REPORT

Feasibility Study Report

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Hazardous Waste Remediation
NYSDEC Region 1

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

September 2003

September 2003

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Transmitted Via Federal Express

September 19, 2003

Mr. David A. Camp, P.E.
Environmental Engineer 2
New York State Department of Environmental Conservation
Division of Environmental Remediation
Bureau of Eastern Remedial Action
625 Broadway, 12th Floor
Albany, NY 12233-7015

Re: HWD, Inc. Site
Farmingdale, New York
NYSDEC Site No. 152113
BBL Project #: 0604.60405 #2

Dear Mr. Camp:

Please find enclosed for your review, four copies (one unbound) of the Feasibility Study Report for the Hazardous Waste Disposal, Inc. (HWD) site located at 11A Picone Boulevard in Farmingdale, New York. The report has been prepared by Blasland, Bouck & Lee, Inc. (BBL) in accordance with the Consent Order between the New York State Department of Environmental Conservation (NYSDEC) and the HWD Respondents to the Consent Order (the "HWD Group"), which became effective in August 1999 (Index No. W1-0272-95-05). The report identifies and evaluates potential remedial alternatives to address constituents of interest in soil and groundwater at the HWD site. Distribution of the report is in accordance with your September 16, 2003 e-mail letter.

Please do not hesitate to call me at (315) 446-9120 if you have any questions or require additional information.

Sincerely,

BLASLAND, BOUCK & LEE, INC.

John C. Brussel

John C. Brussel, P.E.
Senior Engineer I

JCB/mbg
Enclosures

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cc: Mr. Peter A. Scully, New York State Department of Environmental Conservation – Region 1 (1 copy)
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Mr. Frederick J. Kirschenheiter, P.E., Blasland, Bouck & Lee, Inc.

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11A Picone Boulevard
Farmingdale, New York

September 2003

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Certification Statement

I, Frederick J. Kirschenheiter, P.E., as a licensed Professional Engineer in the State of New York, to the best of my knowledge and based on my inquiry of the persons involved in preparing this document under my direction, certify that the Feasibility Study (FS) for the Hazardous Waste Disposal, Inc. (HWD) site located in Farmingdale, New York, was completed in general accordance with the following:

- the Order on Consent (Consent Order) between the New York State Department of Environmental Conservation (NYSDEC) and the HWD Respondents to the Consent Order (Index No. W1-0728-95-05), which became effective in August 1999; and
- the NYSDEC-approved *Remedial Investigation/Feasibility Study Work Plan* (BBL, 1997) attached to the Consent Order.

Pursuant to the above documents, this FS Report identifies and evaluates potential remedial alternatives to address the presence of volatile organic compounds (VOCs) in soil and groundwater at the HWD site.

FREDERICK J. KIRSCHENHEITER, II
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1. Introduction

1.1 General

This Feasibility Study Report (FS Report) identifies and evaluates potential remedial alternatives to address constituents of interest in soil and groundwater at the Hazardous Waste Disposal, Inc. (HWD) site ("the site") located at 11A Picone Boulevard in Farmingdale, New York. Past site activities, including hazardous waste management using 55-gallon drums, one or more tanks, and an unlined "sludge pit," allegedly resulted in the release of volatile organic compounds (VOCs), primarily chlorinated VOCs, identified in soil and groundwater at the site.

This FS Report has been prepared by Blasland, Bouck, & Lee, Inc. (BBL) in accordance with an Order on Consent (Consent Order) between the New York State Department of Environmental Conservation (NYSDEC) and the HWD Respondents to the Consent Order (the "HWD Group"), which became effective in August 1999 (Index No. W1-0728-95-05). The Consent Order required the Respondents to conduct a Remedial Investigation/ Feasibility Study (RI/FS) for the site consistent with a *Remedial Investigation/Feasibility Study Work Plan* (BBL, 1997), which was approved by the NYSDEC during 1997 and attached to the Consent Order. RI activities completed at the site are summarized in the *Remedial Investigation Report* (BBL, 2002). NYSDEC approval of the amended report was provided in a May 30, 2002 letter to the HWD Group.

This FS Report summarizes relevant background information, identifies remedial action objectives (RAOs), identifies and screens various potential remedial technologies, presents a detailed and comparative analysis of retained technologies to address the RAOs, and recommends a site-wide remedial alternative. The FS Report is based on the results of the:

- information compiled by Fanning, Phillips, and Molnar (FPM) and presented in the *Summary of History and Sampling at the Former Hazardous Waste Disposal, Inc. Site* (FPM, 1995);
- Phase I and II investigations conducted by Gibbs & Hill, Inc. (as a contractor to the NYSDEC) between July 1988 and December 1990. Both investigations are summarized in the *Engineering Investigations at Inactive Hazardous Waste Sites in the State of New York, Phase II Investigation, Hazardous Waste Disposal Site, Site No. 152113, Town of Babylon, Suffolk County, New York* (Gibbs & Hill, 1991);
- RI and supplemental RI activities conducted by BBL on behalf of the HWD Group between November 1999 and February 2001, which are summarized in the NYSDEC-approved *Remedial Investigation Report* (BBL, 2002);
- supplemental soil investigation and soil vapor survey/air pathway evaluation conducted by BBL during August 2002, which are summarized in an October 2, 2002 letter from BBL to the NYSDEC; and
- additional groundwater investigation activities conducted by BBL in support of this FS during April 2003. The results of the additional groundwater investigation activities are summarized in this FS Report.

This FS Report has been prepared in general accordance with the following guidance, directives, and other publications, where appropriate:

- NYSDEC Technical and Administrative Guidance Memorandum (TAGM) #4025 titled, *Guidelines for Remedial Investigations/Feasibility Studies* (NYSDEC, 1989);

- NYSDEC TAGM #4030 titled, *Selection of Remedial Actions at Inactive Hazardous Waste Sites* (NYSDEC, 1990);

- applicable provisions of the New York State Environmental Conservation Law (ECL) and associated regulations, including Title 6 of the New York Code of Rules and Regulations (6 NYCRR) Part 375;

- United States Environmental Protection Agency (USEPA) guidance document titled, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),* Interim Final (USEPA, 1988); and

- applicable provisions of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) regulations contained in Title 40 of the Code of Federal Regulations (CFR) Part 300.

Based on the previous investigation activities conducted at the HWD site, tetrachloroethene (PCE) has been identified in subsurface soil at concentrations exceeding potentially applicable guidance, including the guidance values presented in the NYSDEC Technical and Administrative Guidance Memorandum (TAGM) #4046 titled, *Determination of Soil Cleanup Objectives and Cleanup Levels*, HWR-94-4046, dated January 24, 1994 (NYSDEC, 1994). Five other VOCs, including trichloroethylene (TCE) and benzene, ethylbenzene, toluene, and xylenes (BTEX compounds), were detected in selected subsurface soil samples at concentrations exceeding the TAGM 4046 guidance values, but below the soil action levels presented in NYSDEC TAGM #3028 titled, *"Contained-In Criteria" for Environmental Media* (NYSDEC, 1997), the United States Environmental Protection Agency (USEPA) Region 3 Risk-Based Concentrations (RBCs) for commercial/industrial soil, and the USEPA Region 9 Preliminary Remediation Goals (PRGs) for industrial soil. VOCs have also been detected in groundwater at the site at concentrations exceeding the standards/guidance values presented in the NYSDEC Division of Water, Technical and Operational Guidance Series (TOGS 1.1.1) document titled, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations*, (NYSDEC, 2000).

The RAOs presented in this FS Report have been developed considering the findings of the previous investigation activities and results obtained from an exposure assessment completed as part of the RI. RAOs were originally presented in a November 14, 2002 letter from BBL to the NYSDEC, and have been revised to include one additional RAO as requested by the NYSDEC in a November 26, 2002 letter.

Following NYSDEC review and approval of this FS Report, a *Proposed Remedial Action Plan* (PRAP) will be developed that will identify the preferred remedial alternative, summarize the alternatives considered, and provide the reasons for proposing the preferred remedy. The PRAP will be subject to a 30-day public comment period. Following the public comment period, the NYSDEC will prepare a Record of Decision (ROD), which will identify the site remedy and include a responsiveness summary to public comments and concerns raised during the public comment period.

1.2 Purpose and Objective

The purpose of this FS Report is to identify and evaluate remedial alternatives that are appropriate for site-specific conditions, protective of human health and the environment, and consistent with the aforementioned laws, regulations, and guidance documents. The overall objective of this FS Report is to recommend a remedial alternative for soil and groundwater that satisfies the RAOs for the site.

1.3 Report Organization

This FS Report has been organized into the following sections:

Section		Purpose
Section 1 -	Introduction	Provides background information relevant to the development of the FS Report and remedial alternatives evaluated.
Section 2 -	Standards, Criteria, and Guidelines	Identifies the standards, criteria, and guidelines (SCGs) that guide the development and selection of remedial alternatives.
Section 3 -	Remedial Action Objectives	Develops and presents RAOs for the site that are protective of human health and the environment.
Section 4 -	Technology Screening Summary and Development of Remedial Alternatives	Presents the results of the identification and screening of remedial technologies and the development of remedial alternatives that have the potential to meet the RAOs.
Section 5 -	Detailed Analysis of Remedial Alternatives	Presents a detailed description and screening of remedial alternatives using 6 NYCRR Part 375 evaluation criteria.
Section 6 -	Comparative Analysis of Remedial Alternatives	Presents a comparative analysis of each remedial alternative and the recommended remedial alternative.
Section 7 -	References	Provides a list of references cited in the FS Report.

1.4 Background Information

This section presents relevant background information used to develop and evaluate the remedial alternatives for the site. A description of the site is presented below, followed by a summary of relevant historical information, the topography and drainage features in the vicinity of the site, the geologic and hydrogeologic setting of the site, and groundwater usage in the vicinity of the site. This section also summarizes results obtained from previous investigation activities and the results of a qualitative exposure assessment for potential human and ecological receptors. In addition, an overview of activities completed to address the presence of PCE above a New York State Department of Health (NYSDOH) residential indoor air quality guideline in indoor air within a building immediately south of the site is presented in this section.

