sandy overburden or bedrock can enter the regional aquifer under the landfill. A combination of a slurry wall and grout curtain would be designed to seal off upgradient groundwater sources and minimize groundwater flow through the landfill area. These containment components will be evaluated using groundwater modeling in Subsection 4.2. As a potential enhancement feature for containment, rock drains will also be modeled in Subsection 4.2. Alternative SHL-3 also involves short-term extraction and treatment of contaminated groundwater beneath the landfill, and discharge of treated groundwater to Nonacoicus Brook (Figure 4-1).

As discussed in Section 1, Shepley's Hill Landfill was closed in accordance with Massachusetts Solid Waste Regulations, and is covered with a low-permeability cap containing a 30-mil PVC geomembrane. This cap will continue to minimize vertical infiltration to landfilled waste. In addition the existing cap will be extended over the slurry wall grout curtain, so the two will work as a system to minimize inflow of water.

Approximately 4,500 feet of slurry wall ranging in depth from near ground surface to 80 feet below ground surface (depth to bedrock) is proposed around the southern and eastern boundaries of the landfill. The slurry wall would extend from the edge of the bedrock outcrop near well SHL-15 to a point south of SHL-5 (see Figure 4-1). There are several different types of slurry walls, each providing different benefits. The four most common types are (1) soil/concrete, (2) cement/bentonite, (3) plastic/concrete, and (4) solid concrete. These types of walls vary in strength and permeability, with the soil/bentonite and plastic/ concrete providing the lowest permeabilities (less than $1x10^{-7}$ cm/sec). Solid concrete is the strongest type of wall (used more for structural applications).

The objective of the slurry wall at Shepley's Hill Landfill is to provide a low-permeability barrier to groundwater; therefore, the soil/bentonite wall may be an appropriate choice. The most appropriate type of slurry wall construction will be evaluated further during the detailed analysis section of this report. A soil/bentonite slurry would be prepared from soil excavated from the site, dry bentonite, and water. Some soils with a higher percentage of fines than contained in excavated soil may need to be brought in from off-site. At Shepley's Hill Landfill, there is no clay to key the base of the slurry wall into; it would sit on top of the bedrock surface. Therefore, some groundwater leakage would be expected under the slurry wall.

On the western side of Shepley's Hill Landfill, the bedrock outcrop extends north from well SHL-15 to approximately well SHL-23. It is proposed that a grout curtain cutoff wall, approximately 2,500-feet long, be installed in this outcrop to minimize groundwater flowing from the upgradient bedrock. The cutoff wall would be constructed by installing borings at an estimated spacing of 5 feet on center to an estimated depth of approximately 20 feet. Grout would then be injected to fill the fractures between each boring. Additional field data would be required before final design to better define the extent of bedrock fractures, which would allow for a more accurate estimate of boring depth, spacing, and grout mixture.

Construction of the 4,500-foot long slurry wall and the 2,500-foot long grout curtain should minimize future groundwater inflow to Shepley's Hill Landfill. The natural gradient of the site would cause the groundwater within the confines of the cap, slurry wall and grout curtain to discharge to the north. Since further infiltration of groundwater into this area would be minimized, over time this alternative would likely result in a lowering of the groundwater table. Uncontaminated groundwater flowing from the south and west of the landfill would be diverted around the slurry wall and grout curtain. As part of the modeling in Subsection 4.2, rock drains will be evaluated as potential containment components to aid in groundwater diversion.

Extraction wells would be installed along the eastern edge of the landfill within the area contained by the slurry wall to pump contaminated groundwater from the contained area to a treatment system. Groundwater would be pumped and treated at a rate equaling the natural drainage from the enclosed area plus leakage under the slurry wall.

The number of extraction wells and the pump rate required to extract contaminated groundwater will be based on modeling estimates described in Subsection 4.2. Although groundwater treatment technologies will not be evaluated in this alternative, the most promising ex situ treatment technologies discussed in Subsections 4.1.5 and 4.1.6 would be combined with this containment alternative during detailed analysis. Treated groundwater would be discharged to Nonacoicus Brook.

This alternative would also include all aspects of the Limited Action alternative, including zoning and deed restrictions, surface drainage improvements, cover system maintenance, long-term groundwater and landfill gas monitoring, and five-year site reviews.

### 4.1.4 Alternative SHL-4: Containment/In Situ Oxidation

This alternative proposes the same containment scenario as Alternative SHL-3. Groundwater contained within the confines of the cap, slurry wall, and grout curtain would be allowed to flow along its natural gradient in a northerly direction. Contaminated groundwater flowing through the opening between the northern extent of the slurry wall and the grout curtain, would be treated by in situ oxidation (Figure 4-2).

In situ oxidation is a treatment technology that involves injection of a chemical into groundwater to change the redox potential and render inorganic contaminants immobile. Hydrogen peroxide would be injected to oxidize the iron in the groundwater and co-precipitate arsenic and other inorganics (Rouse, 1993).

Precipitated inorganics would remain in the aquifer. Injection wells would be installed at the north end of the landfill for chemical injection into the aquifer.

Hydrogen peroxide would be stored on site near the injection well(s). A pipeline approximately 3,000-feet long would be installed to deliver potable water from an on-post water line to the treatment area. Hydrogen peroxide would be mixed with the potable water to the required concentration, and this mixture would be pumped into the aquifer through injection wells. Inorganics would precipitate out of the groundwater in the vicinity of the injection wells. Treated groundwater would continue to flow north and discharge into Nonacoicus Brook and the Nashua River. The proposed location for injection is between wells SHL-23 and SHL-5. The requirements and effectiveness of the injection system will be evaluated using groundwater modeling in Subsection 4.2. Additionally, a treatability study or pilot scale study would be required to evaluate the performance of this alternative.

As in Alternative SHL-3, it is anticipated that the groundwater table within the landfill will be lowered because of the installation of the slurry wall and grout curtain. Chemical injection for in situ oxidation treatment may be reduced or eliminated once the groundwater table within the containment area is lowered, and remedial action objectives have been met.

This alternative would also include all aspects of the Limited Action alternative, including zoning and deed restrictions, surface drainage improvements, cover system maintenance, long-term groundwater and landfill gas monitoring and five-year site reviews.

### 4.1.5 Alternative SHL-5: Collection/Ion Exchange Treatment/Surface Water Discharge

Alternative SHL-5 includes: (1) collection of contaminated groundwater prior to migrating off-site; (2) ion exchange treatment to reduce contaminants to acceptable discharge concentrations; and (3) discharge of treated groundwater to Nonacoicus Brook. A groundwater barrier to the west of Plow Shop Pond may be required to prevent the extraction system from pulling water from the Pond. This barrier would consist of a soil/bentonite slurry wall constructed along the eastern edge of the landfill. This slurry wall would extend approximately 1,600 feet south from well SHL-21, and would intercept the most heavily contaminated groundwater associated with Shepley's Hill Landfill (Figure 4-3). The slurry wall would range in depth from 50 to 80 feet. The effectiveness of a slurry wall will be evaluated through groundwater modeling in Subsection 4.2. Extraction system design and pumping requirements will be evaluated using groundwater modeling in Subsection 4.2.

Alternative SHL-5 proposes that the groundwater be piped to an ion exchange treatment system. The treatment system may be constructed on the 10-acre open area south of Plow Shop Pond as few other open areas exist on the site. The specific location and layout of the treatment system will be discussed in greater detail during the detailed analysis.

Ion exchange treatment is a reversible process in which inorganic ions are removed from the aqueous phase by exchange with relatively non-toxic ions held by an ion exchange material in contact with the water. The exchange material can consist of natural clay, zeolites or synthetic resins. The extent to which the exchange of anions and/or cations occurs depends on the nature and concentration of the ion, the type of resin, and its saturation.

The ion exchange process may be operated using batch or continuous modes. Important factors to consider in the design of an ion exchange system include: selection of appropriate resin to remove contaminants of concern, optimization of column flow-through rates, and determination of the required regeneration rate. Specific ion exchange media, including resins to effectively remove arsenic and other inorganics in the groundwater, will be evaluated during detailed analysis. A treatability study would be required to evaluate various ion exchange media.

Contaminants in the resin regeneration brine created during treatment would be considerably more concentrated than in the influent groundwater and likely would be disposed of at a RCRA-permitted treatment, storage, and disposal (TSD) facility.

Following treatment, the groundwater would be discharged into Nonacoicus Brook.

Because the source material (Shepley's Hill Landfill) will remain on site, zoning, deed restrictions, surface drainage improvements, cover system maintenance, long-term groundwater and landfill gas monitoring, and five-year site reviews would be implemented as a part of this alternative.

### 4.1.6 Alternative SHL-6: Collection/Chemical Precipitation Treatment/Surface Water Discharge

This alternative involves the same groundwater collection system as discussed in Alternative SHL-5 (including a potential groundwater barrier). Groundwater would then be piped to an Aeration/Chemical Precipitation treatment system, and treated water would be discharged to Nonacoicus Brook.

Aeration of groundwater would oxidize iron and arsenic to less soluble forms that are amenable to precipitation. Chemicals to adjust pH and flocculants would then be combined with aerated groundwater to continue precipitation of iron, arsenic, and other inorganic contaminants. Precipitated metals would be separated from treated groundwater in a settling tank.

There are three common types of chemical addition systems that can be used for chemical precipitation treatment; (1) the carbonate system, (2) the hydroxide system, and (3) the sulfide system. Their use depends on the conditions that must be achieved for minimum solubility of inorganics in the waste stream. During detailed analysis, these systems would be evaluated for the specific inorganics in Shepley's Hill groundwater. A treatability study would be required to evaluate different chemical addition systems for use in this alternative.

Treated groundwater would be discharged to Nonacoicus Brook. Following the determination of whether the precipitated metal treatment sludge is hazardous or nonhazardous, it would be transported off-site and disposed of at a RCRA-permitted TSD facility or a solid waste landfill.

Zoning, deed restrictions, surface drainage improvements, cover system maintenance, long-term groundwater and landfill gas monitoring, and five-year site reviews would be included as a part of this alternative.

### 4.1.7 Alternative SHL-7: Collection/Constructed Wetland Treatment/Surface Water Discharge

Alternative SHL-7 proposes the same groundwater collection system as Alternatives SHL-5 and SHL-6. This alternative, however, proposes that groundwater be extracted and piped to a wetland constructed on-site to treat contaminated groundwater. The treated water would be piped to a discharge point in Nonacoicus Brook.

This wetland could be constructed in the sandy open area to the south of Plow Shop Pond. Groundwater would be pumped to this area and allowed to flow through the constructed wetland at a low velocity. Contaminants would be removed by one or more of the following natural processes: filtering of suspended materials from the water, uptake of contaminants through roots of plants, adsorption or exchange of contaminants onto organic matter, and neutralization and precipitation of contaminants. As the water exits the wetland, it would be piped to Nonacoicus Brook for discharge. Accumulated biomass from the wetland may have to be removed over time. If this biomass does not pass the Toxicity Characteristic Leachate Procedure (TCLP) test, it would be transported off-site and disposed of in a RCRA-permitted TSD facility. Otherwise the wetland would remain.

Zoning, deed restrictions, surface drainage improvements, cover system maintenance, long-term groundwater and landfill gas monitoring, and five-year site reviews would be included as part of this alternative.

### 4.1.8 Alternative SHL-8: Groundwater Barrier/In Situ Oxidation

Alternative SHL-8 provides in situ treatment as the groundwater flows north toward Nonacoicus Brook, and passive discharge of treated groundwater to Nonacoicus Brook.

A groundwater barrier to the west of Plow Shop Pond may be required to prevent injection wells from forcing groundwater into the Pond. This barrier would consist of a soil/bentonite slurry wall similar to that presented in Alternatives SHL-5, SHL-6 and SHL-7 and may help to direct easterly flowing groundwater north along a natural gradient. The groundwater barrier will be evaluated through groundwater modeling in Subsection 4.2.

A line of injection wells would be installed between the northern extent of bedrock at well SHL-23 and the northern extent of the slurry wall, south of well SHL-5 (Figure 4-4). As described in Alternative SHL-4, a mixture of hydrogen peroxide and potable water would be injected into groundwater to oxidize iron and coprecipitate arsenic and other inorganics. This alternative includes installation of a 3,000-foot pipeline to deliver potable water from an on-post water line to the treatment area. The hydrogen peroxide would be stored on-site near the groundwater injection wells. Treated groundwater would continue to flow north and discharge into Nonacoicus Brook and the Nashua River, and precipitated inorganics would remain in the aquifer in the vicinity of the injection wells. The requirements and effectiveness of the injection system will be evaluated using groundwater modeling in Subsection 4.2.

Zoning, deed restrictions, surface drainage improvements, cover system maintenance, long-term groundwater and landfill gas monitoring, and five-year site reviews would be included as a part of this alternative.

### 4.1.9 Alternative SHL-9: Collection/Discharge to POTW

Alternative SHL-9 proposes the same groundwater collection system as Alternatives SHL-5, SHL-6, and SHL-7. Groundwater would be pumped from the extraction wells and piped to the Town of Ayer Publicly Owned Treatment Works (POTW). The Town of Ayer POTW is a 1.79 million gallons per day (mgd) capacity activated sludge facility discharging to the Nashua River.

Current data indicate that water pumped to the Town of Ayer POTW would meet the facility's required pretreatment standards. Periodic sampling would monitor compliance with these standards. In the event exceedances occur, pretreatment would be required prior to discharging.

Zoning, deed restrictions, surface drainage improvements, cover system maintenance, long-term groundwater and landfill gas monitoring, and five-year site reviews would be included as a part of this alternative.

### 4.1.10 Alternative SHL-10: Installation of RCRA Cap

Alternative SHL-10 proposes installation of a composite cover system consisting of a geomembrane overlying a geosynthetic clay liner (GCL) on top of the existing cover system. Similar to Alternative SHL-2, this alternative would include institutional controls in the form of zoning and deed restrictions, long-term groundwater and landfill gas monitoring, and five-year site reviews. Evaluation of potential surface drainage improvements would be included as part of cover design activities.

## 4.2 Groundwater Modeling and Screening of Alternatives

This subsection describes the groundwater model developed for Shepley's Hill Landfill, presents groundwater modeling results, and, based on modeling results and screening criteria (i.e., effectiveness, implementability, and cost), screens the alternatives developed in Subsection 4.1.

### 4.2.1 Description of Shepley's Hill Landfill Groundwater Model

Groundwater modeling was conducted for the Shepley's Hill Landfill site to provide an additional basis for screening remedial alternatives for groundwater. Based on previous regional groundwater modeling projects for this area, Engineering Technologies Associates, Inc. (ETA) was assigned the task of constructing the groundwater model. ABB-ES utilized this model to evaluate present (capped) conditions, simulate the proposed alternatives, screen out impractical or inefficient alternatives, and refine the remaining alternatives. These steps are described in the following sections of this FS report.

ETA constructed a groundwater model of the site consisting of two layers, representing the overburden and upper fractured bedrock water-bearing units. The model covered an approximate area of 3,880 feet by 4,280 feet, extending from the crest of Shepley's Hill on the west to Plow Shop Pond on the east, and from approximately 400 feet north of the landfill to nearly 1,000 feet south of it. The model area was discretized (subdivided into an array of smaller blocks) by a grid with uniform 40-foot squares. The U.S. Geological Survey (USGS) groundwater model code MODFLOW-P was used, and the model was calibrated in a transient mode to groundwater level information collected from 1986 to 1993. Hydrogeologic parameter input data was based on RI Addendum Report, other available information and data, and on ETA's regional modeling and recent pumping test at a well along the eastern edge of Shepley's Hill Landfill. With the exception of the groundwater divide along the crest of Shepley's Hill and the ponds, there were no other convenient natural boundaries, so heads from the regional modeling were used as a basis for specifying constant heads around the remainder of the perimeter of the model. During calibration, a short section of the northern model perimeter showed boundary effects, and this was converted to a general head flux-type boundary to allow a better calibration. Details of the model construction and calibration are contained in ETA's report appended to this FS report as Appendix A.

ETA also ran two scenarios to model long-term conditions (100 years from the present): (1) continued current (capped landfill) conditions and estimated average annual rainfall (net infiltration); and (2) simulated long-term conditions if the landfill had not been capped. Model mass balances showed a marked decrease (more than 70%) in the total simulated discharge to Plow Shop Pond for the capped versus non-capped runs. This improved situation due to the cap is discussed in ETA's appended report (see Appendix A).

ABB-ES utilized the transient long-term model and converted it to a steady-state model. This conversion allowed the use of the USGS particle tracking program MODPATH to graphically display groundwater streamlines for groundwater passing beneath, or originating in the northern and easterly portions of the landfill. Particle tracks in Layer 1 (overburden) are shown as Figures 4-5 and 4-6, for the long-term capped and uncapped conditions, respectively. Particle tracks in Layer 2 (rock) are nearly identical to those in Layer 1 for all simulations. In Figures 4-5 and 4-6, the impact of the high bedrock saddle in the center of the landfill is shown by the lack of groundwater in the overburden in the central portion of the landfill, and the extensive separation of the groundwater flows north and south of the high bedrock saddle. Groundwater flow to the north is focused toward the narrow discharge boundary to the north. Diminishing flowpath width to the north is compensated for by the rapidly increasing saturated thickness of the overburden as the bedrock surface dips sharply to the north. Flow in the southern portion of the model moves primarily toward the east, with an element of flow near the central eastern side of the landfill turning north. Landfill capping has significantly reduced the total amount of water in the landfill area. Flow in the capped landfill scenario is directed more northerly due to the relatively stronger influence of the surface water elevations in the ponds. The cap, then, has had a substantial effect in altering local groundwater flow and in reducing potential impact on the ponds by contaminated groundwater. The capped scenario output suggests almost total diversion of groundwater flows from the landfill away from the northern portions of Plow Shop Pond. Monitoring of groundwater in the southern landfill flowpaths (i.e., monitoring wells SHL-7, SHL-18, and SHM-93-18B) does not indicate significant contamination in groundwater in that area. Residual contaminant levels observed in groundwater near the northern portions of Plow Shop Pond would be expected to decrease over time due to flushing with clean groundwater and pond leakage.

### 4.2.2 Sensitivity Analyses

During testing of the model, several model runs were performed to examine the sensitivity of the model to changes in boundary conditions and variations in precipitation/recharge. These runs and their results are presented in this subsection, and implications of the sensitivity analysis for the present and possible future use of the model are discussed.

The principal examined sensitivities included the following:

1. sensitivity to variations in overall net recharge
2. sensitivity to variations in pond elevation
3. sensitivity to uncertainties in top of rock elevation beneath the landfill cover
4. sensitivity to enhanced recharge in the southern part of the model
5. sensitivity to the use of a general head boundary at the northern perimeter of the model
6. sensitivity to variations in specific yield

With the exception of the runs evaluating the effect of choice of specific yield values, sensitivity runs were made for long-term or steady-state conditions.

**4.2.2.1 Variations in Overall Net Recharge.** To examine a suitable range of possible changes in average net recharge over the site, the reported total annual precipitation over the years 1986-92 was reviewed. The values ranged from 42.0 to 51.6 inches per year, or about plus or minus 10 percent about the mean of 47.1.

Since the model had been calibrated to a mean of about 19 inches per year of net recharge, the sensitivity analysis consisted of varying the recharge over the model by plus and minus 10 percent, or about plus or minus 2 inches per year. This was done through the recharge matrix of MODFLOW, varying the multiplier constant in the MODFLOW UDREL2 header line by plus and minus 10 percent, respectively. No attempts were made to recalibrate the model or adjust other parameters. It should be noted, however, that prolonged periods of either higher or lower net recharge would likely result in similar increases or decreases in perimeter heads and in pond elevations, and that the response noted in these sensitivity runs would likely be muted. As it is, while there were general changes in groundwater elevation in the center of the model of about plus or minus one foot, there was no perceptible difference in flow direction of particles introduced in the eastern and northern sections of the model under present conditions (Figures 4-7 and 4-8). The model does not appear to be sensitive to moderate changes in recharge relative to flow direction, and the difference in volume of water introduced in the model would be controlled by modifications in pumping rates for engineered alternatives, if needed.

**4.2.2.2 Variations in Pond Elevation.** The head representing the pond boundaries was selected as representative of pond level. During the course of the year, pond levels vary seasonally. These transient conditions are likely to have only temporary and slight effects on groundwater flows and directions as embodied in the steady-state model. It is of interest to note, however, what the effect would be for a long-term change in the average elevation of the pond. These sensitivity runs were also coupled with examination of the alternate representation of the ponds by the river package under MODFLOW. The representation of the ponds by the river package allowed them to be included in the model, and resulted in a much more stable model in the case of lower heads in the model. (The overburden is thin in the central portion of the model, and reduction of groundwater heads by lowering the perimeter constant head caused the model to become critically unstable and fail.) The model was not calibrated under the river package representation, since pond bottom conductances and vertical gradients near the edge of the pond are not known. A no-flow boundary was assumed through the axis of Plow Shop Pond in this alternate representation. The present and alternate representations of the groundwater flow in the vicinity of the ponds are similar, and for the purposes of the comparison of alternatives modeling, indistinguishable.

The alternative representation of the ponds by the river package does allow a simpler and more stable comparison of the effects of greater or lower pond elevation. This was done by specifying a one foot increase and decrease about the calibrated model value of 216.9 feet in the river package. The results are shown in Figures 4-9 and 4-10 and in Table 4-1. Prolonged elevation changes in the pond do shift the location along the shoreline where the boundary becomes either gaining or losing. However, this does not significantly alter pathlines originating within the landfill. Changes of head near the center of the landfill (row 55, column 55) varied by less than a foot as a result of the variation of the pond elevation by -1 to +1 foot. As seen on the tabulation of flows into and out of the pond, the lower pond stage increases flux into the pond, and the higher head has the reverse effect. Since the alternate representation of the ponds could not be calibrated, these flux rates, while reasonable, must be regarded in a relative sense. In conclusion, flow directions and rates in the model are relatively insensitive to moderate changes in pond elevation.

**4.2.2.3 Uncertainties in Top of Rock Elevation**. The top of rock in the calibrated model represents an interpretation of information obtained from boring logs and from geophysical methods which defined top of rock along the eastern and southern edges of the landfill. Previous interpretations of top of rock (E&E, 1993) had portrayed a north-south trending valley beneath the landfill, but this interpretation was based on fewer boring logs, and the geophysical information was not yet available. Nevertheless, no direct information exists for top of rock beneath the central portion of the landfill. The present interpretation, postulating a bedrock high, or ridge, beneath the landfill, appears to pose a potential for influencing flows. This is true from the standpoint of providing only a thin layer of more permeable overburden for flow in the center of the model, as well as possibly bifurcating the overburden flow system and forcing flows to the east and north on the south and north sides of the ridge, respectively. Certainly if the rock surface were higher than interpreted, this bifurcation would almost certainly occur, as saturated flows in some portions of the model overburden are only a couple of feet thick.

To evaluate the influence of the interpreted ridge, a region of uncertainty in the top of rock was identified in the model (Figure 4-11), and the modeled top of rock was lowered first 10 feet, and then an additional 15 feet (25 feet total) in this area for sensitivity runs. The bottom of layer 2 was also adjusted to maintain transmissivity as in the calibrated model. In lowering the top of rock, it was expected that some overburden nodes which had dried out in the calibrated model would now be wet. Inactive nodes in this area were successively activated, expanding the wetted overburden area until the simulated results indicated that the western edge of the wetted area had been reached. The lowering of the top of rock (Figures 4-12 through 4-15) changed flow patterns only slightly: allowing slightly more flow to be directed north, while slightly less flow moved easterly toward Plow Shop Pond. The lowering of the modeled rock surface also allowed more saturated overburden in the center of the model, and flow directions and gradients more closely resembled those seen in the rock. A slightly broader flow pattern was seen in the runs with the lower rock surface, although the northern flow path is still physically constrained by the rising bedrock of Shepley's Hill to the west, and by the influence of Plow Shop Pond to the east. For purposes of evaluating alternatives, uncertainties in the top of rock surface do not appear significant in the model results.

**4.2.2.4 Enhanced Recharge in Southern Part of Model.** During the calibration, it was apparent that modeled heads were somewhat lower than observed around monitoring well SHL-24. One possible reason for this difference is that recharge was too low in this area of the model. As explained in the model report, recharge was calculated based on the impervious area fraction of the land use. The land use classification around monitoring well SHL-24 was urban open. The actual land use is railroad yard. The original estimate of impervious area fraction was 0.50. During calibration, this was lowered to 0.40. For the actual land use around well SHL-24, the impervious area is probably less than ten percent.

A new transient calibration simulation was performed using an assumed imperviousness fraction of 0.1 in the southern part of the model. The recharge input array was modified and the second half of the calibration simulation from 1991 to 1993 was modeled. Section VII of the model report discusses the results of this evaluation. Heads increased less than 0.1 foot. The weighted mean differences between observed and modeled head changed from 1.0 feet to 0.82 feet. Because this change made no significant difference in the calibration, the model is considered relatively insensitive to small changes in recharge.

The reason that modeled heads at well SHL-24 did not increase more may be the closeness of the monitoring well to Grove Pond. Grove Pond was modeled as a constant head boundary. The hydraulic connection between Grove Pond and overburden aquifer may be much weaker than simulated. Either the hydraulic conductivity is smaller or there may be significant resistance to flow out of Grove Pond.

**4.2.2.5 Use of General Head Boundary.** Section V B of the model report assesses the sensitivity of the model to the change of the northern boundary from a constant head boundary to a general boundary during the transient calibration. The 18 general head boundary cells were changed to constant head cells and the base scenario, as described in Section VI A of the model report, was rerun. Heads changed by less than 0.1 foot across the model. Flows out the northern boundary changed by 0.2 percent after 221 days and by 0.5 percent after 100 years. These changes are less than the numerical precision of the model and are insignificant.

**4.2.2.6 Variations in Specific Yield.** During calibration the specific yield of the model was set to the artificially small value of 0.05. A more realistic value for the sandy overburden is about 0.20, although models rarely calibrate with values of this magnitude because of delayed yield. A numerical model and most traditional analytical formulas that predict groundwater effects assume instantaneous availability of water from storage. This is a good assumption for a confined aquifer, but water table aquifers have a substantial lag in the drainage of water from the unsaturated zone above the water table (delayed yield).

A sensitivity analysis using a specific yield of 0.20 was conducted by rerunning the base scenario. Section VII of the model report discusses the results of this evaluation. The value of specific yield is important for transient runs and in making time-of-travel calculations, and it took slightly longer for the aquifer to reach its steady state position with the larger specific yield. Since alternatives were compared under steady state conditions, the value of the storage coefficient had no effect on these runs and evaluations.

**4.2.2.7 Summary of Sensitivity Evaluations.** None of the sensitivity runs conducted indicated potentials for significant limits on the use of the final calibrated model for evaluating alternatives. Further hydrogeological studies proposed as part of Alternatives SHL-5 and SHL-9 may allow a refinement of both the conceptual and computer models, so that, if needed, the refined model can then be utilized in providing a more detailed representation of the hydrogeological system, and/or in detailed design.

### 4.2.3 Groundwater Modeling Results

The steady-state version of the calibrated model was utilized and run under MODFLOW and MODPATH to evaluate elements of several remedial actions. These elements included: walls and partial walls; upgradient diversion of landfill recharge; injection of reactants to provide in situ treatment; and pumping wells. The results of one model run frequently dictated the extent and location of elements for subsequent runs. Simulation modeling results are discussed in the following sections. Table 4-2 summarizes conditions for all simulation runs, Figures 4-5 through 4-29 present results from selected modeling runs.

**4.2.3.1 Wall and Partial Wall Simulations.** Two of the preliminary alternatives discussed (SHL-3 and SHL-4) utilized a slurry wall installed in the overburden surrounding the landfill groundwater containment components. The wall would prevent influx of upgradient groundwater and contain or divert contaminated groundwater within the landfill. The base final calibrated model, however, indicates that much of the overburden beneath the cap is unsaturated, and that, due to the cap and the natural setting, groundwater flows have been largely diverted away from Plow Shop Pond. A slurry wall surrounding the landfill does not appear effective due to little upgradient influx predicted in the overburden and minimized potential groundwater flux from the northern portion of the landfill towards Plow Shop Pond.

The effects of partial walls along the eastern and southeastern sections of the landfill perimeter as components of Alternatives SHL-3 through SHL-9 were simulated. These components were simulated by making the model elements containing the location of the wall inactive (the new USGS MODFLOW package for horizontal flow barriers had not yet been received), i.e., perfectly impermeable. Four configurations of partial walls were evaluated. Two shorter walls along the eastern edge of the landfill (see Figures 4-16 and 4-17) did not produce significant effects, as flow modeled under these scenarios moves primarily north and/or downward into the fractured rock. Longer walls, extending further south to encompass the extreme southeastern corner of the landfill (see Figures 4-18 and 4-19) were also simulated. These simulations produced decreased flow toward the easterly portions of Plow Shop Pond, however, some flow leaked around the southern end of the wall, and groundwater levels within the southeast portions of the landfill rose significantly, perhaps into waste deposits. Further, the increased heads behind the slurry wall produced increased flow beneath the wall which then proceeded eastward toward the ponds. Model predictions of partial walls to control groundwater flow suggested these walls would be ineffective. However, monitoring wells in the path of the southern flow have shown no significant contamination, and diversion or capture of this flow is believed unnecessary at this time.

**4.2.3.2 Upgradient Diversion of Landfill Recharge Simulations.** With the elimination of the overburden slurry wall as a potentially effective measure, upgradient diversion of recharge to the landfill focused on elimination of recharge to bedrock as containment components for Alternatives SHL-3 through SHL-9. Initially this was attempted by scaling back recharge as input through the recharge matrix along the southwestern edge of the landfill. This would simulate decrease in recharge by either drains or by improving surface runoff measures. However, the model became unstable, and no meaningful results could be obtained by this approach. Using the drain package in MODFLOW, however, the model was stable under most run conditions. Flow into the simulated drains is determined by the specification of a conductance term in the model which accounts for the resistances to flow from the surrounding formation into the drain, and the difference in heads between the formation and the drain invert elevation which comprises the driving force. The use of the invert elevation assumes that the drain is operated such that the free liquid surface is maintained at this elevation (i.e., water levels do not build up during drain operation).

In the simulations that were conducted, conductance terms were varied to determine a maximum flux to the drains that might be achieved. Three drain constructions were simulated, 10, 20, and 30 feet into bedrock, along an approximate 700-foot length of the exposed rock along the central and south-central western perimeter of the landfill. Maximum fluxes into these drains were approximately 1, 3 and 6 gallons per minute (gpm), respectively. Attempts to simulate deeper drains met with numerical instability problems in the model. However, deeper drains may be constructed in segments with expectations of nearly linear increases in water removed with drain depth. Resultant heads from the 30-foot deep drain simulation are shown for model Layers 1 and 2 in Figures 4-20 and 4-21. The removal of about 6 gpm (the 30-foot deep drain) does not represent a large portion of the total flow through the landfill area. Since only a small portion of groundwater flow would be diverted, the use of drains was ineffective.

**4.2.3.3 Injection Simulations.** Two alternatives (SHL-4 and SHL-8) being considered utilized in situ treatment through the injection of reactants to treat groundwater. A preliminary design under consideration consisted of injecting the reactants at the northern end of the landfill at a rate approximately twice that of the natural flow through the area to promote mixing. To counter the effect of the added injection of water in this area, three potential modifications to the preliminary design were considered. These consisted of: (1) adding a north-south oriented gravel drain to improve flow to the north; (2) adding diversion walls to attempt to channel the flow toward the injection well; and (3) adding high permeability drains along the inside (landfill side) of the diversion walls to improve flow characteristics. Reinjection flows of 20 and 40 gpm were considered, with the 20 gpm flow design being taken through the sequence of simulation modifications. Figures 4-22 through 4-25 show the results of the simulations for the reinjection of 20 gpm. The reinjection of 20 gpm alone produced a hydraulic barrier to the natural flow, and forced the landfill groundwater flow around the injected water. No appreciable mixing of the flows was indicated. Adding a simulated downgradient drain (equivalent to a 400-foot long, 10-foot wide channel at 10 times the natural hydraulic conductivity) only slightly improved flow (narrowed the gap produced by the injected flow). Addition of the simulated diversion walls only caused greater mounding around the point of injection and the natural flow to skirt around to the east and west of the 200-foot long diversion walls. Adding inner higher permeability drains to the diversion walls had no apparent effect. Unless the drains have some outlet, they appear to provide only a slightly more permeable pathway, but one which was still dominated by the hydraulic conductivity of the surrounding aquifer. Modeling suggests that injection of reactants to treat groundwater in situ is not effective.

**4.2.3.4 Pumping Simulations.** Pumping was evaluated as a component of Alternatives SHL-3, SHL-5, SHL-6, SHL-7, and SHL-9. Pumping simulations encompassed two areas of the flow system: (1) flow capture from the northern part of the landfill toward the northern boundary; and (2) flow capture from the southern portion of the landfill towards Plow Shop Pond. The latter was regarded as only a possible future remedial measure, as current data do not indicate significant contaminants impacting groundwater in this area.

The pattern of groundwater contours and results of particle tracking runs indicate that the flow becomes focused as it moves northward, and that a single pumping well at the northern tip of the landfill would be adequately positioned to intercept flow. The overall mass balance for the steady-state flow model suggested a total flow to the north of about 65 gpm, with about 45 gpm influx from the pond area. The landfill flow and required well pumping was anticipated to be about 20 to 25 gpm based on this result. Indeed, runs with well rates of 10 and 15 gpm did not adequately capture all particles, while a rate of 20 gpm appeared to capture flow originating from the northern flowpath of water passing under the landfill. The results of the 20 gpm run for Layers 1 and 2 (which were both captured for a well positioned in the overburden only) are shown in Figures 4-26 and 4-27.

Extraction wells positioned along the southeastern perimeter of the landfill were simulated for sake of completeness, as no significant contaminants have been detected along this flowpath. The initial run located a well in the "L" formed in the southeastern corner of the landfill. Flows of 40 gpm provided a fairly wide capture zone, but a few of the more northerly particles eluded capture. A second run was made in which two wells were simulated in this area with flows of 15 gpm for the more northerly well and 25 gpm for the more southerly well. Two wells were selected to provide more flexibility, in addition to the fact that the depth to bedrock decreases as one moves northerly in this area. This occurrence leads to possibly excessive drawdowns at higher pumping rates for the more northerly well. As shown in Figures 4-28 and 4-29, all particles were captured with this two well arrangement, and pumping rates in the more southern well could probably be decreased slightly (to less than a total of 40 gpm) and still maintain capture of the desired groundwater flow.

### 4.2.4 Summary of Groundwater Modeling Results

Groundwater modeling provided information utilized in the screening of the alternatives in Subsection 4.3. Results from groundwater suggest the following:

- landfill capping causes a marked decrease (more than 70 percent) in total simulated discharge to Plow Shop Pond from the landfill area;
- landfill capping significantly reduces the total amount of water in the landfill;
- landfill capping almost totally diverts the groundwater flows from the landfill away from the northern portions of Plow Shop Pond;

- much of the overburden beneath the cap is unsaturated, therefore components for containing and/or diverting groundwater flow in the overburden would not be necessary;
- installation of rock drains to minimize recharge to bedrock fractures would not be effective;
- use of injection wells would create hydraulic barriers and cause groundwater mounding, and therefore would not be effective; and
- groundwater extraction wells would be effective in capturing groundwater flowing from the landfill area.

These results are utilized in Subsection 4.3 to evaluate and screen remedial alternatives.

### 4.3 SCREENING OF ALTERNATIVES

In this subsection, groundwater modeling results presented in Subsection 4.2 are used in conjunction with screening criteria to evaluate the alternatives developed in Subsection 4.1. The alternatives are screened with respect to the criteria of effectiveness, implementability, and cost to meet the requirements of the CERCLA and the NCP. The three criteria used for screening the alternatives are as follows:

**Effectiveness.** Each alternative was judged for its ability to effectively protect human health and the environment by reducing the toxicity, mobility, or volume of contaminants; both short- and long-term effectiveness were evaluated. Short-term effectiveness involves reducing existing risks to the community and workers during the construction and implementation period, identifying expected impacts to the environment and potential mitigative measures during construction and implementation, the alternative's ability to meet remedial action objectives, and the time frame required to achieve remedial action objectives. Long-term effectiveness, which applies after remedial action objectives have been attained, considers the magnitude of the remaining residual risk due to untreated wastes and waste residuals, and the adequacy and reliability of specific technical components and control measures.

Groundwater modeling results were used during the effectiveness evaluation to determine what effect, if any, each alternative would have on the remedial action objectives of preventing off-site migration of contaminated groundwater and preventing contaminated groundwater from contributing to contamination of Plow Shop Pond sediments. Because groundwater modeling indicates that containment features (i.e., slurry wall and grout curtain) are unnecessary for aquifer remediation, alternatives which include full or partial containment (i.e., Alternatives SHL-3 through SHL-9) are subject to either elimination or modification. Justification for elimination or modification of alternatives based on modeling results is presented in the effectiveness screening discussion. Alternatives which are retained after effectiveness screening are further evaluated for implementability and cost. Alternatives which are eliminated during effectiveness screening do not undergo any further screening.

**Implementability.** Each alternative was evaluated in terms of technical and administrative feasibility. In the assessment of short-term technical feasibility, availability of a technology for construction or mobilization and operation, the availability of required services and trained specialists or operators, as well as compliance with action-specific ARARs during the remedial action were considered. Long-term technical feasibility considered the ease of operation and maintenance (O&M), technical reliability replacement, ease of undertaking additional remedial actions, and monitoring of technical controls of residuals and untreated wastes. Administrative feasibility for implementing a given technology addressed coordination with other agencies.

**Cost.** The final criterion for initial screening of alternatives is the cost associated with the given remedy. Absolute accuracy of cost estimates during screening is not essential. The focus should be to make comparative estimates for alternatives with relative accuracy so that cost decisions among alternatives will be sustained as the accuracy of cost estimates improves beyond screening (USEPA, 1988b). Relative capital and O&M costs are discussed at this stage, as well as factors influencing cost sensitivity. Potential liability associated with untreated waste and treatment residuals is also discussed. Cost estimates for alternatives screening are based on generic unit costs, vendor information, cost-estimating guides, and prior similar estimates. Cost estimates for items common to all alternatives or indirect costs do not normally warrant substantial effort during the alternative screening phase (USEPA, 1988b). Actual detailed cost estimates are presented in the detailed analysis of retained alternatives in Section 5 and Appendix B.

**Alternative Evaluation.** For each alternative, a matrix was developed highlighting the alternative's advantages and disadvantages with respect to effectiveness, implementability, and cost. The alternative evaluation matrix presents a clear, concise procedure for screening potential remedial action alternatives. Based on this matrix, a decision was made to either retain the alternative for detailed analysis or eliminate it from further consideration. Screening matrices for each alternative are presented in Tables 4-3 through 4-11.

### 4.3.1 Alternative SHL-2: Limited Action

This alternative relies on the existing cover system to continue to perform as expected and as predicted in the groundwater modeling. Zoning, deed restrictions, and landfill cover system maintenance would be implemented to reduce the potential for exposure. A long-term groundwater monitoring program would be implemented to evaluate groundwater quality over time. A landfill gas monitoring program would also be implemented.

Effectiveness. Groundwater modeling results indicate that capping the landfill has not only reduced recharge into the aquifer underlying the landfill but also favorably influenced the direction of groundwater flow from the landfill. Modeling results suggest almost total diversion of groundwater flows from the landfill away from the northern portions of Plow Shop Pond. The apparent lack of recharge in combination with the influence of surface water elevations in Plow Shop Pond has redirected and focused groundwater flow in a northerly direction (see Figure 4-5). Consequently, this alternative may prevent contaminated landfill groundwater from contributing to contamination of Plow Shop Pond sediments.

The Limited Action alternative would not reduce the toxicity or volume of contaminants in the landfill. However, the recently installed landfill cover system will limit infiltration to wastes and reduce contaminant leaching, thus reducing contaminant mobility. Groundwater does not currently pose a drinking water risk because there are no residential receptors. In addition, zoning and deed restrictions would prevent future use of the aquifer beneath Shepley's Hill Landfill as a source of drinking water. This alternative would be effective in preventing short-term human health risks because cover system maintenance and surface drainage improvements would not require any contaminant handling. No short-term adverse effects on the environment are anticipated.

This alternative does not include measures to prevent groundwater from leaving the site. However, current concentrations of contaminants at the north end of the landfill do not exceed chemical-specific ARARs or PRGs. The long-term groundwater monitoring program included in this alternative would be used to evaluate the continued effectiveness of this alternative. If groundwater monitoring indicates that chemical concentrations in groundwater leaving the site exceed chemical-specific ARARs or PRGs, additional remedial actions would be considered.

Implementability. This alternative would be easy to implement and would not interfere with future remedial actions if needed. Cover system maintenance and drainage improvements are common construction activities. Administrative feasibility of this alternative would be relatively easy, because the U.S. Army could implement institutional controls in the form of zoning and deed restrictions so at the time of property transfer from the U.S. Army to the new owner, this land would not be developed for residential use. Additionally, the only action-specific ARARs which must be met by this alternative are the post-closure requirements of the Massachusetts Solid Waste Management Regulations (310 CMR 19.000). Post-closure requirements have already been implemented at Shepley's Hill Landfill.

Cost. In comparison with the containment and treatment alternatives, the total cost of the Limited Action alternative would be relatively low. Capital costs associated with cover repairs and institutional controls are expected to be low. Annual O&M costs are primarily influenced by groundwater monitoring costs, which are a component of all the alternatives. Although the total cost of this alternative would be relatively low, there is long-term liability associated with untreated groundwater.

Conclusion. This alternative will be retained for detailed analysis. Limited Action provides a low-cost alternative, based on administrative controls and monitoring that would help protect human health, and that may be used in conjunction with other alternatives.

### 4.3.2 Alternative SHL-3: Containment/Collection/Short-term Ex Situ Treatment/Surface Water Discharge

This alternative involves placement of a 4,500-foot long slurry wall and a 2,500-foot long grout curtain around the waste in conjunction with the existing landfill cover system. Additionally, rock drains would be used as containment enhancement features as necessary, to aid in groundwater containment. This alternative was intended to minimize future groundwater contamination by diverting clean groundwater away from landfilled waste. Alternative SHL-3 also includes installation of extraction wells within the area of containment and provides short-term groundwater treatment. All of the components of the Limited Action Alternative are also included.

Effectiveness. Groundwater modeling results (see Subsection 4.2.2) indicate that much of the overburden beneath the cover is unsaturated and that little groundwater influx from the upgradient side, or west-southwest side of the landfill, enters the overburden beneath the landfill. Modeling results also indicate that upgradient diversion of groundwater recharge to the bedrock beneath the landfill (i.e., by grout curtain or fractured rock drains) would lead to only minimal diversion of groundwater flow. Consequently, nearly complete containment by slurry wall and grout curtain is not expected to significantly enhance this alternative's ability to divert groundwater away from the landfill. The cost of slurry wall and grout curtain design and construction would not be justified by the minimal benefits of containment.

Conclusion. Based on groundwater modeling results which indicate that containment would not contribute significantly to meeting remedial action objectives, this alternative has been eliminated from further screening.

### 4.3.3 Alternative SHL-4: Containment/In Situ Oxidation

This alternative involves placement of the same containment system as described in Alternative SHL-3. Alternative SHL-4 also includes installation of injection wells to the north of the landfill, for injection of a hydrogen peroxide solution to treat groundwater by in situ oxidation. This alternative includes all the components of Limited Action.

Effectiveness. Similar to Alternative SHL-3, groundwater modeling results (see Subsection 4.2.2) indicate that nearly complete containment by slurry wall and grout curtain is not expected to significantly enhance this alternative's ability to divert clean groundwater away from the landfill. In addition to the questionable effectiveness of containment, modeling results also indicate that injection of a hydrogen peroxide solution into the aquifer at the north end of the landfill would produce a hydraulic barrier to the natural flow, which would force the landfill groundwater to flow around the injection wells. For this alternative, this could result in the overtopping of the slurry wall at the north end of the landfill by untreated groundwater.

Conclusion. Based on groundwater modeling results which indicate that containment using slurry walls and grout curtains would not contribute significantly to meeting remedial action objectives, and that untreated groundwater may actually bypass in situ oxidation, this alternative has been eliminated from further screening.

### 4.3.4 Alternative SHL-5: Collection/Ion Exchange Treatment/Surface Water Discharge

For this alternative, water would be pumped from extraction wells to an ion exchange system for treatment. This alternative includes optional placement of a 1,600-foot long slurry wall to block continued groundwater flow into Plow Shop Pond. All components of Limited Action would also be included.

Effectiveness. As discussed in Subsection 4.3.1, groundwater modeling results indicate that capping the landfill has not only reduced recharge into the aquifer underlying the landfill but it has favorably influenced the direction of groundwater flow from the landfill. Modeling results suggest almost total diversion of groundwater flows from the landfill away from the northern portions of Plow Shop Pond. Consequently, placement of a slurry wall between the landfill and Plow Shop Pond would not add measurably to this alternative's ability to meet remedial action objectives. Based on groundwater modeling results, this alternative would not include the slurry wall component.

Additionally, modeling suggests extraction wells would be capable of capturing all of the contaminated groundwater flow exiting at the north end of the landfill. Because existing groundwater monitoring data indicate that there is no significant contamination in the groundwater exiting the southeastern portion of the landfill, placement of extraction wells at that location is unnecessary. The ion exchange treatment system, treated groundwater discharge to Nonacoicus Brook, and Limited Action components have been retained in this alternative.

Ion exchange has been proven effective at removing most metals in groundwater. High concentrations of iron in groundwater may necessitate pretreatment prior to ion exchange to minimize clogging of the resin. This alternative would reduce toxicity, mobility, and volume of contaminated groundwater and would meet remedial action objectives during treatment. Groundwater extraction and treatment may be required beyond the 30-year cost evaluation period. Minimal adverse environmental effects would be anticipated from construction of groundwater extraction and treatment systems. Erosion control measures (e.g., silt fencing) would be installed in areas where erosion could potentially affect areas during construction.

Implementability. This alternative would be readily implementable because many contractors and vendors are available for extraction well installation and design and construction of ion exchange treatment systems. Aquifer tests to confirm the number of extraction wells and flow rates would be required. Treatability tests to determine the most effective resin would be required. Long-term O&M would be required for extraction wells, the ion exchange treatment system, and groundwater monitoring. Disposal would be required for spent resins, resin regeneration brine, and possibly iron sludge. Implementation of this alternative would not interfere with future additional remedial actions.

Federal and state action-specific ARARs which regulate the transportation and disposal of groundwater treatment residues must be met by this alternative. No impediments to meeting these action-specific ARARs are expected. This alternative includes construction of a discharge pipeline across delineated floodplain and wetlands between the landfill and Nonacoicus Brook (see Figure 1-6), and construction activities must meet location-specific ARARs pertaining to floodplains and wetlands.

Cost. Because this alternative includes groundwater treatment, the costs associated with treatment system design and construction, and treatment system O&M, would inflate the total cost relative to the Limited Action alternative. However, long-term liability associated with contaminated groundwater would be diminished if this alternative can successfully prevent migration of contaminated groundwater.

Conclusion. Based on groundwater modeling results, this alternative has been modified and will not include slurry wall installation. The groundwater extraction ion exchange treatment, discharge of treated groundwater to Nonacoicus Brook, and all the components of the Minimal Action alternative remain part of this alternative. Groundwater modeling results suggest that this alternative will prevent contaminated groundwater from migrating off site or into Plow Shop Pond by accurately placing the extraction wells. In order to incorporate some flexibility into the preliminary design of this alternative, preliminary location of the extraction wells will be discussed in the detailed analysis.

### 4.3.5 Alternative SHL-6: Collection/Chemical Precipitation Treatment/Surface Water Discharge

This alternative includes the same components as Alternative SHL-5 except groundwater would be treated using chemical precipitation.

Effectiveness. Because this alternative is identical to Alternative SHL-5 except for the proposed treatment system, and preliminary vendor information indicates that ion exchange treatment may be more efficient and cost-effective than chemical precipitation, this alternative will not be retained. However, treatability studies that would be conducted if Alternative SHL-5 is the selected alternative should also include chemical precipitation testing in order to confirm preliminary vendor claims.

Conclusion. This alternative has been eliminated from detailed analysis but chemical precipitation testing should be included in treatability testing should Alternative SHL-5 be the selected alternative for implementation.

### 4.3.6 Alternative SHL-7: Collection/Constructed Wetland Treatment/Surface Water Discharge

This alternative includes the same groundwater extraction system as Alternatives SHL-5 and SHL-6. Extracted groundwater would be pumped from extraction wells to a constructed wetland for treatment of inorganic contaminants by natural processes prior to surface water discharge. All components of Limited Action would also be included.

Effectiveness. As discussed in Subsection 4.3.4, the installation of a slurry wall would not measurably improve the ability of this alternative to meet remedial action objectives. Slurry wall installation has been dropped from this alternative. As also discussed in Subsection 4.3.4, extraction wells would be used to pump groundwater to the wetland.

Constructed wetlands have been demonstrated to be effective for removal of iron, copper, zinc, and manganese when used to treat acid mine drainage (Fennessy and Mitsch, 1989; USEPA, 1990). It is uncertain if man-made wetlands are capable of removing arsenic and other inorganics present in Shepley's Hill Landfill groundwater. A treatability study would be required for effectiveness evaluation for the site-specific contaminants. Minimal adverse environmental effects would be anticipated during construction of this alternative. There is potential for adverse effects on wetlands during construction of the discharge pipeline to Nonacoicus Brooks; however, measures would be taken to minimize adverse effects and damaged areas would be repaired.

Implementability. This alternative would be readily implementable, because space is available southeast of the landfill, and many contractors and vendors are available for extraction well installation and wetland construction. Aquifer tests to confirm the number of extraction wells and flow rates would be required. Long-term operations and maintenance should be minimal because once the wetland has been constructed, it should function with little maintenance. Long-term monitoring downstream of the wetland would be required to assess contaminant removal. This alternative would not interfere with future, additional remedial actions.

There are many uncertainties regarding the long-term technical feasibility of a constructed wetland. The wetland may not function effectively during periods of heavy rain or in the winter if water flowing through it freezes. Therefore, storage of extracted groundwater may be required. Long-term pilot testing would be required to evaluate the process performance. This could adversely affect the U.S. Army's ability to comply with implementation schedules specified in the NCP and IAG. In addition, over time there will probably be an accumulation of biomass in the wetland with concentrated contamination. The removal process and frequency required for contaminated biomass removal is unknown.

Federal and state action-specific ARARs which regulate the transportation and disposal of hazardous soils/sludges (i.e., excavated soil and biomass sludge from the wetland) must be met by this alternative. No impediments to meeting these action-specific ARARs are expected. This alternative includes construction of a discharge pipeline across delineated floodplains and wetlands between the landfill and Nonacoicus Brook (see Figure 1-6), and construction activities must meet location-specific ARARs pertaining to floodplains and wetlands.

Conclusion. This alternative will be eliminated from further consideration because treatment of some of the inorganic contaminants (i.e., arsenic) using constructed wetlands has not been demonstrated to be effective, and there are significant unknown design and operational parameters for constructed wetlands.

### 4.3.7 Alternative SHL-8: Groundwater Barrier/In situ oxidation

For this alternative, hydrogen peroxide and water would be pumped into injection wells installed to implement in situ oxidation treatment. As for previous alternatives, this alternative includes enhancement through placement of a 1,600-foot long slurry wall to block flow into Plow Shop Pond. Groundwater would be diverted to an in situ treatment system. All components of Limited Action would also be included.

Effectiveness. As discussed during screening of Alternative SHL-4, groundwater modeling results (see Subsection 4.2.2) indicate that injection of a hydrogen peroxide solution into the aquifer at the north end of the landfill would produce a hydraulic barrier to the natural flow, which would force the landfill groundwater to flow around the injection wells. Flow around the injection wells would not allow suitable mixing of the injected reactants. Even with the addition of high permeability drains, groundwater would mound and be diverted around the mixing zone. Consequently, contaminated groundwater would continue to migrate off-site without treatment.

Conclusion. Based on groundwater modeling results which indicate that contaminated landfill groundwater would be diverted around injection wells and not be treated, this alternative has been eliminated from detailed analysis.

### 4.3.8 Alternative SHL-9: Collection/Discharge to POTW

This alternative includes the same proposed extraction system as in Alternatives SHL-5, SHL-6, and SHL-7. For this alternative, groundwater would be pumped from extraction wells and discharged to the Town of Ayer POTW for treatment. All components of Limited Action would also be included.

Effectiveness. As discussed in Subsection 4.3.4, the installation of a slurry wall would not measurably add to this alternative's ability to meet remedial action objectives. Therefore, slurry wall installation has been dropped from this alternative. As also discussed in Subsection 4.3.4, extraction wells capable of capturing all of the contaminated groundwater flow would be installed.

Provided groundwater being piped to the Town of Ayer POTW meets influent pretreatment standards, this alternative would meet remedial action objectives. Continued monitoring would be required to document that groundwater meets pretreatment standards. Should groundwater not meet pretreatment standards, pretreatment would be required. Minimal adverse environmental effects would be anticipated from construction of groundwater extraction and treatment systems. Erosion control measures (e.g., silt fencing) would be installed in areas where erosion could potentially affect areas during construction.

Implementability. This alternative is technically feasible and would be easily implemented. Aquifer tests to confirm the number of extraction wells and flow rates would be required. To be implemented, this alternative would require successful negotiations between the U.S. Army and the Town of Ayer POTW for a long-term discharge agreement. Initial conversations with the Town of Ayer POTW indicate that the facility is a 1.79 mgd activated sludge treatment plant operating at approximately 50 percent of its hydraulic capacity, and would consider accepting a discharge of groundwater from Shepley's Hill Landfill provided that pretreatment standards are met. The available capacity is adequate to accept the estimated 20 gpm (0.03 mgd) discharge of groundwater. This alternative would not interfere with future, additional remedial actions.

Federal and state action-specific ARARs which regulate the transportation and disposal of hazardous materials/substances must be met by this alternative. Additionally, groundwater piped to the Town of Ayer POTW would have to comply with the requirements of the General Pretreatment Regulations (40 CFR 403). No impediments to meeting ARARs are expected.

Cost. This alternative includes a groundwater extraction system and piping to the Town of Ayer sewer system. No treatment equipment would be required for this alternative, so capital costs would be minimized. The Town of Ayer would charge sewer user fees, but these fees are anticipated to be less than the cost for the U.S. Army to provide on-site treatment. Long-term liability associated with contaminated groundwater would be diminished if this alternative can successfully prevent off-site migration of contaminated groundwater.

Conclusion. Alternative SHL-9 will be retained for detailed analysis because it will meet remedial action objectives as long as pretreatment standards are met. As with Alternative SHL-5, preliminary location of the extraction wells will be discussed in the detailed analysis.

### 4.3.9 Alternative SHL-10: Installation of RCRA Cap

This alternative proposes the installation of a composite cover system based on RCRA design guidance on top of the existing cover system which is based on Massachusetts Solid Waste Management Regulations. The RCRA final cover system would have a two part hydraulic barrier layer consisting of a layer of a GCL with a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec in intimate contact with a geomembrane, while the existing Massachusetts system has a single layer hydraulic barrier consisting of PVC geomembrane. Prior to installation of the RCRA cover, the top soil would be removed from the existing cover to enable reuse as part of the RCRA cover. This alternative would include implementation of the same institutional controls in the form of deed and zoning restrictions and the same long-term groundwater and landfill gas monitoring programs as Alternative SHL-2. The evaluation of potential surface drainage improvements would be incorporated into the design of the RCRA cover.

Effectiveness. Groundwater modeling results indicate that the existing cap has not only reduced recharge into the aquifer, but also favorably influenced the direction of groundwater flow from the landfill. Modeling results suggest almost total diversion of groundwater flows from the landfill away from the northern portions of Plow Shop Pond. Following its installation, the RCRA cover system should be equally effective at reducing infiltration and leaching, redirecting groundwater flow, and preventing contamination of Plow Shop Pond sediments. Because it relies on the redundancy of a two part hydraulic barrier layer, the RCRA cover system is theoretically a more effective barrier to infiltration than the existing single layer hydraulic barrier. However, actual improvement compared to the existing geomembrane is difficult to quantify. The RCRA cover would have a greater thickness of fill material over the hydraulic barrier layer than the existing cover which may provide greater long-term protection of the hydraulic barrier layer from environmental influences such as freeze/thaw cycles and burrowing animals.

Installing a RCRA cap will not reduce the toxicity or volume of contaminants in the landfill. By reducing infiltration, it will reduce contaminant leaching and contaminant mobility. However, the existing cover system already prevents infiltration and further reductions are difficult to quantify. Groundwater does not currently pose a drinking water risk because there are no residential receptors. Zoning and deed restrictions would prevent future use of the aquifer beneath Shepley's Hill Landfill as a source of drinking water.

There are several potential adverse short-term effects associated with this alternative. Installation of the cap would involve extensive earth moving and construction activities. Construction workers would be exposed to the hazards normally associated with those activities. In addition, if construction activities rip or tear the existing geomembrane, additional health and safety precautions would have to be taken to avoid exposure to potentially hazardous and explosive atmospheres resulting from landfill gas. Both benzene and high concentrations of methane have been detected in gas samples taken from the existing landfill vents.

The community would experience some short-term risks during the construction period from increased truck traffic. Construction of the cover would require delivery of approximately 530,000 cy of fill materials, and dump truck traffic would be heavy during an anticipated eight to ten month haul period. Several routes and entry points to Fort Devens exist and deliveries could be coordinated to reduce traffic hazards and congestion.

Personnel who collect groundwater samples as part of the post-closure monitoring program will need to follow a site-specific HASP and utilize personal monitoring equipment and personal protective equipment to prevent potential exposure to hazardous chemicals.

Short-term risks to the environment would result from the destruction of existing grassland habitat on the existing cover system that may provide nesting habitat for the Grasshopper Sparrow, a state-listed species of special concern. In addition, the existing cover provides nesting and foraging habitat for small animals.

The long-term groundwater monitoring program would be used to evaluate the effectiveness of this alternative. Installing a RCRA cap would not interfere with or prevent the implementation of future remedial actions at Shepley's Hill Landfill. If groundwater monitoring indicates that chemical concentrations in groundwater leaving the site exceed chemical specific ARARs or PRGs, additional remedial actions would be considered.

Implementability. Implementation of this alternative does not present technical or administrative obstacles. Cover system design and installation are common engineering and construction activities. A large amount of fill material will be required, but it is assumed that fill materials can be located within a reasonable hauling distance of Fort Devens. The administrative feasibility of this alternative would be relatively easy. The U.S. Army can implement institutional controls at the time of property transfer to any new owner. Additionally, the identification of action- and location-specific ARARs which might impede implementation is not anticipated.

Cost. The cost of this alternative is high when compared to Alternative SHL-2. This results almost exclusively from capital costs, since long-term monitoring and maintenance programs and costs are similar for the two alternatives. Also similar to Alternative SHL-2, there is a long-term liability associated with untreated groundwater.

Conclusion. This alternative will be retained for detailed analysis to enable comparison of other alternatives with installation of a landfill final cover based on RCRA design guidance.

### 4.4 ALTERNATIVES RETAINED FOR DETAILED ANALYSIS

Table 4-12 summarizes the results of the screening analysis for the 10 alternatives developed for the Shepley's Hill Landfill Operable Unit. The five alternatives retained will be evaluated more thoroughly in Section 5. Those alternatives will then be compared to each other in the comparative analysis in Section 6.

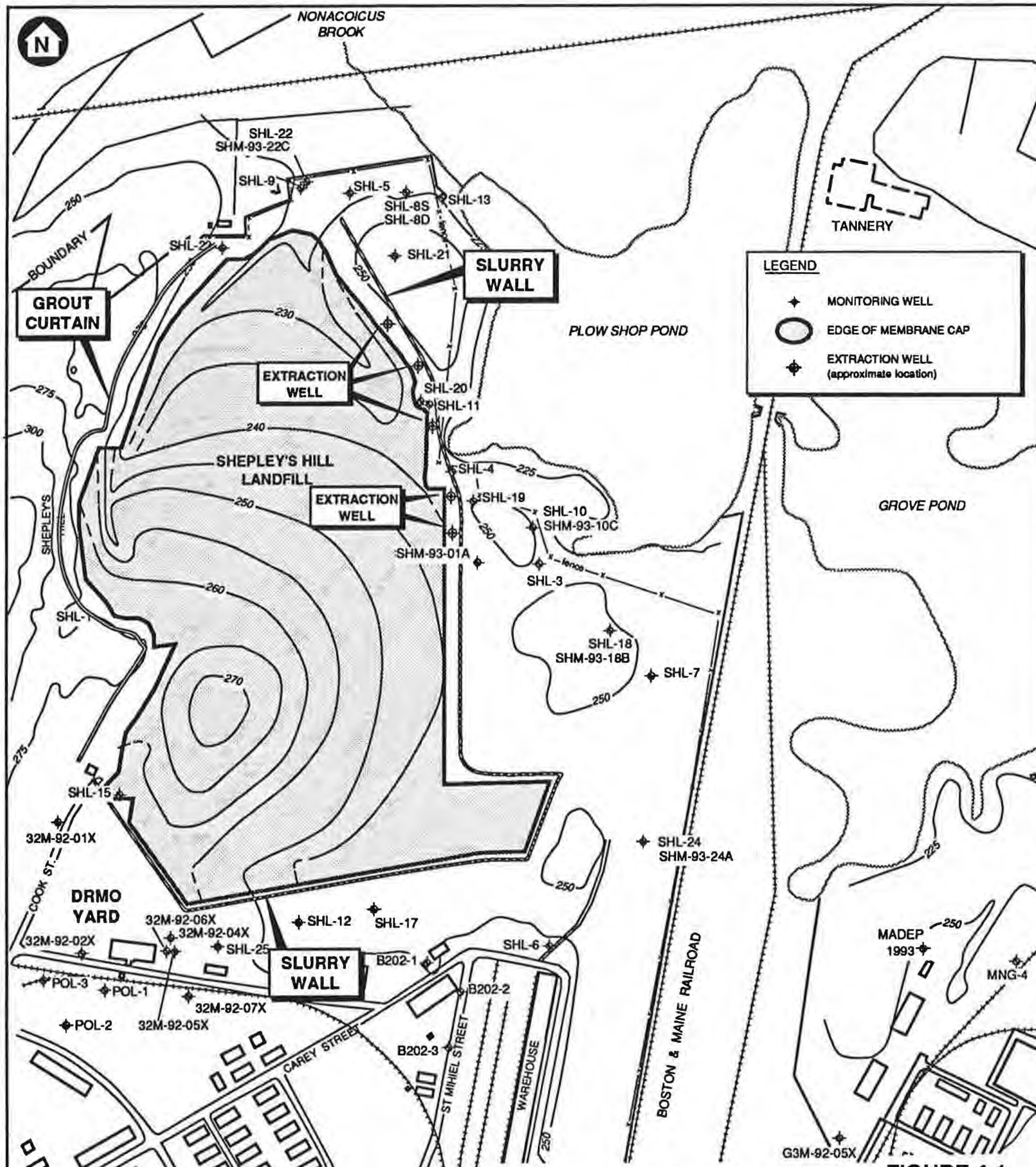



**FIGURE 4-1**
**SLURRY WALL, GROUT CURTAIN AND EXTRACTION WELLS FOR ALTERNATIVE SHL-3**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403007D1S6 H L

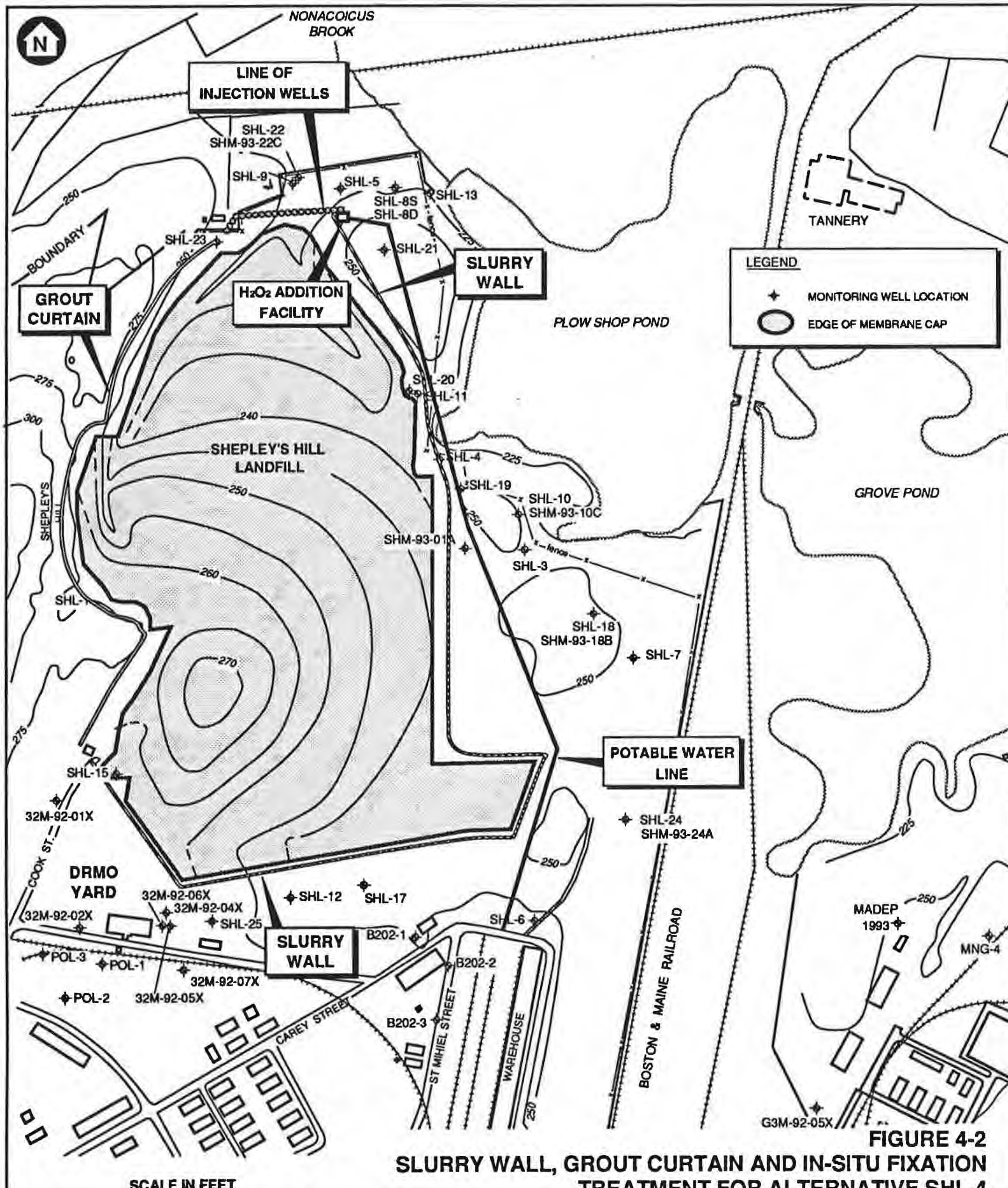



**FIGURE 4-2**
**SLURRY WALL, GROUT CURTAIN AND IN-SITU FIXATION TREATMENT FOR ALTERNATIVE SHL-4**
**SHELPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403007D 1 S6 K

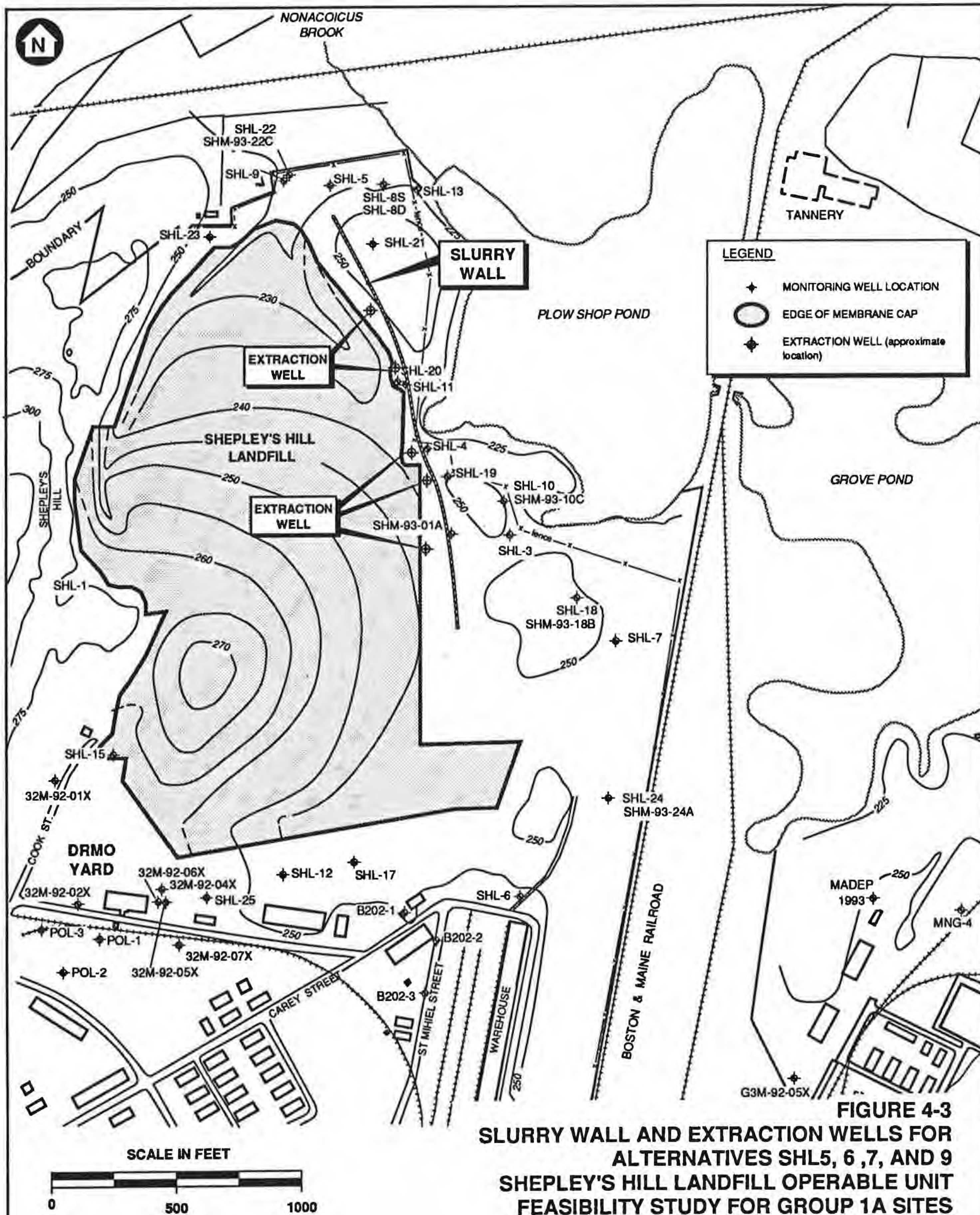



**FIGURE 4-3**
**SLURRY WALL AND EXTRACTION WELLS FOR ALTERNATIVES SHL5, 6 ,7, AND 9**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403007D 1 S6 F M

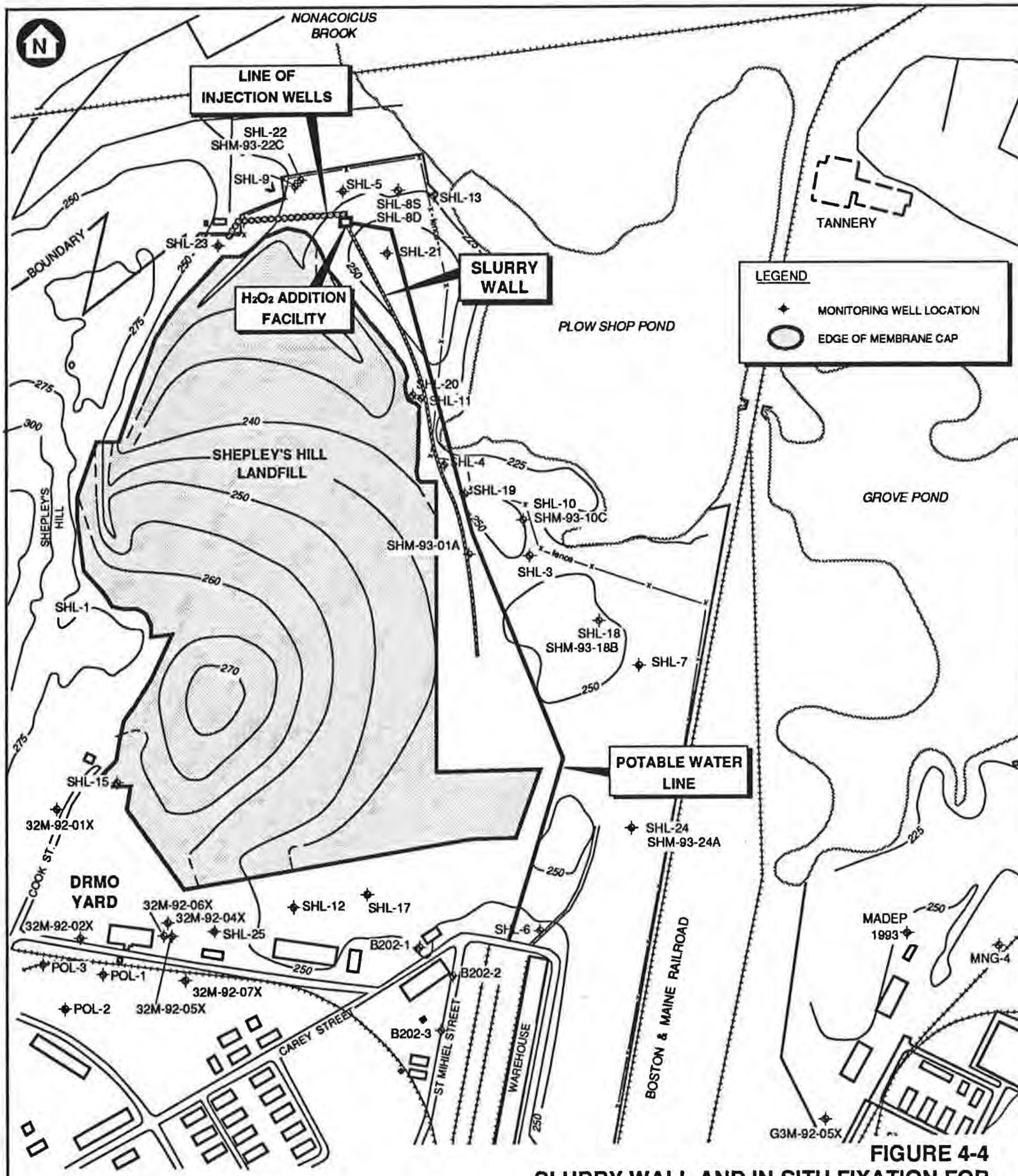
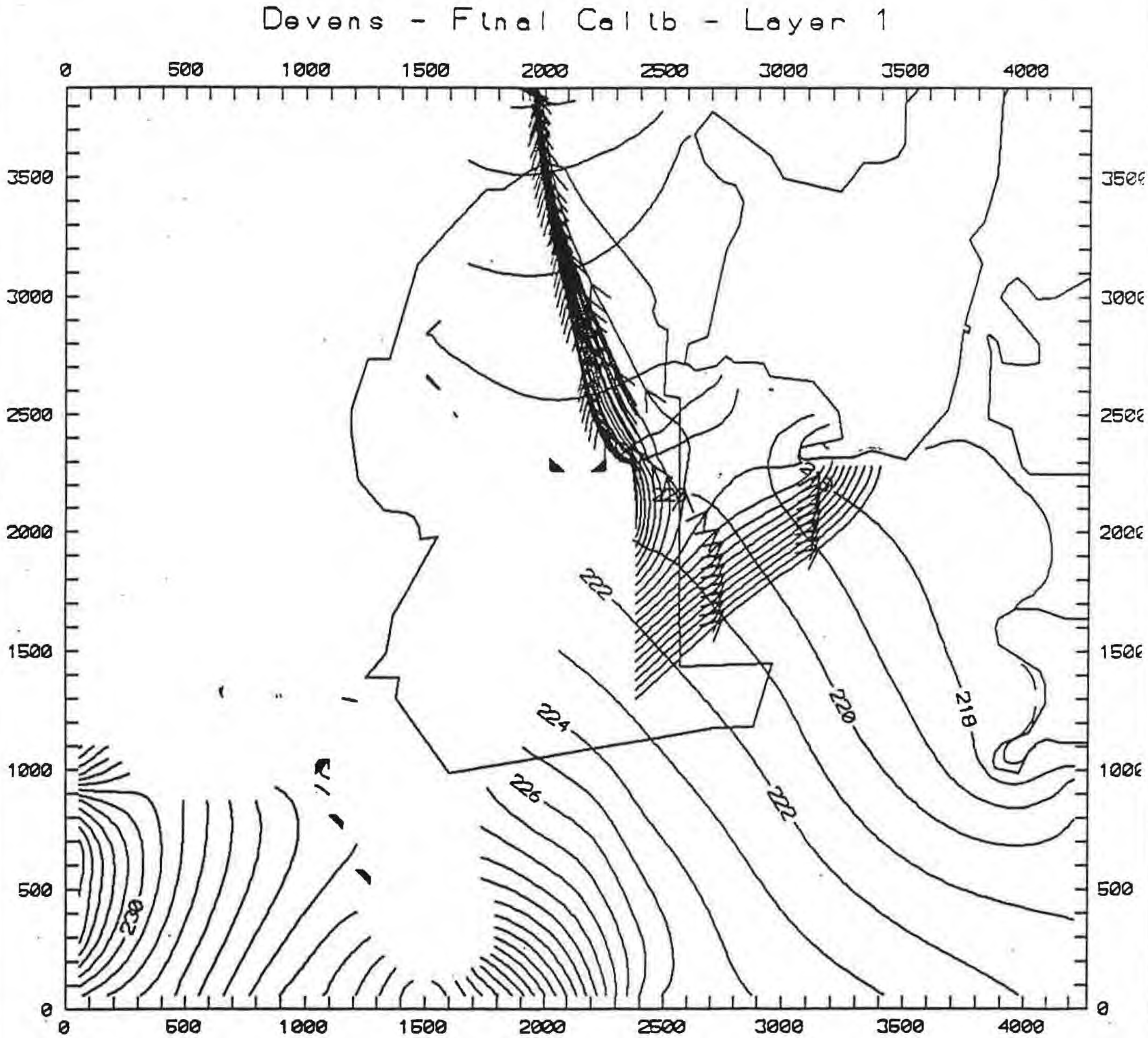



**FIGURE 4-4**
**SLURRY WALL AND IN-SITU FIXATION FOR TREATMENT ALTERNATIVE SHL-8**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9403007D 1S6 G

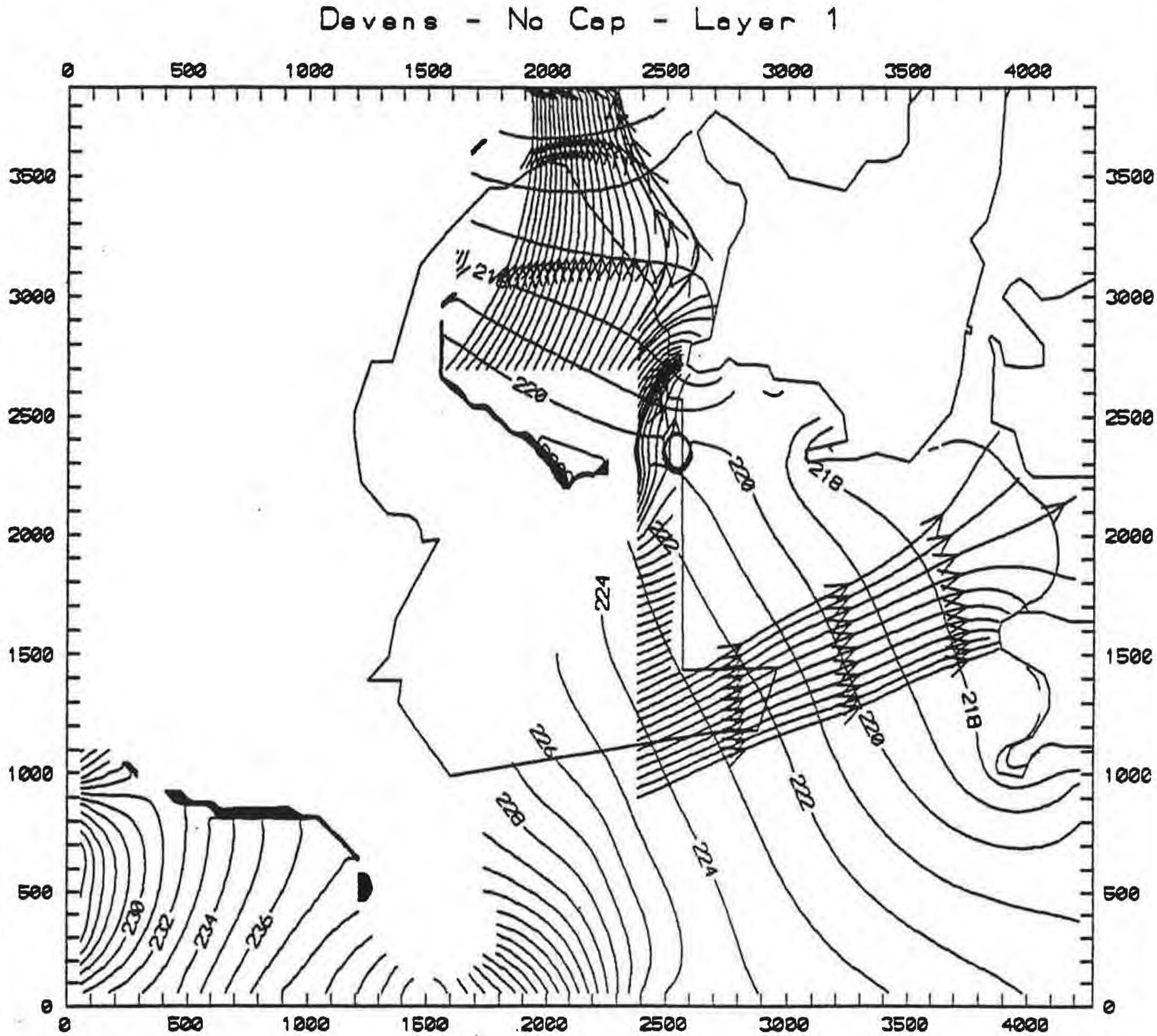



NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.


**FIGURE 4-5**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION SS FINAL**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04




NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

SCALE IN FEET

0 500 1000

**FIGURE 4-6**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION NO CAP**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04

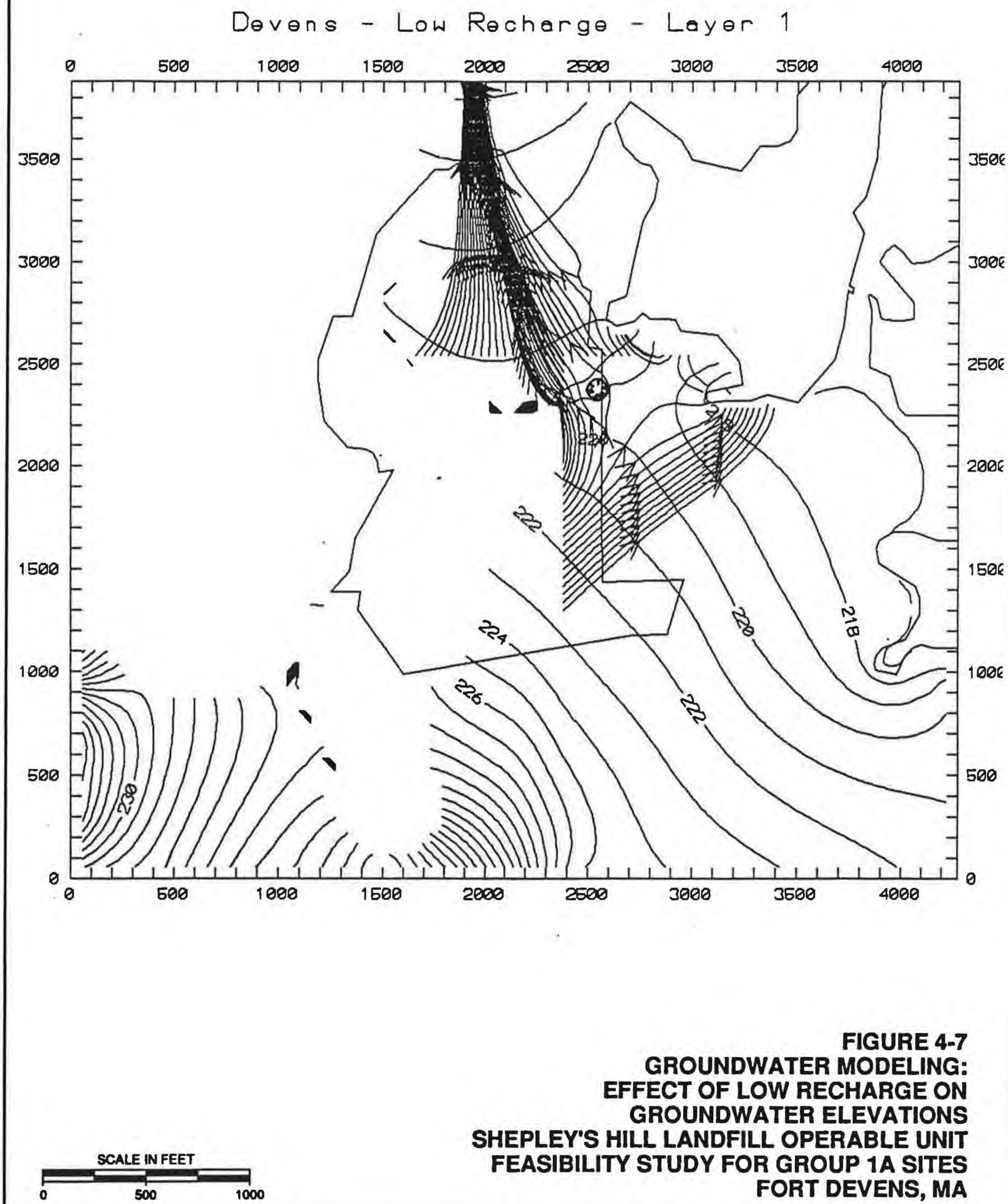



**FIGURE 4-7**
**GROUNDWATER MODELING:**
**EFFECT OF LOW RECHARGE ON**
**GROUNDWATER ELEVATIONS**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12

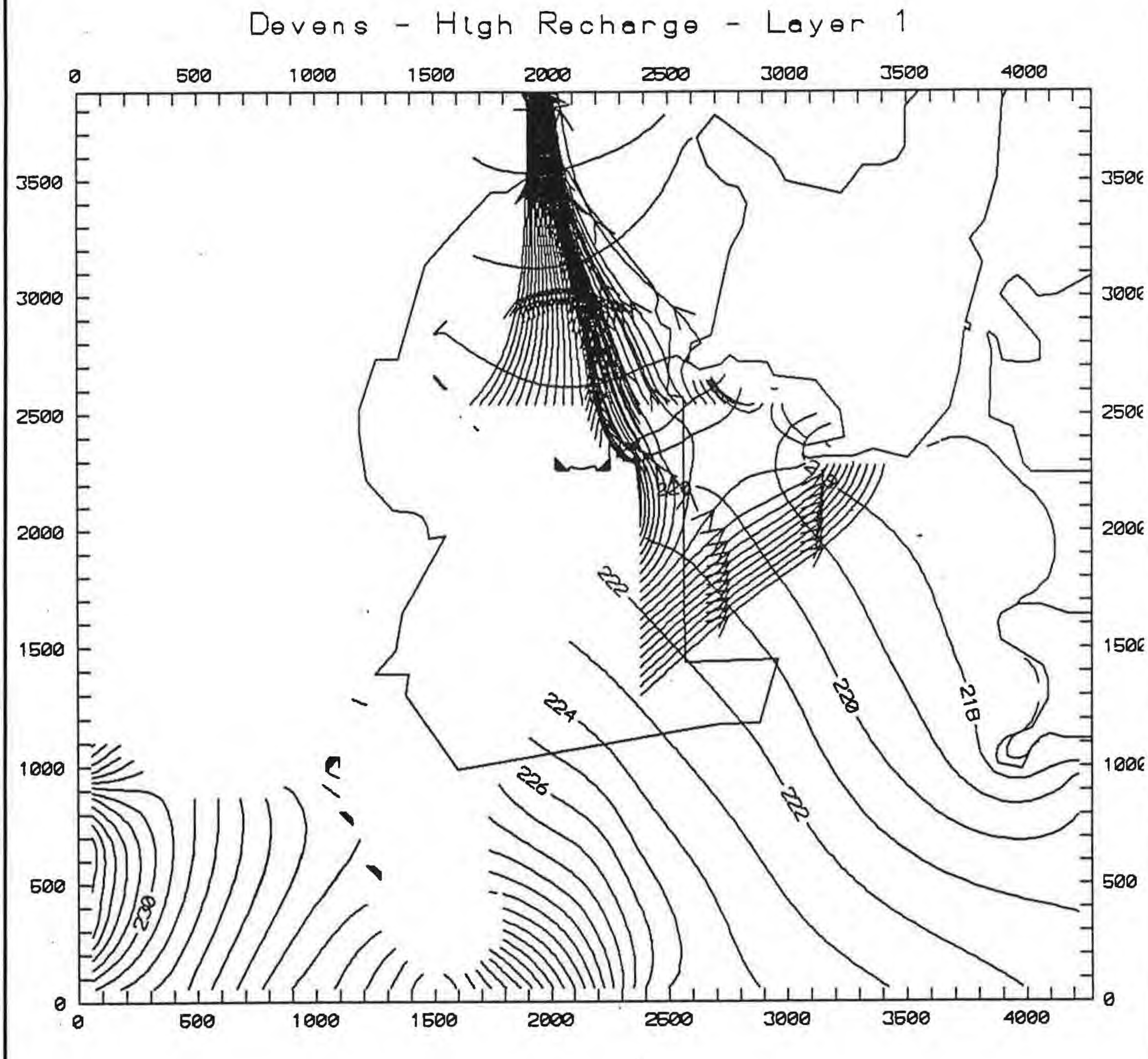



**FIGURE 4-8**
**GROUNDWATER MODELING:**
**EFFECT OF HIGH RECHARGE ON**
**GROUNDWATER ELEVATIONS**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12

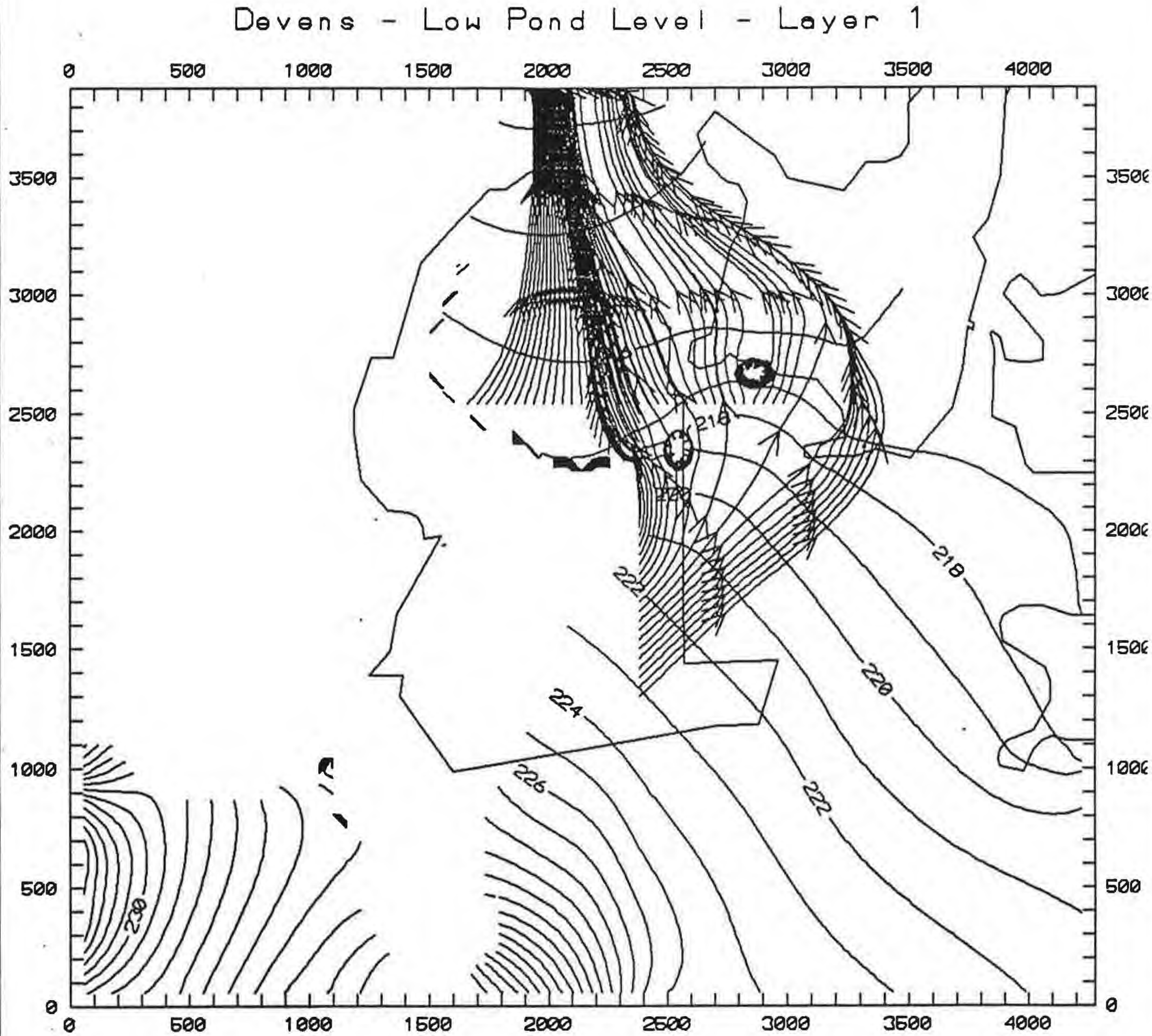
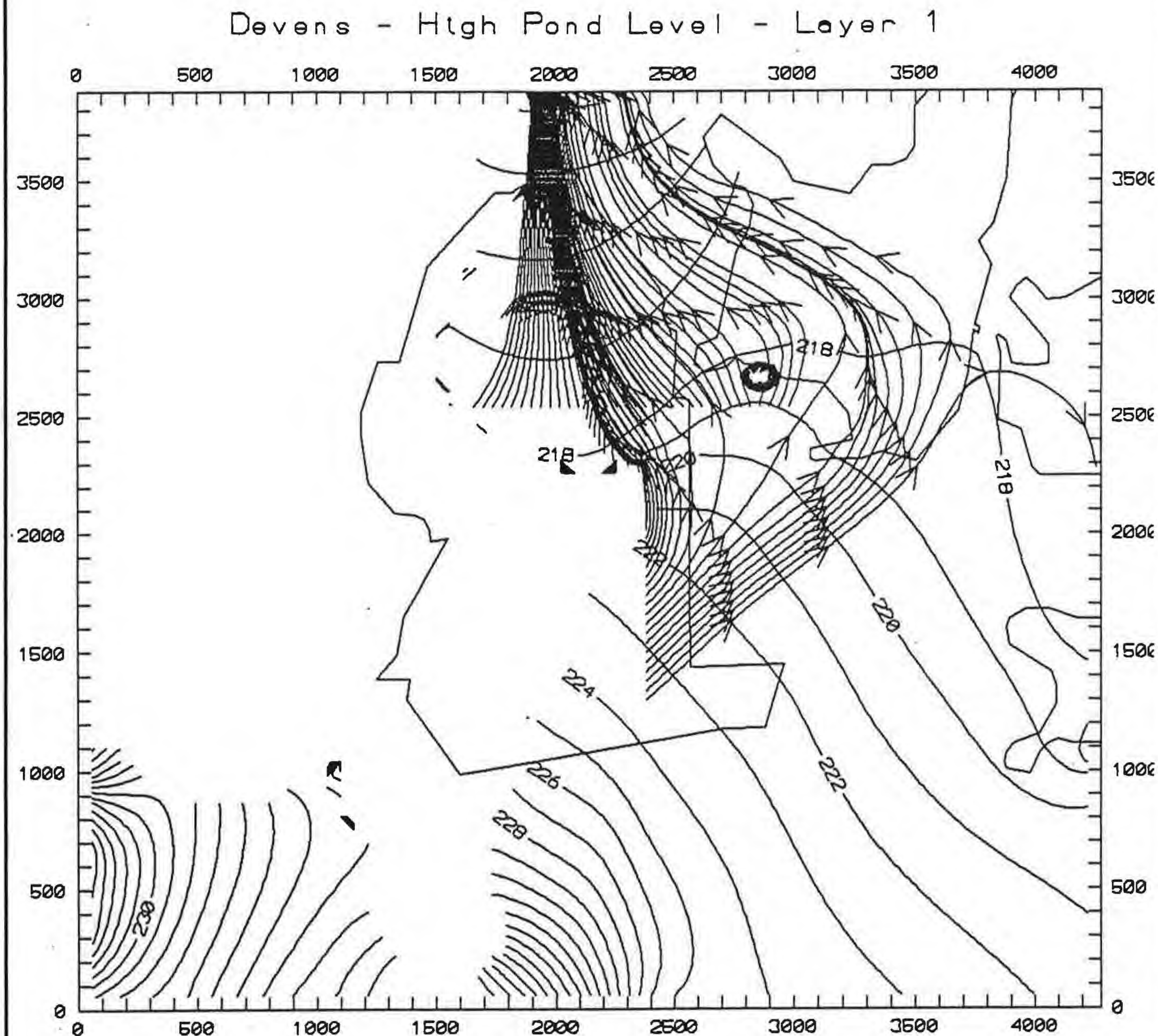




**FIGURE 4-9**
**GROUNDWATER MODELING:**
**EFFECT OF LOW POND ELEVATION ON**
**GROUNDWATER FLOW**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12




SCALE IN FEET

0 500 1000

**FIGURE 4-10**
**GROUNDWATER MODELING:**
**EFFECT OF HIGH POND ELEVATION ON GROUNDWATER FLOW**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12

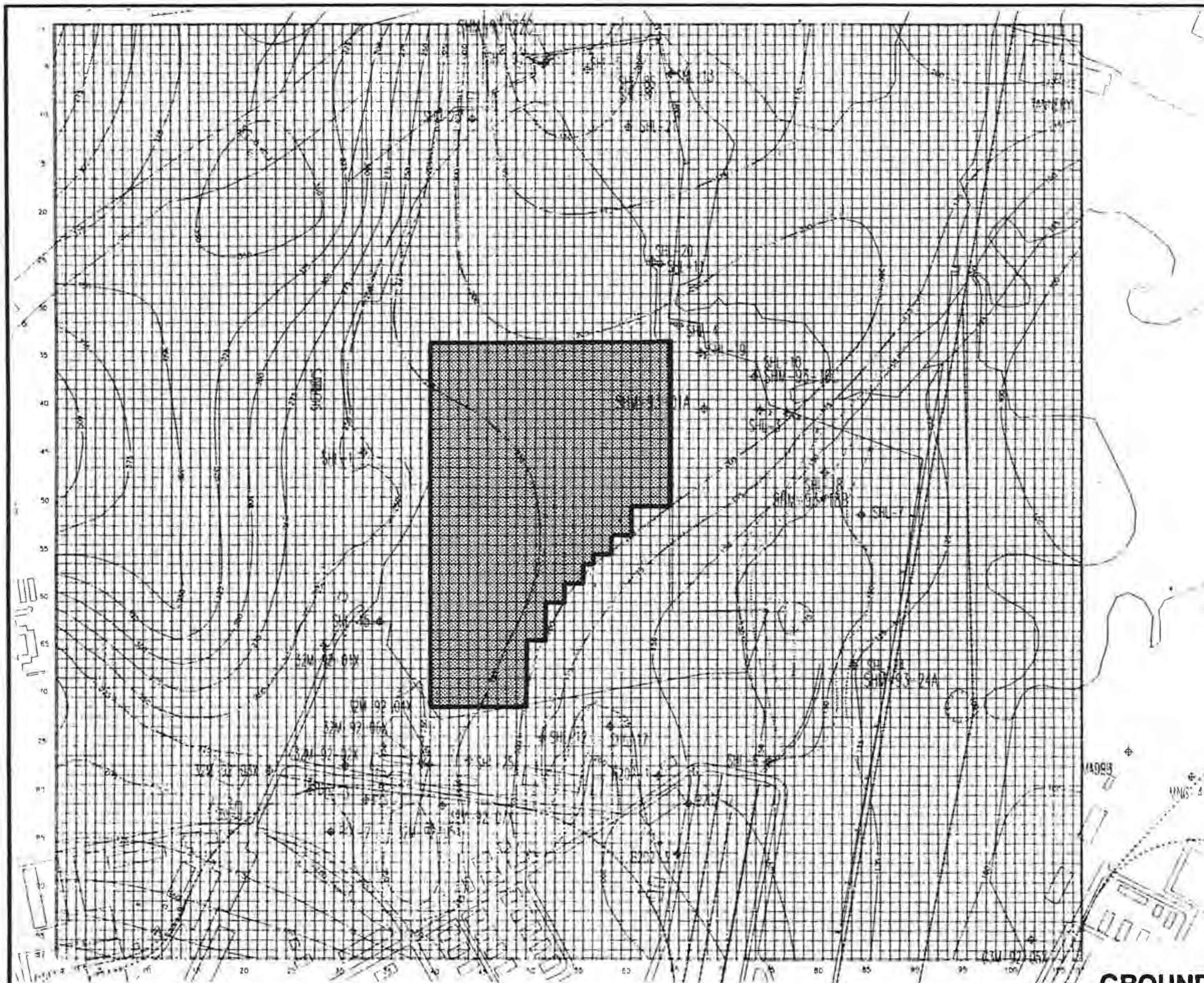



**FIGURE 4-11**
**GROUNDWATER MODELING:**
**AREA OF LOWERED BEDROCK SURFACE**
**SHEPLEY'S HILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12

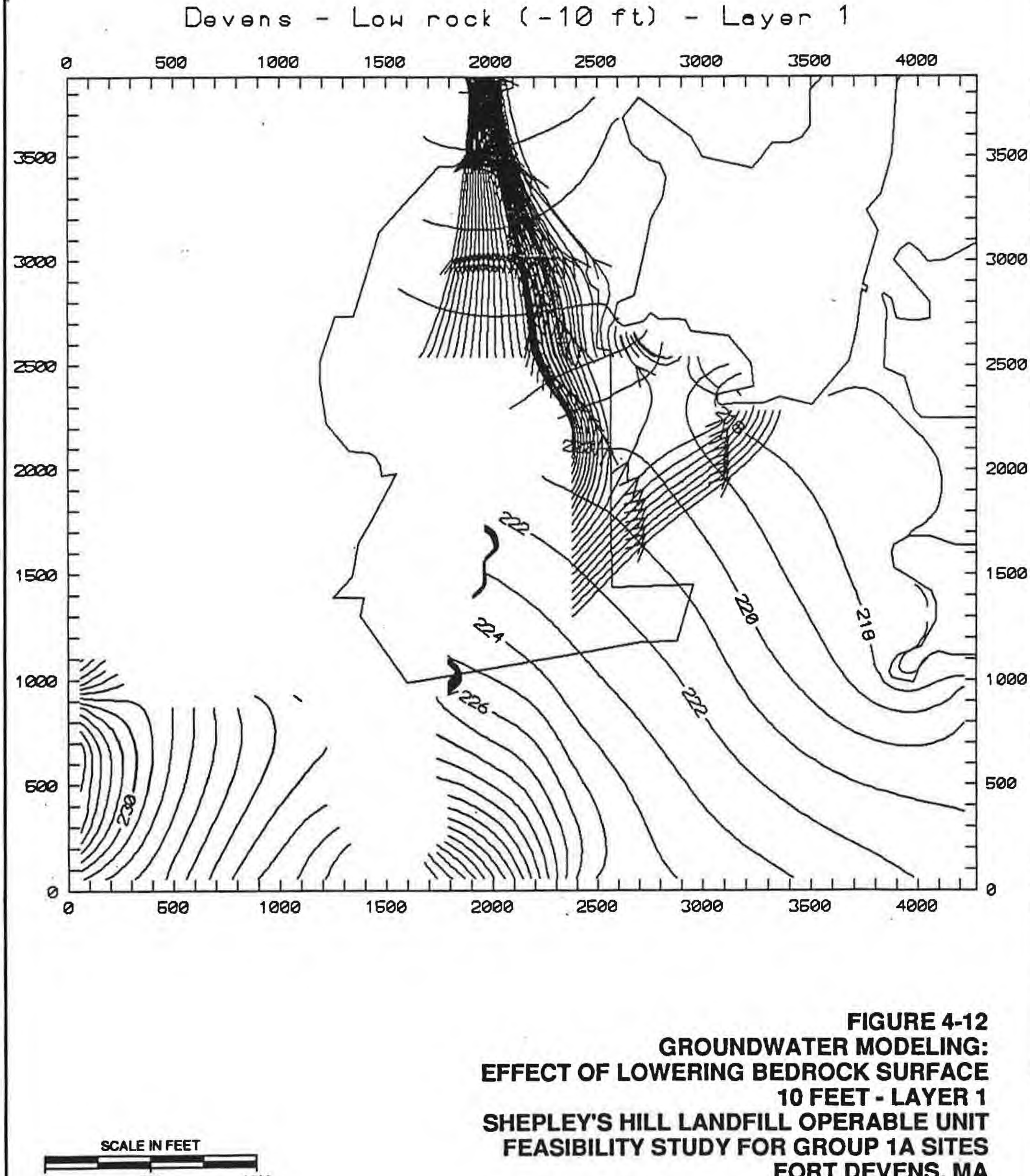



**FIGURE 4-12**
**GROUNDWATER MODELING:**
**EFFECT OF LOWERING BEDROCK SURFACE**
**10 FEET - LAYER 1**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12

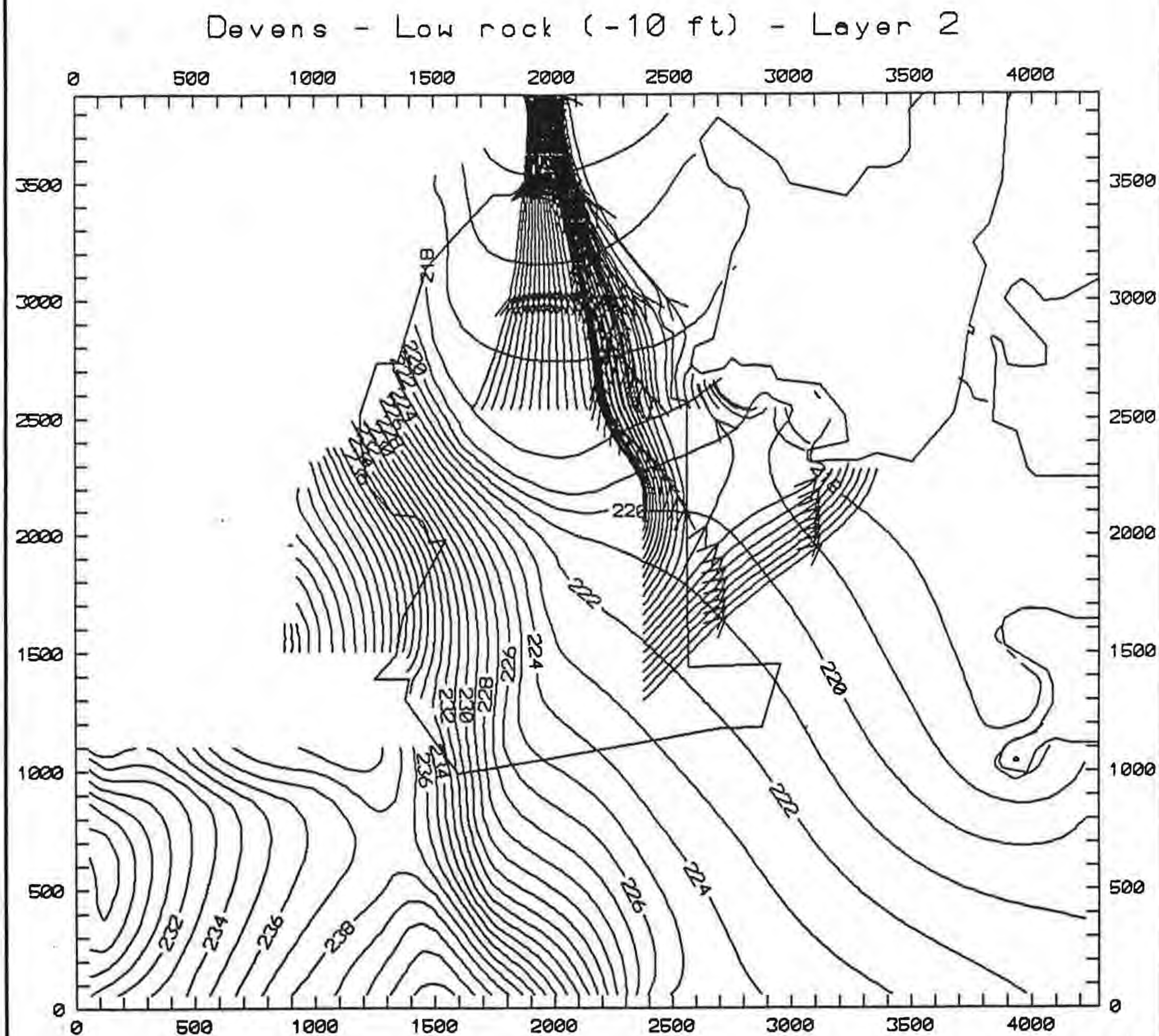



**FIGURE 4-13**
**GROUNDWATER MODELING:**
**EFFECT OF LOWERING BEDROCK SURFACE**
**10 FEET - LAYER 2**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

SCALE IN FEET
0 500 1000

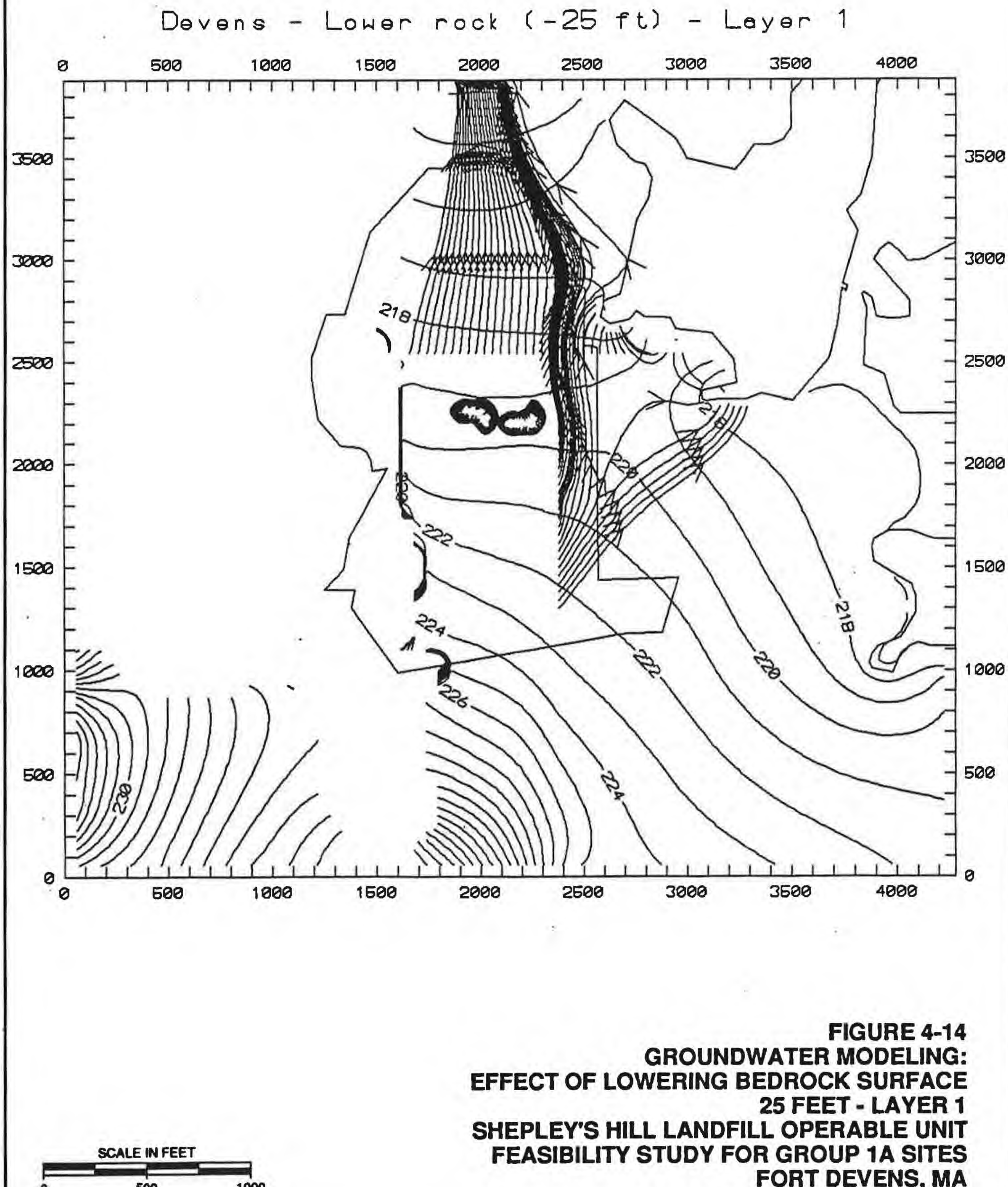



**FIGURE 4-14**
**GROUNDWATER MODELING:**
**EFFECT OF LOWERING BEDROCK SURFACE**
**25 FEET - LAYER 1**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12

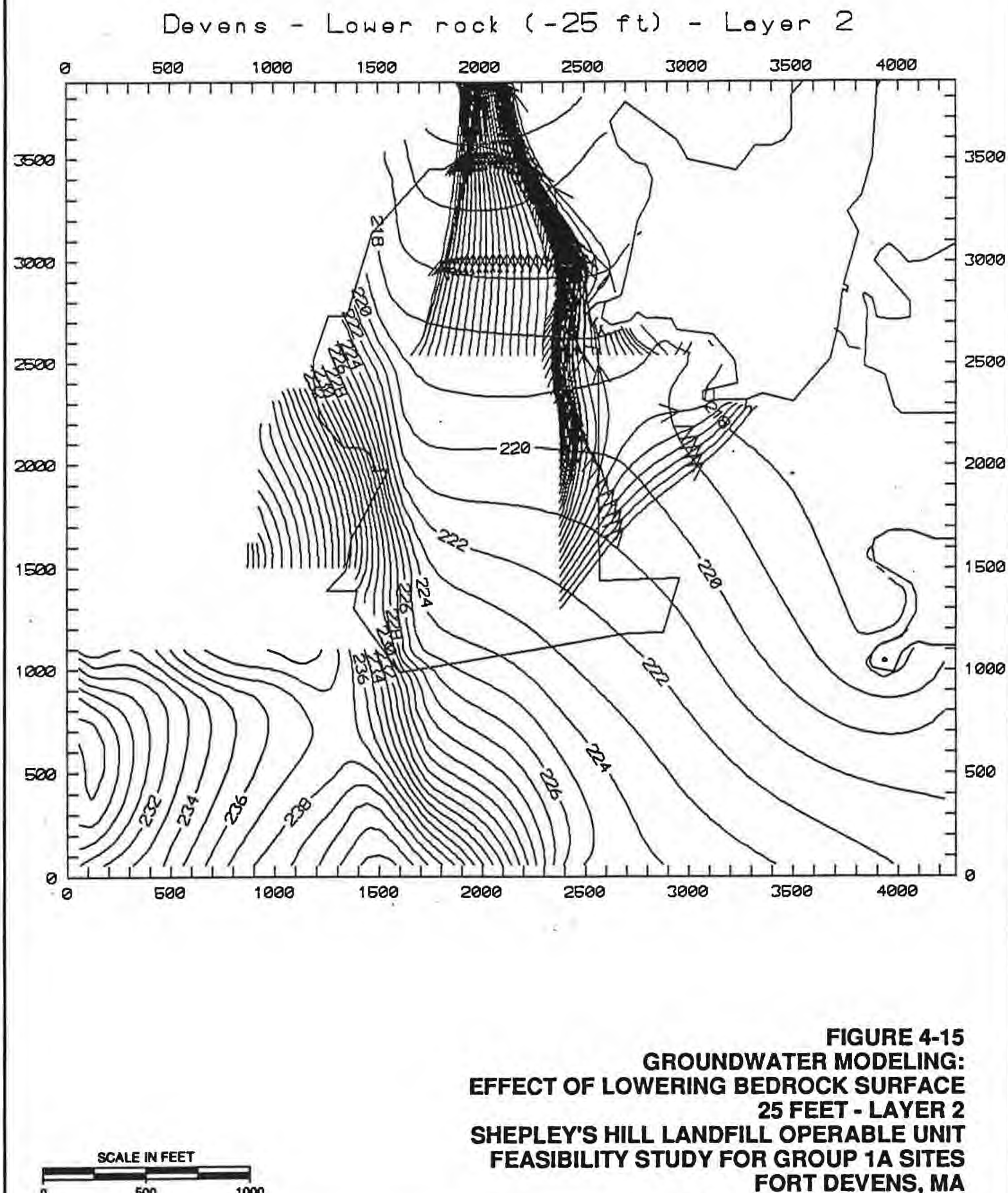
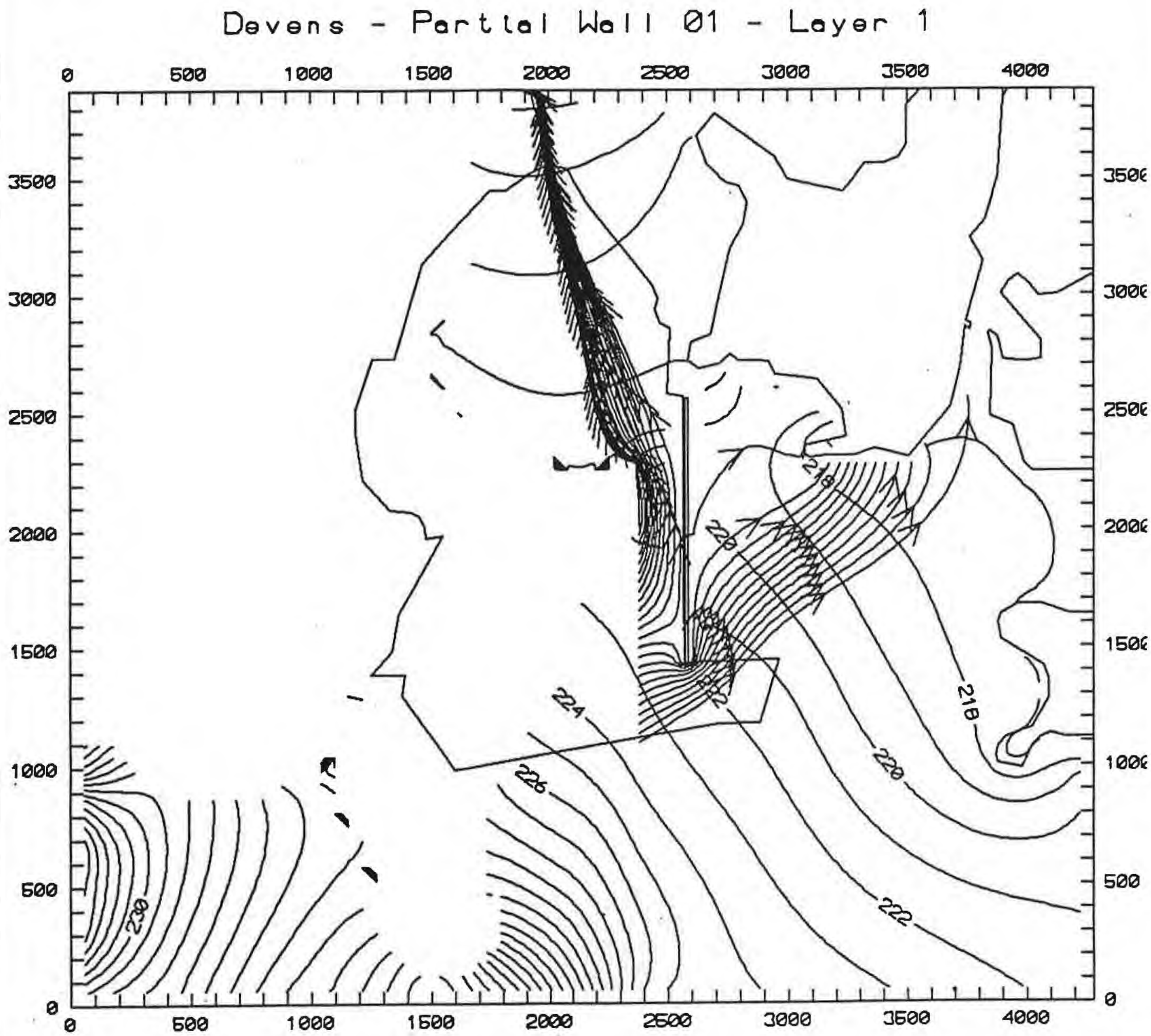



**FIGURE 4-15**
**GROUNDWATER MODELING:**
**EFFECT OF LOWERING BEDROCK SURFACE**
**25 FEET - LAYER 2**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12

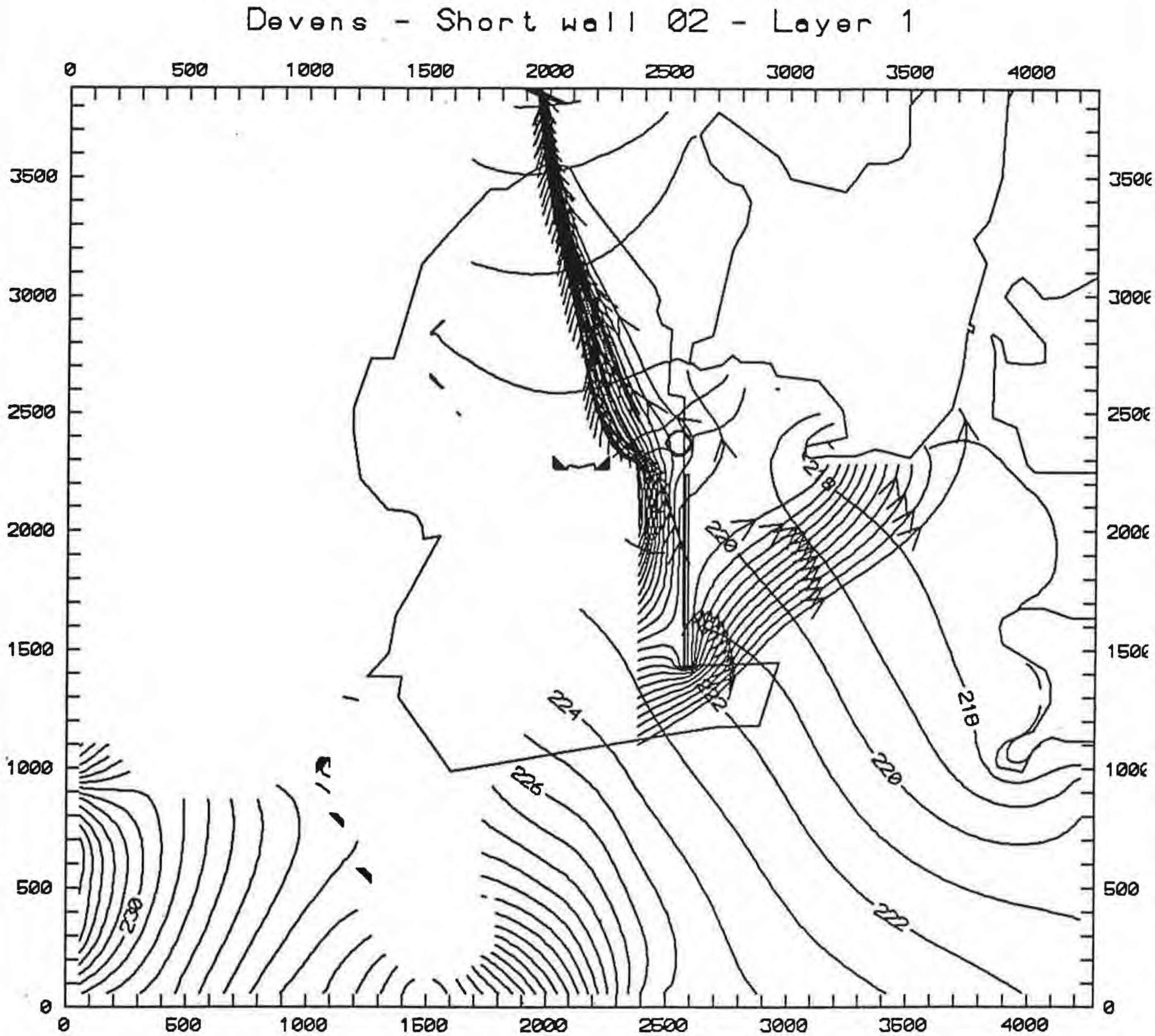



NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.


**FIGURE 4-16**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION PWALL 01**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04



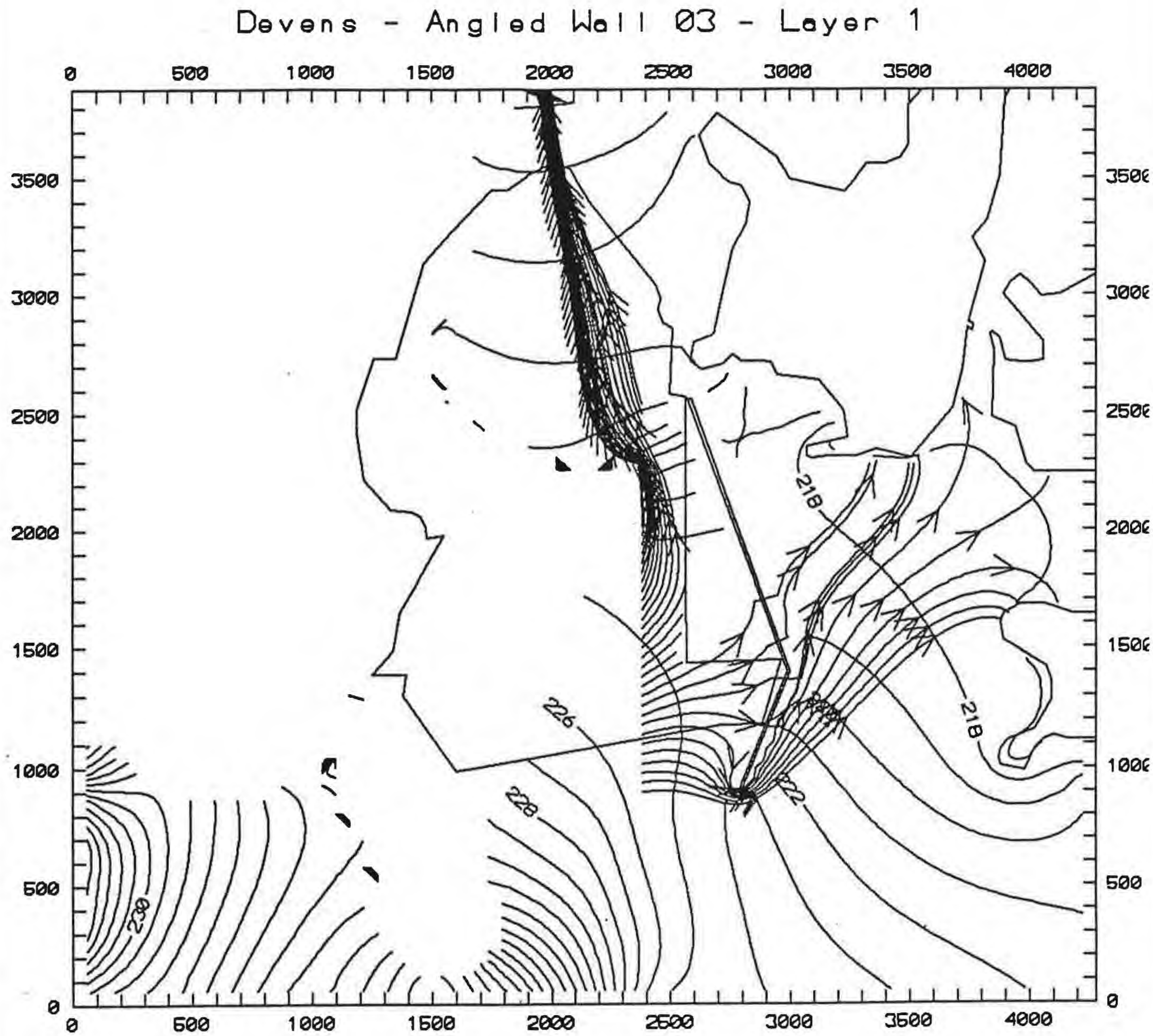

NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

**FIGURE 4-17**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION PWALL 02**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

SCALE IN FEET
0 500 1000

ABB Environmental Services, Inc.

07005-04

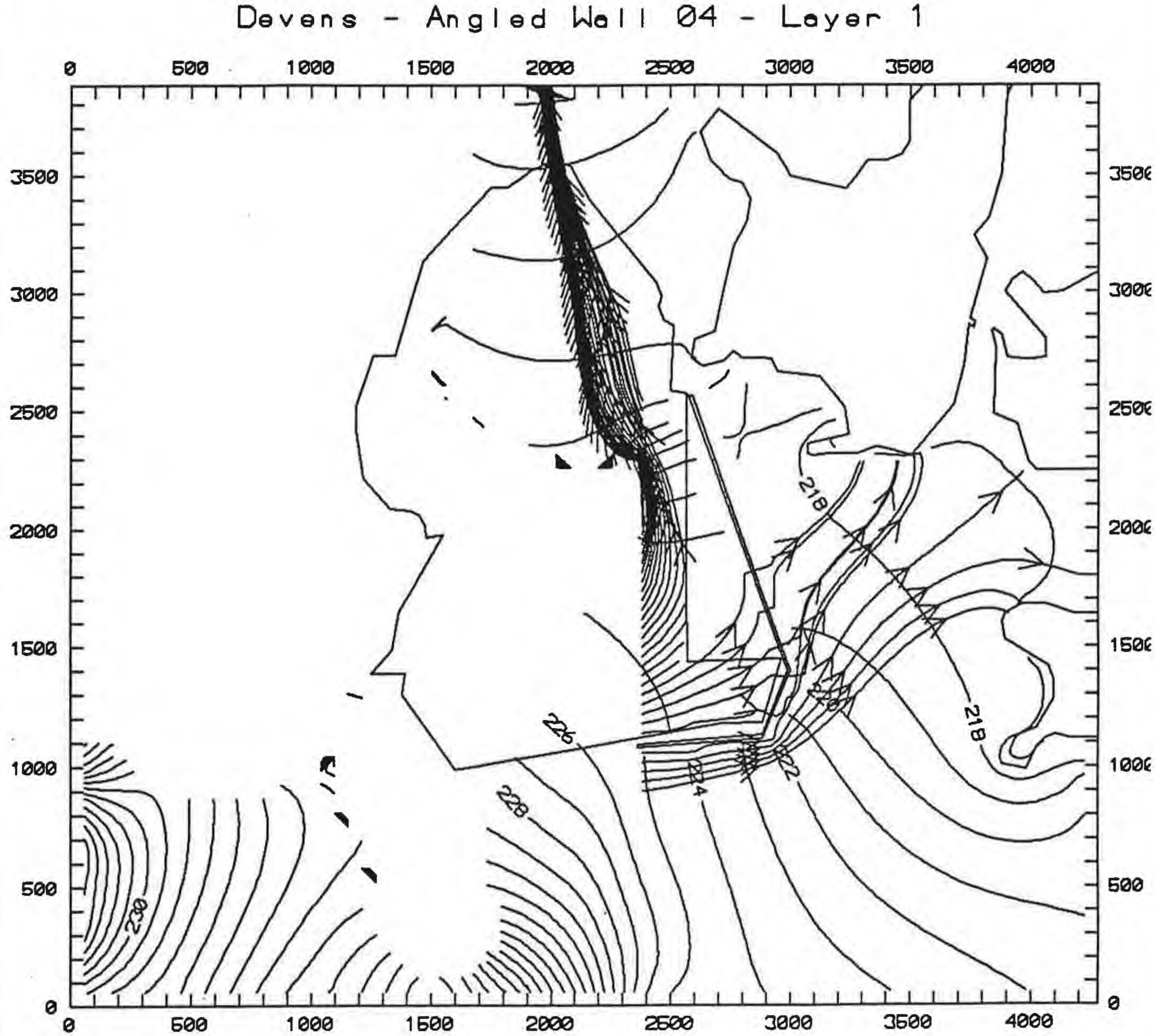



**NOTE**: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.


**FIGURE 4-18**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION PWALL 03**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04




NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

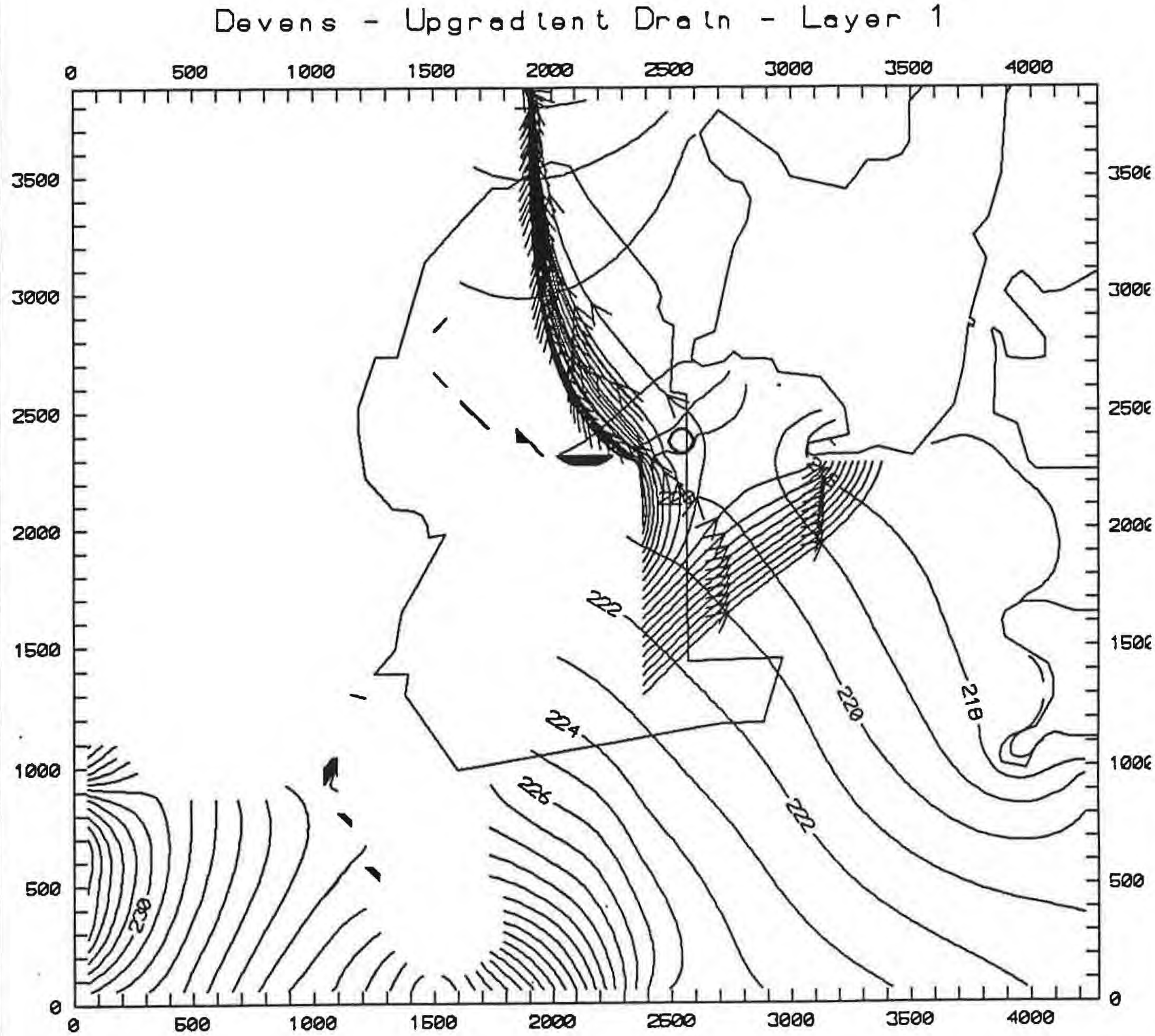
SCALE IN FEET

0 500 1000

**FIGURE 4-19**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION PWALL 04**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04



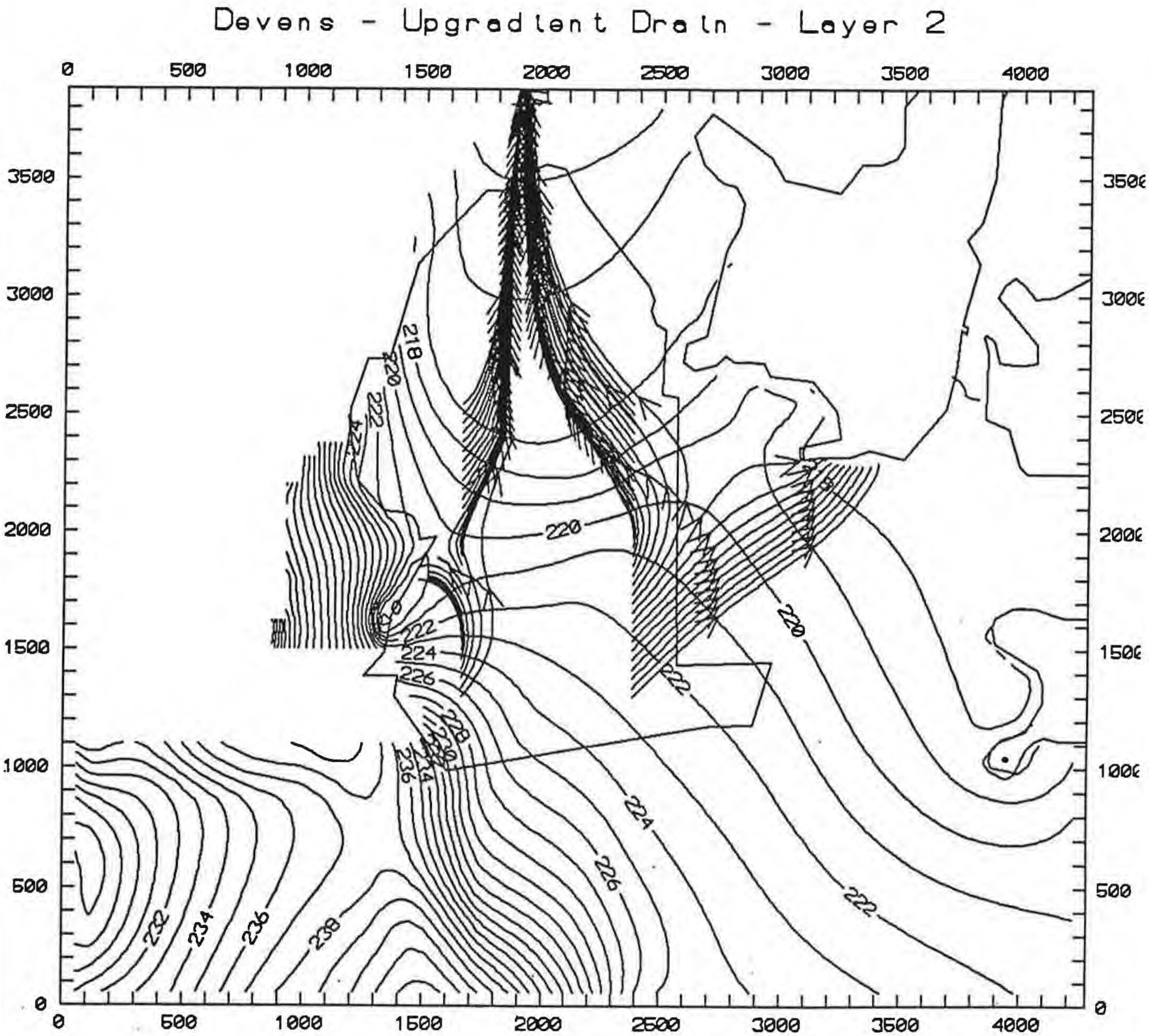

NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

SCALE IN FEET
0 500 1000

**FIGURE 4-20**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION DRAIN - LAYER 1**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

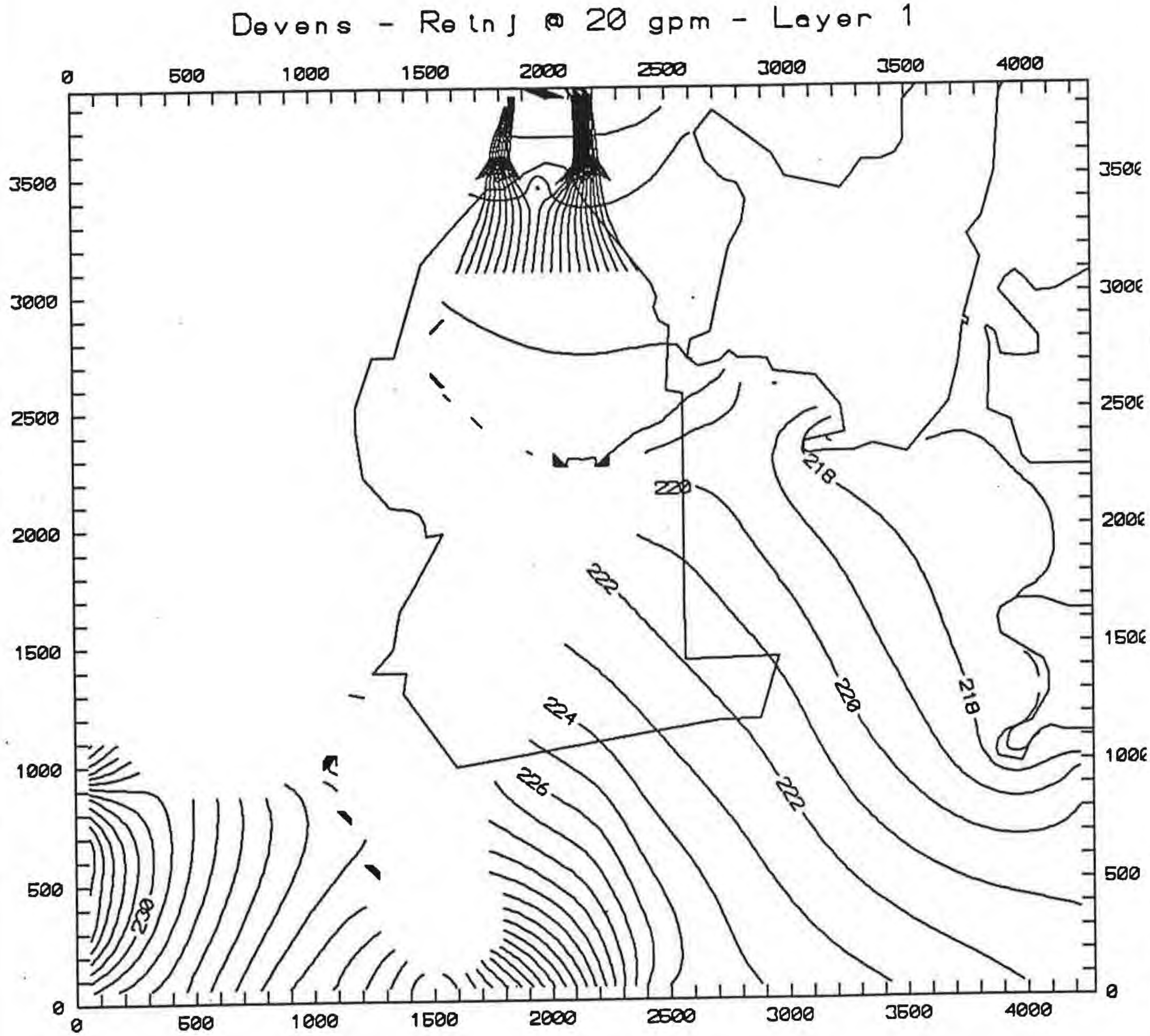
07005-04




**NOTE:** REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

**FIGURE 4-21**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION DRAIN - LAYER 2**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

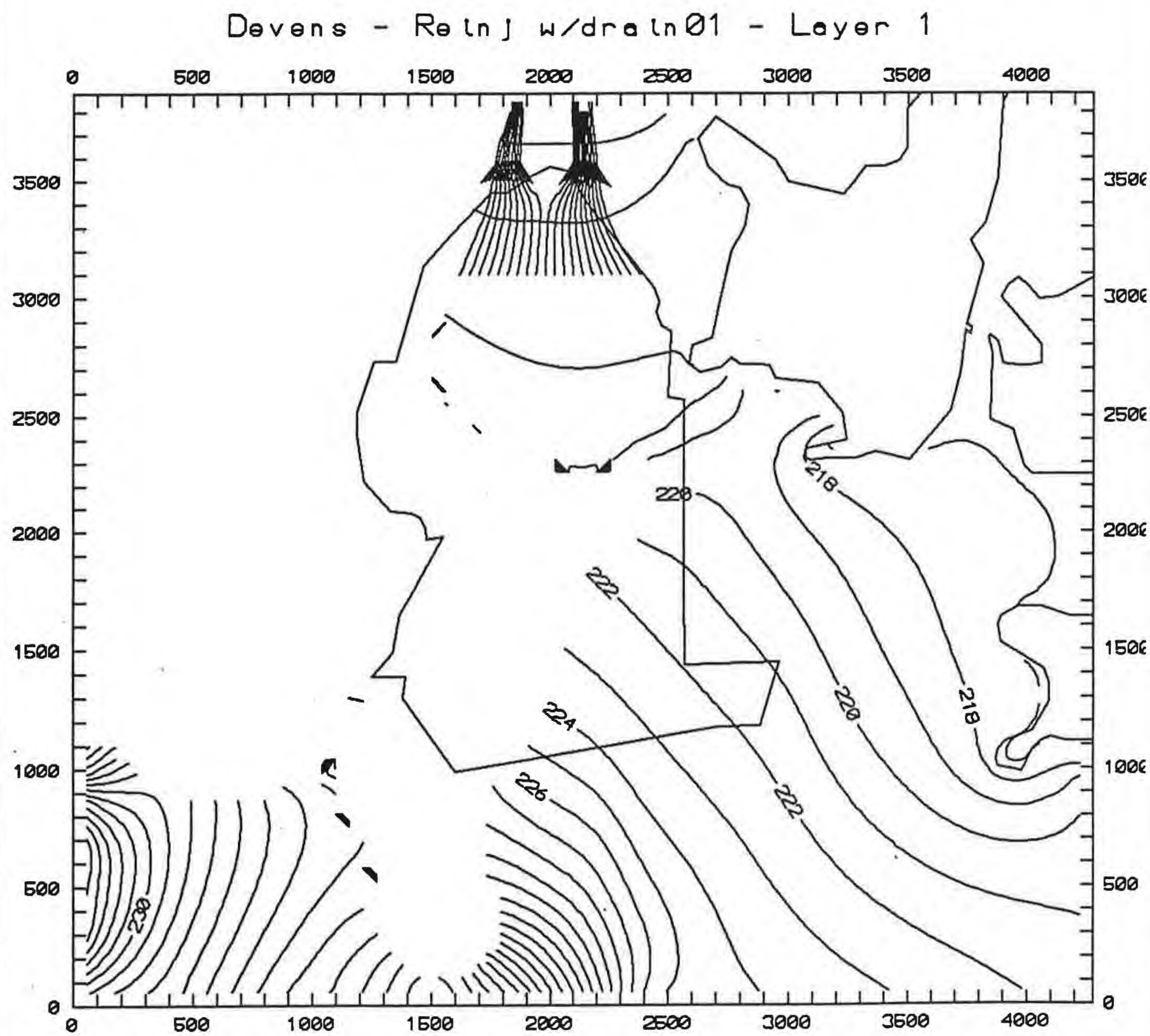



**NOTE**: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.


**FIGURE 4-22**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION REINJ 01**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04




NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

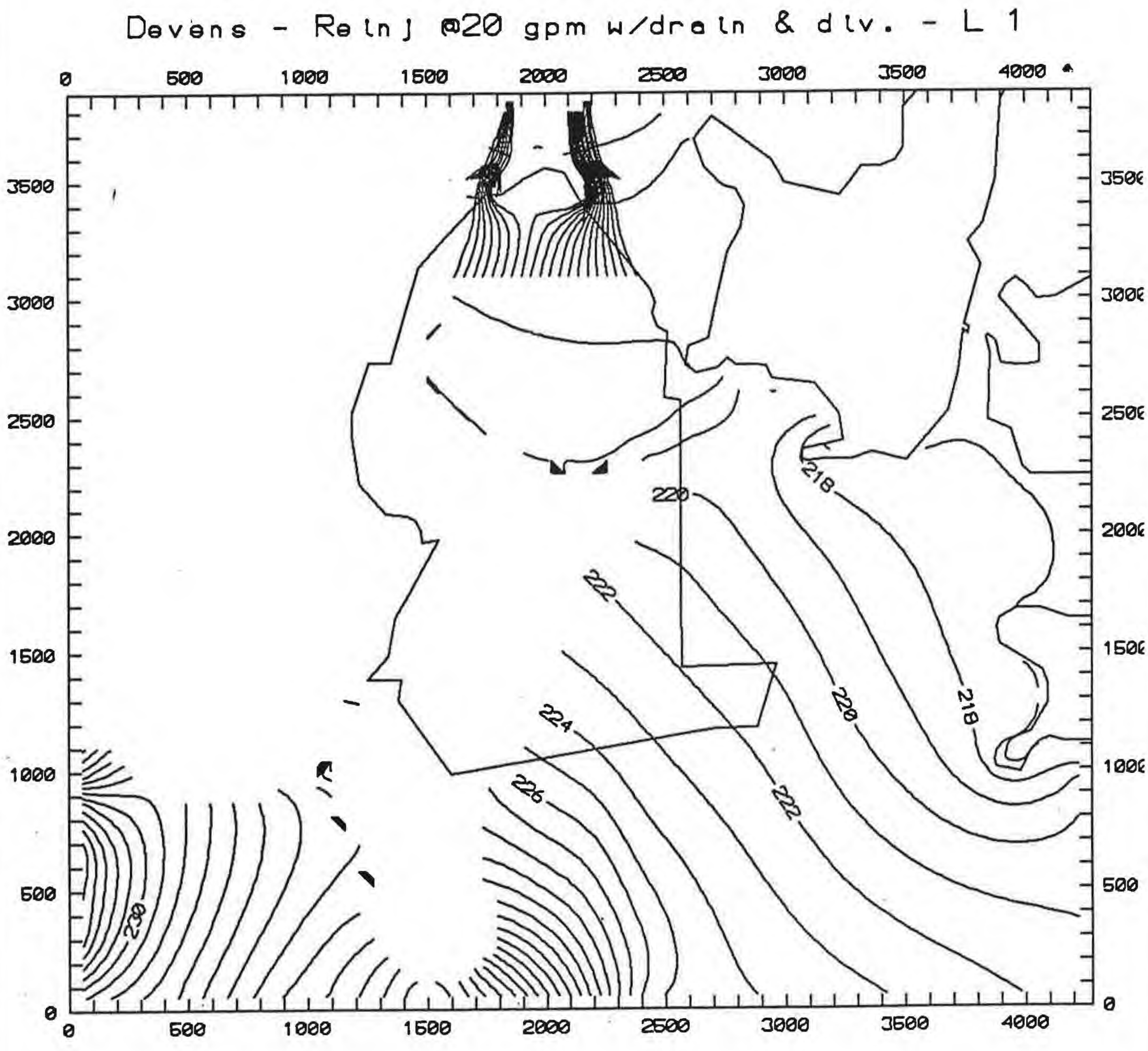
SCALE IN FEET

0 500 1000

**FIGURE 4-23**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION DRAIN 1**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04



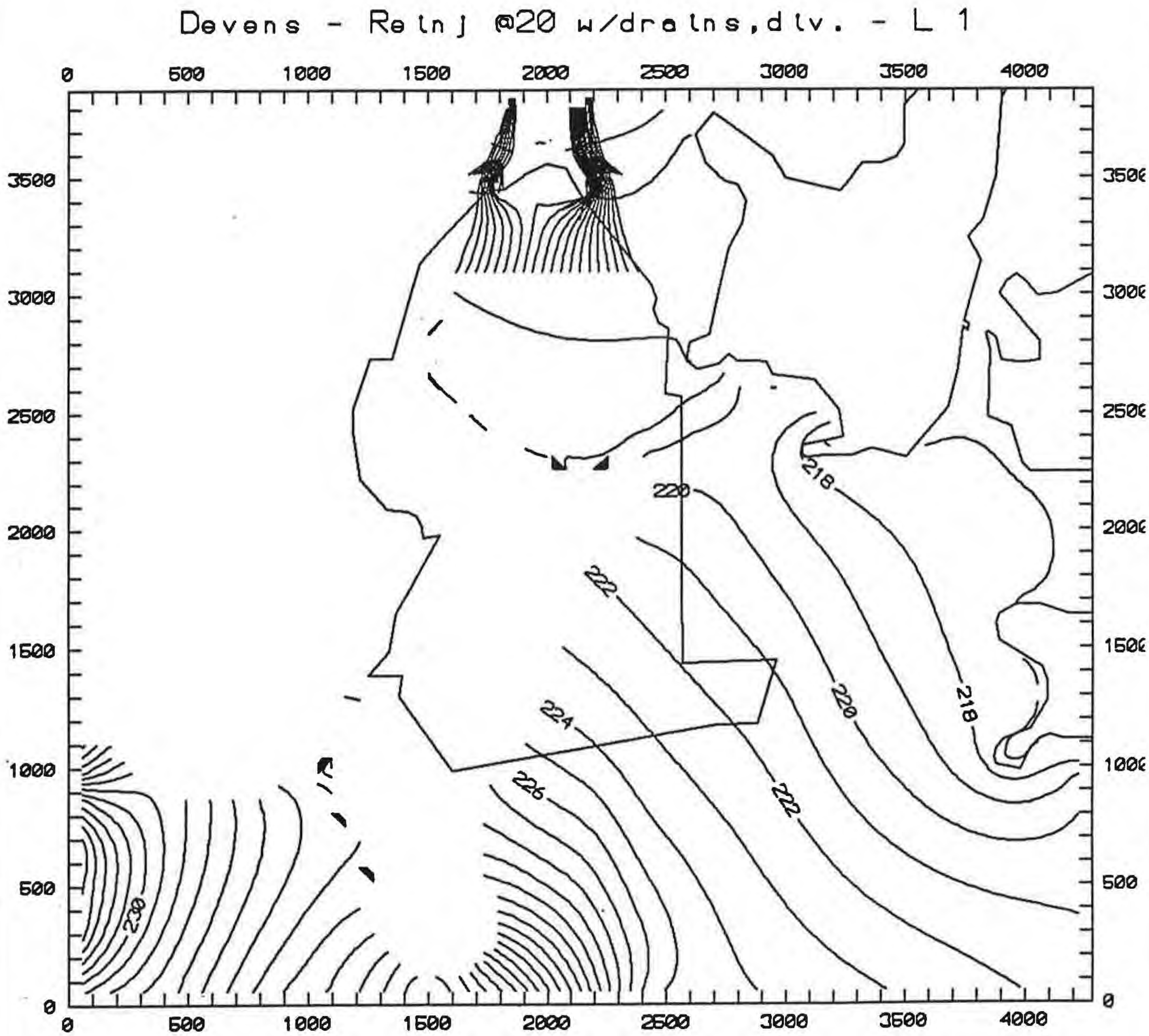

NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

SCALE IN FEET
0 500 1000

**FIGURE 4-24**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION DRAIN 2**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04



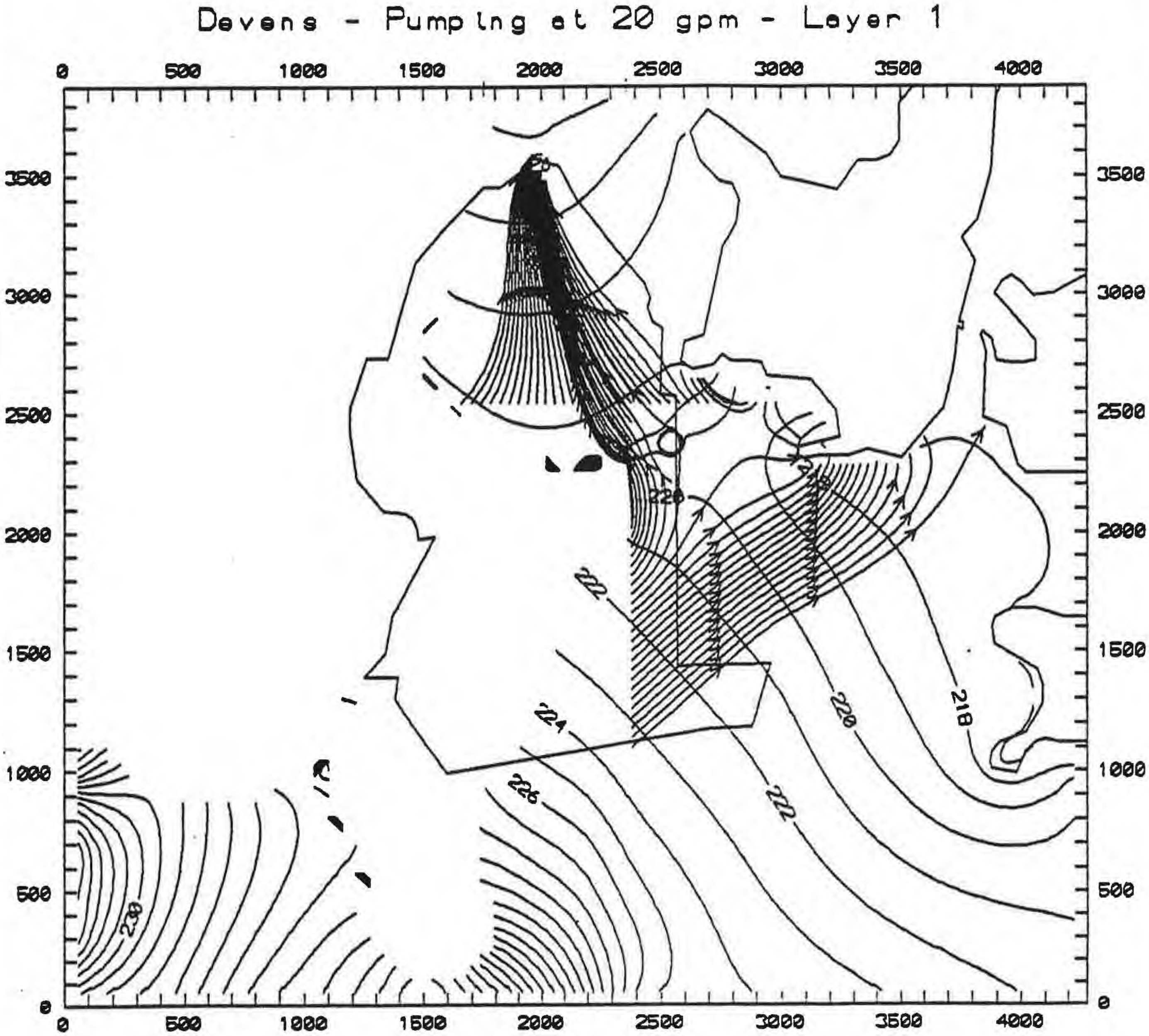

NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

SCALE IN FEET
0 500 1000

**FIGURE 4-25**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION DRAIN 3**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-04



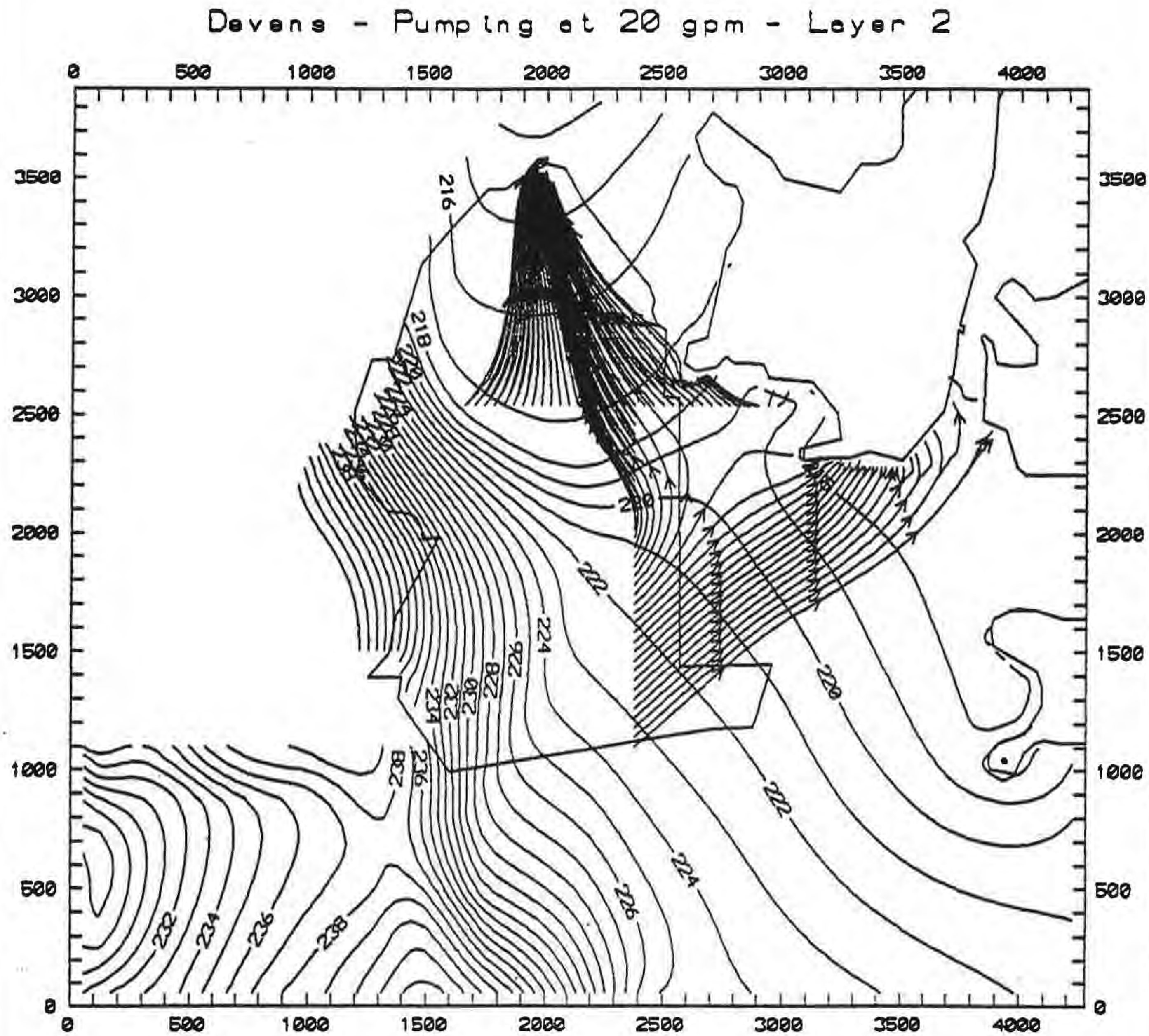

**NOTE:** REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

SCALE IN FEET
0 500 1000

**FIGURE 4-26**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION PUMP 01 - LAYER 1**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

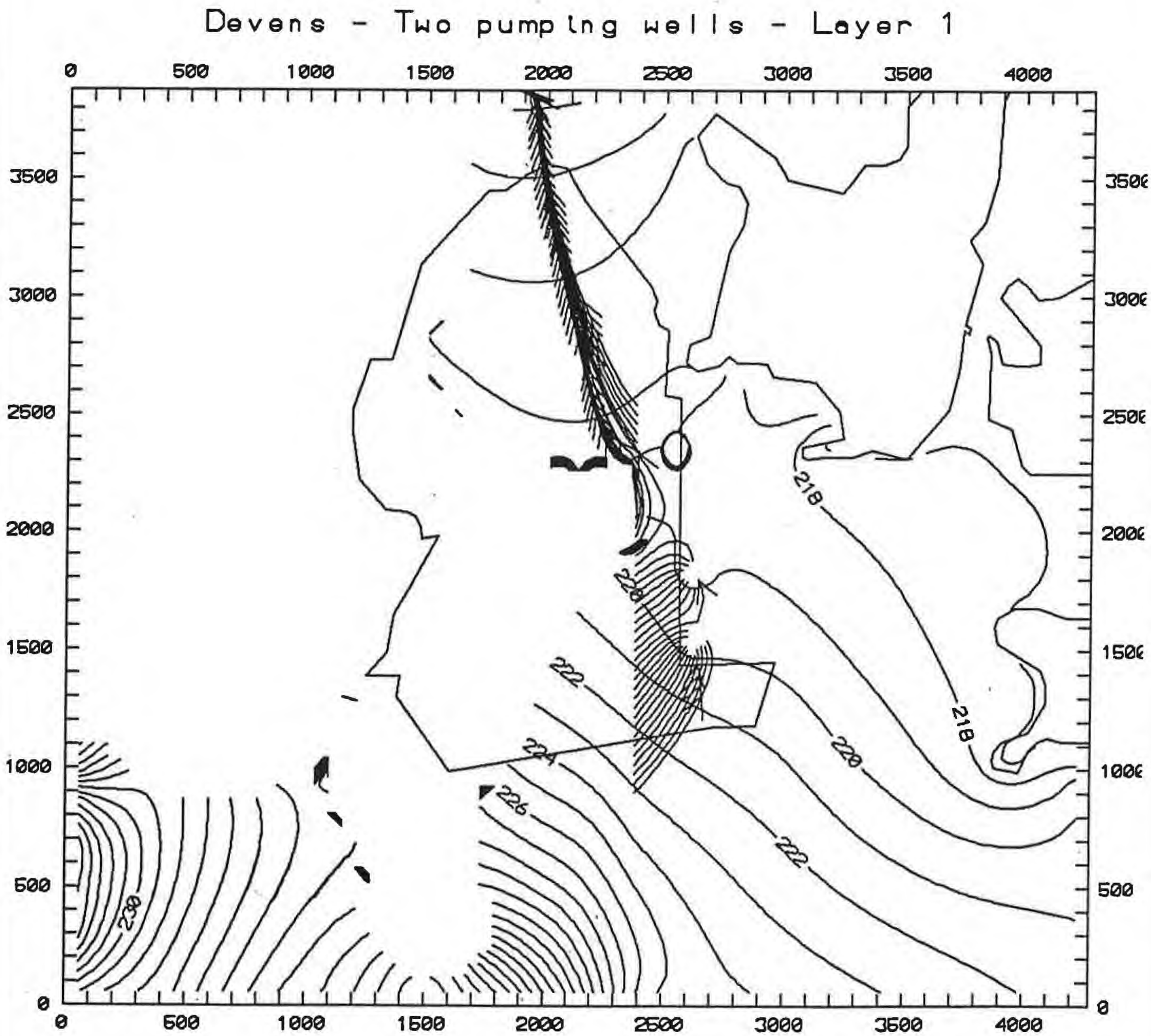
07005-04




**NOTE:** REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

SCALE IN FEET
0 500 1000

**FIGURE 4-27**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION PUMP 02 - LAYER 2**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

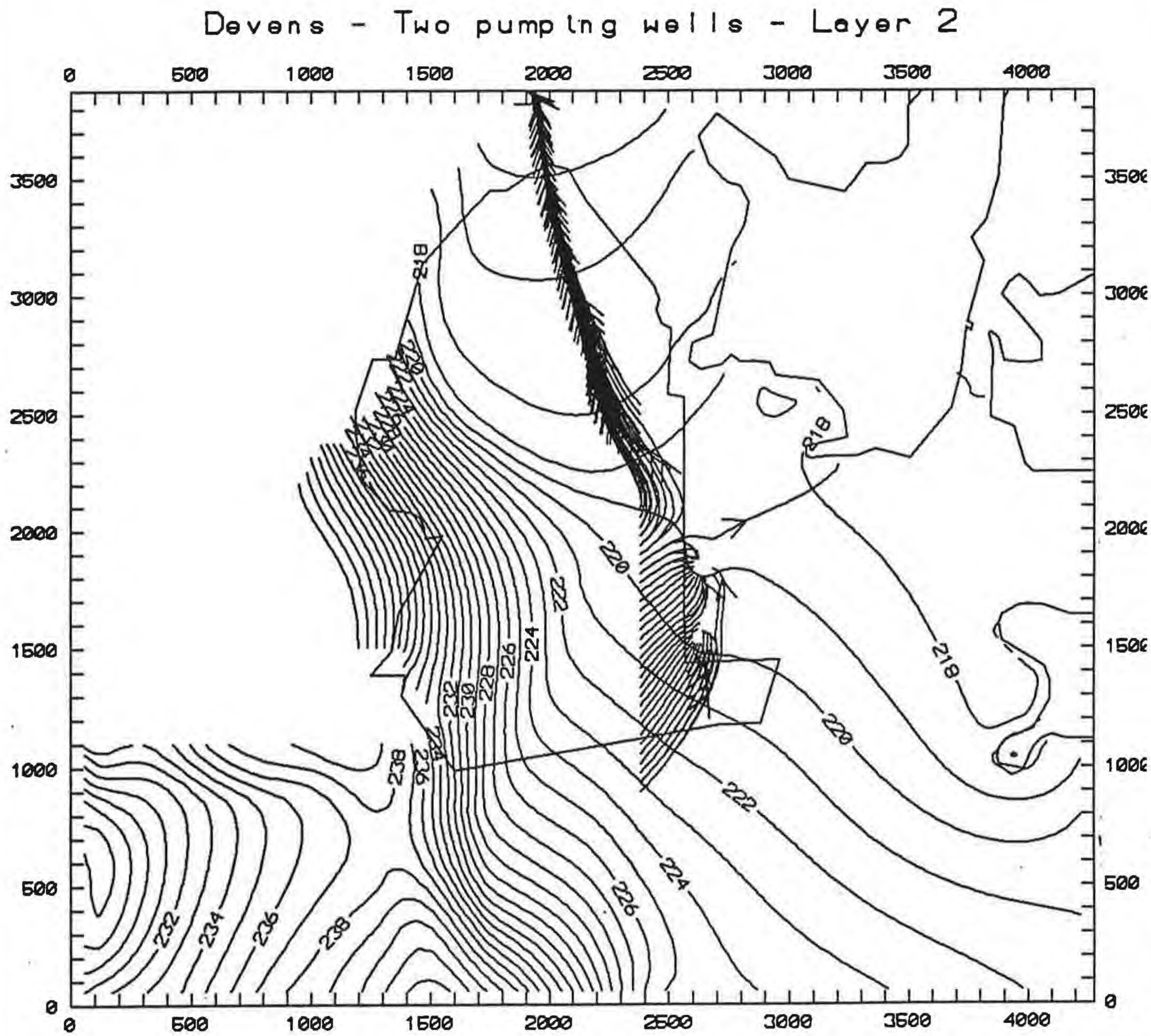



NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

SCALE IN FEET
0 500 1000

**FIGURE 4-28**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION PUMP 05 - LAYER 1**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.




NOTE: REFERENCE TABLE 4-2 FOR RUN IDENTIFICATION DESCRIPTION.

SCALE IN FEET
0 500 1000

**FIGURE 4-29**
**GROUNDWATER MODELING:**
**RUN IDENTIFICATION PUMP 05 - LAYER 2**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

07005-12

## TABLE 4-1
## COMPARISON OF VOLUMETRIC BUDGET FOR LOW AND HIGH POND ELEVATIONS

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| CUMULATIVE VOLUMES | ALTERNATE BOUNDARY | LOW POND ELEVATION | HIGH POND ELEVATION |
|---|---|---|---|
| **IN** | | | |
| Storage | 0.00000 | 0.00000 | 0.00000 |
| Constant Head | 84,765 | 88,199 | 82,736 |
| Recharge | 33,231 | 33,231 | 33,231 |
| River Leakage | 2,792 | 1,492 | 6,027 |
| Head DEP Bounds | 0.00000 | 0.00000 | 0.00000 |
| Total In | 120,788 | 122,923 | 121,976 |
| **OUT** | | | |
| Storage | 0.00000 | 0.00000 | 0.00000 |
| Constant Head | 88,970 | 80,080 | 99,320 |
| Recharge | 0.00000 | 0.00000 | 0.00000 |
| River Leakage | 21,274 | 34,176 | 10,218 |
| Head DEP Bounds | 10,346 | 8,591 | 12,126 |
| Total Out | 120,590 | 122,847 | 121,664 |
| In - Out | 198 | 76 | 312 |
| Percent Discrepancy | 0.16 | 0.06 | 0.26 |

**Notes:** Volumes are cubic feet per day.

## TABLE 4-2
## SUMMARY OF GROUNDWATER MODELING SIMULATION RUNS

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| RUN IDENTIFICATION | SIMULATED CONDITIONS | | CORRESPONDING FIGURE |
|---|---|---|---|
| Partial walls: | | | |
| Pwa1101 | A partial wall 1,120 feet long in overburden along the eastern perimeter of the landfill | | 4-16 |
| Pwa1102 | A partial wall 800 feet long in overburden along the eastern perimeter of the landfill | | 4-17 |
| Pwa1103 | A partial wall 1,800 feet long angled to extend past the SE corner of the landfill | | 4-18 |
| Pwa1104 | A partial wall 2,040 feet long similar to Pwa1103, but which wraps around the southern corner of the landfill | | 4-19 |
| Upgradient drains: | | | |
| Drain | a) | An upgradient drain 10 feet into rock along about a 700-foot length of the western side of the landfill | 4-20 and 4-21 |
| Drain | b) | Same as a), but 20-foot deep drain | 4-20 and 4-21 |
| Drain | c) | Same as a), but 30-foot deep drain | 4-20 and 4-21 |
| Injection simulation: | | | |
| Reinj01 | Injection of 20 gpm at north end of landfill | | 4-22 |
| Reinj02 | Injection of 40 gpm at north end of landfill | | 4-23 |
| Drain1 | Same as Reinj01 with north-south drain added | | 4-24 |
| Drain2 | Same as Drain1 with two 200-foot diversion walls added | | 4-25 |
| Drain3 | Same as Drain2 with inner drains added to diversion walls | | |

(continued)

**TABLE 4-2**
**SUMMARY OF GROUNDWATER MODELING SIMULATION RUNS**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| RUN IDENTIFICATION | SIMULATED CONDITIONS | CORRESPONDING FIGURE |
|---|---|---|
| Pumping simulations: | | |
| Pump01 | Extraction well at north end of landfill at 10 gpm | No Figure |
| Pump02 | Same as Pump01, but with pumping at 20 gpm | 4-26 and 4-27 |
| Pump03 | Single well at 20 gpm near "L" at SE corner of landfill | No Figure |
| Pump04 | Same as Pump03, but at 40 gpm | No Figure |
| Pump05 | Two extraction wells at SE corner of landfill, one at 15 gpm and the second at 25 gpm | 4-28 and 4-29 |
| Pump06 | Same as Pump01, but at 15 gpm | No Figure |
| Other particle tracking: | | |
| SSfinal | Steady-state conversion of final calibrated model to show particle tracks after capping | 4-5 |
| Nocap | Steady-state version of ETA's uncapped model run, converted to allow particle tracking | 4-6 |

**TABLE 4-3**
**ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

This alternative does not provide any remedial actions to treat groundwater. Zoning and deed restrictions, along with landfill cover system maintenance will reduce potential for exposure. Long-term groundwater and landfill gas monitoring and five-year site reviews are included.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Advantages | Advantages | Advantages |
| • Groundwater does not currently pose a drinking water risk because no residential receptors exist. | • Easy to implement zoning and deed restrictions on Army property. | • Low capital costs. |
| • Zoning and deed restrictions would prevent future exposure to groundwater. | • No impediments to meeting action-specific ARARs are expected. | • Low O&M costs for long-term groundwater monitoring and five-year site reviews. |
| • Low potential for short-term worker exposure to contaminants during implementation. | • Cover system repairs, drainage improvements and groundwater monitoring would be easily implemented. | |
| • Landfill cover system will reduce the mobility of contaminants. | | |
| • Groundwater modeling suggests that capping of landfill has: (1) significantly reduced the total amount of water in the landfill area; and (2) almost totally diverted groundwater flow from the landfill away from the northern portions of Plow Shop Pond. | | |
| Disadvantages | Disadvantages | Disadvantages |
| • Does not reduce toxicity or volume of contaminants. | • May require future groundwater treatment. | • Potential for future remedial action costs. |

continued

**TABLE 4-3**
**ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| | • Not consistent with SARA's preference for treatment. | |

**ESTIMATED CAPITAL COST $928,000**

**ESTIMATED PRESENT WORTH OF O&M COSTS $1,291,000**

**ESTIMATED TOTAL PRESENT WORTH $2,219,000**

**CONCLUSION:** This alternative will be **retained** for detailed analysis because it provides administrative controls to protect human health at a low cost.

**Notes:**

SARA = Superfund Amendments and Reauthorization Act
O&M = Operations and maintenance

**TABLE 4-4**
**ALTERNATIVE SHL-3: CONTAINMENT/COLLECTION/SHORT-TERM EX SITU TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

This alternative involves construction of a 4,500-ft.-long slurry wall and a 2,500- ft.-long grout curtain around the waste in conjunction with the existing cover system. The slurry wall and grout curtain should reduce future groundwater contamination by diverting clean groundwater away from landfilled waste. Alternative SHL-3 also includes installation of extraction wells upgradient of the slurry wall and short-term groundwater treatment. Limited action components are included.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Advantages | Advantages | Advantages |
| • None | • Slurry walls, grout curtains, and extraction wells are commonly implemented technologies.<br>• No impediments to meeting action-specific ARARs are expected.<br>• Proposed depths for slurry wall and grout curtain are within the range of available equipment. | • Moderate O&M costs for long-term groundwater monitoring and five- year site reviews. |
| Disadvantages | Disadvantages | Disadvantages |
| • Groundwater modeling indicates that much of the overburden is unsaturated. Installation of a grout curtain and slurry wall would only lead to minimal additional lowering of the groundwater table. | • Extensive bedrock investigations required prior to installation of grout curtain. | • High capital costs for slurry wall, grout curtain, extraction wells and treatment system. |
| • Not keying slurry wall into bedrock may allow some leakage, and groundwater flow may occur beneath the bottom of the grout curtain. | • Tying slurry wall into existing cap would require excavation of periphery cap materials and additional PVC membrane. | |
| • Time required to achieve response objectives and target levels in groundwater is not known. | • Extraction wells and treatment system will require long-term operation and maintenance. | |

# TABLE 4-4
## ALTERNATIVE SHL-3: CONTAINMENT/COLLECTION/SHORT-TERM EX SITU TREATMENT/SURFACE WATER DISCHARGE

## SHEPLEY'S HILL LANDFILL OPERABLE UNIT
## FEASIBILITY STUDY FOR GROUP 1A SITES
## FORT DEVENS, MA

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| • Potential for short-term worker exposure to contaminated groundwater during slurry wall construction and installation of extraction wells. | • Cut and fill may be required to achieve <1% ground surface grade for slurry wall. | |
| • Hydrogeologic evaluation of slurry wall and grout curtain effectiveness must be done. | • May require surface water discharge permit. | |
| | • Installation of discharge pipe to Nonacoicus Brook would require crossing floodplains and delineated wetland. | |

**CONCLUSION:** This alternative will be **eliminated** due to the ineffectiveness of the containment components as demonstrated through groundwater modeling.

**Note:**

O&M = Operations and maintenance

## TABLE 4-5
## ALTERNATIVE SHL-4: CONTAINMENT/IN SITU OXIDATION

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

This alternative involves construction of a 4,500-ft.-long slurry wall and a 2,500-ft.-long grout curtain around the waste in conjunction with the existing cover system. The slurry wall and grout curtain should reduce future groundwater contamination by diverting clean groundwater away from the landfilled waste. Alternative SHL-4 also includes installation of groundwater injection wells at the north end of the landfill, to be used for injection of hydrogen peroxide to treat groundwater by in situ fixation.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Advantages | Advantages | Advantages |
| • Although in situ oxidation has not been used full scale at hazardous waste sites, the chemistry of As co-precipitation with Fe has been proven. | • Slurry walls, grout curtains, and injection wells are commonly implemented technologies. | • Potential low capital and O&M costs for in situ fixation treatment. |
| | • No impediments to meeting action-specific ARARs are expected. | • Moderate O&M costs for long-term groundwater monitoring and five-year site reviews. |
| • In situ oxidation should reduce toxicity and mobility of As by converting it to its less toxic, oxidized form. | • Proposed depths for slurry wall and grout curtain are within the range of available equipment. | |
| | • Vendors for in situ aquifer treatment technologies are available. | |
| | • Hydrogen peroxide and potable water readily available. | |
| | • Treatment system can be operated relatively unattended. | |
| | • No groundwater extraction required. | |
| | • No treatment residuals requiring off-site disposal. | |

**TABLE 4-5**
**ALTERNATIVE SHL-4: CONTAINMENT/IN SITU OXIDATION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Disadvantages | Disadvantages | Disadvantages |
| • Groundwater modeling indicates that much of the overburden is unsaturated. Installation of a grout curtain and slurry wall would only lead to minimal additional lowering of the groundwater table. | • Extensive bedrock investigations required prior to installation of grout curtain. | |
| • Modeling indicated that injection wells would not be effective for injection of hydrogen peroxide. | • Tying slurry wall into existing cap would require excavation of periphery cap materials and additional PVC membrane. | |
| • Not keying slurry wall into bedrock may allow some leakage and groundwater flow may occur beneath the bottom extent of the grout curtain. | • In situ oxidation has not been implemented full scale. | |
| • Time required to achieve response objectives and target levels in groundwater is not known. | • Shallow groundwater table at SHL may limit implementability if significant mounding were to occur. | |
| • Potential for short-term worker exposure to contaminated groundwater during slurry wall construction. | • Precautions for on site storage and handling of hydrogen peroxide required. | |
| • Hydrogeologic evaluation of slurry wall and grout curtain effectiveness must be done. | • Potential for clogging of injection wells may require that a "buffer" be set up around the well. | |
| • Treatability study recommended to confirm feasibility for site specific conditions. | • Redundant wells may be required to account for servicing clogged wells. | |

**TABLE 4-5**
**ALTERNATIVE SHL-4: CONTAINMENT/IN SITU OXIDATION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| | • Long-term treatment required.<br>• Cut and fill may be required to achieve $<1\%$ ground surface grade for slurry wall.<br>• Injection wells may be located within the 100 year floodplain. | |

**CONCLUSION:** This alternative will be **eliminated** due to the ineffectiveness of the containment components and injection wells as demonstrated through groundwater modeling.

**Notes:**

SHL = Shepley's Hill Landfill
As = Arsenic
Fe = Iron
O&M = Operations and Maintenance
PVC = Polyvinyl Chloride

## TABLE 4-6
## ALTERNATIVES SHL-5A AND SHL-5B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

This alternative involves installation of groundwater extraction and ion exchange treatment system. Water would be pumped from an extraction well placed at the northern end of the landfill to an Ion Exchange Treatment System for inorganics removal. Limited action components are included.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Advantages | Advantages | Advantages |
| • Reduces toxicity, mobility, and volume of contaminants in groundwater by long term treatment. | • Extraction wells are commonly implemented technologies. | • None. |
| • Demonstrated effective treatment for removal of inorganic contaminants. | • Ion exchange technology services and resin materials readily available. | |
| • Meets remedial action objectives. | • No impediments to meeting action-specific ARARs are expected. | |
| • Contaminants removed onto a resin, low potential for short term risks to workers. | | |
| Disadvantages | Disadvantages | Disadvantages |
| • Effectiveness may be limited by TDS, pH of groundwater, and valence state of inorganics. | • Aquifer tests required to design extraction system. | • High capital and O&M costs for extraction wells, treatment facility, and long term groundwater treatment and monitoring. |
| • Treatability study recommended to determine most effective resin for waste stream. | • Long-term treatment required. | |
| • Time required to achieve response objectives and target levels in groundwater is not known. | • Extraction wells and treatment system will require long-term operation and maintenance. | |
| • Resin regeneration brine will require treatment or disposal. | • Discharge pipe to Nonacoicus Brook would cross delineated floodplains and wetlands. | |

**TABLE 4-6**
**ALTERNATIVES SHL-5A AND SHL-5B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| • Potential for high iron concentrations to foul resin, may require pretreatment to remove some iron. | | |

**ESTIMATED CAPITAL COST $2,577,000**

**ESTIMATED PRESENT WORTH OF O&M COST $6,549,000**

**ESTIMATED TOTAL PRESENT WORTH $9,126,000**

**CONCLUSION:** This alternative will be **retained** because it provides a demonstrated effective process to reduce levels of inorganic contamination in groundwater. This alternative would meet remedial action objectives.

**Notes:**

TDS = total dissolved solids
O&M = operations and maintenance

**TABLE 4-7**
**ALTERNATIVE SHL-6: COLLECTION/CHEMICAL PRECIPITATION TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

This alternative involves installation of a groundwater extraction and chemical precipitation treatment system. Water would be pumped from an extraction well placed at the northern end of the landfill to a Chemical Precipitation Treatment System for inorganics removal. Limited action components are included.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Advantages | Advantages | Advantages |
| • Reduces toxicity, mobility, and volume of inorganics in groundwater by long-term treatment. | • Extraction wells are commonly implemented technologies. | • None. |
| • Demonstrated effective treatment for removal of inorganic contaminants. | • Chemical precipitation is a conventional technology and equipment and chemicals are readily available. | |
| • Meets remedial action objectives. | • Systems can accommodate a variety of flow rates. | |
| • Low potential for short-term worker exposure during groundwater treatment. | • No impediments to meeting action-specific ARARs are expected. | |
| Disadvantages | Disadvantages | Disadvantages |
| • Treatability study recommended to determine most effective chemical precipitant for waste stream. | • Aquifer tests required to design extraction system. | • High capital and O&M costs for extraction wells, and treatment facility, and long-term groundwater treatment and monitoring. |
| • Time required to achieve response objectives and target levels in groundwater is not known. | • Chemical environment for the precipitation process must be strictly controlled and monitored to maintain correct operating conditions. | |
| • Heavy metal sludge is produced by precipitation process; sludge will require further treatment or disposal. | • Long-term treatment required. | |

**TABLE 4-7**
**ALTERNATIVE SHL-6: COLLECTION/CHEMICAL PRECIPITATION TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| • Potential for short-term worker exposure to contaminated groundwater during slurry wall construction and installation of extraction wells. | • Extraction wells and treatment system will require long-term maintenance. | |
| | • May require surface water discharge permit. | |
| | • Discharge pipe to Nonacoicus Brook would cross delineated floodplains and wetlands. | |

**CONCLUSION:** This alternative will be **eliminated** for detailed analysis because preliminary vendor information indicates that Alternative SHL-5 ion exchange treatment may be more efficient.