1.4.1 Site Location and Description

The HWD site is located at 11A Picone Boulevard in the Village of Farmingdale, Suffolk County, New York and is identified as part of Tax Lot 31.004 in the Suffolk County, New York tax maps. A site location map is presented as Figure 1. The site is approximately 0.5 acres in size and includes an approximately 10,000 square foot area where hazardous waste storage, transfer, and recycling operations were historically conducted. The site is currently owned by Little Joseph Realty, Inc. Guaranteed Overnight Delivery, Inc., an overnight delivery service, currently leases the property from Little Joseph Realty for use as a truck/tractor-trailer parking lot. The site is covered by a concrete slab that is approximately 6- to 8-inches thick. Select areas of the slab have been repaired/replaced with bituminous asphalt pavement. The approximate boundaries of the site are shown on Figure 2.

Access to the site is limited by a chain-link fence to the north, east, and south of the site, and a concrete wall associated with a storage yard west of the site. The site is accessible from Picone Boulevard through a gate along the southern site boundary, and from a paved driveway that enters the northwestern portion of the site.

1.4.2 Site Surroundings

Land use in the vicinity of the site is predominantly commercial/industrial. South of the site, across Picone Boulevard, is a one-story building occupied by R&D Carpet and Tile (R&D) and Ryder Truck. The R&D side of the building includes a garage area used to store new carpet and various adhesives, coatings/sealers, base fillers, cleaners, paints/stains, etc., and an office area/showroom. Ryder Truck operations make up the west side of the R&D building. The Ryder Truck portion of the building is primarily used as a service garage for medium and heavy-duty trucks. A one-story building occupied by Fort Brand Service is located west of the HWD site, immediately west of the storage yard. The Fort Brand Service building is primarily used as a service garage for heavy equipment used in connection with the aviation industry. A furniture warehouse is located west of the Fort Brand Service building. Parking lots for trucking companies/commercial facilities border the HWD site to the north, east, and southeast.

Based on review of historical information, including documents submitted to the NYSDEC and Suffolk County Health Department (SCHD) in connection with previous investigation activities at nearby properties, releases to the subsurface were previously reported from underground storage tanks (USTs)/dispensing systems located at three properties adjacent to the HWD site, including:

- a UST dispensing system at the property west of the HWD site (formerly Ronnie's Truck Repair, now occupied by Fort Brand Service). Groundwater in the vicinity of the dispensing system was found to be impacted by BTEX compounds;

- a UST at an abandoned gasoline station located at an active trucking company property east of the HWD site. The approximate location of the UST is shown on Figure 2. Groundwater at a monitoring well hydraulically downgradient from the UST (monitoring well MW-3, as shown on Figure 2) was found to contain BTEX compounds, naphthalene, 2,4-dimethylphenol, chlorobenzene, and cis-1,2-dichloroethene; and

- a UST "tank field" located at a property south of the HWD site across Picone Boulevard, approximately 150 feet south of the HWD site boundary. The approximate location of the tank field is shown on Figure 2. UST removal activities were conducted and free-phase light non-aqueous phase liquid (LNAPL) was apparently removed. Groundwater quality impacts from BTEX compounds were assessed by the technical consultant, Tyree Brothers Environmental Services, Inc.

As a result of the database search conducted in support of the RI, several additional sites were identified within 1-mile of the HWD site that contain leaking USTs and are included on the NYSDEC spills listing. A copy of the report generated by the database search is included in the *Remedial Investigation Report* (BBL, 2002). In addition to the above-mentioned UST/spill sites, two NYSDEC-listed inactive hazardous waste disposal sites are located within a ½ mile radius of the HWD site, including:

- the Circuitron Corporation site (NYSDEC Site No. 152082) located approximately ½ mile north and hydraulically upgradient from the HWD site. The Circuitron Corporation site is also included on the National Priorities List (NPL) established under CERCLA. The site was formerly used for the manufacture of electronic circuit boards. Solvents and heavy metals used in connection with manufacturing operations were previously discharged to the ground through leaching pools. Chlorinated VOCs, including 1,1,1-trichloroethane (1,1,1-TCA), TCE, PCE, 1,1-dichloroethene (1,1-DCE), and 1,1,-dichloroethane (1,1-DCA) were identified as constituents of interest for the site. 1,1,1-TCA was identified in groundwater at the highest concentration of the individual VOC constituents (up to 5,800 parts per billion [ppb]). Four heavy metals, including arsenic, chromium, copper, and lead were also identified as constituents of interest. Two RODs for the site have been signed by the USEPA, including one during March 1991 and a second during September 1994. The first ROD called for source control, and the second ROD called for cleanup of groundwater within the upper 40 feet of the shallow aquifer, extending approximately 700 feet downgradient from the Circuitron property. The USEPA selected a soil vapor extraction (SVE) system to address VOC-impacted soil, excavation of impacted sediment, and groundwater extraction and treatment via air stripping; and

- the Fairchild Republic Aircraft Main Plant site (NYSDEC Site No. 152130) located approximately ⅛ to ¼-mile south of the HWD site. This site was formerly used for the manufacture of aircraft and related parts. Chlorinated VOCs, mainly TCE and PCE, are the constituents of interest for the site. TCE and PCE were previously identified in soil at concentrations up to 4.4 parts per million (ppm) and 4.0 ppm, respectively, and in groundwater at concentrations up to 1,659 ppb and 5,100 ppb, respectively. Interim remedial measures (IRMs) activities at the site included the construction/operation of an SVE system to address VOC-impacted soil beneath a building, the connection of private wells downgradient from the site to the public water supply, and excavation of soil containing elevated concentrations of chromium. A ROD for the site was signed by the NYSDEC during March 1998. The NYSDEC selected a groundwater extraction and treatment remedy designed to intercept a groundwater plume of VOCs with a total VOC concentration of 1,000 ppb. The NYSDEC also selected a public supply wellhead treatment contingency.

Both the Circuitron Corporation site and Fairchild Republic Aircraft Main Plant site are currently undergoing remediation. According to the NYSDEC, at least 97 aboveground and underground storage tanks were removed from the Fairchild Republic Aircraft Main Plant site.

Based on review of a drawing prepared by Eder Associates in connection with the investigation/remedial activities at the Fairchild Republic Aircraft Main Plant site titled, *Groundwater Quality, Main Plant Site Vicinity*, Drawing No. 4, (dated March 1995), PCE and/or TCE have been identified in groundwater at several other locations (besides the Circuitron Corporation site and Fairchild Republic Aircraft Main Plant site) within approximately two miles of the HWD site, including:

- the Target Rock and Claremont Poly Chemical facilities approximately 1½ and 2 miles, respectively, northwest of the HWD site;

- two wells approximately 1¼ to 1½ miles northwest of the HWD site that appear to be hydraulically downgradient from the Bablyon Landfill;

- the Astro Electroplating, Tronic Plating, and Minmilt Reality facilities approximately 1½ miles northeast of the site; and

- the Brandt Airflex, Kenmark Textiles, and Fire Station sites approximately ½ mile southwest of the HWD site.

The information presented above indicates that groundwater quality impacts have been identified in several areas surrounding the HWD site.

1.4.3 Site History

This subsection provides a brief summary of historic site operations and general environmental information that was previously discussed in the *Remedial Investigation Report* (BBL, 2002). HWD, Inc. operated a hazardous waste storage, transfer, and recycling facility at the site from approximately 1979 to 1982. Information about the site history prior to 1979 was unavailable. Hazardous wastes (primarily spent solvents and acidic wastes) were collected from offsite generators, transported to the site by HWD, Inc., and stored onsite prior to offsite transport and disposal. HWD, Inc. also reportedly utilized the site to recycle spent solvents for resale. Hazardous wastes stored at the site were managed in 55-gallon drums, one or more aboveground storage tanks, and a "sludge pit." The approximate locations of former site features, including the former sludge pit, a former shed, a former hazardous waste storage and treatment area, a former drum storage area, and a former hazardous waste handling and aboveground storage tank area, are shown on a copy of an April 7, 1980 aerial photograph included as Figure 3.

In March 1981, HWD, Inc. reported a vapor discharge from the site to the SCHD. The incident reportedly produced a 150- to 200-foot high visible vapor plume. The USEPA inspected the HWD facility in September 1981. At the time of the inspection, the USEPA noted the presence of 1,900 55-gallon drums of spent solvent and a 2,500-gallon acid tank. The USEPA noted that the majority of the drums stored at the site were leaking at the time of the inspection. The USEPA also noted that HWD, Inc. was operating an ammonium hydroxide scrubbing process on the acid storage tank without a required permit. In addition, USEPA noted that two storm drains were located onsite, and that potentially impacted surface water runoff could conceivably be collected by the storm drains and conveyed to other areas of the site.

SCHD prepared a site visit report sketch, during a June 1982 site visit, which shows a diked storage area, a neutralization tank and associated pump, and a waste sludge pit covered with plastic. During a followup site visit conducted by SCHD during September 1982, approximately 840 55-gallon drums containing wastes and 420 empty 55-gallon drums were observed at the site. The SCHD noted the presence of spills in the storage area at the time of the 1982 inspection.

In November 1982, HWD, Inc. entered into a Consent Order with the NYSDEC that required HWD to cease hazardous waste management operations at the site. All remaining wastes and waste management tanks were reportedly removed from the site during 1984. As the result of a 1985 property inspection by the NYSDEC, the site was listed on the New York State Registry of Inactive Hazardous Waste Sites as a Class 2a site, which is a temporary classification assigned by the NYSDEC for sites that have inadequate and/or insufficient data for inclusion in any of the other site classifications.

At the time of a site reconnaissance in May 1990, the site was being used as a parking lot by J.S. Trucking Company, who was leasing the property from Little Joseph Realty. There were no remaining onsite structures or evidence of equipment or materials used during the previous business activities of HWD, Inc. The site area where historical activities were conducted was observed to be covered with concrete.

1.4.4 Topography and Drainage

Surface topography in the vicinity of the HWD site is shown on Figure 2. As shown on Figure 2, the majority of the site and areas east, south, and west of the site are relatively level with an average elevation of approximately 65 feet above mean sea level (MSL). The concrete-covered portion of the HWD site slopes gently downward from the north-northwest to the south-southeast. The elevation change across the concrete-covered portion of the site is less than approximately 1-foot. An approximately 10- to 12-foot high earthen embankment is located along the northern site boundary. The embankment meets a relatively level area to the north-northwest at an elevation of approximately 80 feet above MSL.

A recharge basin, which was apparently designed to manage storm water runoff from nearby properties, is located approximately 80 to 100 feet north-northeast of the HWD site. Three manholes/catch basins in the central portion of the HWD site convey storm water runoff from the concrete and paved portions of the site to the recharge basin. In addition, a catch basin in the southeastern portion of the HWD site and a series of manholes/catch basins located in Picone Boulevard immediately southeast of the site convey storm water runoff collected from the surrounding area to the recharge basin. The bottom elevation of the recharge basin was not measured as part of the previous investigation activities, but is lower than 50 feet above MSL. The rim of the recharge basin is at approximately 64 feet above MSL. Earthen sidewalls slope inward toward the basin at a slope of up to approximately 2:1 (horizontal: vertical). The surface water elevation in the basin was measured at 54 feet above MSL during the RI (April 11, 2001) and approximately 53 feet above MSL during additional groundwater investigation activities conducted in support of this FS (April 22, 2003).

As indicated in a November 30, 2001 letter from BBL to the NYSDEC, the recharge basin apparently manages storm water runoff by collecting runoff during periods of significant precipitation and allowing the collected runoff to infiltrate into the shallow aquifer over time. This storm water management system is common in this area of Long Island. The surface water elevation in the recharge basin varies depending on precipitation. During significant precipitation events, the recharge basin apparently acts as a groundwater discharge feature which recharges the shallow aquifer. At such times, the recharge basin may locally influence groundwater flow directions and create conditions of radial groundwater flow. However, existing site data suggests that the influence of the basin on groundwater flow is temporal and localized.

1.4.5 Geologic Setting

The site is located on the Northern Atlantic Coastal Plain physiographic province. The Coastal Plain is a seaward-dipping wedge of unconsolidated sediment that ranges in age from Cretaceous to Holocene (Zapecza, 1984). Overburden geology in the vicinity of the site consists of sediments of Late Pleistocene Age overlying Cretaceous Age sediments.

The Upper Pleistocene deposits are reported to be approximately 100 feet thick in the vicinity of the site and up to approximately 700 feet thick in the province. This unit is referred to as the Upper Glacial Unit, and consists of glacial till and outwash deposits. Till deposits characteristically contain clay, sand, gravel, and boulders. Outwash deposits consist of fine to very coarse, quartzose sand, and pebble to boulder size gravel. Characteristically, the till is poorly permeable while the outwash deposits are moderately to highly permeable (Smolensky, Buxton, and Shernoff, 1989). This unconfined Upper Glacial unit lies unconformably on the Cretaceous Age sediments.

The Cretaceous Age sediments in the vicinity of the site are approximately 1,700 feet in thickness as depicted in geologic cross sections by Smolensky, Buxton, and Shernoff. These deposits are composed of two distinct formations, including the Magothy Formation and the underlying Raritan Formation. The Magothy Formation (approximately 1,000 feet in thickness) consists of fine to medium sand (clayey in part) interbedded with lenses and layers of coarse sand, and sandy and solid clay. Colors are gray, white, red, brown, and yellow. This unit lies unconformably on the Raritan Formation. The Raritan Formation (approximately 700 feet in thickness) consists of clay, solid and silty with few lenses and layers of sand in the upper 200 feet of the formation. Colors include gray, red, and white, commonly variegated. The remainder of the formation consists of fine to coarse sand and gravel commonly with clayey matrix and some lenses and layers of solid and silty clay. Colors are yellow, gray, and white; clay is red locally. The upper 200 feet is poorly to very poorly permeable. The remainder of the formation is poorly to moderately permeable (Smolensky, Buxton, and Shernoff, 1989).

The physical and geotechnical properties of the unconsolidated materials in the subsurface at and in the vicinity of the site have been characterized based on observations made during the completion of soil borings as part of the previous investigation activities. Based on the observations, the sequence of unconsolidated materials in the subsurface underlying the site typically consists of:

- approximately 6- to 8-inches of concrete;
- construction debris, described as brick and concrete fragments;
- fill material, consisting of dark brown, fine to coarse sand and medium to coarse gravel, with concrete fragments;
- dark brown, medium to coarse sand and gravel in localized areas; and
- tan, fine to coarse, subangular to subrounded sand and gravel.

Grain size analyses performed on soil samples collected from the soil borings confirmed that the subsurface material beneath the site consists primarily of sand and gravel.

1.4.6 Hydrogeologic Setting

Based on information obtained from the *Hydrogeologic Framework of Long Island, New York* (Smolensky, Buxton, and Shernoff, 1989), groundwater in the vicinity of the HWD site occurs in two major aquifers within the unconsolidated sediments, the Upper Glacial Aquifer and the Magothy Aquifer. The Upper Glacial Aquifer is located within the Pleistocene deposits and regionally is up to approximately 700 feet in thickness. The clay deposits are mostly poorly permeable, but locally have thin moderately permeable layers of sand and gravel. The average horizontal hydraulic conductivity is approximately 270 feet per day (Smolensky, Buxton, and Shernoff, 1989). The Upper Glacial Aquifer in the vicinity of the HWD site is reported to be approximately 100 feet in thickness.

The Magothy Aquifer is regionally separated from the overlying Upper Glacial Aquifer by the Gardiner's Clay Unit, and is the thickest hydrogeologic unit on Long Island (approximately 1,100 feet in thickness). The Magothy Aquifer is separated from the Upper Glacial Aquifer by two low-permeability lenses of silt and clay (the Gardiner's Clay) that unconformably overly the Magothy Formation. Most layers are poorly to moderately permeable. However, there are some localized highly permeable layers. Groundwater is unconfined in the uppermost parts of this aquifer. The Magothy Aquifer serves as the predominant aquifer for public water supply in the region. The average horizontal hydraulic conductivity of the Magothy Aquifer is 50 feet per day (Smolensky, Buxton, and Shernoff, 1989).

Five rounds of water level measurements have been obtained from the permanent monitoring wells at the HWD site between January 2000 and April 2003. Based on these measurements, groundwater has been encountered at depths ranging from approximately 10.1 to 13.4 feet beneath the concrete/paved portions of the site, which corresponds to approximately 55 to 52 feet above MSL. Groundwater contour maps presented in the *Remedial Investigation Report* (BBL, 2002) indicate that groundwater flow beneath the site is generally toward the southeast. However, east-southeast of the HWD site, there is a prominent component of groundwater flow to the west and southwest.

Based on results obtained for specific capacity testing performed during April 2003 as part of the additional groundwater investigation activities, the average hydraulic conductivity of saturated soil in the vicinity of the monitoring wells at and near the HWD site was calculated as 272 feet per day, which is consistent with the 270 feet/day regional conductivity value calculated by the United States Geological Survey (USGS, 1972). As summarized in the Remedial Investigation Report (BBL, 2002), the average linear groundwater flow velocity in saturated soil beneath the HWD site is approximated using Darcy's Law as 0.96 feet/day (approximately 350 feet/year) to 1.93 feet/day (approximately 704 feet/year).

Based on BBL's understanding of the regional hydrogeologic setting, groundwater in the Upper Glacial Aquifer in the vicinity of the site flows generally toward the southeast and ultimately discharges to the Massapequa Creek, located approximately 2¼ miles southeast of the site.

1.4.7 Groundwater Usage

As summarized in the *Remedial Investigation Report* (BBL, 2002), the HWD site and surrounding area are served with potable water by the East Farmingdale Water District. The source of potable water supplied by the water district is five supply wells located in four separate wellfields (East Farmingdale Water District, 1998-2002). Approximately 6,000 people are served by the East Farmingdale Water District. According to the Suffolk County Department of Health Services Bureau of Drinking Water, private wells exist within the Village of Farmingdale. However, the department has no record of their uses (potable versus non-potable) or locations. There are no private wells used for potable water onsite, and no private well locations have been reported in the site vicinity. All nearby residences reportedly use the community water system (Gibbs & Hill, Inc., 1991). All municipal supply wells draw water from the Magothy Aquifer beneath Long Island, which is considered a sole source aquifer by the USGS (USGS, 1987).

Three of the four wellfields in the East Farmingdale Water District are located north (hydraulically upgradient) of the HWD site. The fourth wellfield, which includes two supply wells (Wells 4-1 and 4-2), is located approximately 1.75 miles southeast of the HWD site, adjacent to the Republic Airport. Wells 4-1 and 4-2 are screened at great depths (up to 1,500 feet deep) in the Magothy Formation, which is a different aquifer than the Upper Glacial Aquifer studied as part of the RI for the HWD site. The East Farmingdale Water District reports pumping rates of 1,340 gallons per minute (gpm) for Well 4-1 and 1,300 gpm for Well 4-2 (East Farmingdale Water District, 2000a). The pH is adjusted and chlorine treatment is performed in water withdrawn from each well. Water samples from the wells are routinely analyzed for principle organic contaminants, inorganics, bacteria, and physical parameters. Based on *Annual Drinking Water Quality Reports* provided by the East Farmingdale Water District covering the period between 1998 and 2002, none of these constituents/parameters were detected above regulatory limits in samples collected from 1998 through 2002.

1.5 Previous Investigations

Previous investigations conducted to evaluate conditions at and in the immediate vicinity of the HWD site include:

- Phase I and II investigations conducted by Gibbs & Hill, Inc. (as a contractor to the NYSDEC) between July 1988 and December 1990;
- RI and supplemental RI activities conducted by BBL on behalf of the HWD Group between November 1999 and February 2001;
- a supplemental soil investigation and soil vapor survey/air pathway evaluation conducted by BBL during August 2002; and
- additional groundwater investigation activities conducted by BBL in support of this FS during April 2003.

Work activities performed and results obtained for these investigations are summarized below.

1.5.1 Phase I Investigation

A Phase I Investigation was conducted for the NYSDEC by Roux Associates, Inc. (as a subcontractor to Gibbs & Hill) in July 1988. The purpose of the Phase I Investigation was to evaluate the site using the Hazard Ranking System (HRS). The Phase I Investigation involved a data/records search and assessment, interviews, and a site inspection. The investigation provided a preliminary assessment and characterization of the site, including site history, topography, hydrogeology, potentially hazardous substances, and migration pathways and receptors. However, information obtained as part of the investigation was insufficient to develop an HRS score.

1.5.2 Phase II Investigation

A Phase II Investigation was completed for the NYSDEC by Gibbs & Hill between May 1990 and December 1990. The purpose of the Phase II Investigation was to collect sufficient information to complete an HRS score and determine if site-related constituents had been released to the environment. Work activities completed as part of the Phase II Investigation included the following:

- collecting soil samples from five soil borings at the site (borings B1 through B5) and one boring north of the site (B6);
- collecting two surface water/sediment sample pairs from the recharge basin northeast of the site (samples SW-1/SD-1 and SW-2/SD-2); and
- installing four shallow groundwater monitoring wells (wells MW-1 through MW-4) and collecting groundwater samples from each well.