**Note:**

O&M = operations and maintenance

TABLE 4-8
ALTERNATIVE SHL-7: COLLECTION/CONSTRUCTED WETLAND TREATMENT/SURFACE WATER DISCHARGE

FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

This alternative involves installation of a groundwater extraction system and construction of a wetland. Water would be pumped from an extraction well placed on the northern end of the landfill to a wetland constructed on site for the purpose of treating groundwater by natural processes. Limited Action components are included.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Advantages | Advantages | Advantages |
| • None. | • Extraction wells are commonly implemented technologies. | • Estimated capital costs for wetland treatment would be lower than other treatment alternatives. |
| | • Construction of the wetland requires conventional construction techniques. Equipment and materials are readily available. | • Moderate O&M costs for long-term surface groundwater monitoring and five-year site reviews. |
| | • No impediments to meeting action-specific ARARs are expected. | |
| Disadvantages | Disadvantages | Disadvantages |
| • Although proven effective at removing moderate percentages of Fe, Cu, Zn, and Mn; not demonstrated effective at removing As and other inorganics. | • Aquifer tests required to design extraction system. | • Potential additional capital costs for storage tanks if wetland does not function year round. |
| • Reduction of mobility, toxicity, and volume of contaminated groundwater uncertain. | • Constructed wetland may not function effectively during periods of heavy rain or in the winter. | • Potential additional O&M costs for disposal of accumulated biomass with concentrated contamination. |
| • Time required to achieve response objectives and target levels in groundwater is not known.. | • Long-term monitoring of surface water as it exits wetland to assess contaminant removal. | • Potential costs for additional treatment if wetland is not effective. |
| • Pilot testing recommended to determine wetlands effectiveness at removing arsenic and other inorganics and treatment time. | • Potential disposal of accumulated biomass. | |
| • Potential for ecological exposure to contaminated groundwater during wetlands operation. | • Long-term pilot testing could impact schedules specified in the IAG. | |

**TABLE 4-8**
**ALTERNATIVE SHL-7: COLLECTION/CONSTRUCTED WETLAND TREATMENT/SURFACE WATER DISCHARGE**

**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| • Potential for short-term worker exposure to contaminated groundwater during construction, extraction well installation, and while groundwater is in wetland. | • May require future groundwater treatment if wetland is not effective. | |
| | • Extraction wells would require long-term operation and maintenance. | |
| | • Discharge pipe to Nonacoicus Brook would cross delineated floodplains and wetlands. | |

**CONCLUSION:** This alternative will be **eliminated** from further consideration based on the fact that it has not been demonstrated effective at removing arsenic and possibly other inorganics in groundwater at Shepley's Hill Landfill.

**Note:**

O&M = operations and maintenance
Fe = Iron
Cu = Copper
Zn = Zinc
Mn = Manganese
As = Arsenic

## TABLE 4-9
## ALTERNATIVE SHL-8: GROUNDWATER BARRIER/IN SITU OXIDATION

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

Alternative SHL-8 involves installation of a 1,600-ft.-long slurry wall to block continued groundwater flow into Plow Shop Pond and to divert groundwater to the north. Injection wells would be installed at the north end of the landfill and used for injection of hydrogen peroxide to treat groundwater by in situ fixation.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Advantages | Advantages | Advantages |
| • Long-term in situ oxidation treatment should reduce toxicity and mobility of As by converting it to its less toxic, oxidized form. | • Slurry walls and injection wells are commonly implemented technologies. | • Potential for low capital and O&M costs for in situ oxidation treatment. |
| • Although in situ oxidation treatment has not been used full scale at hazardous waste sites, the chemistry of As co-precipitation with Fe has been proven. | • Proposed depths for slurry wall are within the range of available equipment. | • Moderate O&M costs for long-term groundwater monitoring and five-year site reviews. |
| | • No impediments to meeting action-specific ARARs are expected. | |
| • May meet remedial action objectives. | • Vendors for in situ aquifer treatment technologies are available. | |
| | • Hydrogen peroxide and potable water readily available. | |
| | • Treatment system can be operated relatively unattended. | |
| | • No groundwater extraction required. | |
| | • No treatment residuals requiring off-site disposal. | |

continued

**TABLE 4-9**
**ALTERNATIVE SHL-8: GROUNDWATER BARRIER/IN SITU OXIDATION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Disadvantages | Disadvantages | Disadvantages |
| • Groundwater modeling indicates that much of the overburden is unsaturated. Installation of a grout curtain and slurry wall would only lead to minimal additional lowering of the groundwater table. | • In situ fixation has not been implemented full scale. | • High capital costs for slurry wall and reinjection wells. |
| | • Injection wells may be constructed in the 100-year floodplain. | |
| • Modeling indicates that injection wells would not be effective for injection of hydrogen peroxide. | • Long-term treatment required. | |
| • Time required to achieve response objectives and target levels in groundwater is not known. | • Shallow water table at SHL may limit implementability if significant mounding were to occur. | |
| • Treatability study recommended to confirm site specific conditions. | • Precautions for on site storage and handling of hydrogen peroxide required. | |
| • Potential for short-term worker exposure to contaminated groundwater during slurry wall construction. | • Potential for clogging of injection wells may require that a "buffer" be set up around the well. | |
| | • Redundant wells may be required to account for servicing clogged wells. | |

**CONCLUSION:** This alternative will be **eliminated** due to the ineffectiveness of the barrier components and injection wells as demonstrated through groundwater modeling.

**Notes:**

As = Arsenic
Fe = Iron
O&M = operations and maintenance

## Table 4-10
## Alternatives SHL-9A and SHL-9B: Collection/Discharge to POTW

### Shepley's Hill Landfill Operable Unit
### Feasibility Study for Group 1A Sites
### Fort Devens, MA

This alternative involves installation of a groundwater extraction and discharge system. Water would be pumped from an extraction well placed at the northern end of the landfill to the Ayer POTW. Limited action components are included.

| Effectiveness | Implementability | Cost |
|---|---|---|
| Advantages | Advantages | Advantages |
| • Mobility and volume of contaminants in groundwater discharged to the POTW should be reduced. | • Extraction wells are commonly implemented technologies. | • No capital cost for treatment. |
| • Should meet remedial action objectives. | | • Moderate O&M costs for long-term POTW user fee, and O&M for extraction wells, long-term groundwater monitoring and five-year site reviews. |
| | • No impediments to meeting action-specific or location-specific ARARs are expected. | |
| Disadvantages | Disadvantages | Disadvantages |
| • Continued monitoring of extracted groundwater required to assure that pretreatment standards are met. | • Aquifer tests required to design extraction system. | |
| • Time required to achieve response objectives and target levels in groundwater is not known. | • Requires successful negotiation of long-term discharge agreement with Ayer POTW. | |
| | • Pretreatment of groundwater may be required. | |
| | • Not consistent with SARA's preference for treatment. | |

**ESTIMATED CAPITAL COST $1,184,000**

**ESTIMATED PRESENT WORTH OF O&M COSTS $2,690,000**

**ESTIMATED TOTAL PRESENT WORTH $3,874,000**

**CONCLUSION:** These alternatives will be **retained**. As long as the extracted groundwater meets pretreatment standards for the Ayer POTW, remedial action objectives, including ARARs, would be met.

**Notes:**

POTW = publicly owned treatment works
SARA = Superfund Amendments and Reauthorization Act
O&M = operations and maintenance

**TABLE 4-11**
**ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

This alternative does not provide any remedial actions to treat groundwater. Zoning and deed restrictions, along with installation and maintenance of a new landfill cover system will reduce potential for exposure. Long-term groundwater and landfill gas monitoring and five-year site reviews are included.

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| Advantages | Advantages | Advantages |
| • Groundwater does not currently pose a drinking water risk because no residential receptors exist. | • Easy to implement zoning and deed restrictions on Army property. | |
| • Zoning and deed restrictions would prevent future exposure to groundwater. | • No impediments to meeting action-specific ARARs are expected. | • Low O&M costs for long-term groundwater monitoring and five year site reviews. |
| | • Groundwater and landfill gas monitoring would be easily implemented. | |
| • Landfill cover system will reduce the mobility of contaminants. | | |
| • Effectiveness at reducing infiltration and diverting groundwater flow should be similar to existing cover. | | |
| Disadvantages | Disadvantages | Disadvantages |
| • Does not reduce toxicity or volume of contaminants. | • May require future groundwater treatment. | • High capital cost. |

# TABLE 4-11
# ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP

## SHEPLEY'S HILL LANDFILL OPERABLE UNIT
## FEASIBILITY STUDY FOR GROUP 1A SITES
## FORT DEVENS, MA

| EFFECTIVENESS | IMPLEMENTABILITY | COST |
|---|---|---|
| • Installation of new cover system may pose short-term risks to workers, community, and the environment. | • Not consistent with SARA's preference for treatment. | • Potential for future remedial action costs. |

**ESTIMATED CAPITAL COST $19,645,000**

**ESTIMATED PRESENT WORTH OF O&M COSTS $1,291,000**

**ESTIMATED TOTAL PRESENT WORTH $20,936,000**

**CONCLUSION:** This alternative will be **retained** for detailed analysis because it is protective of human health and is based on RCRA design guidance.

**Notes:**

SARA = Superfund Amendments and Reauthorization Act
O&M = Operations and maintenance

## Table 4-12
## Screening Summary of Alternatives

### Shepley's Hill Landfill Operable Unit
### Feasibility Study for Group 1A Sites
### Fort Devens, MA

| Remedial Alternatives | Retained | Eliminated |
|---|---|---|
| Alternative SHL-1: No Action | X | |
| Alternative SHL-2: Limited Action | X | |
| Alternative SHL-3: Containment/Collection/ Short-term Ex Situ Treatment/Surface Water Discharge | | X |
| Alternative SHL-4: Containment/In Situ Oxidation | | X |
| Alternative SHL-5: Collection/Ion Exchange Treatment/Surface Water Discharge | X | |
| Alternative SHL-6: Collection/Chemical Precipitation Treatment/Surface Water Discharge | | X |
| Alternative SHL-7: Collection/Constructed Wetland Treatment/Surface Water Discharge | | X |
| Alternative SHL-8 Groundwater Barrier/In Situ Oxidation | | X |
| Alternative SHL-9 Collection/Discharge to POTW | X | |
| Alternative SHL-10 Installation of RCRA Cap | X | |

# 5.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed analysis of alternatives provides a detailed description of each of the retained Shepley's Hill Landfill remedial alternatives and evaluates them using the evaluation criteria recommended in USEPA's RI/FS guidance (USEPA, 1988b). These criteria are described in Table 5-1. The first seven of the evaluation criteria serve as a basis for conducting the detailed analysis, and are addressed in this FS. The remaining two criteria, state and community acceptance, will be addressed after the public comment period on the Proposed Plan. The alternatives that are evaluated in this section are those retained after initial screening in Section 4 and listed in Table 4-12. A detailed cost estimate is also included in the detailed analysis for each alternative except the No Action Alternative. Each cost estimate includes a present worth analysis to evaluate expenditures that occur over different time periods. This analysis discounts all future costs to a present worth and allows the cost of remedial alternatives to be compared on an equal basis. Present worth represents the amount of money that, if invested now and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life (USEPA, 1988b). A discount rate of 5 percent before taxes and after inflation was used as recommended in the superfund program (USEPA, 1988b).

The No Action alternative was retained because it will serve as a baseline for the other alternatives. The Limited Action alternative was retained because it provides engineering and administrative controls to maintain the integrity of the existing cover, monitor for potential contaminant releases , and protect human health. The RCRA cap alternative evaluates the replacement of the existing cover with a cover based on RCRA design guidance. The other groundwater alternatives are designed to intercept and treat and/or dispose of contaminated groundwater.

## 5.1 ALTERNATIVE SHL-1: NO ACTION

This subsection describes the No Action alternative and evaluates the alternative using the seven evaluation criteria.

### 5.1.1 Description

The No Action alternative serves as a baseline alternative with which to compare other remedial alternatives for Shepley's Hill Landfill. The No Action alternative does not contain any additional remedial action components to reduce or control potential risks. Existing activities to maintain existing systems and monitor for potential future releases would be discontinued.

### 5.1.2 Remedial Alternative Evaluation

The assessment of this alternative using the evaluation criteria is presented in the following subsections.

**5.1.2.1 Overall Protection of Human Health and the Environment**. Alternative SHL-1 has limited potential for achieving an acceptable level of risk for human receptors, especially over the long-term. The existing landfill cap is currently effective at isolating wastes from receptors and at preventing infiltration and precipitation. Groundwater modeling (see Subsection 4.2.2) suggests that capping of the landfill has significantly reduced the amount of water in the landfill area, and resulted in a more northerly groundwater flow because of the influence of Plow Shop and Grove ponds. The cap has had substantial effects in altering local groundwater flow and reducing potential impacts on the ponds. Groundwater at the north end of the landfill currently meets PRGs. However, without activities to monitor cover integrity and implement even minimal maintenance, cover performance could deteriorate. In addition, without environmental monitoring there will no way to assess the continued effectiveness of the existing cover. No exposure to ecological receptors currently exists.

**5.1.2.2 Compliance with ARARs**. Table 5-2 provides a summary of the ARARs analysis for Alternative SHL-1. The alternative has potential for complying with chemical-specific ARARs and guidance. Currently, groundwater at the north end of the landfill meets PRGs. The existing landfill cap reduces leaching of landfill materials and concomitant groundwater contamination.

Location-specific ARARs regarding floodplains and wetlands would not be triggered by this alternative, because no activities would occur that would adversely impact either floodplains or wetlands in the vicinity of Shepley's Hill

Landfill (see Figure 1-6). No activities would occur to adversely affect the Grasshopper Sparrow and its habitat.

Although the existing landfill cover meets the requirements of the approval given by MADEP pursuant to 310 CMR 19.00 and the performance standards of 310 CMR 19.000, 310 CMR 30.000, 40 CFR 258, and 40 CFR 264, this alternative does not meet post-closure monitoring and maintenance requirements of 310 CMR 19.000, 310 CMR 30.000, 40 CFR 258, or 40 CFR 264.

**5.1.2.3 Long-term Effectiveness and Permanence.** The long-term effectiveness of the existing cover system at controlling leachate generation and groundwater contamination depends on the following factors:

- maintenance of cap integrity
- maintenance of surface water diversion and control systems
- effectiveness of the cover system in diverting groundwater flow patterns
- whether or not leachable landfill materials exist below the water table

Without maintenance activities, the integrity and performance of the cover could be compromised.

**5.1.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment.** Because no treatment processes would be implemented, no reduction through treatment would occur. This alternative would not satisfy the statutory preference for treatment as a principle element of remedial actions.

**5.1.2.5 Short-term Effectiveness.** This alternative does not involve any remedial activities that would endanger the community or environment.

**5.1.2.6 Implementability.** The No Action alternative would be easy to implement and would not interfere with possible future remedial actions. The landfill cover system has already been installed, and additional closure and post-closure activities are not proposed.

No off-site activities requiring permits would occur. No coordination with regulatory agencies would be required.

**5.1.2.7 Cost.** No cost estimate was prepared for Alternative SHL-1.

## 5.2 Alternative SHL-2: Limited Action

This subsection describes the Limited Action alternative, evaluates the alternative using the seven evaluation criteria, and provides a cost estimate.

### 5.2.1 Description

The limited action alternative satisfies the Landfill Post-Closure Requirements of 310 CMR 19.142 to reduce potential future exposure to contaminated groundwater. Key components of the Limited Action alternative include:

- survey of Shepley's Hill Landfill
- evaluation/improvement of stormwater diversion and drainage
- site preparation and mobilization
- landfill cover maintenance
- landfill gas collection system maintenance
- long-term groundwater monitoring
- long-term landfill gas monitoring
- institutional controls
- educational programs
- annual reporting to MADEP and USEPA
- five-year site reviews

Each of these components is described in the following paragraphs. In addition, the long-term groundwater monitoring program has been updated from the existing program based on the hydrogeologic interpretation of the RI Addendum Report and groundwater modeling described in Subsection 4.2.2.

Survey of Shepley's Hill Landfill. Prior to design and implementation of remedial actions at Shepley's Hill Landfill, an accurate topographic survey of the landfill surface is required. No survey has been done since completion of the last phase of landfill capping. A cost estimate is included to conduct an aerial survey of

Shepley's Hill Landfill. Also included is the estimated cost to survey the elevation and horizontal location of monitoring wells or piezometers installed as part of remedial alternative implementation as well as to prepare record drawings.

Evaluation/Improvement of Stormwater Diversion and Drainage. Stormwater diversion and drainage systems at and adjacent to Shepley's Hill Landfill will be evaluated as part of this alternative. Modifications for improvement will be implemented if the evaluation indicates they would be practical and cost-effective. The evaluation will focus on the following items of concern:

- landfill cap runoff patterns and drainage ditch flow capacities
- potential run-under along the western edge of the landfill, particularly where the existing membrane cap may not have a good seal with the underlying bedrock
- the effectiveness of stormwater drainage systems upgradient of the landfill (i.e., at the transfer station, tire recycling station, DRMO yards, and along Market Street) at diverting run-off from potential infiltration areas upgradient of the landfill

The cost estimate contains an allowance for conducting the evaluation and for replacing/installing storm drainage systems. Detailed plans for evaluating stormwater diversion and drainage would be developed during the design phase and submitted for regulatory review and concurrence.

Site Preparation and Mobilization. A 0.25 acre staging area would be constructed on a level area adjacent to Shepley's Hill Landfill. If necessary, gravel would be placed over this area to support heavy equipment and provide for placement of construction materials. Costs are included for mobilization of earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), drill rigs, cranes, dump trucks, and construction-support trailers. A parking lot and decontamination area exist at building T-201 on Carey Street adjacent to the landfill and are assumed to be available for use during remediation.

Landfill Cover Maintenance. A small area of ponded water in the northwestern section of the landfill is proposed to be drained and regraded to minimize stress on the cover system and potential for leakage through the PVC geomembrane.

The area is approximately 100 feet in diameter and is estimated to be about 1 foot deep. The water would be pumped out and the ponded area backfilled with common borrow to bring the area up to the desired grade. A new section of PVC geomembrane would be installed on top of the fill and seamed to the existing geomembrane cap to provide an impermeable surface in this area.

At the northern end of the landfill, erosion of cover soil in sections of the drainage swales has occurred in the past, exposing PVC membrane. This erosion has been repaired, but may require additional repair in the future. A cost to repair the drainage swales is included for this alternative. Figure 5-1 shows the location of potential cover repairs.

Annual inspections are proposed to monitor the condition of the landfill cover at Shepley's Hill Landfill, including monitoring wells, cover surface, and drainage swales to determine if maintenance is needed. Grass will be mowed annually and cover repairs made if required. Landfill maintenance and mowing would be scheduled to minimize potential impacts to Grasshopper Sparrows that may nest on the cover.

Detailed plans for landfill cover maintenance would be developed during the design phase and submitted for regulatory review and concurrence.

Landfill Gas Collection System Maintenance. Annual inspections are proposed to monitor the Shepley's Hill Landfill gas collection system and provide any necessary repairs.

Long-term Groundwater Monitoring. Groundwater monitoring is proposed to monitor groundwater quality at Shepley's Hill Landfill and to assess future environmental impacts. Based on the hydrogeologic interpretation and analytical data presented in the RI Addendum Report and on the groundwater modeling of Subsection 4.2, a modified groundwater monitoring program is proposed. Six wells included in the current monitoring program, but interpreted as cross-gradient, have been deleted and replaced with five existing wells better positioned to monitor downgradient groundwater quality. In addition, installation of three new wells is proposed at the north end of the landfill to create nested triplets of shallow/water table, mid-depth, and deep overburden wells at SHL-9/ SHL-22 and SHL-5. Wells would be sampled semi-annually for a minimum of 30 years, consistent with 310 CMR 19.142. Because this alternative includes institutional controls which would prohibit installation of drinking water wells, semi-annual monitoring should be sufficient. Monitoring locations and analytical parameters are presented in Table 5-3. Detailed plans for long-term groundwater monitoring would be developed during the design phase and submitted for regulatory review and concurrence.

Long-term Landfill Gas Monitoring. During supplemental RI activities, landfill gas was characterized by sampling gas probes and vents at 21 locations at and around the landfill (ABB-ES, 1993b). Review of the analytical data shows that two (benzene and methane) of 20 target analytes were detected in the gas samples. As part of post-closure monitoring activities, landfill gas will be monitored quarterly at landfill gas vents and analyzed in the field by direct reading instruments for lower explosive limit (LEL) and total organic gases. On a semiannual basis, samples will be collected from the two vents with the highest field measurements and analyzed for TCL VOCs. These samples will be collected and analyzed in accordance with USEPA Method TO 14. Detailed plans would be developed during the design phase and submitted for regulatory review and concurrence.

Institutional Controls. Institutional controls are proposed in the form of zoning and deed restrictions for any property released by the U.S. Army during Fort Devens base-closure activities. The Fort Devens Preliminary Reuse Plan, Main and North Posts (EDAW and VHB, 1994) has proposed that U.S. Army land bordering Plow Shop Pond be zoned for open space and rail-related uses. By pre-empting residential use, these controls would help limit human exposure. In addition, the U.S. Army would place deed restrictions on landfill area property to prohibit installation of drinking water wells. This, in combination with landfill capping and long-term groundwater monitoring would protect potential human receptors from risks resulting from exposure to contaminated groundwater. There are no current human receptors for groundwater exposure.

Institutional controls would be drafted, implemented and enforced in cooperation with state and local governments.

Educational Programs. Periodic public meetings and presentations would be conducted to increase public awareness. This would help keep the public informed of the site status, including both its general condition and remaining contaminant levels. This could be accomplished by conducting public meetings every five years coincident with the five-year site reviews for Shepley's Hill Landfill. The presentation would summarize site activities and the results of monitoring programs. The cost estimate for this alternative contains an allowance to prepare for and conduct these public meetings as well as to maintain public records.

Annual Reporting to MADEP and USEPA. Annual reports would be submitted to MADEP and USEPA which would include a description of site activities and summary of results of environmental monitoring programs.

Five-Year Site Reviews. Under CERCLA 121c, any remedial action (or lack thereof) that results in contaminants remaining on-site must be reviewed at least every five years. During five-year reviews, an assessment is made of whether the implemented remedy is protective of human health and the environment and whether the implementation of additional remedial action is appropriate.

The five-year site review for Alternative SHL-2 will evaluate the alternative's effectiveness at reducing potential human health risk from exposure to groundwater and at preventing groundwater from contributing to Plow Shop Pond sediment contamination in excess of human health and ecological risk-based values. This evaluation will be based on how successful the alternative is at attaining PRGs at individual wells in two distinct monitoring well groups. Well Group 1 consists of several existing and proposed wells at the north end of the landfill where PRGs have been attained historically. Well Group 2 consists of several wells along the eastern edge of the landfill where historically PRGs have not been attained. The wells included in each group are listed in the following table.

| Well Group 1 | Well Group 2 |
|---|---|
| SHL-5 | SHL-3 |
| SHL-9 | SHL-4 |
| SHL-22 | SHL-10 |
| SHM-93-22C | SHL-11 |
| Two new wells at SHL-5 | SHL-19 |
| One new well at SHL-22 | SHL-20 |
| | SHM-93-10C |

The goal of Alternative SHL-2 is to maintain groundwater quality below PRGs at Group 1 wells, and to attain PRGs at Group 2 wells. Since groundwater quality historically attains PRGs in Group 1 wells, Alternative SHL-2 will be considered effective if five-year site reviews show that this condition is maintained.

Evaluating effectiveness at Group 2 wells is less straightforward. Installation of the geomembrane cap over the most upgradient areas at Shepley's Hill Landfill (i.e., areas in the Phase IVB closure) was not completed until May 1993. Based on groundwater modeling done for the alternative screening of Section 4, it is estimated that the average time needed for groundwater to travel from these upgradient areas to wells SHL-11 and SHL-20 may be 10 to 14 years or longer. An equal or greater number of years may be needed for downgradient groundwater quality at wells SHL-11 and SHL-20 to attain PRGs. Overall groundwater quality is expected to improve and potential risk is expected to decrease during this period, although at some wells certain chemicals may show small short-term increases in concentration while other chemicals show decreases in concentrations and overall risk is reduced.

The Army proposes to use reduction of risk as a measure of effectiveness, rather than reduction of concentration, because this approach focuses on the cleanup of arsenic which is the primary contributor to risk in the Group 2 wells. This approach prevents a situation in which failure to attain a concentration reduction goal for a minor contributor to risk (e.g., 1,2-dichloroethane where a reduction of 2.5 $\mu$g/L represent a 50 percent reduction in concentration exceeding the PRG) overshadows the achievement of 50 percent or greater reduction in the concentration of arsenic. In the Group 2 wells a 50 percent reduction in the concentration of arsenic approximates a 50 percent reduction in groundwater risk, while a 50 percent reduction in the concentration of 1,2-dichloroethane represents less than a 1 percent reduction in groundwater risk. Alternative SHL-2 will be considered effective if five-year reviews show an ongoing reduction of potential human health risk and the ultimate attainment of PRGs.

The specific criteria for evaluating the effectiveness of Alternative SHL-2 are stated below.

> Group 1 Wells. For Group 1 wells where analyte concentrations have historically attained PRGs, Alternative SHL-2 will be considered effective if concentrations of individual chemicals within individual wells do not

show statistically significant PRG exceedances. To determine statistical significance, the Army will apply methods consistent with the regulations at 40 CFR 264.97, 40 CFR 258.53, and 310 CMR 30.663.

Group 2 Wells. For Group 2 wells where chemical concentrations have exceeded PRGs in the past, Alternative SHL-2 will be considered effective if a 50 percent reduction in the increment of risk between PRG concentrations and baseline concentrations for chemicals of concern within individual wells is achieved by January 1998, if an additional 25 percent (75 percent cumulative) is achieved by January 2003, and if PRGs are attained by January 2008.

The Army will apply methods consistent with the regulations at 40 CFR 264.97, 40 CFR 258.53 and 310 CMR 306.63 to estimate chemical concentrations at baseline conditions. Analytical data collected during RI (August and December 1991) and supplemental RI (March and June 1993) activities will be used to estimate baseline conditions. The detailed approach would be developed during the design phase and submitted for regulatory review and concurrence (E&E, 1993; ABB-ES, 1993b).

A major consideration in assessing the protectiveness of Alternative SHL-2 and whether additional remedial actions may be appropriate will be the basis on which individual PRGs were set. The Army will consider the implementation of additional remedial actions if the above criteria are not met for any chemicals for which PRGs were based on MCLs (40 CFR 141) and for manganese. No MCL has been established for manganese. The PRG for manganese was based on background concentrations because background concentrations exceed the risk based concentration derived from the available reference dose value (5E-3 mg/kg/day). This approach for setting PRGs and for evaluating the effectiveness of landfill closure is consistent with USEPA guidance contained in *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim*, December 1991, and with 40 CFR 258.55.

The Army will not consider additional remedial actions under CERCLA if PRGs are not attained for aluminum and iron. The PRGs for aluminum and iron were based on background concentrations because dose/response values were not available.

Similarly, the Army will not consider additional remedial actions if the PRG is not attained for sodium. The PRG for sodium was based on the health advisory for individuals on a reduced sodium diet.

Surface Water and Leachate Monitoring. Surface water and leachate monitoring are not proposed as part of long-term post-closure monitoring. Surface water monitoring was conducted in Plow Shop Pond during the RI (E&E, 1993). Evaluation of that data in the Ecological Risk Assessment of the RI Addendum Report, however, indicated that the probability of adverse ecological effects from exposure to surface water was low (ABB-ES, 1993b). Therefore, additional surface water monitoring is not proposed. Based on site hydrogeology, the presence of leachate seeps around the landfill cap is unlikely. In addition, the landfill cap is preventing contaminant leaching by infiltrating precipitation, and groundwater modeling suggests that groundwater elevations have dropped below landfill wastes. Thus, generation of leachate should no longer be a concern. Furthermore, there is no leachate collection system beneath the landfill from which to collect a sample. The long-term groundwater monitoring program will provide an on-going means to monitor for groundwater contamination.

### 5.2.2 Remedial Alternative Evaluation

The assessment of this alternative using the evaluation criteria is presented in the following subsections.

**5.2.2.1 Overall Protection of Human Health and the Environment.** Alternative SHL-2 has significant potential for achieving an acceptable level of risk for human receptors. The landfill closure plan, approved in 1985 and implemented in 1986 through 1993, relies on landfill capping and stormwater controls to reduce leaching of landfill materials and contamination of groundwater. Groundwater modeling (see Subsection 4.2.2) suggests that capping of the landfill has significantly reduced the amount of water in the landfill area, and resulted in a more northerly groundwater flow because of the influence of Plow Shop and Grove ponds. The cap has had substantial effects in altering local groundwater flow and reducing potential impacts on the ponds. Groundwater at the north end of the landfill currently meets PRGs. Institutional controls included in this alternative would prevent the use of water from the contaminated aquifer, resulting in reduced potential for human exposure to contaminated groundwater. No exposure to ecological receptors currently exists. The landfill cover maintenance activities will help ensure protection of human health and the environment. If groundwater monitoring indicates that chemical concentrations in groundwater leaving the site exceed chemical specific ARARs or PRGs, additional actions would be considered.

**5.2.2.2 Compliance with ARARs.** Table 5-4 provides a summary of the ARARs analysis for Alternative SHL-2. The alternative has the potential for complying with chemical-specific ARARs and guidance. Currently, groundwater at the north end of the landfill meets PRGs. The existing landfill cap will reduce leaching of landfill materials and concomitant groundwater contamination, and is expected to enable the achievement of PRGs at the east side of the landfill.

Location-specific ARARs regarding floodplains and wetlands would not be triggered by the alternative because no activities would occur that would adversely impact either floodplains or wetlands (see Figure 1-6). Environmental monitoring and landfill cover and gas collection system maintenance activities would be planned to prevent adverse effects on the Grasshopper Sparrow and its habitat as required by the Massachusetts Endangered Species Act (MGL c.131A, s.1.) and implementing regulations (321 CMR 8.00).

The existing landfill cover meets the requirements of the closure plan approval given by MADEP pursuant to 310 CMR 19.00 and the performance standards for cover systems in the RCRA Subtitle C Regulations for Owners and Operators of Permitted Hazardous Waste Facilities (40 CFR 264.310), USEPA Criteria for Solid Waste Landfills (40 CFR 258), Massachusetts Solid Waste Management Regulations (310 CMR 19.000), and Massachusetts Hazardous Waste Management Rules (310 CMR 30.000). Table 5-5 summarizes the cover system performance standards for each of these regulations and briefly discusses how compliance is achieved. Proposed post-closure long-term monitoring and maintenance activities will meet the requirements of 40 CFR 258, 40 CFR 264, 310 CMR 19.000, and 310 CMR 30.000.

**5.2.2.3 Long-term Effectiveness and Permanence.** The long-term effectiveness of the implemented landfill closure plan at controlling leachate generation and groundwater contamination depends on the following factors:

- maintenance of cap integrity

- maintenance of surface water diversion and control systems
- effectiveness of the cover system in diverting groundwater flow patterns
- whether or not leachable landfill materials exist below the water table

The operation and maintenance requirements of 310 CMR 19.130 and the post-closure requirements of 310 CMR 19.142 specifically address the first two of these items by stipulating that actions be taken to mitigate conditions that will compromise the integrity and purpose of the final cover. An example of such a condition is the ponded area in the northwestern sector of the landfill. This area will be repaired as part of Alternative SHL-2 to reduce the likelihood of a stress induced failure of the cap. With proper maintenance, the cover system should effectively prevent infiltration of precipitation and concomitant leaching for the 30-year cost evaluation period. Groundwater modeling presented in Subsection 4.2.2 generated groundwater contours which are included on Figures 4-5 to 4-29. These predicted groundwater elevation contours are overlain on top of ground contours at Shepley's Hill prior to landfilling activities on Figure 5-2. As shown on Figure 5-2, groundwater modeling predicts that groundwater elevations are below pre-landfill ground elevations, suggesting that no waste would be in contact with groundwater. Modeling also suggests that capping of the landfill has significantly reduced the amount of water in the landfill area, and that flow is directed northerly because of the influence of Plow Shop and Grove ponds. Long-term groundwater monitoring will allow assessment of the overall effectiveness of the cover system at protecting groundwater quality.

In addition to the measure of long-term effectiveness achieved through implementation of the landfill post-closure requirements of 310 CMR 19.142, this alternative provides institutional controls in the form of zoning and deed restrictions. To be effective, institutional controls must be enforced by both private parties and government agencies. If implemented off-site, institutional controls require the cooperation of adjacent property owners. Because of this, institutional controls do not always possess high reliability or long-term effectiveness. Nonetheless, institutional controls will be an important part of any remedial action at Shepley's Hill Landfill.

**5.2.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment.** Because no treatment processes would be implemented, no reduction through treatment would occur. However, by reducing infiltration, the cover system would reduce leachate generation, groundwater contamination, and the potential for receptors to be exposed to contaminants. This alternative would not satisfy the statutory preference for treatment as an element of remedial actions.

**5.2.2.5 Short-term Effectiveness.** This alternative does not involve remedial activities that would endanger the community or environment. Cover system installation is complete at Shepley's Hill Landfill and there are no known human receptors for contaminated groundwater. Personnel who collect groundwater samples as part of the post-closure monitoring program will need to follow a site-specific Health and Safety Plan (HASP) and utilize personal monitoring equipment and personal protective equipment to prevent potential exposure to hazardous chemicals.

**5.2.2.6 Implementability.** This alternative would be easy to implement and would not interfere with possible future remedial actions. The landfill cover system has been installed and services and materials to implement landfill post-closure requirements are readily available. Placement of zoning and deed restrictions on property currently owned by the U.S. Army would be easily implemented.

No off-site activities requiring permits would be undertaken. The five-year review process would require coordination among regulatory agencies, and enforcement of zoning and deed restrictions would require cooperation with the Town of Ayer.

**5.2.2.7 Cost.** A cost estimate was prepared for Alternative SHL-2 to assist in selecting a remedial alternative. The estimate contains the following principal elements:

- capital cost
- O&M cost

Capital costs consist of direct and indirect costs. Direct costs for this alternative include institutional controls, site preparation and mobilization, landfill cover repairs, evaluation of stormwater drainage, and installation of additional monitoring wells. A 25 percent contingency was included in direct cost items to account for unforeseen project complexities (e.g., adverse weather conditions, and increased construction standby times).

Indirect costs include expenditures for contractors' overhead and profit and additional administrative, engineering, and legal services that are not part of actual alternative installation, but are required to complete site closure. These include engineering expenses, legal fees, health and safety costs, and contingency allowances.

Engineering design was estimated at 10 percent of the total direct costs. Costs for health and safety were estimated at 5 percent of the total direct costs. Legal, administrative, and permitting costs were estimated at 5 percent of total direct cost.

O&M costs include expenditures associated with the groundwater monitoring program and landfill cover and gas collection system inspection and maintenance. Massachusetts Solid Waste Management annual reporting costs, as well as 5-year site reviews required by CERCLA, are included as part of the O&M costs.

Table 5-6 summarizes the cost estimate for Alternative SHL-2. Capital costs are estimated at $714,000. Operation and maintenance costs are estimated to be $84,000 per year. The estimated total present worth of Alternative SHL-2 is estimated to be $2,219,000 for a 30-year period. Cost calculations are included in Appendix B.

## 5.3 ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE

This subsection describes the groundwater extraction and ion exchange treatment alternative. As stated in Subsection 4.2, groundwater modeling indicates that extraction wells would be capable of capturing contaminated groundwater after the groundwater flow pattern has been reestablished after the recent landfill capping.

In order to incorporate some flexibility into the preliminary design of this treatment alternative, this alternative will be restructured into two alternatives SHL-5A and SHL-5B. SHL-5A would use extraction wells located at the northern end of the landfill to capture contaminated groundwater as suggested through groundwater modeling. SHL-5B would utilize extraction wells located between the landfill and Plow Shop Pond. Alternative SHL-5B provides flexibility in the preliminary design to account for the level of inaccuracy inherent in mathematical modeling of groundwater systems. All other aspects of these two alternatives are the same. To avoid redundancy in evaluating these equivalent alternatives, the following evaluation using the seven evaluation criteria and the following cost estimate apply to both alternatives SHL-5A and SHL-5B. Descriptions of all alternative components, except for the location of the extraction wells, also apply to both alternatives.

This subsection describes the ion exchange treatment alternatives, evaluates the alternatives using the seven evaluation criteria, and provides a cost estimate.

### 5.3.1 Description

Alternatives SHL-5A and SHL-5B consist of components that, in conjunction with the existing landfill cover, are proposed to prevent potential off-site migration of existing contaminated groundwater. The alternatives consist of: (1) constructing a groundwater extraction system; (2) constructing an on-site groundwater treatment facility; (3) installing an effluent pipeline for treated groundwater, and; (4) pumping and treating groundwater to remove groundwater contaminants (i.e., aluminum, arsenic, iron, and manganese). Figure 5-3 shows the proposed locations of the extraction system, the treatment facility, and the effluent pipeline. Key components of Alternative SHL-5A and SHL-5B are:

- survey of Shepley's Hill Landfill
- evaluation/improvement of stormwater diversion and drainage
- pre-design hydrogeologic study
- design of groundwater extraction, treatment, and discharge systems
- site preparation and mobilization
- groundwater extraction system construction
- ion exchange treatment facility construction
- ion exchange treatment facility operation
- treated groundwater discharge
- landfill cover maintenance
- landfill gas collection system maintenance
- long-term groundwater monitoring

account for unforeseen project complexities (e.g., adverse weather conditions, and increased construction standby times).

Indirect costs include expenditures for contractors' overhead and profit and additional administrative, engineering, and legal services that are not part of actual alternative installation, but are required to complete site closure. These include engineering expenses, legal fees, health and safety costs, and contingency allowances.

Engineering design was estimated at 10 percent of the total direct costs. Costs for health and safety were estimated at 5 percent of the total direct costs. Legal, administrative, and permitting costs were estimated at 5 percent of total direct cost.

O&M costs include expenditures associated with the groundwater monitoring program and landfill cover and gas collection system inspection and maintenance. Massachusetts Solid Waste Management annual reporting costs, as well as 5-year site reviews required by CERCLA, are included as part of the O&M costs.

Table 5-6 summarizes the cost estimate for Alternative SHL-2. Capital costs are estimated at $214,000. Operation and maintenance costs are estimated to be $84,000 per year. The estimated total present worth of Alternative SHL-2 is estimated to be $2,219,000 for a 30-year period. Cost calculations are included in Appendix B.

## 5.3 ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE

This subsection describes the groundwater extraction and ion exchange treatment alternative. As stated in Subsection 4.2, groundwater modeling indicates that extraction wells would be capable of capturing contaminated groundwater after the groundwater flow pattern has been reestablished after the recent landfill capping.

In order to incorporate some flexibility into the preliminary design of this treatment alternative, this alternative will be restructured into two alternatives SHL-5A and SHL-5B. SHL-5A would use extraction wells located at the northern end of the landfill to capture contaminated groundwater as suggested through groundwater modeling. SHL-5B would utilize extraction wells located between the landfill and Plow Shop Pond. Alternative SHL-5B provides flexibility in the preliminary design to account for the level of inaccuracy inherent in mathematical modeling of groundwater systems. All other aspects of these two alternatives are the same. To avoid redundancy in evaluating these equivalent alternatives, the following evaluation using the seven evaluation criteria and the following cost estimate apply to both alternatives SHL-5A and SHL-5B. Descriptions of all alternative components, except for the location of the extraction wells, also apply to both alternatives.

This subsection describes the ion exchange treatment alternatives, evaluates the alternatives using the seven evaluation criteria, and provides a cost estimate.

### 5.3.1 Description

Alternatives SHL-5A and SHL-5B consist of components that, in conjunction with the existing landfill cover, are proposed to prevent potential off-site migration of existing contaminated groundwater. The alternatives consist of: (1) constructing a groundwater extraction system; (2) constructing an on-site groundwater treatment facility; (3) installing an effluent pipeline for treated groundwater, and; (4) pumping and treating groundwater to remove groundwater contaminants (i.e., aluminum, arsenic, iron, and manganese). Figure 5-3 shows the proposed locations of the extraction system, the treatment facility, and the effluent pipeline. Key components of Alternative SHL-5A and SHL-5B are:

- survey of Shepley's Hill Landfill
- evaluation/improvement of stormwater diversion and drainage
- pre-design hydrogeologic study
- design of groundwater extraction, treatment, and discharge systems
- site preparation and mobilization
- groundwater extraction system construction
- ion exchange treatment facility construction
- ion exchange treatment facility operation
- treated groundwater discharge
- landfill cover maintenance
- landfill gas collection system maintenance
- long-term groundwater monitoring

- long-term landfill gas monitoring
- institutional controls
- educational programs
- annual reporting to MADEP and USEPA
- five-year site reviews

The remedial alternative conceptual design described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes. Treatability/pilot studies will be required in the design phase to develop actual design parameters and confirm performance.

Survey of Shepley's Hill Landfill. The survey of Shepley's Hill Landfill proposed for this alternative would be similar to that proposed for Alternative SHL-2.

Evaluation/Improvement of Stormwater Diversion and Drainage. The stormwater evaluation/improvement task proposed for this alternative would be similar to that proposed for Alternative SHL-2.

Pre-design Hydrogeologic Study. Prior to design of these alternatives, a hydrogeologic study is recommended. The purpose of this study would be to gather additional hydrogeologic information for use in refining the groundwater flow model developed for Shepley's Hill Landfill (see Subsection 4.2.2). Refinement of the model would help optimize the design of the extraction wells in controlling contaminant migration from Shepley's Hill Landfill, and further evaluate the effects on the overall hydrogeologic system as a result of the implementation of this alternative.

Prior to further modeling, additional field information would be required. Installation of two nested piezometer pairs and a single piezometer within the limits of waste at Shepley's Hill Landfill is proposed. Additional hydrogeologic information in the vicinity of Plow Shop Pond would also be required. Four piezometer nests, two nested piezometer pairs and two nested triplets, around the western and southwestern edges of Plow Shop Pond are proposed. At least one round of synoptic water levels at these piezometers and monitoring wells within close proximity to the landfill is also proposed.

Design of Groundwater Extraction, Treatment, and Discharge Systems. Following collection and development of necessary data, the design of the groundwater extraction, treatment, and discharge systems will be finalized. Data necessary to finalize design includes survey, hydrogeologic, and treatability data. This data would be integrated during design to enable preparation of appropriate and cost-effective extraction, treatment, and discharge systems. The collection of survey and hydrogeologic data has already been discussed. Treatability studies are recommended to develop data on the most appropriate treatment approach. Cost estimates have been based on assumed pretreatment steps and assumed ion exchange resins at assumed loadings. These assumptions should be confirmed prior to final design. Although ion exchange remains the strongest treatment candidate, chemical precipitation should also be evaluated during the treatability studies. It may also be desirable to investigate innovative variations of ion exchange, such as oxide-coated filter media.

Site Preparation and Mobilization. A staging area would be constructed on a level area adjacent to Shepley's Hill Landfill. If needed, gravel would be placed over this area to support heavy equipment and provide for placement of construction materials. Costs are included for mobilization of earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), drill rigs, cranes, dump trucks, and construction-support trailers. A parking lot and decontamination area exist at building T-201 on Carey Street adjacent to the landfill and are assumed to be available for use during remediation.

Groundwater Extraction System Construction. As presented in Section 4.2, numerical modeling of groundwater flow conditions at Shepley's Hill Landfill were conducted using MODFLOW and MODPATH. Modeling of present conditions indicated that after capping of the landfill, groundwater contours and particle tracking runs quickly become focused as groundwater flows northward, and that extraction wells at the northern tip of the landfill would be adequately positioned to intercept flow. This extraction well location is utilized in Alternative SHL-5A. To provide flexibility in the preliminary design and account for the level of accuracy inherent in mathematical modeling of groundwater systems, Alternative SHL-5B uses extraction wells located west of Plow Shop Pond to capture contaminated groundwater should groundwater flow patterns differ from those predicted through groundwater modeling.

Additional modeling was performed to estimate the pumping rate that would be required to intercept contaminated groundwater flow from Shepley's Hill Landfill. Results indicated that a single extraction well, screened across the saturated thickness of the overburden, would need to pump at approximately 20 gpm to capture flow originating from the northern flowpath. Modeling also indicated that a well located at the western edge of Plow Shop Pond pumping at approximately 20 gpm would be sufficient to capture groundwater flow through the landfill.

The preliminary design of the groundwater extraction and treatment systems utilizes the results of the modeling presented in Section 4.2.2 for preliminary sizing of equipment and cost estimation purposes. Refinement of the numerical model after the predesign hydrogeologic study may affect both sizing and cost estimation.

For both alternatives, one extraction well is proposed to prevent potential off-site migration of contaminated groundwater. The extraction well would be located at the northern end of the landfill for Alternative SHL-5A, and west of Plow Shop Pond for Alternative SHL-5B. At both locations the well would be outside of the extent of the impermeable cover (see Figure 5-3). The proposed extraction well would be screened across the entire saturated thickness of the overburden aquifer. The well would be equipped with a submersible pump capable of pumping up to 30 gpm. A preliminary design pumping rate of 30 gpm was used to allow flexibility in the preliminary design should additional groundwater modeling require a higher pumping rate. For the purpose of preparing cost estimates, both alternatives assume continual pumping for 30 years at a rate of 30 gpm. The extraction well would be six inches in diameter, and constructed of stainless steel. Grain size of the sandpack material in the annular space around the screen would be compatible with the slot size of the screen. A protective casing would be installed and grouted in place.

Extracted groundwater would be pumped to the treatment facility through buried influent piping. The influent piping would be connected to the side of the extraction well below frost line through a pitless adapter within the well. This adapter would allow access to the submersible pump through the top of the well. The conduit for instrumentation and controls/wiring would be installed in the same trench with the influent pipe.

Two manholes would be located along the influent trench at the topographical high points to allow installation and function of air-release valves. Double-wall influent pipe would be used because the trench and piping would be located outside of the landfill cap. It is proposed that pump control equipment be located within the treatment facility.

Typically, contaminant concentrations in groundwater collected by extraction wells will be more dilute than that detected in monitoring wells. However, accurate prediction of future concentrations is difficult and depends on several factors. These include: (1) flowrate of groundwater beneath the landfill, and available groundwater for mixing and dilution with leachate; (2) mass of contaminants contributed to leachate; and (3) fluid generation/release in the landfill. For purposes of this FS, a weighted-average concentration was calculated for the inorganic contaminants of concern as an estimate of influent concentrations to the treatment facility. This weighted average was calculated by averaging unfiltered contaminant concentrations detected in adjacent monitoring wells along the eastern edge of the landfill. Estimated influent concentrations for contaminants of concern are listed in Table 5-7. Assumptions and calculations for influent concentrations are presented in Appendix C.

Ion Exchange Treatment Facility Construction. The most promising ex situ treatment for Shepley's Hill Landfill groundwater is ion exchange. A permanent groundwater treatment facility would be constructed south of Plow Shop Pond (see Figure 5-3). An asphalt access road would be constructed from Saratoga Street to the treatment facility. The building would be a pre-engineered structure installed on a reinforced concrete pad. A drain and sump would be built into the pad to collect spilled liquids and recirculate them back into the treatment system. The drain and sump system, alone or in conjunction with a curb system, will be sized to provide secondary containment equal to the volume of the largest treatment tank. Instrumentation provided with treatment system components would include water level controllers that would respond to abnormally high or low levels in vessels which could result from vessel overflows or ruptures. The controllers would shut down extraction well pumps and/or treatment facility pumps, as required, in the event of treatment system failure. Electrical service would be supplied to the treatment facility for lights, HVAC, and operation of pumps and treatment systems. The nearest source capable of providing sufficient electricity to the treatment facility is located on Saratoga Street, approximately 1,600 feet south of the proposed location of the treatment facility.

Water would be supplied to the treatment facility for potentially backwashing sand and carbon filters, maintenance, cleaning, and fire fighting. The nearest source of water is a 12-inch water line located on Saratoga Street, approximately 1,200 feet south of the proposed location of the treatment facility.

Equipment installed in the treatment facility would include a 10,000-gallon feed/storage tank, one 30 gpm service and one 30 gpm standby feed pump. Sand and carbon filtration systems will be installed to reduce the concentrations of TSS and total dissolved solids that could interfere with the performance of the ion exchange system. In addition, the treatment facility will include a backwash settling tank for handling backwash from the sand and carbon filters, a diaphragm pump for pumping slurry from the backwash settling tank to a filter press, and a two cubic foot filter press (Figure 5-4). The ion exchange portion of the treatment system would include cation and anion exchange columns, a regeneration waste tank for storage of waste from ion exchange resin regeneration, a pump for pumping regeneration waste to an atmospheric evaporator, and an atmospheric evaporator (see Figure 5-4).

The sand filtration system would consist of three 18-inch diameter by 66-inch long pressure vessels and the carbon filtration system would consist of two 18-inch diameter by 66-inch long pressure vessels. Each vessel would contain five cubic feet of media.

The ion exchange system would consist of two parallel trains of one cation exchange column in series with one anion exchange column (see Figure 5-4). The two cation exchange columns would each contain approximately 29.5 cubic feet of resin and would be approximately 42 inches in diameter and have a bed depth of 36 inches. The two anion exchange columns would each contain approximately 44.25 cubic feet of resin and would be approximately 48 inches in diameter and have a bed depth of 43.2 inches.

Floor space required in the treatment facility building for equipment is estimated to be approximately 1,250 square feet. Allowing for approximately 500 square feet for a office/control center and storage space, the floor space required for the building is estimated to be 1,750 square feet. For preliminary design and cost-estimating purposes, the building would occupy a foot print of 50 feet by 35 feet.

Ion Exchange Treatment Facility Operation. This alternative assumes an influent flow of 30 gpm to the treatment system over 30 years of operation. For purposes of this FS, the volume/mass of secondary wastes generated during groundwater treatment and the cost for system operation is assumed to be constant over 30 years of operation. The assumed contaminant concentrations in the influent from the extraction wells and the estimated surface water discharge limits are presented in Table 5-7.

Operation of the treatment facility would consist of pumping groundwater from the feed/storage tank through the filtration and ion exchange systems to the effluent pipe.

The sand filtration system would remove suspended solids from the groundwater. Two of the vessels would be in service while the third is on standby or in the backwash cycle. During backwash, process water is pumped through the stand-by filter and its effluent is directed to the service filter requiring cleaning. Backwash water is then directed to the backwash settling tank, where solids that settle out are pumped to the filter press. Filtrate from the filter press is returned to the feed/storage tank (see Figure 5-4).

The carbon filtration system would remove organics and any suspended solids that may remain in the effluent after the sand filtration system. One of the vessels would be in service while the other is on standby or in backwash. The backwash process removes solids but would not remove organics adsorbed to the carbon. Spent carbon would have to be removed from the vessels for regeneration or disposal. The estimated carbon usage rate based on an average (i.e., 4.3 milligrams per liter [mg/L]) TOC concentration in groundwater at Shepley's Hill Landfill is 1 pound per 10,000 gallons of water treated. On-line instrumentation can be used to determine when carbon saturation has occurred.

The ion exchange system would remove dissolved solids from the groundwater. During groundwater treatment, one column train would be in service while the other is on standby or in the regeneration cycle. During resin regeneration in the cation columns, sulfuric acid is circulated through the column, resulting in demineralization of cationic contaminants in the resin. During resin regeneration in the anion columns, sodium hydroxide is circulated through the column, resulting in demineralization of anionic contaminants in the resin. In both cases, regeneration waste would be directed to the waste storage tank from which the waste would be pumped to a 30-gallon-per-hour atmospheric evaporation system (see Figure 5-4).

Secondary wastestreams are generated during backwashing of the sand and carbon filtration systems and during resin regeneration in the ion exchange system. The following quantities were calculated from a groundwater flow of 30 gpm into the treatment system. Using RI data to calculate an average total suspended solids concentration of 113 mg/L, approximately one pound of solids would be filtered out of every 1,000 gallons of groundwater pumped through the sand and carbon filtration systems. Therefore, at a flow rate of 30 gpm, approximately 45 pounds per day of solids would be generated. Assuming the filter cake produced by the filter press is 35 percent solids by weight, approximately 125 pounds per day of filter cake would require disposal. The filter cake would be discharged into drums or a dumpster for temporary storage in the treatment facility building. Prior to transporting the filter cake to an off-site disposal facility, samples would be collected to "fingerprint" the waste and the resulting analyses interpreted by the receiving off-site disposal facility to determine if acceptance criteria are met. Off-site treatment of filter cake may be required prior to disposal and would likely consist of stabilization/solidification to reduce the mobility of metals in the filter cake.

Each column in the ion exchange system is expected to require resin regeneration every two days of operation. An estimated 660 gallons of 11 percent sulfuric acid and 830 gallons of 11 percent sodium hydroxide will be required for each regeneration cycle. Consequently, a total of 1,490 gallons of waste would be generated every two days of ion exchange system operation. The waste streams would be combined, neutralized, and filtered prior to concentration in an atmospheric evaporator. Assuming the evaporation system achieves a 95 percent volume reduction, approximately 75 gallons of concentrate would be generated every two days. Based on the volumetric ratio, the concentration of analytes in the concentrate would be 800 times that in untreated groundwater. The concentrate would likely be discharged into a temporary storage tank in the treatment facility building. Similar to the off-site disposal of filter cake, samples would be collected to fingerprint the waste and determine if additional treatment is needed prior to disposal. Off-site treatment, if required, would likely consist of stabilization/solidification to reduce the mobility of metals in the concentrate.

For purposes of the FS, weekly sampling is assumed to be required to monitor performance of the treatment system. One sample would be collected from the treatment system influent and one sample would be collected from the treatment system effluent. Each sample would be analyzed for VOCs and metals.

Treated Groundwater Discharge. The effluent from the treatment facility would be discharged through a gravity flow pipeline to Nonacoicus Brook. Access manholes would be placed every 500 feet along the discharge pipeline. Figure 5-3 shows a proposed location for placement of the effluent pipeline.

Nonacoicus Brook is classified as a Class B waterbody and as such is designated as habitat for fish, other aquatic life and wildlife, and for primary and secondary contact regulation. While the classification standards require that Class B waters be suitable for a source of drinking water supply with appropriate treatment, Nonacoicus Brook is not used as a drinking water supply. Therefore, tentative discharge limitations for the discharge of treated groundwater to Nonacoicus Brook were calculated to prevent exceedances of AWQC for the protection of fresh water aquatic life at the average 7-day, 10-year low flow (7Q10) in the brook (see Table 5-7 and Appendix D). In instances where the background concentration exceeded the calculated limitation, the limitation was set equal to the background value. The 7Q10 for Nonacoicus Brook was estimated to be approximately 2.6 cubic feet per second by proportioning the 7Q10 for the Nashua River at East Pepperell to the drainage area of Nonacoicus Brook at the outlet of Plow Shop Pond. AWQC have not been established for sodium; however, adverse effects are not expected from the discharge of groundwater containing the observed sodium concentrations to Nonacoicus Brook.

Landfill Cover Maintenance. The landfill cover maintenance program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Landfill Gas Collection System Maintenance. The landfill gas collection system maintenance program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Long-term Groundwater Monitoring. The long-term groundwater monitoring program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Long-term Landfill Gas Monitoring. The long-term landfill gas monitoring program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Institutional Controls. The institutional controls proposed for this alternative are the same as those proposed for Alternative SHL-2.

Educational Programs. The educational programs proposed for this alternative are the same as those proposed for Alternative SHL-2.

Annual Reporting to MADEP and USEPA. The reporting proposed for this alternative is the same as that proposed for Alternative SHL-2.

Five-Year Site Reviews. Under CERCLA 121c, any remedial action (or lack thereof) that results in contaminants remaining on-site must be reviewed at least every five years. During five-year reviews, an assessment is made of whether the implemented remedy is protective of human health and the environment and whether the implementation of additional remedial action is appropriate. Data collected during the long-term groundwater monitoring program would provide information for these reviews.

Alternative SHL-5 will be considered effective if concentrations of individual chemicals within individual wells do not show statistically significant PRG exceedances after sufficient time is allowed to achieve redirection of groundwater flow and capture of contaminated groundwater. To determine statistical significance, the Army will apply methods consistent with the regulations at 40 CFR 264.97, 40 CFR 258.53, and 310 CMR 30.663. The time to achieve capture of contaminated groundwater would be estimated from the pre-design studies hydrogeologic studies that are a part of this alternative. Detailed plans for evaluating performance would be developed during the design phase and submitted for regulatory review and concurrence.

A major consideration in assessing the protectiveness of Alternative SHL-5 and whether additional remedial actions may be appropriate would be the basis on which individual PRGs were set. The Army would consider the implementation of additional remedial actions if the PRGs are not met for any chemicals for which PRGs were based on MCLs (40 CFR 141) and for manganese. No MCL has been established for manganese. The PRG for manganese was based on background concentrations because background concentrations exceed the risk based concentration derived from the available reference dose value (5E-3 mg/kg/day). This approach for setting PRGs and for evaluating the effectiveness of landfill closure is consistent with USEPA guidance contained in *Risk*

*Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim,* December 1991, and with 40 CFR 258.55.

The Army will not consider additional remedial actions under CERCLA if PRGs are not attained for aluminum and iron. The PRGs for aluminum and iron were based on background concentrations because dose/response values were not available.

Similarly, the Army will not consider additional remedial actions if the PRG is not attained for sodium. The PRG for sodium was based on the health advisory for individuals on a reduced sodium diet.

### 5.3.2 Remedial Alternative Evaluation

The assessment of Alternatives SHL-5A and SHL-5B using the evaluation criteria is presented in the following subsections.

**5.3.2.1 Overall Protection of Human Health and the Environment.** Alternatives SHL-5A and SHL-5B have significant potential for achieving an acceptable level of risk for human receptors. The existing cap reduces leaching of contaminants from waste materials in the unsaturated zone, while the extraction system would capture contaminated groundwater for treatment. Institutional controls would provide added protection by preventing potential ingestion of groundwater from the landfill. There is no current human or ecological exposure to groundwater.

**5.3.2.2 Compliance with ARARs.** Table 5-8 provides a summary of the ARARs analysis for Alternatives SHL-5A and SHL-5B. The alternatives have the potential to fully comply with chemical-specific ARARs and guidance. Contaminated groundwater would be extracted and treated. MCLs and Massachusetts Maximum Contaminant Level (MMCLs) would be achieved in the aquifer downgradient of the landfill by capturing and treating groundwater. MCLs and MMCLs would be expected to be achieved over time in the aquifer beneath the landfill. Currently, groundwater at the north end of the landfill meets PRGs.

Location-specific ARARs regarding floodplains and wetlands may be triggered by construction of a discharge pipeline to Nonacoicus Brook (see Figure 1-6). All construction activities as well as landfill cover and gas collection system maintenance activities must be planned to prevent adverse effects to the Grasshopper Sparrow and its habitat as required by the Massachusetts Endangered Species Act (MGLc.131A, s.1).

Several action-specific ARARs apply to these alternatives. The filter cake generated as a result of backwashing the sand and carbon filtration systems and the concentrate from ion exchange resin regeneration could be characteristic hazardous wastes and would be subject to RCRA regulations. Because this is a CERCLA site, a NPDES permit would not be required for the on-site discharge of stormwater runoff from the construction site, but would be required for the off-site discharge of treated groundwater to Nonacoicus Brook. However, substantive requirements would need to be met. This alternative will comply with the post-closure requirements for a solid waste landfill at 310 CMR 19.000.

**5.3.2.3 Long-Term Effectiveness and Permanence.** The long-term effectiveness of these alternatives for limiting human and ecological exposure to groundwater contaminants depends on the following factors:

- the effectiveness of the cover system;
- the effectiveness of the groundwater extraction system for capturing contaminated groundwater downgradient of the landfill; and
- the effectiveness of institutional controls.

Effectiveness of the cover system and institutional controls is evaluated in Subsection 5.2.2.3. The effectiveness of the groundwater extraction system is discussed in the following paragraphs.

Data acquired during the pre-design hydrogeologic study would be used to design an effective and efficient groundwater extraction system. The effectiveness of groundwater extraction systems for intercepting contaminant plumes in similar hydrogeologic settings has been demonstrated at other sites. It should be noted that performance of the cover system may impact the need for groundwater extraction and treatment. Should the cover system affect groundwater flow as predicted by the modeling performed in Subsection 4.2.2, contaminant concentration may decrease, and groundwater extraction may not be necessary.

**5.3.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment.** The extraction and treatment by ion exchange would not reduce the toxicity or volume of contaminants, but capture and extraction of contaminated groundwater would reduce contaminant mobility.

The sand filtration system would remove suspended solids, and the ion exchange system would remove dissolved solids. The RI supplemental data indicate that aluminum is present primarily in the suspended phase and that arsenic, iron, and manganese are present in both the suspended and dissolved phases. Organic contaminants and a minor amount of suspended solids would be removed from groundwater in the carbon filtration system.

Treatment by sand filtration and ion exchange would not permanently reduce the toxicity, mobility, or volume of metals (i.e., aluminum, arsenic, iron, and manganese), but would concentrate them into a manageable form for off-site transport and treatment. Approximately 125 pounds of filter cake would be generated from the sand and carbon filtration systems each day and approximately 40 gallons of concentrate would be generated from the ion exchange system each day. Off-site treatment of both filter cake and concentrate would likely consist of stabilization/solidification, which has been successfully used to reduce the mobility of metals.

Treatment by carbon filtration would reduce the mobility of organic contaminants adsorbed to the carbon and would concentrate them into a manageable form for off-site transport and treatment. Off-site treatment of spent carbon would likely be thermal reactivation in an incinerator, which would destroy adsorbed organic contaminants.

**5.3.2.5 Short-Term Effectiveness.** These alternatives would present minimal potential risk to site workers and the community but potentially significant risk to the environment. Remedial activities which could present potential risk to site workers and the community would be the handling/transportation of residues from the groundwater treatment facility. Adherence to RCRA and U.S. Department of Transportation (DOT) regulations affecting handling/ transportation of hazardous wastes would reduce the risk of community exposure to an uncontrolled release of hazardous materials to a safe level.

Potentially significant impact to the environment could be realized if construction of the groundwater extraction system and maintenance of the landfill adversely affected the habitat of the Grasshopper Sparrow. The Grasshopper Sparrow currently nests in the vicinity of Shepley's Hill Landfill and nesting areas would have to be identified prior to construction activities. The construction schedule and activities could be modified to limit construction activities during the nesting season and/or avoid direct impacts on the bird.

Personnel who collect groundwater samples as part of the post-closure monitoring program will need to follow a site-specific HASP and utilize personal monitoring and personal protective equipment to prevent exposure to hazardous chemicals. Workers involved in operation and maintenance activities at the groundwater treatment facility would likewise need to be trained in the use of appropriate monitoring and protective/safety equipment. However, based on available groundwater monitoring data, acute hazards are not anticipated.

**5.3.2.6 Implementability**. Services and materials to implement landfill post-closure requirements are readily available and the placement of zoning and deed restrictions on property currently owned by the U.S. Army would be easily implemented. Enforcement would require cooperation with the Town of Ayer.

The components of these alternatives should be easy to construct and operate. Many engineering companies are qualified to design groundwater extraction, treatment, and discharge facilities. Construction can be accomplished using common equipment and techniques.

Sand and carbon filtration are proven technologies for removal of suspended solids and organic contaminants, respectively. Ion exchange is a proven technology for removal of dissolved metals. Ancillary equipment, such as evaporators and filter presses, is used commonly in industrial and wastewater treatment processes. Weekly monitoring of the treatment system influent and effluent would ensure that the system is operating normally and that discharge limits are not exceeded.

Implementation of either alternative would not prevent the undertaking of additional remedial actions. The need for implementation of groundwater extraction and treatment is dependent upon the performance of the landfill cover system. Should the cover system perform as groundwater modeling indicates, contaminant concentrations may decrease, and groundwater extraction may not be necessary.

Residues (i.e., filter cake and concentrate) generated during treatment facility operation would require off-site disposal. The residues may be characteristic hazardous waste and treatment by stabilization/solidification may be required prior to disposal at a licensed landfill. The volume of residues would be relatively small (i.e., approximately 23 tons of filter cake and 15,000 gallons of concentrate annually), and a problem in identifying and obtaining off-site treatment and disposal capacity is not anticipated.

Capital costs consist of direct and indirect costs. Direct costs for this alternative include institutional controls, site preparation and mobilization, landfill cover repairs, evaluation of stormwater drainage, and installation of additional monitoring wells. A 25 percent contingency was included in direct cost items to account for unforeseen project complexities (e.g., adverse weather conditions, and increased construction standby times).

Indirect costs include expenditures for contractors' overhead and profit and additional administrative, engineering, and legal services that are not part of actual alternative installation, but are required to complete site closure. These include engineering expenses, legal fees, health and safety costs, and contingency allowances.

Engineering design was estimated at 10 percent of the total direct costs. Costs for health and safety were estimated at 5 percent of the total direct costs. Legal, administrative, and permitting costs were estimated at 5 percent of total direct cost.

O&M costs include expenditures associated with pumping and treating contaminated groundwater, monitoring treatment system influent and effluent, the groundwater monitoring program, and landfill cover and gas collection system inspection and maintenance. Annual reporting costs, as well as 5-year site reviews required by CERCLA, are included as part of the O&M costs.

Table 5-9 summarizes the cost estimate for these alternatives. Total direct and indirect costs are estimated to be $2,577,000. O&M costs are estimated to be

$426,000 per year. The estimated total present worth of Alternatives SHL-5A and SHL-5B is $9,126,000 based on a 30-year period. Cost calculations are included in Appendix B.

## 5.4 ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW

This subsection describes the POTW discharge alternative. As with Alternative SHL-5, in order to incorporate some flexibility into the preliminary design of this treatment alternative, this alternative will be restructured into two alternatives SHL-9A and SHL-9B. SHL-9A would use an extraction well(s) located at the northern end of the landfill, where modeling suggests groundwater will be focused, to capture contaminated groundwater. SHL-9B would utilize an extraction well(s) located between the landfill and Plow Shop Pond. Alternatives SHL-9A and SHL-9B provide flexibility in the preliminary design to account for the level of accuracy inherent in mathematical modeling of groundwater systems. All other aspects of these two alternatives are the same. To avoid redundancy in evaluating these equivalent alternatives, the following evaluation using the seven evaluation criteria and the following cost estimate apply to both Alternatives SHL-9A and SHL-9B. Descriptions of all alternative components, except for the location of the extraction well(s), also apply to both alternatives.

This subsection describes the POTW discharge alternatives, evaluates the alternatives using the seven evaluation criteria, and provides a cost estimate.

### 5.4.1 Description

Alternatives SHL-9A and SHL-9B include the following components:
(1) constructing a groundwater extraction system; (2) installing an effluent pipeline for extracted groundwater; (3) connecting the effluent pipeline to the Town of Ayer sewer system; and (4) pumping and discharging groundwater to the Town of Ayer POTW. Figure 5-5 shows the proposed locations of the extraction system, effluent pipeline, and discharge to the Town of Ayer sewer system. Key components of Alternative SHL-9 are:

- survey of Shepley's Hill Landfill
- evaluation/improvement of stormwater diversion and drainage
- pre-design hydrogeologic study

- design of groundwater extraction and discharge systems
- site preparation and mobilization
- groundwater extraction system construction
- untreated groundwater discharge to Town of Ayer POTW
- landfill cover maintenance
- landfill gas collection system maintenance
- long-term groundwater monitoring
- long-term landfill gas monitoring
- institutional controls
- educational programs
- annual reporting to MADEP and USEPA
- five-year site reviews

The remedial alternative conceptual design described in the following paragraphs is preliminary and was developed for evaluation and cost-estimating purposes.

Survey of Shepley's Hill Landfill. The survey of Shepley's Hill Landfill proposed for this alternative would be similar to that proposed for Alternative SHL-2.

Evaluation/Improvement of Stormwater Diversion and Drainage. The stormwater evaluation/improvement task proposed for this alternative would be similar to that proposed for Alternative SHL-2.

Pre-design Hydrogeologic Study. The pre-design hydrogeologic study proposed for this alternative would be similar to that proposed for Alternative SHL-5.

Design of Groundwater Extraction and Discharge Systems. Following collection and development of necessary data, the design of the groundwater extraction and discharge systems will be finalized. Data necessary to finalize design includes survey and hydrogeologic data. This data would be integrated during design to enable preparation of appropriate and cost-effective extraction and discharge systems.

Site Preparation and Mobilization. Site preparation and mobilization for this alternative would be similar to that proposed for Alternative SHL-5.

Groundwater Extraction System Construction. The groundwater extraction system for Alternatives SHL-9A and SHL-9B would be the same extraction system proposed for Alternatives SHL-5A and SHL-5B (see Subsection 5.3.1). Extracted groundwater would be pumped to the proposed discharge location through buried piping. Piping would be connected to the extraction well below the frost line through a pitless adapter within the well to allow access to the pump through the top of the well. Piping would terminate at a discharge manhole approximately 250 feet to the west of the northern end of the landfill for discharge into the Town of Ayer's POTW for treatment (see Figure 5-5). Double-walled piping would be used because of the location of the piping outside the boundary of the landfill. Controls and other extraction system equipment are anticipated to be minimal, and would be housed near the extraction well.

Typically, contaminant concentrations in groundwater collected by extraction wells will be more dilute than those detected in monitoring wells. However, accurate prediction of future concentrations is difficult and depends on several factors. These include: (1) flowrate of groundwater beneath the landfill, and available groundwater for mixing and dilution with leachate; (2) mass of contaminants contributed to leachate; and (3) fluid generation/release in the landfill. For purposes of this FS, a weighted-average concentration was calculated for the inorganic contaminants of concern as an estimate of influent concentrations to the treatment facility. This weighted average was calculated by averaging unfiltered contaminant concentrations detected in adjacent monitoring wells along the eastern edge of the landfill. Table 5-10 compares estimated influent concentrations for contaminants of concern with Town of Ayer POTW pretreatment standards. Assumptions and calculations for influent concentrations are presented in Appendix C.

Untreated Groundwater Discharge to Town of Ayer POTW. The Town of Ayer POTW utilizes an activated sludge system to treat domestic and industrial sewage. The POTW currently disposes of its sludge at a dedicated, permitted landfill. The facility has a design hydraulic capacity of 1.79 mgd with approximately 50 percent available, and is currently being upgraded with ceramic fine bubble diffusers to attain/restore design aeration capability. POTW representatives indicated that the facility is operating in compliance with its National Pollutant Discharge Elimination System (NPDES) permit.

Prior to discharging groundwater into the Town of Ayer sewer system, negotiations must be completed between the Army and the Ayer POTW for a long-term discharge agreement. In order for a POTW to meet its discharge requirements, POTWs establish influent limits that must not be exceeded. The POTW's influent local limits are provided in Table 5-10. Also shown on Table 5-10 are the estimated discharge concentrations expected in groundwater extracted from Shepley's Hill Landfill. These concentrations were based on analytical results for unfiltered samples and should represent a conservative (i.e., high) estimate of contaminant concentrations. Provided that the discharge from Shepley's Hill Landfill meets local limits, pretreatment would not be required.

The proposed discharge to the sewer would be at a discharge manhole that would be located approximately 250 feet west of the northern end of the landfill on Scully Road (see Figure 5-5). POTW representatives indicated that sewage flows by gravity from Scully Road to the main pump station, and that the sewer line is not combined with storm sewers. The main pump station would be able to handle an additional flow of 30 gpm. Continued monitoring by the U.S. Army would be required to document that groundwater meets pretreatment standards. Should groundwater not meet pretreatment standards, modifications to the system would be required.

Landfill Cover Maintenance. The landfill cover maintenance program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Landfill Gas Collection System Maintenance. The landfill gas collection system maintenance program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Long-term Groundwater Monitoring. The long-term groundwater monitoring program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Long-term Landfill Gas Monitoring. The long-term landfill gas monitoring program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Institutional Controls. The institutional controls proposed for this alternative are the same as those proposed for Alternative SHL-2.

Educational Programs. The educational programs proposed for this alternative are the same as those proposed for Alternative SHL-2.

Annual Reporting to MADEP and USEPA. The reporting proposed for this alternative is the same as that proposed for Alternative SHL-2.

Five-Year Site Reviews The five-year site reviews proposed for this alternative are the same as that proposed for Alternative SHL-5.

### 5.4.2 Remedial Alternative Evaluation

The assessment of these alternatives using the evaluation criteria is presented in the following subsections.

**5.4.2.1 Overall Protection of Human Health and the Environment.** Alternatives SHL-9A and SHL-9B have significant potential for achieving an acceptable level of risk for human and ecological receptors downgradient of Shepley's Hill Landfill. The existing cap would reduce leaching of contaminants from waste material in the unsaturated zone, while the extraction system would capture contaminated groundwater for discharge to the POTW for treatment. Institutional controls would provide added protection by preventing potential ingestion of groundwater from the landfill.

**5.4.2.2 Compliance with ARARs.** Table 5-11 provides a summary of the ARARs analysis for Alternatives SHL-9A and SHL-9B. These alternatives have the potential to fully comply with chemical-specific ARARs and guidance. MCLs and MMCLs would be achieved in the aquifer downgradient of the landfill by capturing and extracting contaminated groundwater. MCLs and MMCLs would be expected to be achieved over time in the aquifer beneath the landfill. Currently, groundwater at the north end of the landfill meets PRGs.

Location-specific ARARs should all be met by these alternatives since only minimal excavation would be required to install the extraction well and discharge pipeline. All construction activities as well as landfill cover and gas collection system maintenance activities must be planned to prevent adverse effects on the Grasshopper Sparrow and its habitat as required by the Massachusetts Endangered Species Act (MGLc.131A,s.1).

Action-specific ARARs apply to this alternative. The discharge of non-domestic wastewater to a POTW must comply with the Clean Water Act, General

Pretreatment Program (40 CFR Part 403). These alternatives would comply with the action-specific landfill post-closure requirements of 310 CMR 19.142.

**5.4.2.3 Long-term Effectiveness and Permanence**. The long-term effectiveness of these alternatives for limiting human and ecological exposure to groundwater contaminants depends on the following factors:

- the effectiveness of the cover system;
- the effectiveness of groundwater extraction system for capturing contaminated groundwater downgradient of the landfill;
- the ability of the Town of Ayer POTW to treat extracted groundwater for the remediation period; and
- the effectiveness of the Town of Ayer sludge disposal landfill
- the effectiveness of institutional controls.

The effectiveness of the cover system, institutional controls, and groundwater extraction systems are evaluated in Subsections 5.2.2.3, and 5.3.2.3, respectively.

The current concentrations of contaminants in the extracted groundwater meet influent pretreatment requirements at the POTW. Provided that groundwater contaminant concentrations do not increase significantly, and theoretical estimates of influent concentrations are not exceeded, extracted groundwater would not require pretreatment and the POTW would be capable of treating the discharge. Long-term monitoring would evaluate contaminant concentrations in groundwater at Shepley's Hill Landfill. If pretreatment of groundwater is needed, it would likely consist of ion exchange or chemical precipitation as discussed for Alternatives SHL-5A and SHL-5B, respectively. The duration of extraction and discharge required to remediate the groundwater at Shepley's Hill Landfill is not known. Prior to implementing this alternative, a long-term discharge agreement must be established between the U.S. Army and the Town of Ayer POTW. This agreement should include provisions for renewal should the duration of the alternative be longer than the 30-year costing period. It should be noted that performance of the cover system may impact the need for groundwater extraction and treatment. Should the cover system affect groundwater flow as predicted by the modeling performed in Subsection 4.2.2, contaminant concentration may decrease, and groundwater extraction may not be necessary.

**5.4.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment.** Groundwater extraction and discharge to the Town of Ayer POTW would not reduce the toxicity or volume of contaminants, but capture and extraction of contaminated groundwater would reduce contaminant mobility in the groundwater.

Sludge generated at the POTW would require disposal. This sludge would contain contaminants removed from discharged groundwater from Shepley's Hill Landfill. The POTW currently disposes of its sludge at a dedicated and permitted landfill. Provided that the extracted groundwater meets pretreatment criteria established by the POTW, sludge disposal practices would not be affected.

**5.4.2.5 Short-term Effectiveness.** These alternatives would present minimal potential risk to site workers and the community, but potentially significant risk to the environment. Remedial activities which could present potential risk to site workers and the community would be the intrusive activities performed during the installation of the extraction system. Following a site-specific HASP and utilizing personal monitoring and protective equipment to prevent exposure to contaminants would be required. Personnel who collect groundwater samples as part of the post-closure monitoring would also be required to follow a site-specific HASP and utilize personal monitoring and protective equipment.

Potentially significant impact to the environment could be realized if construction of the groundwater extraction system and maintenance of the landfill adversely affected the habitat of the Grasshopper Sparrow. The Grasshopper Sparrow currently nests in the vicinity of Shepley's Hill Landfill, and any nesting areas at Shepley's Hill Landfill would have to be identified prior to construction activities. The construction schedule and activities could be modified to limit construction activities during the nesting season and/or avoid direct impacts on the bird.

**5.4.2.6 Implementability.** Services and materials to implement post-closure requirements are readily available. The placement of zoning and deed restrictions on property currently owned by the U.S. Army would be easily implemented. Enforcement would require cooperation with the Town of Ayer.

Components of these alternatives should be easy to construct and operate. Many engineering companies are qualified to design groundwater extraction systems. Construction can be accomplished using common equipment and techniques. The need for implementation of groundwater extraction and treatment is dependent upon the performance of the landfill cover system. Should the cover system perform as groundwater modeling indicates, contaminant concentrations may decrease, and groundwater extraction may not be necessary.

Implementation of this alternative would require the U.S. Army and the Town of Ayer's POTW to reach a long-term discharge agreement. Initial conversations with the POTW indicate a willingness to consider accepting the discharge provided that pretreatment requirements are met. The POTW does have available hydraulic capacity to handle a 30 gpm discharge. POTWs are required to notify the regulatory agency issuing NPDES permits in its state of any new introduction of pollutants to the POTW by an indirect discharger.

According to the NCP, no federal, state, or local permits are required for on-site response actions conducted pursuant to CERCLA, although coordination with review agencies is recommended.

**5.4.2.7 Cost.** One cost estimate was prepared for Alternatives SHL-9A and SHL-9B to assist in selecting a remedial alternative. The only cost differences between the two alternatives would be in the amount of piping required to transport extracted groundwater to the discharge location. For evaluation purposes, the estimated costs for the two alternatives would be within design cost contingencies. The estimate contains the following principal elements:

- capital cost
- O&M costs

Capital cost consists of direct and indirect costs. Direct costs for Alternatives SHL-9A and SHL-9B include institutional controls, site preparation and mobilization, landfill cover repairs, extraction system construction, and discharge line construction. A 25 percent contingency was included in direct cost items to account for unforeseen project complexities (e.g., adverse weather conditions, inadequate site characterization, and increased construction standby items).

O&M costs include cost expenditures associated with pumping contaminated groundwater, discharging water to the POTW, monitoring extracted groundwater for compliance with pretreatment discharge limits, the groundwater monitoring program, and landfill cover and gas collection system inspection and maintenance. Annual reporting costs, as well as five-year site reviews required by CERCLA, are included as part of the O&M costs.

Table 5-12 summarizes the cost estimate for Alternative SHL-9. The total direct cost is estimated to be $1,184,000. O&M costs are approximated to be $175,000 per year. The estimated total present worth of Alternatives SHL-9A and SHL-9B is $3,874,000 for a 30-year period. Cost calculations are included in Appendix B.

## 5.5 ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP

This subsection describes Alternative SHL-10, evaluates the alternative using the seven evaluation criteria, and provides a cost estimate.

### 5.5.1 Description

Alternative SHL-10 is designed to satisfy the closure requirements of RCRA Subtitle C described in 40 CFR 264 by the installation of a landfill composite final cover. The cover will prevent infiltration of precipitation into the waste and potential future exposure to contaminated groundwater. Key components of Alternative SHL-10 include:

- survey of Shepley's Hill Landfill
- test pitting/boring program
- borrow study
- design of cover system
- site preparation and mobilization
- construction of cover system
- landfill cover maintenance
- landfill gas collection system maintenance
- long-term groundwater monitoring
- long-term landfill gas monitoring
- institutional controls
- educational programs

- annual reporting to MADEP and USEPA
- five-year site reviews

Survey of Shepley's Hill Landfill. In conjunction with the test pitting program and prior to design of a new landfill cover and rerouting of storm water drains, an accurate topographic survey of the landfill surface would be required. A cost is included to conduct an aerial survey of Shepley's Hill Landfill. Also included is the cost to survey the elevation and horizontal location of test pits and new groundwater monitoring wells. A final survey to prepare record drawings is included.

Test Pitting/Boring Program. Prior to the design of the new cover system, a series of test pits and borings would be made to confirm the interpreted extent of landfilled waste. The regrading of waste material, particularly around the edge of the landfill, may be desirable to help achieve design surface slopes and optimize the footprint of the new cover. Test pits and borings will provide information needed to facilitate design decisions. For cost estimating purposes, excavation of 20 test pits and drilling of 10 40-foot deep borings was assumed.

Borrow Study. Installation of a RCRA cover will require an estimated 600,000 cubic yards (cy) of soil. Approximately 70,000 cy can be recovered from the existing cover, but the remaining 530,000 cy must be hauled to the site. A borrow study is proposed to determine if suitable materials can be obtained from Fort Devens sources.

Design of Cover System. The cover system will be designed to meet the performance criteria of 40 CFR 264.310 and be consistent with USEPA guidance in *Design and Construction of RCRA/CERCLA Final Covers* (USEPA, 1991b). These standards and guidance are listed below.

Performance Criteria:

1) provide long-term minimization of migration of liquids through the closed landfill;

2) function with minimum maintenance;

3) promote drainage and minimize erosion or abrasion of the cover;

4) accommodate settling and subsidence so that the cover's integrity is maintained; and

5) have a permeability (hydraulic conductivity) less than or equal to the permeability of any bottom liner system or natural subsoils present.

Design Guidance:

1) Low Hydraulic Conductivity Geomembrane/Soil Layer. A 60-cm (24-inch) layer of compacted natural or amended soil with a maximum hydraulic conductivity of $1x10^{-7}$ cm/sec in intimate contact with a minimum 0.5-mm (20-mil) geomembrane liner.

2) Drainage Layer. A minimum 30-cm (12-inch) soil layer having a minimum hydraulic conductivity of $1x10^{-2}$ cm/sec, or a layer of geosynthetic material having the same characteristics.

3) Top, Vegetative/Soil Layer. A top layer with vegetation (or an armored top surface) and a minimum of 60 cm (24-inch) of soil graded at a slope between 3 and 5 percent.

As part of the design process, stormwater drainage systems at and adjacent to Shepley's Hill Landfill will be evaluated. Although cap drainage patterns are expected to be similar to established patterns, they will be modified for improvement if practical and cost-effective alternatives are identified. The effectiveness of stormwater drainage systems upgradient of the landfill (i.e., at the transfer station, DRMO yards, and along Market Street) at diverting run-off from potential infiltration areas upgradient of the landfill will be evaluated. It is possible that the discharge of several storm drains south of the landfill would be relocated.

Site Preparation and Mobilization. A 10- to 15-acre staging area would be constructed on a level area adjacent to Shepley's Hill Landfill to park and maintain equipment and to stockpile materials. Gravel would be placed over this area as needed to support heavy equipment and facilitate storage/stockpiling of construction materials. Costs are included for mobilization of earth-moving equipment (e.g., backhoes, front-end loaders, and bulldozers), drill rigs, cranes, dump trucks, and construction-support trailers. A decontamination area and small parking lot exist at building T-201 on Carey Street adjacent to the landfill and are assumed to be available for use during remediation.

Construction of Cover System. The cover system would be constructed to achieve the five performance criteria for Subtitle C covers provided in 40 CFR 264.310 and to be consistent with USEPA guidance in *Design and Construction of RCRA/CERCLA Final Covers* (USEPA, 1991b). To prevent reopening of the landfill and the potential for infiltration of precipitation that would occur if the existing cover were removed, it is proposed that the RCRA cover would be constructed on top of the existing cover. Topsoil would be stripped from the existing cover, however, for reuse in the RCRA cover. The existing gas vent system and PVC geomembrane would be left in place. Existing gas vent risers would be extended to accommodate the increased thickness of the RCRA cover.

Following stripping and stockpiling of topsoil, the landfill surface would be graded and compacted as necessary to achieve the recommended slope of three to five percent. Although Phases II, III, and IV of the existing closure appear to meet the three percent requirement, an estimated 30 acres of Phase I have a 2 percent slope. The cost estimate for this alternative includes 120,000 cy of subgrade soil to increase the slope in the north portion of the existing Phase I closure to 3 percent. If the predesign survey indicates that additional areas do not meet the minimum slope requirement, additional fill or a regulatory waiver would be required. It is expected that final contours of the RCRA cover would be similar to the contours of the existing cover.

The composite hydraulic barrier layer will be installed on top of the drainage layer of the existing cover. Clean fill would be added if needed to protect/ cushion the hydraulic barrier layer. The proposed hydraulic barrier layer would consist of a 40-mil thick very low density polyethylene (VLDPE) geomembrane in intimate contact with a GCL. The GCL would be used instead of 24-inches of compacted natural or amended soil because of its relative ease of installation and excellent performance characteristics, and because there is no known local source of suitable low-permeability soil. A major reason for use of a geomembrane in the existing cover was lack of a local source of low-permeability soil. The proposed hydraulic barrier layer will have a hydraulic conductivity of less than $1x10^{-7}$ cm/sec.

A 12-inch thick drainage layer of granular soil with a minimum hydraulic conductivity of $1x10^{-2}$ cm/sec would be placed above the hydraulic barrier. This would be followed by a layer of geotextile to prevent the migration of fines from the 18-inch thick filter/buffer layer located above the geotextile. Finally a 6-inch thick topsoil layer capable of supporting vegetation will be placed on top. Design tasks will include evaluating the possible cost advantage of using synthetic drainage nets instead of granular soil for the gas venting and drainage layers. The cost estimate is based on use of granular material. The total thickness of soil above the hydraulic barrier layer is proposed to be 36 inches.

It is anticipated that the landfill would be accessed from its southern end and that capping would proceed from north to south. The estimated construction time is two construction seasons (i.e., two years). Erosion controls would be implemented during construction to prevent siltation of Plow Shop Pond and Nonacoicus Brook as a result of construction activities. Engineering controls would be used to control dust during construction. Construction work is not expected within wetlands or floodplain areas.

The effect of stormwater discharges on groundwater flow beneath the landfill will be evaluated during cover design.

The cost estimate includes the cost of rerouting several existing storm drains south of the landfill so that they discharge at new locations farther to the east.

Landfill Cover Maintenance. Annual inspections are proposed to monitor the condition of the landfill cover at Shepley's Hill Landfill, including monitoring wells, cover surface, and drainage swales to determine if maintenance is needed. Grass will be mowed annually and cover repairs made if required.

Landfill Gas Collection System Maintenance. The landfill gas collection system maintenance program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Long-term Groundwater Monitoring. The long-term groundwater monitoring program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Long-term Landfill Gas Monitoring. The long-term landfill gas monitoring program proposed for this alternative is the same as that proposed for Alternative SHL-2.

Institutional Controls. The institutional controls proposed for this alternative are the same as those proposed for Alternative SHL-2.

Educational Programs. The educational programs proposed for this alternative are the same as those proposed for Alternative SHL-2.

Annual Reporting to MADEP and USEPA. The reporting proposed for this alternative is the same as that proposed for Alternative SHL-2.

Five-Year Site Reviews The five-year site reviews proposed for this alternative are the same as that proposed for Alternative SHL-2.

### 5.5.2 Remedial Alternative Evaluation

The assessment of this alternative using the evaluation criteria is presented in the following subsections.

**5.5.2.1 Overall Protection of Human Health and the Environment.**
Alternative SHL-10 has significant potential for achieving an acceptable level of risk for human receptors. Groundwater modeling (see Subsection 4.2.2) suggests that the existing landfill cap has significantly reduced the amount of water in the landfill area, and resulted in a more northerly groundwater flow. The existing cap has had substantial effects in altering local groundwater flow and reducing potential impacts on Plow Shop and Grove ponds. Groundwater at the north end of the landfill currently meets PRGs. Installing a RCRA cap over the existing cap would be expected to achieve similar long-term results. Institutional controls included in this alternative would prevent the use of water from the contaminated aquifer, resulting in reduced potential for human exposure to contaminated groundwater. No exposure to ecological receptors currently exists.

**5.5.2.2 Compliance with ARARs.** Table 5-13 provides a summary of the ARARs analysis for Alternative SHL-10. The alternative has the potential for complying with chemical-specific ARARs and guidance. Currently, groundwater at the north end of the landfill meets PRGs. Installation of a RCRA cap would be expected to achieve a similar reduction in the leaching of landfill materials and concomitant groundwater contamination as is expected for the existing cap.

Location-specific ARARs regarding floodplains and wetlands would not be triggered by the alternative because no activities would occur that would adversely impact either floodplains or wetlands. Installation of the cover would potentially disrupt the habitat of the Grasshopper Sparrow, a state-listed species of special concern and therefore might not comply with the Massachusetts Endangered Species Act (MGL c.131A, s.1). A field survey would be required to confirm specific nesting locations. Landfill cover and gas collection system maintenance activities would be planned to prevent future adverse effects on the Grasshopper Sparrow and its habitat if the sparrow re-establishes on the cover.

This alternative will comply with the landfill cover performance standards and design guidance of RCRA Subtitle C (40 CFR 264.310), an action-specific ARAR, for landfill final covers with the following exception: a GCL would be substituted for 24-inches of compacted soil. This substitution would meet Subtitle C performance standards. It would also meet the performance standards for cover systems in the USEPA Criteria for Solid Waste Landfills (40 CFR 258), Massachusetts Solid Waste Management Regulations (310 CMR 19.000), and Massachusetts Hazardous Waste Management Rules (310 CMR 30.000). The proposed long-term monitoring and maintenance activities will also comply with post-closure requirements of these regulations.

**5.5.2.3 Long-term Effectiveness and Permanence**. The long-term effectiveness and permanence of this alternative is expected to be similar to that of Alternative SHL-2. Tests conducted by USEPA indicate that a properly installed composite cover system can prevent infiltration and leakage better than either a clay layer or geomembrane alone. It is not known, however, if implementation of this alternative would reduce contaminant leaching and groundwater contamination more than would be achieved by Alternative SHL-2. In addition, because of the relatively high permeability of overburden sands in the area, lowering of the groundwater table beyond the lowering achieved by Alternative SHL-2 may not occur.

With proper maintenance, the proposed components cover should last for the 30-year evaluation period.

**5.5.2.4 Reduction of Toxicity, Mobility, and Volume through Treatment**. Because no treatment processes would be implemented, no reduction through treatment would occur. Similar to Alternative SHL-2, the cover system, by reducing infiltration, would reduce leachate generation, groundwater contamination, and the potential for receptors to be exposed to contaminants. This alternative would not satisfy the statutory preference for treatment as an element of remedial actions.

**5.5.2.5 Short-term Effectiveness**. This alternative would involve extensive earth moving and construction activities. Construction workers would be exposed to the potential hazards normally associated with earth moving and construction activities. In addition, if the existing cover is breached, additional health and safety precautions would have to be taken to avoid exposure to hazardous and explosive atmospheres resulting from landfill gas. Both benzene and high concentrations of methane have been detected in gas samples taken from the existing landfill vents.

The community would experience some short-term inconvenience during the construction period from increased truck traffic. Construction of the cover would require delivery of approximately 530,000 cy of fill materials; the equivalent of approximately 53,000 10-cy dump truck loads. An estimated 240 to 300 truckloads per day would be required to deliver this material during an anticipated eight to ten month haul period. Several routes and entry points to Fort Devens exist and deliveries could be coordinated to reduce traffic hazards and congestion.

Personnel who collect groundwater samples as part of the post-closure monitoring program will need to follow a site-specific HASP and utilize personal monitoring equipment and personal protective equipment to prevent potential exposure to hazardous chemicals.

Short-term risks to the environment would result from the destruction of existing grassland habitat on the existing cover system that may provide nesting habitat for the Grasshopper Sparrow, a state-listed species of concern. In addition, the existing cover provides nesting and foraging habitat for small animals.

**5.5.2.6 Implementability**. The installation of the RCRA cover can be accomplished using standard construction procedures and conventional earthmoving equipment. Many engineering and construction companies are qualified and potentially available to do the design and construction work. The importing of an estimated 460,000 cy of soil to the site will be required for cover construction; the soil is assumed to be available at or near Fort Devens. If an adequate supply of high hydraulic conductivity material (i.e., $k = 1x10^{-2}$ to $1x10^{-3}$ cm/sec) is difficult to obtain, it may be possible to use synthetic drainage nets. Other construction materials such as the GCL and geomembrane are readily available. Implementation of this alternative would not limit or interfere with the ability to perform future remedial actions.

Services and materials to implement landfill post-closure requirements are readily available and the placement of zoning and deed restrictions on property currently owned by the U.S. Army would be easily implemented.

According to the NCP, no federal, state, or local permits are required for on-site response actions conducted pursuant to CERCLA, although coordination with review agencies is recommended. This alternative would not involve off-site activities requiring permits. The five-year review process would require coordination among regulatory agencies and enforcement of zoning and deed restrictions would require cooperation with the Town of Ayer.

**5.5.2.7 Cost.** A cost estimate was prepared for Alternative SHL-10 to assist in selecting a remedial alternative. The estimate contains the following principal elements:

- capital cost
- O&M cost

Capital costs consist of direct and indirect costs. O&M costs include expenditures associated with post-closure monitoring and maintenance of the cover system and environmental systems (i.e., grass mowing and maintaining groundwater monitoring wells and the gas-venting system).

Table 5-14 summarizes the cost estimate for Alternative SHL-10. Capital costs are estimated at $19,645,000. Operation and maintenance costs are estimated to be $84,000 per year. The estimated total present worth of Alternative SHL-10 is estimated to be $20,936,000 for a 30-year period. Cost calculations are included in Appendix B.

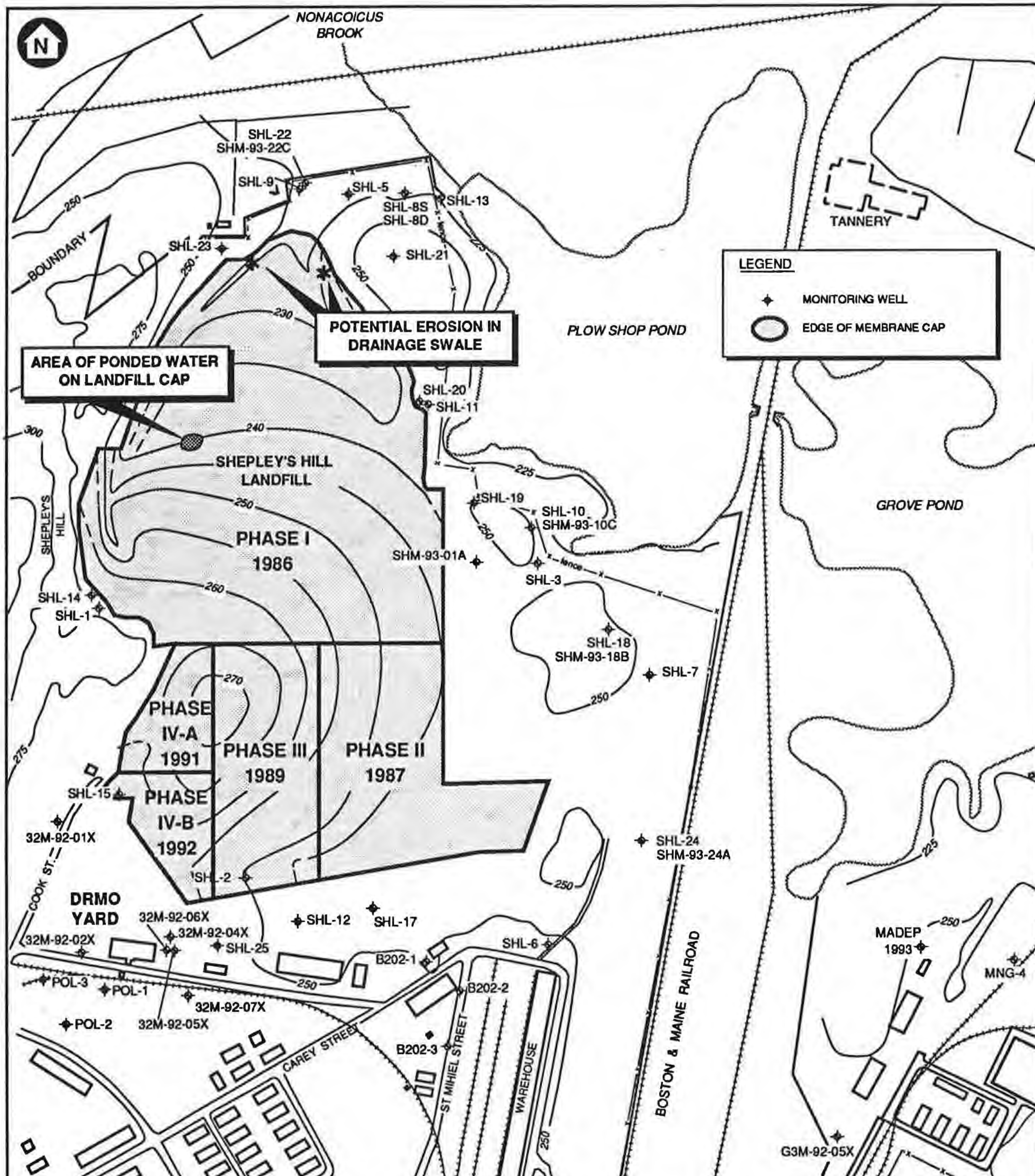



**FIGURE 5-1**
**ALTERNATIVE SHL-2: LIMITED ACTION**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9402037D 1 S6 M

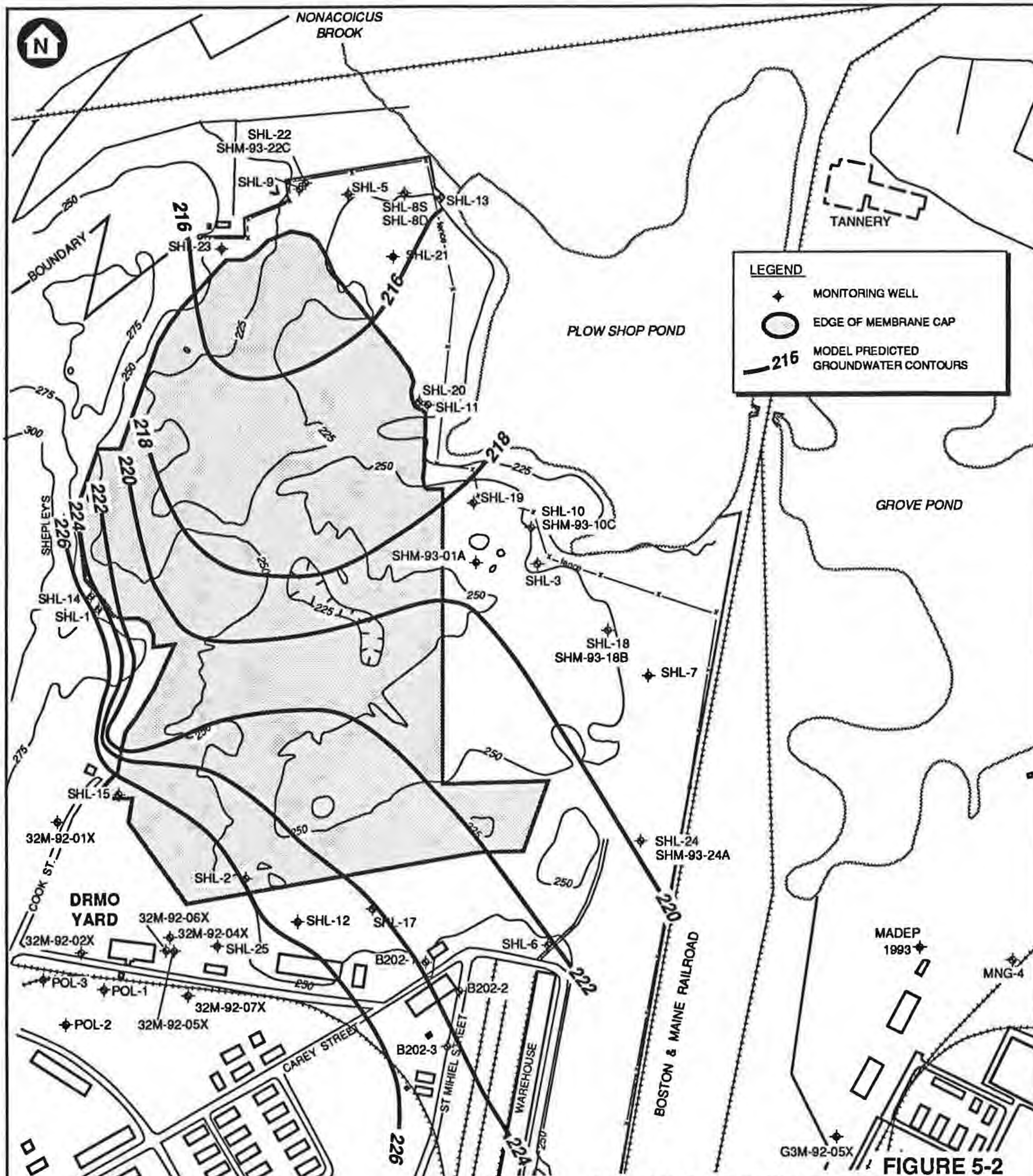



**FIGURE 5-2**
**HISTORIC GROUND ELEVATIONS AND MODEL PREDICTED GROUNDWATER CONTOURS**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

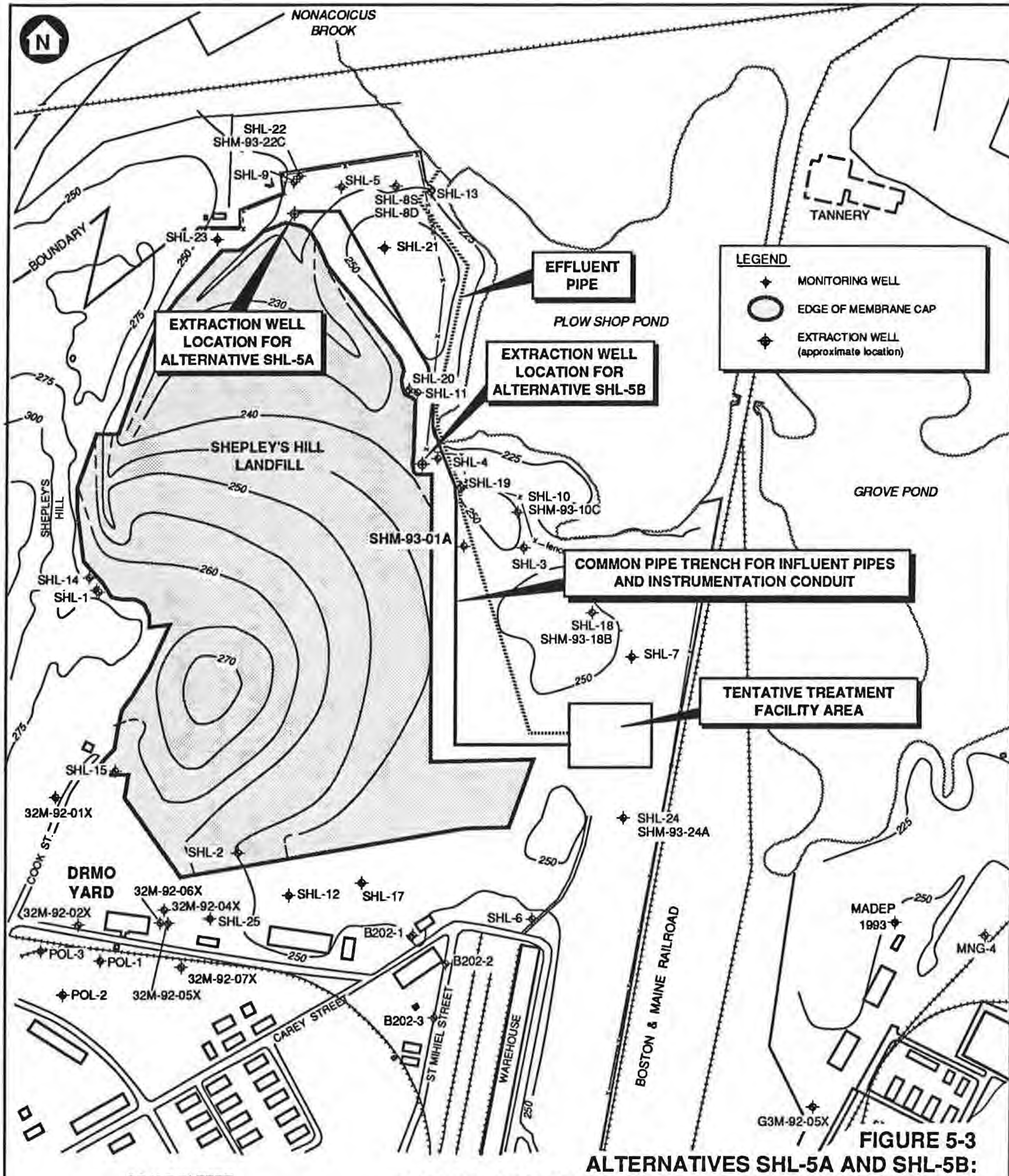



FIGURE 5-3
ALTERNATIVES SHL-5A AND SHL-5B:
COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

ABB Environmental Services, Inc.

9402037D 1 S6 F K

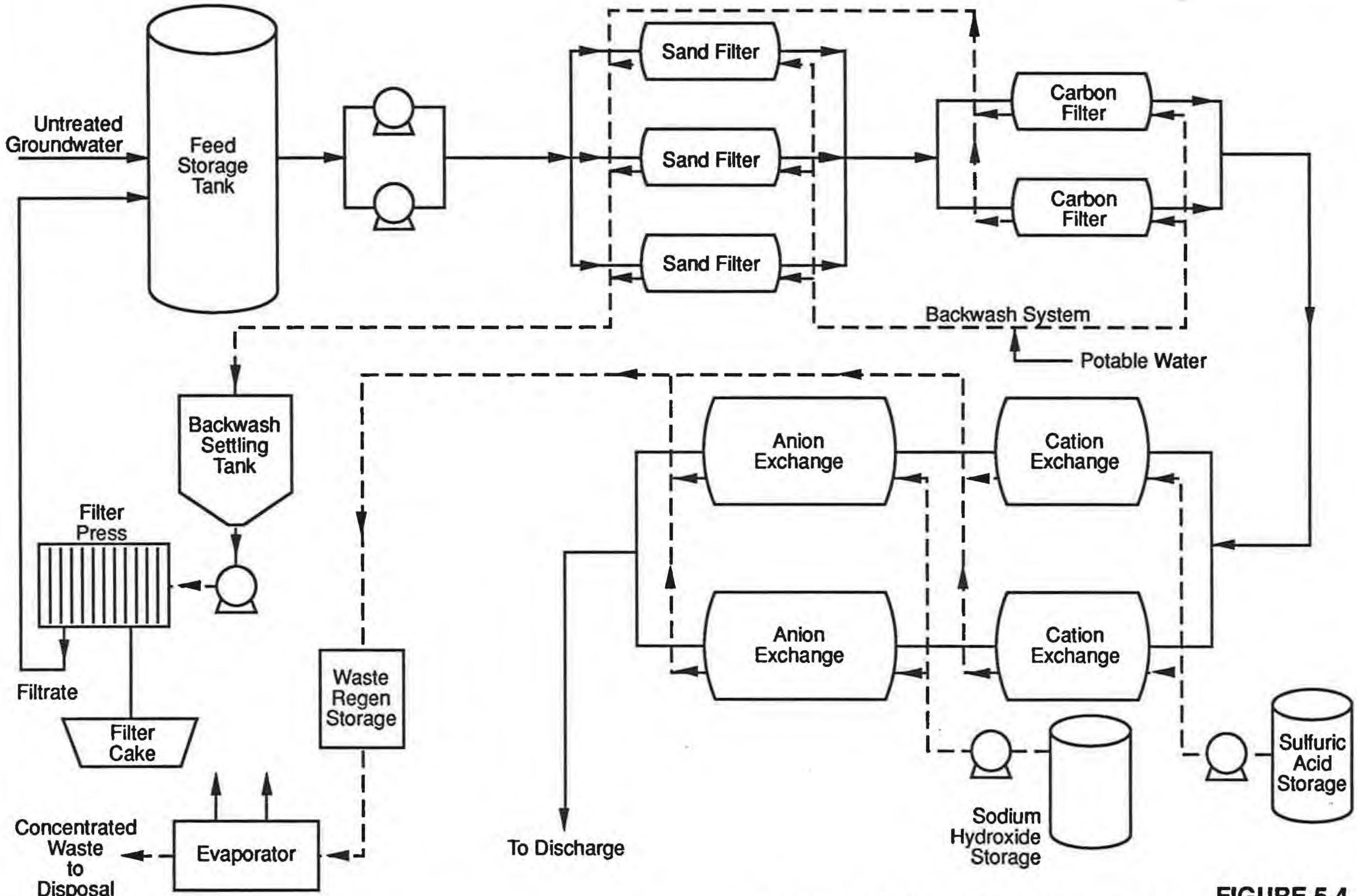



**FIGURE 5-4**
**ALTERNATIVE SHL-5: PROCESS FLOW DIAGRAM**
**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9402038D

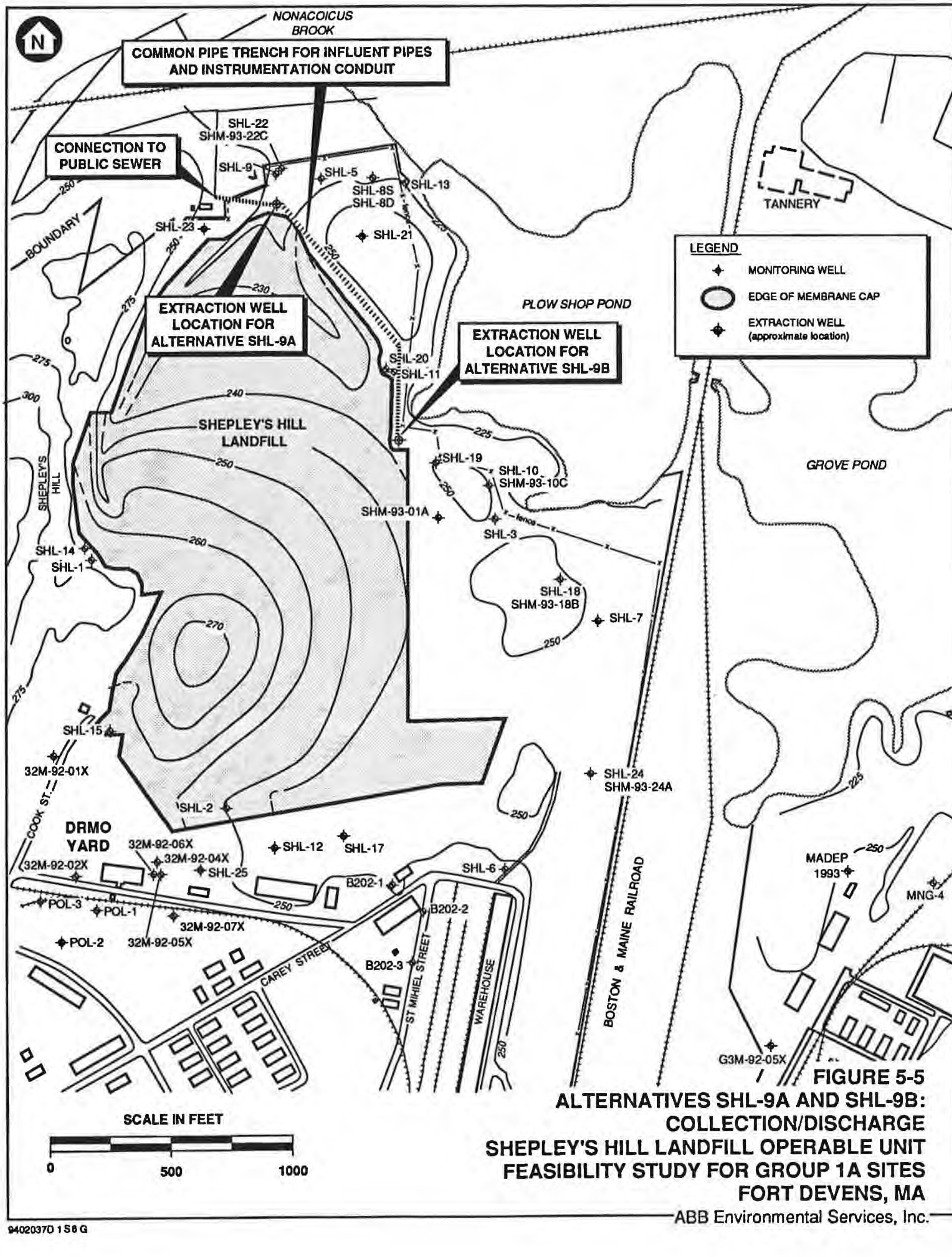



FIGURE 5-5
ALTERNATIVES SHL-9A AND SHL-9B: COLLECTION/DISCHARGE
SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

**TABLE 5-1**
**ALTERNATIVE EVALUATION CRITERIA**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

---

**THRESHOLD CRITERIA (must be met by each alternative)**

- OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT - Assesses how well an alternative, as a whole, achieves and maintains protection of human health and the environment.
- COMPLIANCE WITH ARARS - Assesses how the alternative complies with location-, chemical-, and action-specific ARARs, and whether a waiver is required or justified.

**PRIMARY CRITERIA (basis of alternative evaluation)**

- LONG-TERM EFFECTIVENESS AND PERMANENCE - Evaluates the effectiveness of the alternative in protecting human health and the environment after response objectives have been met. Includes consideration of the magnitude of residual risks and the adequacy and reliability of controls.
- REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT - Evaluates the effectiveness of treatment processes used to reduce toxicity, mobility, and volume of hazardous substances. This criterion considers the degree to which treatment is irreversible, and the type and quantity of residuals remaining after treatment.
- SHORT-TERM EFFECTIVENESS - Examines the effectiveness of the alternative in protecting human health and the environment during the construction and implementation of a remedy until response objectives have been met. Considers the protection of the community, workers, and the environment during implementation of remedial actions.
- IMPLEMENTABILITY - Assesses the technical and administrative feasibility of an alternative and availability of required goods and services. Technical feasibility considers the ability to construct and operate a technology and its reliability, the ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of a remedy. Administrative feasibility considers the ability to obtain approvals from other parties or agencies and extent of required coordination with other parties or agencies.
- COST - Evaluates the capital and operation and maintenance cost of each alternative.

**BALANCING CRITERIA**

- STATE ACCEPTANCE - This criterion considers the state's preferences among or concerns about alternatives.
- COMMUNITY ACCEPTANCE - This criterion considers the communities preferences among or concerns about alternatives.

---

**Table 5-2**
**Synopsis of Federal and State ARARs for Alternative SHL-1: No Action**

**Shepley's Hill Landfill Operable Unit**
**Feasibility Study for Group 1A Sites**
**Fort Devens, MA**

| Authority | Location Characteristic | Requirement | Status | Requirement Synopsis | Action to be Taken to Attain Requirement |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Floodplains | Floodplain Management Executive Order No. 11988, [40 CFR Part 6, App. A] | Applicable | Requires federal agencies to evaluate the potential adverse effects associated with direct and indirect development of a floodplain. Alternatives that involve modification/construction within a floodplain may not be selected unless a determination is made that no practicable alternative exists. If no practicable alternative exists, potential harm must be minimized and action taken to restore and preserve the natural and beneficial values of the floodplain. | No activities will occur to trigger this requirement. |
| | Wetlands | Protection of Wetlands Executive Order No. 11990 | Applicable | Under this Order, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands.<br>If remediation is required within wetland areas, and no practical alternative exists, potential harm must be minimized and action taken to restore natural and beneficial values. | No activities will occur to trigger this requirement. |

**TABLE 5-2**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-1: NO ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Surface Waters Endangered Species | Fish and Wildlife Coordination Act [16 USC 661 et seq.; 40 CFR Part 302] | Applicable | Actions which affect species/habitat require consultation with DOI, FWS, NMFS, and/or state agencies, as appropriate, to ensure that proposed actions do not jeopardize the continued existence of the species or adversely modify or destroy critical habitat. The effects of water-related projects on fish and wildlife resources must be considered. Action must be taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources. Consultation with the responsible agency is also strongly recommended for on-site actions. Under 40 CFR Part 300.38, these requirements apply to all response activities under the NCP. | No activities will occur to trigger this requirement. |
| | Endangered Species | Endangered Species Act [16 USC 1531 et seq.; 50 CFR Part 402] | Applicable | This act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or modification of their habitat. | No activities will occur to trigger this requirement. |

**TABLE 5-2**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-1: NO ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| State Regulatory Authority | Floodplains Wetlands | Massachusetts Wetland Protection Act and Regulations [MGL c. 131 s. 40; 310 CMR 10.00] | Applicable | Wetlands and land subject to flooding are protected under this Act and these regulations. Activities that will remove, dredge, fill, or alter protected areas (defined as areas within the 100-year floodplain) are subject to regulation and must file a Notice of Intent (NOI) with the municipal conservation commission and obtain a Final Order of Conditions before proceeding with the activity. A Determination of Applicability or NOI must be filed for activities such as excavation within a 100 foot buffer zone. The regulations specifically prohibit loss of over 5,000 square feet of bordering vegetated wetland. Loss may be permitted with replication of any lost area within two growing seasons. | No activities will occur to trigger this requirement. |
| | Endangered Species | Massachusetts Endangered Species Act and implementing regulations [MGL c. 131A, s. 1 et seq.; 321 CMR 8.00] | Applicable | Actions must be conducted in a manner which minimizes the impact to Massachusetts listed endangered species and species listed by the Massachusetts Natural Heritage Program. | No activities will occur to trigger this requirement. |

**TABLE 5-2**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-1: NO ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Area of Critical Environmental Concern | Areas of Critical Environmental Concern (ACEC) [301 CMR 12.00] | Relevant and Appropriate | An ACEC is of regional, state, or national importance or contains significant ecological systems with critical inter-relationships among a number-of-components. An eligible area must contain features from four or more of the following groups: (1) fishery habitats; (2) coastal feature; (3) estuarine wetland; (4) inland wetland; (5) inland surface water; (6) water supply area (i.e., aquifer recharge area); (7) natural hazard area (i.e., floodplain); (8) agricultural area; (9) historical/archeological resources; (10) habitat resource (i.e., for endangered wildlife; or (11) special use areas. | No activities will occur to trigger this requirement. |

(continued)

**TABLE 5-2**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-1: NO ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Groundwater | SDWA, National Primary Drinking Water Standards, MCLs [40 CFR Parts 141.11 - 141.16 and 141.50-191.51] | Relevant and Appropriate | The NPDWR establishes MCLs and non-zero MCLGs for several common organic and inorganic contaminants. These MCLs specify the maximum permissible concentrations of contaminants in public drinking water supplies. MCLs are federally enforceable standards based in part on the availability and cost of treatment techniques. | No monitoring activities will occur to evaluate compliance with these requirements. |
| State Regulatory Authority | Surface water | Massachusetts Surface Water Quality Standards [314 CMR 4.00] | Applicable | Massachusetts Surface Water Quality Standards designate the most sensitive uses for which surface waters of the Commonwealth are to be enhanced, maintained and protected and designate minimum water quality criteria for sustaining the designated uses. Surface waters at Fort Devens are classified as Class B. Surface waters assigned to this class are designated as habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation. | No monitoring activities will occur to evaluate compliance with these requirements. |

(continued)

**TABLE 5-2**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-1: NO ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Groundwater | Massachusetts Groundwater Quality Standards [314 CMR 6.00] | Applicable | Massachusetts Groundwater Quality Standards designate and assign uses for which groundwaters of the Commonwealth shall be maintained and protected and set forth water quality criteria necessary to maintain the designated uses. Groundwater at Fort Devens is classified as Class I. Groundwaters assigned to this class are fresh groundwaters designated as a source of potable water supply. | No monitoring activities will occur to evaluate compliance with these requirements. |
| | Groundwater | Massachusetts Drinking Water Standards and Guidelines [310 CMR 22.00] | Relevant and Appropriate | The Massachusetts Drinking Water Standards and Guidelines list Massachusetts Maximum Contaminant Levels (MMCLs) which apply to water delivered to any user of a public water supply system as defined in 310 CMR 22.00. Private residential wells are not subject to the requirements of 310 CMR 22.00; however, the standards are often used to evaluate private residential contamination especially in CERCLA activities. | No monitoring activities will occur to evaluate compliance with these requirements. |
| | Air | Massachusetts Ambient Air Quality Standards [310 CMR 6.00] | Relevant and Appropriate | Regulations specify primary and secondary ambient air quality standards to protect public health and welfare for certain pollutants | No monitoring activities will occur to evaluate compliance with these requirements. |

(continued)

**TABLE 5-2**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-1: NO ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Air | Massachusetts Air Pollution Control Regulations [310 CMR 7.00] | Relevant and Appropriate | Regulations pertain to the prevention of emissions in excess of Massachusetts or national ambient air quality standards or in excess of emission limitations in those regulations. | No monitoring activities will occur to evaluate compliance with these requirements. |

(continued)

**TABLE 5-2**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-1: NO ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Solid waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle D, 40 CFR 258] | Relevant and Appropriate | RCRA Subtitle D regulates the generation, transport, storage, treatment, and disposal of solid wastes. Regulations at 40 CFR 258 govern preparedness and prevention, closure, and post-closure at municipal solid waste landfills. | Performance of existing cap will not be evaluated to determine compliance with the substantive requirements of federal solid waste regulations. |
| | Hazardous waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle C, 40 CFR 260,264] | Relevant and Appropriate | RCRA Subtitle C regulates the generation, transport, storage, treatment, and disposal of hazardous wastes. Regulations at 40 CFR 264 govern preparedness and prevention, closure, and post-closure at landfills. | Performance of existing cap will not be evaluated to determine compliance with the substantive requirements of federal hazardous waste regulations. |
| State Regulatory Authority | Solid waste landfill construction, operation, closure, and post-closure. | Massachusetts Solid Waste Management Regulations [310 CMR 19.100] | Applicable | These regulations outline the requirements for construction, operation, closure, and post-closure at solid waste management facilities in the Commonwealth of Massachusetts. | Performance of the existing cap will not be evaluated to determine compliance with the substantive requirements of these regulations. Post-closure monitoring requirements will not be met. |
| | Hazardous waste landfill construction, operation, closure, and post-closure | Massachusetts Hazardous Waste Regulations [310 CMR 30.00] | Relevant and Appropriate | Regulates handling, storage, treatment, disposal, and record keeping at hazardous waste facilities. | Performance of the existing cap will not be evaluated to determine compliance with the substantive requirements of Massachusetts hazardous waste regulations. |

**Notes:**

DOI =
FWS =
NMFS =

### TABLE 5-3
### PROPOSED LONG-TERM GROUNDWATER MONITORING PROGRAM

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| MONITORING WELL LOCATIONS | MONITORING PARAMETERS |
|---|---|
| SHL-3 | <u>Volatile Organic Compounds</u> |
| SHL-4 | USEPA Method 624 plus acetone, 2-butanone, 2-methyl pentanone, and xylenes |
| SHL-5 | |
| SHL-9 | <u>Inorganics</u> |
| SHL-10 | Arsenic |
| SHL-11 | Barium |
| SHL-19 | |
| SHL-20 | Cadmium |
| SHL-22 | Chromium |
| | Cyanide |
| SHM-93-10C | Iron |
| SHM-93-22C | Lead |
| 3 Newly Installed Wells | Manganese |
| | Mercury |
| | Selenium |
| | Silver |
| | Copper |
| | Zinc |
| | |
| | <u>General Parameters</u> |
| | pH (measured in field) |
| | Temperature (measured in field) |
| | Specific Conductance (measured in field) |
| | Dissolved Oxygen (measured in field) |
| | Oxidation-reduction potential (measured in field) |
| | Total Dissolved Solids |

continued

# TABLE 5-3
## PROPOSED LONG-TERM GROUNDWATER MONITORING PROGRAM

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| MONITORING WELL LOCATIONS | MONITORING PARAMETERS |
|---|---|
| | Total Suspended Solids |
| | Chloride |
| | Hardness |
| | Nitrite-Nitrate as N |
| | Sulfate |
| | Alkalinity |
| | Biochemical Oxygen Demand |
| | Chemical Oxygen Demand |
| | Total Organic Carbon |

**Note:**

Groundwater elevations will be measured as part of the groundwater sampling program.

**TABLE 5-4**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Floodplains | Floodplain Management Executive Order No. 11988, [40 CFR Part 6, App. A] | Applicable | Requires federal agencies to evaluate the potential adverse effects associated with direct and indirect development of a floodplain. Alternatives that involve modification/construction within a floodplain may not be selected unless a determination is made that no practicable alternative exists. If no practicable alternative exists, potential harm must be minimized and action taken to restore and preserve the natural and beneficial values of the floodplain. | To the extent that any activity associated with this alternative takes place in the floodplain, the activity will be altered to comply with the law. |
| | Wetlands | Protection of Wetlands Executive Order No. 11990 | Applicable | Under this Order, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands.<br>If remediation is required within wetland areas, and no practical alternative exists, potential harm must be minimized and action taken to restore natural and beneficial values. | To the extent that any activity associated with this alternative takes place in wetlands, the activity will be altered to comply with the law. |

**TABLE 5-4**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Surface Waters Endangered Species | Fish and Wildlife Coordination Act [16 USC 661 et seq.; 40 CFR Part 302] | Applicable | Actions which affect species/habitat require consultation with DOI, FWS, NMFS, and/or state agencies, as appropriate, to ensure that proposed actions do not jeopardize the continued existence of the species or adversely modify or destroy critical habitat. The effects of water-related projects on fish and wildlife resources must be considered. Action must be taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources. Consultation with the responsible agency is also strongly recommended for on-site actions. Under 40 CFR Part 300.38, these requirements apply to all response activities under the NCP. | No off-site remedial actions performed for this alternative. On-site actions would be minimal and would include agency consultation prior to implementation. |
| | Endangered Species | Endangered Species Act [16 USC 1531 et seq.; 50 CFR Part 402] | Applicable | This act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or modification of their habitat. | To minimize impact, landfill cover maintenance would be performed after nesting areas of the Grasshopper Sparrow have been identified. |

**TABLE 5-4**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| State Regulatory Authority | Floodplains Wetlands | Massachusetts Wetland Protection Act and Regulations [MGL c. 131 s. 40; 310 CMR 10.00] | Applicable | Wetlands and land subject to flooding are protected under this Act and these regulations. Activities that will remove, dredge, fill, or alter protected areas (defined as areas within the 100-year floodplain) are subject to regulation and must file a Notice of Intent (NOI) with the municipal conservation commission and obtain a Final Order of Conditions before proceeding with the activity. A Determination of Applicability or NOI must be filed for activities such as excavation within a 100 foot buffer zone. The regulations specifically prohibit loss of over 5,000 square feet of bordering vegetated wetland. Loss may be permitted with replication of any lost area within two growing seasons. | If remedial activities alter more than 5,000 square feet of protected area, the affected area will be restored within two growing seasons. |
| | Endangered Species | Massachusetts Endangered Species Act and implementing regulations [MGL c. 131A, s. 1 et seq.; 321 CMR 8.00] | Applicable | Actions must be conducted in a manner which minimizes the impact to Massachusetts listed endangered species and species listed by the Massachusetts Natural Heritage Program. | To minimize impacts, landfill cover maintenance would be performed after nesting areas of the Grasshopper Sparrow have been identified. |

**TABLE 5-4**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Area of Critical Environmental Concern | Areas of Critical Environmental Concern (ACEC) [301 CMR 12.00] | Relevant and Appropriate | An ACEC is of regional, state, or national importance or contains significant ecological systems with critical inter-relationships among a number-of-components. An eligible area must contain features from four or more of the following groups: (1) fishery habitats; (2) coastal feature; (3) estuarine wetland; (4) inland wetland; (5) inland surface water; (6) water supply area (i.e., aquifer recharge area); (7) natural hazard area (i.e., floodplain); (8) agricultural area; (9) historical/archeological resources; (10) habitat resource (i.e., for endangered wildlife; or (11) special use areas. | Activities must be controlled to minimize impacts to nesting areas of the Grasshopper Sparrow. |

**TABLE 5-4**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Groundwater | SDWA, National Primary Drinking Water Standards, MCLs [40 CFR Parts 141.11 - 141.16 and 141.50-191.51] | Relevant and Appropriate | The NPDWR establishes MCLs and non-zero MCLGs for several common organic and inorganic contaminants. These MCLs specify the maximum permissible concentrations of contaminants in public drinking water supplies. MCLs are federally enforceable standards based in part on the availability and cost of treatment techniques. | MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. |
| State Regulatory Authority | Surface water | Massachusetts Surface Water Quality Standards [314 CMR 4.00] | Applicable | Massachusetts Surface Water Quality Standards designate the most sensitive uses for which surface waters of the Commonwealth are to be enhanced, maintained and protected and designate minimum water quality criteria for sustaining the designated uses. Surface waters at Fort Devens are classified as Class B. Surface waters assigned to this class are designated as habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation. | Discharges associated with remedial actions will be controlled/monitored to ensure that surface waters meet standards. |

**TABLE 5-4**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Groundwater | Massachusetts Groundwater Quality Standards [314 CMR 6.00] | Applicable | Massachusetts Groundwater Quality Standards designate and assign uses for which groundwaters of the Commonwealth shall be maintained and protected and set forth water quality criteria necessary to maintain the designated uses. Groundwater at Fort Devens is classified as Class I. Groundwaters assigned to this class are fresh groundwaters designated as a source of potable water supply. | MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. |
| | Groundwater | Massachusetts Drinking Water Standards and Guidelines [310 CMR 22.00] | Relevant and Appropriate | The Massachusetts Drinking Water Standards and Guidelines list Massachusetts Maximum Contaminant Levels (MMCLs) which apply to water delivered to any user of a public water supply system as defined in 310 CMR 22.00. Private residential wells are not subject to the requirements of 310 CMR 22.00; however, the standards are often used to evaluate private residential contamination especially in CERCLA activities. | MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. |

**TABLE 5-4**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Air | Massachusetts Ambient Air Quality Standards [310 CMR 6.00] | Relevant and Appropriate | Regulations specify primary and secondary ambient air quality standards to protect public health and welfare for certain pollutants | Ambient Air Quality Standards will be used to evaluate the performance of this alternative. If standards are exceeded, the interim remedy will be re-evaluated. |
| | Air | Massachusetts Air Pollution Control Regulations [310 CMR 7.00] | Relevant and Appropriate | Regulations pertain to the prevention of emissions in excess of Massachusetts or national ambient air quality standards or in excess of emission limitations in those regulations. | Ambient Air Quality Standards will be used to evaluate the performance of the cap. If standards are exceeded, the interim remedy will be re-evaluated. |

**TABLE 5-4**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Solid waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle D, 40 CFR 258] | Relevant and Appropriate | RCRA Subtitle D regulates the generation, transport, storage, treatment, and disposal of solid wastes. Regulations at 40 CFR 258 govern preparedness and prevention, closure, and post-closure at municipal solid waste landfills. | Performance of this alternative as an interim remedy will be evaluated to determine compliance with the substantive requirements of federal solid waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |
| | Hazardous waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle C, 40 CFR 260,264] | Relevant and Appropriate | RCRA Subtitle C regulates the generation, transport, storage, treatment, and disposal of hazardous wastes. Regulations at 40 CFR 264 govern preparedness and prevention, closure, and post-closure at landfills. | Performance of this alternative as an interim remedy will be evaluated to determine compliance with the substantive requirements of federal hazardous waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |
| State Regulatory Authority | Solid waste landfill construction, operation, closure, and post-closure. | Massachusetts Solid Waste Management Regulations [310 CMR 19.100] | Applicable | These regulations outline the requirements for construction, operation, closure, and post-closure at solid waste management facilities in the Commonwealth of Massachusetts. | This alternative includes components to meet post-closure requirements at Shepley's Hill Landfill. |

# TABLE 5-4
## SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-2: LIMITED ACTION

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Hazardous waste landfill construction, operation, closure, and post-closure | Massachusetts Hazardous Waste Regulations [310 CMR 30.00] | Relevant and Appropriate | Regulates handling, storage, treatment, disposal, and record keeping at hazardous waste facilities. | Performance of this alternative as an interim remedy will be evaluated to determine compliance with the substantive requirements of Massachusetts hazardous waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |

**Notes:**

DOI =
FWS =
NMFS =

TABLE 5-5
SUMMARY OF COVER SYSTEM PERFORMANCE STANDARDS

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

REGULATION AND PERFORMANCE STANDARD

| MASSACHUSETTS SOLID WASTE REGULATIONS 310 CMR 19.000 | RCRA SUBTITLE C 40 CFR 264 | RCRA SUBTITLE D 40 CFR 258 | MASSACHUSETTS HAZARDOUS WASTE REGULATIONS 310 CMR 30.000 | HOW COMPLIANCE IS ACHIEVED BY EXISTING COVER |
|---|---|---|---|---|
| Minimize percolation of water into landfill. | Minimize migration of liquids through landfill. | Minimize infiltration through landfill. | Minimize migration of liquids through landfill. | Geomembrane installations such as the existing one at Shepley's Hill Landfill have a permeability of $1 \times 10^{-7}$ cm/sec or less that minimizes infiltration and migration of liquid into landfilled waste. Sloped surface promotes runoff and minimizes infiltration. Vegetation promotes evapotranspiration. |
| | Have a permeability less than or equal to bottom liner or subsoils. | Have a permeability less than or equal to bottom liner or subsoils or less than $1 \times 10^{-5}$ cm/sec, whichever is less. | Have a permeability less than or equal to bottom liner. | Existing geomembrane permeability is less than that of sands underlying landfill. There is no bottom liner. |
| Promote drainage of precipitation. | Promote drainage and minimize erosion. | | Promote drainage and minimize erosion of cover. | The existing cover is sloped to promote drainage and vegetated to prevent erosion. |

(continued)

**TABLE 5-5**
**SUMMARY OF COVER SYSTEM PERFORMANCE STANDARDS**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

**REGULATION AND PERFORMANCE STANDARD**

| MASSACHUSETTS SOLID WASTE REGULATIONS 310 CMR 19.000 | RCRA SUBTITLE C 40 CFR 264 | RCRA SUBTITLE D 40 CFR 258 | MASSACHUSETTS HAZARDOUS WASTE REGULATIONS 310 CMR 30.000 | HOW COMPLIANCE IS ACHIEVED BY EXISTING COVER |
|---|---|---|---|---|
| Minimize erosion of final cover. | | Minimize erosion of final cover. | | The existing cover is sloped and vegetated to minimize erosion. |
| | Function with minimum maintenance. | | Function with minimum maintenance. | The existing cover was constructed in a manner to minimize maintenance. Monitoring and maintenance of cover systems to maintain integrity is normal practice. |
| Facilitate gas venting. | | | | The existing collection piping and riser system facilitate gas venting. Analysis of gas samples from vents confirms that they function. |
| Accommodate settling and subsidence to continue to meet performance standards. | Accommodate settling and subsidence to maintain cover integrity. | | Accommodate settling and subsidence to maintain cover integrity. | Landfill materials were compacted and graded during construction of the existing cap to accommodate settling. Maintenance actions are possible to maintain cover integrity if or when settling occurs. |
| Ensure isolate of wastes from environment. | | | | The existing cover isolates wastes from potential terrestrial receptors by covering them with soil and lowers groundwater to elevations interpreted to be below waste. |

TABLE 5–6
COST SUMMARY TABLE
ALTERNATIVE SHL–2: LIMITED ACTION

FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| ITEM | COST |
|---|---|
| DIRECT COSTS | |
| Mobilization | $90,000 |
| Landfill cover repairs | $611,000 |
| Institutional controls and educational programs | $13,000 |
| TOTAL DIRECT COST | $714,000 |
| INDIRECT COSTS | |
| Health and Safety @ 5% of total direct cost | $36,000 |
| Legal, Administrative, Permitting @ 5% of total direct cost | $36,000 |
| Engineering @ 10% of total direct cost | $71,000 |
| Services during construction @ 10% of total direct cost | $71,000 |
| TOTAL INDIRECT COST | $214,000 |
| TOTAL CAPITAL (DIRECT AND INDIRECT) COST | $928,000 |
| OPERATION AND MAINTENANCE COSTS | |
| Total annual operating and maintenance costs | $84,000 |
| TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS) | $1,219,000 |
| TOTAL PRESENT WORTH OF ALTERNATIVE | $2,219,000 |

## TABLE 5-7
## GROUNDWATER INFLUENT AND DISCHARGE LIMITATIONS

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| PARAMETER | AWQC AQUATIC LIFE (μg/L) | BACKGROUND CONCENTRATION (μg/L)[1] | ESTIMATED GROUNDWATER INFLUENT CONCENTRATION (μg/L)[2] | ALLOWABLE EFFLUENT CONCENTRATION IN 30 GPM DISCHARGE TO MEET AWQC (μg/L)[3] | ASSUMED DISCHARGE LIMITATION IN 30 GPM DISCHARGE TO NONACOICUS BROOK (μg/L) |
|---|---|---|---|---|---|
| INORGANICS | | | | | |
| Aluminum | 87 | <81.5 | 1,870 | 1,876[C] | 1,876 |
| Arsenic | 190 | <7.0 | 150 | 7,445[C] | 7,445 |
| Chromium | 88[A] | <4.5 | NE | 3,442[C] | 3,442 |
| Copper | 4.8[A] | <4.6 | 7.3 | 102[C] | 102 |
| Iron | 1,000 | 377[B] | 15,300 | 25,235 | 25,235 |
| Lead | 0.85[A] | <4.74 | 3.8 | D | 4.7 |
| Manganese | NE | 490 | 2,635 | 20,839[E] | 20,839 |
| Nickel | 65[A] | 8.8 | NE | 2,251 | 2,251 |

**Notes:**

1 = Background concentration based on sample SW-SHL-15 from Nonacoicus Brook unless noted (E&E, 1993).
2 = Based on the time-weighted average using CORA model. See Appendix C.
3 = Calculated to meet AWQC in Nonacoicus Brook at 7Q10. See Appendix D.
A = AWQC based on hardness of 35 mg $CaCO_3$/L.
B = Iron in sample SW-SHL-15 was reported at 1,100 μg/L; however in 13 samples from Plow Shop Pond iron ranged between 214-500 μg/L with an average of 377 μg/L. The average was considered a better representation and was used for calculation purposes.
C = Background concentrations used were one-half of sample quantitation limit (SQL).
D = Calculated concentration is less than background concentration.
E = Calculated concentration based on 1,000 μg/L from McKee and Wolf, 1963/USEPA, 1976.
NE = Not Established.

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5:**
**COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Floodplains | Floodplain Management Executive Order No. 11988 | Applicable | Requires federal agencies to evaluate the potential adverse effects associated with direct and indirect development of a floodplain. Alternatives that involve modification/construction within a floodplain may not be selected unless a determination is made that no practicable alternative exists. If no practicable alternative exists, potential harm must be minimized and action taken to restore and preserve the natural and beneficial values of the floodplain. | Any construction activities within a floodplain or wetland, including construction of a discharge pipeline to Nonacoicus Brook, will be done in a manner to minimize impacts. Altered areas will be repaired or restored. |
| | Wetlands | Protection of Wetlands Executive Order No. 11990 [40 CFR Part 6 App. A] | Applicable | Under this Order, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands. If remediation is required within wetland areas, and no practical alternative exists, potential harm must be minimized and action taken to restore natural and beneficial values. | Any construction activities within a floodplain or wetland, including construction of a discharge pipeline to Nonacoicus Brook, will be done in a manner to minimize impacts. Altered areas will be repaired or restored. |

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Surface Waters Endangered Species | Fish and Wildlife Coordination Act [16 USC 661 et seq.; 40 CFR Part 302] | Applicable | Actions which affect species/habitat require consultation with DOI, FWS, NMFS, and/or state agencies, as appropriate, to ensure that proposed actions do not jeopardize the continued existence of the species or adversely modify or destroy critical habitat. The effects of water-related projects on fish and wildlife resources must be considered. Action must be taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources.<br>Consultation with the responsible agency is also strongly recommended for on-site actions.<br>Under 40 CFR Part 300.38, these requirements apply to all response activities under the NCP. | No off-site remedial actions performed for this alternative. On-site actions would include agency consultation prior to and during implementation. |
| | Endangered Species | Endangered Species Act [16 USC 1531 et seq.; 50 CFR Part 402] | Applicable | This act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or modification of their habitat. | To minimize impacts, remedial actions would be performed after nesting areas of the Grasshopper Sparrow have been identified. |

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5:**
**COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| State Regulatory Authority | Floodplains Wetlands | Massachusetts Wetland Protection Act and regulations [MGL c. 131 s. 40; 310 CMR 10.00] | Applicable | Wetlands and land subject to flooding are protected under this Act and these regulations. Activities that will remove, dredge, fill, or alter protected areas (defined as areas within the 100-year floodplain) are subject to regulation and must file a Notice of Intent (NOI) with the municipal conservation commission and obtain a Final Order of Conditions before proceeding with the activity. A Determination of Applicability or NOI must be filed for activities such as excavation within a 100 foot buffer zone. The regulations specifically prohibit loss of over 5,000 square feet of bordering vegetated wetland. Loss may be permitted with replication of any lost area within two growing seasons. | If remedial activities alter more than 5,000 square feet of protected area, the affected area will be restored within two growing seasons. |
| | Endangered Species | Massachusetts Endangered Species Act and implementing regulations [MGL c. 131A, s. 1 et seq.; 321 CMR 8.00] | Applicable | Actions must be conducted in a manner which minimizes the impact to Massachusetts-listed endangered species and species listed by the Massachusetts Natural Heritage Program. | To minimize impacts, remedial actions would be performed after nesting areas of the Grasshopper Sparrow have been identified. |

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5:**
**COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Area of Critical Environmental Concern | Areas of Critical Environmental Concern (ACEC) [301 CMR 12.00] | Relevant and Appropriate | An ACEC is of regional, state, or national importance or contains significant ecological systems with critical inter-relationships among a number-of-components. An eligible area must contain features from four or more of the following groups: (1) fishery habitats; (2) coastal feature; (3) estuarine wetland; (4) inland wetland; (5) inland surface water; (6) water supply area (i.e., aquifer recharge area); (7) natural hazard area (i.e., floodplain); (8) agricultural area; (9) historical/archeological resources; (10) habitat resource (i.e., for endangered wildlife; or (11) special use areas. | Activities must be controlled to minimize impacts to nesting areas of the Grasshopper Sparrow. |

(continued)

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5:**
**COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Surface water | CWA, Ambient Water Quality Criteria [40 CFR 131; Quality Criteria for Water 1986] | Relevant and Appropriate | Federal AWQC include (1) human health based criteria developed for 95 carcinogenic and noncarcinogenic compounds and (2) acute and chronic toxicity values for the protection of aquatic life. AWQC for the protection of human health provide protective concentrations for exposure from ingesting contaminated water and contaminated aquatic organisms, and from ingesting contaminated aquatic organisms alone. Remedial actions involving contaminated surface water or discharge of contaminants to surface water must consider the uses of the water and the circumstances of the release or threatened release; this determines whether AWQC are relevant and appropriate. | The discharge to Nonacoicus Brook will be monitored to ensure that AWQC are not exceeded in the brook. |

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5:**
**COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Groundwater | SDWA, National Primary Drinking Water Standards, MCLs [40 CFR Parts 141.11 - 141.16 and 141.50-141.51] | Relevant and Appropriate | The NPDWR establishes MCLs and non-zero MCLGs for several common organic and inorganic contaminants. These MCLs specify the maximum permissible concentrations of contaminants in public drinking water supplies. MCLs are federally enforceable standards based in part on the availability and cost of treatment techniques. | MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. |
| State Regulatory Authority | Surface water | Massachusetts Surface Water Quality Standards [314 CMR 4.00] | Applicable | Massachusetts Surface Water Quality Standards designate the most sensitive uses for which surface waters of the Commonwealth are to be enhanced, maintained and protected and designate minimum water quality criteria for sustaining the designated uses. Surface waters at Fort Devens are classified as Class B. Surface waters assigned to this class are designated as habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation. | Discharges associated with remedial actions will be monitored/controlled to ensure that surface waters meet standards. |

## TABLE 5-8
## SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Groundwater | Massachusetts Groundwater Quality Standards [314 CMR 6.00] | Applicable | Massachusetts Groundwater Quality Standards designate and assign uses for which groundwaters of the Commonwealth shall be maintained and protected and set forth water quality criteria necessary to maintain the designated uses. Groundwater at Fort Devens is classified as Class I. Groundwaters assigned to this class are fresh groundwaters designated as a source of potable water supply. | Massachusetts Groundwater Quality Standards will be used to evaluate the performance of this alternative. If standards are exceeded, the interim remedy will be re-evaluated. |
| | Groundwater | Massachusetts Drinking Water Standards and Guidelines [310 CMR 22.00] | Relevant and Appropriate | The Massachusetts Drinking Water Standards and Guidelines list Massachusetts Maximum Contaminant Levels (MMCLs) which apply to water delivered to any user of a public water supply system as defined in 310 CMR 22.00. Private residential wells are not subject to the requirements of 310 CMR 22.00; however, the standards are often used to evaluate private residential contamination especially in CERCLA activities. | MMCLs will be used to evaluate the performance of this alternative. If MMCLs are exceeded, the interim remedy will be re-evaluated. |

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5:**
**COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Air | Massachusetts Ambient Air Quality Standards [310 CMR 6.00] | Relevant and Appropriate | Regulations specify primary and secondary ambient air quality standards to protect public health and welfare for certain pollutants | Ambient Air Quality Standards will be used to evaluate the performance of this alternative. If standards are exceeded, the interim remedy will be re-evaluated. |
| | Air | Massachusetts Air Pollution Control Regulations [310 CMR 7.00] | Relevant and Appropriate | Regulations pertain to the prevention of emissions in excess of Massachusetts or national ambient air quality standards or in excess of emission limitations in those regulations. | Ambient Air Quality Standards will be used to evaluate the performance of this alternative. If standards are exceeded, the interim remedy will be re-evaluated. |

(continued)

**Table 5-8**
**Synopsis of Federal and State ARARs for Alternative SHL-5:**
**Collection/Ion Exchange Treatment/Surface Water Discharge**

**Shepley's Hill Landfill Operable Unit**
**Feasibility Study for Group 1A Sites**
**Fort Devens, MA**

| Authority | Action | Requirement | Status | Requirement Synopsis | Action to be Taken to Attain Requirement |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Construction over/in navigable waters | Rivers and Harbors Act of 1899 [33 USC 401 et seq.] | Applicable | Section 10 of the Rivers and Harbors Act of 1899 requires authorization from the Secretary of the Army, acting through the U.S. Army Corps of Engineers (USACE), for the construction of any structure in or over any "navigable water of the U.S.," the excavation from or deposition of material in such waters, or any obstruction or alteration in such waters. | Permits not required for CERCLA on-site actions, substantive requirements would be met. |
| | Control of surface water runoff. Direct discharge to surface water | CWA, NPDES Permit Program [40 CFR 122, 125] | Applicable | The NPDES permit program specifies the permissible concentration or level of contaminants in the discharge from any point source to waters of the United States. Both on-site and off-site discharges to surface waters are required to meet the requirements of the issued NPDES permit, including discharge limitations, monitoring requirements, and best management practices. | Permits not required for CERCLA on-site actions, substantive requirements would be met. |
| | Solid waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle D, 40 CFR 258] | Relevant and Appropriate | RCRA Subtitle D regulates the generation, transport, storage, treatment, and disposal of solid wastes. Regulations at 40 CFR 258 govern preparedness and prevention, closure, and post-closure at municipal solid waste landfills. | Performance of this alternative as an interim remedy will be evaluated to determine compliance with the substantive requirements of federal solid waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5:**
**COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Hazardous waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle C, 40 CFR 260,264] | Relevant and Appropriate | RCRA Subtitle C regulates the generation, transport, storage, treatment, and disposal of hazardous wastes. Regulations at 40 CFR 264 govern preparedness and prevention, closure, and post-closure at landfills. | Performance of this alternative as in interim remedy will be evaluated to determine compliance with the substantive requirements of federal hazardous waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |
| | Placement of excavated soil/ sediment. Disposal of treatment residues | RCRA, Land Disposal Restrictions [40 CFR 268] | Applicable | Land disposal of RCRA hazardous wastes without specified treatment is restricted. Remedial actions must be evaluated to determine if they constitute "placement" and if LDRs are applicable. The LDRs require that wastes must be treated either by a treatment technology or to a specific concentration prior to disposal in a RCRA Subtitle C permitted facility. | Filter cake and concentrate from ion exchange regeneration would be tested to evaluate if they are classified as a characteristic hazardous waste for proper disposal. |
| State Regulatory Authority | Excavation/ construction | Massachusetts Air Pollution Control Regulations [310 CMR 6.00 - 7.00] | Applicable | Particulate emissions from remedial activities must not exceed an annual geometric mean of 50 g/m$^3$ and a maximum 24-hour concentration of 150 mg/m$^3$ (primary standard). Carbon monoxide, nitrogen dioxide, and lead are also regulated. A permit and BACT approval are required prior to operation. Visible emissions are limited. | Emissions will be managed through engineering controls. |

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5:**
**COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Solid waste landfill construction, operation, closure, and post-closure. | Massachusetts Solid Waste Management Regulations [310 CMR 19.100] | Applicable | These regulations outline the requirements for construction, operation, closure, and post-closure at solid waste management facilities in the Commonwealth of Massachusetts. | This alternative includes components to meet post-closure requirements at Shepley's Hill Landfill. |
| | Hazardous waste landfill construction, operation, closure, and post-closure | Massachusetts Hazardous Waste Regulations [310 CMR 30.00] | Relevant and Appropriate | Regulates handling, storage, treatment, disposal, and record keeping at hazardous waste facilities. | Performance of this alternative as in interim remedy will be evaluated to determine compliance with the substantive requirements of Massachusetts hazardous waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |
| | Construction over/in a waterway | Massachusetts Waterways Act [MGL c. 91; 310 CMR 9.00] | Applicable | The Massachusetts Waterways Act and regulations require that a license from MADEP be obtained for any work in or over any tidelands, river or stream (with respect to which public funds have been expended), or great pond, or outlet thereof. | Permits not required for CERCLA on-site actions, substantive requirements would be met. |

(continued)

**TABLE 5-8**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Activities that potentially affect surface water quality | Massachusetts Water Quality Certification and Certification for Dredging [314 CMR 9.00] | Applicable | For activities that require a MADEP Wetlands Order of Conditions to dredge or fill navigable waters or wetlands, a Chapter 91 Waterways License, a USACE permit or any major permit issued by USEPA (e.g., CWA NPDES permit), a Massachusetts Division of Water Pollution Control Water Quality Certification is required pursuant to 314 CMR 9.00. | A water quality certification would be acquired prior to constructing a discharge location in Nonacoicus Brook. |

TABLE 5-9
COST SUMMARY TABLE
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE

FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| ITEM | COST |
|---|---|
| DIRECT COSTS | |
| Hydrogeological study | $126,000 |
| Treatability/Pilot Testing | $65,000 |
| Site preparation and mobilization | $283,000 |
| Ditch and Landfill cover repairs | $611,000 |
| Extraction system/discharge pipe construction | $152,000 |
| Treatment facility construction | $733,000 |
| Institutional controls and educational programs | $13,000 |
| TOTAL DIRECT COST | $1,983,000 |
| INDIRECT COSTS | |
| Health and Safety @ 5% of total direct cost | $99,000 |
| Legal, Administrative, Permitting @ 5% of total direct cost | $99,000 |
| Engineering @ 10% of total direct cost | $198,000 |
| Services during construction @ 10% of total direct cost | $198,000 |
| TOTAL INDIRECT COST | $594,000 |
| TOTAL CAPITAL (DIRECT AND INDIRECT) COST | $2,577,000 |
| OPERATION AND MAINTENANCE COSTS | |
| Total annual operating and maintenance costs | $426,000 |
| TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS) | $6,549,000 |
| TOTAL PRESENT WORTH OF ALTERNATIVE | $9,126,000 |

g:\t65\usaec\tables\fdfs\shl\5-9.WK1

**TABLE 5-10**
**AYER POTW PRETREATMENT REQUIREMENTS**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FT. DEVENS, MA**

| PARAMETER | ESTIMATED GROUNDWATER INFLUENT CONCENTRATION (μg/L)[1] | AYER POTW LOCAL LIMIT (μg/L) |
|---|---|---|
| INORGANICS | | |
| Aluminum | 1,870 | NE |
| Arsenic | 150 | 300 |
| Chromium | NE | 2,000 |
| Copper | 7.3 | 1,000 |
| Iron | 15,300 | NE |
| Lead | 3.8 | 250 |
| Manganese | 2,635 | NE |
| Nickel | NE | 1,000 |

**Notes:**

1 = Based on time-weighted average for unfiltered samples using CORA model. See Appendix C for calculations.
NE = Not Established.

## TABLE 5-11
## SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Floodplains | Floodplain Management Executive Order No. 11988 [40 CFR Part 6, App. A] | Applicable | Requires federal agencies to evaluate the potential adverse effects associated with direct and indirect development of a floodplain. Alternatives that involve modification/construction within a floodplain may not be selected unless a determination is made that no practicable alternative exists. If no practicable alternative exists, potential harm must be minimized and action taken to restore and preserve the natural and beneficial values of the floodplain. | Any construction activities within a floodplain or wetland, including construction of a force main will be done in a manner to minimize impacts. Altered areas will be repaired to restored. |
| | Wetlands | Protection of Wetlands Executive Order No. 11990 | Applicable | Under this Order, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands.<br>If remediation is required within wetland areas, and no practical alternative exists, potential harm must be minimized and action taken to restore natural and beneficial values. | Any construction activities within a floodplain or wetland, including construction of a force main will be done in a manner to minimize impacts. Altered areas will be repaired to restored. |

**TABLE 5-11**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Surface Waters Endangered Species | Fish and Wildlife Coordination Act [16 USC 661 et seq.; 40 CFR Part 302] | Applicable | Actions which affect species/habitat require consultation with DOI, FWS, NMFS, and/or state agencies, as appropriate, to ensure that proposed actions do not jeopardize the continued existence of the species or adversely modify or destroy critical habitat. The effects of water-related projects on fish and wildlife resources must be considered. Action must be taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources. Consultation with the responsible agency is also strongly recommended for on-site actions. Under 40 CFR Part 300.38, these requirements apply to all response activities under the NCP. | No off-site remedial actions performed for this alternative. On-site actions would include agency consultation prior to and during implementation. |
| | Endangered Species | Endangered Species Act [16 USC 1531 et seq.; 50 CFR Part 402] | Applicable | This act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or modification of their habitat. | To minimize impacts, remedial actions would be performed after nesting areas of the Grasshopper Sparrow have been identified. |

**TABLE 5-11**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| State Regulatory Authority | Floodplains Wetlands | Massachusetts Wetland Protection Act and Regulations [MGL c. 131 s. 40; 310 CMR 10.00] | Applicable | Wetlands and land subject to flooding are protected under this Act and these regulations. Activities that will remove, dredge, fill, or alter protected areas (defined as areas within the 100-year floodplain) are subject to regulation and must file a Notice of Intent (NOI) with the municipal conservation commission and obtain a Final Order of Conditions before proceeding with the activity. A Determination of Applicability or NOI must be filed for activities such as excavation within a 100 foot buffer zone. The regulations specifically prohibit loss of over 5,000 square feet of bordering vegetated wetland. Loss may be permitted with replication of any lost area within two growing seasons. | If remedial activities alter more than 5,000 square feet of protected area, the affected area will be restored within two growing seasons. |
| | Endangered Species | Massachusetts Endangered Species Act and implementing regulations [MGL c. 131A, s. 1 et seq.; 321 CMR 8.00] | Applicable | Actions must be conducted in a manner which minimizes the impact to Massachusetts listed endangered species and species listed by the Massachusetts Natural Heritage Program. | To minimize impacts, remedial actions would be performed after nesting areas of the Grasshopper Sparrow have been identified. |

TABLE 5-11
SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Area of Critical Environmental Concern | Areas of Critical Environmental Concern (ACEC) (301 CMR 12.00) | Relevant and Appropriate | An ACEC is of regional, state, or national importance or contains significant ecological systems with critical inter-relationships among a number-of-components. An eligible area must contain features from four or more of the following groups: (1) fishery habitats; (2) coastal feature; (3) estuarine wetland; (4) inland wetland; (5) inland surface water; (6) water supply area (i.e., aquifer recharge area); (7) natural hazard area (i.e., floodplain); (8) agricultural area; (9) historical/archeo-logical resources; (10) habitat resource (i.e., for endangered wildlife; or (11) special use areas. | Activities must be controlled to minimize impacts to nesting areas of the Grasshopper Sparrow. |

**TABLE 5-11**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Groundwater | SDWA, National Primary Drinking Water Standards, MCLs [40 CFR Parts 141.11 - 141.16 and 141.50-141.51] | Relevant and Appropriate | The NPDWR establishes MCLs and non-zero MCLGs for several common organic and inorganic contaminants. These MCLs specify the maximum permissible concentrations of contaminants in public drinking water supplies. MCLs are federally enforceable standards based in part on the availability and cost of treatment techniques. | MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be evaluated. |
| State Regulatory Authority | Surface water | Massachusetts Surface Water Quality Standards [314 CMR 4.00] | Applicable | Massachusetts Surface Water Quality Standards designate the most sensitive uses for which surface waters of the Commonwealth are to be enhanced, maintained and protected and designate minimum water quality criteria for sustaining the designated uses. Surface waters at Fort Devens are classified as Class B. Surface waters assigned to this class are designated as habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation. | Discharges associated with remedial actions will be controlled/monitored to ensure that surface waters meet standards. |

**TABLE 5-11**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Groundwater | Massachusetts Groundwater Quality Standards [314 CMR 6.00] | Applicable | Massachusetts Groundwater Quality Standards designate and assign uses for which groundwaters of the Commonwealth shall be maintained and protected and set forth water quality criteria necessary to maintain the designated uses. Groundwater at Fort Devens is classified as Class I. Groundwaters assigned to this class are fresh groundwaters designated as a source of potable water supply. | Massachusetts Groundwater Quality Standards will be used to evaluate performance of this alternative. If standards are exceeded, the interim remedy will be re-evaluated. |
| | Groundwater | Massachusetts Drinking Water Standards and Guidelines [310 CMR 22.00] | Relevant and Appropriate | The Massachusetts Drinking Water Standards and Guidelines list Massachusetts Maximum Contaminant Levels (MMCLs) which apply to water delivered to any user of a public water supply system as defined in 310 CMR 22.00. Private residential wells are not subject to the requirements of 310 CMR 22.00; however, the standards are often used to evaluate private residential contamination especially in CERCLA activities. | MMCLs will be used to evaluate performance of this alternative. If MMCLs are exceeded, the interim remedy will be re-evaluated. |

**TABLE 5-11**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| State Regulatory Authority | Floodplains Wetlands | Massachusetts Wetland Protection Act and Regulations [MGL c. 131 s. 40; 310 CMR 10.00] | Applicable | Wetlands and land subject to flooding are protected under this Act and these regulations. Activities that will remove, dredge, fill, or alter protected areas (defined as areas within the 100-year floodplain) are subject to regulation and must file a Notice of Intent (NOI) with the municipal conservation commission and obtain a Final Order of Conditions before proceeding with the activity. A Determination of Applicability or NOI must be filed for activities such as excavation within a 100 foot buffer zone. The regulations specifically prohibit loss of over 5,000 square feet of bordering vegetated wetland. Loss may be permitted with replication of any lost area within two growing seasons. | If remedial activities alter more than 5,000 square feet of protected area, the affected area will be restored within two growing seasons. |

**TABLE 5-11**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Discharge to POTW. | CWA, General Pretreatment Program [40 CFR Part 403] | Applicable | Discharges of nondomestic wastewater to POTWs must comply with the general prohibitions of this regulation, as well as categorical standards, and local pretreatment standards. | Discharge to POTW would be sampled to evaluate compliance with pre-treatment standards. |
| | Solid waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle D, 40 CFR 258] | Relevant and Appropriate | RCRA Subtitle D regulates the generation, transport, storage, treatment, and disposal of solid wastes. Regulations at 40 CFR 258 govern preparedness and prevention, closure, and post-closure at municipal solid waste landfills. | Performance of this alternative as in interim remedy will be evaluated to determine compliance with the substantive requirements of federal hazardous waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |
| | Hazardous waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle C, 40 CFR 260,264] | Relevant and Appropriate | RCRA Subtitle C regulates the generation, transport, storage, treatment, and disposal of hazardous wastes. Regulations at 40 CFR 264 govern preparedness and prevention, closure, and post-closure at landfills. | Performance of this alternative as in interim remedy will be evaluated to determine compliance with the substantive requirements of federal hazardous waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |

(continued)

**TABLE 5-11**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| State Regulatory Authority | Excavation/ construction | Massachusetts Air Pollution Control Regulations [310 CMR 6.00 - 7.00] | Applicable | Particulate emissions from remedial activities must not exceed an annual geometric mean of 50 g/m$^3$ and a maximum 24-hour concentration of 150 mg/m$^3$ (primary standard). Carbon monoxide, nitrogen dioxide, and lead are also regulated. A permit and BACT approval are required prior to operation. Visible emissions are limited. | Emissions will be managed through engineering controls. |
| | Solid waste landfill construction, operation, closure, and post-closure | Massachusetts Solid Waste Management Regulations [314 CMR 19.100] | Applicable | These regulations outline the requirements for construction, operation, closure, and post closure at solid waste management facilities in the Commonwealth of Massachusetts. | This alternative includes components to meet post-closure requirements at Shepley's Hill Landfill. |
| | Hazardous waste landfill construction, operation, closure, and post-closure | Massachusetts Hazardous Waste Regulations [310 CMR 30.00] | Relevant and Appropriate | Regulates handling, storage, treatment, disposal, and record keeping at hazardous waste facilities. | Performance of this alternative as in interim remedy will be evaluated to determine compliance with the substantive requirements of Massachusetts hazardous waste regulations. If the substantive requirements are not met at the appropriate time, the interim remedy will be re-evaluated. |

TABLE 5-12
COST SUMMARY TABLE
ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW

FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| ITEM | COST |
|---|---|
| DIRECT COSTS | |
| Hydrogeological study | $126,000 |
| Site preparation and mobilization | $134,000 |
| Ditch and landfill cover repairs | $611,000 |
| Extraction system/discharge pipe construction | $26,000 |
| Institutional controls and educational programs | $13,000 |
| TOTAL DIRECT COST | $910,000 |
| INDIRECT COSTS | |
| Health and Safety @ 5% of total direct cost | $46,000 |
| Legal, Administrative, Permitting @ 5% of total direct cost | $46,000 |
| Engineering @ 10% of total direct cost | $91,000 |
| Services during construction @ 10% of total direct cost | $91,000 |
| TOTAL INDIRECT COST | $274,000 |
| TOTAL CAPITAL (DIRECT AND INDIRECT) COST | $1,184,000 |
| OPERATION AND MAINTENANCE COSTS | |
| Total annual operating and maintenance costs | $175,000 |
| TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS) | $2,690,000 |
| TOTAL PRESENT WORTH OF ALTERNATIVE | $3,874,000 |

## TABLE 5-13
## SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Floodplains | Floodplain Management Executive Order No. 11988, [40 CFR Part 6, App. A] | Applicable | Requires federal agencies to evaluate the potential adverse effects associated with direct and indirect development of a floodplain. Alternatives that involve modification/construction within a floodplain may not be selected unless a determination is made that no practicable alternative exists. If no practicable alternative exists, potential harm must be minimized and action taken to restore and preserve the natural and beneficial values of the floodplain. | To the extent that any activity associated with this alternative takes place in the floodplain, the activity will be altered to comply with the law. |
| | Wetlands | Protection of Wetlands Executive Order No. 11990 | Applicable | Under this Order, federal agencies are required to minimize the destruction, loss, or degradation of wetlands, and preserve and enhance natural and beneficial values of wetlands.<br>If remediation is required within wetland areas, and no practical alternative exists, potential harm must be minimized and action taken to restore natural and beneficial values. | To the extent that any activity associated with this alternative takes place in wetlands, the activity will be altered to comply with the law. |

**TABLE 5-13**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Surface Waters Endangered Species | Fish and Wildlife Coordination Act [16 USC 661 et seq.; 40 CFR Part 302] | Applicable | Actions which affect species/habitat require consultation with DOI, FWS, NMFS, and/or state agencies, as appropriate, to ensure that proposed actions do not jeopardize the continued existence of the species or adversely modify or destroy critical habitat. The effects of water-related projects on fish and wildlife resources must be considered. Action must be taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources. Consultation with the responsible agency is also strongly recommended for on-site actions. Under 40 CFR Part 300.38, these requirements apply to all response activities under the NCP. | No off-site remedial actions performed for this alternative. On-site actions would include agency consultation prior to implementation. |
| | Endangered Species | Endangered Species Act [16 USC 1531 et seq.; 50 CFR Part 402] | Applicable | This act requires action to avoid jeopardizing the continued existence of listed endangered or threatened species or modification of their habitat. | Installation of a new landfill cover would destroy any existing nesting areas of the Grasshopper Sparrow. |

**TABLE 5-13**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| State Regulatory Authority | Floodplains Wetlands | Massachusetts Wetland Protection Act and Regulations [MGL c. 131 s. 40; 310 CMR 10.00] | Applicable | Wetlands and land subject to flooding are protected under this Act and these regulations. Activities that will remove, dredge, fill, or alter protected areas (defined as areas within the 100-year floodplain) are subject to regulation and must file a Notice of Intent (NOI) with the municipal conservation commission and obtain a Final Order of Conditions before proceeding with the activity. A Determination of Applicability or NOI must be filed for activities such as excavation within a 100 foot buffer zone. The regulations specifically prohibit loss of over 5,000 square feet of bordering vegetated wetland. Loss may be permitted with replication of any lost area within two growing seasons. | If remedial activities alter more than 5,000 square feet of protected area, the affected area will be restored within two growing seasons. |
| | Endangered Species | Massachusetts Endangered Species Act and implementing regulations [MGL c. 131A, s. 1 et seq.; 321 CMR 8.00] | Applicable | Actions must be conducted in a manner which minimizes the impact to Massachusetts listed endangered species and species listed by the Massachusetts Natural Heritage Program. | Activities would be controlled and planned to minimize impacts to nesting areas of the Grasshopper Sparrow. Inspite of this, existing nesting areas would be destroyed during construction activities. |

**TABLE 5-13**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | LOCATION CHARACTERISTIC | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Area of Critical Environmental Concern | Areas of Critical Environmental Concern (ACEC) [301 CMR 12.00] | Relevant and Appropriate | An ACEC is of regional, state, or national importance or contains significant ecological systems with critical inter-relationships among a number-of-components. An eligible area must contain features from four or more of the following groups: (1) fishery habitats; (2) coastal feature; (3) estuarine wetland; (4) inland wetland; (5) inland surface water; (6) water supply area (i.e., aquifer recharge area); (7) natural hazard area (i.e., floodplain); (8) agricultural area; (9) historical/archeological resources; (10) habitat resource (i.e., for endangered wildlife; or (11) special use areas. | Activities would be controlled and planned to minimize impacts to nesting areas of the Grasshopper Sparrow. Inspite of this, existing nesting areas would be destroyed during construction activities. |

# TABLE 5-13
## SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP

### SHEPLEY'S HILL LANDFILL OPERABLE UNIT
### FEASIBILITY STUDY FOR GROUP 1A SITES
### FORT DEVENS, MA

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Groundwater | SDWA, National Primary Drinking Water Standards, MCLs [40 CFR Parts 141.11 - 141.16 and 141.50-191.51] | Relevant and Appropriate | The NPDWR establishes MCLs and non-zero MCLGs for several common organic and inorganic contaminants. These MCLs specify the maximum permissible concentrations of contaminants in public drinking water supplies. MCLs are federally enforceable standards based in part on the availability and cost of treatment techniques. | MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. |
| State Regulatory Authority | Surface water | Massachusetts Surface Water Quality Standards [314 CMR 4.00] | Applicable | Massachusetts Surface Water Quality Standards designate the most sensitive uses for which surface waters of the Commonwealth are to be enhanced, maintained and protected and designate minimum water quality criteria for sustaining the designated uses. Surface waters at Fort Devens are classified as Class B. Surface waters assigned to this class are designated as habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation. | Discharges associated with remedial actions will be controlled/monitored to ensure that surface waters meet standards. |

**TABLE 5-13**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Groundwater | Massachusetts Groundwater Quality Standards [314 CMR 6.00] | Applicable | Massachusetts Groundwater Quality Standards designate and assign uses for which groundwaters of the Commonwealth shall be maintained and protected and set forth water quality criteria necessary to maintain the designated uses. Groundwater at Fort Devens is classified as Class I. Groundwaters assigned to this class are fresh groundwaters designated as a source of potable water supply. | MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. |
| | Groundwater | Massachusetts Drinking Water Standards and Guidelines [310 CMR 22.00] | Relevant and Appropriate | The Massachusetts Drinking Water Standards and Guidelines list Massachusetts Maximum Contaminant Levels (MMCLs) which apply to water delivered to any user of a public water supply system as defined in 310 CMR 22.00. Private residential wells are not subject to the requirements of 310 CMR 22.00; however, the standards are often used to evaluate private residential contamination especially in CERCLA activities. | MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. |

**TABLE 5-13**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | CHEMICAL MEDIUM | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| | Air | Massachusetts Ambient Air Quality Standards [310 CMR 6.00] | Relevant and Appropriate | Regulations specify primary and secondary ambient air quality standards to protect public health and welfare for certain pollutants | Ambient Air Quality Standards will be used to evaluate the performance of this alternative. If standards are exceeded, the interim remedy will be re-evaluated. |
| | Air | Massachusetts Air Pollution Control Regulations [310 CMR 7.00] | Relevant and Appropriate | Regulations pertain to the prevention of emissions in excess of Massachusetts or national ambient air quality standards or in excess of emission limitations in those regulations. | Ambient Air Quality Standards will be used to evaluate the performance of the cap. If standards are exceeded, the interim remedy will be re-evaluated. |

**TABLE 5-13**
**SYNOPSIS OF FEDERAL AND STATE ARARS FOR ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| AUTHORITY | ACTION | REQUIREMENT | STATUS | REQUIREMENT SYNOPSIS | ACTION TO BE TAKEN TO ATTAIN REQUIREMENT |
|---|---|---|---|---|---|
| Federal Regulatory Authority | Solid waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle D, 40 CFR 258] | Relevant and Appropriate | RCRA Subtitle D regulates the generation, transport, storage, treatment, and disposal of solid wastes. Regulations at 40 CFR 258 govern preparedness and prevention, closure, and post-closure at municipal solid waste landfills. | Performance of this alternative will be evaluated to determine compliance with the substantive requirements of federal solid waste regulations. |
| | Hazardous waste landfill construction, operation, closure, and post-closure | Resource Conservation and Recovery Act (RCRA) [Subtitle C, 40 CFR 260,264] | Relevant and Appropriate | RCRA Subtitle C regulates the generation, transport, storage, treatment, and disposal of hazardous wastes. Regulations at 40 CFR 264 govern preparedness and prevention, closure, and post-closure at landfills. | This alternative includes components to meet the substantive requirements of these regulations. |
| State Regulatory Authority | Solid waste landfill construction, operation, closure, and post-closure. | Massachusetts Solid Waste Management Regulations [310 CMR 19.100] | Applicable | These regulations outline the requirements for construction, operation, closure, and post-closure at solid waste management facilities in the Commonwealth of Massachusetts. | This alternative includes components to meet the substantive requirements of these regulations. |
| | Hazardous waste landfill construction, operation, closure, and post-closure | Massachusetts Hazardous Waste Regulations [310 CMR 30.00] | Relevant and Appropriate | Regulates handling, storage, treatment, disposal, and record keeping at hazardous waste facilities. | Performance of this alternative will be evaluated to determine compliance with the substantive requirements of Massachusetts hazardous waste regulations. |

**Notes:**

DOI =
FWS =
NMFS =

TABLE 5-14
COST SUMMARY TABLE
ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP

FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| ITEM | COST |
|---|---|
| DIRECT COSTS | |
| Site preparation and mobilization | $281,000 |
| Installation of RCRA Cap | $14,817,000 |
| Institutional controls and educational programs | $13,000 |
| TOTAL DIRECT COST | $15,111,000 |
| INDIRECT COSTS | |
| Health and Safety @ 5% of total direct cost | $756,000 |
| Legal, Administrative, Permitting @ 5% of total direct cost | $756,000 |
| Engineering @ 10% of total direct cost | $1,511,000 |
| Services during construction @ 10% of total direct cost | $1,511,000 |
| TOTAL INDIRECT COST | $4,534,000 |
| TOTAL CAPITAL (DIRECT AND INDIRECT) COST | $19,645,000 |
| OPERATION AND MAINTENANCE COSTS | |
| Total annual operating and maintenance costs | $84,000 |
| TOTAL PRESENT WORTH OF O&M COSTS (5% FOR 30 YEARS) | $1,291,000 |
| TOTAL PRESENT WORTH OF ALTERNATIVE | $20,936,000 |

# 6.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents a comparison of the seven remedial alternatives, (Alternatives SHL-1, SHL-2, SHL-5A, SHL-5B, SHL-9A, SHL-9B, and SHL-10) that were the focus of the detailed evaluation, highlighting the relative advantages and disadvantages of the alternatives with respect to the seven evaluation criterion. The evaluation is performed to assist decision-makers in selecting a remedy that cost-effectively meets the remedial action objectives. The evaluation criteria are divided into three specific categories during remedy selection: Threshold Criteria, Primary Balancing Criteria, and Modifying Criteria. Threshold criteria include Overall Protection of Human Health and the Environment, and Compliance with ARARs. Alternatives must meet threshold criteria to be chosen as the selected remedy. Primary balancing criteria include: Long-term Effectiveness and Permanence; Reduction of Toxicity, Mobility, and Volume through Treatment; Short-term Effectiveness; Implementability; and Cost. These criteria are used to compare alternatives. Modifying criteria include State and Community acceptance, and will be addressed in the Record of Decision. Results of the evaluation are summarized in Table 6-1.

## 6.1 Overall Protection of Human Health and the Environment

This criteria, according to CERCLA, must be met for a remedial alternative to be chosen as a final site remedy. At Shepley's Hill Landfill the existing cover system isolates landfill materials from the environment, blocks infiltration, and based on computer modeling diverts groundwater flow from discharging to Plow Shop Pond. Historical groundwater monitoring between the landfill and Plow Shop Pond has shown analyte concentrations in excess of PRGs; however, no current residential exposure to groundwater has been identified, and the existing cap prevents infiltration of contaminants into groundwater downgradient of the landfill. Alternatives SHL-1, SHL-2, SHL-5A, SHL-5B, SHL-9A, and SHL-9B, all of which rely on the existing cover to isolate waste, prevent infiltration, and reduce groundwater discharge to the pond, are considered equally protective of human health under current exposure scenarios. Alternative SHL-10 which proposes to replace the existing geomembrane cover with a composite cover would not afford significantly greater protection under current conditions.

Differences in protectiveness may exist under future exposure conditions. Alternative SHL-1 proposes no action to prevent future residential exposure to groundwater or to maintain and monitor the long-term performance of the existing cover. The remaining alternatives all propose to implement zoning and deed restrictions to prevent future residential exposure to groundwater and to maintain and monitor long-term cover performance. Once installed, the composite cover system proposed for Alternative SHL-10 would be younger and therefore potentially provide protection longer than the existing cover. However, its protectiveness at any given time would not be significantly greater than the anticipated performance of the existing cover. In addition, the five-year site reviews proposed for all alternatives provide the opportunity to implement additional remedial actions if they are needed. The installation of a composite cover system could be considered in the future if the existing cover system does not perform as anticipated. Alternatives SHL-5A, SHL-5B, SHL-9A, and SHL-9B, in addition to their reliance on the existing cover system, propose to extract contaminated groundwater for subsequent treatment and discharge. They therefore provide some redundancy or backup to achieve PRGs if the existing cover system does not perform as anticipated.

There is no ecological exposure to groundwater. Reductions in infiltration and leaching coupled with the diversion of groundwater that would have discharged to Plow Shop Pond will provide protection of the environment. The potential differences in effectiveness of the evaluated alternatives at protecting the environment are similar to the differences discussed for future protection of human health.

### 6.2 Compliance with ARARs

Location-specific ARARs identified for the Shepley's Hill Landfill Operable Unit include regulations that protect wetlands, floodplains, and endangered species (i.e. the Grasshopper Sparrow). Alternatives SHL-1, SHL-2, SHL-9A and SHL-9B would not involve any activities anticipated to trigger wetlands or floodplain ARARs. Alternatives SHL-5A and SHL-5B would require construction of a discharge pipeline to Nonacoicus Brook which may trigger wetland and floodplain ARARs. Activities for all alternatives would be conducted or altered to comply with wetlands and floodplain ARARs. All of the alternatives would be subject to ARARs protecting endangered species. Activities performed for any of the alternatives would be planned to prevent or minimize adverse effects on the Grasshopper Sparrow and its habitat. In spite of this, implementation of Alternative SHL-10 would result in destruction of any existing nesting areas of the Grasshopper Sparrow at the landfill.

Alternatives SHL-1, SHL-2, and SHL-10 rely on cover system performance to comply with chemical-specific ARARs and PRGs. Currently groundwater at the northern end of the landfill meets PRGs, and landfill capping is expected to reduce leaching of landfill materials and concomitant groundwater contamination, thereby achieving PRGs along the eastern edge of the landfill. Alternatives SHL-5A and SHL-5B, and SHL-9A and SHL-9B would comply with chemical-specific ARARs and PRGs with a combination of landfill capping and groundwater extraction. Groundwater exceeding PRGs would be extracted and treated or disposed of prior to exiting the site.

Several action-specific ARARs have been identified for the Shepley's Hill Landfill Operable Unit; the most important are the ones relating to landfill cover systems and landfill closure. The Massachusetts Solid Waste Management Regulations at 310 CMR 19.000 have been identified as applicable. USEPA Regulations for Owners and Operators of Permitted Hazardous Waste Facilities at 40 CFR 264 (RCRA Subtitle C), as well as USEPA Criteria for Municipal Solid Waste Landfills at 40 CFR 258 (RCRA Subtitle D), and Massachusetts Hazardous Waste Management Rules at 310 CMR 30.000 have all been identified as relevant and appropriate.

The design of the existing cover system at Shepley's Hill Landfill was approved by MADEP in 1985 pursuant to Massachusetts Sanitary Landfill regulations at 310 CMR 19.00. Provisions in 310 CMR 19.000 indicate that the conditions of the 1985 approval satisfy 310 CMR 19.000, therefore the existing cover is considered to comply with the applicable cover system requirements of 310 CMR 19.000. In addition, the existing cover meets the general performance standards of 310 CMR 19.000. The existing cover system also meets the performance standards of RCRA Subtitle C at 40 CFR 264.310, RCRA Subtitle D at 40 CFR 258, and Massachusetts Hazardous Waste Regulations at 310 CMR 30.000. The existing cover varies from USEPA guidance for RCRA final covers primarily in that has a geomembrane hydraulic barrier rather than a composite hydraulic barrier. Alternatives SHL-1, SHL-2, SHL-5A, SHL-5B, SHL-9A, and SHL-9B, which rely on the existing cover, are therefore considered to comply with the applicable or relevant and appropriate requirements for cover systems. The cover system of Alternative SHL-10 would be designed to meet the applicable or relevant and appropriate requirements for cover systems as well as RCRA design guidance. The long-term monitoring and maintenance programs of all alternatives except Alternative SHL-1 would be designed to comply with the applicable requirements of 310 CMR 19.000.

Action-specific ARARs for landfill post-closure requirements would be met by all of the alternatives except Alternative SHL-1. Alternatives SHL-5A and SHL-5B would be required to meet the substantive requirements of a NPDES permit to discharge treated groundwater to Nonacoicus Brook. These alternatives would also be required to meet ARARs for disposal of filter cake and resin regeneration concentrate from groundwater treatment and to meet substantive requirements of a USACE permit, a MADEP license, and a Massachusetts water quality certification to construct a discharge pipeline to Nonacoicus Brook. Alternatives SHL-9A and SHL-9B would be required to meet the CWA General Pretreatment Requirements to discharge to the Town of Ayer POTW. Federal and state air quality regulations would be met by all the alternatives. Dust suppression techniques would be utilized, when necessary, for Alternatives SHL-5A, SHL-5B, SHL-9A, SHL-9B, and SHL-10 intrusive activities to meet air quality regulations.

### 6.3 Long-Term Effectiveness and Permanence

This criterion evaluates the magnitude of residual risk and the reliability of controls after the response objectives have been met. Alternatives SHL-1, SHL-2, and SHL-10 rely on the effectiveness of a landfill cover system to achieve the remedial action objectives. The other alternatives utilize groundwater extraction and treatment in addition to the cover system to achieve remedial action objectives. All of the alternatives except SHL-1 include landfill post-closure and long-term groundwater monitoring to evaluate the long-term effectiveness. All the alternatives except SHL-1 include institutional controls. Institutional controls require cooperation by private parties and government agencies to be reliable and effective.

Alternatives SHL-5A, SHL-5B, SHL-9A, and SHL-9B would utilize data obtained from the pre-design hydrogeological investigation to design an extraction system. This would allow design of an extraction system that is effective in capturing contaminated groundwater. However, groundwater extraction would not prevent landfill waste and/or its leachate from potentially contaminating the underlying aquifer; these alternatives rely on the cover system as discussed earlier.

## 6.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion evaluates whether the alternatives meet the statutory preference for treatment under CERCLA. This criterion evaluates the reduction of toxicity, mobility, or volume of contaminants and the type and quantity of treatment residuals. Alternatives SHL-1, SHL-2, and SHL-10 do not meet the statutory preference for treatment under CERCLA since these alternatives do not treat groundwater.

Alternatives SHL-5A, SHL-5B, SHL-9A, and SHL-9B meet the CERCLA statutory preference for treatment. These alternatives would reduce the mobility of contaminants by extracting the groundwater for treatment or disposal. Alternatives SHL-5A and SHL-5B would generate concentrated waste streams from removal of contaminants that would require disposal. Alternatives SHL-9A and SHL-9B would discharge extracted groundwater to the Town of Ayer POTW. The POTW generates sludge from treating influent water that would require disposal.

## 6.5 Short-Term Effectiveness

Potential adverse impacts to the surrounding community, workers, and environment are considered during remedial action selection. Site work for any activities, including groundwater sampling, would require adherence to the HASP. Alternatives SHL-1 and SHL-2 would have the least impact during implementation because no intrusive activities would be required. Alternatives SHL-5A, SHL-5B, SHL-9A, and SHL-9B involve installation of underground piping. These activities would be performed following a HASP. Alternatives SHL-5A and SHL-5B would require transportation of treatment residuals and adherence to RCRA and DOT transportation regulations.

Site activities would be performed to minimize effects on the Grasshopper Sparrow and its habitat. Maintenance schedules for Alternatives SHL-2, SHL-5A, SHL-5B, SHL-9A, and SHL-9B would be prepared to limit activities during the nesting season. Construction schedules for Alternatives SHL-5A, SHL-5B, SHL-9A, and SHL-9B would be prepared to limit activities during nesting season to avoid direct impacts on the bird. Alternative SHL-10 would destroy existing nesting areas of the Grasshopper Sparrow at the landfill.

## 6.6 IMPLEMENTABILITY

This criterion evaluates each alternative's ease of construction and operation; administrative feasibility; and availability of services, equipment, and materials to construct and operate the technology. Also evaluated is the ease of undertaking additional remedial actions.

Post-closure requirements included in all of the alternatives present no implementation problems. Equipment and services required for monitoring and maintenance are readily available. Zoning and deed restriction (i.e., institutional controls) included in all alternatives, except SHL-1, could be easily implemented by the U.S. Army. Enforcement by the Town of Ayer would be required.

Groundwater extraction systems used in Alternatives SHL-5A, SHL-5B, SHL-9A, and SHL-9B would be easily designed and constructed. Many engineering companies are capable of designing and installing extraction systems. The treatment system proposed for Alternatives SHL-5A and SHL-5B utilize sand filtration, carbon adsorption, and ion exchange, all of which are proven technologies with vendors available. Alternatives SHL-9A and SHL-9B would require a long-term discharge agreement between the Army and the Town of Ayer POTW prior to implementation. Initial discussions with representatives from the Town of Ayer POTW indicate a willingness to consider accepting the discharge. Many engineering and construction companies are qualified to design and install the cover system of Alternative SHL-10.

## 6.7 COST

Capital, O&M, and present worth costs were estimated for each alternative. The alternatives with the lowest capital costs are those that do not include extensive construction activities such as Alternatives SHL-1 and SHL-2. Alternatives

SHL-5A and SHL-5B have higher capital costs because they include construction of an extraction system, on-site treatment facility, and discharge pipeline. Alternatives SHL-9A and SHL-9B include only construction of an extraction system and discharge pipeline and therefore do not cost as much as Alternatives SHL-5A and SHL-5B. Alternative SHL-10, which includes extensive construction, has the highest cost and the lowest apparent benefit per dollar. All of the alternatives except Alternative SHL-1 include O&M costs for post-closure monitoring and maintenance. Alternatives SHL-5A, SHL-5B, SHL-9A, and SHL-9B include O&M costs associated with groundwater extraction and treatment.

After the present worth of each remedial action alternative is calculated, individual costs may be evaluated through a sensitivity analysis if there is sufficient uncertainty concerning specific assumptions.

The majority of the costs associated with Alternative SHL-2 are O&M costs supporting the long-term monitoring program for Shepley's Hill Landfill. A relatively high degree of certainty is associated with the components of these alternatives; therefore, a sensitivity analysis was not performed.

Alternatives SHL-5A and SHL-5B both utilize groundwater extraction and treatment (ion exchange) to remediate groundwater at Shepley's Hill Landfill. A relatively high degree of certainty is associated with the capital costs for these alternatives; however, the duration of these alternative is uncertain. These alternatives would be operated until groundwater at Shepley's Hill Landfill achieves PRGs. For cost estimating purposes, it was assumed that the system would operate for 30 years. Should PRGs be met in 15 years, the present worth of this alternative would be reduced by approximately 23 percent to approximately $7,000,000.

Alternatives SHL-9A and SHL-9B chiefly involve groundwater extraction and disposal at a POTW facility. A relatively high degree of certainty is associated with the capital costs of this alternatives, however, the duration of these alternatives is an uncertainty. These alternatives would be operated until groundwater at Shepley's Hill Landfill achieves PRGs. For cost estimating purposes, it was assumed that the system would operate for 30 years. Should PRGs be met in 15 years, the present worth of these alternatives would be reduced by approximately 22 percent to approximately $3,000,000.