The Phase II investigation sampling locations are shown on Figures 4 and 5. Samples collected as part of the Phase II investigation were submitted for laboratory analysis for Target Compound List (TCL) VOCs, TCL semi-volatile organic compounds (SVOCs), Target Analyte List (TAL) inorganics, polychlorinated biphenyls (PCBs), and pesticides.

Laboratory analytical results indicate that low concentrations of chlorinated VOCs (namely PCE, TCE, and 1,2-DCE) were identified in soil samples collected from selected sampling locations at the site. The highest concentration of an individual VOC constituent identified in soil was 0.58 ppm (PCE at sampling location B-1). None of the VOC constituent concentrations identified in soil exceed the TAGM 4046 soil guidance values. Inorganics were identified in the Phase II Investigation soil samples at concentrations that appeared to be consistent with typical background concentrations in the vicinity of the site. PCBs and pesticides were not identified at concentrations exceeding laboratory detection limits in any of the Phase II Investigation soil samples.

TCE, ethylbenzene, toluene, and xylenes were identified in groundwater hydraulically upgradient from the HWD site (at monitoring well MW-1) at concentrations between 5 ppb and 91 ppb, which are equal to or exceed the 5 ppb NYSDEC groundwater quality standard established for each constituent. Chlorinated VOCs, including PCE, TCE, 1,2-DCE, and 1,1,1-TCA, were identified in groundwater beneath the HWD site (at monitoring well MW-2) at concentrations of 790 ppb, 130 ppb, 59 ppb, and 6 ppb, respectively, which exceed the 5 ppb NYSDEC groundwater quality standard established for each constituent. Lower concentrations of chlorinated VOCs and a suite of other VOCs not identified in groundwater beneath the HWD site (ethylbenzene, toluene, xylenes, chloroethane, chlorobenzene, 1,1-DCA, and vinyl chloride) were identified in groundwater at monitoring well MW-3, located hydraulically sidegradient to the HWD site. The VOC concentrations identified at monitoring well MW-3 exceed NYSDEC groundwater quality standards. Only one VOC constituent, methylene chloride (a common laboratory artifact), was identified in groundwater at monitoring well MW-4 northeast of the site.

Three SVOCs (phenol, naphthalene, and 2-methylnaphthalene) were identified in groundwater at monitoring well MW-3 at concentrations of 32 ppb, 65 ppb, and 32 ppb, respectively, which exceed NYSDEC groundwater quality standards. SVOCs were not identified above laboratory detection limits in groundwater at the other monitoring well locations. Inorganic concentrations identified in the Phase II Investigation groundwater samples appeared to be consistent with typical background concentrations in the vicinity of the site. PCBs and pesticides were not identified at concentrations exceeding laboratory detection limits in any of the Phase II Investigation groundwater samples. Site-related constituents of interest were not detected in surface water or sediment samples collected from the recharge basin northeast of the site.

Based on the results of the Phase II Investigation, the NYSDEC reclassified the site on the Inactive Hazardous Waste Site Registry from Class 2a to Class 2. The Class 2 designation indicates "a significant threat to pubic health or the environment and that action is required."

Subsequent to the Phase II Investigation, FPM (representing Little Joseph Realty) installed two upgradient groundwater monitoring wells (monitoring wells MW-5 and MW-6) to evaluate whether chemical constituents were migrating onto the HWD site. PCE was detected in a groundwater sample collected from monitoring well MW-6 at a concentration of 9 ppb, which exceeded the 5 ppb NYSDEC groundwater quality standard. 1,1-DCA and 1,1,1-TCA were detected in the groundwater samples collected from monitoring wells MW-5 and MW-6 at concentrations exceeding laboratory detection limits, but less than the NYSDEC groundwater quality standards. The analytical data indicated that there were sources of VOCs hydraulically upgradient from the HWD site.

1.5.3 Remedial Investigation

An RI was completed by BBL on behalf of the HWD Group between November 1999 and February 2000 and included a:

- ground-penetrating radar (GPR) geophysical survey to determine the presence and location of subsurface drainage structures and other subsurface structures;
- soil investigation to further evaluate the potential presence, concentration, and extent of chemical constituents in soil at the site;
- groundwater water investigation to vertically and horizontally profile the presence and concentration of chemical constituents in groundwater at and surrounding the site; and
- qualitative exposure assessment to determine potentially complete pathways of exposure for both current and hypothetical future receptors that may come in contact with site-related constituents of interest.

Supplemental RI soil and groundwater investigation activities were completed by BBL between January 2001 and April 2001 primarily to further evaluate the extent of VOCs in soil near the suspected location of the former sludge pit, to further evaluate groundwater quality hydraulically downgradient from the pit, and to evaluate whether a confining unit (Gardiner's Clay) is present beneath the site. Work activities completed as part of the RI and supplemental RI soil and groundwater investigations included the following:

- completing soil borings at 11 locations at/directly east of the site (locations SB-4 through SB-12, SB-16, and SB-17, as shown on Figures 4 and 5) using a conventional drill rig and hollow-stem auger drilling techniques. Each soil boring was advanced to the apparent groundwater table. Two soil samples collected from each soil boring were submitted for laboratory analysis for TCL VOCs. The samples from each boring, except SB-17, were also analyzed for TCL SVOCs, TAL inorganics, PCBs, total organic carbon (TOC), and grain size distribution. Sampling intervals were selected by field personnel based on visual characterization and results obtained for headspace screening using a photoionization detector (PID). At each soil boring location, one sample was collected from the interval that exhibited the highest PID headspace screening measurement or where the soil was observed to be stained or discolored. At boring locations where no impacts were observed, one sample was collected from the 2-foot interval halfway between the ground surface and the groundwater table. The second sample was collected from the 2-foot interval directly above the groundwater table;
- completing soil borings at 12 locations around the suspected location of the former sludge pit (locations GP-1 through GP-12, as shown on Figure 4) using a Geoprobe® drill rig and direct-push sampling techniques. Each soil boring was advanced to the apparent groundwater table. Two soil samples collected from each soil boring were submitted for laboratory analysis for TCL VOCs based on visual characterization and field screening results, using the approach described above;
- collecting groundwater grab samples from Hydropunch™ borings completed at 16 locations (locations HP-1 through HP-15 and HP-17, as shown on Figures 4 and 5). As shown on Figure 4, Hydropunch™ sampling locations HP-4 through HP-12 coincided with soil boring locations SB-4 through SB-12, and Hydropunch™ sampling location HP-17 coincided with soil boring location SB-17. The Hydropunch™ sampling was performed as a field screening tool to identify groundwater quality at specific depth intervals within the Upper Glacial Aquifer, to vertically and horizontally evaluate potential impacts to groundwater from site-related constituents in the Upper Glacial Aquifer, and to guide the vertical placement of well screens for deep permanent monitoring wells. At each Hydropunch™ sampling location (except location HP-17), a total of four groundwater samples were collected, including one sample just below the groundwater table and three samples from correspondingly deeper intervals, each approximately 30 vertical feet apart. At Hydropunch™ sampling location HP-17, groundwater samples were collected at 80, 90, 100, 110, and 120 feet below ground surface (bgs). Field measurements of groundwater pH, conductivity, dissolved oxygen,

oxidation-reduction potential, temperature, and turbidity were measured during sampling. Each groundwater sample was submitted for laboratory analysis for TCL VOCs. The Gardiner's Clay unit was not identified in any of the Hydropunch™ borings, which were advanced to depths of between 95 and 120 feet bgs;

- installing three deep groundwater monitoring wells (monitoring wells MW-1D, MW-2D, and MW-3D, as shown on Figure 2) near existing shallow groundwater monitoring wells to better define the vertical extent of VOCs in groundwater. Monitoring well screen intervals were selected based on expedited analytical results for the Hydropunch™ groundwater samples collected from locations HP-13, HP-14, and HP-15. The top of each 10-foot long well screen was placed nearly 30 feet below the groundwater table. One shallow groundwater monitoring well (monitoring well MW-7, as shown on Figure 2) was also installed to further evaluate groundwater quality hydraulically downgradient from the former sludge pit. Well development and surveying activities were conducted following installation of the monitoring wells;

- collecting groundwater samples from the permanent monitoring wells in the vicinity of the site during an initial sampling event in January 2000 and a second sampling event in February 2001. Groundwater samples were collected from monitoring wells MW-1 through MW-6 and MW-1D through MW-3D during each sampling event. During the February 2001 sampling event, groundwater samples were also collected from monitoring well MW-7. Field measurements of groundwater pH, conductivity, dissolved oxygen, oxidation-reduction potential, temperature, and turbidity were measured during each sampling event. The groundwater samples collected during each event were submitted for laboratory analysis for TCL VOCs. In addition, groundwater samples collected during the January 2000 sampling event were also submitted for laboratory analysis for TCL SVOCs, PCBs, TAL inorganics, total suspended solids (TSS), total dissolved solids (TDS), and diesel range organics; and

- obtaining four rounds of water level measurements from groundwater monitoring wells in the vicinity of the site (January 2000, July 2000, February 2001, and April 2001) and from a staff gauge installed in the recharge basin northeast of the site (April 2001). Based on the water level measurements, the groundwater flow direction across the HWD site is toward the southeast. However, east of the site, there is a prominent component of groundwater flow to the west/southwest.

The RI soil and groundwater investigation results are summarized below, followed by results obtained for the qualitative exposure assessment.

1.5.3.1 Soil Investigation Results

Based on the validated laboratory analytical results obtained for the RI, PCE is the primary constituent of concern in soil at the site. PCE was identified at concentrations exceeding the NYSDEC TAGM 4046 guidance value of 1.4 ppm in soil at 13 RI sampling locations, including locations GP-1 through GP-9 and SB-5, SB-8, SB-16, and SB-17, as shown on Figure 6. The concentrations of PCE identified in soil above the TAGM 4046 guidance value were between 13 ppm and 190 ppm, with one exception: PCE was identified at soil sampling location GP-9 (in the former hazardous waste storage and treatment area) at a concentration of 440 ppm. PCE was not identified at concentrations exceeding the 1.4 ppm TAGM 4046 guidance value at soil sampling locations more than approximately 15 feet north, 12 feet south, 25 feet east, and 15 feet west of a "reinforced concrete pad" identified during the GPR geophysical survey and shown on Figure 4. The area of soil where PCE was identified at concentrations above the TAGM 4046 guidance value appears to coincide with the former hazardous waste storage area and former drum storage area. At each sampling location where PCE was identified, the PCE concentration diminished with depth. The vertical extent of soil containing PCE at concentrations exceeding the 1.4 ppm TAGM 4046 guidance value is between approximately 6 and 13 feet bgs.