The majority of costs associated with Alternative SHL-10 are associated with construction activities. A relatively high degree of certainty is associated with these activities; therefore, a sensitivity analysis was not performed.

TABLE 6-1
COMPARATIVE ANALYSIS SUMMARY

SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FEASIBILITY STUDY FOR GROUP 1A SITES
FORT DEVENS, MA

| ASSESSMENT FACTORS | ALTERNATIVE SHL-1: NO ACTION | ALTERNATIVE SHL-2: LIMITED ACTION | ALTERNATIVES SHL-5A AND B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE | ALTERNATIVES SHL-9A AND B: COLLECTION/ DISCHARGE TO POTW | ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP |
|---|---|---|---|---|---|
| **Overall Protection of Human Health and the Environment** | | | | | |
| Human Health | · Relies on cover system performance and its predicted effects on groundwater flow to protect human receptors. | · Protection of human health provided through implementation of institutional controls and performance of cover system. | · Protection of human health provided through implementation of institutional controls, extraction of groundwater, and performance of cover system. | · Protection of human health provided through implementation of institutional controls, extraction of groundwater, and performance of cover system. | · Protection of human health provided through implementation of institutional controls and performance of cover system. |
| Environment | · No ecological exposures identified. Groundwater modeling suggests recent capping would divert flow away from northern portions of Plow Shop Pond. | · No ecological exposures identified. Groundwater modeling suggests recent capping would divert flow away from northern portions of Plow Shop Pond. | · Would extract groundwater, preventing it from leaving the site. | · Would extract groundwater, preventing it from leaving the site. | · No ecological exposures identified. Groundwater modeling suggests capping would divert flow away from northern portions of Plow Shop Pond. |
| **Compliance with ARARs** | | | | | |
| Location-Specific | · No actions taken that would trigger ARARs. | · Activities will be conducted/ altered to comply with wetlands and floodplain ARARs.<br>· Site activities would be planned to prevent adverse effects on the Grasshopper Sparrow and its habitat. | · Activities will be conducted/altered to comply with wetlands and floodplain ARARs.<br>· Site activities would be planned to prevent adverse effects on the Grasshopper Sparrow and its habitat. | · Activities will be conducted/altered to comply with wetlands and floodplain ARARs.<br>· Site activities would be planned to prevent adverse effects on the Grasshopper Sparrow and its habitat. | · Activities will be conducted/altered to comply with wetlands and floodplain ARARs.<br>· Site activities would destroy any nesting areas of Grasshopper Sparrow. |
| Chemical-Specific | · No activities will occur to evaluate compliance with chemical-specific ARARs or PRGs. | · Long-term groundwater monitoring will be implemented to evaluate compliance with chemical-specific ARARs and PRGs. | · Long-term groundwater monitoring will be implemented to evaluate compliance with chemical-specific ARARs and PRGs. | · Long-term groundwater monitoring will be implemented to evaluate compliance with chemical-specific ARARs and PRGs. | · Long-term groundwater monitoring will be implemented to evaluate compliance with chemical-specific ARARs and PRGs. |

(continued)

**TABLE 6-1**
**COMPARATIVE ANALYSIS SUMMARY**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| ASSESSMENT FACTORS | ALTERNATIVE SHL-1: NO ACTION | ALTERNATIVE SHL-2: LIMITED ACTION | ALTERNATIVES SHL-5A AND B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE | ALTERNATIVES SHL-9A AND B: COLLECTION/ DISCHARGE TO POTW | ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP |
|---|---|---|---|---|---|
| | | · Long-term landfill gas monitoring will be implemented to evaluate compliance with Ambient Air Quality Standards.<br>· MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. | · Long-term landfill gas monitoring will be implemented to evaluate compliance with Ambient Air Quality Standards.<br>· Groundwater exceeding PRGs would be extracted and treated prior to exiting the site.<br>· Would capture groundwater prior to leaving site and potentially discharging to nearby wetlands and surface water.<br>· Groundwater discharge would be treated and monitored to prevent AWQC exceedances in Nonacoicus Brook. | · Long-term landfill gas monitoring will be implemented to evaluate compliance with Ambient Air Quality Standards.<br>· Groundwater exceeding PRGs would be extracted prior to leaving the site and discharged to the Town of Ayer POTW.<br>· Would capture groundwater prior to leaving site and potentially discharging to nearby wetlands and surface water. | · Long-term landfill gas monitoring will be implemented to evaluate compliance with Ambient Air Quality Standards.<br>· MCLs will be used to evaluate the performance of this alternative. If MCLs are exceeded, the interim remedy will be re-evaluated. |
| Action-Specific | · Complies with cover system requirements of 310 CMR 19.000.<br>· Meets cover system performance standards of 310 CMR 30.000, 40 CFR 264, and 40 CFR 258. | · Complies with cover system requirements of 310 CMR 19.000.<br>· Meets cover system performance standards of 310 CMR 30.000, 40 CFR 264, and 40 CFR 258. | · Complies with cover system requirements of 310 CMR 19.000.<br>· Meets cover system performance standards of 310 CMR 30.000, 40 CFR 264, and 40 CFR 258. | · Complies with cover system requirements of 310 CMR 19.000.<br>· Meets cover system performance standards of 310 CMR 30.000, 40 CFR 264, and 40 CFR 258. | · Complies with cover system requirements of 310 CMR 19.000.<br>· Meets cover system performance standards of 310 CMR 30.000, 40 CFR 264, and 40 CFR 258. |

(continued)

**TABLE 6-1**
**COMPARATIVE ANALYSIS SUMMARY**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| ASSESSMENT FACTORS | ALTERNATIVE SHL-1: NO ACTION | ALTERNATIVE SHL-2: LIMITED ACTION | ALTERNATIVES SHL-5A AND B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE | ALTERNATIVES SHL-9A AND B: COLLECTION/ DISCHARGE TO POTW | ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP |
|---|---|---|---|---|---|
| | · Varies from USEPA design guidance for hazardous waste landfill covers.<br>· Landfill post-closure requirements would not be met. | · Varies from USEPA design guidance for hazardous waste landfill covers.<br>· Landfill post-closure requirements would be met. | · Varies from USEPA design guidance for hazardous waste landfill covers.<br>· Landfill post-closure requirements would be met.<br>· Would be required to meet substantive requirements of a NPDES permit to discharge to Nonacoicus Brook.<br>· Would be required to meet substantive requirements of a USACE permit, MADEP license, and Massachusetts water quality certification to construct discharge line to Nonacoicus Brook.<br>· Disposal of treatment residuals would be required to meet RCRA regulations. | · Varies from USEPA design guidance for hazardous waste landfill covers.<br>· Landfill post-closure requirements would be met.<br>· Discharge to POTW required to meet CWA General Pretreatment Requirements. | · Meets USEPA design guidance for hazardous waste landfill covers.<br>· Landfill post-closure requirements would be met. |
| **Long-Term Effectiveness and Permanence** | | | | | |
| Adequacy and Reliability of Controls | · No actions taken to evaluate long-term effectiveness. | · Post-closure and long-term groundwater monitoring would evaluate long-term effectiveness. | · Post-closure and long-term groundwater monitoring would evaluate long-term effectiveness. | · Post-closure and long-term groundwater monitoring would evaluate long-term effectiveness. | · Post-closure and long-term groundwater monitoring would evaluate long-term effectiveness. |

(continued)

**TABLE 6-1**
**COMPARATIVE ANALYSIS SUMMARY**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| ASSESSMENT FACTORS | ALTERNATIVE SHL-1: NO ACTION | ALTERNATIVE SHL-2: LIMITED ACTION | ALTERNATIVES SHL-5A AND B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE | ALTERNATIVES SHL-9A AND B: COLLECTION/ DISCHARGE TO POTW | ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP |
|---|---|---|---|---|---|
| Magnitude of Residual Risk | · Landfill leachate and waste may contaminate aquifer underlying landfill if cover system is not effective. | · Landfill leachate and waste may contaminate aquifer underlying landfill if cover system is not effective. | · Landfill leachate and waste may contaminate aquifer underlying landfill if cover system is not effective.<br>· Pre-design hydrogeological investigation would allow more effective design of groundwater extraction system. | · Landfill leachate and waste may contaminate aquifer underlying landfill if cover system is not effective.<br>· Pre-design hydrogeological investigation would allow more effective design of groundwater extraction system. | · Landfill leachate and waste may contaminate aquifer underlying landfill if cover system is not effective. |
| **Reduction of Toxicity, Mobility, or Volume through Treatment** | | | | | |
| Reduction of Toxicity, Mobility, or Volume | · None | · None | · Mobility reduced by extracting groundwater prior to leaving the site.<br>· Volume reduced by generating concentrated waste on carbon and filter cake. | · Mobility reduced by extracting groundwater prior to leaving the site. | · None |
| Irreversible Treatment | · Not applicable, no treatment. | · Not applicable, no treatment. | · Treatment irreversible. | · Treatment at POTW irreversible. | · Not applicable, no treatment. |

(continued)

**TABLE 6-1**
**COMPARATIVE ANALYSIS SUMMARY**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| ASSESSMENT FACTORS | ALTERNATIVE SHL-1: NO ACTION | ALTERNATIVE SHL-2: LIMITED ACTION | ALTERNATIVES SHL-5A AND B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE | ALTERNATIVES SHL-9A AND B: COLLECTION/ DISCHARGE TO POTW | ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP |
|---|---|---|---|---|---|
| Type and Quantity of Residuals Remaining after Treatment | · Not applicable. | · Not applicable. | · Treatment residuals include: Filter cake - estimated 125 lbs/day. Regeneration concentrate - 75 gal/2 days.<br>· Spent activated carbon. | · Treatment residuals (i.e., sludge) would be generated at the POTW. | · Not applicable. |
| Statutory Preference for Treatment | · Not satisfied. | · Not satisfied. | · Satisfied. | · Satisfied. | · Not satisfied. |
| **Short-Term Effectiveness** | | | | | |
| Community Protection | · No actions taken that would pose short-term risk. | · Risk to community minimized through monitoring. | · Transport of treatment residuals would follow DOT and RCRA regulations to protect community.<br>· Dust controls utilized during intrusive activities. | · Dust controls utilized during intrusive activities. | · Risk to community minimized through monitoring.<br>· Increased truck traffic presents potential risk. |
| Worker Protection | · No actions taken that would pose short-term risk. | · All site activities would require following a HASP. | · All site activities would require following a HASP. | · All site activities would require following a HASP. | · All site activities would require following a HASP. |
| Environmental Impacts | · No actions taken that would pose short-term risk. | · All site activities would be performed to minimize effects on the Grasshopper Sparrow and its habitat. | · All site activities would be performed to minimize effects on the Grasshopper Sparrow and its habitat. | · All site activities would be performed to minimize effects on the Grass-hopper Sparrow and its habitat. | · Any existing nesting areas of Grasshopper Sparrow would be destroyed.<br>· Workers exposed to risks construction activities. |

(continued)

**TABLE 6-1**
**COMPARATIVE ANALYSIS SUMMARY**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| ASSESSMENT FACTORS | ALTERNATIVE SHL-1: NO ACTION | ALTERNATIVE SHL-2: LIMITED ACTION | ALTERNATIVES SHL-5A AND B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE | ALTERNATIVES SHL-9A AND B: COLLECTION/ DISCHARGE TO POTW | ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP |
|---|---|---|---|---|---|
| Time Until Action is Complete | · No action implemented. | · Up to 12 months required for engineering evaluations, design, and construction. | · Pumping would continue until PRGs met. Since leachate and landfill waste would not be eliminated, pumping could continue indefinitely.<br>· Up to 18 months required for pre-design studies, design, and construction. | · Pumping would continue until PRGs met. Since leachate and landfill waste would not be eliminated, pumping could continue indefinitely.<br>· Up to 15 months required for pre-design, study, and construction. | · Up to 3 years for design and construction. |
| **Implementability** | | | | | |
| Ability to Construct and Operate | · No construction or operation needed. | · Construction and operation would follow conventional practice. | · Vendors available to construct extraction and treatment systems.<br>· Oversight required during operation. | · Vendors available to construct extraction and discharge systems.<br>· Minimal oversight required during operation. | · Construction and operation would follow conventional practice. |
| Ease of Undertaking Additional Action | · Would not interfere with future actions. | · Would not interfere with future actions. | · Would not interfere with future actions. | · Would not interfere with future actions. | · Would not interfere with future actions. |
| Ability to Monitor Effectiveness | · Effectiveness would not be monitored. | · Effectiveness would be monitored by monitoring groundwater. | · Effectiveness would be monitored by monitoring groundwater. | · Effectiveness would be monitored by monitoring groundwater. | · Effectiveness would be monitored by monitoring groundwater. |
| Ability to Obtain Approvals and Coordinate with Other Agencies | · No approvals or coordination required. | · Institutional controls would require cooperation by the Town of Ayer. | · Institutional controls would require cooperation by the Town of Ayer.<br>· Would be required to meet substantive requirements of NPDES permit to discharge to Nonacoicus Brook. | · Institutional controls would require cooperation by the Town of Ayer.<br>· Would require long-term discharge agreement between the U.S. Army and the Town of Ayer POTW. | · Institutional controls would require cooperation by the Town of Ayer. |

(continued)

**TABLE 6-1**
**COMPARATIVE ANALYSIS SUMMARY**

**SHEPLEY'S HILL LANDFILL OPERABLE UNIT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

| ASSESSMENT FACTORS | ALTERNATIVE SHL-1: NO ACTION | ALTERNATIVE SHL-2: LIMITED ACTION | ALTERNATIVES SHL-5A AND B: COLLECTION/ION EXCHANGE TREATMENT/SURFACE WATER DISCHARGE | ALTERNATIVES SHL-9A AND B: COLLECTION/ DISCHARGE TO POTW | ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP |
|---|---|---|---|---|---|
| | | | · Would be required to meet substantive requirements of USACE permit, MADEP license, and Massachusetts Water Quality Certification to construct discharge. | | |
| Availability of Services and Capacity | · No services required. | · Sampling and analytical services available.<br>· Design and construction services available locally or regionally. | · Sampling and analytical services available.<br>· Off-site disposal of treatment residuals required. | · Sampling and analytical services available.<br>· Design and construction services available locally or regionally. | · Sampling and analytical services available.<br>· Design and construction services available locally or regionally. |
| Availability of Equipment Specialists and Materials | · No equipment, specialists, or materials needed. | · Available locally or regionally. | · Available locally or regionally. | · Available locally or regionally. | · Available locally or regionally. |
| Availability of Technologies | · Not applicable. | · Groundwater monitoring is a common technology. | · Groundwater monitoring is a common technology.<br>· Ion exchange is a common technology for treatment of inorganics. | · Groundwater monitoring is a common technology. | · Groundwater monitoring is a common technology.<br>· Capping technology is readily implementable. |
| Cost | | | | | |
| Capital Cost | $0 | $928,000 | $2,577,000 | $1,184,000 | $19,645,000 |
| Annual O&M Cost | $0 | $84,000 | $426,000 | $175,000 | $84,000 |
| Present Worth Cost (based on a 30-year period) | $0 | $2,219,000 | $9,126,000 | $3,874,000 | $20,936,000 |

# APPENDIX A

# GROUNDWATER MODEL OF SHEPLEY'S HILL LANDFILL AREA

# Ground Water Model of the Shepley's Hill Landfill Area

Prepared for:

ABB Environmental Services
110 Free St.
Portland, ME, 04101

by
Engineering Technologies Associates, Inc.
3458 Ellicott Center Drive #101
Ellicott City, MD, 21043

July 15, 1994

## TABLE OF CONTENTS

## LIST OF FIGURES

**LIST OF TABLES**

## I. INTRODUCTION

Engineering Technologies Associates, Inc. (ETA) has been retained by ABB Environmental Services (ABB-ES) to develop a ground water model of the Shepley's Hill landfill area at Fort Devens, Massachusetts. The model will assist in the ongoing feasibility study (FS) of the site. The work is being conducted under ABB-ES subcontract 93-24-001G as part of a project for the U.S. Army Environmental Center (DAAA15-91-D-0008/0004).

## II. OBJECTIVE

The objective of the model is to simulate the ground water flow beneath the Fort Devens Shepley's Hill landfill and to evaluate the effectiveness of various alternative remedial actions on controlling ground water contamination.

## III. BACKGROUND

Shepley's Hill landfill occupies approximately 84 acres in the northeast corner of the Main Post at Fort Devens. Wastes potentially disposed of in the landfill include incinerator ash, glass, spent shell casings, flammable fluids, and asbestos (ABB-ES, 1993).

Groundwater at the landfill is contaminated with low concentrations of volatile organic compounds and metals of which aluminum, arsenic, and manganese are the most significant. Based on the pattern of arsenic in sediment in Plow Shop Pond, the landfill caused the contamination of the ground water flowing into the pond (ABB-ES, 1993).

## IV. CONCEPTUAL MODEL OF GROUND WATER FLOW

Ground water at the Shepley's Hill landfill flows east and north towards Plow Shop Pond and Nonacoicus Brook. The principal aquifer at the site is the overburden which consists of sandy glacial outwash. Small amounts of ground water flow through fractures in the bedrock, following essentially the same flow pattern as ground water in the overburden. A ground water divide runs along the crest of Shepley's Hill and through the DRMO yard to the south. Recharge occurs throughout the area except where the landfill was capped, or buildings, roads, and parking lots have created other impervious areas.

The landfill was capped in stages from 1986 to 1992. The landfill cap prevents recharge to the water table aquifer and results in declining water table elevations.

By calibrating a numerical model of ground water flow to the water table decline in this period, the future decline may be predicted. A declining water table will reduce the ground water contamination reaching Plow Shop Pond.

## V. MODEL DESIGN

### A. MODFLOWP

MODFLOWP is a version of the U.S. Geological Survey Modular, Three-Dimensional, Finite-difference, Ground-Water Flow Model (MODFLOW) which can be used to estimate parameters by nonlinear regression. Parameters are estimated by minimizing a weighted least-squares objective function by the modified Gauss-Newton method or by a conjugate-direction method. The following parameters may be estimated: transmissivity and storage coefficient of confined layers; hydraulic conductivity and specific yield of unconfined layers; vertical leakance; vertical anisotropy (used to calculate vertical leakance); horizontal anisotropy; hydraulic conductances of rivers, streams, drains and general head boundaries; recharge, maximum evapotranspiration, pumpage, and constant head boundary elevations. Spatial variation in parameters is defined by the user. Data used to estimate parameters can include existing parameter estimates, observed hydraulic heads and observed stream gain and loss. Model output includes statistics for analyzing parameter estimates; these statistics may be used to quantify the reliability of the resulting model.

MODFLOWP was selected for the modeling of the Shepley's Hill landfill because of the relative homogeneity of the glacial outwash, the quantity of monitoring well water level data available, and the more objective nature of the resulting calibration. The original intent was to use MODFLOWP to estimate the hydraulic conductivities, storage factors (specific yield for the water table aquifer and storage coefficient for the bedrock), and vertical leakance using a nonlinear regression procedure. This intention was not fulfilled for a number of reasons. First, there were very few monitoring wells in the bedrock. This lack of data made attempts at automatic calibration of the bedrock aquifer parameters futile. Second, MODFLOWP and the preconditioned conjugate gradient solver package (PCG2) were not able to converge when overburden aquifer transmissivity was a parameter. This is a known problem with MODFLOWP in a highly heterogeneous aquifer (Hill, 1992, p.227). MODFLOWP was still useful for model calibration, however, because it calculates statistics that compare the model to the observed data.

One change was made to MODFLOWP for this project. When using MODFLOWP for transient problems using the parameter estimation package, an initial steady state time step (time step zero) is added to the simulation. As will be explained later, the model was calibrated in successive transient periods. In order to successfully perform the calibration, MODFLOWP was modified to keep the initial time step (0) at the same length as the first input transient step.

## B. Grid and Boundaries

Figure 1 shows the model grid. There were 107 columns and 97 rows at a 40 foot equal spacing. Figure 1 also shows the boundaries of the model relative to the physical features of the site. The crest of Shepley's Hill was a noflow boundary. Plow Shop and Grove Ponds were represented as constant head boundaries. The remaining boundaries were initially constant head boundaries, although, as explained later, the northern boundary was changed during the calibration.

Model boundaries were far enough from the landfill cap to have no significant impact on the simulation of the effect of the cap on the ground water flow. Where no natural boundary, watershed divide or surface water body, existed within the model grid, constant head boundaries were created based on the calibrated results of a previous regional modeling effort (ETA, 1993).

The grid extends to the south and east beyond the current watershed divide. This was intentionally done to allow the watershed divide to potentially move to the east as the water table beneath the Shepley's Hill landfill falls in response to capping. Allowing the watershed divide to move over time results in a more realistic model.

The grid was aligned with the State Plane coordinate system to expedite the preparation of model input. A model with fewer inactive grids could have been developed by rotating the grid to the east so that the rows were aligned with the Shepley's Hill watershed divide. The project schedule dictated a less efficient configuration that was easier and quicker to develop.

During the calibration of the model, the northern constant head boundary (row 1) was changed to a general head boundary. The monitoring wells on the north side of the landfill cap did not fluctuate enough because they were too close to a constant head boundary. The overburden aquifer constant head boundary was replaced by a general head boundary. The bedrock aquifer constant head boundary was replaced by a noflow boundary. The general head boundary assumed a constant head elevation of 213 feet above mean sea level that was 200 feet north of row 1 connected to the model by a transmissivity of 4000 $ft^2$/day. This change permitted heads to fluctuate north of the landfill, and the calibration to be improved.

This general head boundary represents Nonacoicus Brook and the associated wetlands that exist to the north of the Shepley's Hill landfill. Nonacoicus Brook is a perennial stream that is a sink for ground water flow in the overburden. Downstream from Plow Shop Pond, Nonacoicus Brook is surrounded by wetlands. These wetlands are an expression of the water table in the overburden. For the purposes of this modeling study, simulating Nonacoicus Brook and the associated wetlands as a constant head boundary is a reasonable approximation.

### C. Aquifer Delineation

Two layers were used to simulate the ground water flow at the Shepley's Hill landfill, the overburden and bedrock. ABB-ES developed a bedrock elevation map which was digitized into AUTOCAD and the contour points extracted into a file by ETA. The Golden Software SURFER program was then used to grid these data. This gridded data then became a model input file. Figure 2 shows the results of the reinterpolation of the bedrock map.

During the calibration, both layers of the model were simulated as constant transmissivity layers. In a water table or convertible aquifer layer, transmissivity is calculated at each iteration as the product of hydraulic conductivity and saturated thickness. In a constant transmissivity layer, transmissivities are calculated outside the model for each grid cell the same way, and then input to the model and remain constant throughout the simulation. Then transmissivities were adjusted, a new water table calculated, and transmissivities recalculated, and reinput to the model. The calibration procedure is described in Section V.G. of this report.

The model was converted back to a water table aquifer for simulating scenarios. The bedrock aquifer was assumed to have a thickness of 50 feet for these scenarios. Ground water flow through the bedrock is through fractures in the rock. Fracturing is more common close to the top of the bedrock where weathering occurs. The choice of 50 feet as the thickness of flow was a professional judgment that had no impact on the calibration or the alternative evaluation because:

- ground water flow through the bedrock aquifer is insignificant in comparison to the flow through the overburden aquifer; and
- the bedrock aquifer is confined under most of the modeled area.

The conversion of the overburden to a water table aquifer was used to identify areas of little or no saturation in the overburden aquifer.

### D. Recharge

Potential monthly recharge was calculated as a function of precipitation and average monthly potential evapotranspiration. Actual recharge for each grid cell was calculated as a function of the potential recharge and land cover. On the sandy surface soils that are typical for the site, the full potential recharge was applied. Where the landfill has been capped with an impermeable membrane, recharge was taken as zero. Buildings, roads, and bedrock outcrops reduced recharge to an intermediate proportion.

Daily precipitation data were obtained from the National Climatic Data Center for the period from January 1986 to April 1993 for six cooperative weather stations that surround Fort Devens. These stations were: Ashburnham, Framingham, Lowell, Natick, Pepperell, and the Worcester Airport. Precipitation data were also obtained from Fort Devens. A weather station was operated at the Moore Army Airfield until February 1993. These precipitation readings were typically not over a full 24 hour period, however, and were not used in developing monthly precipitation estimates for the Shepley's Hill Landfill.

A computer program was written to read in daily precipitation data from the six stations, calculate a daily weighted average precipitation, and sum monthly and yearly totals. Weighing factors were calculated for each day to exclude missing data. Although six stations were used in the average, it was rare to have data from more than four of them for any given day. The original intention was to develop station weights as a function of the distance of the station from Fort Devens. Testing of the program indicated that the resulting averages were insensitive to the assigned station weights; similar results were calculated for different weighing schemes. This result occurred because of climatic similarity between stations and because of the missing data. When only two stations were used in calculating the daily weighted average, they were both important. Because the calculated averages were insensitive to the weights, equal weights were used in the calculations. Calculated yearly weighted averaged precipitation was:

| | |
|---|---|
| 1986 | 49.2 inches |
| 1987 | 45.2 inches |
| 1988 | 42.0 inches |
| 1989 | 52.6 inches |
| 1990 | 51.6 inches |
| 1991 | 50.1 inches |
| 1992 | 43.6 inches |

Only a partial year of data for 1993 were available so it was not possible to calculate the yearly precipitation. Figure 3 shows the hydrograph of monthly precipitation for the calibration period.

Potential recharge was calculated from these monthly precipitation values by subtracting evapotranspiration. This recharge value was used in model grids where there were flat, sandy soils and no impervious area. Evapotranspiration was calculated using the Blaney-Criddle formula. The resulting potential evapotranspiration was:

| Month | ET (inches) |
|---|---|
| Jan | 0.81 |
| Feb | 0.99 |
| March | 2.14 |
| April | 3.55 |
| May | 5.26 |
| June | 6.28 |
| July | 6.84 |
| Aug | 6.11 |
| Sept | 4.52 |
| Oct | 3.14 |
| Nov | 1.81 |
| Dec | 1.01 |

If the calculated potential recharge was less than one inch, recharge was assumed to be one inch for the month. This convention was an attempt to account for the fact that precipitation is not evenly spread over the month, but occurs on several days, so recharge occurs even if monthly evapotranspiration is greater than precipitation.

The one inch of recharge in the summer months accounts for precipitation greater than the soil moisture deficit percolating below the root zone and becoming ground water recharge even in months where precipitation is less than potential evapotranspiration. While qualitatively this concept is fairly straightforward, to quantify the complex relationship between evapotranspiration, precipitation and infiltration rate is difficult. An unsaturated zone numerical model could potentially calculate recharge, but given the wide variability in infiltration rates due to soil heterogeneity, and macropores, even numerical models of the unsaturated zone fail to yield accurate recharge estimates. Recharge occurs in many climates where potential evapotranspiration is greater than precipitation every month. Recharge and the resulting meteoric water resource in these climates occur only because some precipitation events cause infiltration to percolate below the root zone before evapotranspiration can take place. The estimate of one inch is a professional judgment to recognize this complex phenomena.

The resulting monthly potential recharge values were further reduced by the impervious area of the land cover. The capping of the landfill with an impermeable membrane from 1986 to 1992 was represented in four stages: 1986, 1987, 1989, and 1991. The landfill cap was assumed to prevent any recharge from occurring in these areas.

A visual inspection of the landfill in December of 1993 indicated that substantial amounts of runoff from the cap and Shepley's Hill travel down the drainage ditch on the northwest side of the fill and then infiltrate into the sandy soil at the north end of the landfill. This phenomena was simulated by multiplying the potential recharge values by five in this area. This area was directly north of the landfill cap in rows 5 through 8 and columns 50 through 58. It covered an area of 57600 $ft^2$. A second infiltration area was at the southeast corner of the landfill cap. This area was in row 70 and columns 60 through 65 and was simulated by multiplying the potential recharge values by two. It covered an area of 9600 ft.

Recharge was reduced to one-half the potential value on the Shepley's Hill bedrock outcrop. Less infiltration and recharge was assumed to occur on the rock. This is a common assumption in the northeastern United States (Lyford and Cohen, 1988; Morrisey, Randall and Williams, 1988). Parts of Shepley's Hill were assumed not contain a saturated bedrock aquifer (the bedrock transmissivity was assumed to apply over the upper 50 feet of bedrock thickness).

The runoff from Shepley's Hill was assumed to recharge at the edge of the overburden aquifer. The first active overburden aquifer cell in each row on the east side of Shepley's Hill received recharge at a rate of 1.5 times the potential recharge rate.

In the southern area of the model, there was considerable development including roads, parking lots and pavement. Land use mapping was obtained from the Massachusetts Division of Environmental Protection Geographic Information System. There were six composite categories of land use that were summarized by model grid cell. Each land use was assigned a fraction of impervious area.

| | |
|---|---|
| wetland | 1.00 |
| water | 1.00 |
| residential | 0.30 |
| commercial | 0.65 |
| urban open | 0.50 |
| open land | 0.00 |

Recharge was assigned to model grid cells by subtracting the impervious area fraction from one and multiplying by the potential recharge as previously determined.

During the calibration, the urban open area impervious area fraction was changed from 0.5 to 0.4. Model predicted water levels were below observed levels in the southern model area where the railroad is. The railroad does not contribute any appreciable impervious area, so the impervious area fraction area was lowered.

A constant rate of recharge was assumed for the post calibration simulation. The potential recharge rate was calculated by subtracting potential evapotranspiration from average monthly precipitation and summing the total for the year. In any month when average monthly precipitation minus potential evapotranspiration was less than one inch, recharge was assumed to be one inch for the month.

| Month | Average Precipitation (in) | Potential Evapotranspiration (in) | Recharge (in) |
|---|---|---|---|
| Jan | 3.79 | 0.81 | 2.98 |
| Feb | 3.11 | 0.99 | 2.12 |
| March | 3.95 | 2.14 | 1.81 |
| April | 3.71 | 3.55 | 1.00 |
| May | 3.54 | 5.26 | 1.00 |
| June | 3.60 | 6.28 | 1.00 |
| July | 3.44 | 6.84 | 1.00 |
| Aug | 3.68 | 6.11 | 1.00 |
| Sept | 3.86 | 4.52 | 1.00 |
| Oct | 3.31 | 3.14 | 1.00 |
| Nov | 4.15 | 1.81 | 2.34 |
| Dec | 3.88 | 1.01 | 2.87 |
| Total | 44.02 | 42.46 | 19.12 |

During the calibration process, the water table dropped and grid cells became unsaturated in both the bedrock and overburden aquifers on the flanks of Shepley's Hill. These grid cells and the recharge assigned to them were effectively removed from model simulations. To account for this effect, recharge as amplified by adding up the dry grid cells in each row of the model from the noflow boundary at the Shepley's Hill watershed divide to the first active grid cell in the bedrock aquifer. All of the recharge lost in the dry grid cells, up to a maximum of five grids, was assumed to recharge the aquifer at first active grid cell in each row.

### E. Initial Heads

The first calibration efforts used the steady state heads from the previous regional modeling effort (ETA, 1993) as the initial position of the potentiometric surface in 1986. These heads were interpolated to the grid centers of the model. Adjustments to these heads were made at constant head boundaries at Plow Shop and Grove Pond; a constant elevation of 216.9 was set at this boundary. This was the average elevation of Grove and Plow Shop Ponds during 1992 and 1993 (stage measurements as reported in IRDIMIS). The southwestern and southern constant head boundary elevations were also adjusted. The regional model used a 2000-foot grid spacing, so it did not adequately simulate the watershed boundary between the Shepley's Hill Landfill and the Willow Creek watershed. This boundary is defined by bedrock outcrops including Shepley's Hill. The south and southwestern constant head boundaries were adjusted to reflect the actual water table elevations.

The calibration effort indicated that the calibration was sensitive to the initial heads assumed. There was inadequate data to map the water table in 1986 before the landfill was capped. The previous regional model (ETA, 1993) was run without the landfill cap (changing recharge values in five grid cells), but the result differed only slightly from the regional modeling with the landfill cap. Finally, a reasonable set of initial heads were simulated by running the model to an approximate steady state position by removing the landfill cap and using a recharge rate of 19 inches/year.

### F. Initial Aquifer Parameter Values

Initial estimates of aquifer parameters were based on the results of the previous Fort Devens regional ground water flow modeling and professional judgment. Hydraulic conductivity of the overburden aquifer was estimated to be 50 ft/day based on the calibrated regional model (ETA, 1993). The specific yield of the overburden aquifer was initially estimated at 0.1, which is a typical value for sand. The transmissivity of the bedrock aquifer was estimated to be 72 $ft^2$/day based on the calibrated regional model (ETA, 1993). The storage coefficient of the bedrock aquifer was estimated at 0.0001, a typical value for a confined aquifer. The leakance between aquifers was estimated at 0.01 $day^{-1}$, based on the calibrated regional model (ETA, 1993). These values were altered during the calibration.

### G. Calibration

The targets for the calibration of the model were observed monitoring well water levels from 1986 through March 1993. As explained in the recharge section of this report, precipitation data were only available through April of 1993. The vast majority of the available data were from 1991 through 1993; only a few measurements were available from 1986 through 1990. The calibration simulations were therefore conducted in two steps. The first simulation was from 1986 through 1990 with monthly stress periods. Only qualitative comparisons were made between the model results and the monitoring well data in this time period. The second simulation was from 1991 through April 1993. The parameter estimation package of MODFLOWP was used to statistically compare model results and the monitoring well data in this time period.

No steady state calibration was conducted because there were no data from any time period that would approximate a steady state condition. The hypothesis being tested with the model was that the landfill cap would prevent recharge to the overburden and the water table would decline. Construction of the cap began in 1986 and completed in 1992. There were insufficient data available prior to the construction of the cap to calibrate the model at steady state.

A number of problems were encountered during the calibration. For many of the initial parameter sets, the model failed to converge. The overburden aquifer was unsaturated or had very thin saturated thicknesses in a number of areas adjacent to bedrock outcrops. When the overburden aquifer was simulated as a water table aquifer under transient conditions, grid cells became dry during periods of low recharge. When grid cells dry up in MODFLOW (and MODFLOWP) they are dry for the remainder of the simulation, and the aquifer continually shrinks during the simulations. This situation was undesirable for the calibration. One potential solution to this problem is to rewet dry nodes during the simulation. There is a modified version of the Block Centered Flow Package (BCF2) (McDonald et al, 1991) that allows cells to rewet during simulations. This package of FORTRAN code was compiled and tried, but the problem become highly nonlinear and did not converge. A second solution is to linearize the model by converting water table layers to constant transmissivity layers. The methodology for this conversion was previously described in Section II.C. of this report. The linearization resulted in a robust model that converged without difficulty, although it added an iterative step, the conversion from water table to constant transmissivity at intervals in the calibration process.

The original intent of using MODFLOWP on the project was to use the parameter estimation feature of MODFLOWP to calibrate the model. This was not possible because of the extreme variation in saturated thickness from grid to grid resulting in large variations in transmissivity even when the aquifers were linearized. This variation resulted in a matrix that the preconditioned conjugate gradient solver package (PCG2) was unable to solve because it was not diagonally dominant. This is a known shortcoming of the MODFLOWP model (Hill, 1992, p. 227). The preconditioned conjugate gradient solver package (PCG2) was able to solve the matrix when the parameter estimation package was not used.

Calibration proceeded using MODFLOWP to produce the calibration statistics for the model. The hydraulic conductivity of the overburden aquifer was reduced to 40 ft/day. The transmissivity of the bedrock aquifer was reduced to 36 $ft^2$/day.

The specific yield of the overburden was reduced to 0.05, although it likely that the correct specific yield is not this small.

The low values of specific yield were an artifact of the transient calibration. The model simulated the monthly average recharge to the aquifer. Water levels were measured at a particular day and time. These measured water levels may have been preceded by a day of precipitation or by a week of dry weather. Given that water levels at the Shepley's Hill landfill respond rapidly to precipitation events, one would not expect that monitoring well water levels would match simulated monthly average water levels. The reduction in specific yield was an attempt to calibrate the model.

The most difficult part of the model to calibrate was near the bedrock outcrops around the DRMO yard. Numerous lithologic logs and well records were reviewed and the mapping appears consistent with interpretation of the logs. No gross errors in bedrock mapping were made. Bedrock is at shallow depths throughout this area and overburden saturated thickness is small and/or nonexistent. The model, when simulating the overburden as a water table aquifer and the bedrock as a convertible (confined or water table) aquifer, constantly dried up in this area. The pattern of inactive grid cells was adjusted manually to attempt to leave channels of overburden for the ground water to flow through around the bedrock outcrops. Ultimately, this attempt was unsuccessful. The Willow Creek and Plow Shop Pond/Grove Pond/ Nonacoicus Brook watersheds are effectively separated by a bedrock high with thin or no saturation of the overburden aquifer. This was an important revision of the conceptual model where it was assumed that the watershed boundary would move in response to the lowering of the water levels beneath at the landfill.

Given the large difference in hydraulic conductivity between the overburden and the bedrock, the distribution of saturated overburden thickness was one of the most important factors in the model calibration. Areas with thinly saturated overburden typically ran dry in model simulations assuming a water table aquifer in the overburden. When this occurred, there was an immediate steepening of the gradient in that grid cell. The calibration was conducted using a constant transmissivity assumption in the overburden aquifer with thin saturated thicknesses in grid cells that typically ran dry under water table conditions. Thus, one of the critical model parameters was the saturated thickness, which is a function of the simulated water table elevation and the bedrock elevation.

The statistical results of the calibration are shown in Appendix A. The weighted residual from 341 monitoring well observations from 1991 to 1993 was 1.0 feet. The weighted residual is the same as the mean difference between observed and simulated water levels since all measurements were given the same weight. Figure 4 shows the bedrock aquifer heads predicted by the model at the end of the calibration period (April 1993). Bedrock aquifer heads were very similar to the overburden aquifer heads where both layers were active. The plots for the overburden and bedrock aquifers were similar. Figure 5 shows the observed (interpreted under the landfill where there are not data) piezometric surface (ABB-ES, 1993). The observed piezometric surface does not distinguish between the overburden and bedrock aquifers, because water levels in overburden and bedrock monitoring wells indicate very small vertical gradients (as in the model). The modeled and observed surfaces are similar except for directly under the landfill (where there are no monitoring wells and measurements) where the water table is simulated as substantially lower than the interpreted water table (see Figure 3-7 in ABB-ES, 1993).

Figures 6 through 9 show plots of water levels versus time for both monitoring well observations and heads simulated by the model. The model response is generally correct with most trends reproduced, however, the model response is muted. The inability to simulate the full response of the aquifer to precipitation events is a consequence of the timing of recharge. In the model, recharge was calculated for each month and applied equally over the month in two time steps. In reality, precipitation falls in a few days of the month and rapidly infiltrates causing the water table to rise. In ETA's pump testing of monitoring well SHM-93-10C in November, a thunderstorm occurred. Monitoring well SHL-10 responded almost immediately and rose 0.2 foot in minutes. When the storm was over, the water level fell almost as fast. It is not possible to accurately simulate daily fluctuations of the water table with monthly recharges. The overburden specific yield was reduced to 0.05 in an attempt to improve model responsiveness.

## VI. SCENARIOS

### A. BASE CASE

One of the objectives of the modeling was to quantify the decline of the water table that has occurred due to the capping of the Shepley's Hill landfill. The model was run for 100 years using the calibrated aquifer parameters, average recharge (19 inches/year) and the current cap configuration to quantify the decline.

Figure 10 shows the decline of the water table versus time at the location of monitoring well SHL-12. The overburden water table declines about a foot more over the 100 year simulation period, with all of this decline occurring the first five years. Basically, most of the impact of the cap on the water table has probably already occurred, and the impact is somewhat small, less than normal fluctuations of the water table.

Figure 11 shows the water table in the overburden aquifer at the end of 100 years of simulation. It is basically the same configuration as shown in Figure 4, with the exception that a substantial area in the middle of the landfill is unsaturated. In reality, there is probably a thin saturated thickness in much of this area, however, the flow of water through this thin zone of saturation in the overburden is negligible when compared to areas with substantial saturated thickness. Figure 12 shows the potentiometric surface of the bedrock aquifer. It is basically the same as the overburden water table where the overburden water table exists.

Inspection of Figures 6 through 10 indicates that the decline in the water table at the Shepley's Hill landfill has been small, and less than normal fluctuations in response to recharge.

### B. No Landfill Cap

To quantify the impact of the landfill cap on the ground water at the Shepley's Hill landfill site, a second run was made assuming the landfill cap did not exist. All other parameters were the same as the base case. Figure 13 shows the water table in the overburden. Figure 14 shows the potentiometric surface of the bedrock aquifer. Differences between these figures and Figures 11 and 12 (the base case) are small. The landfill cap does, however, greatly reduce the flow of ground water into Plow Shop Pond, as the following table indicates.

Table 1
Comparison of Ground Water Flows
With and Without Shepley's Hill Landfill Cap

Flows in cubic feet/day
(+ is groundwater flowing in from boundary)
(- is groundwater flowing out to boundary)

| | Overburden | | |
|---|---|---|---|
| Boundary | With | Without cap | reduction |
| northern and Nonacoicus Brook | -11535 | -372 | -3000.8% |
| Plow Shop Pond | -1235 | -4231 | 70.8% |
| Grove Pond | -39091 | -41720 | 6.3% |
| southern | 69983 | 65532 | -6.8% |
| eastern | -49287 | -49907 | 1.2% |

(Table 1 Continued)

| | Bedrock Aquifer | | |
|---|---|---|---|
| | With | Without cap | reduction |
| northern and Nonacoicus Brook | 18 | -372 | -3000.8% |
| Plow Shop Pond | -427 | -4231 | 70.8% |
| Grove Pond | 1649 | -41720 | 6.3% |
| southern | 804 | 65532 | -6.8% |
| eastern | 442 | -49907 | 1.2% |

Ground water flow to Plow Shop Pond has been reduced by almost 71 percent. The landfill cap causes ground water flow to the northern boundary to substantially increase. With the landfill cap in place, water runs off the cap and infiltrates at the north side of the landfill. This recharge flows out at the north end of the model towards Nonacoicus Brook. Flow to Grove Pond, and the eastern and southern boundaries of the model are not significantly impacted by the landfill cap as one would expect. Bedrock aquifer flows are generally two orders of magnitude smaller than overburden aquifer flows and are not impacted significantly by the landfill cap.

## VII. SENSITIVITY ANALYSIS

### A. Enhanced Recharge in Southern Part of Model

During the calibration, it was apparent that modeled heads were somewhat lower than observed around monitoring well SHL-24. One possible reason for this difference is that recharge was too low in this area of the model. As explained in section V.D., recharge was calculated based on the impervious area fraction of the land use. The land use classification around monitoring well SHL-24 was urban open. The actual land use is railroad yard. The original estimate of impervious area fraction was 0.50. During calibration, this was lowered to 0.40. For the actual land use around SHL-24, the impervious area is probably less than ten percent. A new transient calibration simulation was performed using an assumed imperviousness fraction of 0.1 in the southern part of the model.

The recharge input array was modified and the second half of the calibration simulation from 1991 to 1993 was modeled. Figure 15 shows the results of the simulation. Heads increased less than 0.1 foot. The weighted mean differences between observed and modeled head changed from 1.0 feet to 0.82 feet. The model is relatively insensitive to small changes in recharge, thus this change made no significant difference in the calibration.

The reason that modeled heads at SHL-24 did not increase more is the closeness of the monitoring well to Grove Pond. Grove Pond was modeled as a constant head boundary. The hydraulic connection between Grove Pond and overburden aquifer may be much weaker than simulated. Either the hydraulic conductivity is smaller or there may be significant resistance to flow out of Grove Pond.

### B. General Head Boundary Sensitivity

Section V.B. discussed the change of the northern boundary from a constant head boundary to a general boundary during the transient calibration. The sensitivity of this change was assessed.

The 18 general head boundary cells were changed to constant head cells and the base scenario, as described in section VI.A., was rerun. Heads changed by less than 0.1 foot across the model. Flows out the northern boundary changed by 0.2 percent after 221 days and by 0.5 percent after 100 years. These changes are less than the numerical precision of the model and are insignificant.

### C. Specific Yield

The specific yield of the model was set to an artificially small value, 0.05, during the calibration. A more realistic value for the sandy overburden is about 0.20, although models rarely calibrate with values of this magnitude because of delayed yield. A numerical model and most traditional analytical formulas that predict ground water impact assume instantaneous availability of water from storage. This is a good assumption for a confined aquifer, but water table aquifers have a substantial lag in the drainage of water from the unsaturated zone above the water table (delayed yield).

A sensitivity analysis using a specific yield of 0.20 was conducted by rerunning the base scenario (documented in Section VI.A.). Figure 16 shows the results of this run. It takes slightly longer for the aquifer to reach its steady state position with the larger specific yield. Since alternatives were compared under steady state conditions, the value of the storage coefficient had no impact on these runs and evaluations.

## VIII. REFERENCES

ABB Environmental Services, Inc.,"Fort Devens Feasibility Study for Group 1A Sites, Final Remedial Investigation Addendum Report Data Item A009", U.S. Army Environmental Center, December 1993.

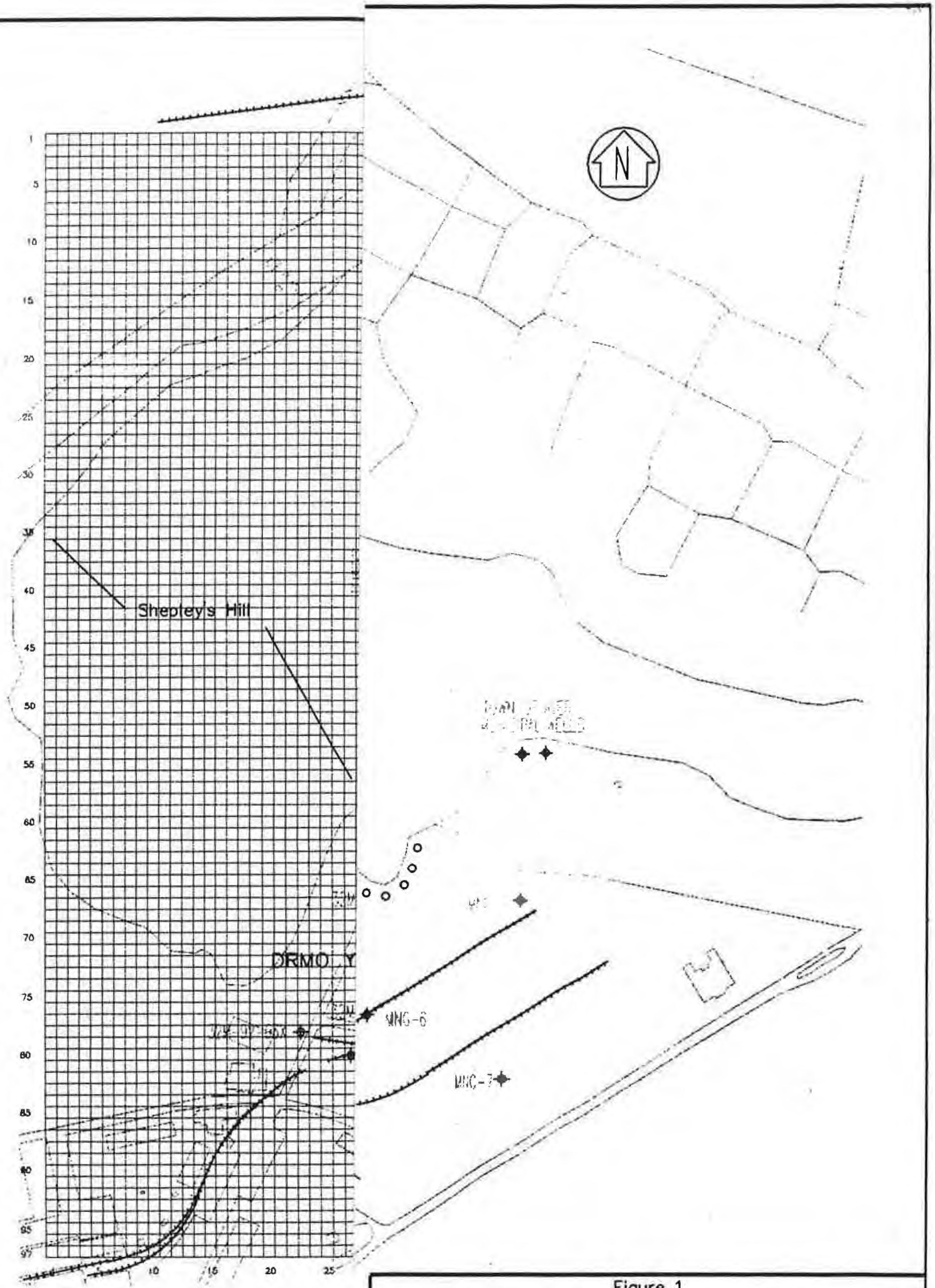
Engineering Technologies Associates, Inc., 1993," Ground Water Flow Model at Fort Devens", U.S. Army Toxic and Hazardous Materials Agency Contract DAAA15-89-D-0009/0008.

Hill, M.P.,1992, "A Computer Program (MODFLOWP) for Estimating Parameters of a Transient, Three-Dimensional, Ground-Water Flow Model Using Nonlinear Regression", USGS Open-File Report 91-484.

Lyford,F. and Cohen,A., 1988, "Estimation of Water Available for Recharge to Sand and Gravel Aquifers in the Glaciated Northeastern United States" in Regional aquifer systems of the United States--the northeast glacial aquifers, ed. by Randall and Johnson, Water Resources Association Monograph Series No. 11,.

McDonald,M.G., Harbaugh,A.W., Orr,B.R., Ackerman,D.J.,"A Method of Converting No-Flow Cells to Variable-Head Cells for the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model", USGS Open-File Report 91-536.

Morrisey,D., Randall,A. and Williams,J., 1988, "Upland Runoff as a Major Source of Recharge to Stratified Drift in the Glaciated Northeast" in Regional aquifer systems of the United States--the northeast glacial aquifers, ed. by Randall and Johnson, Water Resources Association Monograph Series No. 11.



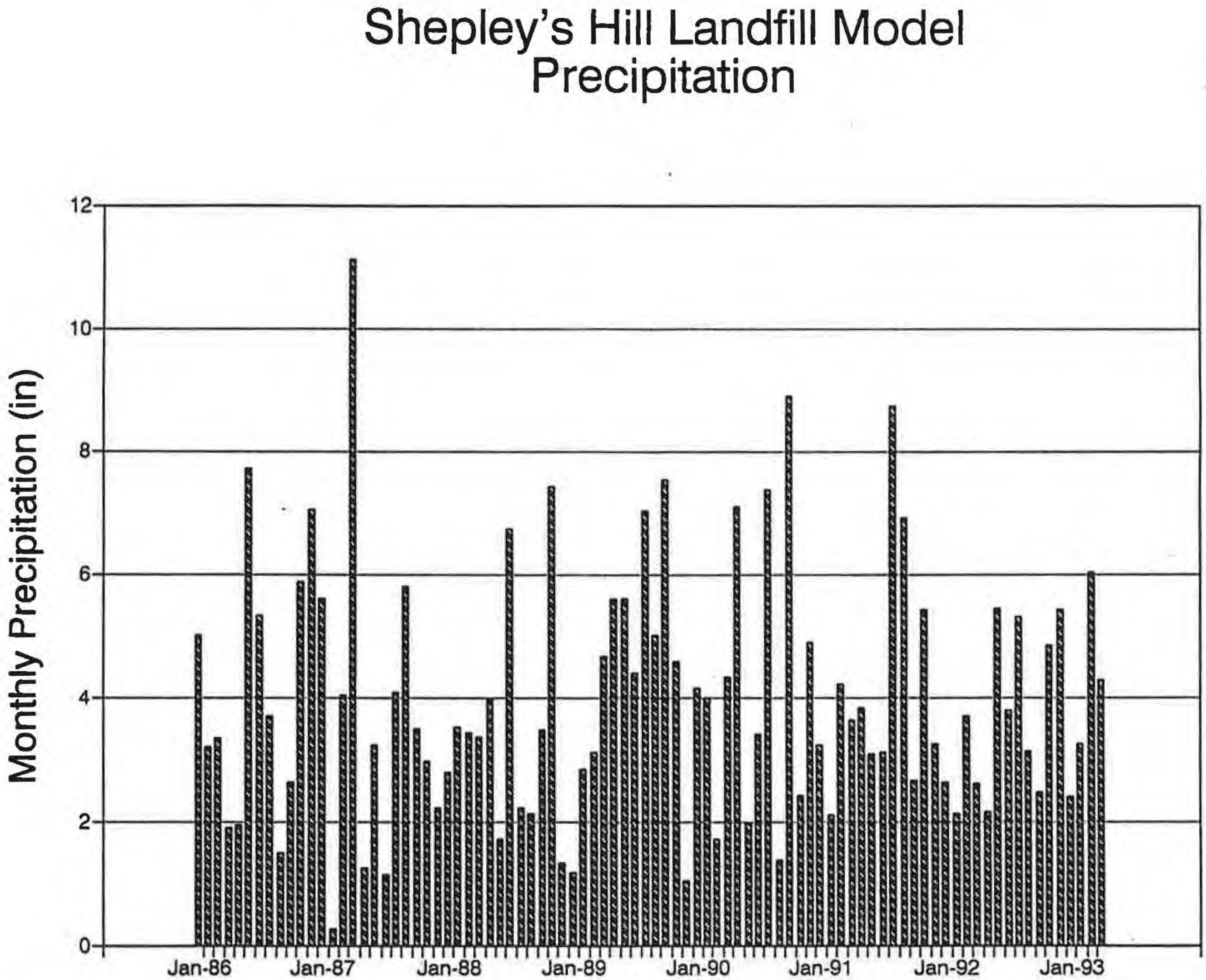

ENGINEERING ASSOCIA

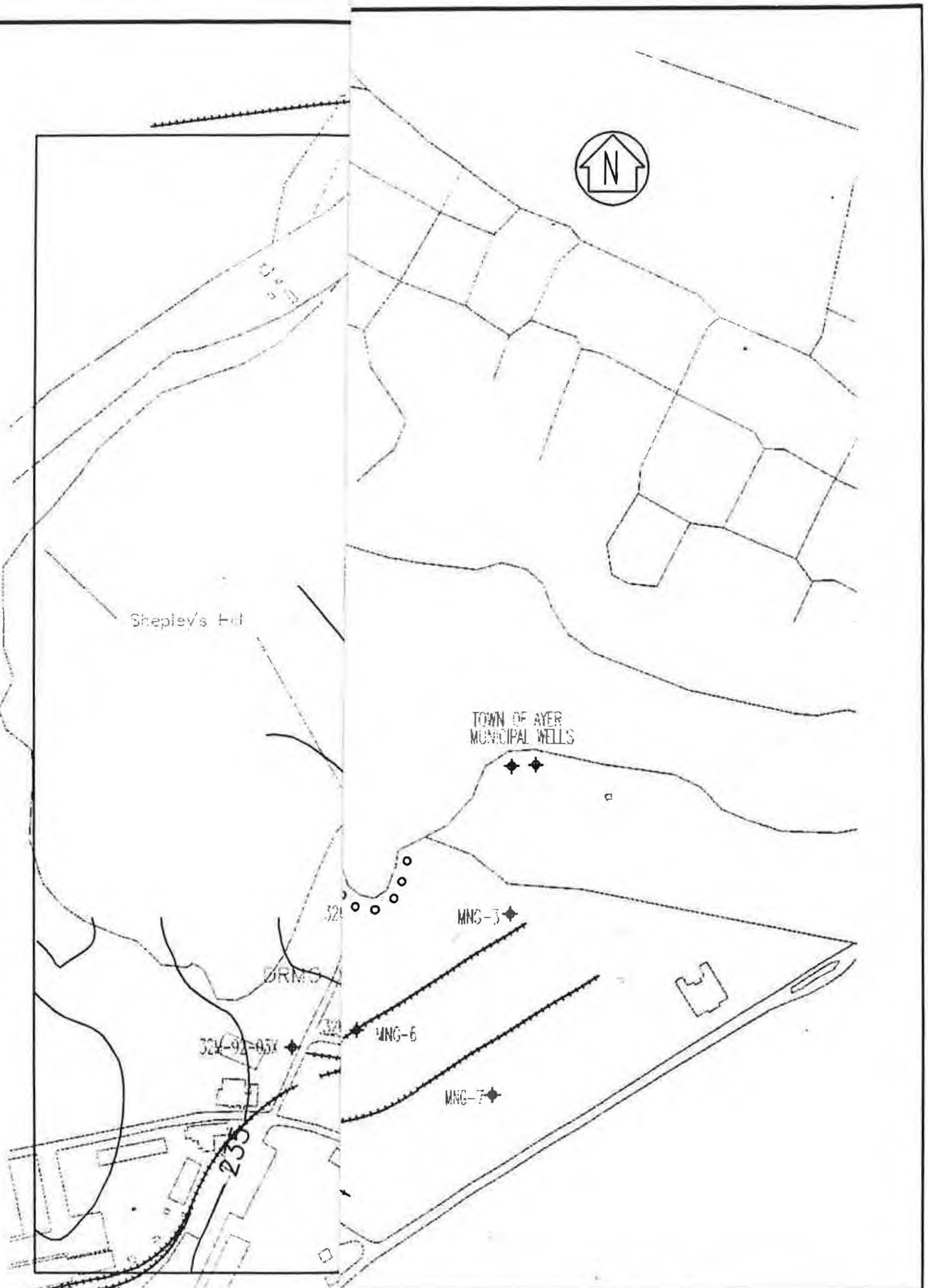
Figure 1

Model Grid

| SCALE: 1" = 500' | CONTRACT NO.: 93320.10 | DATE: 1-94 |
| --- | --- | --- |

FIGURE 3


Shepley's Hill Landfill Model
Precipitation
Monthly Precipitation (in)
0
2
4
6
8
10
12
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93



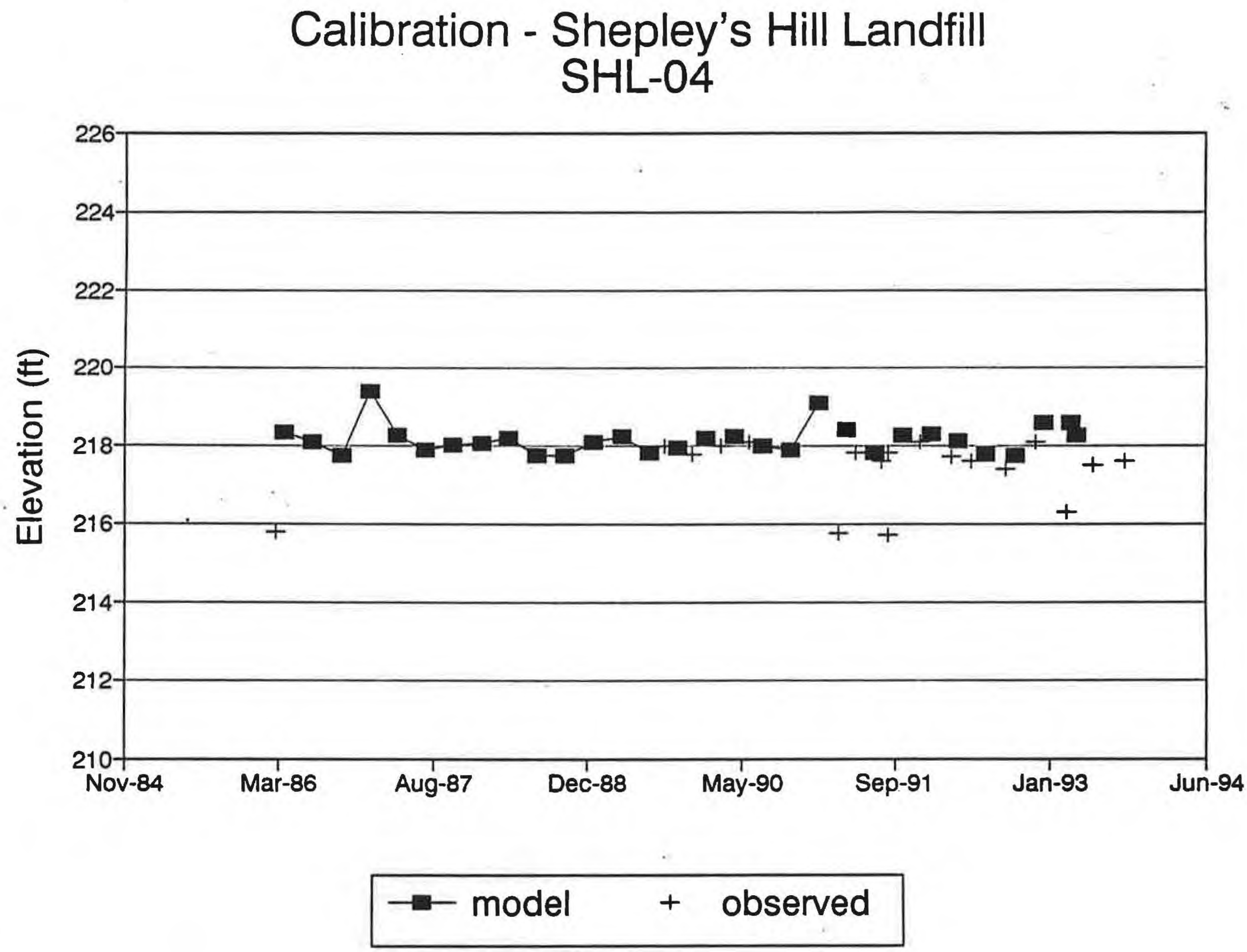

ENGINEERING ... ASSOCI...

FIGURE 4

SIMULATED BEDROCK AQUIFER
POTENTIOMETRIC SURFACE
APRIL 1993

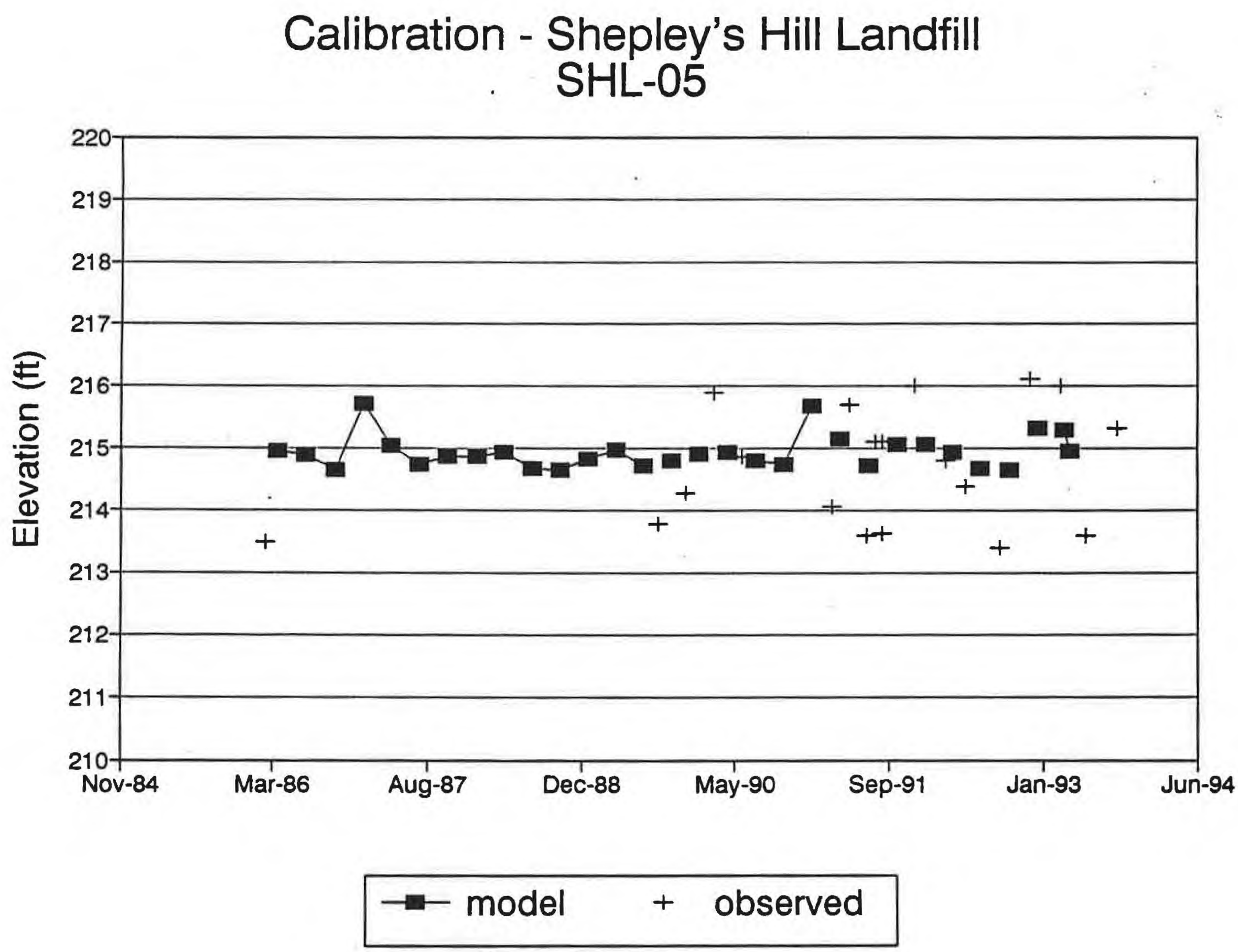
| SCALE: 1" = 500' | CONTRACT NO.: 93320.10 | DATE: 1-94 |
|---|---|---|

**FIGURE 6**



Calibration - Shepley's Hill Landfill
SHL-04
Elevation (ft)
226
224
222
220
218
216
214
212
210
Nov-84
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
model
observed

**FIGURE 7**



Calibration - Shepley's Hill Landfill
SHL-05
Elevation (ft)
220
219
218
217
216
215
214
213
212
211
210
Nov-84
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
model
observed

**FIGURE 8**

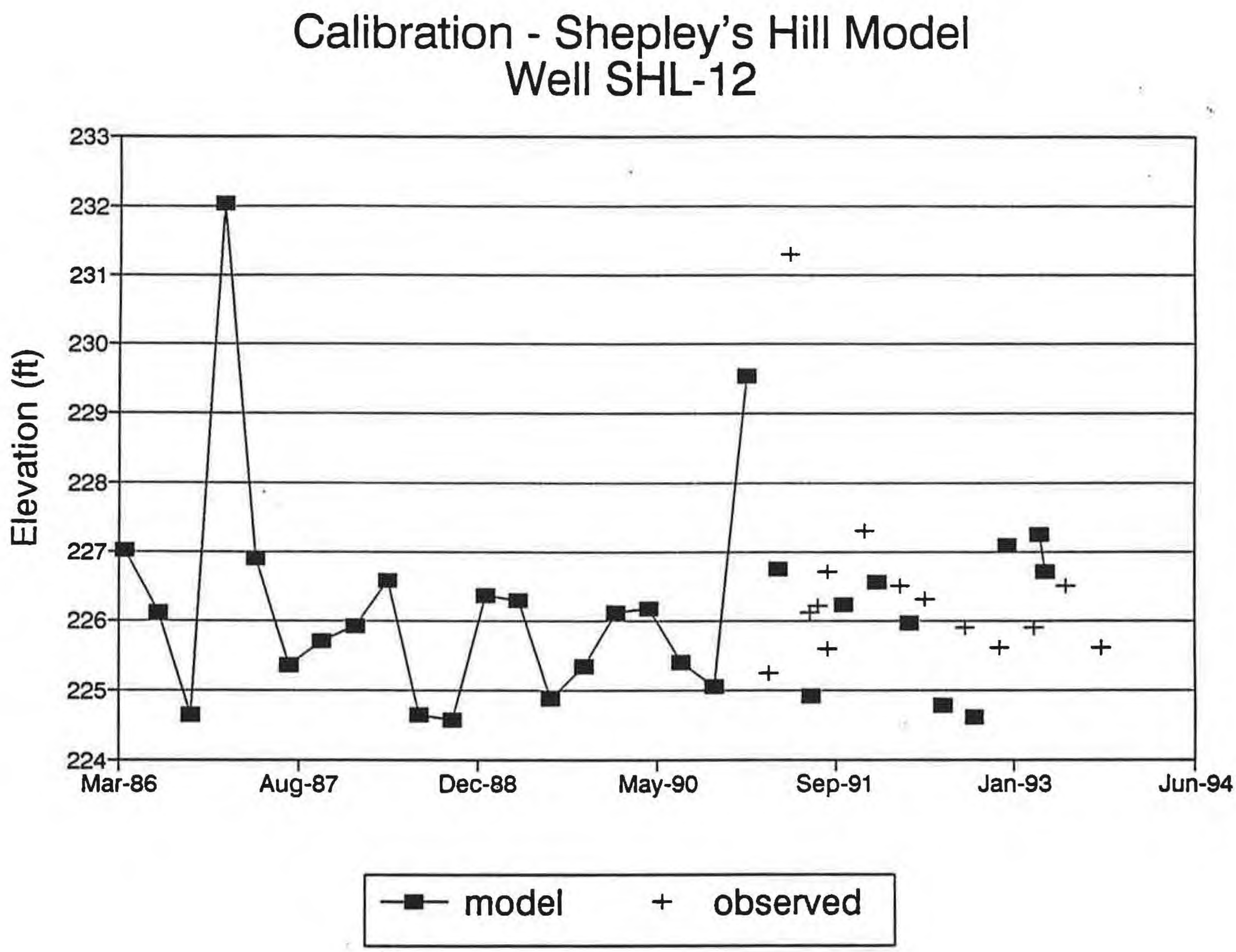
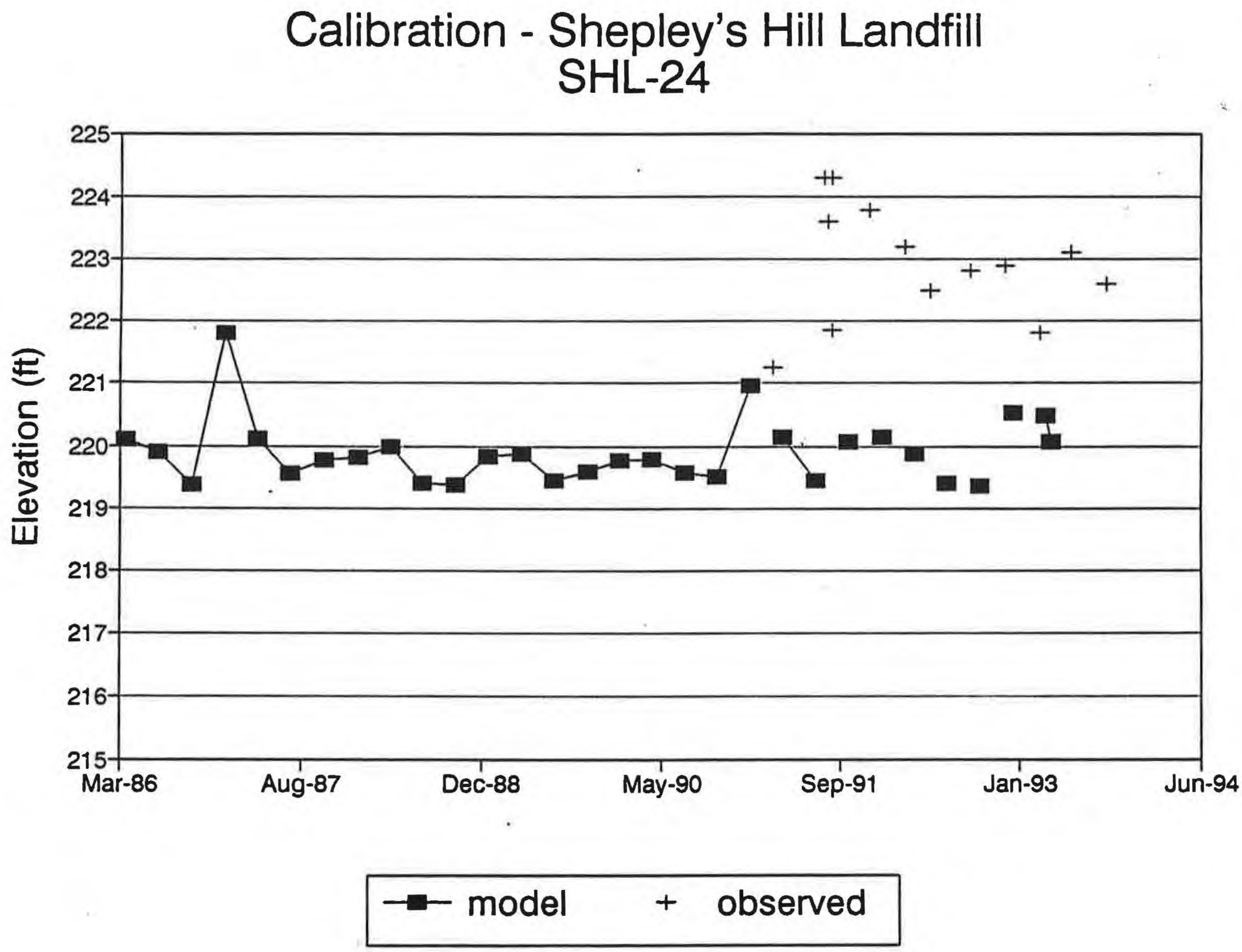

Calibration - Shepley's Hill Model
Well SHL-12
Elevation (ft)
233
232
231
230
229
228
227
226
225
224
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
model
observed

**FIGURE 9**



Calibration - Shepley's Hill Landfill
SHL-24
Elevation (ft)
225
224
223
222
221
220
219
218
217
216
215
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
model
observed

**FIGURE 10**

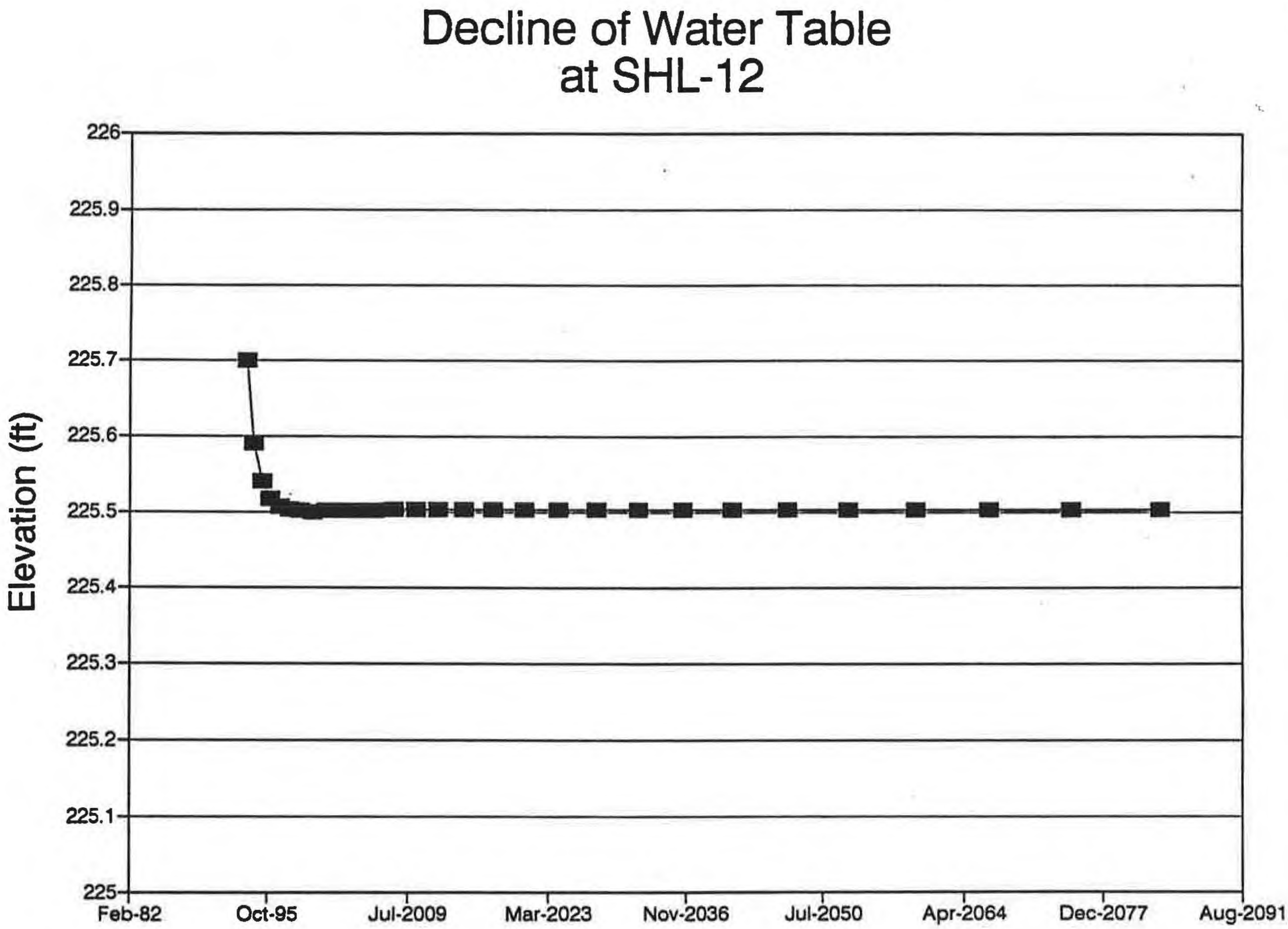

Decline of Water Table
at SHL-12
Elevation (ft)
226
225.9
225.8
225.7
225.6
225.5
225.4
225.3
225.2
225.1
225
Feb-82
Oct-95
Jul-2009
Mar-2023
Nov-2036
Jul-2050
Apr-2064
Dec-2077
Aug-2091

**FIGURE 15**

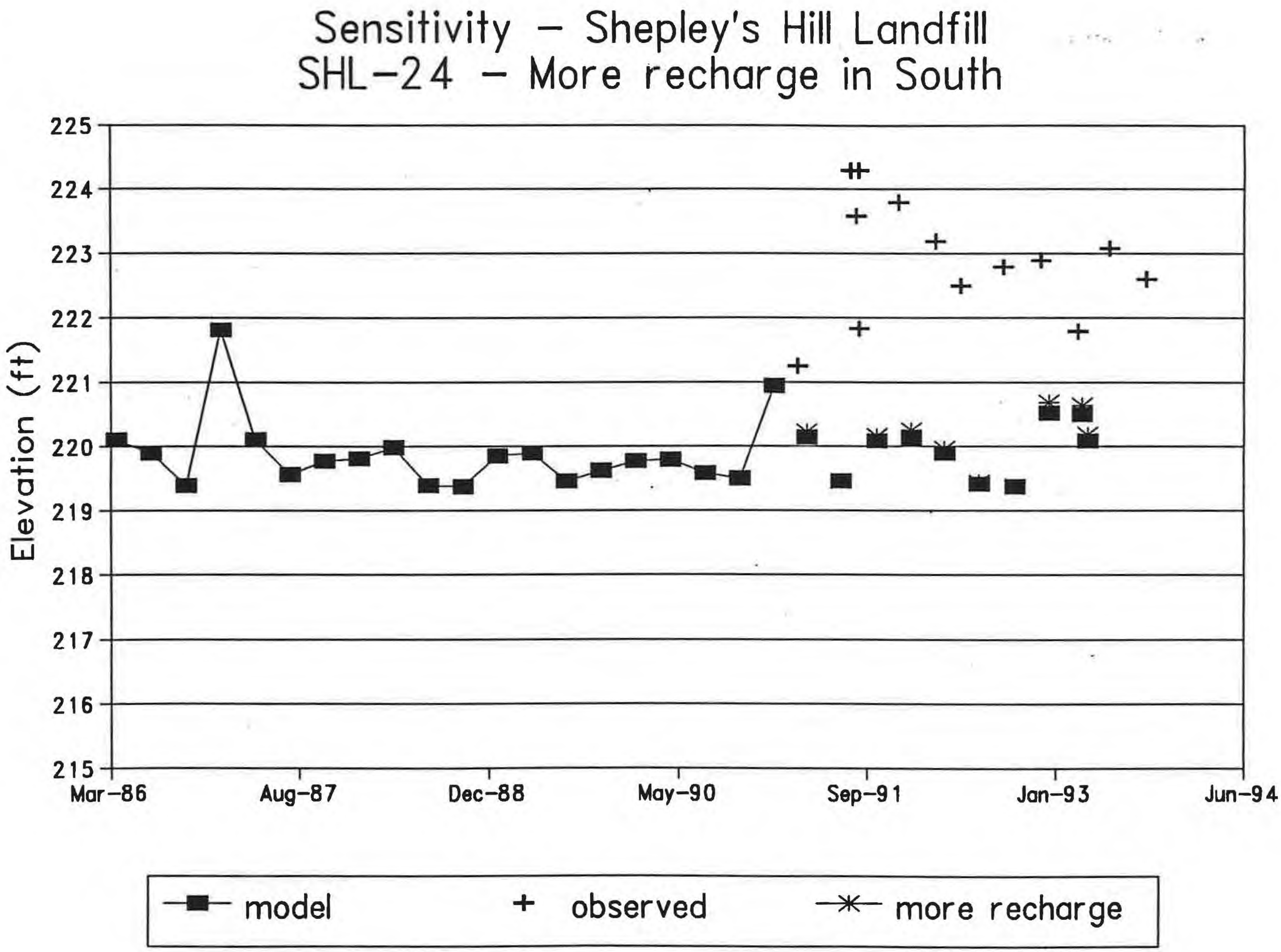
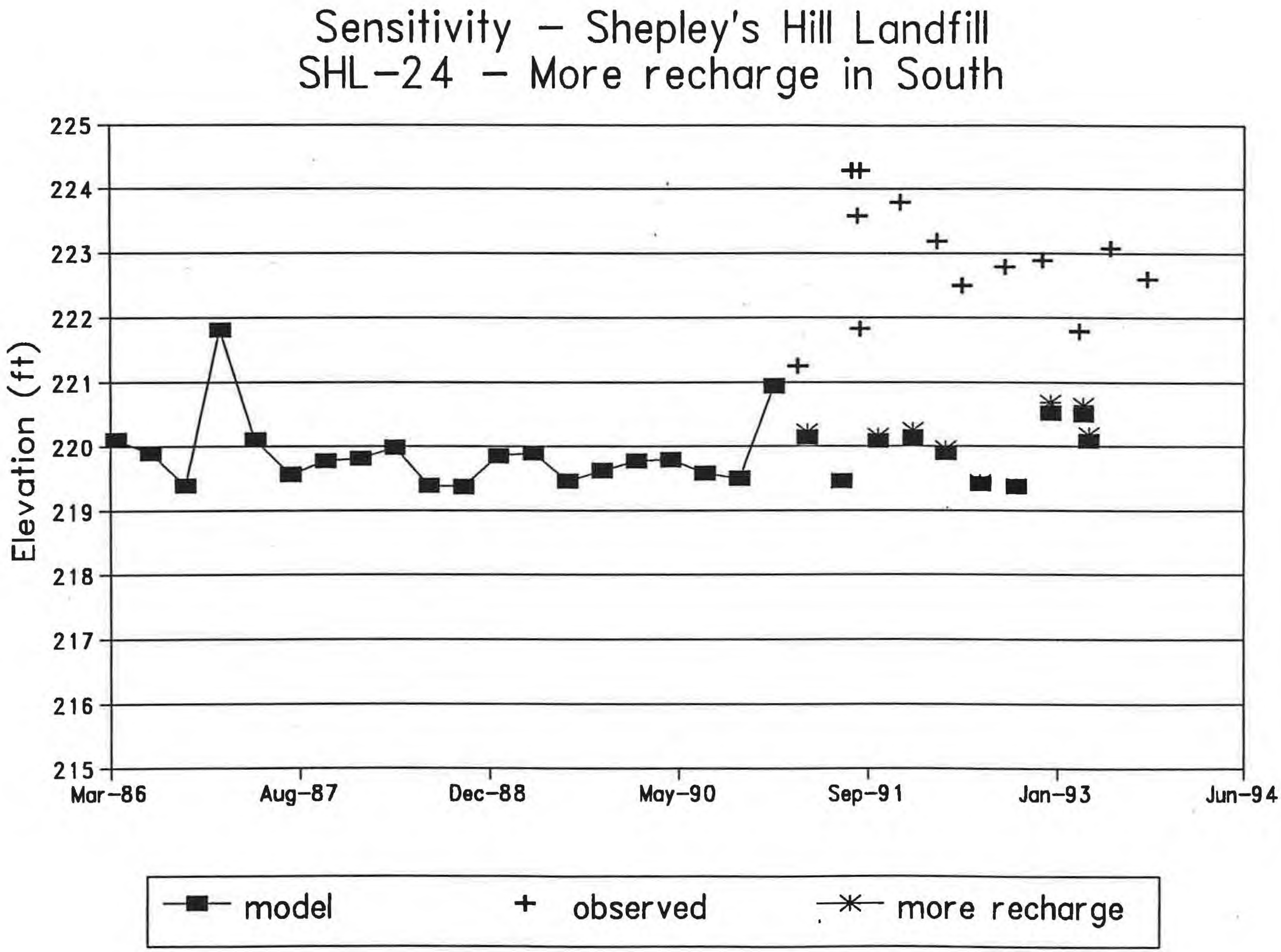
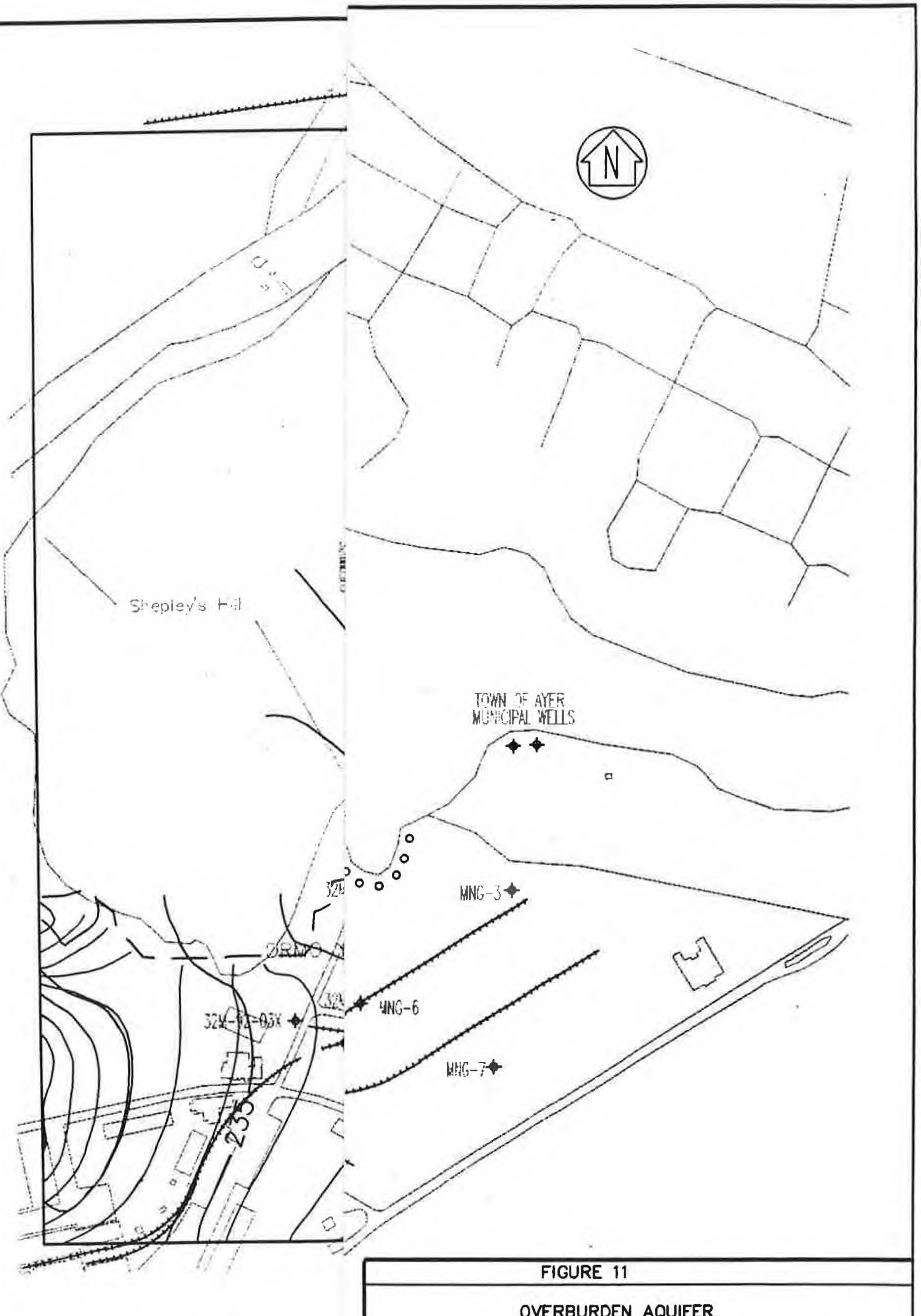

Sensitivity – Shepley's Hill Landfill
SHL-24 – More recharge in South
Elevation (ft)
225
224
223
222
221
220
219
218
217
216
215
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
model
observed
more recharge

**FIGURE 16**



Sensitivity - Shepley's Hill Landfill
SHL-24 - More recharge in South
Elevation (ft)
225
224
223
222
221
220
219
218
217
216
215
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
model
observed
more recharge

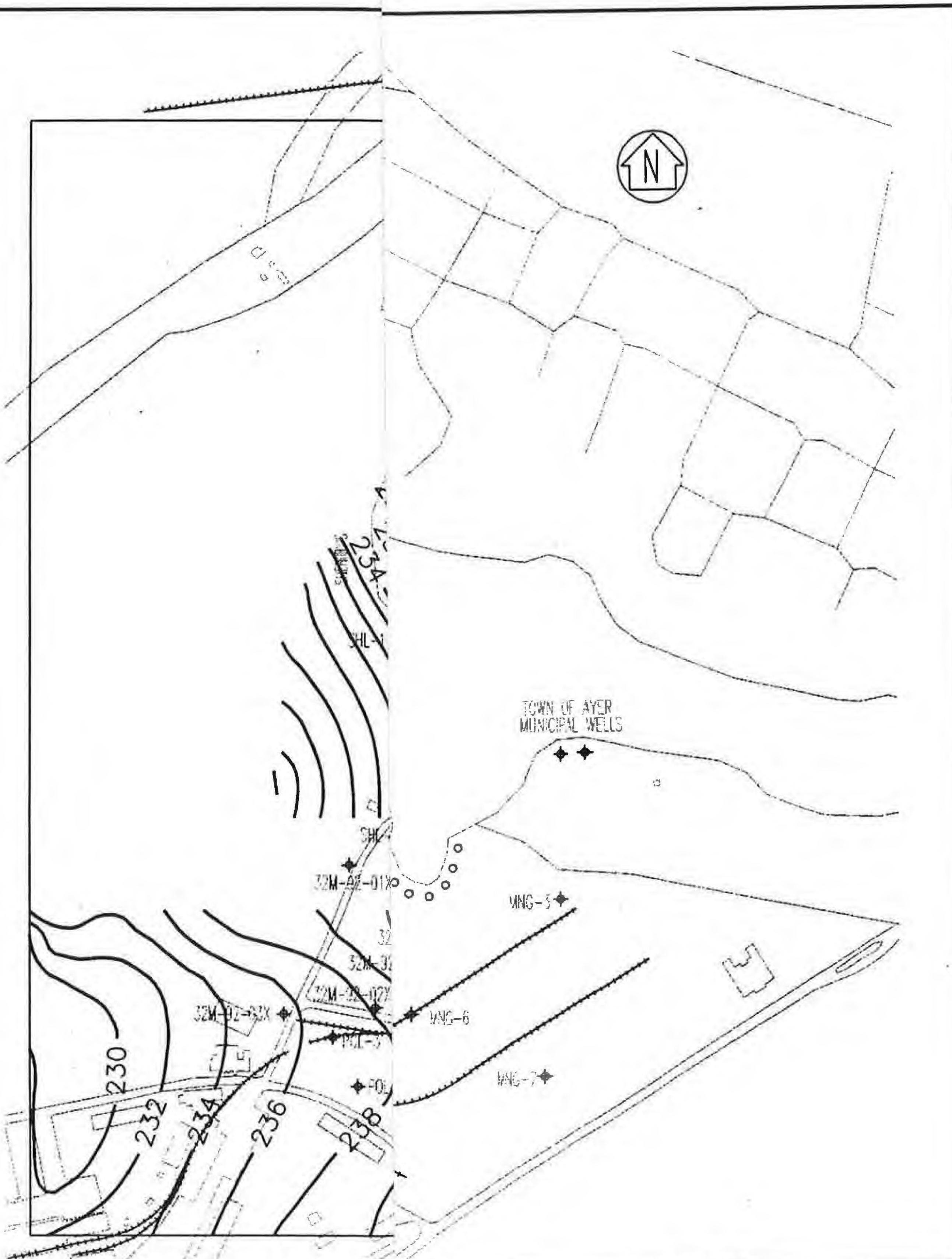



ENGINEERIN
ASSOCI

FIGURE 11

OVERBURDEN AQUIFER
WATER TABLE AFTER
100 YEARS BASE SCENARIO

| SCALE: 1" = 500' | CONTRACT NO.: 93320.10 | DATE: 1-94 |
|---|---|---|




ENGINEERING TI
ASSOCIATES

FIGURE 12

BEDROCK AQUIFER
POTENTIOMETRIC SURFACE AFTER
100 YEARS BASE SCENARIO

| SCALE: 1" = 500' | CONTRACT NO.: 93320.10 | DATE: 1-94 |
|---|---|---|

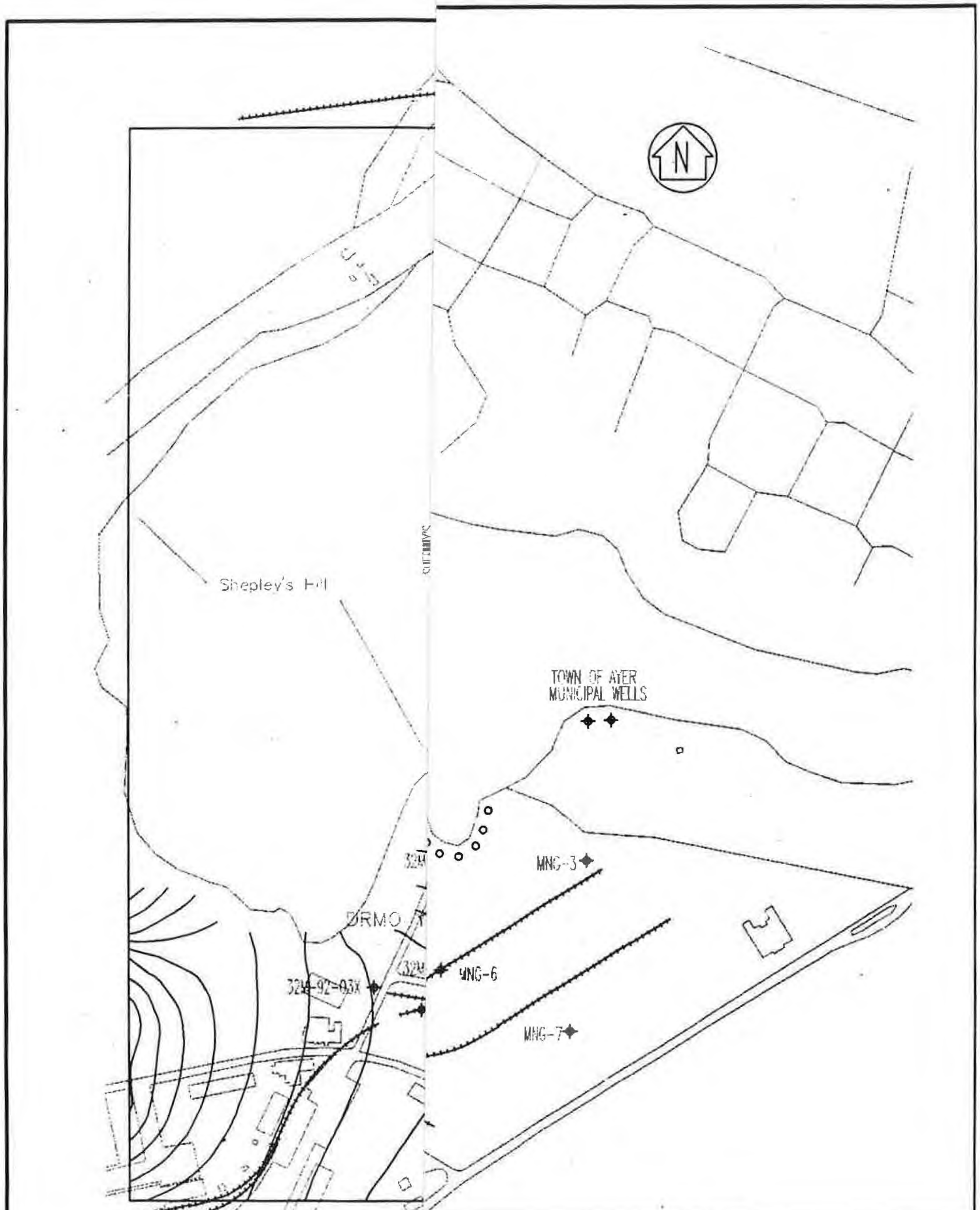



FIGURE 13

OVERBURDEN AQUIFER POTENIOMETRIC
SURFACE AFTER 100 YEARS
NO LANDFILL CAP SCENARIO

| SCALE: 1" = 500' | CONTRACT NO.: 93320.10 | DATE: 1–94 |
|---|---|---|

ENGINEERIN
ASSOCI

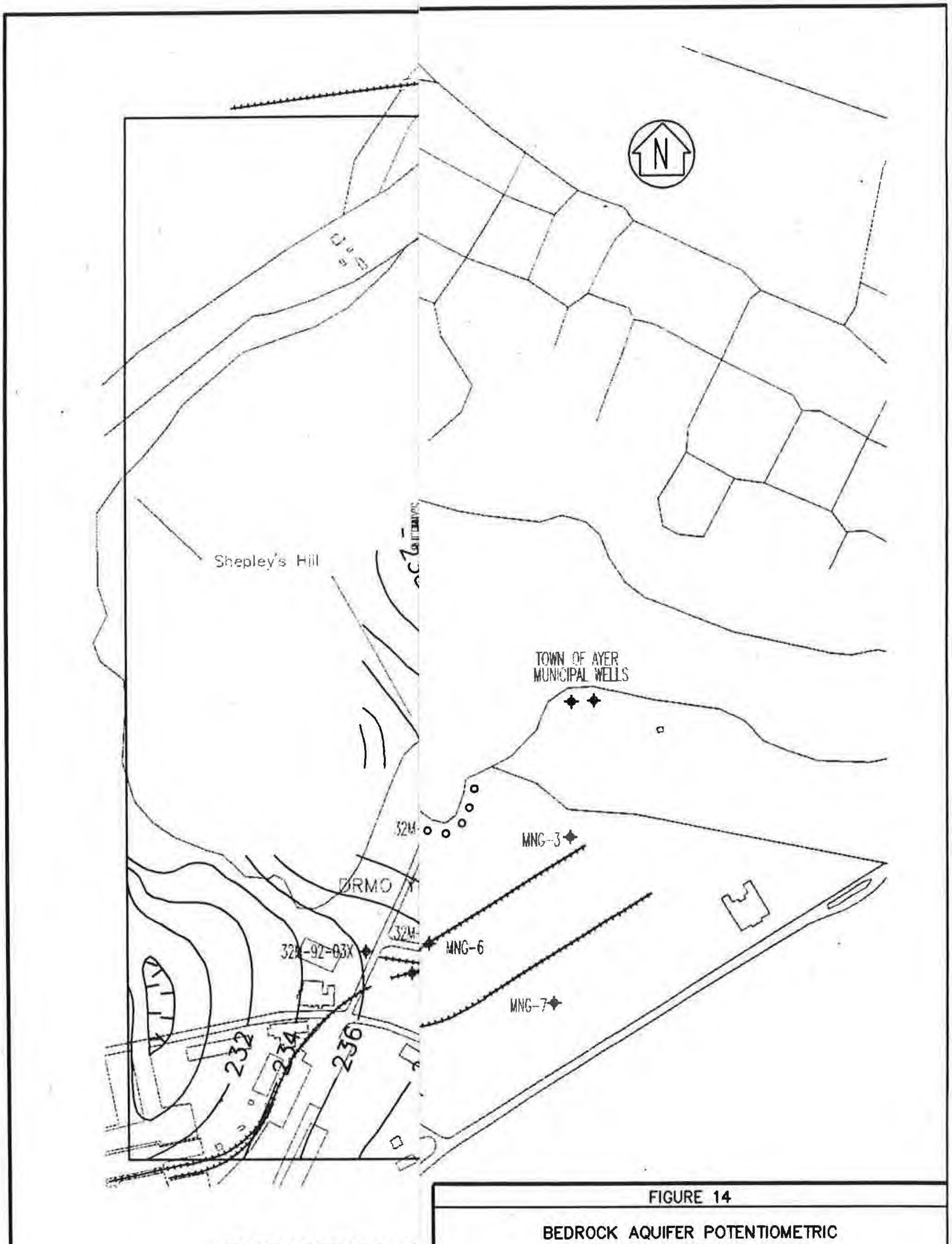



FIGURE 14

BEDROCK AQUIFER POTENTIOMETRIC SURFACE AFTER 100 YEARS NO LANDFILL SCENARIO

| SCALE: 1" = 500' | CONTRACT NO.: 93320.10 | DATE: 1-94 |
|---|---|---|

# APPENDIX A

# MODFLOWP OUTPUT

# CALIBRATION FROM 1991 TO 1993

(Not Included In This Report)

# APPENDIX B

## DETAILED COST ASSUMPTIONS AND CALCULATIONS

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-1: NO ACTION | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 09-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-1: NO ACTION
COST SUMMARY TABLE

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| DIRECT COST OF ALTERNATIVE SHL-1: NO ACTION | | | | $0 |
| TOTAL DIRECT COST OF ALTERNATIVE SHL-1: NO ACTION | | | | $0 |
| INDIRECT COST OF ALTERNATIVE SHL-1: NO ACTION | | | | |
| HEALTH AND SAFETY | | | 5.00% | $0 |
| LEGAL, ADMIN, PERMITTING | | | 5.00% | 0 |
| ENGINEERING | | | 10.00% | 0 |
| SERVICES DURING CONSTRUCTION | | | 10.00% | 0 |
| TOTAL INDIRECT COST OF ALTERNATIVE SHL-1: NO ACTION | | | | $0 |
| TOTAL CAPITAL (DIRECT + INDIRECT) COST | | | | $0 |
| OPERATING AND MAINTENANCE COSTS | | | | |
| TOTAL ANNUAL OPERATING AND MAINTENANCE COSTS | | | | $0 |
| TOTAL PRESENT WORTH OF ANNUAL O&M COSTS (5% FOR THIRTY YEARS) | | | | $0 |
| TOTAL COST OF ALTERNATIVE SHL-1: NO ACTION | | | | $0 |

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-2: LIMITED ACTION | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 09-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-2: LIMITED ACTION
COST SUMMARY TABLE

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| DIRECT COST OF ALTERNATIVE SHL-2: LIMITED ACTION | | | | |
| MOBILIZATION | | | | $90,000 |
| DITCH AND LANDFILL COVER REPAIRS | | | | 611,000 |
| INSTITUTIONAL CONTROLS | | | | 13,000 |
| TOTAL DIRECT COST OF ALTERNATIVE SHL-2: LIMITED ACTION | | | | $714,000 |
| INDIRECT COST OF ALTERNATIVE SHL-2: LIMITED ACTION | | | | |
| HEALTH AND SAFETY | | | 5.00% | $36,000 |
| LEGAL, ADMIN, PERMITTING | | | 5.00% | 36,000 |
| ENGINEERING | | | 10.00% | 71,000 |
| SERVICES DURING CONSTRUCTION | | | 10.00% | 71,000 |
| TOTAL INDIRECT COST OF ALTERNATIVE SHL-2: LIMITED ACTION | | | | $214,000 |
| TOTAL CAPITAL (DIRECT + INDIRECT) COST | | | | $928,000 |
| OPERATING AND MAINTENANCE COSTS | | | | |
| TOTAL ANNUAL OPERATING AND MAINTENANCE COSTS | | | | $84,000 |
| TOTAL PRESENT WORTH OF ANNUAL O&M COSTS (5% FOR THIRTY YEARS) | | | | $1,291,000 |
| TOTAL COST OF ALTERNATIVE SHL-2: LIMITED ACTION | | | | $2,219,000 |

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-2: LIMITED ACTION | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 09-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |

ESTIMATOR: P. R. MARTIN

| ALTERNATIVE SHL-2: LIMITED ACTION<br>SITE PREPARATION & MOBILIZATION<br>DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| SITE PREPARATION | | | | |
| STAGING AREA | | | | |
| CLEAR & GRUB LIGHT VEGETATION | 0.25 | AC | 3825.00 | $956 |
| GRADE | 410 | CY | 2.00 | 820 |
| GRAVEL - 12" THICK | 1210 | SY | 3.50 | 4,235 |
| PARKING AREA - USE EXISTING AREA - OK AS IS | | | | 0 |
| DECON AREA - USE EXISTING AREA - OK AS IS | | | | 0 |
| SURVEY | 1 | LS | 25000.00 | 25,000 |
| MOBILIZATION | | | | |
| EQUIPMENT (IN OR OUT) | | | | |
| FRONT END LOADER | 2 | EA | 500.00 | 1,000 |
| DUMP TRUCK | 4 | EA | 250.00 | 1,000 |
| BACKHOE | 2 | EA | 250.00 | 500 |
| OFFICE TRAILER | 1 | MON | 150.00 | 150 |
| STORAGE TRAILER | 1 | MON | 150.00 | 150 |
| TRAILER DELIVERY, SET-UP, REMOVAL | 2 | EA | 300.00 | 600 |
| TOILET | 4 | WK | 25.00 | 100 |
| WATER COOLER | 4 | WK | 25.00 | 100 |
| WATER | 20 | DAY | 15.00 | 300 |
| TELEPHONE SERVICE | 1 | MON | 500.00 | 500 |
| ELECTRICITY | 1 | MON | 250.00 | 250 |
| PICK-UP | 1 | MON | 1000.00 | 1,000 |
| OFFICE EQUIPMENT | 1 | MON | 1000.00 | 1,000 |
| PUMPS, TOOLS, MINOR EQUIPMENT | 1 | LS | 2500.00 | 2,500 |
| LABORER (1 MAN*5 DAY/MAN*8 HR/DAY) | 40 | MNHR | 30.00 | 1,200 |
| CARPENTER (1 MAN*5 DAY/MAN*8 HR/DAY) | 40 | MNHR | 38.00 | 1,520 |
| ELECTRICIAN (1 MAN*5 DAY/MAN*8 HR/DAY) | 40 | MNHR | 41.50 | 1,660 |
| SITE SUPERINTENDANT (1 MON*210HR/MON) | 210 | MNHR | 60.00 | 12,600 |
| FOREMAN (1 MON*210HR/MON) | 210 | MNHR | 50.00 | 10,500 |
| CLERK/TYPIST (1 MON*168HR/MON) | 168 | MNHR | 25.00 | 4,200 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 18,159 |
| TOTAL MOBILIZATION | | | | $90,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-2: LIMITED ACTION
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-2: LIMITED ACTION
DITCH & LANDFILL COVER REPAIRS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| DITCH REPAIR | | | | |
| CLEAN DITCH – BACKHOE & OPERATOR | 2 | DAY | 1300.00 | $2,600 |
| LABORER – 2 EA | 32 | MNHR | 30.00 | 960 |
| DUMP TRUCK & DRIVER | 2 | DAY | 665.00 | 1,330 |
| RIPRAP – 1' THICKx15'Wx500'L | 300 | CY | 30.00 | 9,000 |
| LANDFILL COVER REPAIRS | | | | |
| FILL & PATCH "POND" IN COVER | | | | |
| BACKHOE & OPERATOR | 5 | DAY | 1300.00 | 6,500 |
| LABORER – 4 EA, 2 WKS/EA | 320 | MNHR | 30.00 | 9,600 |
| FILL MATERIAL | 300 | CY | 20.00 | 6,000 |
| GEOMEMBRANE | 60000 | SF | 0.35 | 21,000 |
| VIBRATORY PLATE COMPACTOR | 5 | DAY | 60.00 | 300 |
| 10-3 DRAINAGE SAND | 1100 | CY | 8.00 | 8,800 |
| FILTER FABRIC | 60000 | SF | 0.16 | 9,600 |
| 1' VEGETATIVE COVER | 1200 | CY | 7.50 | 9,000 |
| SEED, FERTILIZE, MULCH | 2 | AC | 2000.00 | 4,000 |
| SPREAD & COMPACT, EQUIP & OPER | 5 | DAY | 1450.00 | 7,250 |
| EVALUATION/IMPROVEMENT OF STORMWATER DIVERSION AND DRAINAGE | | | | |
| EVALUATION OF LANDFILL CAP RUNOFF PATTERNS, DITCH CAPACITIES, STORMWATER DRAINAGE SYSTEMS UPGRADIENT OF LANDFILL AND, RUN-UNDER ALONG WESTERN EDGE OF LANDFILL | 1 | LS | 43000.00 | 43,000 |
| REPLACE/INSTALL STORM SEWERS/DRAINS | | | | |
| 18" DIA RCP | 800 | LF | 45.00 | 36,000 |
| 24" DIA RCP | 800 | LF | 55.00 | 44,000 |
| 36" DIA RCP | 1600 | LF | 100.00 | 160,000 |
| REDUCE RUN-UNDER ALONG WESTERN EDGE | 1 | LS | 90000.00 | 90,000 |
| MONITORING WELL DRILLING | 3 | EA | 6600.00 | 19,800 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 122,260 |
| TOTAL DITCH & LANDFILL COVER REPAIRS | | | | $611,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES
ALTERNATIVE SHL-2: LIMITED ACTION
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

JOB # 7005-12
DATE 09-Sep-94

ESTIMATOR: P. R. MARTIN

| ALTERNATIVE SHL-2: LIMITED ACTION INSTITUTIONAL CONTROLS DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| INSTITUTIONAL CONTROLS | 1 | LS | 10000.00 | $10,000 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 3,000 |
| TOTAL INSTITUTIONAL CONTROLS | | | | $13,000 |

APPENDIX B

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-2: LIMITED ACTION | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 09-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

| ALTERNATIVE SHL-2: LIMITED ACTION<br>ANNUAL O&M COSTS<br>DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| LANDFILL COVER MAINTENANCE | | | | |
| GENERAL REPAIR | | | | |
| DUMP TRUCK & DRIVER | 1 | DAY | 665.00 | $665 |
| FRONT END LOADER & OPERATOR | 1 | DAY | 800.00 | 800 |
| LABORER - 2 EA | 16 | MNHR | 30.00 | 480 |
| MATERIALS | 1 | LS | 500.00 | 500 |
| INSPECTION - 2 DAY @ 2 MEN/DAY | 32 | MNHR | 75.00 | 2,400 |
| MOWING - TRACTOR AND OPERATOR | 4 | DAY | 500.00 | 2,000 |
| GROUNDWATER MONITORING<br>14 WELLS, SEMI-ANNUALLY | 2 | EVENT | 8560.00 | 17,120 |
| GROUNDWATER SAMPLE ANALYSIS<br>14 SAMPLES PLUS 3 QA/QC EQUIVALENT<br>SEMI-ANNUALLY, VOCs, INORGANICS, WATER QUALITY PARAMETERS | 34 | SMPL | 785.00 | 26,690 |
| LANDFILL GAS MONITORING<br>18 POINTS, QUARTERLY AND ANALYSIS | 4 | EVENT | 3000.00 | 12,000 |
| LANDFILL GAS COLLECTION SYSTEM MAINTENANCE | | | | |
| LABORER | 8 | MNHR | 30.00 | 240 |
| MATERIALS | 1 | LS | 250.00 | 250 |
| TWO YEAR REPORT TO DEP - ANNUALIZED | 0.4878 | LS | 1000.00 | 488 |
| FIVE YEAR EDUCATIONAL PROGRAM<br>PUBLIC MEETING - ANNUALIZED | 0.1810 | LS | 5000.00 | 905 |
| FIVE YEAR SITE REVIEW - ANNUALIZED | 0.1810 | LS | 15000.00 | 2,715 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 16,748 |
| TOTAL ANNUAL O&M COSTS | | | | $84,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES JOB # 7005–12
ALTERNATIVE SHL–5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT DATE 09–Sep–94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL–5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
COST SUMMARY TABLE

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| DIRECT COST OF ALTERNATIVE SHL–5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE | | | | |
| HYDROGEOLOGICAL STUDY | | | | $126,000 |
| TREATABILITY/PILOT TESTING | | | | 65,000 |
| SITE PREPARATION AND MOBILIZATION | | | | 283,000 |
| DITCH AND LANDFILL COVER REPAIRS | | | | 611,000 |
| EXTRACTION SYSTEM/DISCHARGE PIPE CONSTRUCTION | | | | 152,000 |
| TREATMENT FACILITY CONSTRUCTION | | | | 733,000 |
| INSTITUTIONAL CONTROLS | | | | 13,000 |
| TOTAL DIRECT COST OF ALTERNATIVE SHL–5: COLLECTION/ ION EXCHANGE TREATMENT/DISCHARGE | | | | $1,983,000 |
| INDIRECT COST OF ALTERNATIVE SHL–5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE | | | | |
| HEALTH AND SAFETY | | | 5.00% | $99,000 |
| LEGAL, ADMIN, PERMITTING | | | 5.00% | 99,000 |
| ENGINEERING | | | 10.00% | 198,000 |
| SERVICES DURING CONSTRUCTION | | | 10.00% | 198,000 |
| TOTAL INDIRECT COST OF ALTERNATIVE SHL–5: COLLECTION/ ION EXCHANGE TREATMENT/DISCHARGE | | | | $594,000 |
| TOTAL CAPITAL (DIRECT + INDIRECT) COST | | | | $2,577,000 |
| OPERATING AND MAINTENANCE COSTS | | | | |
| TOTAL ANNUAL OPERATING AND MAINTENANCE COSTS | | | | $426,000 |
| TOTAL PRESENT WORTH OF ANNUAL O&M COSTS (5% FOR THIRTY YEARS) | | | | $6,549,000 |
| TOTAL COST OF ALTERNATIVE SHL–5: COLLECTION/ ION EXCHANGE TREATMENT/DISCHARGE | | | | $9,126,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| HYDROGEOLOGICAL STUDY | | | | |
| MODELING, PERMEABILITY TESTS, WATER LEVELS, WELL INSTALLATION LABOR | 1 | LS | 57000.00 | $57,000 |
| PIEZOMETER INSTALLATION<br>1 SINGLE<br>4 NESTED PAIRS<br>2 NESTED TRIPLETS | 1 | LS | 44000.00 | 44,000 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 25,000 |
| TOTAL HYDROGEOLOGICAL STUDY | | | | $126,000 |
| TREATABILITY/PILOT TESTING | 1 | LS | 52000.00 | $52,000 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 13,000 |
| TOTAL TREATABILITY/PILOT TESTING | | | | $65,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
SITE PREPARATION AND MOBILIZATION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| SURVEY | 1 | LS | 25000.00 | $25,000 |
| SITE PREPARATION | | | | |
| STAGING AREA | | | | |
| CLEAR & GRUB LIGHT VEGETATION | 1 | AC | 3825.00 | 3,825 |
| GRADE | 1640 | CY | 2.00 | 3,280 |
| GRAVEL – 12" THICK | 4840 | SY | 3.50 | 16,940 |
| PARKING AREA | | | | |
| USE EXISTING AREA – OK AS IS | | | | |
| DECON AREA | | | | |
| USE EXISTING AREA – OK AS IS | | | | 0 |
| SUBTOTAL SITE PREPARATION | | | | $24,045 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
SITE PREPARATION AND MOBILIZATION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| SITE PREPARATION - TOTAL PAGE SHL5-3 | | | | $24,045 |
| MOBILIZATION | | | | |
| EQUIPMENT (IN OR OUT) | | | | |
| FRONT END LOADER | 2 | EA | 500.00 | 1,000 |
| DUMP TRUCK | 2 | EA | 250.00 | 500 |
| BACKHOE | 2 | EA | 250.00 | 500 |
| OFFICE TRAILER | 6 | MON | 150.00 | 900 |
| STORAGE TRAILER | 6 | MON | 150.00 | 900 |
| TRAILER DELIVERY, SET-UP, REMOVAL | 2 | EA | 300.00 | 600 |
| TOILET - 2 EA | 52 | WK | 25.00 | 1,300 |
| WATER COOLER - 2 EA | 52 | WK | 25.00 | 1,300 |
| WATER | 260 | DAY | 15.00 | 3,900 |
| TELEPHONE SERVICE | 6 | MON | 500.00 | 3,000 |
| ELECTRICITY | 6 | MON | 250.00 | 1,500 |
| PICK-UP | 6 | MON | 1000.00 | 6,000 |
| OFFICE EQUIPMENT | 6 | MON | 1000.00 | 6,000 |
| PUMPS, TOOLS, MINOR EQUIPMENT | 1 | LS | 2500.00 | 2,500 |
| LABORER (2 MEN*5 DAY/MAN*8 HR/DAY) | 80 | MNHR | 30.00 | 2,400 |
| CARPENTER (2 MEN*5 DAY/MAN*8 HR/DAY) | 80 | MNHR | 38.00 | 3,040 |
| ELECTRICIAN (2 MEN*5 DAY/MAN*8 HR/DAY) | 80 | MNHR | 41.50 | 3,320 |
| SITE SUPERINTENDANT (6 MON*210HR/MON) | 1260 | MNHR | 60.00 | 75,600 |
| FOREMAN (6 MON*210HR/MON) | 1260 | MNHR | 50.00 | 63,000 |
| CLERK/TYPIST (6 MON*168HR/MON) | 1008 | MNHR | 25.00 | 25,200 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 56,495 |
| TOTAL SITE PREPARATION AND MOBILIZATION | | | | $283,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
DITCH & LANDFILL COVER REPAIRS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| DITCH REPAIR | | | | |
| CLEAN DITCH - BACKHOE & OPERATOR | 2 | DAY | 1300.00 | $2,600 |
| LABORER - 2 EA | 32 | MNHR | 30.00 | 960 |
| DUMP TRUCK & DRIVER | 2 | DAY | 665.00 | 1,330 |
| RIPRAP - 1' THICKx15'Wx500'L | 300 | CY | 30.00 | 9,000 |
| LANDFILL COVER REPAIRS | | | | |
| FILL & PATCH "POND" IN COVER | | | | |
| BACKHOE & OPERATOR | 5 | DAY | 1300.00 | 6,500 |
| LABORER - 4 EA, 2 WKS/EA | 320 | MNHR | 30.00 | 9,600 |
| FILL MATERIAL | 300 | CY | 20.00 | 6,000 |
| GEOMEMBRANE | 60000 | SF | 0.35 | 21,000 |
| VIBRATORY PLATE COMPACTOR | 5 | DAY | 60.00 | 300 |
| 10-3 DRAINAGE SAND | 1100 | CY | 8.00 | 8,800 |
| FILTER FABRIC | 60000 | SF | 0.16 | 9,600 |
| 1' VEGETATIVE COVER | 1200 | CY | 7.50 | 9,000 |
| SEED, FERTILIZE, MULCH | 2 | AC | 2000.00 | 4,000 |
| SPREAD & COMPACT, EQUIP & OPER | 5 | DAY | 1450.00 | 7,250 |
| EVALUATION/IMPROVEMENT OF STORMWATER DIVERSION AND DRAINAGE | | | | |
| EVALUATION OF LANDFILL CAP RUNOFF PATTERNS, DITCH CAPACITIES, STORMWATER DRAINAGE SYSTEMS UPGRADIENT OF LANDFILL AND, RUN-UNDER ALONG WESTERN EDGE OF LANDFILL | 1 | LS | 43000.00 | 43,000 |
| REPLACE/INSTALL STORM SEWERS/DRAINS | | | | |
| 18" DIA RCP | 800 | LF | 45.00 | 36,000 |
| 24" DIA RCP | 800 | LF | 55.00 | 44,000 |
| 36" DIA RCP | 1600 | LF | 100.00 | 160,000 |
| REDUCE RUN-UNDER ALONG WESTERN EDGE | 1 | LS | 90000.00 | 90,000 |
| MONITORING WELL DRILLING | 3 | EA | 6600.00 | 19,800 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 122,260 |
| TOTAL DITCH & LANDFILL COVER REPAIRS | | | | $611,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
EXTRACTION SYSTEM/DISCHARGE PIPE CONSTRUCTION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| EXTRACTION SYSTEM CONSTRUCTION | | | | |
| 6" EXTRACTION WELL | 1 | EA | 6700.00 | $6,700 |
| 5 HP PUMP & CONTROLS | 1 | EA | 4000.00 | 4,000 |
| 4"/2" PE CONTAINMENT/FORCE MAIN | 2500 | LF | 20.00 | 50,000 |
| AIR RELEASE MANHOLE | 2 | EA | 3500.00 | 7,000 |
| DISCHARGE PIPE CONSTRUCTION | | | | |
| 4" DIA PE GRAVITY DISCHARGE PIPE | 3000 | LF | 15.00 | 45,000 |
| MANHOLE | 6 | EA | 2500.00 | 15,000 |
| RIPRAP AT OUTLET | 10 | CY | 30.00 | 300 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 30,700 |
| TOTAL EXTRACTION SYSTEM/DISCHARGE PIPE CONSTRUCTION | | | | $152,000 |

APPENDIX B

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
TREATMENT FACILITY CONSTRUCTION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| PRE-ENGINEERED STRUCTURE ON CONCRETE SLAB (28'x44'x15'H) | 1232 | SF | 65.00 | $80,080 |
| BUILDING HVAC & PLUMBING | 1232 | SF | 40.00 | 49,280 |
| BUILDING ELECTRICAL | 1232 | SF | 40.00 | 49,280 |
| CONCRETE CHEMICAL CONTAINMENT BERM | 40 | LF | 10.00 | 400 |
| INTERIOR PARTITION (ELEC ROOM/OFFICE) | 200 | SF | 8.00 | 1,600 |
| OFFICE CEILING | 150 | SF | 5.00 | 750 |
| OFFICE DOOR | 1 | EA | 750.00 | 750 |
| OFFICE WINDOW | 1 | EA | 400.00 | 400 |
| SEPTIC SYSTEM | 1 | LS | 5000.00 | 5,000 |
| ELECTRICAL SERVICE | 1600 | LF | 20.00 | 32,000 |
| POTABLE WATER LINE | 1200 | LF | 25.00 | 30,000 |
| FIRE HYDRANT | 1 | EA | 1000.00 | 1,000 |
| SUBTOTAL TREATMENT FACILITY | | | | $250,540 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
TREATMENT FACILITY CONSTRUCTION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| TOTAL PAGE SHL 5-7 | | | | $250,540 |
| TREATMENT SYSTEM | | | | |
| FEED PUMPS AND 10,000 GAL EQUALIZATION TANK | 1 | LS | 20000.00 | 20,000 |
| SAND FILTRATION EQUIPMENT | 1 | LS | 7950.00 | 7,950 |
| CARBON FILTRATION EQUIPMENT | 1 | LS | 6125.00 | 6,125 |
| BACKWASH SOLIDS REMOVAL EQUIPMENT | 1 | LS | 12580.00 | 12,580 |
| FILTER PRESS | 1 | LS | 16600.00 | 16,600 |
| ION EXCHANGE EQUIPMENT | 1 | LS | 75000.00 | 75,000 |
| EVAPORATION EQUIPMENT | 1 | LS | 65000.00 | 65,000 |
| INSTALLATION | 1 | LS | 40000.00 | 40,000 |
| START-UP & TRAINING | 1 | LS | 18500.00 | 18,500 |
| START-UP MONITORING & ANALYSIS | 1 | LS | 10000.00 | 10,000 |
| AIR COMPRESSOR | 1 | LS | 10000.00 | 10,000 |
| PROCESS PIPING - 4" SCH 80 PVC (PIPE, FITTINGS, SUPPORTS, VALVES, ETC.) | 250 | LF | 40.00 | 10,000 |
| PROCESS POWER CIRCUITS | 500 | LF | 10.00 | 5,000 |
| INSTRUMENTATION NOT SUPPLIED WITH EQUIPMENT | 10 | EA | 1000.00 | 10,000 |
| INSTRUMENTATION CIRCUITS | 500 | LF | 8.00 | 4,000 |
| CONTROL PANEL/MCC | 1 | LS | 25000.00 | 25,000 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 146,705 |
| TOTAL TREATMENT FACILITY CONSTRUCTION | | | | $733,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
INSTITUTIONAL CONTROLS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| INSTITUTIONAL CONTROLS | 1 | LS | 10000.00 | $10,000 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 3,000 |
| TOTAL INSTITUTIONAL CONTROLS | | | | $13,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE

| ANNUAL O&M COSTS<br>DESCRIPTION | QTY | UNIT | UNIT<br>COST | TOTAL |
|---|---|---|---|---|
| LANDFILL COVER GENERAL REPAIR | | | | |
| GENERAL MAINTENANCE | | | | |
| DUMP TRUCK & DRIVER | 1 | DAY | 665.00 | $665 |
| FRONT END LOADER & OPERATOR | 1 | DAY | 800.00 | 800 |
| LABORER - 2 EA | 16 | MNHR | 30.00 | 480 |
| MATERIALS | 1 | LS | 500.00 | 500 |
| MOWING - TRACTOR & OPERATOR | 4 | DAY | 500.00 | 2,000 |
| INSPECTION - 2 DAY @ 2 MEN/DAY | 32 | MNHR | 75.00 | 2,400 |
| INFLUENT & EFFLUENT GROUNDWATER WEEKLY MONITORING | | | | |
| VOCs | 104 | SMPL | 300.00 | 31,200 |
| INORGANICS - METALS | 104 | SMPL | 270.00 | 28,080 |
| INORGANICS - WATER QUAL PARAMETERS | 24 | SMPL | 215.00 | 5,160 |
| GROUNDWATER MONITORING | | | | |
| 14 WELLS, SEMI-ANNUALLY | 2 | EVENT | 8560.00 | 17,120 |
| GROUNDWATER SAMPLE ANALYSIS | 34 | SMPL | 785.00 | 26,690 |
| 14 SAMPLES PLUS 3 SAMPLE QA/QC EQUIVALENT | | | | |
| SEMI-ANNUALLY, VOCs, INORGANICS, WATER QUALITY PARAMETERS | | | | |
| LANDFILL GAS MONITORING | | | | |
| 18 POINTS, QUARTERLY AND ANALYSIS | 4 | EVENT | 3000.00 | 12,000 |
| | | | TOTAL THIS PAGE | $127,095 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-5: COLLECTION/ION EXCHANGE TREATMENT/DISCHARGE
ANNUAL O&M COSTS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| TOTAL PREVIOUS PAGE | | | | $127,095 |
| TREATMENT FACILITY OPERATION | | | | |
| FILTER PUMP | 15768 | MGAL | 0.70 | 11,038 |
| CARBON REPLACEMENT | 15768 | MGAL | 0.15 | 2,365 |
| SLUDGE DISPOSAL | 15768 | MGAL | 0.15 | 2,365 |
| IX ACID | 15768 | MGAL | 0.25 | 3,942 |
| IX CAUSTIC | 15768 | MGAL | 0.40 | 6,307 |
| IX EVAPORATOR | 15768 | MGAL | 3.10 | 48,881 |
| IX WASTE | 15768 | MGAL | 2.79 | 43,993 |
| IX PUMP | 15768 | MGAL | 0.02 | 315 |
| OPERATOR | 2080 | MNHR | 40.00 | 83,200 |
| BUILDING LIGHTING | 32400 | KWHR | 0.07 | 2,268 |
| BUILDING HEATING OIL | 500 | GAL | 1.00 | 500 |
| MISCELLANEOUS ELECTRICAL | 20000 | KWHR | 0.07 | 1,400 |
| EXTRACTION WELL PUMP | 33100 | KWHR | 0.07 | 2,317 |
| LANDFILL GAS COLLECTION SYSTEM MAINTENANCE | | | | |
| LABORER - 1 EA | 8 | MNHR | 30.00 | 240 |
| MATERIALS | 1 | LS | 250.00 | 250 |
| TWO YEAR REPORT TO DEP ANNUALIZED | 0.4878 | LS | 1000.00 | 488 |
| FIVE YEAR EDUCATIONAL PROGRAM PUBLIC MEETING - ANNUALIZED | 0.1810 | LS | 5000.00 | 905 |
| FIVE YEAR SITE REVIEW - ANNUALIZED | 0.1810 | LS | 15000.00 | 2,715 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 85,417 |
| TOTAL ANNUAL O&M COSTS | | | | $426,000 |

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 09-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
COST SUMMARY TABLE

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| DIRECT COST OF ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW | | | | |
| HYDROGEOLOGICAL STUDY | | | | $126,000 |
| SITE PREPARATION AND MOBILIZATION | | | | 134,000 |
| DITCH AND LANDFILL COVER REPAIRS | | | | 611,000 |
| EXTRACTION SYSTEM/DISCHARGE PIPE CONSTRUCTION | | | | 26,000 |
| INSTITUTIONAL CONTROLS | | | | 13,000 |
| TOTAL DIRECT COST OF ALTERNATIVE SHL-9: COLLECTION/ DISCHARGE TO POTW | | | | $910,000 |
| INDIRECT COST OF ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW | | | | |
| HEALTH AND SAFETY | | | 5.00% | $46,000 |
| LEGAL, ADMIN, PERMITTING | | | 5.00% | 46,000 |
| ENGINEERING | | | 10.00% | 91,000 |
| SERVICES DURING CONSTRUCTION | | | 10.00% | 91,000 |
| TOTAL INDIRECT COST OF ALTERNATIVE SHL-9: COLLECTION/ DISCHARGE TO POTW | | | | $274,000 |
| TOTAL CAPITAL (DIRECT + INDIRECT) COST | | | | $1,184,000 |
| OPERATING AND MAINTENANCE COSTS | | | | |
| TOTAL ANNUAL OPERATING AND MAINTENANCE COSTS | | | | $175,000 |
| TOTAL PRESENT WORTH OF ANNUAL O&M COSTS (5% FOR THIRTY YEARS) | | | | $2,690,000 |
| TOTAL COST OF ALTERNATIVE SHL-9: COLLECTION/ DISCHARGE TO POTW | | | | $3,874,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| HYDROGEOLOGICAL STUDY | | | | |
| MODELING, PERMEABILITY TESTS, WATER LEVELS, WELL INSTALLATION LABOR | 1 | LS | 57000.00 | $57,000 |
| PIEZOMETER INSTALLATION<br>1 SINGLE<br>4 NESTED PAIRS<br>2 NESTED TRIPLETS | 1 | LS | 44000.00 | 44,000 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 25,000 |
| TOTAL HYDROGEOLOGICAL STUDY | | | | $126,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
SITE PREPARATION AND MOBILIZATION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| SITE PREPARATION | | | | |
| STAGING AREA | | | | |
| CLEAR & GRUB LIGHT VEGETATION | 0.25 | AC | 3825.00 | $956 |
| GRADE | 410 | CY | 2.00 | 820 |
| GRAVEL - 12" THICK | 1210 | SY | 3.50 | 4,235 |
| PARKING AREA - USE EXISTING AREA - OK AS IS | | | | |
| DECON AREA - USE EXISTING AREA - OK AS IS | | | | |
| SURVEY | 1 | LS | 25000.00 | 25,000 |
| SUBTOTAL SITE PREPARATION | | | | $31,011 |

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 09-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
SITE PREPARATION AND MOBILIZATION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| SITE PREPARATION - SHEET 9-3 | | | | $31,011 |
| MOBILIZATION | | | | |
| EQUIPMENT (IN OR OUT) | | | | |
| FRONT END LOADER | 2 | EA | 500.00 | $1,000 |
| DUMP TRUCK | 2 | EA | 250.00 | 500 |
| BACKHOE | 2 | EA | 250.00 | 500 |
| OFFICE TRAILER | 2 | MON | 150.00 | 300 |
| STORAGE TRAILER | 2 | MON | 150.00 | 300 |
| TRAILER DELIVERY, SET-UP, REMOVAL | 2 | EA | 300.00 | 600 |
| TOILET - 2 EA | 16 | WK | 25.00 | 400 |
| WATER COOLER - 2 EA | 16 | WK | 25.00 | 400 |
| WATER | 80 | DAY | 15.00 | 1,200 |
| TELEPHONE SERVICE | 2 | MON | 500.00 | 1,000 |
| ELECTRICITY | 2 | MON | 250.00 | 500 |
| PICK-UP | 2 | MON | 1000.00 | 2,000 |
| OFFICE EQUIPMENT | 2 | MON | 1000.00 | 2,000 |
| PUMPS, TOOLS, MINOR EQUIPMENT | 1 | LS | 2500.00 | 2,500 |
| LABORER (2 MEN*5 DAY/MAN*8 HR/DAY) | 80 | MNHR | 30.00 | 2,400 |
| CARPENTER (2 MEN*5 DAY/MAN*8 HR/DAY) | 80 | MNHR | 38.00 | 3,040 |
| ELECTRICIAN (2 MEN*5 DAY/MAN*8 HR/DAY) | 80 | MNHR | 41.50 | 3,320 |
| SITE SUPERINTENDANT (2 MON*210HR/MON) | 420 | MNHR | 60.00 | 25,200 |
| FOREMAN (2 MON*210HR/MON) | 420 | MNHR | 50.00 | 21,000 |
| CLERK/TYPIST (2 MON*168HR/MON) | 336 | MNHR | 25.00 | 8,400 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 26,429 |
| TOTAL SITE PREPARATION AND MOBILIZATION | | | | $134,000 |

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 09-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
DITCH & LANDFILL COVER REPAIRS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| DITCH REPAIR | | | | |
| CLEAN DITCH - BACKHOE & OPERATOR | 2 | DAY | 1300.00 | $2,600 |
| LABORER - 2 EA | 32 | MNHR | 30.00 | 960 |
| DUMP TRUCK & DRIVER | 2 | DAY | 665.00 | 1,330 |
| RIPRAP - 1' THICKx15'Wx500'L | 300 | CY | 30.00 | 9,000 |
| LANDFILL COVER REPAIRS | | | | |
| FILL & PATCH "POND" IN COVER | | | | |
| BACKHOE & OPERATOR | 5 | DAY | 1300.00 | 6,500 |
| LABORER - 4 EA, 2 WKS/EA | 320 | MNHR | 30.00 | 9,600 |
| FILL MATERIAL | 300 | CY | 20.00 | 6,000 |
| GEOMEMBRANE | 60000 | SF | 0.35 | 21,000 |
| VIBRATORY PLATE COMPACTOR | 5 | DAY | 60.00 | 300 |
| 10-3 DRAINAGE SAND | 1100 | CY | 8.00 | 8,800 |
| FILTER FABRIC | 60000 | SF | 0.16 | 9,600 |
| 1' VEGETATIVE COVER | 1200 | CY | 7.50 | 9,000 |
| SEED, FERTILIZE, MULCH | 2 | AC | 2000.00 | 4,000 |
| SPREAD & COMPACT, EQUIP & OPER | 5 | DAY | 1450.00 | 7,250 |
| EVALUATION/IMPROVEMENT OF STORMWATER DIVERSION AND DRAINAGE | | | | |
| EVALUATION OF LANDFILL CAP RUNOFF PATTERNS, DITCH CAPACITIES, STORMWATER DRAINAGE SYSTEMS UPGRADIENT OF LANDFILL AND, RUN-UNDER ALONG WESTERN EDGE OF LANDFILL | 1 | LS | 43000.00 | 43,000 |
| REPLACE/INSTALL STORM SEWERS/DRAINS | | | | |
| 18" DIA RCP | 800 | LF | 45.00 | 36,000 |
| 24" DIA RCP | 800 | LF | 55.00 | 44,000 |
| 36" DIA RCP | 1600 | LF | 100.00 | 160,000 |
| REDUCE RUN-UNDER ALONG WESTERN EDGE | 1 | LS | 90000.00 | 90,000 |
| MONITORING WELL DRILLING | 3 | EA | 6600.00 | 19,800 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 122,260 |
| TOTAL DITCH & LANDFILL COVER REPAIRS | | | | $611,000 |

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 09-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
EXTRACTION SYSTEM/DISCHARGE PIPE CONSTRUCTION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| EXTRACTION SYSTEM CONSTRUCTION | | | | |
| 6" EXTRACTION WELL | 1 | EA | 6700.00 | $6,700 |
| 2 HP PUMP & CONTROLS | 1 | EA | 3500.00 | 3,500 |
| 3"/1.5" PE CONTAINMENT/FORCE MAIN | 500 | LF | 20.00 | 10,000 |
| CONNECT TO EXISTING MANHOLE | 1 | LS | 500.00 | 500 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 5,300 |
| TOTAL EXTRACTION SYSTEM/DISCHARGE PIPE CONSTRUCTION | | | | $26,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
INSTITUTIONAL CONTROLS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| INSTITUTIONAL CONTROLS | 1 | LS | 10000.00 | $10,000 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 3,000 |
| TOTAL INSTITUTIONAL CONTROLS | | | | $13,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005-12
ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT — DATE 09-Sep-94
FT. DEVENS, MASSACHUSETTS
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-9: COLLECTION/DISCHARGE TO POTW
ANNUAL O&M COSTS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| LANDFILL COVER MAINTENANCE | | | | |
| GENERAL REPAIR | | | | |
| DUMP TRUCK & DRIVER | 1 | DAY | 665.00 | $665 |
| FRONT END LOADER & OPERATOR | 1 | DAY | 800.00 | 800 |
| LABORER - 2 EA | 16 | MNHR | 30.00 | 480 |
| MATERIALS | 1 | LS | 500.00 | 500 |
| INSPECTION - 2 DAY @ 2 MEN/DAY | 32 | MNHR | 75.00 | 2,400 |
| MOWING - TRACTOR & OPERATOR | 4 | DAY | 500.00 | 2,000 |
| EFFLUENT GROUNDWATER WEEKLY MONITORING | | | | |
| VOCs | 52 | SMPL | 300.00 | 15,600 |
| INORGANICS | 52 | SMPL | 270.00 | 14,040 |
| GROUNDWATER MONITORING | 2 | EVENT | 8560.00 | 17,120 |
| 14 WELLS, SEMI-ANNUALLY | | | | |
| GROUNDWATER SAMPLE ANALYSIS | 34 | SMPL | 785.00 | 26,690 |
| 14 SAMPLES PLUS 3 SAMPLE QA/QC EQUIVALENT | | | | |
| SEMI-ANNUALLY, VOCs, INORGANICS, WATER QUALITY PARAMETERS | | | | |
| LANDFILL GAS MONITORING | 4 | EVENT | 3000.00 | 12,000 |
| 18 POINTS, QUARTERLY AND ANALYSIS | | | | |
| AYER WWTP FEE | 21080 | CCF | 2.00 | 42,160 |
| EXTRACTION WELL PUMP | 13070 | KWHR | 0.07 | 915 |
| LANDFILL GAS COLLECTION SYSTEM MAINTENANCE | | | | |
| LABORER - 1 EA | 8 | MNHR | 30.00 | 240 |
| MATERIALS | 1 | LS | 250.00 | 250 |
| TWO YEAR REPORT TO DEP - ANNUALIZED | 0.4878 | LS | 1000.00 | 488 |
| FIVE YEAR EDUCATIONAL PROGRAM | | | | |
| PUBLIC MEETING - ANNUALIZED | 0.1810 | LS | 5000.00 | 905 |
| FIVE YEAR SITE REVIEW - ANNUALIZED | 0.1810 | LS | 15000.00 | 2,715 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 35,033 |
| TOTAL ANNUAL O&M COSTS | | | | $175,000 |

APPENDIX B

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 12-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP
COST SUMMARY TABLE

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| DIRECT COST OF ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP | | | | |
| MOBILIZATION | | | | $281,000 |
| COVER SYSTEM | | | | 14,817,000 |
| INSTITUTIONAL CONTROLS | | | | 13,000 |
| TOTAL DIRECT COST OF ALTERNATIVE SHL-10: INSTALLTION OF RCRA CAP | | | | $15,111,000 |
| INDIRECT COST OF ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP | | | | |
| HEALTH AND SAFETY | | | 5.00% | $756,000 |
| LEGAL, ADMIN, PERMITTING | | | 5.00% | 756,000 |
| ENGINEERING | | | 10.00% | 1,511,000 |
| SERVICES DURING CONSTRUCTION | | | 10.00% | 1,511,000 |
| TOTAL INDIRECT COST OF ALTERNATIVE SHL-10: INSTALLTION OF RCRA CAP | | | | $4,534,000 |
| TOTAL CAPITAL (DIRECT + INDIRECT) COST | | | | $19,645,000 |
| OPERATING AND MAINTENANCE COSTS | | | | |
| TOTAL ANNUAL OPERATING AND MAINTENANCE COSTS | | | | $84,000 |
| TOTAL PRESENT WORTH OF ANNUAL O&M COSTS (5% FOR THIRTY YEARS) | | | | $1,291,000 |
| TOTAL COST OF ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP | | | | $20,936,000 |

APPENDIX B

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES — JOB # 7005–12
ALTERNATIVE SHL–10: INSTALLATION OF RCRA CAP
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FT. DEVENS, MASSACHUSETTS — DATE 12–Sep–94
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL–10: INSTALLATION OF RCRA CAP
SITE PREPARATION & MOBILIZATION

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| SITE PREPARATION | | | | |
| STAGING AREA | | | | |
| CLEAR & GRUB LIGHT VEGETATION | 15 | AC | 3825.00 | $57,375 |
| GRADE | 15 | AC | 3300.00 | 49,500 |
| GRAVEL – 12" THICK | 1210 | SY | 3.50 | 4,235 |
| PARKING AREA – USE EXISTING AREA – OK AS IS | | | | |
| DECON AREA – USE EXISTING AREA – OK AS IS | | | | |
| SURVEY | 1 | LS | 25000.00 | 25,000 |
| MOBILIZATION – EQUIPMENT (IN OR OUT) | | | | |
| DOZER | 4 | EA | 1500.00 | 6,000 |
| DUMP TRAILER – 20 CY | 14 | EA | 800.00 | 11,200 |
| FRONT END LOADER | 4 | EA | 1250.00 | 5,000 |
| DUMP TRUCK – 12 CY | 4 | EA | 675.00 | 2,700 |
| BACKHOE | 4 | EA | 1500.00 | 6,000 |
| COMPACTOR | 28 | EA | 700.00 | 19,600 |
| OFFICE TRAILER | 1 | MON | 150.00 | 150 |
| STORAGE TRAILER | 1 | MON | 150.00 | 150 |
| TRAILER DELIVERY, SET–UP, REMOVAL | 2 | EA | 300.00 | 600 |
| TOILET | 4 | WK | 25.00 | 100 |
| WATER COOLER | 4 | WK | 25.00 | 100 |
| WATER | 20 | DAY | 15.00 | 300 |
| TELEPHONE SERVICE | 1 | MON | 500.00 | 500 |
| ELECTRICITY | 1 | MON | 250.00 | 250 |
| PICK–UP | 1 | MON | 1000.00 | 1,000 |
| OFFICE EQUIPMENT | 1 | MON | 1000.00 | 1,000 |
| PUMPS, TOOLS, MINOR EQUIPMENT | 1 | LS | 2500.00 | 2,500 |
| LABORER (1 MAN*5 DAY/MAN*8 HR/DAY) | 40 | MNHR | 30.00 | 1,200 |
| CARPENTER (1 MAN*5 DAY/MAN*8 HR/DAY) | 40 | MNHR | 38.00 | 1,520 |
| ELECTRICIAN (1 MAN*5 DAY/MAN*8 HR/DAY) | 40 | MNHR | 41.50 | 1,660 |
| SITE SUPERINTENDANT (1 MON*210HR/MON) | 210 | MNHR | 60.00 | 12,600 |
| FOREMAN (1 MON*210HR/MON) | 210 | MNHR | 50.00 | 10,500 |
| CLERK/TYPIST (1 MON*168HR/MON) | 168 | MNHR | 25.00 | 4,200 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 56,060 |
| TOTAL MOBILIZATION | | | | $281,000 |

APPENDIX B

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES JOB # 7005-12
ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FT. DEVENS, MASSACHUSETTS DATE 12-Sep-94
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP

| COVER SYSTEM DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| TEST PITTING/BORINGS TO CONFIRM LIMITS OF WASTE | 1 | LS | 20000.00 | $20,000 |
| BORROW STUDY | 1 | LS | 5000.00 | 5,000 |
| STRIP AND STOCKPILE EXISTING MATERIALS | | | | |
| TOPSOIL | 67760 | CY | 3.75 | 254,100 |
| BUILD-UP TO ACHIEVE 3% FINAL GRADE | 120000 | CY | 8.00 | 960,000 |
| CONTOUR TO ACHIEVE FINAL GRADE | 30 | AC | 2500.00 | 75,000 |
| COMPACTION | 30 | AC | 3500.00 | 105,000 |
| GAS VENT LAYER (USE EXISTING SYSTEM) | 0 | CY | 14.00 | 0 |
| GAS VENT PIPING, 4" DIA (USE EXISTING SYSTEI | 0 | LF | 5.00 | 0 |
| EXTEND GAS VENT RISERS | 18 | EA | 500.00 | 9,000 |

TOTAL THIS PAGE $1,428,100

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 12-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP

| COVER SYSTEM DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| TOTAL PAGE SHL10-3 | | | | $1,428,100 |
| CUSHION LAYER | 67760 | CY | 14.00 | 948,640 |
| GEOSYNTHETIC CLAY LINER | 84 | AC | 30000.00 | 2,520,000 |
| GEOMEMBRANE, 40 MIL VLDPE | 84 | AC | 20000.00 | 1,680,000 |
| DRAINAGE LAYER | 135520 | CY | 14.00 | 1,897,280 |
| GEOTEXTILE | 84 | AC | 5000.00 | 420,000 |
| BUFFER/FILTER LAYER | 135520 | CY | 10.00 | 1,355,200 |
| TOPSOIL LAYER | | | | |
| REUSE STOCKPILED MATERIAL | 67760 | CY | 7.00 | 474,320 |
| NEW MATERIAL | 67760 | CY | 10.00 | 677,600 |
| RIPRAP DRAINAGE DITCHES, 1' THICK | 833 | CY | 30.00 | 24,990 |
| REPLACE/INSTALL STORM SEWERS/DRAINS | | | | |
| 18" DIA RCP | 800 | LF | 45.00 | 36,000 |
| 24" DIA RCP | 800 | LF | 55.00 | 44,000 |
| 36" DIA RCP | 1600 | LF | 100.00 | 160,000 |
| FERTILIZE, SEED, MULCH | 84 | AC | 2000.00 | 168,000 |
| MONITORING WELL DRILLING | 3 | EA | 6600.00 | 19,800 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 2,963,070 |
| TOTAL COVER SYSTEM | | | | $14,817,000 |

PROJECT: FEASIBILITY STUDY FOR GROUP 1A SITES
ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP
JOB # 7005-12
LOCATION: SHEPLEY'S HILL LANDFILL OPERABLE UNIT
FT. DEVENS, MASSACHUSETTS
DATE 12-Sep-94
ENGINEER: ABB ENVIRONMENTAL SERVICES, INC.

ESTIMATOR: P. R. MARTIN

ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP
INSTITUTIONAL CONTROLS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| INSTITUTIONAL CONTROLS | 1 | LS | 10000.00 | $10,000 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 3,000 |
| TOTAL INSTITUTIONAL CONTROLS | | | | $13,000 |

| | | | |
|---|---|---|---|
| PROJECT: | FEASIBILITY STUDY FOR GROUP 1A SITES<br>ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP | JOB # | 7005-12 |
| LOCATION: | SHEPLEY'S HILL LANDFILL OPERABLE UNIT<br>FT. DEVENS, MASSACHUSETTS | DATE | 12-Sep-94 |
| ENGINEER: | ABB ENVIRONMENTAL SERVICES, INC. | | |
| ESTIMATOR: | P. R. MARTIN | | |

ALTERNATIVE SHL-10: INSTALLATION OF RCRA CAP
ANNUAL O&M COSTS

| DESCRIPTION | QTY | UNIT | UNIT COST | TOTAL |
|---|---|---|---|---|
| LANDFILL COVER MAINTENANCE | | | | |
| GENERAL REPAIR | | | | |
| DUMP TRUCK & DRIVER | 1 | DAY | 665.00 | $665 |
| FRONT END LOADER & OPERATOR | 1 | DAY | 800.00 | 800 |
| LABORER - 2 EA | 16 | MNHR | 30.00 | 480 |
| MATERIALS | 1 | LS | 500.00 | 500 |
| INSPECTION - 2 DAY @ 2 MEN/DAY | 32 | MNHR | 75.00 | 2,400 |
| MOWING - TRACTOR & OPERATOR | 4 | DAY | 500.00 | 2,000 |
| GROUNDWATER MONITORING<br>14 WELLS, SEMI-ANNUALLY | 2 | EVENT | 8560.00 | 17,120 |
| GROUNDWATER SAMPLE ANALYSIS<br>14 SAMPLES PLUS 3 SAMPLE QA/QC EQUIVALENT<br>SEMI-ANNUALLY, VOCs, INORGANICS, WATER QUALITY PARAMETERS | 34 | SMPL | 785.00 | 26,690 |
| LANDFILL GAS MONITORING<br>18 POINTS, QUARTERLY AND ANALYSIS | 4 | EVENT | 3000.00 | 12,000 |
| LANDFILL GAS COLLECTION SYSTEM MAINTENANCE | | | | |
| LABORER - 1 EA | 8 | MNHR | 30.00 | 240 |
| MATERIALS | 1 | LS | 250.00 | 250 |
| TWO YEAR REPORT TO DEP - ANNUALIZED | 0.4878 | LS | 1000.00 | 488 |
| FIVE YEAR EDUCATIONAL PROGRAM | | | | |
| PUBLIC MEETING - ANNUALIZED | 0.1810 | LS | 5000.00 | 905 |
| FIVE YEAR SITE REVIEW - ANNUALIZED | 0.1810 | LS | 15000.00 | 2,715 |
| UNDEVELOPED DESIGN DETAILS ~25% | | | | 16,748 |
| TOTAL ANNUAL O&M COSTS | | | | $84,000 |

# APPENDIX C

# CALCULATIONS OF INFLUENT CONCENTRATIONS

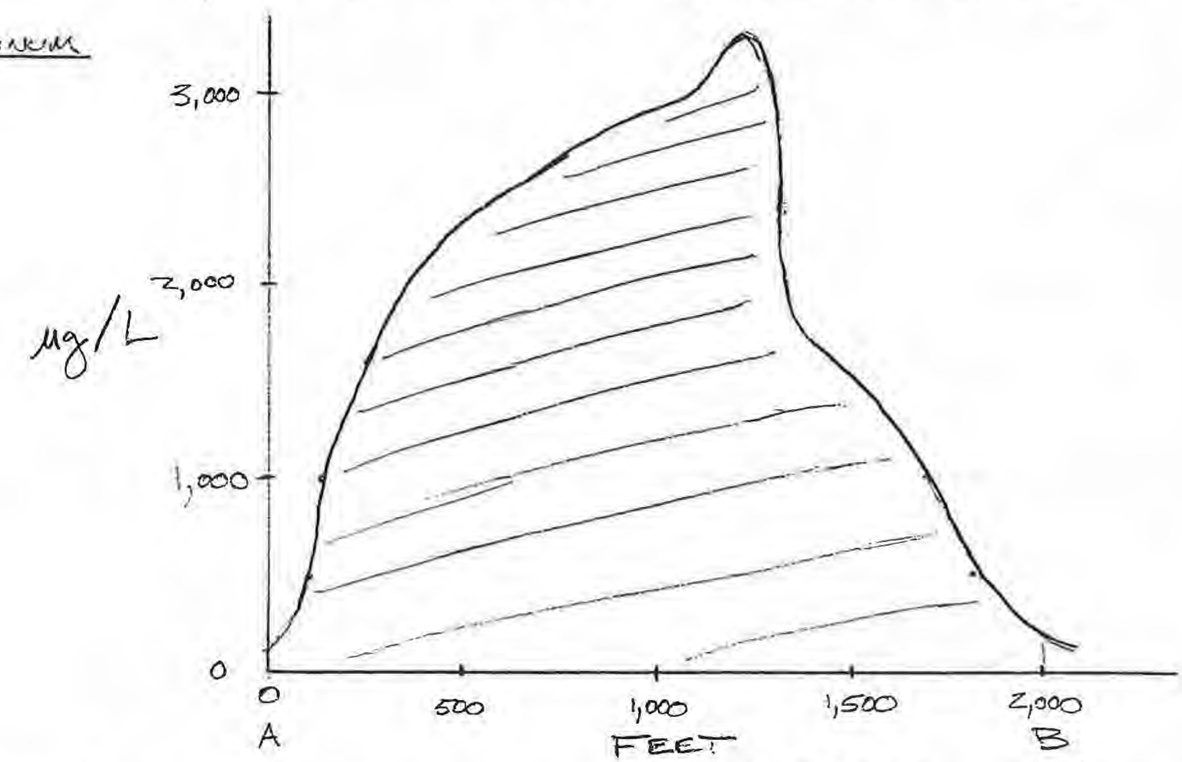
| PROJECT | COMP. BY | JOB NO. |
|---|---|---|
| TREATMENT PLANT INFLUENT CONCENTRATIONS – SHEPLEY'S HILL LANDFILL | JSM | 7005-07 |
| | CHK. BY: SNP | DATE: 8/11/93 |

REFERENCE: COST OF REMEDIAL ACTION MODEL, VERSION 3.0
SECTION 4 OF USERS MANUAL
"ESTIMATING CONCENTRATION IN RECOVERY WELLS"

ASSUMPTIONS:
1. PRODUCTION RATE IS UNIFORM THROUGHOUT THE LENGTH OF THE WELL SCREEN.
2. FLOW TO WELL IS STEADY AND DISPERSIVE EFFECTS IGNORED.
3. CONTAMINANT CONCENTRATIONS ARE UNIFORM THROUGHOUT THE LENGTH OF THE WELL SCREEN.
4. NO BIOCHEMICAL TRANSFORMATION OF CONTAMINANTS.
5. CALCULATED INFLUENT CONCENTRATIONS ARE DERIVED FROM MONITORING DATA WHICH REPRESENTS A GENERAL TREND OF CONTAMINATION IN A CROSS-SECTION ACROSS THE SITE.

SEQUENCE FOR EXTRACTION WELL INFLUENT CONCENTRATIONS:
1) PLOT CONCENTRATION CONTOURS ON SITE FIGURE.
2) PLOT CONCENTRATION VS. LENGTH OF CROSS-SECTION.
3) MEASURE AREA UNDER CURVE USING A PLANIMETER.
4) DIVIDE AREA UNDER CURVE BY CROSS-SECTION LENGTH
⟹ YIELDING WEIGHTED AVERAGE CONCENTRATIONS

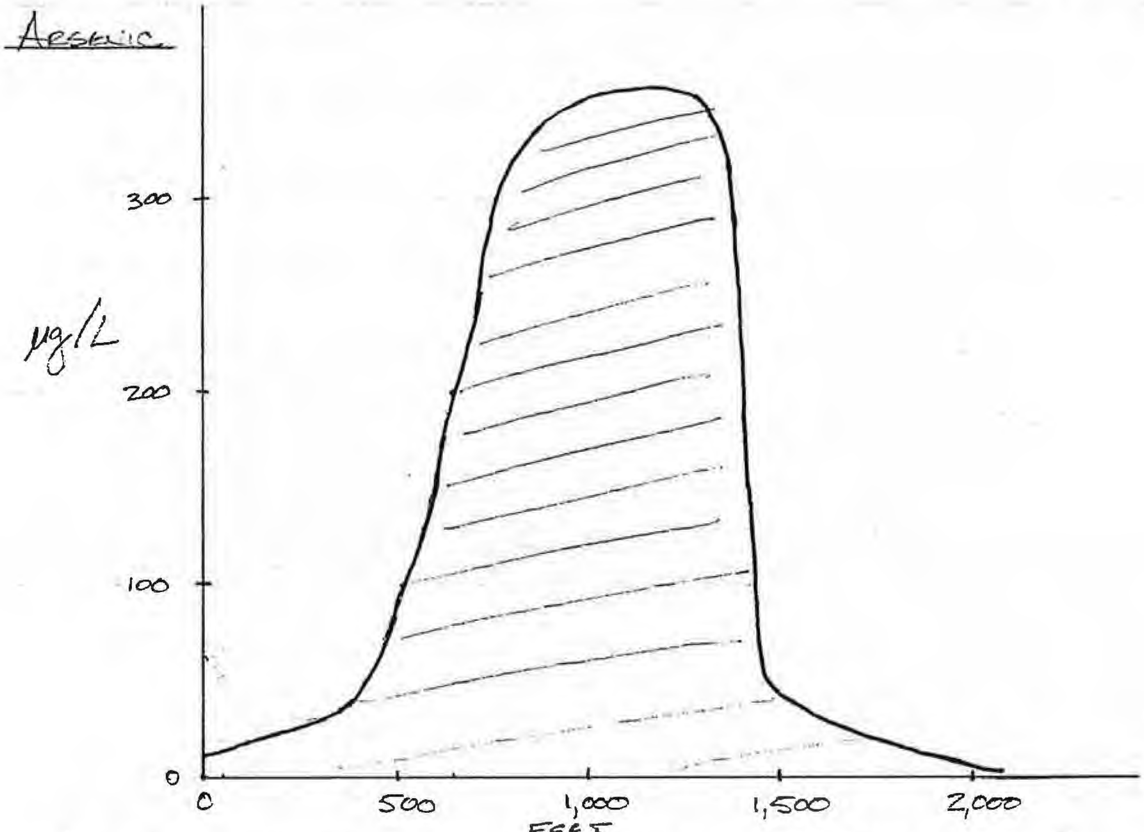
ALUMINUM




USING PLANIMETER, AREA UNDER CURVE = 3,735,507 FT-μg/L
⟹ ALUMINUM INFLUENT CONCENTRATION = 3,735,507/2,000 = 1,867 μg/L

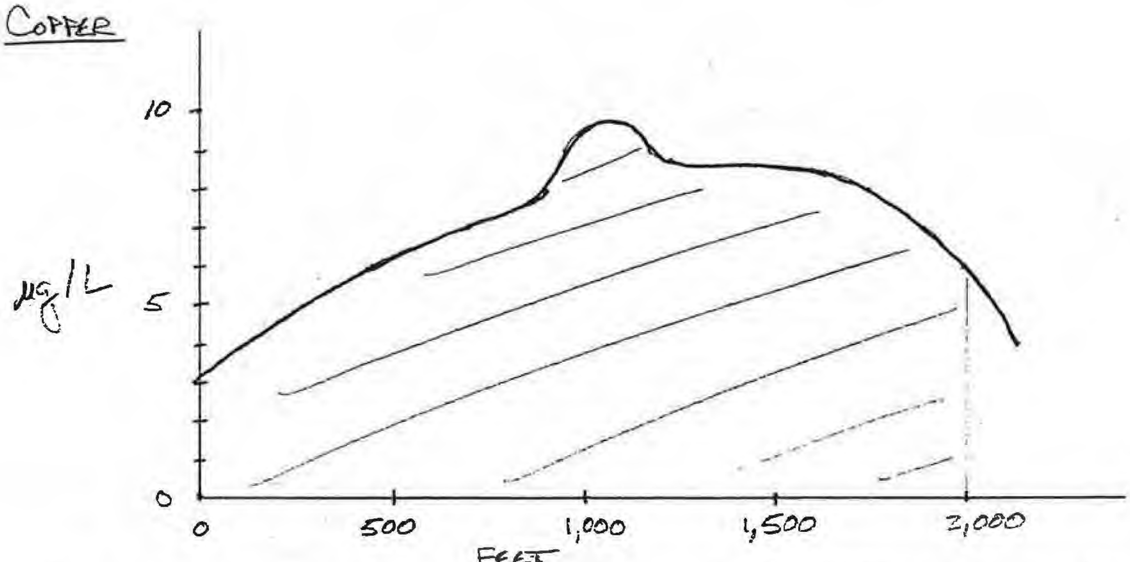
| PROJECT | COMP. BY JSM | JOB NO. 7005-07 |
|---|---|---|
| | CHK. BY SWP | DATE 8/11/93 |

ARSENIC



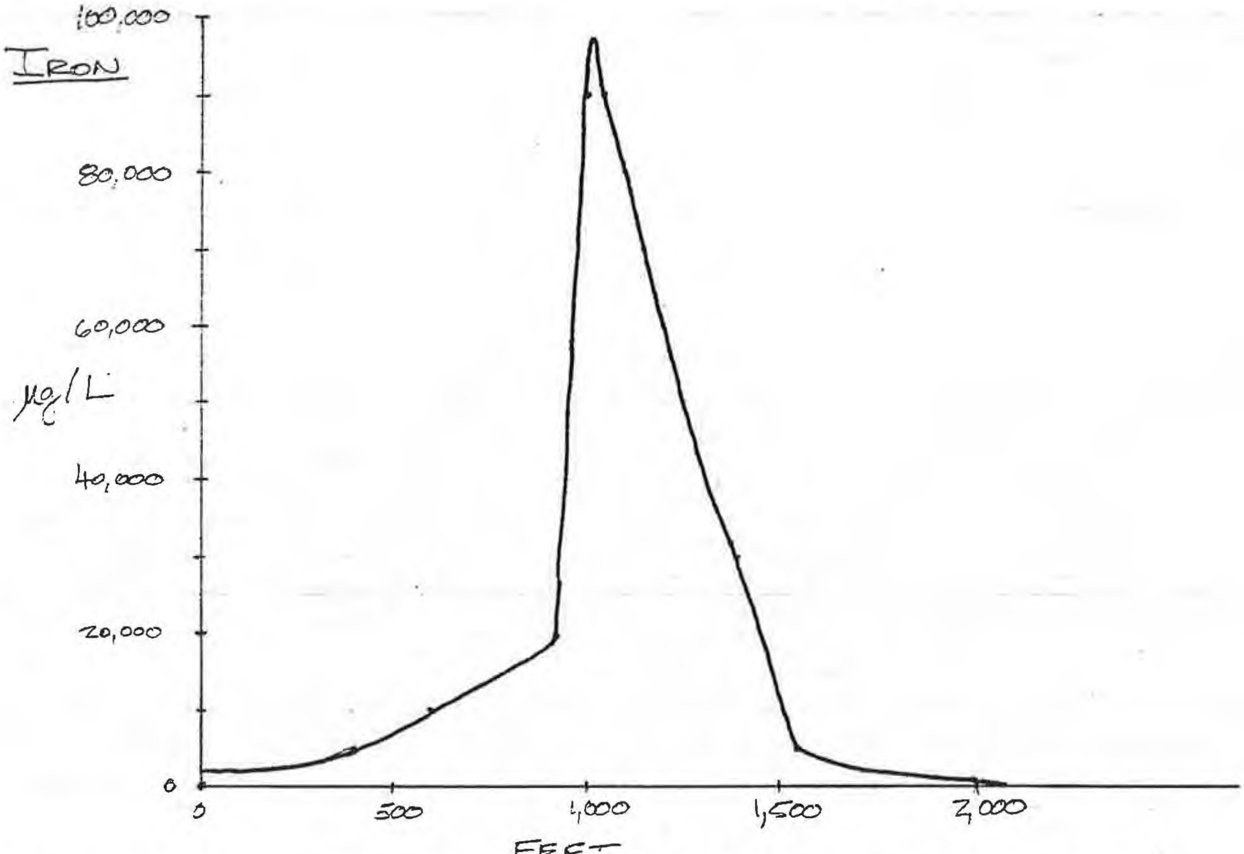

USING PLANIMETER, AREA UNDER CURVE = 299,150 FT-µg/L
⟹ ARSENIC INFLUENT CONCENTRATION = 299,150/2,000
= 150 µg/L

COPPER

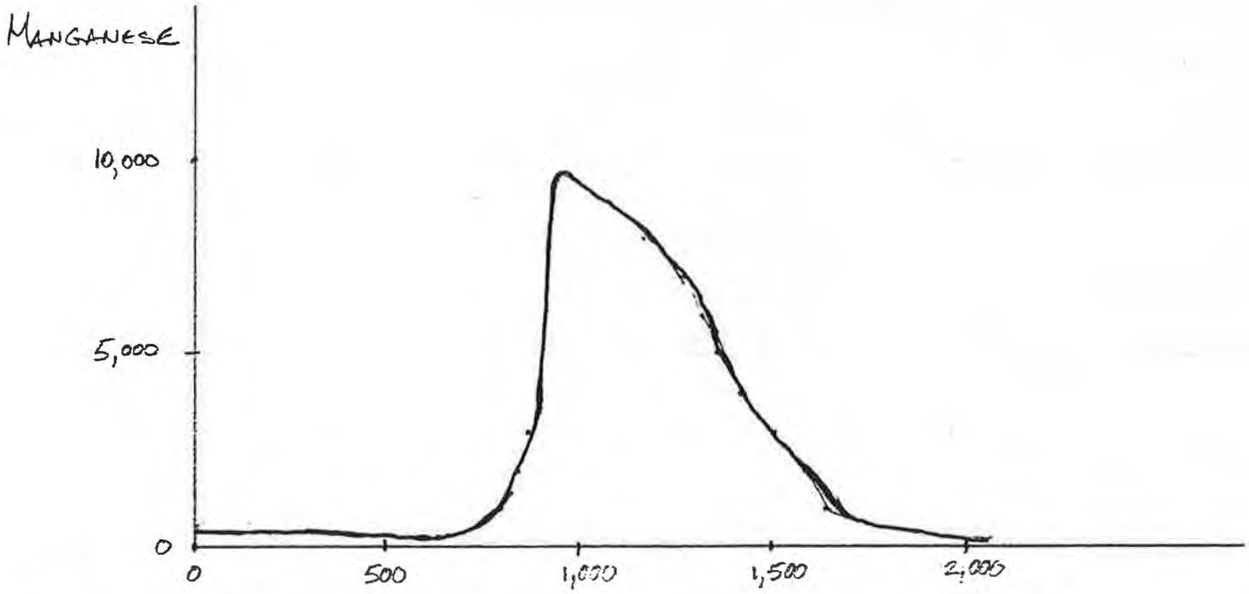



USING PLANIMETER, AREA UNDER CURVE = 14,550 FT-µg/L
⟹ COPPER INFLUENT CONCENTRATION = 14,550/2,000 ≅ 7.3 µg/L

| PROJECT | COMP. BY | JOB NO. |
|---|---|---|
| | JSM | 7005-07 |
| | CHK. BY | DATE |
| | SNP | 8/11/93 |



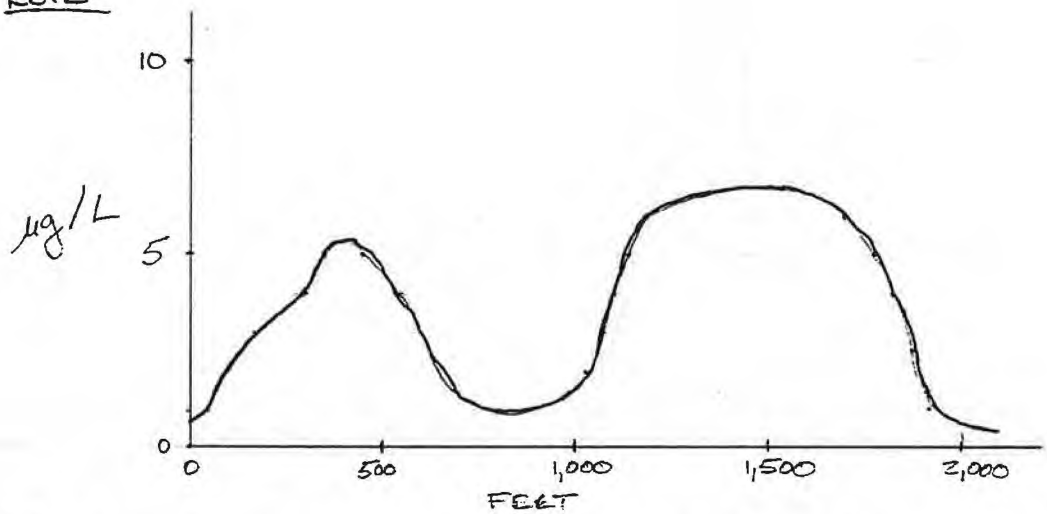

USING PLANIMETER, AREA UNDER CURVE = 30,612,561 FT-µg/L
⟹ IRON INFLUENT CONCENTRATION = 15,306 µg/L




USING PLANIMETER, AREA UNDER CURVE = 5,270,010 FT-µg/L
⟹ MANGANESE CONCENTRATION = 2,635 µg/L

| PROJECT | COMP. BY JSM | JOB NO. 7005-07 |
|---|---|---|
| | CHK. BY SNP | DATE 8/11/93 |

LEAD




USING PLANIMETER, AREA UNDER CURVE = 7,672 FT-µg/L
⇒ LEAD INFLUENT CONCENTRATION = 7,672 / 2,000 = 3.8 µg/L

IN SUMMARY:

| CONTAMINANT | TREATMENT PLANT INFLUENT CONCENTRATIONS |
|---|---|
| ALUMINUM | 1,870 µg/L |
| ARSENIC | 150 |
| COPPER | 7.3 |
| IRON | 15,306 |
| MANGANESE | 2,635 |
| LEAD | 3.8 |

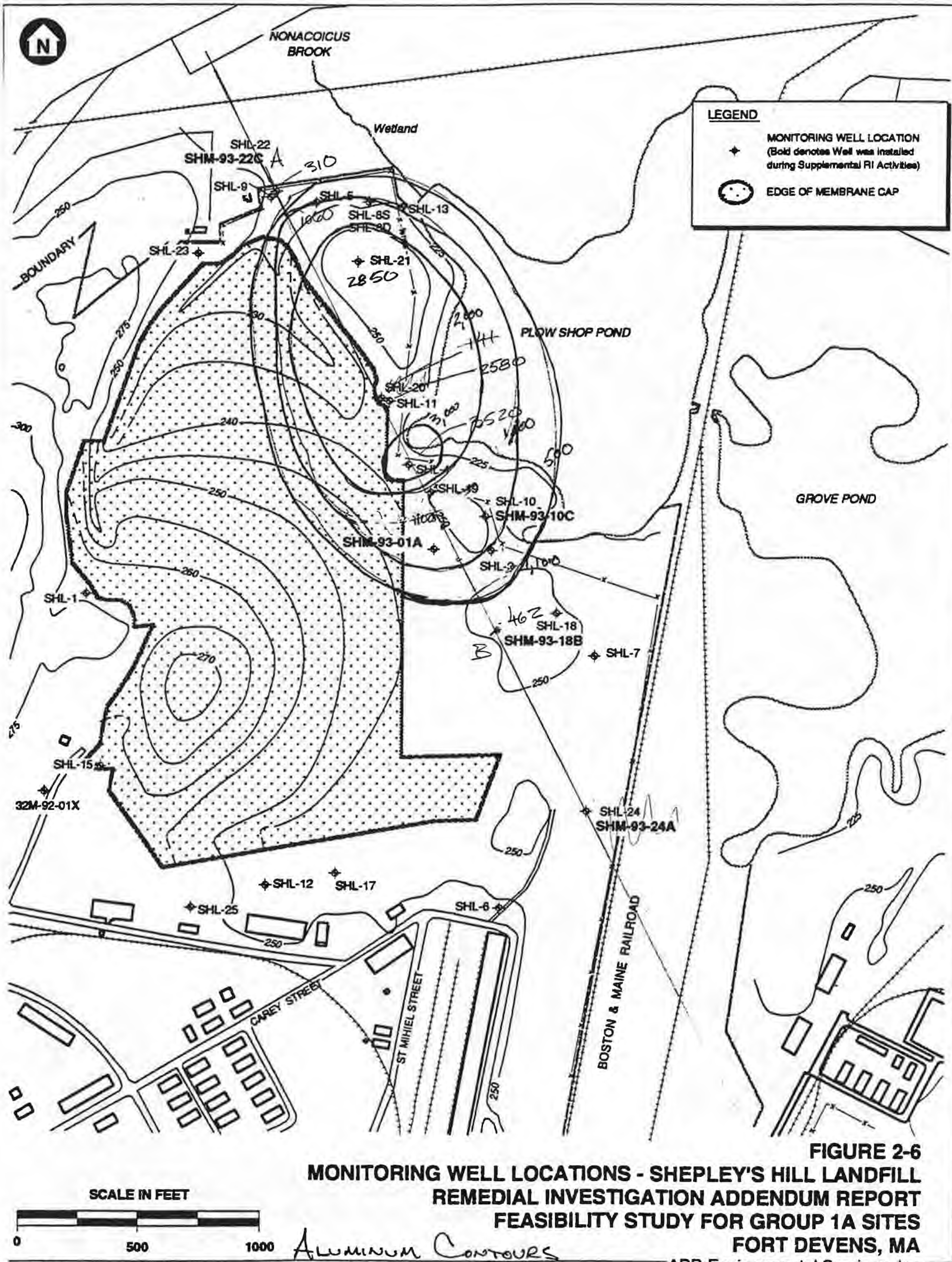



**FIGURE 2-6**
**MONITORING WELL LOCATIONS - SHEPLEY'S HILL LANDFILL**
**REMEDIAL INVESTIGATION ADDENDUM REPORT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ALUMINUM CONTOURS

ABB Environmental Services, Inc.

PAGE 6

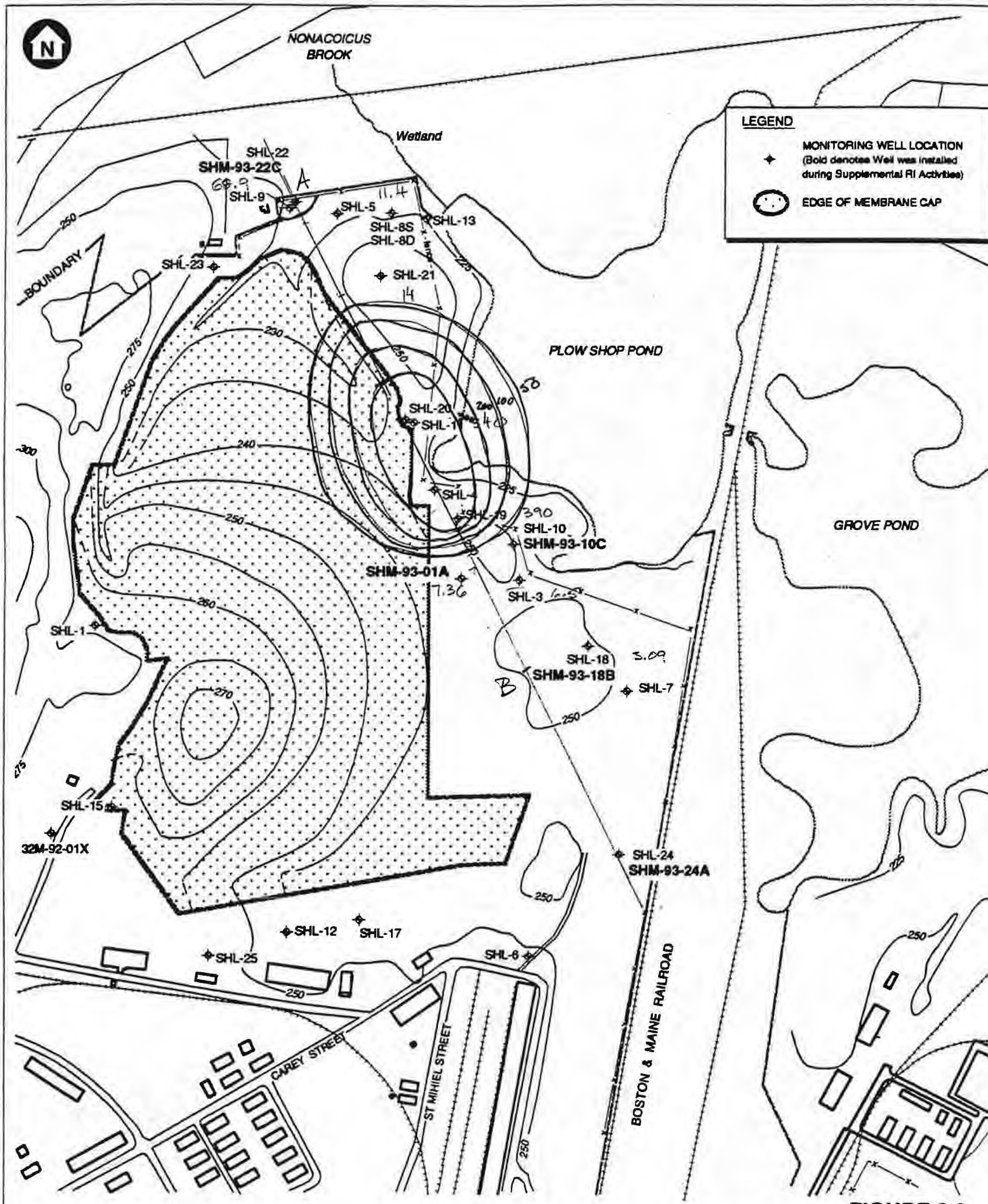


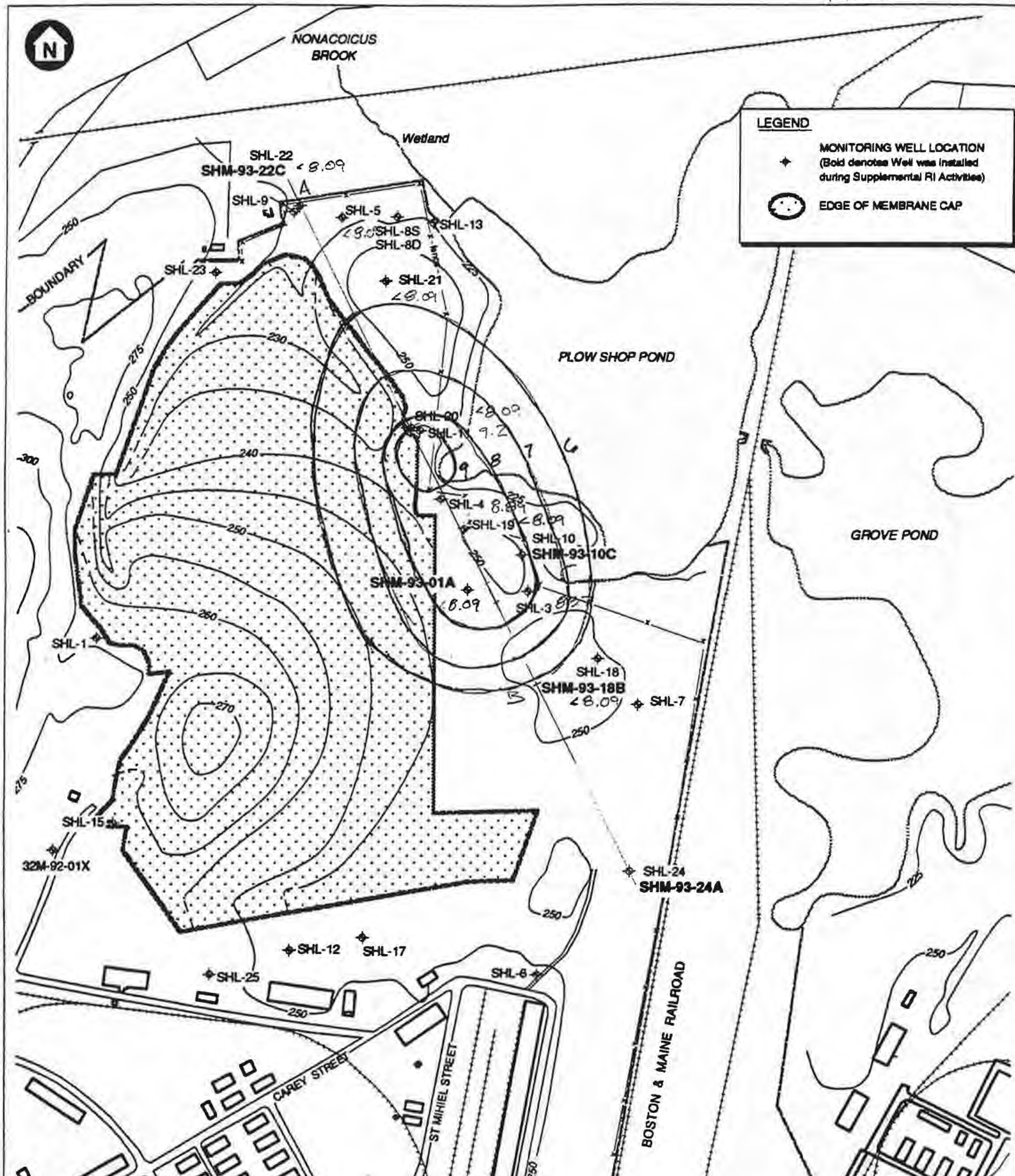

**FIGURE 2-6**
**MONITORING WELL LOCATIONS - SHEPLEY'S HILL LANDFILL**
**REMEDIAL INVESTIGATION ADDENDUM REPORT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

Arsenic Contours

ABB Environmental Services, Inc.

9303022D1ST

PAGE 7




Copper Contours

**FIGURE 2-6**
**MONITORING WELL LOCATIONS - SHEPLEY'S HILL LANDFILL**
**REMEDIAL INVESTIGATION ADDENDUM REPORT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

ABB Environmental Services, Inc.

9303022D1ST

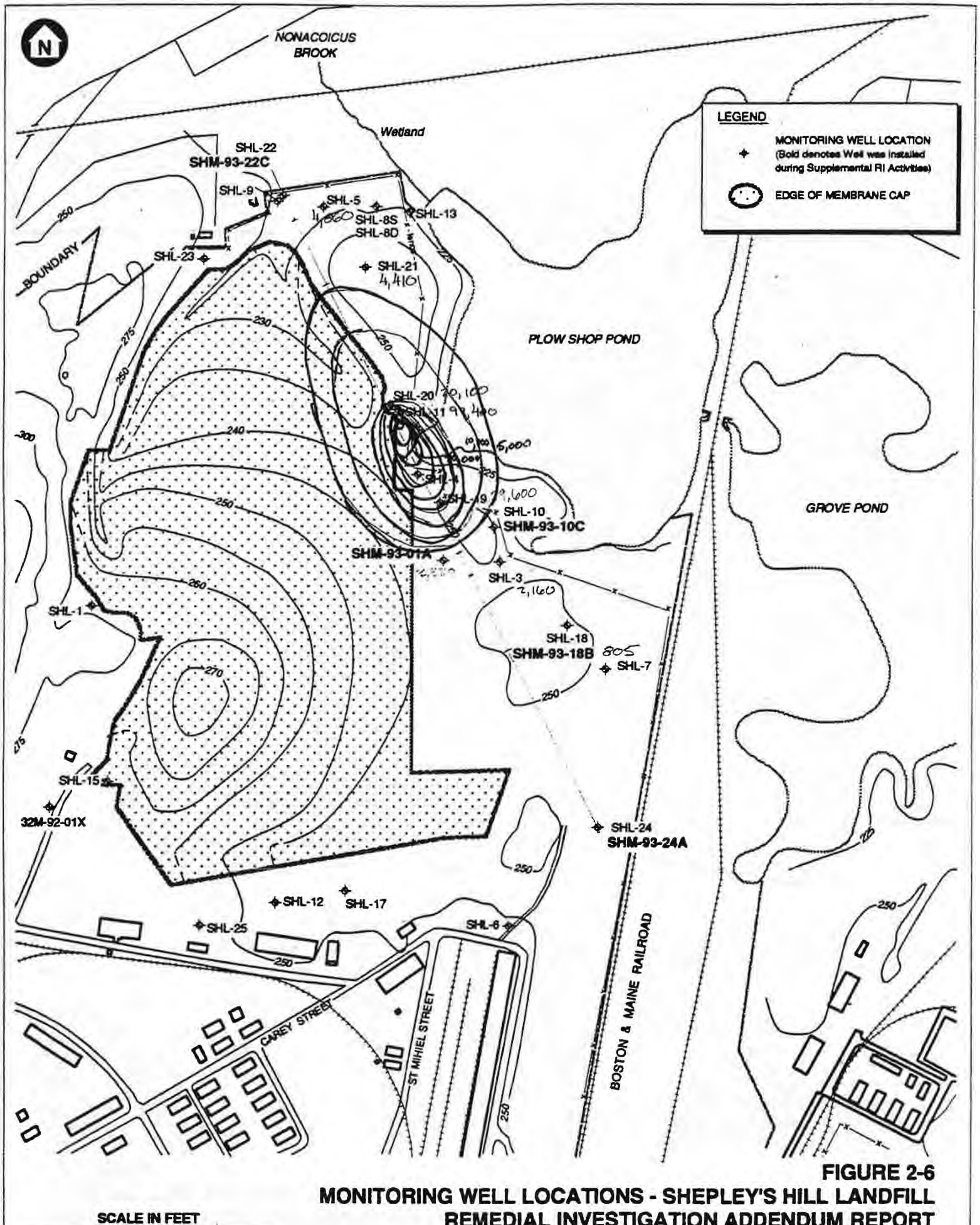



**FIGURE 2-6**
**MONITORING WELL LOCATIONS - SHEPLEY'S HILL LANDFILL**
**REMEDIAL INVESTIGATION ADDENDUM REPORT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**
ABB Environmental Services, Inc.

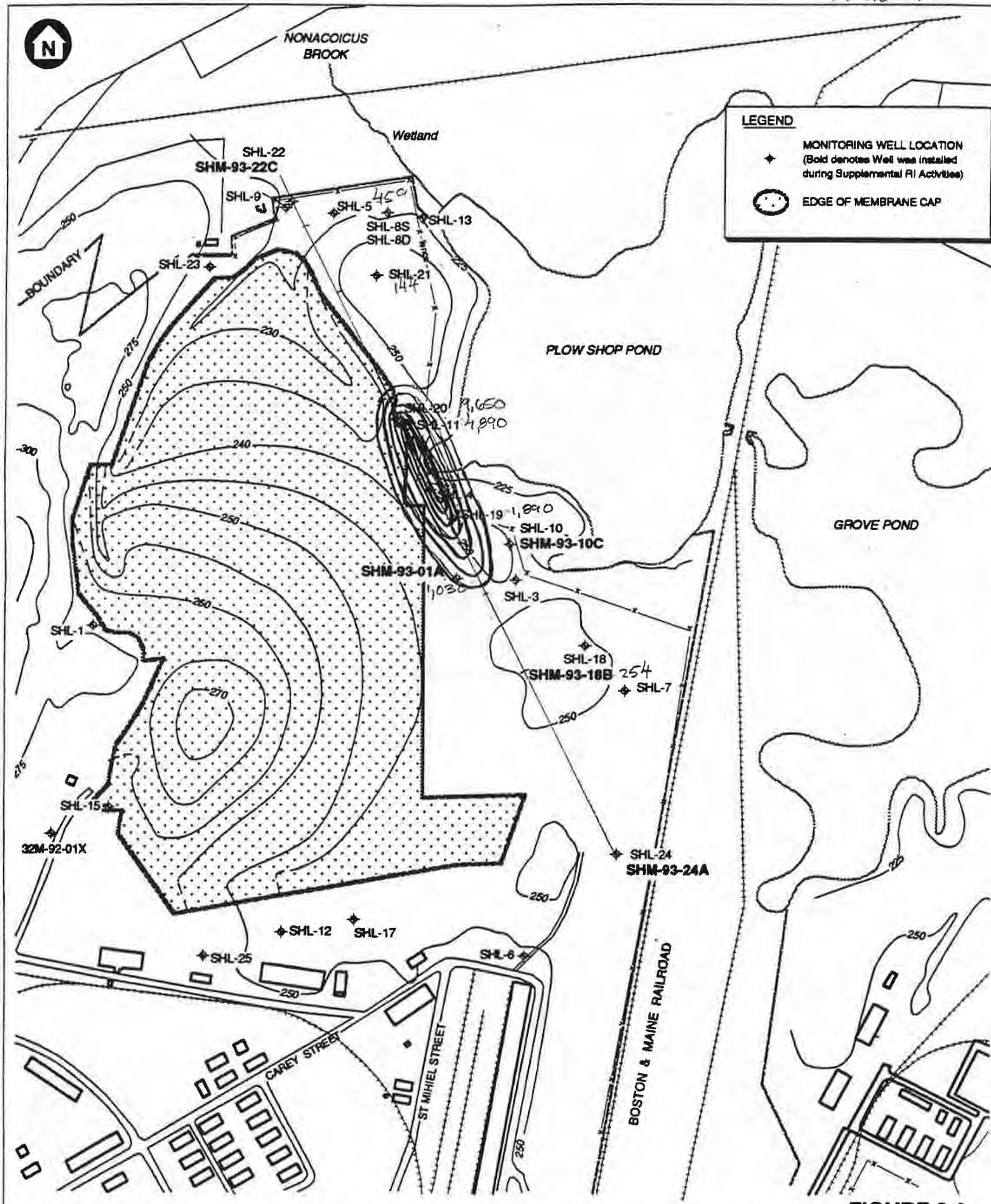



**FIGURE 2-6**
**MONITORING WELL LOCATIONS - SHEPLEY'S HILL LANDFILL**
**REMEDIAL INVESTIGATION ADDENDUM REPORT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**

MANGANESE CONTOURS

9303022D1ST

ABB Environmental Services, Inc.