TCE and BTEX compounds were detected in subsurface soil at concentrations exceeding the TAGM 4046 guidance values, but below the soil action levels presented in NYSDEC TAGM #3028 titled, *"Contained-In Criteria" for Environmental Media*, the USEPA Region 3 RBCs for commercial/industrial soil, and the USEPA Region 9 PRGs for industrial soil. The RI soil analytical results for TCE and BTEX compounds are summarized below. The sampling depths referenced below are relative to the bottom of the concrete slab/ asphalt pavement that covers the HWD site/adjacent area.

- TCE was identified at concentrations exceeding the 0.7 ppm TAGM 4046 guidance value at only two of the RI soil sampling locations, including locations GP-5 (0-2') and GP-9 (0-2'). These are the same locations where the highest PCE concentrations were identified in soil. The TCE concentrations identified at these locations were "estimated" at 0.98 ppm and 3.5 ppm, respectively. A concentration is referred to as "estimated" when laboratory mass spectral data indicates the presence of the compound with a result less than the laboratory detection limit.

- BTEX compounds were identified at concentrations exceeding the TAGM 4046 guidance values at only two of the RI soil sampling locations, including SB-9 (in the southeastern portion of the site) and SB-11 (approximately 65 feet southeast of SB-9). Benzene was identified at sampling location SB-9 (12-14') at an estimated concentration of 0.31 ppm, above the 0.06 ppm TAGM 4046 guidance value. Ethylbenzene, toluene, and xylenes were identified at sampling location SB-11 (12-14') at concentrations of 31 ppm, 12 ppm (estimated), and 110 ppm, which exceed the TAGM 4046 guidance values of 5.5 ppm, 1.5 ppm, and 1.2 ppm, respectively. No other individual VOC constituents were identified above the TAGM 4046 guidance values at locations SB-9 and SB-11.

Phenol was identified at soil sampling location SB-7 (8-10') at an estimated concentration of 0.18 ppm, which exceeds the 0.030 ppm TAGM 4046 guidance value. No other SVOCs besides phenol were identified in the RI soil samples at concentrations exceeding the TAGM 4046 guidance values.

Inorganic concentrations identified in the RFI soil samples appeared to be consistent with typical background concentrations in the vicinity of the site. PCBs were identified in 11 RFI soil sampling locations at concentrations ranging from 0.24 ppm at sampling location SB-6 (12-14') to 5.7 ppm at sampling location SB-11 (12-14'). The PCB concentrations identified in the soil samples are below the 10 ppm TAGM 4046 subsurface soil guidance value. Trace levels of pesticides were detected at two RFI soil sampling locations (SB-5 and SB-9). The pesticide concentrations did not exceed available TAGM 4046 guidance values.

1.5.3.2 Groundwater Investigation Results

Based on the validated laboratory analytical results obtained for the RI, PCE is the primary constituent of concern in groundwater at the site. PCE was identified at concentrations exceeding the 5 ppb NYSDEC groundwater quality standard presented in TOGS 1.1.1 in groundwater samples collected from two shallow onsite groundwater monitoring wells located downgradient from former site operations, including monitoring wells MW-2 and MW-7. PCE was identified in the samples from these wells at concentrations up to 360 ppb and 1,100 ppb, respectively. PCE was also identified in groundwater samples collected from shallow groundwater monitoring wells located hydraulically upgradient from the site, including MW-1 and MW-6, at estimated maximum concentrations of 6 ppb and 16 ppb (respectively). The detection of PCE in wells MW-1 and MW-6 and the previous detection of PCE in other wells that appear to be hydraulically upgradient from the

HWD site (i.e., wells at the Target Rock and Claremont Poly Chemical facilities that were installed/sampled by others as part of various site investigations), indicates that there are other past or present sources of PCE to groundwater in the area besides the HWD site.

Breakdown products of PCE, including TCE and 1,2-DCE, were identified in the groundwater samples collected from monitoring wells MW-2 and MW-7 at concentrations exceeding the NYSDEC groundwater quality standard of 5 ppb for both constituents, but the concentrations were one to two orders of magnitude lower than the PCE concentrations. Specifically, TCE was identified in RI groundwater samples collected from monitoring well MW-2 and MW-7 at estimated concentrations up to 14 ppb and 22 ppb, respectively, and 1,2-DCE was identified in RI groundwater samples collected from these wells at estimated concentrations up to 8 ppb and 9 ppb, respectively. Similar concentrations of TCE above the 5 ppb NYSDEC groundwater quality standard have also been identified in groundwater at other sites located hydraulically upgradient from the HWD site.

PCE and TCE were not detected in the groundwater samples collected from monitoring well MW-3 at concentrations exceeding laboratory detection limits. However, 1,2-DCE and a suite of other VOCs and SVOCs not identified in groundwater beneath the HWD site (i.e., three BTEX compounds, chlorobenzene, 2,4-dimethylphenol, and naphthalene) were identified in the groundwater samples collected from monitoring well MW-3 at concentrations exceeding the NYSDEC groundwater quality standards. Based on groundwater potentiometric surface maps developed for the RI/FS, monitoring well MW-3 is located hydraulically sidegradient to the HWD site. The detection of VOCs and SVOCs in groundwater at monitoring well MW-3 appears to be unrelated to the HWD site, and is likely related to historical groundwater quality impacts from leaking USTs located nearby.

VOCs were not detected at concentrations exceeding NYSDEC groundwater quality standards in any of the RI groundwater samples collected from the deep permanent monitoring wells located at and in the vicinity of the site (monitoring wells MW-1D, MW-2D, and MW-3D) or from shallow monitoring wells MW-4 and MW-5. Aside from two SVOCs identified in the groundwater samples collected from monitoring well MW-3 (2,4-dimethylphenol and naphthalene), SVOCs were not identified at concentrations exceeding NYSDEC groundwater quality standards in any of the RI groundwater samples. Inorganic concentrations identified in the RI groundwater samples appeared to be consistent with typical background concentrations in the vicinity of the site. PCBs were not detected in any of the RI groundwater samples at concentrations exceeding laboratory detection limits, which ranged from 0.51 to 0.53 ppb. Diesel range organics were identified only in the groundwater samples collected from monitoring well MW-3.

VOCs were identified in several of the groundwater grab samples collected from the Hydropunch™ soil borings at concentrations exceeding the NYSDEC groundwater quality standards. However, the Hydropunch™ sampling approach provided field screening level results only. Analytical results from Hydropunch™ boring groundwater samples did not correlate to analytical results from adjacent shallow and deep permanent groundwater monitoring wells. The differences in analytical results between the groundwater samples collected from the Hydropunch™ borings and permanent monitoring wells were attributed to the methodology used to collect the samples resulting in differences in the amount of suspended particulates in the samples. The turbidity levels in the groundwater samples collected from the Hydropunch™ borings were on the order of 1,000 nephelometric turbidity units (NTUs) while the turbidity levels in the groundwater samples collected via low-flow methods from the permanent wells ranged from 0.0 to 22.4 NTUs. Review of the groundwater turbidity data and VOC soil and groundwater analytical results suggests that the VOC concentrations identified in the Hydropunch™ groundwater samples were biased high due to VOCs adsorbed onto particulates in the samples. Based on available data, the Hydropunch™ sample results do not appear to accurately depict the amount of VOC constituents dissolved in groundwater.

1.5.3.3 Qualitative Exposure Assessment Results

The qualitative exposure assessment evaluated potential exposures to site-related constituents of interest under current and hypothetical future site conditions. Based on site-specific information and results obtained for the RI, no complete exposure pathways were identified for human or ecological receptors within the boundaries of the HWD site.

The assessment concluded that complete exposure pathways could exist in the future, if the HWD site were developed for residential use and/or private water supply wells were installed at the site under a "no-action" scenario. If the concrete surface cover is removed, the potential for complete exposure pathways may exist for excavation workers, commercial/industrial workers, trespassers, and ecological receptors. Under this hypothetical future scenario, receptors could potentially be exposed to soil via incidental ingestion, dermal contact, and inhalation of particulates. In the unlikely event that a private well is installed at the site, hypothetical commercial/industrial workers or residents may be exposed to site-related constituents in groundwater via ingestion, dermal contact, and inhalation of vapors.

Data presented in the *Remedial Investigation Report* (BBL, 2002) suggests that it is highly unlikely that site-related constituents of interest would ever affect the downgradient municipal supply wells of the East Farmingdale Water District, and analytical results for these wells do not indicate the potential for future complete groundwater exposure pathways for district customers. As discussed in Subsection 1.4.7 of this FS Report, *Annual Drinking Water Quality Reports* provided by the East Farmingdale Water District for the period between 1998 and 2002 indicate that constituents of interest related to the HWD site have not been detected above regulatory limits in water samples collected from the municipal supply wells. In addition, as summarized in the *Remedial Investigation Report* (BBL, 2002), all wastes were removed from the HWD site in 1984, there is a significant distance between the site and the municipal supply wells (1.75 miles), the wells are screened at great depths (up to 1,500 feet) in a different aquifer to that studied at the HWD site, and constituents detected in groundwater at the HWD site tend to attenuate in the aquifer materials naturally over time. Also, site-related constituents of interest were not identified at concentrations exceeding NYSDEC groundwater quality standards in groundwater samples collected from the deeper monitoring wells installed during the RI.

It was concluded that potentially compete exposure pathways exist for commercial/industrial workers or hypothetical future residents at the site if exposed to VOCs originating from groundwater beneath the site. Under this scenario, VOCs from groundwater could infiltrate to indoor air within future onsite and nearby offsite buildings. To determine whether hypothetical exposures via soil gas migration into indoor air would be significant, the *Remedial Investigation Report* (BBL, 2002) compared VOC constituent concentrations detected in shallow onsite groundwater monitoring well MW-2 during the RI and supplemental RI to "Method 1 GW-2" groundwater standards derived by the Massachusetts Department of Environmental Protection (MDEP) to be protective of indoor air exposures. The MDEP numeric standards were used as a basis for comparison because they were formally promulgated and represent regulatory risk-based standards specifically developed for this potential exposure pathway that are conservative. As indicated in the *Remedial Investigation Report* (BBL, 2002), VOC concentrations detected in groundwater at monitoring well MW-2 did not exceed MDEP "Method 1 GW-2" standards. The comparison suggested that constituents in onsite groundwater would not pose a significant risk to hypothetical future residents via the indoor air inhalation pathway.