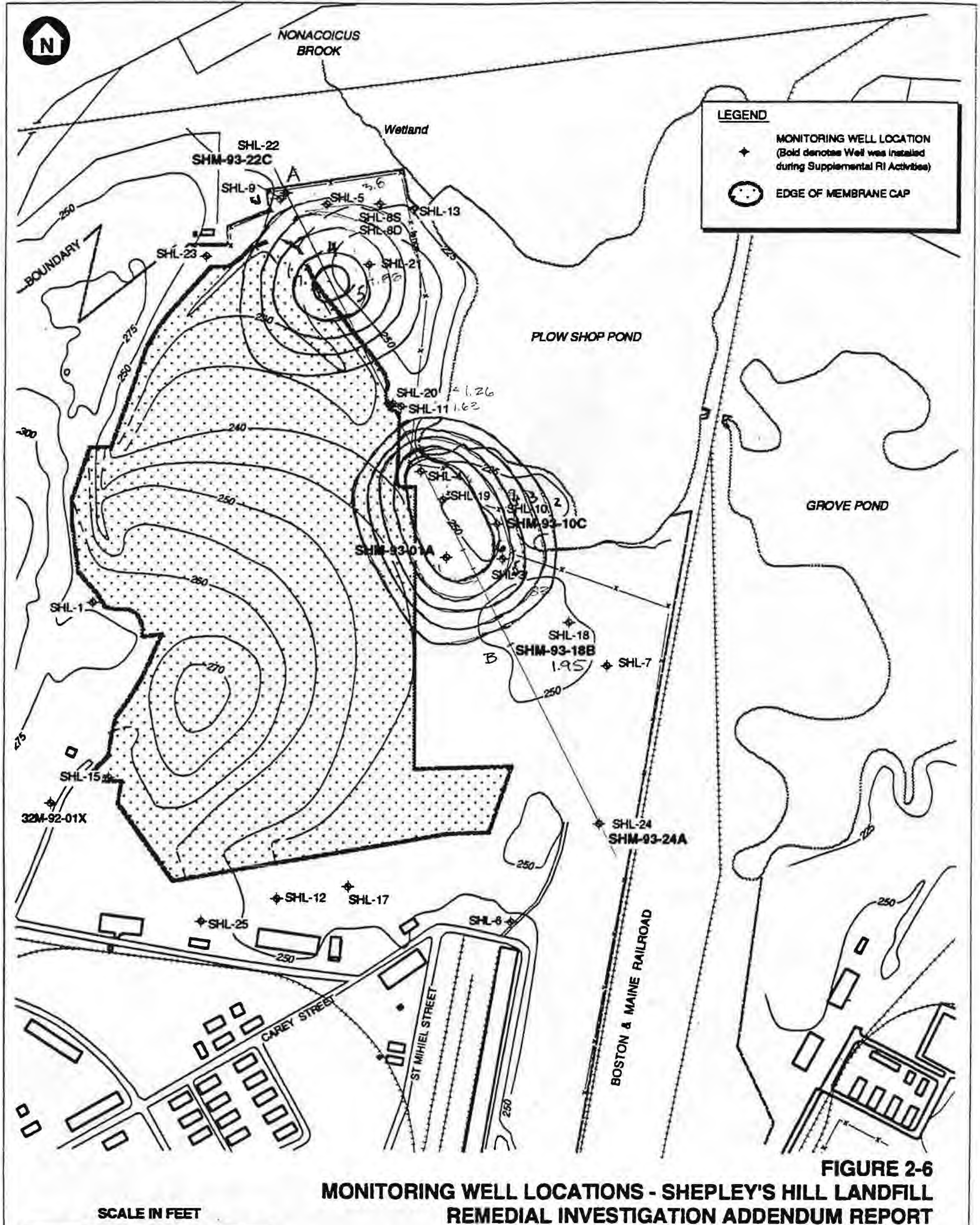



**FIGURE 2-6**
**MONITORING WELL LOCATIONS - SHEPLEY'S HILL LANDFILL**
**REMEDIAL INVESTIGATION ADDENDUM REPORT**
**FEASIBILITY STUDY FOR GROUP 1A SITES**
**FORT DEVENS, MA**
ABB Environmental Services, Inc.

# APPENDIX D

# CALCULATIONS OF DISCHARGE LIMITS

Calculation of Discharge Limitations

Backcalculate to prevent exceedances of AWQC in Nonacoicus Brook.

Ce = allowable effluent concentration
AWQC = Ambient water quality criteria, fresh water chronic, see backup calcs.
7Q10 = 7 day 10-year low flow in Nonacoicus Brook
Cb = ambient concentration in brook (i.e., sample SW-SHL-15)
Qe = effluent flow
SQL = sample quantitation limit

$$Ce = \frac{(AWQC)(7Q10 + Qe) - (7Q10)(Cb)}{Qe}$$

Aluminum

| | | | | |
|---|---|---|---|---|
| AWQC | = | 87 ug/L | Ce30= | 1876 ug/L |
| 7Q10 | = | 1167 gpm | Ce60= | 982 ug/L |
| Cb | = | 41 ug/L | | |
| Qe30 | = | 30 gpm | | Cb is one-half the SQL |
| Qe60 | = | 60 gpm | | |

Arsenic

| | | | | |
|---|---|---|---|---|
| AWQC | = | 190 ug/L | Ce30= | 7445 ug/L |
| 7Q10 | = | 1167 gpm | Ce60= | 3817 ug/L |
| Cb | = | 3.5 ug/L | | fresh water chronic |
| Qe30 | = | 30 gpm | | Cb is one-half the SQL |
| Qe60 | = | 60 gpm | | |

Chromium

| | | | | |
|---|---|---|---|---|
| AWQC | = | 88 ug/L | Ce30= | 3422 ug/L |
| 7Q10 | = | 1167 gpm | Ce60= | 1755 ug/L |
| Cb | = | 2.3 ug/L | | |
| Qe30 | = | 30 gpm | | Cb is one-half the SQL |
| Qe60 | = | 60 gpm | | |

Copper

| | | | | |
|---|---|---|---|---|
| AWQC | = | 4.8 ug/L | Ce30= | 102 ug/L |
| 7Q10 | = | 1167 gpm | Ce60= | 53 ug/L |
| Cb | = | 2.3 ug/L | | |
| Qe30 | = | 30 gpm | | Cb is one-half SQL |
| Qe60 | = | 60 gpm | | |

Manganese

| | | | | |
|---|---|---|---|---|
| AWQC | = | 1000 ug/L | Ce30= | 20839 ug/L |
| 7Q10 | = | 1167 gpm | Ce60= | 10920 ug/L |
| Cb | = | 490 ug/L | | 1000 from McKee and Wolf 1963 |
| Qe30 | = | 30 gpm | | Cb = observed in SW-SHL-15 |
| Qe60 | = | 60 gpm | | |

Nickel

| | | | | |
|---|---|---|---|---|
| AWQC | = | 65 ug/L | Ce30= | 2251 ug/L |
| 7Q10 | = | 1167 gpm | Ce60= | 1158 ug/L |
| Cb | = | 8.8 ug/L | | |
| Qe30 | = | 30 gpm | | |
| Qe60 | = | 60 gpm | | |

Iron

| | | | | |
|---|---|---|---|---|
| AWQC | = | 1000 ug/L | Ce30= | 25235 ug/L |
| 7Q10 | = | 1167 gpm | Ce60= | 13117 ug/L |
| Cb | = | 377 ug/L | | |
| Qe30 | = | 30 gpm | | fresh water chronic |
| Qe60 | = | 60 gpm | | Cb = avg in Plow Shop Pond |

Lead

| | | | | |
|---|---|---|---|---|
| AWQC | = | 0.85 ug/L | Ce30= | -59 ug/L |
| 7Q10 | = | 1167 gpm | Ce60= | -29 ug/L |
| Cb | = | 2.4 ug/L | | |
| Qe30 | = | 30 gpm | | Cb is one-half the SQL |
| Qe60 | = | 60 gpm | | |

| PROJECT | COMP. BY | JOB NO. |
|---|---|---|
| Shepley's Hill Landfill FS | SNP | 7005-04 |
| AWQC Values - Discharge Limitations | CHK. BY | DATE 3/4/94 |

Based on the Water Quality Criteria Summary Concentrations published by U.S. EPA - May 1, 1991

Aluminum - see 53 FR 33178

according to above guidance use 87 µg/L

Arsenic - freshwater chronic criteria is 190 µg/L

Chromium - the freshwater chronic criteria in the above mentioned guidance is based on a Hardness of 100 mg/L
Actual Hardness values are ~35 mg $CaCO_3$/L
according to 50 FR 30788, the 4 day average concentration in µg/L of Chromium(III) can not exceed

$$Cr = e^{(0.8190[\ln[Hardness]+1.561)}$$

$$Cr = e^{(0.8190[\ln 35]+1.561)}$$

$$Cr = 88 \mu g/L$$

Copper - Similar to chromium, according to 50 FR 30789, the 4 day average concentration in µg/L of copper can not exceed

$$Cu = e^{(0.8545[\ln hardness]-1.465)}$$

$$Cu = e^{(0.8545(\ln 35)-1.465)}$$

$$Cu = 4.8 \mu g/L$$

Iron - freshwater chronic criteria is 1000 µg/L

| PROJECT | COMP. BY SNP | JOB NO. 7005-04 |
|---|---|---|
| | CHK. BY | DATE 3/4/94 |

Lead - Similar to Chromium and copper, according to 50 FR 30791, the 4 day average concentration in ug/L of lead can not exceed

$$Pb = e^{(1.266[\ln(\text{hardness})] - 4.661)}$$

$$Pb = e^{(1.266[\ln 35] - 4.661)}$$

$$Pb = 0.85\ \mu g/L$$

Manganese - not established

Nickel - Similar to chromium and copper, according to 51 FR 43666, the 4 day average concentration in ug/L of Nickel can not exceed

$$Ni = e^{(0.8460[\ln \text{hardness}] + 1.1645)}$$

$$Ni = e^{(0.8460(\ln 35) + 1.1645)}$$

$$Ni = 65\ \mu g/L$$

# APPENDIX E

## WETLAND EVALUATION TECHNIQUE
## SHEPLEY'S HILL LANDFILL AREA

**NEW ENGLAND ENVIRONMENTAL, INC.**

Environmental Consulting Services

800 Main Street
Amherst, MA 01002
(413) 256-0202
FAX (413) 256-1092

24 November 1993

Mr. John Bleiler
ABB Environmental Services, Inc.
Corporate Place 128
107 Audubon Road
Wakefield, MA 01880

RE: Response to agency comments on WET assessment, Fort Devens, MA.
NEE file #93-1011

Dear Mr. Bleiler:

As requested, New England Environmental, Inc. (NEE) has reviewed the comments relative to the WET assessment of Cold Spring Brook and Plow Shop Ponds on the Fort Devens site. Below, we have listed each comment and our response:

**Comment 0-1**: "The watersheds, input zones, and service areas for each assessment area need to be described and added to Figure 1. The locality and region used in the analysis also need to be defined".

NEE response: The watershed boundaries for each AA were originally included within Figure 1, although they were not labeled. Figure 1 has been revised so that the watershed boundaries within the figure have been labelled. AA1 has a small watershed, and almost the entire area is shown on Figure 1. However, the watershed for AA2 is very extensive, and covers a large portion of the USGS Ayer and Hudson Quadrangles. Therefore, the entire watershed could not be shown on Figure 1. Attached are photocopies of the USGS maps, which show the entire watershed.

As stated in the WET manual, the input zone "includes the area 300 feet upslope from the AA boundary". Since the AAs are not tributaries, the other variables of the IZ are not used. The IZs were not originally shown on Figure 1 for purposes of clarity; however, they have been added to Figure 1 and are represented by a dashed line around each AA.

The WET manual defines Service Area as "the point to which the service is delivered....The potential exists for any number of service areas to occur downstream of the AA". The watershed of AA1 is less than 20 square miles. Therefore, according to the WET manual, Service Areas within 5 miles downstream of the AA should be considered. Since the watershed of AA2 is greater than 20 square miles, the WET manual states that service areas within 10 miles downstream should be considered. Thus, it would be unreasonable to detail all Service Areas for each AA.

The Locality and Region were defined in the Site Documentation Form A attached to the report. Locality was defined as the Town of Ayer, while Region was defined as the State of Massachusetts.

**Comment 0-2**: "The discussion on these pages [4-8] needs to be augmented since the text often does not adequately describe why a particular function or value received a particular rating. For example, on Page 8 paragraph 2, the text provides no explanation as to why the two functions listed received MODERATE ratings".

NEE response: This section has been augmented in order to provide information on the WET value assigned for each function. However, it must be understood that the rating assigned by WET for a particular function is based upon the responses to a wide range of questions. A complete discussion of why a particular function or value received a particular rating is beyond the scope of the report; see the Keys in the *Method for Wetland Functional Assessment* (1983) and the *Wetland Evaluation Technique Literature Review and Evaluation Rationale* (Adamus et al, 1991) for the complete list of questions and responses and their impact upon the WET results.

**Comment 0-3**: "The HIGH rating for breeding wildlife is questionable for Plow Shop Pond due to poor emergent growth and low vegetation/water interspersion, which would provide relatively poor quality brood-rearing habitat for waterfowl".

NEE response: The High rating referenced (page 8, paragraph 1), is under the Social Significance evaluation of Plow Shop Pond. The Social Significance, or the value of the wetland to society, of this function is determined by WET to be "High" due to the existence of "at least one wildlife species that is on USFWS National Species of Special Emphasis List (Table 1) and is rare or declining in the region". Table 1 lists black duck, a species which is declining in the region and which has been sighted in the AA by NEE biologists.

The poor emergent growth and low vegetation and water interspersion in Plow

Shop Pond are two factors which would reduce the Effectiveness of the area for waterfowl breeding. However, there are a number of other factors which contribute to WET's "High" rating for this function. For example, Plow Shop Pond is located near forested wetlands; these adjacent wetlands of a different type are of high importance as a predictor for breeding (WET literature review). Similarly, the edge of the wetland contains "special habitat features" as defined by WET, such as fruit bearing shrubs (highbush blueberry) and mast-bearing trees (oak); this is also of high importance to this function. Other factors contributing to the "High" rating by WET include the substrate type, low salinity, and the fact that there are preferred food plants within the AA such as *Nymphaea odorata* and *Brasenia schreberi*, which are considered by WET to be preferred food plants for waterfowl.

**Comment 0-4**: "The assumptions used in the impact evaluation need to be more completely stated. In particular, the text needs to discuss if it is assumed that groundwater will be remediated, if Grove Pond will be concurrently remediated (these two issues relate to recontamination impacts on the wetlands), and if any wetlands restoration procedures (e.g., plantings) were assumed".

NEE response: While groundwater remediation and the clean up of Grove Pond may take place, we have not assumed that this work will be completely effective in eliminating contaminants. Therefore, Question 27, which asks "is there a source that contributes waterborne contaminants (in concentrations hazardous to aquatic life) to the AA?" was answered "yes" for both the AA's and IA's. For most of the other questions, these assumptions, although perhaps important for a qualitative review of the effectiveness of the proposed remediation work, would have no impact on the outcome of the WET evaluation. For example, Question 26, "Nutrient Sources", asks if there is any potential nutrient source, such as a landfill, which is contributing nutrients to the AA. Even with groundwater remediation, there would still be a potential nutrient source, and the answer to this question would still be "yes". Similarly, the WET assessment would be the same with or without restoration plantings, since a three year time period was assumed for the IA assessment, which would allow for the natural re-establishment of vegetation without plantings. As stated in our report: "This time period is arbitrary, and was chosen to represent a sufficient length of time for aquatic bed vegetation to become re-established. If a shorter time period had been chosen, the WET assessment would have yielded more pronounced impacts. Conversely, since many of the impacts from the proposed work will become less important over time, a WET assessment of the area 5 or 10 years further into the future would have yielded fewer differences between the pre and post development functions and values."

**Comment 0-5**: "Due to the reduction in vegetation from dredging, it is not clear why functions such as production export are not predicted to be lower than existing (baseline) conditions. Please discuss".

NEE Response: As stated under the response to Question 0-4 above, the IA evaluation was conducted at a point in time three years subsequent to the dredging work, during which time the floating-leaved vegetation would likely have become re-established. If a shorter period of tifne had been used in the evaluation, then our evaluation would have assumed that the vegetation would not have had sufficient time to become re-established. As a result, the value of the production export function would have been reduced by the WET program.

**Comment 0-6**: "Grove Pond has significant sediment contamination and would not be a suitable reference wetland for the analysis described. Please modify the text accordingly".

NEE Response: The reference to Grove Pond has been deleted from the text.

Enclosed is a copy of our WET assessment which incorporates the above revisions. Please do not hesitate calling if you have any additional questions or comments.

Sincerely yours,
New England Environmental, Inc.

Ward W. Smith
Wetland Specialist/Soil Scientist

Michael J. Marcus
Senior Biologist
Principal

WWS/if
enc.

NEW ENGLAND ENVIRONMENTAL, INC.

# WETLAND EVALUATION TECHNIQUE (WET 2.0)

## PLOW SHOP AND COLD SPRING BROOK PONDS
## FORT DEVENS, AYER, MASSACHUSETTS

**Revised 24 November 1993**

**Prepared For:**

**ABB Environmental Services, Inc.**
**Northeast Region**
**Corporate Place 128**
**107 Audubon Road**
**Wakefield, MA 01880**

**Prepared By:**

**New England Environmental, Inc.**
**800 Main Street**
**Amherst, MA 01002**

**NEE File: 93-1011**

# I. WET 2.0 EVALUATIONS

## Introduction to WET

Wetland Evaluation Technique (WET) assessments were conducted on the existing and post-impact conditions in Cold Spring Pond and Plow Shop Pond, which are located on and adjacent to the Fort Devens Military Installation in Ayer, Massachusetts. WET is a standardized evaluation technique for wetlands which yields a rapid assessment of many of the recognized values and functions of a wetland. Functions and values were evaluated in a Level 2 WET assessment, which is generally considered to be a reasonable balance between time, available information, and level of confidence for most situations. WET uses a standardized manual and answer sheet to provide input data for the WET computer program (See Appendix 1). After data are entered into the WET program, a "Low", "Medium", or "High" value is assigned to each function based upon this input.

A combination of eleven functions (i.e., physical, chemical, and biological characteristics) and values (characteristics beneficial to society) are evaluated by the WET program. Each of these functions and values is defined below. These definitions are found in *Wetland Evaluation Technique Literature Review and Evaluation Rationale* (Adamus et al, 1991).

* **Ground Water Recharge** "is the movement of surface water or precipitation into the ground water flow system".

* **Ground Water Discharge** "is the movement (usually laterally or upward) of ground water into surface water".

* **Floodflow Alteration** "is the process by which peak flows from run-off, surface flow, ground water interflow and discharge, and precipitation enter a wetland and are stored or delayed in their downslope journey".

* **Sediment Stabilization** "consists of both shoreline anchoring and dissipation of erosive forces".

* **Sediment/Toxicant Retention** "is the process by which suspended solids and chemical contaminants such as pesticides and heavy metals adsorbed to them are retained and deposited within a wetland".

* **Nutrient Removal/Transformation** "includes the storage of nutrients within the sediment or plant substrate; the transformation of inorganic nutrients to their

organic forms; and the transformation and subsequent removal of one nutrient (nitrogen) as a gas".

* **Production Export** "refers to the flushing of relatively large amounts of organic material (specifically, carbon from net annual primary and secondary productivity) from the wetland to downstream or adjacent deeper waters".

* **Wildlife Diversity/Abundance** "is the support of a notably great on-site diversity and/or abundance of wetland-dependant birds".

* **Aquatic Diversity/Abundance** "is the support of a notably great on-site diversity and/or abundance of fish or invertebrates that are mainly confined to the water and saturated soils".

* **Uniqueness/Heritage** "includes the use of wetlands for aesthetic enjoyment, nature study, education, scientific research, open space, preservation of rare or endemic species, protection of archaeologically or geologically unique features, maintenance of historic sites, and an infinite number of other mostly intangible uses".

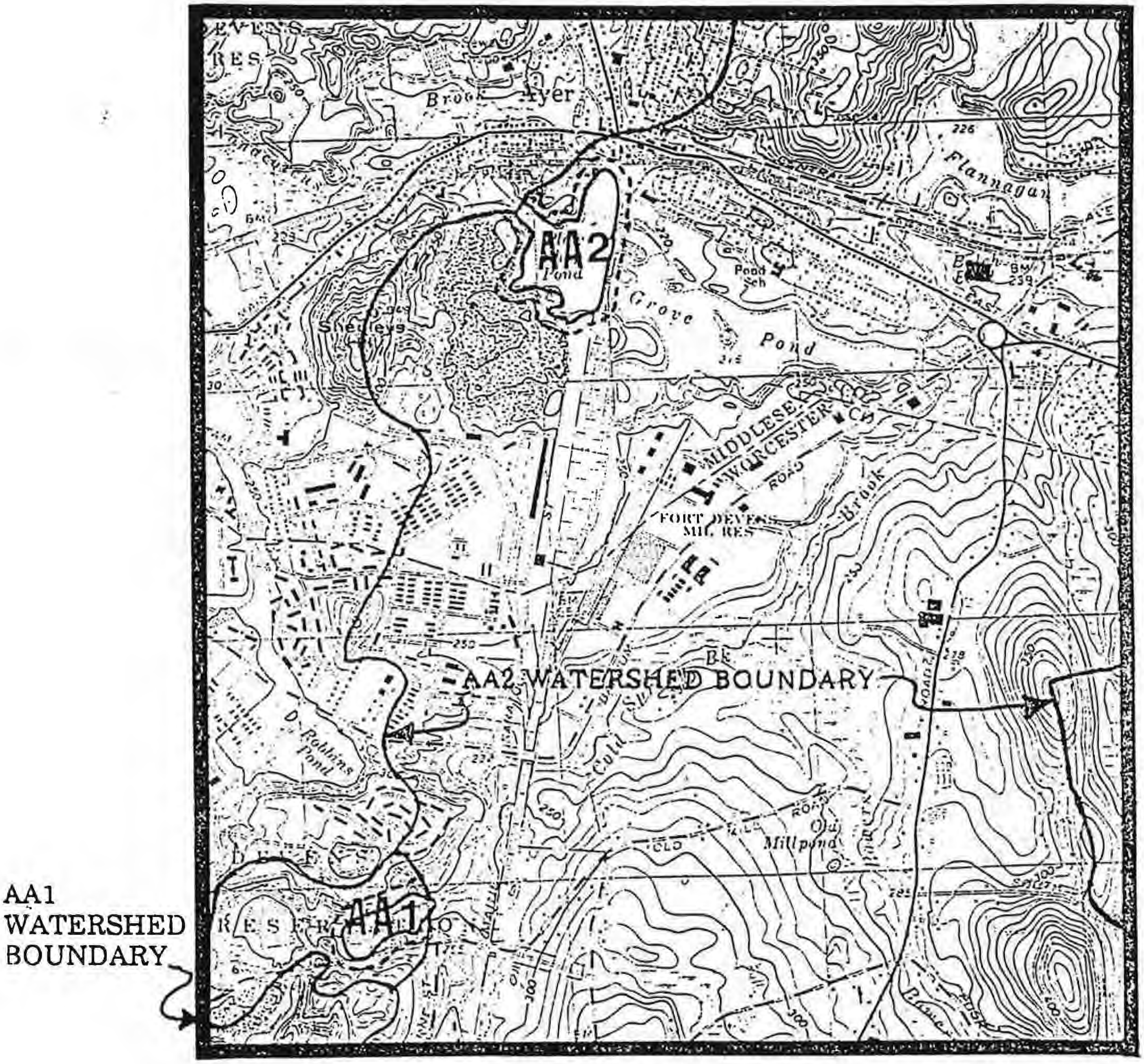
* **Recreation** "includes both consumptive (e.g., sport fishing, food gathering, hunting) and nonconsumptive (e.g., swimming, canoeing, kayaking, birding) forms of recreation that are water dependant and occur in either an incidental or obligatory manner in wetlands".

The above listed functions and values were evaluated by WET in the following contexts: **Social Significance** (the value of the wetland to society); **Effectiveness** (the capability of the wetland to provide the function); and **Opportunity** (the opportunity of the wetland to provide the function).

Using the criteria described in the WET manual, the Assessment Area (AA) for each pond was determined to include not only the ponds, but the surrounding fringe of woody wetland vegetation as well. A WET assessment was conducted based upon the entire AA. A WET evaluation of the probable impacts resulting from removing one foot of sediment from the bottom of each pond was conducted at a point in time three years subsequent to the completion of the work. No detailed plans have yet been formulated for the precise extent of the remediation work. In order to provide a meaningful comparison between the wetlands before and after this work, the boundaries of each Impact Area (IA) were assumed to be

FIGURE 1

**NEW ENGLAND ENVIRONMENTAL, INC.**




USGS AYER QUADRANGLE
SCALE: 1:25,000

identical to the AA boundary for each pond, although not all of the AA may be altered by the remediation work.

Data for the WET analysis were collected from a number of sources, including the following: site visits by NEE personnel; site reports and documentation provided by ABB, Inc.; previous ecological investigations data by Ecology & Environment, Inc. (June, 1992); the Soil Survey of Middlesex County; FEMA floodplain maps; the USGS Ayer quadrangle; and telephone conversations with the Soil Conservation Service, Natural Heritage and Endangered Species Program, and the National Climactic Data Center. Our evaluation of the WET results is based in part upon the *Wetland Evaluation Technique Literature Review and Evaluation Rationale* (Adamus et al, 1991) and the *Method for Wetland Functional Assessment* (1983).

## Cold Spring Brook Pond (AA1)

The first Assessment Area (AA1), Cold Spring Brook Pond, is located to the west of Marne Street (see Figure 1). The boundaries of this AA include the fringe of shrub swamp and wooded swamp which lies to the north of the pond. The western boundary of AA1 is the inlet stream from the upgradient wetland, while the eastern boundary is the culverted outlet beneath Patton Road. The southern limit of this AA is primarily a landfill slope.

### Social Significance of AA1

Social Significance is the value of a wetland to society. As shown in Table 1, WET rates the value of Cold Spring Brook Pond to society as "High" for Wildlife Diversity and Abundance as well as Uniqueness and Heritage. The Social Significance of Plow Shop Pond for Wildlife Diversity and Abundance is rated by WET as "High" based upon the existence of black duck, a species that is on the USFWS National Species of Special Emphasis List and is declining in the region. The Social Significance of the Uniqueness and Heritage value is rated as "High" due, in part, to the presence of a long-term monitoring program on the adjacent landfill.

**Table 1: Summary of Wet Results for Cold Spring Brook Pond**

| | Social Significance | Effectiveness | Opportunity |
|---|---|---|---|
| Ground Water Recharge | M | L | * |
| Ground Water Discharge | M | M | * |
| Floodflow Alteration | L | M | M |
| Sediment Stabilization | L | H | * |
| Sediment/Toxicant Retention | L | H | H |
| Nutrient Removal/Transformation | L | H | H |
| Production Export | * | M | * |
| Wildlife Diversity/Abundance | H | * | * |
| Wildlife D/A Breeding | * | H | * |
| Wildlife D/A Migration | * | H | * |
| Wildlife D/A Wintering | * | L | * |
| Aquatic Diversity/Abundance | L | L | * |
| Uniqueness/Heritage | H | * | * |
| Recreation | L | * | * |

Note: "H" = High, "M" = Moderate, "L" = Low, "U" = Uncertain, and "*"'s identify conditions where functions and values are not evaluated

The Social Significance of the ground water functions are rated by WET as "Moderate" for this wetland, which is largely due to the downgradient wellfields. The remainder of the evaluated functions are "Low" in Social Significance. The low value of many of these functions is due in part to the small size and watershed of this AA. In addition, the Social Significance of the Floodflow Alteration function is low due to the lack of features of social or economic value within the floodplain to the AA. The Social Significance of the Sediment/Toxicant retention and Nutrient Removal/Transformation functions are low due in part to a lack of surface water drinking supplies or swimming areas downstream. The Social Significance of the Aquatic Diversity/Abundance is Low due to the lack of commercial fishing, recognized fisheries value of the AA, or the lack of any fish species which are on the USFWS National Species of Special Emphasis List. The Social Significance of the Recreation function is Low due to the fact that the AA is not a major public access point to a recreational waterway, nor is it recognized as an area which provides recreational opportunities that are locally deficient. The Social Significance of the Sediment Stabilization function is low because the AA does not act as a buffer to features situated in erosion prone areas.

**Effectiveness of AA1**

Effectiveness is the capability of a wetland to perform a given function. Using this parameter, WET rates Cold Spring Brook Pond as "High" for Sediment/Toxicant Retention, Nutrient Removal/Transformation, and Wildlife Breeding and Migration. The Effectiveness of the wetland in performing the Sediment/Toxicant Retention and Nutrient Removal/Transformation functions is enhanced by a number of factors including the low water velocity, constricted outlet, and the shallow water depth within this area. The Effectiveness of the wetland to provide the wildlife functions is based upon a number of factors, including the interspersion of openwater and vegetation in the wetland, the diversity of the different vegetation types, the shape of the upland/wetland edge, and the sapric substrates within the wetland. Since this function is relative to waterfowl, the fact that Cold Spring Brook Pond has several aquatic bed species which are important food sources for waterfowl increases the Effectiveness of this wetland for Wildlife Diversity/Abundance Migration.

The Effectiveness of this Assessment Area is rated as "Moderate" for Ground Water Discharge, Floodflow Alteration, and Production Export. The wetland is determined to be moderately effective for Ground Water Discharge due to a number of factors, including the landscape position of the AA. Floodflow Alteration Effectiveness is enhanced by the constricted outlet to the wetland. The Effectiveness of Production Export is a function of factors such as the vegetation classes found in the AA and the relatively large portion of its watershed the wetland occupies.

The Effectiveness of this wetland to provide several functions/values is rated as "Low" by WET. For example, the area will have a low value for wintering waterfowl (Wildlife Diversity/Abundance Wintering) due to the fact that it is a shallow wetland and becomes completely frozen during the winter months. Groundwater Recharge is Low due the wet key functions; since a level 3 assessment was not run, question 60 was not answered "N", and the program assigned a "low" value. If question 60 had been answered "N", the WET program would have yielded an "Uncertain" rating. However, the majority of wetlands in New England are not recharge wetlands. Aquatic Diversity/Abundance is low due to the presence of the adjacent landfill combined with the lack of a perennial outlet, which would tend to trap contaminants within the AA.

**Opportunity of AA1**

Most of the functions and values are not evaluated for Opportunity in a Level 2 WET Assessment. Of the three functions/values evaluated, the opportunity for Cold Spring Pond to perform the Sediment/Toxicant Retention and Nutrient Removal/Transformation functions is rated as "High" by WET. Cold Spring Pond has the opportunity to provide these functions due to the proximity of the adjacent landfill. Floodflow Alteration is rated as "Moderate" by WET based upon the high percentage of the watershed this wetland occupies. While the watershed is small, which reduces the opportunity for this function, there are relatively few wetlands upgradient of this area, which increases the opportunity for this function.

**Plow Shop Pond (AA2)**

Plow Shop Pond (AA2) is located downgradient of AA1, and is situated close to the center of Ayer (see Figure 1). The upper limit of this Assessment Area is the culverted inlet from Grove Pond, while the lower limit is the dammed outlet. The AA includes the narrow fringe of scrub-shrub and forested wetland which surrounds the Pond.

**Table 2: Summary of Wet Results for Plow Shop Pond**

| | Social Significance | Effectiveness | Opportunity |
|---|---|---|---|
| Ground Water Recharge | H | U | * |
| Ground Water Discharge | H | L | * |
| Floodflow Alteration | L | M | M |
| Sediment Stabilization | L | M | * |
| Sediment/Toxicant Retention | M | H | H |
| Nutrient Removal/Transformation | M | L | H |
| Production Export | * | M | * |
| Wildlife Diversity/Abundance | H | * | * |
| Wildlife D/A Breeding | * | H | * |
| Wildlife D/A Migration | * | L | * |
| Wildlife D/A Wintering | * | L | * |
| Aquatic Diversity/Abundance | L | L | * |
| Uniqueness/Heritage | H | * | * |
| Recreation | L | * | * |

Note: "H" = High, "M" = Moderate, "L" = Low, "U" = Uncertain, and "*"'s identify conditions where functions and values are not evaluated

**Social Significance of AA2**

Functions which WET determines to be "High" for the Social Significance of Plow Shop Pond are Ground Water Recharge, Ground Water Discharge, Wildlife Diversity and Abundance, and Uniqueness and Heritage. The significance of Plow Shop Pond for the groundwater functions is due to its proximity to water supply wellfields and the permeable sediments within the area. Like Cold Spring Brook Pond, The Social Significance of Plow Shop Pond for Wildlife Diversity and Abundance is rated by WET as "High" based upon the existence of black duck, a species that is on the USFWS National Species of Special Emphasis List and is declining in the region. The Social Significance of the Uniqueness and Heritage value is rated as "High" due, in part, to the presence of a long-term monitoring program on the adjacent landfill.

The Social Significance of the Sediment/Toxicant Retention and Nutrient Removal/Transformation functions in this wetland are rated as "Moderate" by WET. Both of these ratings are due to the elevated levels of nutrients and other pollutants resulting from the adjacent landfill.

WET rates the Social Significance and Effectiveness of Plow Shop Pond as "Low" for several functions. The Social Significance of the Aquatic Diversity/Abundance is Low due to the lack of commercial fishing, recognized fisheries value of the AA, or the lack of any fish species which are on the USFWS National Species of Special Emphasis List. The Social Significance of the Recreation function is Low due to the fact that the AA is not a major public access point to a recreational waterway, nor is it recognized as an area which provides recreational opportunities that are locally deficient. The Social Significance of the Floodflow Alteration function is low due to the lack of features of social or economic value within the floodplain to the AA. The Social Significance of the Sediment Stabilization function is low because the AA does not act as a buffer to features situated in erosion prone areas.

**Effectiveness of AA2**

The Effectiveness, or the capability of AA2 to preform a given function, is rated as "High" for Sediment/Toxicant retention and Wildlife Diversity/Abundance Breeding. As with AA1, the Effectiveness of this wetland for Sediment/Toxicant retention is a function of the physical parameters of the Pond including the constricted outlet, low water velocity, and shallow depth. The breeding function for wildlife, while reduced somewhat by the poor emergent growth and low vegetation and water interspersion in Plow Shop Pond, is raised by a number of other factors which contribute to WET's "High" rating for this function. For example, Plow Shop Pond is located near forested wetlands; these adjacent wetlands of a different type are of high importance as a predictor for breeding (WET literature review). Similarly, the edge of the wetland contains "special habitat features" as defined by WET, such as fruit bearing shrubs (highbush blueberry) and mast-bearing trees (oak); this also is of high importance to this function. Other factors contributing to the "High" rating by WET include the substrate type, low salinity, and the fact that there are preferred food plants within the AA such as *Nymphaea odorata* and *Brasenia schreberi*, which are considered by WET to be preferred food plants for waterfowl.

WET rates the effectiveness of AA2 for Floodflow Alteration, Sediment Stabilization, and Production Export as "Moderate". The moderate rating for Floodflow alteration is based upon such features as the restricted outlet, which allows it to provide for flood storage. However, the AA does not have any of the features which would yield a "High" rating for this function, such as a regulated outlet.

Sediment Stabilization is also rated as "Moderate" due to the lack of features resulting in either a High or Low rating. According to the WET Manual: "Wetlands rated HIGH for this function must be characterized by one of the following characteristics: potential erosive forces present, unsheltered or Zone C greater than Zones A and B, ditches, canals, or levees are present that confine water, high water velocity, evidence of long-term erosion, or a water table influenced by an upstream impoundment. In addition, one of the following characteristics must also be present: rubble substrate, protective of nearby shorelines, greater than 20 ft width of erect vegetation, presence of forest of scrub-shrub, or good water and vegetation interspersion. The only type of wetland considered capable of being rated LOW is one in which there is no flowing water, no boat wakes, no open water wider than 100 ft, and no eroding areas abutting the wetland, as well as having no vegetation (erect or submerged) or rubble."

Like Sediment Stabilization, the "Moderate" rating for Production Export is due to the lack of factors which would result in either a High or Low rating. "To attain a rating of HIGH, the assessment area must have conditions favoring primary productivity...If the wetland system is palustrine the following conditions must be present: significant areas of erect vegetation, potential erosive conditions, Zone B greater than 10% of AA, potential for expansive flooding, potential for eutrophic conditions or high levels of dissolved solids, high plant productivity, and fringe or island situation. In addition, for all wetland systems, one of the following conditions must not be present: moss-lichen class extensive, sandy substrate, water velocity high or AA unsheltered, low water\vegetation interspersion, presence of direct alteration, artificially manipulated water levels, small watershed, or low levels of suspended solids. To attain a rating of LOW, the AA must have no permanent or intermittent outlets regardless of the levels of productivity present." Since Plow Shop Pond has low interspersion, a "High" rating could not be assigned by WET. Likewise, the permanent inlet and outlet precludes the "Low" rating.

The remainder of the functions and values evaluated by WET are rated as "Low" for Effectiveness. It is interesting to note that WET determines that the Effectiveness of this wetland for the Aquatic Diversity/Abundance function is "Low". As defined previously, this function is "the support of a notably great on-site diversity and/or abundance of fish or invertebrates that are mainly confined to the water and saturated soil". However, although the WET program predicts that this function is "Low" for Plow Shop Pond, our qualitative evaluation is that the Pond is very valuable for this function based upon the abundance of breeding fish. Based upon our on-site visit, we believe that this wetland is very effective at supporting an abundance of warm-water fish species. Ground Water Discharge is rated as low because the wetland has only one of the characteristics that would qualify it as "High" for this function, a relatively stable water level. Nutrient Removal/Transformation rates Low due to the lack of extensive erect vegetation within the wetland. Wildlife Diversity/Abundance Migration and Wintering are rated as "Low" based, in part, upon the fact that Plow Shop Pond is frozen for more than one month during the winter.

### Opportunity of AA2

The results for Opportunity for Plow Shop Pond are identical to those for Cold Spring Pond (AA1). As with AA1, most of the functions and values were not evaluated by WET for Opportunity in this Level 2 WET Assessment. The opportunity for Plow Shop Pond to perform the Sediment/Toxicant Retention and Nutrient Removal/Transformation functions is rated as "High" by WET due to the proximity of the adjacent landfill. The opportunity for AA2 to provide for Floodflow Alteration was rated as "Moderate" by WET. This is likely due in part to the relatively large watershed relative to the size of the AA.

## Impact Area Evaluations

Both Assessment Areas were evaluated based upon the probable impacts resulting from the removal of one foot of sediment from the bottom of each pond. Each Impact Area was evaluated at a point in time three years subsequent to the completion of this work. This time period is arbitrary, and was chosen by NEE to represent a sufficient length of time for aquatic bed vegetation to become re-established. If a shorter time period had been chosen, the WET assessment would have yielded more pronounced impacts. Conversely, since many of the impacts from the proposed work will become less important with time, a WET assessment of the area 5 or 10 years further into the future would have yielded fewer differences between the pre- and post- development functions and values. Although it can be assumed that groundwater remediation will take place, we did not assume that this work will be completely effective in eliminating contaminants from these wetlands.

WET predicts that the Effectiveness of both IAs will be reduced for the Sediment/Toxicant Retention and Wildlife Diversity/Abundance-Breeding functions, while the Nutrient Removal/Transformation function will be reduced within Cold Spring Brook Pond. The reduction in the Effectiveness of the Sediment/Toxicant Removal function and the Nutrient Removal/Transformation function is due to the alteration of the wetlands. Alterations which destroy vegetation that slows water movement reduces the ability of the wetland to retain sediments. Wetlands which have been excavated are less likely to remove and/or transform nutrients in the water column. In addition, the removal of one foot of sediment will increase the depth of these waterbodies, and deeper wetlands may be less likely to retain sediments and toxicants than shallower wetlands. Finally, the conversion of the substrates within portions of Plow Shop Pond from muck to sand and gravel will reduce the ability of the wetland to trap sediments.

Wildlife Diversity/Abundance-Breeding was determined to be reduced subsequent to the alteration of the area. This is due to the disruption of wetland functions that are important to wildlife following alterations. However, if we had modeled this for longer than 3 years following the alteration, then this would not have had an impact on WET.

Other functions, such as Production Export, were unchanged over the baseline values for the AAs. Production Export is likely unchanged because of the time period used. As previously discussed, the three year time period is likely

**Table 3: Summary of Wet Results for Cold Spring Pond, Post-Impact**

| | Social Significance | Effectiveness | Opportunity |
|---|---|---|---|
| Ground Water Recharge | M | L | * |
| Ground Water Discharge | M | M | * |
| Floodflow Alteration | L | M | M |
| Sediment Stabilization | L | H | * |
| Sediment/Toxicant Retention | L | L | H |
| Nutrient Removal/Transformation | L | L | H |
| Production Export | * | M | * |
| Wildlife Diversity/Abundance | H | * | * |
| Wildlife D/A Breeding | * | L | * |
| Wildlife D/A Migration | * | H | * |
| Wildlife D/A Wintering | * | L | * |
| Aquatic Diversity/Abundance | L | L | * |
| Uniqueness/Heritage | H | * | * |
| Recreation | L | * | * |

Note: "H" = High, "M" = Moderate, "L" = Low, "U" = Uncertain, and "*"'s identify conditions where functions and values are not evaluated

**Table 4: Summary of Wet Results for Plow Shop Pond, Post-Impact**

| | Social Significance | Effectiveness | Opportunity |
|---|---|---|---|
| Ground Water Recharge | H | U | * |
| Ground Water Discharge | H | L | * |
| Floodflow Alteration | L | M | M |
| Sediment Stabilization | L | M | * |
| Sediment/Toxicant Retention | M | L | H |
| Nutrient Removal/Transformation | M | L | H |
| Production Export | * | M | * |
| Wildlife Diversity/Abundance | H | * | * |
| Wildlife D/A Breeding | * | L | * |
| Wildlife D/A Migration | * | L | * |
| Wildlife D/A Wintering | * | L | * |
| Aquatic Diversity/Abundance | L | L | * |
| Uniqueness/Heritage | H | * | * |
| Recreation | L | * | * |

Note: "H" = High, "M" = Moderate, "L" = Low, "U" = Uncertain, and "*"'s identify conditions where functions and values are not evaluated sufficient to allow floating-leaved vegetation to become re-established. If a shorter period of time had been used in the evaluation, then this function would have shown a decrease over baseline conditions.

**WET Summary**

A standardized evaluation technique, WET (Wetland Evaluation Technique), was used to conduct assessments on the existing and post-impact conditions in Cold Spring Brook Pond and Plow Shop Pond on the Fort Devens site. The WET analysis determined that the value of both of these wetlands to society is "High" for Wildlife Diversity and Abundance as well as Uniqueness and Heritage. The value of Plow Shop Pond to society is also "High" for Ground Water Recharge and Ground Water Discharge.

WET predicts that the proposed removal of one foot of sediment from the bottom of these ponds will reduce the effectiveness of both wetlands to preform the Sediment/Toxicant Retention and Wildlife Diversity/Abundance-Breeding functions. The Nutrient Removal/Transformation function will be reduced within Cold Spring Brook Pond by the work as predicted by WET.

## II. OTHER WETLAND FUNCTIONAL ASSESSMENT METHODS

### Hollands and McGee

A Hollands & McGee (H&M) Wetland Functional Assessment (1985) was conducted on Plow Shop Pond and Cold Spring Pond by Ecology and Environment, Inc. as part of their assessment of these wetlands. The Hollands and McGee method was developed by private consulting firms (IEP and Normandeau), and the details of conducting or evaluating this method are generally not available to the public, nor has the complete method been published. The ecological elements in H&M are based largely on the work of Golet & Larson (1974). However, since this method was developed and tested in Massachusetts in 1975, it has the potential for broad applications in the functional assessments of wetlands in this region. The H&M method evaluates 10 wetland functions which incorporate biological, hydrological and socio-cultural interests.

The primary uses of the Hollands and Mcgee method are to compare different wetlands in a region (i.e. a town, county, etc.) so that the relative importance of functional values can be made. This method has been successfully used to evaluate and compare hundreds of wetlands in municipalities in Massachusetts, New Hampshire, and Wisconsin. Although Hollands and McGee (1985) believe that their method compares favorably with more complex methods such as Adamus (1983), which was the precursor to WET 2.0, the two methods have a very different approach. The H&M method relies on expert field personnel which include, at a minimum, a geologist, hydrologist, botanist, and an ecologist to collect site specific detailed data on the wetland(s) being investigated. WET, on the other hand, is designed to be conducted primarily from the office, with minimal field work and non-technical staff. In this respect, the H&M method is similar to the newer Hydrogeomorphic approach which is discussed below.

The H&M wetland evaluation conducted for Cold Spring Brook Pond and Plow Shop Pond provides no regional basis from which to make a decision on the level of the functions found in these wetlands. For instance, the biological model for Plow Shop Pond received a H&M score of 110, while Cold Spring Pond rated 102 for this function. Both were identified as "Moderate" due to a range of scores of this model between 29-158, with a mean of 93. However, practical use of this model indicates that a score of 110 is generally considered "Low" on a regional basis for this part of Massachusetts. Although the H&M system rates these wetlands as "Moderate" in reference to other functional models which require the output of the biological model, without a comparison of other reference wetlands in the regions, the rating of individual wetland functional values is not appropriate using the H&M method.

## Hydrogeomorphic Properties

A recent development in the functional assessment of wetlands is to classify wetlands based on hydrogeomorphic (HGM) properties as is discussed by Brinson et. al (1993, in press). This method is based on a scientific team approach, as in the H&M method, and uses the four following guidelines, or logic train to qualify a function for this method: 1) the function must be clearly defined; 2) it must have recognizable sustaining forces; 3) the function must have hydrologic, geomorphic, or ecologic significance either on the site or off the site; and 4) it must have indicators that can be documented and combined into a functional index that is scaled to reference wetlands.

The HGM method classifies wetlands based on their major properties, such as the geomorphic setting, the sources of water supplying the wetland, and the hydrodynamics of water within the wetland. By first grouping the different wetlands into the HGM classes with similar properties, the functional assessment is defined to address the functions which are linked. This step represents the scientific basis for the presence of the function. The next step is to develop functional profiles for each wetland class. Finally, a scale for expressing functions by using reference wetlands is developed. These reference wetlands are developed for each wetland class in order to serve as the benchmarks for the HGM classes. The reference wetlands are also critical to the setting of goals for compensatory mitigation, and become a standard from which success or failure may be measured. For example, in the H&M wetland functional assessment of both Plow Shop Pond and Cold Spring Brook Pond, no reference was made to the surrounding wetlands, even though there are similar ponds with aquatic beds located in close proximity. A modeled value is of little use if it cannot be compared with either a standard, or a point of reference.

As discussed by the Conservation Foundation (1988), Brinson et al. and Larson and Mazzarese (in press), the general approach which is used to assess the functions of wetlands is to use a generic list of possible wetland functions, and then look for evidence that the wetland being assessed actually performs the functions. As an example, if a given wetland has permanent standing water, is connected to a larger body of water, and has interspersion of both emergent and submerged vegetation, as in Cold Spring Brook Pond, then it will likely support fish populations, and will thus be determined to have a high probability of aquatic food web support. This general approach has several problems in that a generic series of questions fails to explicitly define the relationship between properties of the wetland and the functions it is supposed to be performing. This "Black Box" approach (Brinson, et al) makes it difficult for the user to understand, learn from, or question the assumed relationships between wetland properties and functions. In fact, these procedures are applied without ever acknowledging the wetland class and its associated attributes.

The HGM approach emphasizes the use of reference wetland populations for the documentation of the relationship between disturbance and function. As such, they are viewed as natural laboratories and as targets for creation and restoration activities. For example, under this approach there is no need to develop complex and detailed design criteria that specify the number of trees to plant, the species composition of the plant community, or the slope and hydroperiod of the wetland surface. Rather, the species composition, cover, density, and other properties of the reference wetlands of a given class can serve as the goals for mitigation. Of importance to any future wetlands mitigation at Fort Devens is that the Discrete use of reference wetland populations in the region of the Base eliminates the need to consider "opportunity" and "effectiveness" as necessary conditions for high rankings of some functions.

## Summary

Based on our experience using WET 2.0, Hollands and McGee, and other wetland functional assessment methods, it is our opinion that, if restoration of these wetlands is necessary, then the functional assessments of Plow Shop Pond and Cold Spring Brook Pond should also be compared with other regional wetlands which contain similar characteristics. While WET provides a generic functional assessment of the wetlands, a comparison with other reference wetlands of similar classes would provide a necessary ingredient for future mitigation work. Any future remediation success of Plow Shop Pond must be measured against not only the existing conditions of the Pond, but against other non-impacted Ponds in the region.

## III. QUALITATIVE WETLAND EVALUATIONS

### A. COLD SPRING BROOK POND

**Introduction**

The area surrounding Cold Spring Brook Pond was examined on June 16, 1993. This pond was formed by the construction of Patton Road and the subsequent blockage of the culverted outlet to the wetland. The pond is essentially a dammed part of Cold Spring Brook, with the dam created by a road culvert that passes under Patton Road. Possible dredge spoils and piled peat material are located around parts of the pond perimeter, and this indicates that the pond may have been dredged in the past. The pond is adjacent to the Cold Spring Brook Landfill site (on the west and south) and a magazine storage area (to the west). Cold Spring Brook Pond was generally evaluated as part of a WET evaluation and as part of a qualitative evaluation for plant communities, wetland types, and ecological structure. The purpose of this section is to present a qualitative wetland evaluation of the existing wetland system.

**Plant Communities**

Four major plant communities were observed within Cold Spring Pond and its fringe wetland: an Aquatic Bed Plant Community; an Emergent Plant Community; a Shrub/Scrub type; and Forested Swamp. Each of these is described separately below.

**Aquatic Bed Plant Community**

The majority of the Cold Spring Pond wetland system is occupied by an open water aquatic bed plant community. Although the exact bathometric depths are unknown, much of the pond is relatively shallow, and is able to support rooted aquatic plant life that responds to a two meter phototrophic zone. Sweet water lily (*Nymphaea odorata*), water shield (*Brasenia schreberi*), water marigold (*Megalodonta beckii*), duckweed (*Spirodela* spp.), and coontail (*Ceratophyllum demersum*) were noted in this plant community.

## Emergent Plant Community

Much of the shoreline border contains emergent marsh plants, although this band of vegetation is relatively narrow. These plants are generally obligate to facultative wetland plants as rated by the *National List of Plant Species that Occur in Wetlands* (Reed, 1988); these species can easily survive extended periods of saturated soils and flooded conditions. The following plants were observed around the shoreline in the emergent marsh community: tussock sedge (*Carex stricta*), bearded sedge (*Carex comosa*), purple iris (*Iris versicolor*), cattail (*Typha latifolia*), water willow (*Justicia americana*), purple loosestrife (*Lythrum salicaria*), and bugleweed (*Lycopus virginica*).

## Shrub/Scrub Plant Community

At the western end of the pond and along parts of the pond perimeter there exists a shrub/scrub wetland plant community. The plant community on the western end is dominated by button bush (*Cephalanthus occidentalis*), smooth alder (*Alnus serrulata*), and silky dogwood (*Cornus amomum*). The understory in this area contains enchanter's nightshade (*Circaea alpina*), sedges (*Carex* spp.), and spotted jewelweed (*Impatiens capensis*). Other perimeter shrub/scrub wetlands are scattered along the perimeter of the pond and contain swamp azalea (*Rhododendron viscosum*), highbush blueberry (*Vaccinium corymbosum*), fetterbush (*Leucothoe racemosa*), winterberry holly (*Ilex verticilatta*), sheep laurel (*Kalmia angustifolia*), maleberry (*Lyonia lingustrina*), and red chokeberry (*Aronia arbutifolia*).

## Forested Swamp

There are a few small areas of wetland that are red maple swamps. These areas are located along the fringe of the wetland system and on the peninsula which extends into the pond on its northwestern side. Although red maple (*Acer rubrum*) dominates these areas, gray birch (*Betula populifolia*), silky dogwood (*Cornus amomum*), smooth alder (*Alnus serrulata*), and swamp dewberry (*Rubus hispidus*) are common.

On the southeastern side of this wetland system there is a swamp which is dominated by white pines (*Pinus strobus*) in addition to red maple (*Acer rubrum*). The understory in this area contains american hazelnut, cinnamon fern, and clubmoss.

## Wildlife Habitat

Although this report is not intended to provide a detailed habitat evaluation, we will briefly discuss the importance of the evaluated area to wildlife. The open water in Cold Spring Pond provides valuable wildlife habitat for many waterfowl species including black ducks, mallards, wood ducks, great blue heron, green heron, and canada goose. While few of these birds nest here, it is very valuable for forage habitat, providing ample hunting and foraging opportunities. Evidence of breeding black duck was observed within this wetland, and the presence of a wood duck nesting box indicates that this species may be breeding here, or has nested here in the past. The wetland is used by a great variety of reptiles and amphibians including: painted turtle; snapping turtle; bullfrog; pickerel frog, green frog, northern water snake, and others. Mammals likely using the area include muskrat, beaver, raccoon, opossum, and northern water shrew. Although there is no recent beaver activity, signs of past beaver activity exist, particularly in the location of the forested landfill area.

The plant community in the wetland and surrounding upland provides good forage, cover, and escape habitat for wildlife. There are many fruit bearing shrubs and trees, as well as good diversity between strata providing ample nesting, foraging, and breeding habitat for a variety of birds and mammals. The area also has a strong ecotone where forest meets open water. As a general assessment, it is our opinion that this pond, as it presently exists, provides a diverse and valuable wildlife habitat.

The open water area provides potential habitat for a variety of benthic macroinvertebrates and fish. Water quality is the driving force that dictates which species can inhabit this particular environment. The most likely fish that may be found in this pond are golden shiners, yellow bullhead, pumpkinseed, and bluegill. Some evidence of fishing in this pond (bobbers, worm containers, fish-hook packages, etc.) was observed, particularly near the outlet end of the pond.

## Observed Impacts

Based upon our field observations, the biology of Cold Spring Brook Pond appears to be at relatively normal levels. However, there is a small pond upgradient of Cold Spring Brook Pond which is heavily discolored with a rust colored substance. The aquatic plant life in this pond is reduced in diversity, abundance, and apparent overall health as compared with the downstream Cold Spring Brook

Pond. The channel draining this small pond contains similar coloration as well as a lack of plant and animal diversity and abundance. The small amount of discoloration in Cold Spring Brook pond is primarily near the inlet from this upgradient channel. No other noticeable plumes or areas of apparently impacted plant and animal life were observed.

## Wetland Permits

The wetland Resource Areas around Cold Spring Pond have been previously delineated and surveyed by another consultant. Based on our review of the flagged wetland boundaries, it is our opinion that these flagged boundaries do not accurately depict the wetlands which are jurisdictional under the Massachusetts Wetlands Protection Act (M.G.L. chapter 131, section 40) and Regulations (310 CMR 10.00) or under Section 401 and Section 404 of the Clean Water Act. In general, we found that the flagged wetland boundary underestimated the area of wetlands based both upon vegetative criteria, as specified in the Regulations (310 CMR 10.00) to the Act, as well as the three parameter approach as outlined in the *U.S. Army Corps of Engineers Wetland Delineation Manual* (1987).

Only the Ayer Conservation Commission, or the Massachusetts Department of Environmental Protection on appeal, can make the final determination of the extent of the wetland resource areas which are regulated under state law. Similarly, the extent of wetlands which are subject to federal jurisdiction under Section 404 of the Clean Water Act can be determined only by the U.S. Army Corps of Engineers.

### Massachusetts Wetland Protection Act

All wetlands on this site are subject to protection under the Massachusetts Wetlands Protection Act. Under the Regulations to the Act, protectable wetlands are broken down into "Resource Areas". The wetland Resource Areas on site include:

* Land Under Waterway or Waterbody (Cold Spring Brook Pond and the streams)
* Bank (the Banks of the Pond and streams)
* Bordering Vegetated Wetland

No portions of this property are within the 100 year floodplain according to the Flood Insurance Rate Map (Ayer, MA. Panel 3 of 4, 1982). The site does not fall within the estimated range of state-listed rare wetlands wildlife according to the 1993 Natural Heritage and Endangered Species Program Atlas.

Any work which occurs within 100 feet of the wetland Resource Areas on the site is subject to the jurisdiction of the Ayer Conservation Commission, and will require the filing of either a Request for Determination of Applicability or a Notice of Intent. It is possible that any large-scale remediation project would be approved as a Limited Project under section 10.53(4) in the wetlands regulations.

**Federal Wetland Jurisdiction under Section 401 of the Clean Water Act**

All projects which propose to alter wetlands require Water Quality Certification under Section 401 of the Federal Clean Water Act before work can proceed. Since October 1, 1992 the D.E.P. regions have been administering the 401 Program and now use the state criteria to determine the boundary of wetlands protectable under 401. If the proposed work will alter in excess of 5,000 square feet of wetlands, then the project will be subject to an alternatives analysis and a more lengthy review process by the D.E.P., and may possibly be denied Certification.

**Federal Wetland Jurisdiction under Section 404 of the Clean Water Act**

All wetlands on the property are subject to protection under Section 404 of the Clean Water Act. The boundary of wetlands which are protectable under Section 404 is different than that delineated under the Wetlands Protection Act and Section 401 of the Clean Water Act. On this site, it appears that the flagged wetland boundary does not reflect the extent of the wetlands which would be delineated based upon the methodology described in the *U.S. Army Corps of Engineers Wetland Delineation Manual* (1987). This manual describes a multiple parameter methodology which uses the presence of hydric soils, hydrophytic vegetation, and wetland hydrology to establish the boundary of the wetlands. This manual has superseded the more recent *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (1989) for federal wetland boundary delineations.

**TABLE 5: PLANT SPECIES FOUND IN WETLANDS, COLD SPRING BROOK POND, FORT DEVENS, AYER, MASSACHUSETTS**

| COMMON NAME | SCIENTIFIC NAME | INDICATOR STATUS* |
|---|---|---|
| **Trees** | | |
| Red Maple | *Acer rubrum* | FAC |
| Gray Birch | *Betula populifolia* | FAC |
| Green Ash | *Fraxinus pennsylvanica* | FACW |
| Red Pine | *Pinus resinosa* | FACU |
| White Pine | *Pinus strobus* | FACU |
| Quaking Aspen | *Populus tremula* | FACU |
| Black Cherry | *Prunus serotina* | FACU |
| White Oak | *Quercus alba* | FACU- |
| Red Oak | *Quercus rubra* | FACU- |
| American Elm | *Ulmus americana* | FACW- |
| **Shrubs** | | |
| Speckled Alder | *Alnus rugosa* | FACW+ |
| Smooth Alder | *Alnus serrulata* | OBL |
| Red Chokeberry | *Aronia arbutifolia* | FACW |
| Common Buttonbush | *Cephalanthus occidentalis* | OBL |
| Silky Dogwood | *Cornus amomum* | FACW |
| American Hazelnut | *Corylus americana* | FACU- |
| Witch Hazel | *Hamamelis virginiana* | FAC- |
| Winterberry Holly | *Ilex verticillata* | FACW+ |
| Sheep Laurel | *Kalmia angustifolia* | FAC |
| Fetterbush | *Leucothoe racemosa* | FACW |
| Maleberry | *Lyonia ligustrina* | FACW |
| Mountain Holly | *Nemopanthus mucronatus* | OBL |
| Swamp Azalea | *Rhododendron viscosum* | OBL |
| Willows | *Salix* spp. | FACW |
| Meadowsweet | *Spirea latifolia* | FAC+ |
| Steeplebush | *Spirea tomentosa* | FACW |
| Highbush Blueberry | *Vaccinium corymbosum* | FACW- |

| | | |
|---|---|---|
| Lowbush Blueberry | *Vaccinium angustifolium* | FACU- |
| Wild Raisin | *Viburnum cassinoides* | FACW |
| Northern Arrowwood | *Viburnum recognitum* | FACW- |

**Ilianas**

| | | |
|---|---|---|
| Poison Ivy | *Toxicodendron radicans* | FAC |
| Grape | *Vitis* spp. | FACW-FACU |

**Ferns**

| | | |
|---|---|---|
| Spinulose Woodfern | *Dryopteris spinulosa* | FAC+ |
| Field Horsetail | *Equisetum arvense* | FAC |
| Princess Pine Clubmoss | *Lycopodium obscurum* | FACU |
| Sensitive Fern | *Onoclea sensibilis* | FACW |
| Cinnamon Fern | *Osmunda cinnamomea* | FACW |
| Interrupted Fern | *Osmunda claytoniana* | FAC |
| Royal Fern | *Osmunda regalis* | OBL |
| Bracken Fern | *Pteridium aquilinum* | FACU |
| New York Fern | *Thelypteris noveboracensis* | FAC |
| Marsh Fern | *Thelypteris thelypteroides* | FACW+ |

**Forbs**

| | | |
|---|---|---|
| Jack-In-The-Pulpit | *Arisaema triphyllum* | FACW- |
| Swamp Milkweed | *Asclepias incarnata* | OBL |
| Aster | *Aster* spp. | |
| Spotted Wintergreen | *Chimaphila maculata* | UPL |
| Goldthread | *Coptis trifolia* | FACW |
| Spotted Joe-Pye-Weed | *Eupatoriadelphus maculatus* | FACW |
| Boneset | *Eupatorium perfoliatum* | FACW+ |
| Bedstraw | *Galium* spp. | |
| Hawkweeds | *Hieracium* spp. | UPL |
| Bluets | *Houstonia* spp. | FAC-FACU |
| Spotted Jewelweed | *Impatiens capensis* | FACW |
| Yellow Iris | *Iris pseudoacorus* | OBL |
| Blueflag Iris | *Iris versicolor* | OBL |

| | | |
|---|---|---|
| Duckweed | *Lemna* spp. | OBL |
| Bugleweed | *Lycopus virginicus* | OBL |
| Purple Loosestrife | *Lythrum salicaria* | FACW+ |
| Canada Maylower | *Maianthemum canadense* | FAC- |
| Water-Millfoil | *Myriophyllum* spp. | OBL |
| Water Lily | *Nuphar* spp. | OBL |
| Pale Smartweed | *Polygonum lapathifolium* | FACW+ |
| Pickerelweed | *Pontederia cordata* | OBL |
| Pondweed | *Potamogeton* spp. | OBL |
| Swamp Buttercup | *Ranunculus septentrionalis* | OBL |
| Blackberry | *Rubus* spp. | |
| Dewberry | *Rubus hispidus* | FACW |
| Curled Dock | *Rumex crispus* | FACU |
| Arrowhead | *Saggitaria latifolia* | OBL |
| Tall Goldenrod | *Solidago altissima* | FACU- |
| Rough Goldenrod | *Solidago rugosa* | FAC |
| Skunk Cabbage | *Symplocarpus foetidus* | OBL |
| Common Cattail | *Typha latifolia* | OBL |
| Violet | *Viola* spp. | FACW-OBL |

**<u>Grasses and Grasslike Species</u>**

| | | |
|---|---|---|
| Fringed Sedge | *Carex crinita* | OBL |
| Broom Sedge | *Carex scoparia* | FACW |
| Tussock Sedge | *Carex stricta* | OBL |
| Blunt Broom Sedge | *Carex tribuloides* | FACW+ |
| Other Sedges | *Carex* spp. | FACW-OBL |
| Spike-Rush | *Eleocharis* spp. | FACW+-OBL |
| Other Grasses | *Graminaceae* | |
| Canada Rush | *Juncus canadensis* | OBL |
| Soft Rush | *Juncus effusus* | FACW+ |
| Rice Cut-Grass | *Leersia oryzoides* | OBL |
| Haircap Moss | *Polytrichum commune* | FACU** |
| Sphagnum Moss | *Sphagnum* spp. | OBL** |

| Category | Symbol | Definition |
|---|---|---|
| OBLIGATE HYDROPHYTE | OBL | Nearly always occurs in wetlands (>99%) |
| FACULTATIVE WETLAND | FACW | Usually occurs in wetlands (67% to 99%) |
| FACULTATIVE | FAC | Commonly occurs in both wetlands and uplands (34% to 66% in wetlands) |
| FACULTATIVE UPLAND | FACU | Usually occurs in uplands, but may occasionally occur in wetlands (1% to 33%) |
| UPLAND | UPL | Nearly always occurs in uplands (<1% in wetlands) |

A positive (+) sign behind the Facultative Indicator categories indicates a frequency toward the higher end of the category (more frequently found in wetlands), while a negative (-) sign indicates a frequency toward the lower end of the category (less frequently found in wetlands).

D = Dominant (> 50% cover)
C = Common (11%-49% cover)
O = Occasional (1%-10% cover)

* 1988 Wetland Plant List, Northeast Region. National Wetlands Inventory, U.S. Fish and Wildlife Service.

** Indicator status for mosses assigned by experience of NEE personnel; mosses are not rated by Wetland Plant List (1988).

**PLOW SHOP POND**

## Introduction

The Plow Shop Pond wetlands were examined on June 16, 1993 by New England Environmental, Inc. (NEE) biologists. This pond and the adjacent wetlands are located in the northeast corner of the Main Post at Fort Devens, adjacent to the Shepley's Hill Landfill. The pond receives water from Grove Pond and a relatively large upgradient watershed. The Pond drains into Nonacoicus Brook, which eventually discharges into the Nashua River. Plow Shop Pond is an impounded area, with the primary outlet feeding Nonacoicus Brook. Plow Shop Pond is approximately 30 acres in size. This area and the associated wetlands were evaluated by New England Environmental, Inc. as part of a WET evaluation of wetland functional values, and as part of a qualitative evaluation for plant communities, wetland types, and ecological regime. The purpose of this section is to present a qualitative evaluation of the existing wetland system.

## Plant Communities

Four major plant communities were observed within Plow Shop Pond and its fringe wetland, although the vast majority of the system is Aquatic Bed. The Emergent Plant Community, Shrub/Scrub type, and Forested Swamp are found in a narrow band which surrounds the Pond. Each of these plant communities is described separately below.

### Aquatic Bed Plant Community

The majority of this wetland system is an open water aquatic bed plant community. Much of the area is less than 6.6 feet deep, which helps to describe it as shallow and capable of supporting a dense rooted vascular plant community. Sweet water lily (*Nymphaea odorata*), water shield (*Brasenia schreberi*), duckweed (*Spirodela spp.*), coontail (*Ceratophyllum demersum*), milfoil (*Myriophyllum spp.*), northern arrowhead (*Sagittaria cuneata*), and pickerelweed (*Pontedaria cordata*) were all noted in this community and comprise 80-90% of the plant species present.

### Emergent Plant Community

Emergent marsh plants were noted along the majority of the shoreline border. These plants are generally obligate wetland species, with some facultative wetland plant species also present. The following species were noted along the shoreline as part of the emergent plant community: tussock sedge (*Carex stricta*), bugleweed (*Lycopus virginica*), bearded sedge (*Carex comosa*), purple iris (*Iris versicolor*), broadleaf cattail (*Typha latifolia*), yellow iris (*Iris pseudacorus*), eastern burreed (*Sparganium americanum*), soft-stemmed bullrush (*Scirpus validus*), water smartweed (*Polygonum punctatum*), purple loosestrife (*Lythrum salicaria*), and lurid sedge (*Carex lurida*).

### Shrub/Scrub Wetland Plant Community

The majority of the wetland fringe around Plow Shop Pond contains a shrub/scrub wetland plant community. This plant community is found in association with many small red maple (*Acer rubrum*) saplings. The shrub/scrub plant community contains the following species: smooth alder (*Alnus serrulata*), speckled alder (*Alnus rugosa*), highbush blueberry (*Vaccinium corymbosum*), maleberry (*Lyonia lingustrina*), swamp azalea (*Rhododendron viscosum*), northern arrow-wood (*Viburnum recognitum*), wild raisin (*Viburnum cassanoides*), mountain holly (*Nemopanthus mucronta*), sheep laurel (*Kalmia angustifolia*), silky dogwood (*Cornus amomum*), ironwood (*Carpinius caroliniana*), witch-hazel (*Hammamelis virginiana*), and winterberry holly (*Ilex verticilata*). The understory of this narrow fringe community contained many species including spotted jewelweed (*Impatiens capensis*), marsh fern (*Thelypteris thelypteroides*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnomomea*), skunk cabbage (*Symplocarpus foetidus*), peat moss (*Sphagnum spp.*), haircap moss (*Polytrichum commune*), staghorn clubmoss (*Lycopodium clavatum*), virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicondendron radicans*).

### Forested Swamp Community

In an area adjacent near the pond outlet (Nonacoicus Brook), there is a red maple swamp forested wetland. The overstory is dominated by red maple and gray birch (*Betula populifolia*), and silver maple (*Acer saccharinum*). In the shrub layer wild raisin, nannyberry (*Viburnum lentago*), and highbush blueberry are found. The understory is dominated by cinnamon fern, marsh fern, jewelweed, and joe-pye weed (*Eupatorium maculatum*).

## Wildlife Habitat

Although it is beyond the scope of this report to provide a detailed wildlife habitat evaluation of Plow Shop Pond, we are providing a general discussion of the more important wildlife habitats which were evaluated in this study. The approximately 30 acres of open water found in Plow Shop Pond presently provides excellent brood-rearing and migratory feeding habitat for many waterfowl species including black duck, mallard, wood duck, great blue heron, green-backed heron, and canada goose. Although there are suitable nesting areas for waterfowl adjacent to the Pond, we did not observe any waterfowl broods during our one day site visit. The pond area has large areas of aquatic vegetation for forage and brood-rearing by many species of dabbling ducks and geese, and is likely to be heavily used by migrating waterfowl. There is little habitat interspersion or cover within the main body of the pond, which reduces somewhat the habitat value for several waterfowl species (i.e. wood duck), although the several wooded coves and outlet wetland provide additional habitat interspersion.

The Plow Shop Pond wetland system is used by a variety of reptiles and amphibians which were observed within the area including: painted turtle; snapping turtle; northern water snake; bullfrog; and green frog. Although several species of salamanders are likely to occur within this wetland complex, none were observed during our site visit. Mammals observed or which are likely using the area are muskrat, beaver, raccoon, opossum, and northern water shrew. There is some recent sign of beaver activity along the southern edge of the pond, and muskrat were observed in several of the small coves. Raccoon tracks were observed within the wetlands.

The plant community in the wetland and surrounding upland provides good shade, forage, cover, and escape habitat. There are a diverse variety of fruit and mast bearing shrubs and trees (ie. highbush blueberry, red oak), and a good interspersion of plant strata providing nesting, foraging, and breeding habitat for many different bird and mammal species. A very large and important ecotone exists where open water meets forest and shrub areas. As a general assessment, it is our opinion that Plow Shop Pond and the adjacent wetlands presently provides good wildlife habitat for a diverse group of fish and animal species.

The open water area of Plow Shop Pond provides potential habitat for a variety of benthic macroinvertebrates and warm water fish. Water quality is the primary ingredient in determining which species inhabit this environment. The most likely fish that may be found in this pond, and those which we observed are: golden shiners; yellow bullhead; pumpkinseed; bluegill; large mouth bass; and chain pickerel. Ample evidence exists of fishing in the area (rod-holders, bait cans, trash, bobbers, etc.). There are presently posted warning signs which indicate that Plow Shop Pond is a catch and release area only.

Our site inspection was impressed by the large numbers of nesting bluegills found around almost the entire perimeter of the pond in shallow gravelly substrates. Equally impressive were the large number and the great size of large mouth bass which were observed near the inlet, the outlet, and throughout the aquatic bed.

## Observed Impacts

Shepley's Hill Landfill is situated to an area south and adjacent to Plow Shop Pond. Two coves extend from the main body of the Pond towards the landfill, and these coves contain a red precipitate. This precipitate was not observed in any other areas of the Pond. In the northern cove, a steady plume of groundwater was observed to be discharging into the area.

There was a marked contrast of the plant communities within these two coves as compared to the greater body of water of Plow Shop Pond, with a general lack of plant diversity, especially in the northern cove. In addition, several dead trees (white pine and red maples) were observed adjacent to the northern cove. No other obvious tree diebacks were observed around the entire perimeter of Plowshop Pond. The aquatic plant life in the northern cove was sparse and unhealthy in appearance in comparison with the rest of the pond, and much of the aquatic vegetation had absorbed the rust-colored precipitate. Almost all of the pond bottom in the northern cove was rust-colored. Several nesting bluegills were observed within the northern cove.

At the southern cove, similar observations were made, although the observed impacts were less pronounced. At this cove, there was no observed plume of water entering the area, and there was less discoloration. The area did appear to contain a lack of diversity in aquatic plant species. No fish were observed in the southern cove.

## Wetland Permits

The wetland Resource Areas around Plow Shop Pond have been previously delineated and surveyed by another consultant. New England Environmental, Inc. generally agrees with the boundaries as established by the flags in the field, however; only the Ayer Conservation Commission, or the Massachusetts Department of Environmental Protection on appeal, can make the final determination of the extent of the wetlands which are regulated under state law. Similarly, the extent of wetlands which are subject to federal jurisdiction under Section 404 of the Clean Water Act can be determined only by the U.S. Army Corps of Engineers.

**Massachusetts Wetlands Protection Act**

All wetlands on this site are subject to protection under the Massachusetts Wetlands protection Act. Under the Regulations of the Act, protectable wetlands are broken down into "Resource Areas". According to the Flood Insurance Rate Map (Ayer, MA., Panel 3 of 4), there is a significant area surrounding Plow Shop Pond which is subject to flooding in the 100 year storm event. This area of flooding extends to adjacent areas down stream. The wetland Resource Areas on the site include:

* Land Under a Waterway and Waterbody (Plow Shop Pond and inlet/outlet)
* Bank (the Banks of the Pond and streams)
* Bordering Vegetated Wetland
* Bordering Land Subject to Flooding (100 year floodplain)

The site does not fall within the estimated range of state-listed rare wetlands wildlife according to the 1993 Natural Heritage and Endangered Species Program Atlas.

A wetland filing with the Ayer Conservation Commission will be required for any proposed remediation work. It is likely that any large-scale remediation project can be approved as a Limited Project under section 10.53(4) or perhaps other appropriate sections in the wetlands regulations.

**Federal Wetland Jurisdiction under Section 401 of the Clean Water Act**

All projects which propose to alter wetlands require Water Quality Certification under Section 401 of the Federal Clean Water Act before work can proceed. Since October 1, 1992 the D.E.P. regions have been administering the 401 Program and now use the state criteria to determine the boundary of wetlands protectable under 401. If the proposed work will alter in excess of 5,000 square feet of wetlands, then the project will be subject to an alternatives analysis and a more lengthy review process by the D.E.P., and may possibly be denied Certification.

**Federal Wetland Jurisdiction under Section 404 of the Clean Water Act**

All wetlands on the property are subject to protection under Section 404 of the Clean Water Act. The boundary of wetlands which are protectable under Section 404 is different than that delineated under the Wetlands Protection Act and Section 401 of the Clean Water Act. On this site, it appears that the flagged wetland boundary generally coincides with the line which would have been delineated based solely upon the methodology described in the *U.S. Army Corps of Engineers Wetland Delineation Manual* (1987). This manual describes a multiple parameter methodology which uses the presence of hydric soils, hydrophytic vegetation, and wetland hydrology to establish the boundary of the wetlands. This manual has superseded the more recent *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (1989) for federal wetland boundary delineations.

**TABLE 5: PLANT SPECIES FOUND IN PLOW SHOP POND WETLANDS.**

| COMMON NAME | SCIENTIFIC NAME | INDICATOR STATUS* |
|---|---|---|
| **Trees** | | |
| Red Maple | *Acer rubrum* | FAC |
| Silver Maple | *Acer saccharinum* | FACW |
| Gray Birch | *Betula populifolia* | FAC |
| Ironwood | *Carpinus caroliniana* | FAC |
| Red Pine | *Pinus resinosa* | FACU |
| White Oak | *Quercus alba* | FACU- |
| Red Oak | *Quercus rubra* | FACU- |
| American Elm | *Ulmus americana* | FACW- |
| **Shrubs** | | |
| Speckled Alder | *Alnus rugosa* | FACW+ |
| Smooth Alder | *Alnus serrulata* | OBL |
| Common Buttonbush | *Cephalanthus occidentalis* | OBL |
| Silky Dogwood | *Cornus amomum* | FACW |
| American Hazelnut | *Corylus americana* | FACU- |
| Black Huckleberry | *Gaylussacia baccata* | FACU |
| Witch Hazel | *Hamamelis virginiana* | FAC- |
| Sheep Laurel | *Kalmia angustifolia* | FAC |
| Maleberry | *Lyonia ligustrina* | FACW |
| Sweetgale | *Myrica gale* | OBL |
| Mountain Holly | *Nemopanthus mucronatus* | OBL |
| Pink Azalea | *Rhododendron nudiflorum* | FAC |
| Swamp Azalea | *Rhododendron viscosum* | OBL |
| Staghorn Sumac | *Rhus typhina* | UPL |
| Willows | *Salix* spp. | FACW |
| American Elderberry | *Sambucus canadensis* | FACW- |
| Meadowsweet | *Spirea latifolia* | FAC+ |
| Steeplebush | *Spirea tomentosa* | FACW |
| Highbush Blueberry | *Vaccinium corymbosum* | FACW- |
| Wild Raisin | *Viburnum cassinoides* | FACW |

| | | |
|---|---|---|
| Nannyberry | *Viburnum lentago* | FAC |
| Northern Arrowwood | *Viburnum recognitum* | FACW- |

**Ilianas**

| | | |
|---|---|---|
| Virginia Creeper | *Parthenocissus quinquefolia* | FACU |
| Poison Ivy | *Toxicodendron radicans* | FAC |

**Ferns**

| | | |
|---|---|---|
| Lady Fern | *Athyrium Filix-femina* | FAC |
| Spinulose Woodfern | *Dryopteris spinulosa* | FAC+ |
| Staghorn Clubmoss | *Lycopodium clavatum* | FAC |
| Sensitive Fern | *Onoclea sensibilis* | FACW |
| Cinnamon Fern | *Osmunda cinnamomea* | FACW |
| Royal Fern | *Osmunda regalis* | OBL |
| Bracken Fern | *Pteridium aquilinum* | FACU |
| New York Fern | *Thelypteris noveboracensis* | FAC |

**Forbs**

| | | |
|---|---|---|
| Ground Nut | *Apios americana* | FACW |
| Jack-In-The-Pulpit | *Arisaema triphyllum* | FACW- |
| Aster | *Aster* spp. | |
| Bog Hemp | *Boehmeria cylindrica* | FACW+ |
| Water Shield | *Brasenia schreberi* | OBL |
| Coontail | *Ceratophyllum demersum* | OBL |
| Goldthread | *Coptis trifolia* | FACW |
| Spotted Joe-Pye-Weed | *Eupatoriadelphus maculatus* | FACW |
| Strawberry | *Fragaria virginiana* | FACU |
| Bedstraw | *Galium* spp. | |
| Hawkweeds | *Hieracium* spp. | UPL |
| Bluets | *Houstonia* spp. | FAC-FACU |
| Spotted Jewelweed | *Impatiens capensis* | FACW |
| Yellow Iris | *Iris pseudoacorus* | OBL |
| Blueflag Iris | *Iris versicolor* | OBL |
| Bugleweed | *Lycopus virginicus* | OBL |
| Yellow Loosestrife | *Lysimachia terrestris* | OBL |
| Purple Loosestrife | *Lythrum salicaria* | FACW+ |

| | | |
|---|---|---|
| Canada Maylower | *Maianthemum canadense* | FAC- |
| Water Marigold | *Megalodonta beckii* | OBL |
| Forget-me-not | *Myosotis scorpioides* | OBL |
| Water-Millfoil | *Myriophyllum* spp. | OBL |
| Sweet Water Lily | *Nymphaea odorata* | OBL |
| Pale Smartweed | *Polygonum lapathifolium* | FACW+ |
| Pickerelweed | *Pontederia cordata* | OBL |
| Pondweed | *Potamogeton* spp. | OBL |
| Common Cinquefoil | *Potentilla simplex* | FACU- |
| Buttercup | *Ranunculus spp.* | FAC-OBL |
| Blackberry | *Rubus* spp. | |
| Dewberry | *Rubus hispidus* | FACW |
| Raspberry | *Rubus* spp. | |
| Arrowhead | *Saggitaria latifolia* | OBL |
| Rough Goldenrod | *Solidago rugosa* | FAC |
| Goldenrod | *Solidago* spp. | |
| Skunk Cabbage | *Symplocarpus foetidus* | OBL |
| Common Cattail | *Typha latifolia* | OBL |

**Mosses and Grass-like Plants**

| | | |
|---|---|---|
| Blue Joint Grass | *Calamagrostis canadensis* | FACW+ |
| Fringed Sedge | *Carex crinita* | OBL |
| Lurid Sedge | *Carex lurida* | OBL |
| Broom Sedge | *Carex scoparia* | FACW |
| Stalk-Grain Sedge | *Carex stipata* | OBL |
| Tussock Sedge | *Carex stricta* | OBL |
| Blunt Broom Sedge | *Carex tribuloides* | FACW+ |
| Other Sedges | *Carex* spp. | FACW-OBL |
| Other Grasses | *Graminaceae* | |
| Timothy | *Phleum pratense* | FACU |
| Flat Bluegrass | *Poa compressa* | |
| Haircap Moss | *Polytrichum commune* | FACU** |
| Softstem Bulrush | *Scirpus validus* | OBL |
| Bur Reed | *Sparganium* spp. | OBL |
| Sphagnum Moss | *Sphagnum* spp. | OBL** |

| Category | Symbol | Definition |
|---|---|---|
| OBLIGATE HYDROPHYTE | OBL | Nearly always occurs in wetlands (>99%) |
| FACULTATIVE WETLAND | FACW | Usually occurs in wetlands (67% to 99%) |
| FACULTATIVE | FAC | Commonly occurs in both wetlands and uplands (34% to 66% in wetlands) |
| FACULTATIVE UPLAND | FACU | Usually occurs in uplands, but may occasionally occur in wetlands (1% to 33%) |
| UPLAND | UPL | Nearly always occurs in uplands (<1% in wetlands) |

A positive (+) sign behind the Facultative Indicator categories indicates a frequency toward the higher end of the category (more frequently found in wetlands), while a negative (-) sign indicates a frequency toward the lower end of the category (less frequently found in wetlands).

D = Dominant (> 50% cover)
C = Common (11%-49% cover)
O = Occasional (1%-10% cover)

* 1988 Wetland Plant List, Northeast Region. National Wetlands Inventory, U.S. Fish and Wildlife Service.

** Indicator status for mosses assigned by experience of NEE personnel; mosses are not rated by Wetland Plant List (1988).

## REFERENCES

Adamus, Paul R. 1982. A Method for Wetland Functional Assessment. Office of Research, Environmental Division, Federal Highway Administration, US Dept. of Transportation, Washington, D.C.

Adamus, Paul R. and L.T. Stockwell. 1983. A Method for Wetland Functional Assessment: Volumes I and II. Critical review and Evaluation Concepts. Technical Report FHWA-IP-82-83. Office of Research, Environmental Division, Federal Highway Administration, US Dept. of Transportation, Washington, D.C.

Adamus, Paul R., Stockwell, Lauren T., Clairain, Ellis J., Jr., Morrow, Michael E., Rozas, Lawrence P., and Smith, R. Daniel. 1991. Wetland Evaluation Technique (WET); Volume I: Literature Review and Evaluation Rationale. Technical report WRP-DE-2, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brinson, M.M., W. Druczynsk, L.C. Lee, W.L. Nutter, R.D. Smith and D.F. Whigham. In Press. Developing an approach for assessing the functions of wetlands. In W.J. Mitsch and R.E. Turner (eds.) Wetlands of the World: Biogeochemistry, Ecological Engineering, Modelling and Management. Elsevier Publishers, Amsterdam.

Brinson, Mark M. and R. Daniel Smith. 1993. Development of logic trains in hydrogeomorphic assessments of wetland functioning. In ASLO and SWS Meeting Abstracts, Edmonton, Alberta.

Conservation Foundation. 1988. Protecting America's Wetlands: an action agenda. Final Report. Washington, D.C. 69pp.

Golet, F.C. and J. S. Larson. 1974. Classification of freshwater wetlands in the glaciated northeast. Bur. Sport Fish. and Wild. Res. Publ. 116. Washington, D.C. 56. pp.

Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service, Washington, D.C. Cooperative technical publication. 107pp.

Hollands, G. Garrett, and Dennis W. McGee. 1985. A Method for Assessing the Functions of Wetlands. In Proceedings; National Wetlands Assessment Symposium, Portland, ME.

Larson. J.S. and D.B. Mazzarese. (in press). Rapid wetland assessment: history and application to management. In W.J. Mitsch and R.E. Turner (eds.) Wetlands of the World: Biogeochemistry, Ecological Engineering, Modelling and Management. Elsevier Publishers, Amsterdam.

Michener, Martin C. 1983. Wetland site index for summarizing botanical studies. Wetlands 3: 180-191.

Reed, P.B., Jr. 1988. National list of plant species that occur in wetlands: Northeast (Region 1). U.S. Fish Wildl. Serv. Biol. Rep. 88(26.1). 111pp.

U.S. Army Corps of Engineers. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. 100pp.

# APPENDIX E

## WET DATA FORMS

WET - COLDSPRIN

## FORM A: SITE DOCUMENTATION (Page 1 of 2)

**Part 1 - Background Information** AA 1

Evaluation Site: COLD SPRING POND Date: 6-18-93

Site Location (Section, Range, and Township): AYER

Has the evaluator taken a training course in WET Version 2.0? YES

Agencies/Experts Contacted: SCS, NOAA, MA F+W, NAT. HERITAGE

Circle the assessment levels to be completed? (SS-1) (SS-2) (E/O-1&2) E/O-3 HS

Is the wetland tidal or nontidal? If the wetland is nontidal, indicate the month(s) that represent wet, dry, and average conditions, or if only average annual condition will be used, give rationale. Also, indicate if the previous 12 months of precipitation has been above, below, or near normal.

Nontidal Wet Cond. – [illegible] – [illegible], Veg – [illegible]; Dry Cond. [illegible] – Hydrology – Aug. Veg – [illegible] Ave. Cond – [illegible] – June Veg – Sept.

Is this evaluation an estimate of past conditions or a prediction of future conditions? (If answer is yes, explain nature and source of predictive data.)

NO

Will alternative ratings be used to evaluate any of the functions or values (if yes, explain)? NO

**Part 2 - Identification and Delineation of Evaluation Areas**

Sketch a map on the following page, or attach a suitable map (photocopy of topgraphic map) that shows the following information: SEE FIGURE 1

- Boundaries of the AA, IA, and IZ, and the location of service areas.
- Watershed boundaries of AA, and service areas.
- Extent of surface water in the AA during the wet and dry seasons.
- Open water (channels and pools) within and adjacent to the AA.
- Normal direction of channel or tidal flow
- Normal direction of wind-driven waves or current.
- Impact area(s).
- Scale of distance and north compass direction.

Explain the procedures used to identify or delineate the AA, IA, IZ, service areas, and the watersheds of these areas if they differed from the guidelines outlined in Section 2.7. N/A

-- Continued --

# FORM A: SITE DOCUMENTATION (Page 2 of 2)

**Part 2 (Cont.)**

Estimate the extent of the following areas:

Assessment Area = ±3 acres
Impact Area = N/A acres (only if applicable)
Watershed of AA = ±50 acres/ 0.08 miles$^2$ (acres x 0.0016 = miles)
Wetlands in AA = ±3 acres
Wetlands in the watershed of closest service area = 7500 acres
Wetlands and deepwater in the watershed of closest service area = 7500 acres

How were locality and region defined for this evaluation?
locality - Town (Ayer)
Region - State (Massachusetts)

Sketch of Evaluation Areas (or attach map):

See Figure 1

## FORM B: EVALUATION ANSWER SHEET

Evaluation Site: Cold Spring Pond AA-1

### SOCIAL SIGNIFICANCE EVALUATION - LEVEL 1

3.1.1 "Red Flags"

Comments/Assumptions

s1. Y **N** U — NOT LISTED BY MA. NAT. HERITAGE
s2. Y **N** U
s3. Y **N** U
s4. Y **N** U
s5. Y **N** U
s6. Y **N** U

3.1.2 On-site Social Significance

Comments/Assumptions

s7. Y **N** U I
s8. **Y** N U I - SUPERFUND SITE

3.1.3 Off-site Social Significance

Comments

s9. Y **N** U I
s10. **Y** N U
s11. **Y** N U
s12. Y **N** U
s13. Y N **U**
s14. Y **N** U
s15. **Y** N U I · ESTIMATED HABITAT MAP
s16. **Y** N U I · GROVE POND WELL FIELD
s17. **Y** N U I
s18. Y **N** U I
s19. Y **N** U
s20. Y **N** U NO IMPORTANT FISH

Comments

s21. **Y** N U BLACK DUCK/WOOD DUCK
s22. **Y** N U I
s23. Y **N** U
s24. Y **N** U
s25. **Y** N U - SUPERFUND SITE
s26. Y **N** U
s27. Y **N** U - NO LOCAL [illegible]
s28. Y **N** U
s29. Y **N** U - [illegible]
s30. Y **N** U
s31. Y **N** U - [illegible]

### SOCIAL SIGNIFICANCE EVALUATION - LEVEL 2

Context Region (Circle one)
Standard Density Circle
**Locality**
Hydrologic Unit

Question #

Comments/Assumptions

1 Y **N** - [illegible]
2 Y **N** - [illegible]
3 Y N - [illegible]
4 Y N - [illegible]

FORM B (Cont.) 

Evaluation Site: COLD SPRING [illegible]

**EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 1 (OFFICE)**

| Q.# | WETLAND CONDITION X̄ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 1.1 | Y (N) | | | |
| 1.2 | Y (N) | | | - [illegible] SCS |
| 1.3 | (Y) N | | | |
| 2.1.1 | Y (N) | | | |
| 2.1.2 | Y (N) | | | |
| 2.1.3 | Y (N) | | | |
| 2.2.1 | Y (N) I | | | |
| 2.2.2 | (Y) N I | | | FIELD OBS |
| 3.1 | (Y) N | | | |
| 3.2 | Y (N) | | | NWI MAPS |
| 3.3 | Y (N) | | | NWI MAPS |
| 4.1 | (Y) N | | | - NASHUA/MERRIMACK RIVER |
| 4.2A | (Y) N | | | - USGS |
| 4.2B | Y (N) | | | |
| 4.2C | Y (N) | | | |
| 4.2D | Y (N) | | | |
| 5.1.1 | | Y (N) | | |
| 5.1.2 | | Y (N) | | |
| 5.2 | | (Y) N | | |
| 6.1 | Y (N) | | | USGS |
| 6.2 | (Y) N | | | FIELD INVESTIGATION |
| 7 | Y N (I) | | | |
| 8.1 | Y (N) | | | - FIELD OBS |
| 8.2 | (Y) N | | | |
| 8.3 | (Y) N | | | - USGS & FIELD |
| 8.4 | Y (N) | | | |
| 9.1 | | (Y) N | | - CONSTRICTED OUTLET |
| 9.2 | | Y (N) I | | |
| 9.3 | | Y (N) I | | - GNDWATER DIS. |
| 10A | (Y) N | | | - AQUATIC BED |
| 10B | Y (N) | | | |
| 10C | Y (N) | | | |
| 10D | Y (N) | | | |
| 10E | Y (N) | | | |
| 10F | Y (N) | | | |

Evaluation Site: COLD SPRING – AA 1

| Q.# | X̄ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 11 | Y (N) | Y (N) | Y (N) | |
| 12A | Y N | Y N | Y N | DOMINANT A - AQUATIC |
| 12Aa | Y N | Y N | Y N | BED, ROOTED VASCULAR |
| 12Ab | Y N | Y N | Y N | |
| 12Ac | Y N | Y N | Y N | |
| 12Ad | Y N | Y N | Y N | |
| 12Ae | Y N | Y N | Y N | EDGE B - SHRUB/SCRUB |
| 12B | Y N | Y N | Y N | BROAD LEAF DECIDUOUS |
| 12Ba | Y N | Y N | Y N | |
| 12Bb | Y N | Y N | Y N | |
| 12Bc | Y N | Y N | Y N | C - AQUATIC BED, |
| 12Bd | Y N | Y N | Y N | ROOTED VASCULAR |
| 12Be | (Y) N | (Y) N | (Y) N | |
| 12C | Y N | Y N | Y N | |
| 12Ca | Y N | Y N | Y N | |
| 12Cb | Y N | Y N | Y N | |
| 12Cc | (Y) N | (Y) N | (Y) N | |
| 12Cd | Y N | Y N | Y N | |
| 12D | Y N | Y N | Y N | |
| 12Da | Y N | Y N | Y N | |
| 12Db | Y N | Y N | Y N | |
| 12E | Y N | Y N | Y N | |
| 13A | Y N | Y N | Y N | |
| 13Aa | Y N | Y N | Y N | >10% - AQUATIC BE |
| 13Ab | Y N | Y N | Y N | |
| 13Ac | Y N | Y N | Y N | >10% - FORESTED F |
| 13Ad | Y N | Y N | Y N | |
| 13Ae | (Y) N | (Y) N | (Y) N | >10% - SHRUB/SCRUB |
| 13B | Y N | Y N | Y N | |
| 13Ba | Y N | Y N | Y N | |
| 13Bb | Y N | Y N | Y N | |
| 13Bc | Y N | Y N | Y N | |
| 13Bd | Y N | Y N | Y N | |
| 13Be | (Y) N | (Y) N | (Y) N | |
| 13C | Y N | Y N | Y N | |
| 13Ca | Y N | Y N | Y N | |
| 13Cb | Y N | Y N | Y N | |
| 13Cc | (Y) N | (Y) N | (Y) N | |
| 13Cd | Y N | Y N | Y N | |
| 13D | Y N | Y N | Y N | |
| 13Da | Y N | Y N | Y N | |
| 13Db | Y N | Y N | Y N | |
| 13E | Y N | Y N | Y N | |

FORM B (Cont.) 

Evaluation Site: COLD SPRING POND - AA 1

| Q.# | $\bar{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 14.1 | Y N | Y N | Y N | FIELD OBSERV. |
| 14.2 | Y N | Y N | Y N | |
| 15.1A | Y N I | | | |
| 15.1B | Y N I | FIELD OBSERV. | | |
| 15.1C | Y N I | | | |
| 15.2 | Y N I | NO CHANNEL FLOW | | |
| 16A | Y N | Y N | Y N | |
| 16B | Y N | Y N | Y N | FIELD OBSERV. |
| 16C | Y N | Y N | Y N | |
| 17 | Y N | < 70% ANY CLASS | | |
| 18 | Y N I | | | |
| 19.1A | Y N I - TREES, TOPO | | | |
| 19.1B | Y N I | | | |
| 19.2 | Y N I | | | |
| 19.3 | Y N I | | | |
| 20.1 | Y N I | | | |
| 20.2 | Y N I | | | |
| 21A | Y N - MOSTLY FORESTED ALTHOUGH SIG. LANDFILL AREA | | | |
| 21B | Y N | | | |
| 21C | Y N | | | |
| 21D | Y N | | | |
| 21E | Y N | | | |
| 22.1.1 | Y N | | | |
| 22.1.2 | Y N I | | | |
| 22.2 | Y N | | | |
| 22.3 | Y N I | | | |
| 23 | Y N CONSTRICTING CULVERTS | | | |
| 24.1 | Y N I - SCS SOILS MAP | | | |
| 24.2 | Y N I | | | |
| 24.3 | Y N I | | | |
| 24.4 | Y N I | | | |
| 24.5 | Y N | | | |
| 25.1 | Y N - LANDFILL | | | |
| 25.2A | Y N I | | | |
| 25.2B | Y N I | | | |
| 25.3 | Y N - UNSTABLE SOILS | | | |

FORM B (Cont.)

Evaluation Site: COLD SPRING POND AA1

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D | Comments |
|---|---|---|---|---|
| 26.1 | (Y) N | | | – LANDFILL |
| 26.2 | Y (N) I | | | – GRNDWTR DISCH. |
| 26.3 | (Y) N I | | | – CHANNEL FROM UPGRADIENT AA |
| 27.1 | (Y) N | | | LANDFILL |
| 27.2 | Y (N) I | | | |
| 27.3 | (Y) N I | | | CHANNEL FROM UPGRADIENT AA |

EFFFECTIVENESS/OPPORTUNITY EVALUATION – LEVEL 2 (FIELD)

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D | Comments |
|---|---|---|---|---|
| 28 | Y (N) | | | |
| 29.1 | (Y) N | | | SHRUBS ON AA [illegible] |
| 29.2 | Y (N) | | | 7% |
| 30. | (Y) N | (Y) N | (Y) N | |
| 31.1 | (Y) N | (Y) N | (Y) N | |
| 31.2 | (Y) N | (Y) N | (Y) N | |
| 31.3 | (Y) N | (Y) N | (Y) N | |
| 31.4 | (Y) N I | (Y) N I | Y (N) I | – WINTER |
| 31.5 | (Y) N | (Y) N | (Y) N | |
| 31.6A | Y (N) | Y (N) | Y (N) | |
| 31.6B | (Y) N | (Y) N | (Y) N | |
| 31.6C | Y (N) | Y (N) | Y (N) | |
| 31.6D | Y (N) | Y (N) | Y (N) | |
| 31.6E | Y (N) | Y (N) | Y (N) | |
| 32A | (Y) N | | | |
| 32B | Y (N) | | | |
| 32C | Y (N) | | | |
| 32D | Y (N) | | | |
| 32E | Y (N) | | | |
| 32F | Y (N) | | | |
| 32G | Y (N) | | | |
| 32H | Y (N) | | | |
| 32I | Y (N) | | | |
| 32J | Y (N) | | | |
| 32K | Y (N) | | | |

FORM B (Cont.)



Evaluation Site: COLD SPRING POND AA1

WETLAND CONDITION

| Q.# | $\bar{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 33A | Y N | | | |
| 33B | Y N | | | |
| 33C | Y N | | | |
| 33D | Y N | | | |
| 33E | Y N | | | |
| 33F | Y N | | | |
| 33G | Y N | | | |
| 33H | Y N | | | |
| 33I | Y N | | | |
| 33J | Y N | | | |
| 33K | Y N | | | |
| 34.1 | Y N | | | - USGS - OBSERVED FIELD DATA |
| 34.2 | Y N | | | |
| 34.3.1 | Y N | | | |
| 34.3.2 | Y N I | | | |
| 35.1 | Y N I | | | FEMA MAP, FIELD OBSERV |
| 35.2 | Y N I | | | |
| 36.1.1 | Y N | Y N | Y N | |
| 36.1.2 | Y N | Y N | Y N | |
| 36.2.1 | Y N | Y N | Y N | |
| 36.2.2 | Y N | Y N | Y N | - CATTAILS TUSSOCK SEDGE |
| 36.2.3 | Y N | Y N | Y N | |
| 37 | Y N | | | |
| 38.1 | Y N | | | - OBSERVANT AA |
| 38.2 | Y N | | | |
| 38.3 | Y N | | | |
| 38.4 | Y N | | | |
| 38.5 | Y N | | | |
| 38.6 | Y N | | | |
| 38.7 | Y N | | | - NWI MAPS |
| 38.8 | Y N I | | | |
| 39 | Y N | | | |
| 40.1 | Y N I | | | |
| 40.2 | Y N I | | | |
| 41.1 | | Y N I | | |
| 41.2 | | Y N I | | |

FORM B (Cont.)



Evaluation Site: Cold Spring Pond A-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D |
|---|---|---|---|
| 42.1.1 | Y N I | Y N I | Y N I |
| 42.1.2 | Y N I | Y N I | Y N I |
| 42.1.3 | Y N I | Y N I | Y N I |
| 42.2.1 | Y N I | Y N I | Y N I |
| 42.2.2 | Y N I | Y N I | Y N I |
| 42.2.3 | Y N I | Y N I | Y N I |
| 43A | Y N | Y N | Y N |
| 43B | Y N | Y N | Y N |
| 43C | Y N | Y N | Y N |
| 43D | Y N | Y N | Y N |
| 43E | Y N | Y N | Y N |
| 43F | Y N | Y N | Y N |
| 43G | Y N | Y N | Y N |
| 43H | Y N | Y N | Y N |
| 43I | Y N | Y N | Y N |
| 44A | Y N | Y N | Y N |
| 44B | Y N | Y N | Y N |
| 44C | Y N | Y N | Y N |
| 44D | Y N | Y N | Y N |
| 44E | Y N | Y N | Y N |
| 44F | Y N | Y N | Y N |
| 44G | Y N | Y N | Y N |
| 44H | Y N | Y N | Y N |
| 44I | Y N | Y N | Y N |
| 45A | Y N | | |
| 45B | Y N | | |
| 45C | Y N | | |
| 45D | Y N | | |
| 45E | Y N | | |
| 45F | Y N | | |
| 45G | Y N | | |
| 46A | Y N | Y N | Y N |
| 46B | Y N | Y N | Y N |
| 46C | Y N | Y N | Y N |
| 47A | Y N | | |
| 47B | Y N | | |
| 47C | Y N | | |

FORM B (Cont.)



Evaluation Site: Cold Spring Pond AA1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D |
|---|---|---|---|
| 48A | Y N I | Y N I | Y N I |
| 48B | Y N I | Y N I | Y N I |
| 48C | Y N I | Y N I | Y N I |
| 48D | Y N I | Y N I | Y N I |
| 48E | Y N I | Y N I | Y N I |
| 48F | Y N I | Y N I | Y N I |
| 49.1.1 | Y N I | Y N I | Y N I |
| 49.1.2 | Y N I | Y N I | Y N I |
| 49.2 | Y N I | Y N I | Y N I |
| 49.3 | Y N I | Y N I | Y N I |
| 50. | Y N | Y N | Y N |

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 3 (DETAILED DATA)

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D |
|---|---|---|---|
| 51.1 | Y N U | | |
| 51.2 | Y N U | | |
| 52.1 | Y N I U | | |
| 52.2 | Y N I U | | |
| 53.1 | Y N I U | | |
| 53.2 | Y N I U | | |
| 54 | Y N U | Y N U | Y N U |
| 55.1 | Y N U | | |
| 55.2 | Y N U | | |
| 55.3 | Y N U | | |
| 55.4 | Y N U | | |
| 56.1 | Y N I U | | |
| 56.2 | Y N I U | | |
| 57.1 | Y N U | | |
| 57.2 | Y N U | | |
| 58. | Y N U | | |

Evaluation Site: ______________________________

| | WETLAND CONDITION | | | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| Q.# | $\bar{X}$ | W | D | |
| 59.1 | Y N I U | | | |
| 59.2 | Y N I U | | | |
| 60 | Y N U | | | |
| 61 | Y N I U | | | |
| 62 | Y N U | | | |
| 63.1 | Y N I U | | | |
| 63.2 | Y N I U | | | |
| 64 | | Y N I U | | |

## FORM C: SUPPLEMENTARY OBSERVATIONS

Evaluation Site: Gold Spring Pond AA#1

Indicate the species, species groups, and activities that are actually observed, reliably reported, or known to occur at the AA on a regular basis.

| FISH SPECIES GROUPS* | OBSERVED/REPORTED |
|---|---|
| 1. Warmwater Group | (Y) or N |
| 2. Coldwater Group | Y or (N) |
| 3. Northern Lake Group | (Y) or N |
| 4. Coldwater Riverine Group | Y or (N) |

| FISH SPECIES | | OBSERVED/REPORTED |
|---|---|---|
| 22 Yellow Perch | 26 Pumpkinseed N | (Y) or N |
| 10 [illegible] | | (Y) or N |
| 7 Smallmouth Bass | | Y or (N) |
| 40 Redbreasted Sunfish N | | |

| WATERFOWL SPECIES GROUPS** | | NESTING | MIGRATING | WINTERING |
|---|---|---|---|---|
| 1. Prairie Dabblers | 110 | Y or (N) | (Y) or N | Y or (N) |
| 2. Black Duck | 113 | Y or N | (Y) or N | Y or (N) |
| 3. Wood Duck | 116 | (Y) or N | (Y) or N | Y or (N) |
| 4. Common and Red-Breasted Mergansers | 119 | Y or (N) | Y or N | Y or (N) |
| 5. Hooded Merganser | 122 | Y or N | Y or N | Y or (N) |
| 6. Canvasback, Redhead, Ruddy Duck | 125 | Y or N | Y or N | Y or (N) |
| 7. Ring-necked Duck | 128 | Y or N | Y or N | Y or (N) |
| 8. Greater and Lesser Scaup | 131 | Y or N | Y or N | Y or (N) |
| 9. Common Goldeneye | 134 | Y or N | Y or N | Y or (N) |
| 10. Bufflehead | 137 | Y or N | Y or N | Y or (N) |
| 11. Whistling Ducks | 140 | Y or N | Y or N | Y or (N) |
| 12. Inland Geese | 143 | Y or N | Y or N | Y or (N) |
| 13. Tundra Swan | 146 | Y or N | Y or N | Y or (N) |
| 14. Brant | 149 | Y or N | Y or N | Y or (N) |

[illegible]

| BIRD SPECIES | OBSERVED/REPORTED |
|---|---|
| ✓ [illegible] | (Y) or N |
| ✓ [illegible] | (Y) or N |
| ✓ Green Heron | (Y) or N |

RECREATIONAL ACTIVITIES

| | | | |
|---|---|---|---|
| (Hiking) | Sailing | Snowmobiling | Research |
| (Birdwatching) | Power Boating | Skiing | Educational Fieldtrips |
| (Photography) | Canoeing | Snowshoeing | Horseback Riding |
| Swimming | Kayaking | (Ice Skating) | |

CONSUMPTIVE ACTIVITIES

[illegible]

| | | | |
|---|---|---|---|
| Agriculture | Fur Harvesting | (Commercial/Sport Fishing) | Peat Harvesting |
| (Hunting) | Timber Harvest | Natural Food Gathering | Water Supply |

[illegible]

* Fish species groups are explained on page 138

** Waterfowl species groups are explained on page 1647

# FORM D: EVALUATION SUMMARY SHEET

Evaluation Site: ______________________________

## Wetland Functions and Values

| | Social Significance | Effectiveness | Opportunity |
|---|---|---|---|
| Ground Water Recharge | ____ | ____ | * |
| Ground Water Discharge | ____ | ____ | * |
| Floodflow Alteration | ____ | ____ | ____ |
| Sediment Stabilization | ____ | ____ | * |
| Sediment/Toxicant Retention | ____ | ____ | ____ |
| Nutrient Removal/Transform. | ____ | ____ | ____ |
| Production Export | * | ____ | * |
| Wildlife Diversity/Abundance** | ____ | * | * |
| Breeding | * | ____ | * |
| Migration | * | ____ | * |
| Wintering | * | ____ | * |
| Aquatic Diversity/Abundance | ____ | ____ | * |
| Uniqueness/Heritage | ____ | * | * |
| Recreation | ____ | * | * |

## Habitat Suitability Evaluation

Fish Species Groups:

__________ Group ___ __________ Group ___ __________ Group ___

Waterfowl Species Groups:

| | Breeding | Migration | Wintering |
|---|---|---|---|
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |

Fish, Invertebrate, and Bird Species:

| | | | | | |
|---|---|---|---|---|---|
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |

Levels of assessment completed: S-1 S-2 E/O-1 E/O-2 E/O-3 HS

Evaluation is for the: AA IA (Note: if the evaluation is for an IA, documentation of the AA evaluation must be presented with this evaluation).

Is there any evidence that suggests ratings contrary to the above (explain)?

______________________________

Were alternative sources used for any of the ratings above (explain)? ________

______________________________

The loss rate for ______________________ (identify locality/region) between 19__ and 19__ for ______________________ (identify wetland type) was __________ (acres/year or % loss).

* WET does not evaluate this function or value in these terms.

** Wildlife Diversity/Abundance assesses only wetland-dependent birds. Other wildlife (e.g., game mammals) should be evaluated using other methods.

POST PLOW

FORM A: SITE DOCUMENTATION (Page 1 of 2)

**Part 1 - Background Information**

Evaluation Site: PLOWSHOP POND IA 2 POST IMPACT - 3 yrs Date: 6/21/93

Site Location (Section, Range, and Township): AYER MA

Has the evaluator taken a training course in WET Version 2.0? Yes

Agencies/Experts Contacted: SCS NOAA

Circle the assessment levels to be completed? (SS-1) (SS-2) (E/O-1&2) E/O-3 HS

Is the wetland tidal or nontidal? If the wetland is nontidal, indicate the month(s) that represent wet, dry, and average conditions, or if only average annual condition will be used, give rationale. Also, indicate if the previous 12 months of precipitation has been above, below, or near normal.
Nontidal, Wet Cond - hydrology - March Veget - May Dry Cond - Hydrol - June Veg - Nov. Avg Cond - Hydrol - [illegible] Veg. Sept.

Is this evaluation an estimate of past conditions or a prediction of future conditions? (If answer is yes, explain nature and source of predictive data.)
No

Will alternative ratings be used to evaluate any of the functions or values (if yes, explain)? No

**Part 2 - Identification and Delineation of Evaluation Areas**

Sketch a map on the following page, or attach a suitable map (photocopy of topgraphic map) that shows the following information:

-- Boundaries of the AA, IA, and IZ, and the location of service areas. See Figure
-- Watershed boundaries of AA, and service areas.
-- Extent of surface water in the AA during the wet and dry seasons.
-- Open water (channels and pools) within and adjacent to the AA.
-- Normal direction of channel or tidal flow
-- Normal direction of wind-driven waves or current.
-- Impact area(s).
-- Scale of distance and north compass direction.

Explain the procedures used to identify or delineate the AA, IA, IZ, service areas, and the watersheds of these areas if they differed from the guidelines outlined in Section 2.7. N/A

-- Continued --

FORM A: SITE DOCUMENTATION (Page 2 of 2)

Part 2 (Cont.)

Estimate the extent of the following areas:

Assessment Area = N/A acres
Impact Area = ±25 acres (only if applicable)
Watershed of AA = — acres/ ±25 miles$^2$ (acres x 0.0016 = miles)
Wetlands in AA = ±25 acres
Wetlands in the watershed of closest service area = >500 acres
Wetlands and deepwater in the watershed of closest service area = >500 acres

How were locality and region defined for this evaluation?
locality - Town (Ayer)
(Region - State (Massachusetts))

Sketch of Evaluation Areas (or attach map):
See Figure 1.

## FORM B: EVALUATION ANSWER SHEET

Evaluation Site: *Plowshop Pond* I A-2

### SOCIAL SIGNIFICANCE EVALUATION - LEVEL 1

**3.1.1 "Red Flags"**

Comments/Assumptions

| | | | |
|---|---|---|---|
| s1. | Y | **(N)** | U |
| s2. | Y | **(N)** | U |
| s3. | Y | **(N)** | U |
| s4. | Y | **(N)** | U |
| s5. | Y | **(N)** | U |
| s6. | **(Y)** | N | U |

**3.1.2 On-site Social Significance**

| | | | | | Comments/Assumptions |
|---|---|---|---|---|---|
| s7. | Y | **(N)** | U | I | |
| s8. | **(Y)** | N | U | I | Superfund site |

**3.1.3 Off-site Social Significance**

| | | | | | Comments |
|---|---|---|---|---|---|
| s9. | Y | **(N)** | U | I | "Y" s10 |
| s10. | Y | **(N)** | U | | ch. due to |
| s11. | Y | N | **(U)** | | <10% & open |
| s12. | Y | **(N)** | U | | water 77% |
| s13. | Y | N | **(U)** | | |
| s14. | Y | **(N)** | U | | |
| s15. | **(Y)** | N | U | I | |
| s16. | **(Y)** | N | U | I | |
| s17. | **(Y)** | N | U | I | |
| s18. | Y | **(N)** | U | I | |
| s19. | Y | **(N)** | U | | |
| s20. | Y | **(N)** | U | | |

| | | | | | Comments |
|---|---|---|---|---|---|
| s21. | **(Y)** | N | U | | |
| s22. | **(Y)** | N | U | I | |
| s23. | Y | **(N)** | U | | |
| s24. | Y | **(N)** | U | | |
| s25. | **(Y)** | N | U | | — Superfund. |
| s26. | Y | **(N)** | U | | No [illegible], [illegible] |
| s27. | Y | **(N)** | U | | |
| s28. | Y | **(N)** | U | | |
| s29. | Y | **(N)** | U | | |
| s30. | Y | **(N)** | U | | |
| s31. | **(Y)** | N | U | | |

### SOCIAL SIGNIFICANCE EVALUATION - LEVEL 2

Context Region (Circle one)
- Standard Density Circle
- **(Locality)**
- Hydrologic Unit

Question #

| | | | Comments/Assumptions |
|---|---|---|---|
| 1 | Y | **(N)** | Same as [illegible] |
| 2 | Y | **(N)** | |
| 3 | Y | **(N)** | |
| 4 | Y | **(N)** | |

FORM B (Cont.)



Evaluation Site: Plowshop IA - 2

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 1 (OFFICE)

| | WETLAND CONDITION | | | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| Q.# | $\bar{X}$ | W | D | |
| 1.1 | Y N | | | |
| 1.2 | Y N | | | |
| 1.3 | Y N | | | |
| 2.1.1 | Y N | | | |
| 2.1.2 | Y N | | | |
| 2.1.3 | Y N | | | |
| 2.2.1 | Y N I | | | |
| 2.2.2 | Y N I | | | |
| 3.1 | Y N | | | |
| 3.2 | Y N | | | |
| 3.3 | Y N | | | |
| 4.1 | Y N - [illegible] | | | |
| 4.2A | Y N | | | |
| 4.2B | Y N | | | |
| 4.2C | Y N | | | |
| 4.2D | Y N | | | |
| 5.1.1 | | Y N | | |
| 5.1.2 | | Y N | | |
| 5.2 | | Y N | | |
| 6.1 | Y N | | | |
| 6.2 | Y N | | | |
| 7 | Y N I | | | |
| 8.1 | Y N | | | |
| 8.2 | Y N | | | |
| 8.3 | Y N | | | |
| 8.4 | Y N | | | |
| 9.1 | | Y N | | |
| 9.2 | | Y N I | | |
| 9.3 | | Y N I | | |
| 10A | Y N | | | |
| 10B | Y N | | | |
| 10C | Y N | | | |
| 10D | Y N | | | |
| 10E | Y N | | | |
| 10F | Y N | | | |

FORM B (Cont.)



Evaluation Site: Plowshop IA-2

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 11 | Y (N) | Y (N) | Y (N) |
| 12A | Y (N) | Y (N) | Y (N) |
| 12Aa | Y (N) | Y (N) | Y (N) |
| 12Ab | Y (N) | Y (N) | Y (N) |
| 12Ac | Y (N) | Y (N) | Y (N) |
| 12Ad | Y (N) | Y (N) | Y (N) |
| 12Ae | Y (N) | Y (N) | Y (N) |
| 12B | Y (N) | Y (N) | Y (N) |
| 12Ba | Y (N) | Y (N) | Y (N) |
| 12Bb | Y (N) | Y (N) | Y (N) |
| 12Bc | Y (N) | Y (N) | Y (N) |
| 12Bd | Y (N) | Y (N) | Y (N) |
| 12Be | (Y) N | (Y) N | (Y) N |
| 12C | Y (N) | Y (N) | Y (N) |
| 12Ca | Y (N) | Y (N) | Y (N) |
| 12Cb | Y (N) | Y (N) | Y (N) |
| 12Cc | (Y) N | (Y) N | (Y) N |
| 12Cd | Y (N) | Y (N) | Y (N) |
| 12D | Y (N) | Y (N) | Y (N) |
| 12Da | Y (N) | Y (N) | Y (N) |
| 12Db | Y (N) | Y (N) | Y (N) |
| 12E | Y (N) | Y (N) | Y (N) |
| 13A | Y (N) | Y (N) | Y (N) |
| 13Aa | Y (N) | Y (N) | Y (N) |
| 13Ab | Y (N) | Y (N) | Y (N) |
| 13Ac | Y (N) | Y (N) | Y (N) |
| 13Ad | Y (N) | Y (N) | Y (N) |
| 13Ae | Y (N) | Y (N) | Y (N) |
| 13B | Y (N) | Y (N) | Y (N) |
| 13Ba | Y (N) | Y (N) | Y (N) |
| 13Bb | Y (N) | Y (N) | Y (N) |
| 13Bc | Y (N) | Y (N) | Y (N) |
| 13Bd | Y (N) | Y (N) | Y (N) |
| 13Be | (Y) N | (Y) N | (Y) N |
| 13C | Y (N) | Y (N) | Y (N) |
| 13Ca | Y (N) | Y (N) | Y (N) |
| 13Cb | Y (N) | Y (N) | Y (N) |
| 13Cc | (Y) N | (Y) N | (Y) N |
| 13Cd | Y (N) | Y (N) | Y (N) |
| 13D | Y (N) | Y (N) | Y (N) |
| 13Da | Y (N) | Y (N) | Y (N) |
| 13Db | Y (N) | Y (N) | Y (N) |
| 13E | Y (N) | Y (N) | Y (N) |

FORM B (Cont.)



Evaluation Site: Plowshop IA-7

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 14.1 | Y N | Y N | Y N | |
| 14.2 | Y N | Y N | Y N | |
| 15.1A | Y N I | | | |
| 15.1B | Y N I | | | |
| 15.1C | Y N I | | | |
| 15.2 | Y N I | | | |
| 16A | Y N | Y N | Y N | |
| 16B | Y N | Y N | Y N | |
| 16C | Y N | Y N | Y N | |
| 17 | Y N | | | |
| 18 | Y N I | | | |
| 19.1A | Y N I | | | |
| 19.1B | Y N I | | | |
| 19.2 | Y N I | | | |
| 19.3 | Y N I | | | |
| 20.1 | Y N I | | | |
| 20.2 | Y N I | | | |
| 21A | Y N | | | |
| 21B | Y N | | | |
| 21C | Y N | | | |
| 21D | Y N | | | |
| 21E | Y N | | | |
| 22.1.1 | Y N | | | |
| 22.1.2 | Y N I | | | |
| 22.2 | Y N | | | |
| 22.3 | Y N I | | | |
| 23 | Y N | | | |
| 24.1 | Y N I | | | |
| 24.2 | Y N I | | | |
| 24.3 | Y N I | | | |
| 24.4 | Y N I | | | |
| 24.5 | Y N | | | |
| 25.1 | Y N | | | |
| 25.2A | Y N I | | | |
| 25.2B | Y N I | | | |
| 25.3 | Y N | | | |

FORM B (Cont.)

Evaluation Site: Cold Springs I A-2

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 26.1 | Y N | | |
| 26.2 | Y N I | | |
| 26.3 | Y N I | | |
| 27.1 | Y N | | |
| 27.2 | Y N I | | |
| 27.3 | Y N I | | |

## EFFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 2 (FIELD)

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 28 | Y N | | |
| 29.1 | Y N | | |
| 29.2 | Y N | | |
| 30 | Y N | Y N | Y N |
| 31.1 | Y N | Y N | Y N |
| 31.2 | Y N | Y N | Y N |
| 31.3 | Y N | Y N | Y N |
| 31.4 | Y N I | Y N I | Y N I |
| 31.5 | Y N | Y N | Y N |
| 31.6A | Y N | Y N | Y N |
| 31.6B | Y N | Y N | Y N |
| 31.6C | Y N | Y N | Y N |
| 31.6D | Y N | Y N | Y N |
| 31.6E | Y N | Y N | Y N |
| 32A | Y N | | |
| 32B | Y N | | |
| 32C | Y N | | |
| 32D | Y N | | |
| 32E | Y N | | |
| 32F | Y N | | |
| 32G | Y N | | |
| 32H | Y N | | |
| 32I | Y N | | |
| 32J | Y N | | |
| 32K | Y N | | |

FORM B (Cont.)



Evaluation Site: Plowshop IA-2

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D |
|---|---|---|---|
| 33A | Y N | | |
| 33B | Y N | | |
| 33C | Y N | | |
| 33D | Y N | | |
| 33E | Y N | | |
| 33F | Y N | | |
| 33G | Y N | | |
| 33H | Y N | | |
| 33I | Y N | | |
| 33J | Y N | | |
| 33K | Y N | | |
| 34.1 | Y N | | |
| 34.2 | Y N | | |
| 34.3.1 | Y N | | |
| 34.3.2 | Y N I | | |
| 35.1 | Y N I | | |
| 35.2 | Y N I | | |
| 36.1.1 | Y N | Y N | Y N |
| 36.1.2 | Y N | Y N | Y N |
| 36.2.1 | Y N | Y N | Y N |
| 36.2.2 | Y N | Y N | Y N |
| 36.2.3 | Y N | Y N | Y N |
| 37 | Y N | | |
| 38.1 | Y N | | |
| 38.2 | Y N | | |
| 38.3 | Y N | | |
| 38.4 | Y N | | |
| 38.5 | Y N | | |
| 38.6 | Y N | | |
| 38.7 | Y N | | |
| 38.8 | Y N I | | |
| 39 | Y N | | |
| 40.1 | Y N I | | |
| 40.2 | Y N I | | |
| 41.1 | | Y N I | |
| 41.2 | | Y N I | |

FORM B (Cont.)



Evaluation Site: Plowshop I+2

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 42.1.1 | Y N I | Y N I | Y N I |
| 42.1.2 | Y N I | Y N I | Y N I |
| 42.1.3 | Y N I | Y N I | Y N I |
| 42.2.1 | Y N I | Y N I | Y N I |
| 42.2.2 | Y N I | Y N I | Y N I |
| 42.2.3 | Y N I | Y N I | Y N I |
| 43A | Y N | Y N | Y N |
| 43B | Y N | Y N | Y N |
| 43C | Y N | Y N | Y N |
| 43D | Y N | Y N | Y N |
| 43E | Y N | Y N | Y N |
| 43F | Y N | Y N | Y N |
| 43G | Y N | Y N | Y N |
| 43H | Y N | Y N | Y N |
| 43I | Y N | Y N | Y N |
| 44A | Y N | Y N | Y N |
| 44B | Y N | Y N | Y N |
| 44C | Y N | Y N | Y N |
| 44D | Y N | Y N | Y N |
| 44E | Y N | Y N | Y N |
| 44F | Y N | Y N | Y N |
| 44G | Y N | Y N | Y N |
| 44H | Y N | Y N | Y N |
| 44I | Y N | Y N | Y N |
| 45A | Y N | | |
| 45B | Y N | | |
| 45C | Y N | | |
| 45D | Y N | | |
| 45E | Y N | | |
| 45F | Y N | | |
| 45G | Y N | | |
| 46A | Y N | Y N | Y N |
| 46B | Y N | Y N | Y N |
| 46C | Y N | Y N | Y N |
| 47A | Y N | | |
| 47B | Y N | | |
| 47C | Y N | | |

— assumed [illegible] [illegible] in maj. of area

FORM B (Cont.)



Evaluation Site: Plow Shop AA2

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D |
|---|---|---|---|
| 48A | Y N I | Y N I | Y N I |
| 48B | Y N I | Y N I | Y N I |
| 48C | Y N I | Y N I | Y N I |
| 48D | Y N I | Y N I | Y N I |
| 48E | Y N I | Y N I | Y N I |
| 48F | Y N I | Y N I | Y N I |
| 49.1.1 | Y N I | Y N I | Y N I |
| 49.1.2 | Y N I | Y N I | Y N I |
| 49.2 | Y N I | Y N I | Y N I |
| 49.3 | Y N I | Y N I | Y N I |
| 50. | Y N | Y N | Y N |

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 3 (DETAILED DATA)

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D |
|---|---|---|---|
| 51.1 | Y N U | | |
| 51.2 | Y N U | | |
| 52.1 | Y N I U | | |
| 52.2 | Y N I U | | |
| 53.1 | Y N I U | | |
| 53.2 | Y N I U | | |
| 54 | Y N U | Y N U | Y N U |
| 55.1 | Y N U | | |
| 55.2 | Y N U | | |
| 55.3 | Y N U | | |
| 55.4 | Y N U | | |
| 56.1 | Y N I U | | |
| 56.2 | Y N I U | | |
| 57.1 | Y N U | | |
| 57.2 | Y N U | | |
| 58. | Y N U | | |

FORM B (Cont.)



Evaluation Site: ______________________________

| | WETLAND CONDITION | | | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| Q.# | $\bar{X}$ | W | D | |
| 59.1 | Y N I U | | | |
| 59.2 | Y N I U | | | |
| 60 | Y N U | | | |
| 61 | Y N I U | | | |
| 62 | Y N U | | | |
| 63.1 | Y N I U | | | |
| 63.2 | Y N I U | | | |
| 64 | | Y N I U | | |

# FORM C: SUPPLEMENTARY OBSERVATIONS

**Evaluation Site:** ____________________

Indicate the species, species groups, and activities that are actually observed, reliably reported, or known to occur at the AA on a regular basis.

| FISH SPECIES GROUPS* | OBSERVED/REPORTED |
|---|---|
| 1. Warmwater Group | Y or N |
| 2. Coldwater Group | Y or N |
| 3. Northern Lake Group | Y or N |
| 4. Coldwater Riverine Group | Y or N |

| FISH SPECIES | OBSERVED/REPORTED |
|---|---|
| ____________________ | Y or N |
| ____________________ | Y or N |
| ____________________ | Y or N |

| WATERFOWL SPECIES GROUPS** | OBSERVED/REPORTED | | |
|---|---|---|---|
| | NESTING | MIGRATING | WINTERING |
| 1. Prairie Dabblers | Y or N | Y or N | Y or N |
| 2. Black Duck | Y or N | Y or N | Y or N |
| 3. Wood Duck | Y or N | Y or N | Y or N |
| 4. Common and Red-Breasted Mergansers | Y or N | Y or N | Y or N |
| 5. Hooded Merganser | Y or N | Y or N | Y or N |
| 6. Canvasback, Redhead, Ruddy Duck | Y or N | Y or N | Y or N |
| 7. Ring-necked Duck | Y or N | Y or N | Y or N |
| 8. Greater and Lesser Scaup | Y or N | Y or N | Y or N |
| 9. Common Goldeneye | Y or N | Y or N | Y or N |
| 10. Bufflehead | Y or N | Y or N | Y or N |
| 11. Whistling Ducks | Y or N | Y or N | Y or N |
| 12. Inland Geese | Y or N | Y or N | Y or N |
| 13. Tundra Swan | Y or N | Y or N | Y or N |
| 14. Brant | Y or N | Y or N | Y or N |

| BIRD SPECIES | OBSERVED/REPORTED |
|---|---|
| ____________________ | Y or N |
| ____________________ | Y or N |
| ____________________ | Y or N |

## RECREATIONAL ACTIVITIES

| | | | |
|---|---|---|---|
| Hiking | Sailing | Snowmobiling | Research |
| Birdwatching | Power Boating | Skiing | Educational Fieldtrips |
| Photography | Canoeing | Snowshoeing | Horseback Riding |
| Swimming | Kayaking | Ice Skating | |

## CONSUMPTIVE ACTIVITIES

| | | | |
|---|---|---|---|
| Agriculture | Fur Harvesting | Commercial/Sport Fishing | Peat Harvesting |
| Hunting | Timber Harvest | Natural Food Gathering | Water Supply |

* Fish species groups are explained on page 138
** Waterfowl species groups are explained on page 1647

# FORM D: EVALUATION SUMMARY SHEET

Evaluation Site: ______________________________

## Wetland Functions and Values

| | Social Significance | Effectiveness | Opportunity |
|---|---|---|---|
| Ground Water Recharge | ____ | ____ | * |
| Ground Water Discharge | ____ | ____ | * |
| Floodflow Alteration | ____ | ____ | ____ |
| Sediment Stabilization | ____ | ____ | * |
| Sediment/Toxicant Retention | ____ | ____ | ____ |
| Nutrient Removal/Transform. | ____ | ____ | ____ |
| Production Export | * | ____ | * |
| Wildlife Diversity/Abundance** | ____ | * | * |
| Breeding | * | ____ | * |
| Migration | * | ____ | * |
| Wintering | * | ____ | * |
| Aquatic Diversity/Abundance | ____ | ____ | * |
| Uniqueness/Heritage | ____ | * | * |
| Recreation | ____ | * | * |

## Habitat Suitability Evaluation

Fish Species Groups:

__________ Group ___ __________ Group ___ __________ Group ___

Waterfowl Species Groups:

| | Breeding | Migration | Wintering |
|---|---|---|---|
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |

Fish, Invertebrate, and Bird Species:

| | | | | | |
|---|---|---|---|---|---|
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |

Levels of assessment completed: S-1 S-2 E/O-1 E/O-2 E/O-3 HS

Evaluation is for the: AA IA (Note: if the evaluation is for an IA, documentation of the AA evaluation must be presented with this evaluation).

Is there any evidence that suggests ratings contrary to the above (explain)?

______________________________

Were alternative sources used for any of the ratings above (explain)? __________

______________________________

The loss rate for ____________________ (identify locality/region) between 19__ and 19__ for ____________________ (identify wetland type) was __________ (acres/year or % loss).

* WET does not evaluate this function or value in these terms.

** Wildlife Diversity/Abundance assesses only wetland-dependent birds. Other wildlife (e.g., game mammals) should be evaluated using other methods.

DATA NAME: PLOWSHOP



FORM A: SITE DOCUMENTATION (Page 1 of 2)

Part 1 - Background Information AA 2

Evaluation Site: PLOWSHOP POND-EXIST. Date: 6-18-93

Site Location (Section, Range, and Township): AYER, MA.

Has the evaluator taken a training course in WET Version 2.0? YES

Agencies/Experts Contacted: SCS NOAA MA DF+W

Circle the assessment levels to be completed? (SS-1) (SS-2) (E/O-1&2) E/O-3 HS

Is the wetland tidal or nontidal? If the wetland is nontidal, indicate the month(s) that represent wet, dry, and average conditions, or if only average annual condition will be used, give rationale. Also, indicate if the previous 12 months of precipitation has been above, below, or near normal.
NONTIDAL - WET CONDITIONS - HYDROLOGY - MARCH, VEGET. MAY, DRY COND. - HYDROLOGY - AUG, VEGETATION - NOV. + AVG COND - HYDROL - JUNE, VEG - SEPT.

Is this evaluation an estimate of past conditions or a prediction of future conditions? (If answer is yes, explain nature and source of predictive data.)
NO

Will alternative ratings be used to evaluate any of the functions or values (if yes, explain)? NO

Part 2 - Identification and Delineation of Evaluation Areas

Sketch a map on the following page, or attach a suitable map (photocopy of topgraphic map) that shows the following information:

- -- Boundaries of the AA, IA, and IZ, and the location of service areas. (See Figure
- -- Watershed boundaries of AA, and service areas.
- -- Extent of surface water in the AA during the wet and dry seasons.
- -- Open water (channels and pools) within and adjacent to the AA.
- -- Normal direction of channel or tidal flow
- -- Normal direction of wind-driven waves or current.
- -- Impact area(s).
- -- Scale of distance and north compass direction.

Explain the procedures used to identify or delineate the AA, IA, IZ, service areas, and the watersheds of these areas if they differed from the guidelines outlined in Section 2.7. N/A

-- Continued --

FORM A: SITE DOCUMENTATION (Page 2 of 2)

Part 2 (Cont.)

Estimate the extent of the following areas:

Assessment Area = ± 25 acres
Impact Area = N/A acres (only if applicable).
Watershed of AA = — acres/ ±25 miles$^2$ (acres x 0.0016 = miles)
Wetlands in AA = ±25 acres
Wetlands in the watershed of closest service area = >500 acres
Wetlands and deepwater in the watershed of closest service area = >500 acres

How were locality and region defined for this evaluation?
Locality – Town (AYER)
Region – State (Massachusetts)

Sketch of Evaluation Areas (or attach map):

See Figure 1

## FORM B: EVALUATION ANSWER SHEET

Evaluation Site: PLOWSHOP POND AA Z

### SOCIAL SIGNIFICANCE EVALUATION - LEVEL 1

**3.1.1 "Red Flags"**

Comments/Assumptions

s1. Y (N) U - NOT LISTED BY MA. NATURAL HERITAGE
s2. Y (N) U
s3. Y (N) U
s4. Y (N) U
s5. Y (N) U
s6. Y (N) U

**3.1.2 On-site Social Significance**

Comments/Assumptions

s7. Y (N) U I
s8. (Y) N U I - SUPERFUND SITE ADJ. PLOWSHOP POND

**3.1.3 Off-site Social Significance**

Comments

s9. Y (N) U I
s10. Y (N) U - "Y" changed to "N"
s11. Y (N) U because (1) <15% ...
s12. Y (N) U
✓ s13. Y N (U) (2) wells >7%
s14. Y (N) U
s15. (Y) N U I - NAT. HER.
s16. (Y) N U I - GROVE POND WELL FIELD
s17. (Y) N U I
s18. Y (N) U I
s19. Y (N) U -
s20. Y (N) U

Comments

s21. (Y) N U - BLACK ..., WELL ...
s22. (Y) N U I
s23. Y (N) U
s24. Y (N) U
s25. (Y) N U - SUPERFUND SITE
s26. Y (N) U
s27. Y (N) U -
s28. Y (N) U
s29. Y (N) U -
s30. Y (N) U
s31. (Y) N U -

### SOCIAL SIGNIFICANCE EVALUATION - LEVEL 2

Context Region (Circle one)
- Standard Density Circle
- (Locality)
- Hydrologic Unit

Question #

Comments/Assumptions

✓ 1 Y (N) -
2 Y (N) -
3 Y (N) - ... ABOVE ...
4 Y (N) - FLOOD ... YEAR ...

Evaluation Site: • PLOWSHOP POND - FT. DEVENS, AYER, MA - AAZ

## EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 1 (OFFICE)

| Q.# | WETLAND CONDITION X̄ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 1.1 | Y (N) | | | |
| 1.2 | Y (N) - EROSIVITY FACTOR 125-150 [illegible] | | | |
| 1.3 | (Y) N | | | |
| 2.1.1 | Y (N) | | | |
| 2.1.2 | (Y) N | | | |
| 2.1.3 | Y (N) | | | |
| 2.2.1 | Y (N) I | | | |
| 2.2.2 | Y (N) I - USGS TOPO + FIELD OBS. | | | |
| 3.1 | (Y) N | | | |
| 3.2 | (Y) N NWI MAP | | | |
| 3.3 | Y (N) | | | |
| 4.1 | (Y) N - [illegible] 100 mi | | | |
| 4.2A | Y (N) | | | |
| 4.2B | (Y) N | | | |
| 4.2C | Y (N) | | | |
| 4.2D | Y (N) | | | |
| 5.1.1 | | (Y) N ~3% | | |
| 5.1.2 | | Y (N) | | |
| 5.2 | | (Y) N - [illegible] | | |
| 6.1 | Y (N) | | | |
| 6.2 | Y (N) | | | |
| 7 | Y N (I) | | | |
| 8.1 | (Y) N | | | |
| 8.2 | Y (N) | | | |
| 8.3 | (Y) N | | | |
| 8.4 | Y (N) | | | |
| 9.1 | | (Y) N - constr. outlet - a & c true | | |
| 9.2 | | Y (N) I | | |
| 9.3 | | Y (N) I | | |
| 10A | (Y) N | | | |
| 10B | Y (N) | | | |
| 10C | Y (N) | | | |
| 10D | Y (N) | | | |
| 10E | Y (N) | | | |
| 10F | Y (N) | | | |

Evaluation Site: PLOWSHOP POND AA-2

WETLAND CONDITION

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 11 | Y **N** | Y **N** | Y **N** |
| 12A | Y N | Y N | Y N |
| 12Aa | Y N | Y N | Y N |
| 12Ab | Y N | Y N | Y N |
| 12Ac | Y N | Y N | Y N |
| 12Ad | Y N | Y N | Y N |
| 12Ae | Y N | Y N | Y N |
| 12B | Y N | Y N | Y N |
| 12Ba | Y N | Y N | Y N |
| 12Bb | Y N | Y N | Y N |
| 12Bc | Y N | Y N | Y N |
| 12Bd | Y N | Y N | Y N |
| 12Be | **Y** N | **Y** N | **Y** N |
| 12C | Y N | Y N | Y N |
| 12Ca | Y N | Y N | Y N |
| 12Cb | Y N | Y N | Y N |
| 12Cc | **Y** N | **Y** N | **Y** N |
| 12Cd | Y N | Y N | Y N |
| 12D | Y N | Y N | Y N |
| 12Da | Y N | Y N | Y N |
| 12Db | Y N | Y N | Y N |
| 12E | Y N | Y N | Y N |
| 13A | Y N | Y N | Y N |
| 13Aa | Y N | Y N | Y N |
| 13Ab | Y N | Y N | Y N |
| 13Ac | Y N | Y N | Y N |
| 13Ad | Y N | Y N | Y N |
| 13Ae | Y N | Y N | Y N |
| 13B | Y N | Y N | Y N |
| 13Ba | Y N | Y N | Y N |
| 13Bb | Y N | Y N | Y N |
| 13Bc | Y N | Y N | Y N |
| 13Bd | Y N | Y N | Y N |
| 13Be | **Y** N | **Y** N | **Y** N |
| 13C | Y N | Y N | Y N |
| 13Ca | Y N | Y N | Y N |
| 13Cb | Y N | Y N | Y N |
| 13Cc | **Y** N | **Y** N | **Y** N |
| 13Cd | Y N | Y N | Y N |
| 13D | Y N | Y N | Y N |
| 13Da | Y N | Y N | Y N |
| 13Db | Y N | Y N | Y N |
| 13E | Y N | Y N | Y N |

COMMENTS/ASSUMPTIONS

Dominant AA - Aquatic Bed, Rooted Vascular

Edge B - Broad Leaved Deciduous

C - Aquatic Bed Rooted Vascular

>10% - Aquatic Bed

>1 Acre - Shrub Edge Along Shoreline

FORM B (Cont.) 

Evaluation Site: PLOWSHOP POND AA2

| Q.# | $\overline{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 14.1 | Y (N) | Y (N) | Y (N) | – NONE OBSERVED |
| 14.2 | Y (N) | Y (N) | Y (N) | |
| 15.1A | (Y) N I | | | |
| 15.1B | Y (N) I | | | |
| 15.1C | Y (N) I | | | |
| 15.2 | Y N (I) | | | NO CHANNEL [illegible] |
| 16A | (Y) N | (Y) N | (Y) N | PERSONAL AQUATIC [illegible] |
| 16B | Y (N) | Y (N) | Y (N) | |
| 16C | Y (N) | Y (N) | Y (N) | |
| 17 | Y (N) | | | >70% AQUATIC [illegible] OVER ~30 ACRE |
| 18 | Y (N) I | | | REGULAR W/2 [illegible] |
| 19.1A | (Y) N I – 22 [illegible], LA[illegible] TOPO [illegible] | | | |
| 19.1B | Y (N) I | | | |
| 19.2 | Y (N) I | | | |
| 19.3 | Y (N) I – VEG [illegible] | | | |
| 20.1 | Y N (I) | | | |
| 20.2 | Y N (I) | | | |
| 21A | (Y) N [illegible] | | | |
| 21B | Y N | | | |
| 21C | Y N | | | |
| 21D | Y N | | | |
| 21E | Y N | | | |
| 22.1.1 | (Y) N | | | |
| 22.1.2 | Y N (I) | | | |
| 22.2 | Y (N) | | | |
| 22.3 | Y (N) I | | | |
| 23 | Y (N) DAM [illegible] | | | |
| 24.1 | Y (N) I – S[illegible] SOIL MAP[illegible] | | | |
| 24.2 | Y N (I) | | | |
| 24.3 | Y (N) I | | | |
| 24.4 | Y (N) I – | | | |
| 24.5 | Y (N) | | | |
| 25.1 | (Y) N – LANDFILL | | | |
| 25.2A | (Y) N I | | | |
| 25.2B | Y (N) I | | | |
| 25.3 | (Y) N – UNSTABLE SANDY SOILS | | | |

FORM B (Cont.)



Evaluation Site: ______________________

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 26.1 | Y N | | | |
| 26.2 | Y N I | | | BENDWTR DITCH |
| 26.3 | Y N I | | | |
| 27.1 | Y N | | | |
| 27.2 | Y N I | | | |
| 27.3 | Y N I | | | |

## EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 2 (FIELD)

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 28 | Y N | | | |
| 29.1 | Y N | | | |
| 29.2 | Y N | | | |
| 30. | Y N | Y N | Y N | |
| 31.1 | Y N | Y N | Y N | |
| 31.2 | Y N | Y N | Y N | |
| 31.3 | Y N | Y N | Y N | |
| 31.4 | Y N I | Y N I | Y N I | |
| 31.5 | Y N | Y N | Y N | |
| 31.6A | Y N | Y N | Y N | |
| 31.6B | Y N | Y N | Y N | |
| 31.6C | Y N | Y N | Y N | |
| 31.6D | Y N | Y N | Y N | |
| 31.6E | Y N | Y N | Y N | |
| 32A | Y N | | | |
| 32B | Y N | | | |
| 32C | Y N | | | |
| 32D | Y N | | | |
| 32E | Y N | | | |
| 32F | Y N | | | |
| 32G | Y N | | | |
| 32H | Y N | | | |
| 32I | Y N | | | |
| 32J | Y N | | | |
| 32K | Y N | | | |

FORM B (Cont.) 

Evaluation Site: ______________________________

| Q.# | $\bar{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| | **WETLAND CONDITION** | | | |
| 33A | (Y) N | | | |
| 33B | Y (N) | | | |
| 33C | Y (N) | | | |
| 33D | Y (N) | | | |
| 33E | Y (N) | | | |
| 33F | Y (N) | | | |
| 33G | Y (N) | | | |
| 33H | Y (N) | | | |
| 33I | Y (N) | | | |
| 33J | Y (N) | | | |
| 33K | Y (N) | | | |
| 34.1 | Y (N) | | | - DAM [illegible] - ON OLD [illegible] MAPS |
| 34.2 | Y (N) | | | |
| 34.3.1 | (Y) N | | | |
| 34.3.2 | Y (N) I | | | |
| 35.1 | Y (N) I | | | |
| 35.2 | Y N (I) | | | |
| 36.1.1 | (Y) N | (Y) N | (Y) N | |
| 36.1.2 | Y (N) | Y (N) | Y (N) | |
| 36.2.1 | (Y) N | (Y) N | (Y) N | |
| 36.2.2 | Y (N) | Y (N) | Y (N) | |
| 36.2.3 | Y (N) | Y (N) | Y (N) | |
| 37 | Y (N) | | | |
| 38.1 | Y (N) | | | - DAM [illegible] DOWNSTREAM - [illegible] |
| 38.2 | (Y) N | | | |
| 38.3 | Y (N) | | | |
| 38.4 | Y (N) | | | |
| 38.5 | Y (N) | | | |
| 38.6 | Y (N) | | | |
| 38.7 | (Y) N | | | - FLOOD [illegible] 2 mi downstream |
| 38.8 | Y N (I) | | | |
| 39 | (Y) N | | | TREES [illegible] MAST BEARING [illegible] |
| 40.1 | Y (N) I | | | |
| 40.2 | (Y) N I | | | |
| 41.1 | | (Y) N I | | |
| 41.2 | | Y (N) I | | |

**FORM B (Cont.)**



Evaluation Site: ____________________

| Q.# | $\bar{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 42.1.1 | Y N I | Y N I | Y N I | |
| 42.1.2 | Y N I | Y N I | Y N I | |
| 42.1.3 | Y N I | Y N I | Y N I | |
| 42.2.1 | Y N I | Y N I | Y N I | Downstream River |
| 42.2.2 | Y N I | Y N I | Y N I | - inaccess. to fish |
| 42.2.3 | Y N I | Y N I | Y N I | due to dam. |
| 43A | Y N | Y N | Y N | |
| 43B | Y N | Y N | Y N | |
| 43C | Y N | Y N | Y N | |
| 43D | Y N | Y N | Y N | |
| 43E | Y N | Y N | Y N | - Ecol. Envir. Report |
| 43F | Y N | Y N | Y N | pg 3-20 4/95 |
| 43G | Y N | Y N | Y N | |
| 43H | Y N | Y N | Y N | |
| 43I | Y N | Y N | Y N | |
| 44A | Y N | Y N | Y N | |
| 44B | Y N | Y N | Y N | |
| 44C | Y N | Y N | Y N | |
| 44D | Y N | Y N | Y N | |
| 44E | Y N | Y N | Y N | Field observ. |
| 44F | Y N | Y N | Y N | of aquatics |
| 44G | Y N | Y N | Y N | |
| 44H | Y N | Y N | Y N | |
| 44I | Y N | Y N | Y N | |
| 45A | Y N | | | |
| 45B | Y N | | | |
| 45C | Y N | | | |
| 45D | Y N | | | |
| 45E | Y N | | | |
| 45F | Y N | | | |
| 45G | Y N | | | |
| 46A | Y N | Y N | Y N | |
| 46B | Y N | Y N | Y N | |
| 46C | Y N | Y N | Y N | |
| 47A | Y N | | | |
| 47B | Y N | ESL 8/97 | | |
| 47C | Y N | | | |

FORM B (Cont.)



Evaluation Site: ______________________________

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 48A | Y N I | Y N I | Y N I | |
| 48B | Y N I | Y N I | Y N I | |
| 48C | Y N I | Y N I | Y N I | |
| 48D | Y N I | Y N I | Y N I | |
| 48E | Y N I | Y N I | Y N I | |
| 48F | Y N I | Y N I | Y N I | |
| 49.1.1 | Y N I | Y N I | Y N I | |
| 49.1.2 | Y N I | Y N I | Y N I | |
| 49.2 | Y N I | Y N I | Y N I | |
| 49.3 | Y N I | Y N I | Y N I | |
| 50. | Y N | Y N | Y N | |

EFFECTIVENESS/OPPORTUNITY EVALUATION – LEVEL 3 (DETAILED DATA)

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 51.1 | Y N U | | | |
| 51.2 | Y N U | | | |
| 52.1 | Y N I U | | | |
| 52.2 | Y N I U | | | |
| 53.1 | Y N I U | | | |
| 53.2 | Y N I U | | | |
| 54 | Y N U | Y N U | Y N U | |
| 55.1 | Y N U | | | |
| 55.2 | Y N U | | | |
| 55.3 | Y N U | | | |
| 55.4 | Y N U | | | |
| 56.1 | Y N I U | | | |
| 56.2 | Y N I U | | | |
| 57.1 | Y N U | | | |
| 57.2 | Y N U | | | |
| 58. | Y N U | | | |

FORM B (Cont.) 

Evaluation Site: ______________________________

| WETLAND CONDITION | | | | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| Q.# | $\overline{X}$ | W | D | |
| 59.1 | Y N I U | | | |
| 59.2 | Y N I U | | | |
| 60 | Y N U | | | |
| 61 | Y N I U | | | |
| 62 | Y N U | | | |
| 63.1 | Y N I U | | | |
| 63.2 | Y N I U | | | |
| 64 | | Y N I U | | |

# FORM C: SUPPLEMENTARY OBSERVATIONS

**Evaluation Site:** AA2 Plowshop Pond

Indicate the species, species groups, and activities that are actually observed, reliably reported, or known to occur at the AA on a regular basis.

| FISH SPECIES GROUPS* | OBSERVED/REPORTED |
|---|---|
| 1. Warmwater Group | (Y) or N |
| 2. Coldwater Group | Y or (N) |
| 3. Northern Lake Group | (Y) or N |
| 4. Coldwater Riverine Group | Y or (N) |

| FISH SPECIES | OBSERVED/REPORTED |
|---|---|
| [illegible] | (Y) or N |
| [illegible] | (Y) or N |
| [illegible] | (Y) or N |

| WATERFOWL SPECIES GROUPS** | NESTING | MIGRATING | WINTERING |
|---|---|---|---|
| 1. Prairie Dabblers | (Y) or N | (Y) or N | Y or (N) |
| - 2. Black Duck | Y or (N) | (Y) or N | Y or (N) |
| - 3. Wood Duck | Y or (N) | 117 (Y) or N | 119 Y or (N) |
| 4. Common and Red-Breasted Mergansers | 119 Y or (N) | (Y) or N | Y or (N) |
| 5. Hooded Merganser | 122 Y or (N) | (Y) or N | Y or (N) |
| 6. Canvasback, Redhead, Ruddy Duck | 125 Y or (N) | Y or (N) | Y or (N) |
| 7. Ring-necked Duck | 128 Y or (N) | (Y) or N | Y or (N) |
| 8. Greater and Lesser Scaup | 131 Y or (N) | Y or (N) | Y or (N) |
| 9. Common Goldeneye | 134 Y or (N) | Y or (N) | Y or (N) |
| 10. Bufflehead | 137 Y or (N) | Y or (N) | Y or (N) |
| 11. Whistling Ducks | 140 Y or (N) | Y or (N) | Y or (N) |
| 12. Inland Geese | 143 (Y) or N | (Y) or N | Y or (N) |
| 13. Tundra Swan | 146 Y or (N) | Y or (N) | Y or (N) |
| 14. Brant | 149 Y or (N) | Y or (N) | Y or (N) |

OBSERVED/REPORTED — best judgement very little data available on actual waterfowl use of this pond.

| BIRD SPECIES | OBSERVED/REPORTED |
|---|---|
| Double-crested Cormorant (fish-eater) | (Y) or N |
| 208 Belted Kingfisher | (Y) or N |
| 249 Spotted Sandpiper | (Y) or N |

Tree Swallow 234

## RECREATIONAL ACTIVITIES

(Hiking) Sailing Snowmobiling Research
(Birdwatching) Power Boating Skiing Educational Fieldtrips
(Photography) Canoeing Snowshoeing Horseback Riding
Swimming Kayaking (Ice Skating)

## CONSUMPTIVE ACTIVITIES

Agriculture Fur Harvesting Commercial/Sport Fishing — catch + release only Peat Harvesting
(Hunting) — gun shells found in water Timber Harvest Natural Food Gathering Water Supply

* Fish species groups are explained on page 138
** Waterfowl species groups are explained on page 1647

# FORM D: EVALUATION SUMMARY SHEET

**Evaluation Site:** ______________________________

**Wetland Functions and Values**

| | Social Significance | Effectiveness | Opportunity |
|---|---|---|---|
| Ground Water Recharge | ____ | ____ | * |
| Ground Water Discharge | ____ | ____ | * |
| Floodflow Alteration | ____ | ____ | ____ |
| Sediment Stabilization | ____ | ____ | * |
| Sediment/Toxicant Retention | ____ | ____ | ____ |
| Nutrient Removal/Transform. | ____ | ____ | ____ |
| Production Export | * | ____ | * |
| Wildlife Diversity/Abundance** | ____ | * | * |
| Breeding | * | ____ | * |
| Migration | * | ____ | * |
| Wintering | * | ____ | * |
| Aquatic Diversity/Abundance | ____ | ____ | * |
| Uniqueness/Heritage | ____ | * | * |
| Recreation | ____ | * | * |

**Habitat Suitability Evaluation**

**Fish Species Groups:**

__________ Group ___ __________ Group ___ __________ Group ___

**Waterfowl Species Groups:**

| | Breeding | Migration | Wintering |
|---|---|---|---|
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |

**Fish, Invertebrate, and Bird Species:**

| | | | | | |
|---|---|---|---|---|---|
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |
| __________ | ___ | __________ | ___ | __________ | ___ |

Levels of assessment completed: S-1 S-2 E/O-1 E/O-2 E/O-3 HS
Evaluation is for the: AA IA (Note: if the evaluation is for an IA, documentation of the AA evaluation must be presented with this evaluation).
Is there any evidence that suggests ratings contrary to the above (explain)?
______________________________
Were alternative sources used for any of the ratings above (explain)? ________
______________________________
The loss rate for ______________________ (identify locality/region) between 19__ and 19__ for ______________________(identify wetland type) was __________ (acres/year or % loss).

* WET does not evaluate this function or value in these terms.
** Wildlife Diversity/Abundance assesses only wetland-dependent birds. Other wildlife (e.g., game mammals) should be evaluated using other methods.

POST COLD



# FORM A: SITE DOCUMENTATION (Page 1 of 2)

## Part 1 - Background Information

Evaluation Site: COLD SPRING POND IA 1 Date: 6/21/93
POST-IMPACT - 3 yrs

Site Location (Section, Range, and Township): AYER MA

Has the evaluator taken a training course in WET Version 2.0? YES

Agencies/Experts Contacted: SCS NOAA MA DF+W

Circle the assessment levels to be completed? (SS-1) (SS-2) (E/O-1&2) E/O-3 HS

Is the wetland tidal or nontidal? If the wetland is nontidal, indicate the month(s) that represent wet, dry, and average conditions, or if only average annual condition will be used, give rationale. Also, indicate if the previous 12 months of precipitation has been above, below, or near normal.
NONTIDAL, Wet Cond - hydr - March veg - May Dry Cond - Hydro - Aug veg - Nov, Avg Cond - Hydro - June Veg Sept

Is this evaluation an estimate of past conditions or a prediction of future conditions? (If answer is yes, explain nature and source of predictive data.)
NO

Will alternative ratings be used to evaluate any of the functions or values (if yes, explain)? NO

## Part 2 - Identification and Delineation of Evaluation Areas

Sketch a map on the following page, or attach a suitable map (photocopy of topgraphic map) that shows the following information: SEE FIGURE 1

- -- Boundaries of the AA, IA, and IZ, and the location of service areas.
- -- Watershed boundaries of AA, and service areas.
- -- Extent of surface water in the AA during the wet and dry seasons.
- -- Open water (channels and pools) within and adjacent to the AA.
- -- Normal direction of channel or tidal flow
- -- Normal direction of wind-driven waves or current.
- -- Impact area(s).
- -- Scale of distance and north compass direction.

Explain the procedures used to identify or delineate the AA, IA, IZ, service areas, and the watersheds of these areas if they differed from the guidelines outlined in Section 2.7. N/A

-- Continued --

FORM A: SITE DOCUMENTATION (Page 2 of 2)

Part 2 (Cont.)

Estimate the extent of the following areas:

Assessment Area = N/A acres
Impact Area = ± 3 acres (only if applicable)
Watershed of AA = ± 50 acres/ 0.08 miles$^2$ (acres x 0.0016 = miles)
Wetlands in AA = ± 3 acres
Wetlands in the watershed of closest service area = >500 acres
Wetlands and deepwater in the watershed of closest service area = >500 acres

How were locality and region defined for this evaluation?
Locality - Town
Region - State

Sketch of Evaluation Areas (or attach map):

See Figure 1

FORM B: EVALUATION ANSWER SHEET

Evaluation Site: Cold Spring Pond I A-1

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 1

3.1.1 "Red Flags"

Comments/Assumptions

s1. Y (N) U
s2. Y (N) U
s3. Y (N) U
s4. Y (N) U
s5. Y (N) U
s6. (Y) N U

3.1.2 On-site Social Significance

Comments/Assumptions

s7. Y (N) U I
s8. (Y) N U I — Superfund site

3.1.3 Off-site Social Significance

| | | Comments |
|---|---|---|
| s9. | Y (N) U I | "Y" s10 |
| s10. | Y (N) U | ch. due to |
| s11. | Y N (U) | ≤10% emphrs. |
| s12. | Y (N) U | open water > 7% |
| s13. | Y N (U) | |
| s14. | Y (N) U | |
| s15. | (Y) N U I | |
| s16. | (Y) N U I | |
| s17. | (Y) N U I | |
| s18. | Y (N) U I | |
| s19. | Y (N) U | |
| s20. | Y (N) U | |

| | | Comments |
|---|---|---|
| s21. | (Y) N U | |
| s22. | (Y) N U I | |
| s23. | Y (N) U | |
| s24. | Y (N) U | |
| s25. | (Y) N U | - Superfund |
| s26. | Y (N) U | no SCORP, no dug |
| s27. | Y (N) U | |
| s28. | Y (N) U | |
| s29. | Y (N) U | |
| s30. | Y (N) U | |
| s31. | Y (N) U | |

SOCIAL SIGNIFICANCE EVALUATION - LEVEL 2

Context Region (Circle one)
Standard Density Circle
(Locality)
Hydrologic Unit

Question #

Comments/Assumptions

1 Y (N)
2 Y (N) — same as 1-4
3 Y (N)
4 Y (N)

FORM B (Cont.)



Evaluation Site: Cold Spring IA-1

## EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 1 (OFFICE)

| Q.# | $\bar{X}$ | W | D | COMMENTS/ASSUMPTIONS |
|---|---|---|---|---|
| 1.1 | Y (N) | | | |
| 1.2 | Y (N) | | | |
| 1.3 | (Y) N | | | |
| 2.1.1 | Y (N) | | | |
| 2.1.2 | Y (N) | | | |
| 2.1.3 | Y (N) | | | |
| 2.2.1 | Y (N) I | | | |
| 2.2.2 | (Y) N I | | | |
| 3.1 | (Y) N | | | |
| 3.2 | Y (N) | | | |
| 3.3 | Y (N) | | | |
| 4.1 | (Y) N [illegible] | | | |
| 4.2A | (Y) N | | | |
| 4.2B | Y N | | | |
| 4.2C | Y (N) | | | |
| 4.2D | Y (N) | | | |
| 5.1.1 | | Y (N) | | |
| 5.1.2 | | Y (N) | | |
| 5.2 | | (Y) N | | |
| 6.1 | Y (N) | | | |
| 6.2 | (Y) N | | | |
| 7 | Y N (I) | | | |
| 8.1 | Y (N) | | | |
| 8.2 | (Y) N | | | |
| 8.3 | (Y) N | | | |
| 8.4 | Y N | | | |
| 9.1 | | (Y) N | | |
| 9.2 | | Y (N) I | | |
| 9.3 | | Y (N) I | | |
| 10A | (Y) N | | | |
| 10B | Y (N) | | | |
| 10C | Y (N) | | | |
| 10D | Y (N) | | | |
| 10E | Y (N) | | | |
| 10F | Y (N) | | | |

FORM B (Cont.) 

Evaluation Site: Cold Sp

WETLAND CONDITION — COMMENTS/ASSUMPTIONS

| Q.# | $\overline{X}$ | W | D |
|---|---|---|---|
| 11 | Y N | Y N | Y N |
| 12A | Y N | Y N | Y N |
| 12Aa | Y N | Y N | Y N |
| 12Ab | Y N | Y N | Y N |
| 12Ac | Y N | Y N | Y N |
| 12Ad | Y N | Y N | Y N |
| 12Ae | Y N | Y N | Y N |
| 12B | Y N | Y N | Y N |
| 12Ba | Y N | Y N | Y N |
| 12Bb | Y N | Y N | Y N |
| 12Bc | Y N | Y N | Y N |
| 12Bd | Y N | Y N | Y N |
| 12Be | Y N | Y N | Y N |
| 12C | Y N | Y N | Y N |
| 12Ca | Y N | Y N | Y N |
| 12Cb | Y N | Y N | Y N |
| 12Cc | Y N | Y N | Y N |
| 12Cd | Y N | Y N | Y N |
| 12D | Y N | Y N | Y N |
| 12Da | Y N | Y N | Y N |
| 12Db | Y N | Y N | Y N |
| 12E | Y N | Y N | Y N |
| 13A | Y N | Y N | Y N |
| 13Aa | Y N | Y N | Y N |
| 13Ab | Y N | Y N | Y N |
| 13Ac | Y N | Y N | Y N |
| 13Ad | Y N | Y N | Y N |
| 13Ae | Y N | Y N | Y N |
| 13B | Y N | Y N | Y N |
| 13Ba | Y N | Y N | Y N |
| 13Bb | Y N | Y N | Y N |
| 13Bc | Y N | Y N | Y N |
| 13Bd | Y N | Y N | Y N |
| 13Be | Y N | Y N | Y N |
| 13C | Y N | Y N | Y N |
| 13Ca | Y N | Y N | Y N |
| 13Cb | Y N | Y N | Y N |
| 13Cc | Y N | Y N | Y N |
| 13Cd | Y N | Y N | Y N |
| 13D | Y N | Y N | Y N |
| 13Da | Y N | Y N | Y N |
| 13Db | Y N | Y N | Y N |
| 13E | Y N | Y N | Y N |

FORM B (Cont.)

Evaluation Site: Cold Springs IA-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 14.1 | Y **N** | Y **N** | Y **N** |
| 14.2 | Y **N** | Y **N** | Y **N** |
| 15.1A | Y **N** I | | |
| 15.1B | **Y** N I | | |
| 15.1C | Y **N** I | | |
| 15.2 | Y N **I** | | |
| 16A | Y **N** | Y **N** | Y **N** |
| 16B | **Y** N | **Y** N | **Y** N |
| 16C | Y **N** | Y **N** | Y **N** |
| 17 | **Y** N | | |
| 18 | **Y** N I | | |
| 19.1A | **Y** N I | | |
| 19.1B | Y **N** I | | |
| 19.2 | Y **N** I | | |
| 19.3 | Y **N** I | | |
| 20.1 | Y N I | | |
| 20.2 | Y N I | | |
| 21A | **Y** N | | |
| 21B | Y **N** | | |
| 21C | Y **N** | | |
| 21D | Y **N** | | |
| 21E | Y **N** | | |
| 22.1.1 | **Y** N | | |
| 22.1.2 | Y N **I** | | |
| 22.2 | Y **N** | | |
| 22.3 | Y **N** I | | |
| 23 | Y **N** | | |
| 24.1 | Y **N** I | | |
| 24.2 | Y N **I** | | |
| 24.3 | Y **N** I | | |
| 24.4 | Y **N** I | | |
| 24.5 | Y **N** | | |
| 25.1 | **Y** N | | |
| 25.2A | **Y** N I | | |
| 25.2B | Y **N** I | | |
| 25.3 | **Y** N | | |

FORM B (Cont.)



Evaluation Site: Cold Spring I-7-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 26.1 | Y N | | |
| 26.2 | Y N I | | |
| 26.3 | Y N I | | |
| 27.1 | Y N | | |
| 27.2 | Y N I | | |
| 27.3 | Y N I | | |

## EFFFECTIVENESS/OPPORTUNITY EVALUATION – LEVEL 2 (FIELD)

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 28 | Y N | | |
| 29.1 | Y N | | |
| 29.2 | Y N | | |
| 30 | Y N | Y N | Y N |
| 31.1 | Y N | Y N | Y N |
| 31.2 | Y N | Y N | Y N |
| 31.3 | Y N | Y N | Y N |
| 31.4 | Y N I | Y N I | Y N I |
| 31.5 | Y N | Y N | Y N |
| 31.6A | Y N | Y N | Y N |
| 31.6B | Y N | Y N | Y N |
| 31.6C | Y N | Y N | Y N |
| 31.6D | Y N | Y N | Y N |
| 31.6E | Y N | Y N | Y N |
| 32A | Y N | | |
| 32B | Y N | | |
| 32C | Y N | | |
| 32D | Y N | | |
| 32E | Y N | | |
| 32F | Y N | | |
| 32G | Y N | | |
| 32H | Y N | | |
| 32I | Y N | | |
| 32J | Y N | | |
| 32K | Y N | | |

FORM B (Cont.)



Evaluation Site: Cold Springs I #-1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 33A | Y N | | |
| 33B | Y N | | |
| 33C | Y N | | |
| 33D | Y N | | |
| 33E | Y N | | |
| 33F | Y N | | |
| 33G | Y N | | |
| 33H | Y N | | |
| 33I | Y N | | |
| 33J | Y N | | |
| 33K | Y N | | |
| 34.1 | Y N | | |
| 34.2 | Y N | | |
| 34.3.1 | Y N | | |
| 34.3.2 | Y N I | | |
| 35.1 | Y N I | | |
| 35.2 | Y N I | | |
| 36.1.1 | Y N | Y N | Y N |
| 36.1.2 | Y N | Y N | Y N |
| 36.2.1 | Y N | Y N | Y N |
| 36.2.2 | Y N | Y N | Y N |
| 36.2.3 | Y N | Y N | Y N |
| 37 | Y N | | |
| 38.1 | Y N | | |
| 38.2 | Y N | | |
| 38.3 | Y N | | |
| 38.4 | Y N | | |
| 38.5 | Y N | | |
| 38.6 | Y N | | |
| 38.7 | Y N | | |
| 38.8 | Y N I | | |
| 39 | Y N | | |
| 40.1 | Y N I | | |
| 40.2 | Y N I | | |
| 41.1 | | Y N I | |
| 41.2 | | Y N I | |

FORM B (Cont.)



Evaluation Site: Cold Springs     I A-1

WETLAND CONDITION     COMMENTS/ASSUMPTIONS

| Q.# | $\bar{X}$ | W | D |
|---|---|---|---|
| 42.1.1 | Y N I | Y N I | Y N I |
| 42.1.2 | Y N I | Y N I | Y N I |
| 42.1.3 | Y N I | Y N I | Y N I |
| 42.2.1 | Y N I | Y N I | Y N I |
| 42.2.2 | Y N I | Y N I | Y N I |
| 42.2.3 | Y N I | Y N I | Y N I |
| 43A | Y N | Y N | Y N |
| 43B | Y N | Y N | Y N |
| 43C | Y N | Y N | Y N |
| 43D | Y N | Y N | Y N |
| 43E | Y N | Y N | Y N |
| 43F | Y N | Y N | Y N |
| 43G | Y N | Y N | Y N |
| 43H | Y N | Y N | Y N |
| 43I | Y N | Y N | Y N |
| 44A | Y N | Y N | Y N |
| 44B | Y N | Y N | Y N |
| 44C | Y N | Y N | Y N |
| 44D | Y N | Y N | Y N |
| 44E | Y N | Y N | Y N |
| 44F | Y N | Y N | Y N |
| 44G | Y N | Y N | Y N |
| 44H | Y N | Y N | Y N |
| 44I | Y N | Y N | Y N |
| 45A | Y N | | |
| 45B | Y N | see map | |
| 45C | Y N | | |
| 45D | Y N | | |
| 45E | Y N | | |
| 45F | Y N | | |
| 45G | Y N | | |
| 46A | Y N | Y N | Y N |
| 46B | Y N | Y N | Y N |
| 46C | Y N | Y N | Y N |
| 47A | Y N | | |
| 47B | Y N | | |
| 47C | Y N | | |

FORM B (Cont.)



Evaluation Site: Cold Sp. AA 1

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D |
|---|---|---|---|
| 48A | Y N I | Y N I | Y N I |
| 48B | Y N I | Y N I | Y N I |
| 48C | Y N I | Y N I | Y N I |
| 48D | Y N I | Y N I | Y N I |
| 48E | Y N I | Y N I | Y N I |
| 48F | Y N I | Y N I | Y N I |
| 49.1.1 | Y N I | Y N I | Y N I |
| 49.1.2 | Y N I | Y N I | Y N I |
| 49.2 | Y N I | Y N I | Y N I |
| 49.3 | Y N I | Y N I | Y N I |
| 50. | Y N | Y N | Y N |

EFFECTIVENESS/OPPORTUNITY EVALUATION - LEVEL 3 (DETAILED DATA)

WETLAND CONDITION

COMMENTS/ASSUMPTIONS

| Q.# | X̄ | W | D |
|---|---|---|---|
| 51.1 | Y N U | | |
| 51.2 | Y N U | | |
| 52.1 | Y N I U | | |
| 52.2 | Y N I U | | |
| 53.1 | Y N I U | | |
| 53.2 | Y N I U | | |
| 54 | Y N U | Y N U | Y N U |
| 55.1 | Y N U | | |
| 55.2 | Y N U | | |
| 55.3 | Y N U | | |
| 55.4 | Y N U | | |
| 56.1 | Y N I U | | |
| 56.2 | Y N I U | | |
| 57.1 | Y N U | | |
| 57.2 | Y N U | | |
| 58. | Y N U | | |

## FORM C: SUPPLEMENTARY OBSERVATIONS

**Evaluation Site:** ______________________________

Indicate the species, species groups, and activities that are actually observed, reliably reported, or known to occur at the AA on a regular basis.

| FISH SPECIES GROUPS* | OBSERVED/REPORTED |
|---|---|
| 1. Warmwater Group | Y or N |
| 2. Coldwater Group | Y or N |
| 3. Northern Lake Group | Y or N |
| 4. Coldwater Riverine Group | Y or N |

| FISH SPECIES | OBSERVED/REPORTED |
|---|---|
| ______________ | Y or N |
| ______________ | Y or N |
| ______________ | Y or N |

| WATERFOWL SPECIES GROUPS** | OBSERVED/REPORTED | | |
|---|---|---|---|
| | NESTING | MIGRATING | WINTERING |
| 1. Prairie Dabblers | Y or N | Y or N | Y or N |
| 2. Black Duck | Y or N | Y or N | Y or N |
| 3. Wood Duck | Y or N | Y or N | Y or N |
| 4. Common and Red-Breasted Mergansers | Y or N | Y or N | Y or N |
| 5. Hooded Merganser | Y or N | Y or N | Y or N |
| 6. Canvasback, Redhead, Ruddy Duck | Y or N | Y or N | Y or N |
| 7. Ring-necked Duck | Y or N | Y or N | Y or N |
| 8. Greater and Lesser Scaup | Y or N | Y or N | Y or N |
| 9. Common Goldeneye | Y or N | Y or N | Y or N |
| 10. Bufflehead | Y or N | Y or N | Y or N |
| 11. Whistling Ducks | Y or N | Y or N | Y or N |
| 12. Inland Geese | Y or N | Y or N | Y or N |
| 13. Tundra Swan | Y or N | Y or N | Y or N |
| 14. Brant | Y or N | Y or N | Y or N |

| BIRD SPECIES | OBSERVED/REPORTED |
|---|---|
| ______________ | Y or N |
| ______________ | Y or N |
| ______________ | Y or N |

**RECREATIONAL ACTIVITIES**

| | | | |
|---|---|---|---|
| Hiking | Sailing | Snowmobiling | Research |
| Birdwatching | Power Boating | Skiing | Educational Fieldtrips |
| Photography | Canoeing | Snowshoeing | Horseback Riding |
| Swimming | Kayaking | Ice Skating | |

**CONSUMPTIVE ACTIVITIES**

| | | | |
|---|---|---|---|
| Agriculture | Fur Harvesting | Commercial/Sport Fishing | Peat Harvesting |
| Hunting | Timber Harvest | Natural Food Gathering | Water Supply |

* Fish species groups are explained on page 138
** Waterfowl species groups are explained on page 1647

# FORM D: EVALUATION SUMMARY SHEET

Evaluation Site: ______________________________

**Wetland Functions and Values**

| | Social Significance | Effectiveness | Opportunity |
|---|---|---|---|
| Ground Water Recharge | | | * |
| Ground Water Discharge | | | * |
| Floodflow Alteration | | | |
| Sediment Stabilization | | | * |
| Sediment/Toxicant Retention | | | |
| Nutrient Removal/Transform. | | | |
| Production Export | * | | * |
| Wildlife Diversity/Abundance** | | * | * |
| Breeding | * | | * |
| Migration | * | | * |
| Wintering | * | | * |
| Aquatic Diversity/Abundance | | | * |
| Uniqueness/Heritage | | * | * |
| Recreation | | * | * |

**Habitat Suitability Evaluation**

Fish Species Groups:

__________ Group ___ __________ Group ___ __________ Group ___

Waterfowl Species Groups:

| | Breeding | Migration | Wintering |
|---|---|---|---|
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |
| Group __________ | ___ | ___ | ___ |

Fish, Invertebrate, and Bird Species:

__________ ___ __________ ___ __________ ___
__________ ___ __________ ___ __________ ___
__________ ___ __________ ___ __________ ___
__________ ___ __________ ___ __________ ___

Levels of assessment completed: S-1 S-2 E/O-1 E/O-2 E/O-3 HS
Evaluation is for the: AA IA (Note: if the evaluation is for an IA, documentation of the AA evaluation must be presented with this evaluation).
Is there any evidence that suggests ratings contrary to the above (explain)?
______________________________
Were alternative sources used for any of the ratings above (explain)? __________
______________________________
The loss rate for ____________________ (identify locality/region) between 19__ and 19__ for ____________________ (identify wetland type) was __________ (acres/year or % loss).

* WET does not evaluate this function or value in these terms.
** Wildlife Diversity/Abundance assesses only wetland-dependent birds. Other wildlife (e.g., game mammals) should be evaluated using other methods.

***********************************************************

Habitat Suitability Evaluation Results for "plowshop"

***********************************************************

| Species/Group | Rating | Observed |
|---|---|---|
| Warmwater Fish Group | H | y |
| Warmwater Fish Group | H | y |
| Warmwater Fish Group | H | y |
| Northern Lake Fish Group | H | y |
| Coldwater Fish Group | L | n |
| Coldwater Riverine Fish Group | L | n |
| Waterfowl Group 1 (Breeding) | L | y |
| Waterfowl Group 1 (Migration) | L | y |
| Waterfowl Group 1 (Wintering) | L | y |
| Waterfowl Group 2 (Breeding) | L | n |
| Waterfowl Group 2 (Migration) | L | y |
| Waterfowl Group 2 (Wintering) | L | n |
| Waterfowl Group 3 (Breeding) | M | n |
| Waterfowl Group 3 (Wintering) | L | n |
| Waterfowl Group 4 (Breeding) | L | n |
| Waterfowl Group 4 (Migration) | L | y |
| Waterfowl Group 4 (Wintering) | L | n |
| Waterfowl Group 5 (Breeding) | L | n |
| Waterfowl Group 5 (Migration) | H | y |
| Waterfowl Group 5 (Wintering) | L | n |
| Waterfowl Group 6 (Breeding) | L | n |
| Waterfowl Group 6 (Migration) | M | n |
| Waterfowl Group 6 (Wintering) | L | n |
| Waterfowl Group 7 (Breeding) | L | n |
| Waterfowl Group 7 (Migration) | L | y |
| Waterfowl Group 7 (Wintering) | L | n |
| Waterfowl Group 8 (Breeding) | L | n |
| Waterfowl Group 8 (Migration) | L | n |
| Waterfowl Group 8 (Wintering) | L | n |
| Waterfowl Group 9 (Breeding) | L | n |
| Waterfowl Group 9 (Migration) | M | n |
| Waterfowl Group 9 (Wintering) | L | n |
| Waterfowl Group 10 (Breeding) | L | n |
| Waterfowl Group 10 (Migration) | M | n |
| Waterfowl Group 10 (Wintering) | L | n |
| Waterfowl Group 11 (Breeding) | L | n |
| Waterfowl Group 11 (Migration) | L | n |
| Waterfowl Group 11 (Wintering) | L | n |
| Waterfowl Group 12 (Breeding) | L | y |
| Waterfowl Group 12 (Migration) | H | y |
| Waterfowl Group 12 (Wintering) | L | n |
| Waterfowl Group 13 (Breeding) | L | n |
| Waterfowl Group 13 (Migration) | L | n |
| Waterfowl Group 13 (Wintering) | L | n |
| Waterfowl Group 14 (Breeding) | L | n |
| Waterfowl Group 14 (Migration) | M | n |
| Waterfowl Group 14 (Wintering) | L | n |
| Belted Kingfisher | L | y |
| Spotted Sandpiper | L | y |
| Tree Swallow | M | y |

************************************************************

Habitat Suitability Evaluation Results for "coldsprin"

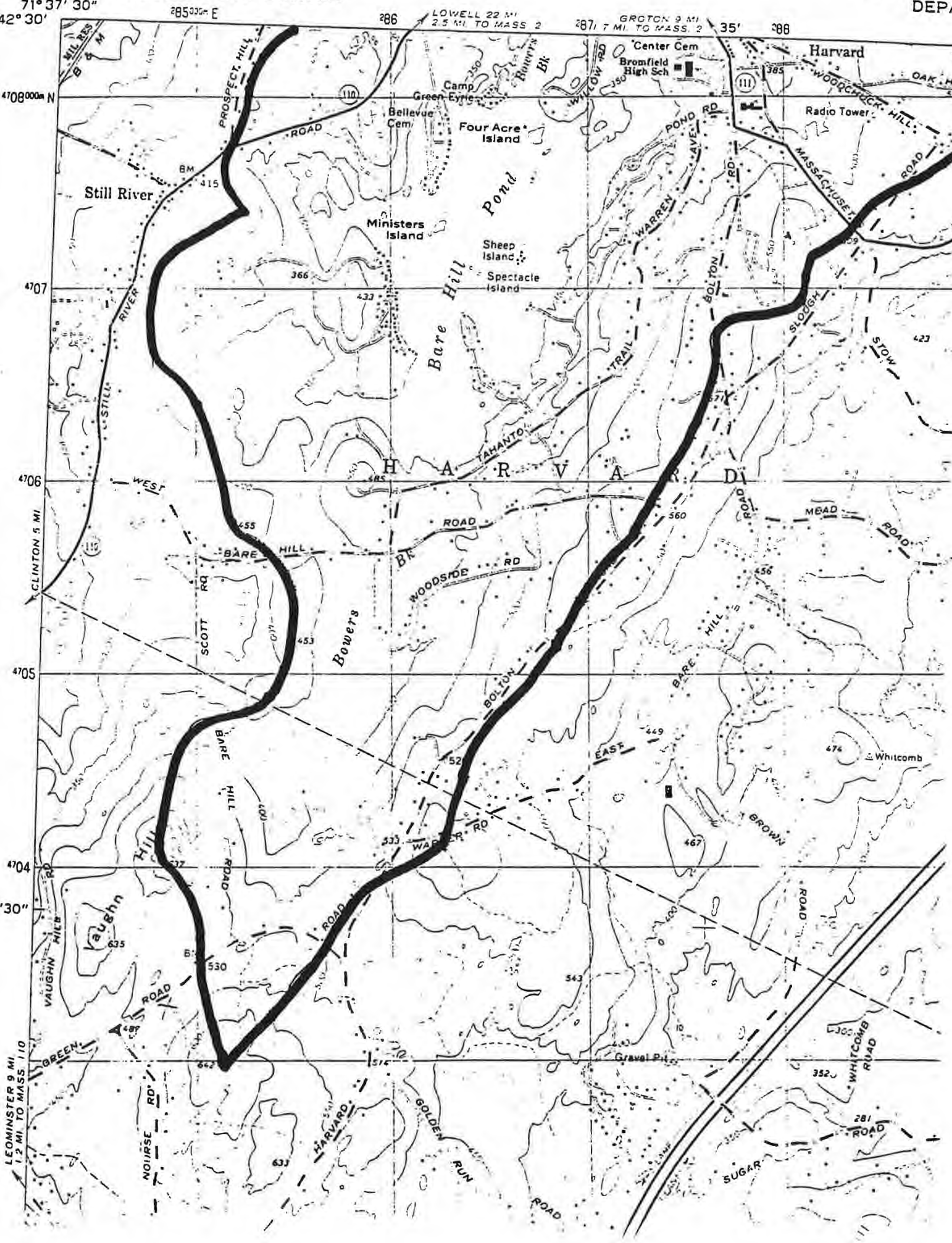
************************************************************

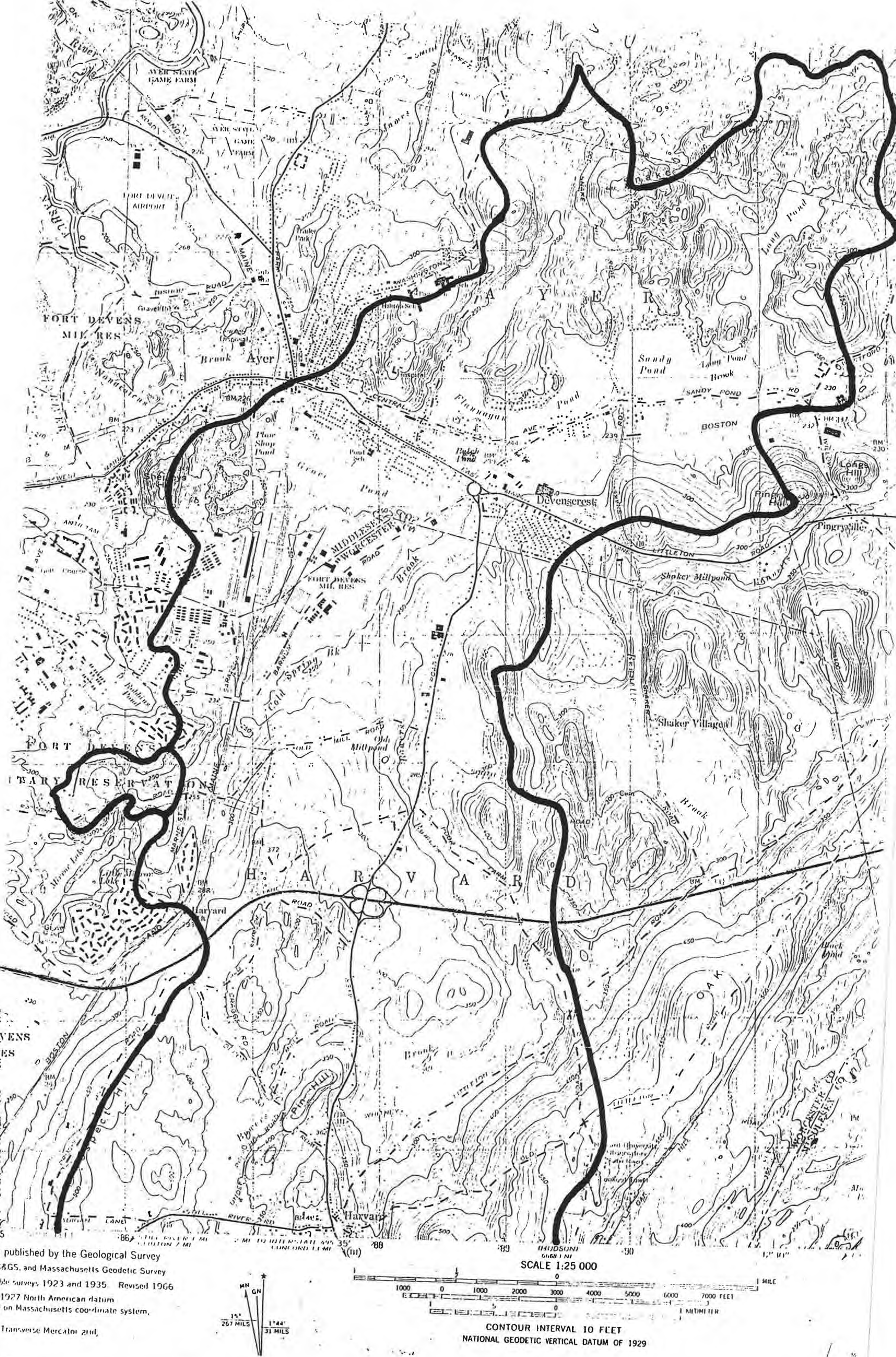
| Species/Group | Rating | Observed |
|---|---|---|
| Warmwater Fish Group | M | n |
| Coldwater Fish Group | L | n |
| Coldwater Riverine Fish Group | L | n |
| Northern Lake Fish Group | H | n |
| Yellow Perch | H | y |
| Bluegill | H | y |
| Smallmouth Bass | M | y |
| Redbreast Sunfish | H | y |
| Pumpkinseed | H | y |
| Waterfowl Group 1 (Breeding) | L | n |
| Waterfowl Group 1 (Migration) | H | y |
| Waterfowl Group 1 (Wintering) | L | n |
| Waterfowl Group 2 (Breeding) | L | n |
| Waterfowl Group 2 (Migration) | H | y |
| Waterfowl Group 2 (Wintering) | L | n |
| Waterfowl Group 3 (Breeding) | H | y |
| Waterfowl Group 3 (Migration) | H | y |
| Waterfowl Group 3 (Wintering) | L | n |
| Waterfowl Group 4 (Breeding) | L | n |
| Waterfowl Group 4 (Migration) | L | y |
| Waterfowl Group 4 (Wintering) | L | n |
| Waterfowl Group 5 (Breeding) | L | n |
| Waterfowl Group 5 (Migration) | H | y |
| Waterfowl Group 5 (Wintering) | L | n |
| Waterfowl Group 6 (Breeding) | L | n |
| Waterfowl Group 6 (Migration) | M | n |
| Waterfowl Group 6 (Wintering) | L | n |
| Waterfowl Group 7 (Breeding) | L | n |
| Waterfowl Group 7 (Migration) | L | y |
| Waterfowl Group 7 (Wintering) | L | n |
| Waterfowl Group 8 (Breeding) | L | n |
| Waterfowl Group 8 (Migration) | L | n |
| Waterfowl Group 8 (Wintering) | L | n |
| Waterfowl Group 9 (Breeding) | L | n |
| Waterfowl Group 9 (Migration) | M | n |
| Waterfowl Group 9 (Wintering) | L | n |
| Waterfowl Group 10 (Breeding) | L | n |
| Waterfowl Group 10 (Migration) | M | n |
| Waterfowl Group 11 (Breeding) | L | n |
| Waterfowl Group 11 (Migration) | L | n |
| Waterfowl Group 11 (Wintering) | L | n |
| Waterfowl Group 12 (Breeding) | L | n |
| Waterfowl Group 12 (Migration) | H | y |
| Waterfowl Group 12 (Wintering) | L | n |
| Waterfowl Group 13 (Breeding) | L | n |
| Waterfowl Group 13 (Migration) | L | n |
| Waterfowl Group 13 (Wintering) | L | n |
| Waterfowl Group 14 (Breeding) | L | n |
| Waterfowl Group 14 (Migration) | M | n |
| Waterfowl Group 14 (Wintering) | L | n |
| Green Heron | M | y |

6669 II SW (SHIRLEY)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COMMON
DEPA






published by the Geological Survey
&GS, and Massachusetts Geodetic Survey
ble surveys 1923 and 1935. Revised 1966
1927 North American datum
on Massachusetts coordinate system.
Transverse Mercator grid,