During January 2002, the NYSDOH conducted air monitoring to evaluate the potential presence of PCE in indoor air at three nearby offsite buildings, including the R&D, Fort Brand Service, and Ryder Truck buildings located along Picone Boulevard south and west of the HWD site. The NYSDOH used organic vapor monitoring badges to collect two indoor air samples from each building via passive diffusion over a 24-hour period. Laboratory analytical results indicated that PCE was detected at concentrations of 22 micrograms per cubic meter ($\mu g/m^3$) and 23 $\mu g/m^3$ in the middle and southern sections of the Ryder Truck garage area, respectively, 170 $\mu g/m^3$ and 180 $\mu g/m^3$ in the lobby and secretary area of the Fort Brand Service Building, and 890 $\mu g/m^3$ and 780 $\mu g/m^3$ in the lobby and secretary area of the R&D building. Activities conducted following NYSDEC and NYSDOH review of this air monitoring data are described below.

1.5.4 Supplemental Soil Investigation and Soil Vapor Survey/Air Pathway Evaluation

Based on the results of the January 2002 air monitoring activities, the NYSDEC requested that a soil vapor survey/air pathway evaluation be conducted to evaluate the potential connection between the VOCs in soil/groundwater at the HWD site and PCE detected by the NYSDOH in indoor air samples noted above. The NYSDEC also requested that a supplemental soil investigation be completed based on review of an undistorted aerial photograph showing former site operations (included as Figure 3) and a field reconnaissance conducted on January 15, 2002. The objectives of the supplemental soil investigation and soil vapor survey/air pathway evaluation were as follows:

- complete the delineation of VOCs in soil at the HWD site; and
- evaluate the potential for VOCs identified in soil and groundwater at the HWD site to migrate via soil vapor to the R&D, Fort Brand Service, and Ryder Truck buildings to the south and west of the HWD site.

The supplemental soil investigation and soil vapor survey/air pathway evaluation were completed by BBL during August 2002 in accordance with a work plan submitted to the NYSDEC via e-mail on July 19, 2002. NYSDEC approval to implement the activities was presented in a July 22, 2002 letter.

Detailed summaries of the work activities performed and results obtained for the supplemental soil investigation and soil vapor survey/air pathway evaluation are presented in an October 2, 2002 letter from BBL to the NYSDEC. The work activities and results are briefly summarized below.

1.5.4.1 Supplemental Soil Investigation

The supplemental soil investigation included the completion of seven direct-push soil borings (borings GP-13 through GP-19, as shown on Figure 4) near the former hazardous waste storage and the former sludge pit at the site. Each soil boring was advanced to the depth of groundwater. Two soil samples collected from each soil boring were submitted for laboratory analysis for TCL VOCs based on visual characterization and field screening results, consistent with the approach used for the RI and supplemental RI.

Laboratory analytical results indicate that PCE was detected in soil sample GP-15 (6-6.5') at a concentration of 2.3 ppm, which exceeds the 1.4 ppm TAGM 4046 soil guidance value. This analytical result does not exceed the 12 ppm soil action level presented in TAGM 3028, the 19 ppm USEPA Region 9 PRG for industrial soil, and the 110 ppm USEPA Region 3 RBC for commercial/industrial soil. VOCs were not detected in any of the other supplemental soil investigation samples at concentrations exceeding TAGM 4046 soil guidance values or other criteria referenced above. Based on the supplemental soil investigation activities, the extent of VOCs in soil at the HWD site was adequately delineated for purposes of this FS Report. The NYSDEC provided concurrence in an October 22, 2002 letter to BBL.

1.5.4.2 Soil Vapor Survey/Air Pathway Evaluation

Work activities performed as part of the soil vapor survey/air pathway evaluation included:

- a building integrity survey to evaluate the potential for VOCs to enter the R&D, Fort Brand Service, and Ryder Truck buildings to the south and west of the HWD site. BBL visually observed the inside of each building to evaluate the physical condition of the buildings and identify potential preferential pathways (sumps, cracks, etc.) for VOC vapors to migrate from the area of impacted soil/groundwater at the HWD site into the buildings;

- a building VOC inventory to identify potential sources of PCE unrelated to the HWD site that may contribute to the PCE levels identified in indoor air at the above-mentioned buildings. BBL developed a list of products potentially containing VOCs (including PCE) that were observed to be in use, handled, and/or stored in the buildings;

- an air handling system evaluation to provide a qualitative understanding of the ability of the air handling systems in the above-mentioned buildings to adequately ventilate the indoor air. The types of air handling systems at the buildings were identified. However, information pertaining to operating speeds of fans and number of air exchanges provided by the heating and cooling systems was unavailable; and

- soil vapor sampling to evaluate the potential presence of VOC soil vapor in subsurface soil between the HWD site and the three above-mentioned buildings. Soil vapor samples were collected at a depth of approximately 2.5 to 3.0 feet bgs from seven direct-push soil borings located along/near Picone Boulevard to the south and west of the HWD site (borings SV-1 through SV-7, as shown on Figure 5). Each soil vapor sample was submitted for laboratory analysis for PCE, TCE, and degradation daughter products of PCE and TCE, including cis-1,2-DCE, 1,1-DCE, 1,1,-DCA, chloroethane, and vinyl chloride.

The NYSDOH conducted additional air monitoring at the R&D building during August 2002 in connection with the soil vapor survey/air pathway evaluation. PCE was identified in indoor air samples collected from the secretary area and lobby of the R&D building at concentrations of 190 $\mu g/m^3$ and 200 $\mu g/m^3$, respectively, which were lower than concentrations identified during the previous January 2002 monitoring event.

Based on the evaluation activities described above, BBL observed that the R&D, Fort Brand Service, and Ryder Truck buildings were each constructed with a concrete slab on grade and no basement. No significant cracks were observed in exposed sections of the cinderblock walls or concrete floors inside the buildings. Sumps were not identified inside any of the buildings. BBL identified products within the Fort Brand Service and Ryder Truck buildings that contained PCE, including brake cleaner in the Fort Brand Service building and degreaser/ parts washer fluid and battery corrosion inhibitor in the Ryder Truck building. BBL identified numerous adhesives, coatings/sealers, base fillers, cleaners, paints/stains, and paint strippers/thinners in the garage area of the R&D building that could potentially contain PCE. However, PCE was not listed as a chemical component on material safety data sheets (MSDS sheets) obtained for the products observed R&D. The composition of several products was listed as proprietary materials. BBL noted that old septic tanks, drainlines, etc. could potentially exist and contribute the presence of PCE to indoor air in these buildings. Later, during an August 2003 site visit, BBL observed a can of PCE-containing parts cleaning product in the R&D facility. An interview with an R&D employee verified the use of PCE at the R&D facility.

Based on the laboratory analytical results obtained from the soil vapor survey, five VOCs (PCE, TCE, cis-1,2-DCE, 1,1-DCA, and vinyl chloride) were identified in the soil vapor samples. The highest VOC concentrations in soil vapor were identified at sampling location SV-2, located south of the HWD site. In general, PCE was identified in the soil vapor samples at higher concentrations than other individual VOC constituents. PCE was identified in each soil vapor sample at concentrations ranging from 0.012 parts per million on a volume basis (ppmv) in sample SV-1 to 97 ppmv in sample SV-2.

Based on the inventory activities completed within the buildings, a number of potential sources besides the HWD site were identified for the PCE identified by the NYSDOH in ambient air samples collected inside the R&D, Ryder Truck, and Fort Brand Service buildings. The maximum indoor air concentration of PCE identified by the NYSDOH (890 µg/m^3 during January 2002) was three orders of magnitude below applicable occupational exposure criteria for PCE established by the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental and Industrial Hygienists (ACGIH), including the 685 milligrams per cubic meter (mg/m^3) OSHA permissible exposure limit (PEL), the 685 mg/m^3 ACGIH short-term exposure limit (STEL), and the 170 mg/m^3 ACGIH threshold limit value (TLV). The OSHA/ACGIH criteria were designed to protect commercial/industrial workers from unacceptable occupational exposures.

The NYSDOH stated that commercial use of PCE at the Ryder Truck and Fort Brand Service buildings rendered the OSHA/ACGIH standards applicable. The finding of PCE-containing parts cleaning product at R&D during the August 2003 site visit supported the conclusion that the OSHA/ACGIH standards also applied to the R&D facility.

1.5.5 Additional Groundwater Investigation

In order to provide site-specific information for the FS, additional groundwater investigation activities were conducted at the HWD site during April 2003. The goal of the additional groundwater investigation activities was to provide data to evaluate the effectiveness of biodegradation as a groundwater remedial alternative. Particular emphasis was placed on evaluating the degradation of PCE and TCE, which had previously been identified at concentrations up to approximately 1 ppm. The groundwater investigation activities were conducted in accordance with:

- a January 31, 2003 work plan letter from BBL to the NYSDEC;
- a March 10, 2003 letter from BBL that responds to comments on the work plan presented in a February 25, 2003 letter from the NYSDEC;
- e-mail letters from BBL to the NYSDEC dated March 26, 2003 and March 28, 2003 that addressed additional NYSDEC comments on the groundwater investigation activities.

NYSDEC approval to implement the additional groundwater investigation activities was provided in a March 28, 2003 letter to BBL.

As indicated in the work plan letter, both PCE and TCE can be transformed and biodegraded in-situ in groundwater by a variety of naturally-occurring microbial-mediated reactions. The additional groundwater investigation activities focused on collecting data to evaluate the presence and extent of biodegradation via *reductive dechlorination* under natural conditions. Reductive dechlorination is a naturally occurring, microbially-mediated process that transforms and ultimately can destroy PCE and TCE in groundwater (at comparatively fast rates). During reductive dechlorination, naturally occurring groundwater micro-organisms sequentially remove chlorine atoms from PCE and TCE molecules, which results in the formation of less chlorinated intermediate byproducts (such as cis-1,2-DCE and vinyl chloride [VC]) until the non-chlorinated ethene molecule is produced. Chloride ions (Cl^-) are also formed as a result of reductive dechlorination. The resulting DCE, VC, and ethene can be oxidized by naturally occurring microorganisms in groundwater. Oxidation of these molecules forms the innocuous byproducts carbon dioxide (CO_2) and chloride. These processes can be represented as follows:

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{DCE} \rightarrow \text{VC} \rightarrow \text{Ethene, } Cl^-$$

$$\text{DCE} \rightarrow CO_2 + Cl^-$$

$$\text{VC} \rightarrow CO_2 + Cl^-$$

$$\text{Ethene} \rightarrow CO_2$$

These biodegradation reactions require the presence of appropriate microorganisms and nutrients, as well as appropriate environmental conditions (circumneutral pH, adequate temperature, reducing geochemical conditions). Reductive dechlorination also requires an alternate supply of organic carbon, such as natural organic matter, DCE, VC, and ethene.

The additional groundwater investigation activities are summarized below, followed by the investigation results.

1.5.5.1 Additional Groundwater Investigation Activities

Work activities performed as part of the additional groundwater investigation included the following:

- installing and developing an additional shallow groundwater monitoring well hydraulically downgradient from the HWD site as requested by the NYSDEC (monitoring well MW-8, as shown on Figure 2). The well installation and development activities were completed on April 10, 2003. A groundwater monitoring well completion log for monitoring well MW-8 is included in Appendix A. The well location and top-of-casing elevation were surveyed following completion of the well installation/development activities;

- collecting groundwater samples from a subset of the existing monitoring wells at/near the site, including wells MW-1D, MW-1 through MW-3, and MW-6 through MW-8, on April 22 and 23, 2003. Specific capacity testing was performed in conjunction with the groundwater sampling (as described in Walton, W.C., 1962) to further evaluate the transmissivity and hydraulic conductivity of the geologic formation surrounding the screened interval of each well;

- obtaining a complete round of groundwater level measurements from each above-listed monitoring well and monitoring wells MW-2D, W-1, and W-3, prior to sampling on April 22, 2003. BBL also obtained a surface water level measurement in the recharge basin northeast of the site (at an existing staff gauge). Groundwater elevations and a surface water elevation were calculated by subtracting the water level measurements obtained at each well and the staff gauge from surveyed reference points. The water level measurements/elevations are summarized in Table 1.

Groundwater samples were collected using low-flow techniques (a peristaltic pump) for laboratory analysis for key indicator parameters of in-situ bioremediation. Groundwater samples were collected using dedicated bailers for laboratory analysis for TCL VOCs (to minimize the potential loss of VOCs through peristaltic pumping agitation). Various indicator parameters were measured during well purging prior to sampling.

The indicator parameters selected for field measurement and laboratory analysis were focused on the in-situ biodegradation processes discussed above. A complete listing of the indicator parameters that were field-measured and submitted for laboratory analysis, and the rationale for selecting each parameter, is presented below.

Parameter	Rationale	Method
Field Parameters		
Dissolved oxygen	Electron acceptor	Flow through cell
pH	Environmental indicator	Flow through cell
Redox potential	Geochemical indicator	Flow through cell
Conductivity	General water quality	Flow through cell
Temperature	Environmental indicator	Flow through cell
Laboratory Parameters		
VOCs	Delineation/initial concentration	USEPA Method 8260
Alkalinty	Buffering capacity	USEPA Method 310.1
Dissolved iron (filtered)	Metabolic byproduct	USEPA Method 6010B
Dissolved organic carbon (filtered)	Alternate electron donor	USEPA Method 9060
Ammonia	Metabolic byproduct	USEPA Method 350.2
Nitrate	Alternate electron acceptor	USEPA Method 9056
Nitrite	Alternate electron acceptor	USEPA Method 9056
Phosphate	Macronutrient	USEPA Method 9056
Chloride	Final byproduct	USEPA Method 9056
Sulfate	Alternate electron acceptor	USEPA Method 9056
Sulfide	Metabolic byproduct	USEPA Method 376.1
Carbon dioxide, ethane, ethene, methane	Metabolic byproducts	Gas chromatography (GC)
Phospholipid fatty acids	Biomass, community structure, and metabolic status of anaerobic microorganisms	Gas chromatography/ Mass Spectrometry (GC/MS)
Dehalococcoides Ethenogenes	Microorganism known to reductively dechlorinate PCE, TCE, DCE, and VC	Polymerase chain-reaction (PCR)

Filtering of the groundwater samples for analysis of dissolved iron and dissolved organic carbon was performed in the field using disposable 0.45 micron glass-fiber filters. Quality assurance/quality control (QA/QC) samples (including blind duplicate, matrix spike, matrix spike duplicate, and trip blank samples) were collected in support of the VOC analyses, as required by the NYSDEC 2000 Analytical Services Protocol (ASP). The blind duplicate sample (sample BD042203) was collected from monitoring well MW-3. Field parameter measurements obtained during the well purging activities prior to sampling are presented on the groundwater sampling logs included in Appendix B.

1.5.5.2 Additional Groundwater Investigation Results

Analytical results obtained from the laboratory analysis of the April 2003 groundwater samples for TCL VOCs are presented in Table 2. Groundwater field/laboratory analytical results for key indicator parameters of in-situ biodegradation are presented in Table 3. Laboratory analytical data reports (Form 1 results) are presented in Appendix C. VOC groundwater analytical results for the April 2003 and previous groundwater sampling events are shown on Figure 7.

Laboratory analytical results for VOCs are discussed below, followed by results obtained for the key indicator parameters of in-situ biodegradation.

<u>VOCs</u>

Laboratory analytical results indicate that PCE, TCE, and cis-1,2-DCE were detected at concentrations exceeding the 5 ppb NYSDEC groundwater quality standard (for each constituent) in each groundwater sample collected at and hydraulically downgradient from the site during April 2003, as summarized below.

Constituent	Concentration (ppb)		
	MW-2	MW-7	MW-8
PCE	1,200	2,600	970
TCE	34	48	25
cis-1,2-DCE	21	38	27

PCE was also identified in the April 2003 groundwater samples collected from upgradient monitoring wells MW-1 and MW-6 at concentrations of 50 and 120 ppb, which exceed the 5 ppb NYSDEC groundwater quality standard. BTEX compounds and chlorobenzene were identified at concentrations exceeding NYSDEC groundwater quality standards in the April 2003 groundwater sample collected from monitoring well MW-3, located hydraulically sidegradient to the HWD site. VOCs were not identified at concentrations exceeding the NYSDEC groundwater quality standards in the April 2003 groundwater sample collected from monitoring well MW-1D.

<u>Key Indicator Parameters of In-Situ Biodegradation</u>

Based on review of the field/laboratory results for key indicator parameters of in-situ biodegradation, there is evidence that in-situ biodegradation and complete reductive dechlorination of chlorinated solvents was occurring in shallow groundwater near monitoring well MW-8 (in the downgradient portion of the site-related VOC plume) and at monitoring well MW-3 (located sidegradient to the HWD site) during the April 2003 sampling event.

The phospholipid fatty acid (PLFA) analytical results indicate that the maximum biomass concentrations were detected at monitoring wells MW-1D, MW-3, and MW-8. PLFA are found within the membranes of all living cells, but decompose quickly upon cell death. Therefore, measurement of PLFA content in groundwater provides a quantitative measure of the viable microbial biomass present. PLFA structural group interpretation is used to relate the complex mixture of PLFA to the organisms present. The PLFA results indicate that the groundwater samples collected from monitoring wells MW-1D, MW-3 and MW-8 contained relatively high proportions of terminally-branched saturated PLFAs (which indicate the presence of anaerobic microorganisms) and branched monoenoic PLFAs (which indicate the presence of metal-reducing microorganisms such as sulfate- and iron-reducing bacteria). These trends correlate well with the relatively high concentrations of carbon dioxide, methane, ethane, and ethene (i.e., metabolic byproducts associated with in-situ biodegradation) at monitoring wells MW-3 and MW-8 and the presence of petroleum chemicals (which can provide organic carbon used for microbiologic growth) at monitoring well MW-3.

The analytical results indicate that *Dehalococcoides Ethenogenes* (*D. Ethenogenes)* was identified in the groundwater at monitoring wells MW-3 and MW-8. *D. Ethenogenes* is the only microorganism species isolated to date capable of complete reductive dechlorination of PCE, TCE, DCE isomers, and vinyl chloride. The presence of *D. Ethenogenes* provides support that reductive dechlorination reactions are causing the increased concentrations of metabolic byproducts identified in groundwater at monitoring wells MW-3 and MW-8. Although *D. Ethenogenes* was not detected above the laboratory detection limit in the groundwater samples collected from the other wells that were sampled, the non-detect results do not indicate that microorganisms are not present in the samples, but only that microorganisms were not present above the laboratory detection limit.

A detailed evaluation of the natural attenuation of VOCs in groundwater at and downgradient from the site, including the framework for evaluating the site-specific data, is presented in Appendix D.

1.6 Activities to Address Indoor Air/Additional Air Monitoring

Based on the results obtained for the indoor air monitoring conducted during August 2002 and NYSDEC comments presented in an October 22, 2003 letter to BBL, various upgrades were made to the existing heating, ventilating, and air conditioning (HVAC) system at the R&D building and additional (follow-up) monitoring activities were conducted. These upgrades and additional monitoring activities are summarized below.

During November 2002, the owner of the R&D building (who is part of the HWD Group), retained a local HVAC contractor who installed the following measures to increase the amount of outdoor air supplied to the R&D building and reduce PCE concentrations:

- a new outdoor air intake connected to the existing HVAC system to increase the amount of outside air supplied to the office space; and
- two exhaust fans with motorized dampers on the roof of the garage to increase the amount of outside air provided in the garage.

The installation activities were completed during mid-November 2002. During December 2002, BBL and the NYSDOH conducted air monitoring to further evaluate the presence and potential sources of PCE in indoor air at the R&D building. In addition, BBL's mechanical/HVAC engineering subcontractor, Lynch Engineering, P.C., conducted an evaluation of the air handling system at the R&D building to:

- evaluate whether the HVAC system at R&D had the capability of providing the correct air exchange volume to reduce indoor air PCE concentrations to below the NYSDOH residential indoor air quality guideline of 100 μg/m^3 (www.health.state.ny.us/nysdoh/environ/btsa/fs_perc.htm, September 2003); and

- identify feasible alternatives for further upgrading the HVAC system to improve air flow/ventilation and reduce indoor air PCE concentrations to below 100 μg/m^3.

The evaluation activities were conducted in accordance with a December 3, 2002 work plan letter from BBL to the NYSDEC. The results of the indoor December 2002 indoor air monitoring activities indicated that PCE was present above the NYSDOH residential indoor air quality guideline of 100 μg/m^3. Based on the results obtained for the December 2002 air monitoring activities, which after additional review activities, did not identify a specific source of PCE within the R&D building (but did not rule out the Ryder Truck degreaser as a potential source for PCE to migrate to R&D), the HWD Group agreed to implement activities in a phased approach to address PCE in indoor air at the R&D building. However, as discussed in Subsection 1.5.4.2, a can of PCE-containing parts cleaning product was later identified in the R&D facility during an August 2003 site visit. An interview with an R&D employee verified the use of PCE at the facility, which supported that OSHA/ACGIH standards were applicable.

An approach for addressing PCE in indoor air of the R&D building was presented in a January 16, 2003 letter from BBL to the NYSDEC. Comments on the approach were presented in a January 27, 2003 letter from the NYSDOH to the NYSDEC and included a request for collecting indoor air samples monthly for six months to evaluate the effectiveness of proposed HVAC system upgrades at reducing the concentration of PCE in the indoor air. The approach implemented to address PCE in the indoor air of the R&D building is summarized below.

Two free-standing portable high-efficiency particulate air (HEPA)/carbon filtration units were installed in the R&D office during January 2003 as an interim measure until permanent upgrades to the HVAC system were designed, installed, and operational. Each unit had 36 pounds of granular-activated vapor-phase carbon arranged in a 4-inch thick bed. Both units were turned on for continuous operation on the 'high' setting and filtered re-circulated air within the office area at a rate of 207 cubic feet per minute (CFM). Two additional filtration units were installed in the office area during February 2003 in accordance with a February 24, 2003 letter from BBL to the NYSDEC.

The design of the HVAC system upgrades was completed during late March 2003. Design drawings stamped by a professional engineer licensed in the State of New York were submitted to the NYSDEC during early April 2003. The new HVAC system heating and cooling units were operational by the end of April 2003, and the four existing HEPA/carbon filtration units were shut off in early May 2003. The upgraded HVAC system consists of:

- a new, nominal 5-ton split system with a ducted gas-fired furnace and a cooling coil piped to a roof-mounted air-cooled condenser system (which is 1-ton larger than the previous system). The new system supplies approximately 2,000 CFM to the office area, of which 350 to 400 CFM (nearly 20% of the re-circulated air supply) is outside air. The previous system supplied approximately 1,600 CFM to the office area, including approximately 150 CFM of outside air. While the old HVAC system fan ran only in connection with a heating/cooling cycle, the new fan runs continuously to maintain positive pressure across the office area to minimize potential vapor intrusion through the building floor slab;

- new 24-inch by 12-inch louvers installed in the bottom panel of each overhead door in the garage area (one louver per door). The louvers allow outside air to sweep across the occupied garage area when the overhead doors are closed and existing roof-mounted exhaust fans are operated; and

- a new, larger gas line from the service main to the new furnace. The size of the gas line servicing the R&D building, which was undersized for the original HVAC system, was increased to supply the correct amount of gas to the new furnace and three existing gas-fired unit heaters in the garage area.

Air monitoring has been conducted on a monthly basis since January 2003, and corrective actions have been completed to address conditions affecting results. The need for additional corrective actions, if any, will be evaluated based on results obtained for planned additional monthly monitoring activities. Results for air monitoring conducted during August 2003 and September 2003 indicate that the HVAC system upgrades are operating as designed.

2. Standards, Criteria & Guidance

2.1 General

This section of the FS Report discusses potential standards, criteria, and guidelines (SCGs) that may apply to the HWD site or apply to certain remedial alternatives evaluated for the HWD site. The identification of SCGs was conducted as set forth in NYSDEC TAGM #4030 titled, *Selection of Remedial Actions at Inactive Hazardous Waste Sites* (NYSDEC, 1990). The potential SCGs are also used to aid in the identification of RAOs but do not dictate a particular alternative and do not establish remedial cleanup levels.

2.1.1 Definition of SCGs

Definitions of the SCGs are presented below.

- *Standards and Criteria* – are 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.
- *Guidelines* – are non-promulgated criteria that are not legal requirements. However, remedial programs should be designed with consideration given to guidelines that, based on professional judgment, are determined to be applicable to the site [6 NYCRR Part 375-1.10(c)(1)(ii)].

2.1.2 Types of SCGs

The NYSDEC has provided guidance on the application of SCGs in the RI/FS process. The potential SCGs considered for the potential remedial alternatives identified in this FS were categorized into the following NYSDEC-recommended classifications:

- *Chemical-Specific SCGs* – These SCGs are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical values for each constituent of concern. These values establish the acceptable amount or concentration of constituents that may be found in, or discharged to, the ambient environment.
- *Action-Specific SCGs* – These SCGs are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous waste management and site cleanup.
- *Location-Specific SCGs* – These SCGs are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in specific locations.

The SCGs identified for the site are summarized below.

2.2 SCGs

The identification of federal and state SCGs for the evaluation of remedial alternatives at the site was a multi-step process that included a review of conditions identified by the RI, including results from the qualitative exposure assessment as summarized in the NYSDEC-approved *Remedial Investigation Report* (BBL, 2002). The SCGs that have been identified for this FS Report are presented in Table 4 and summarized below.

2.2.1 Chemical-Specific SCGs

One set of chemical-specific SCGs that potentially apply to site soil if the soil is to be excavated (and then considered under the Resource Conservation and Recovery Act [RCRA] to be a "waste" that is generated) are the RCRA-regulated levels for Toxicity Characteristic Leaching Procedure (TCLP) constituents, as outlined in 40 CFR Part 261 and 6 NYCRR Part 371. The TCLP constituent levels are a set of numerical criteria at which a solid waste is considered a hazardous waste by the characteristic of toxicity. In addition, the hazardous waste characteristics of ignitability, corrosivity, and reactivity may also apply depending on the results of waste characterization activities.

Another set of chemical-specific SCGs that may apply to the site (e.g., soils that are excavated and determined to be a hazardous waste) are the USEPA Universal Treatment Standards/Land Disposal Restrictions (UTS/LDRs), as listed in 40 CFR Part 268. These standards and restrictions identify those hazardous wastes for which land disposal is restricted and define acceptable treatment technologies or concentration limits for those hazardous wastes on the basis of their waste code characteristics. The UTS/LDRs also provide a set of numerical criteria at which a hazardous waste is restricted from land disposal, based on the concentration of select constituents present. In addition, the UTS/LDRs define hazardous waste soil and hazardous waste debris and specify alternative treatment standards and treatment methods required to treat or destroy hazardous constituents on or in hazardous waste debris.

Pursuant to the USEPA's "Contained-in Policy," environmental media (soil, groundwater, and sediment) and debris impacted by a hazardous waste are subject to RCRA hazardous waste management requirements until they no longer contain the hazardous waste. Specifically, environmental media/debris that has been impacted by a release of characteristic hazardous waste must be managed as hazardous waste until the media/debris no longer exhibits that characteristic (based on laboratory testing). UTS/LDR requirements would continue to apply for the waste in accordance with 40 CFR Part 268. In addition, environmental media/debris containing a listed hazardous waste must be managed as hazardous waste until the media/debris no longer contains the listed hazardous waste at concentrations exceeding health-based levels. Under certain circumstances, the UTS/LDR requirements might continue to apply. Although the USEPA has not established generic health-based "contained-in" levels for listed hazardous wastes, they authorized individual states to establish their own levels. The NYSDEC has established "contained-in" criteria for environmental media and debris, which are presented in TAGM #3028 titled, *"Contained-In Criteria" for Environmental Media* (NYSDEC, 1997).

Groundwater beneath the site is classified as Class GA and, as such, the New York State Groundwater Quality Standards (6 NYCRR Parts 700-705) are potentially-applicable chemical-specific standards even though groundwater at the site is not currently, and will not likely in the future, be used as a potable water supply. These standards identify acceptable levels of constituents in groundwater based on potable use.

The soil guidance values presented in NYSDEC TAGM #4046 titled, *Determination of Soil Cleanup Objectives and Cleanup Levels,* (NYSDEC, 1994) are another set of chemical-specific SCGs that are potentially applicable to the site. These guidance values are considered in developing remedial performance goals for soil at the site.

2.2.2 Action-Specific SCGs

The general health and safety requirements established by OSHA for general industry under 29 CFR Part 1910, and for construction under 29 CFR Part 1926, are action-specific SCGs that may be potentially applicable to each active remedial alternative evaluated in this FS Report.

The New York State regulations contained in 6 NYCRR Parts 364, 370, and 372 for the collection and transportation of regulated waste within New York State are applicable action-specific SCGs for remedial alternatives that involve the offsite transportation of regulated wastes. In addition, the LDRs, which regulate land disposal of RCRA hazardous wastes, are applicable action-specific SCGs for remedial alternatives that involve the offsite disposal of hazardous wastes. In 1998, the USEPA promulgated Phase IV, Part 2 regulations that present alternative LDR treatment standards for hazardous waste soil. The alternative LDR treatment standard for hazardous waste soil is a 90% reduction in constituent concentrations capped at 10 times the UTS (10 x UTS). If concentrations of constituents in excavated soil that is a hazardous waste exceed 10 x UTS, the soil would have to be treated to reduce constituent concentrations to below the 10 x UTS prior to land disposal in a RCRA Subtitle C facility.

Other potentially applicable action-specific SCGs pertain to protecting water and air quality. The National Pollution Discharge Elimination System (NPDES) and the New York State Pollution Discharge Elimination System (SPDES) regulations contained in 40 CFR Part 122 and 6 NYCRR Parts 750-758, respectively, which detail specific requirements for the discharge of chemical constituents to United States and New York State waters, are also potentially applicable action-specific SCGs for remedial alternatives that involve the discharge of treated water to the environment. NYSDEC Air Guide 1, which incorporates applicable federal and New York State regulations and requirements pertaining to air emissions, may be applicable for soil or groundwater alternatives that result in certain air emissions.

2.2.3 Location-Specific SCGs

Location-specific SCGs for the HWD site include local requirements such as local building permit conditions for permanent or semi-permanent facilities constructed during the remedial activities (if any), and influent requirements of publicly owned treatment works (POTW) if water is treated at the site and discharged to a POTW. No floodplains, wetlands, or historic areas were identified at the site. Therefore, location-specific SCGs pertaining to floodplains, wetlands, and historic areas are not applicable to the potential remedial alternatives.

Other potential location-specific SCGs are regulations pertaining to the protection of endangered plant and animal species. In support of the qualitative exposure assessment completed as part of the RI, information regarding the presence of rare, threatened, or endangered plant and animal species within ½ mile of the site was requested and received from the New York State Natural Heritage Program and the U. S. Fish and Wildlife Service (USFWS). According to the Natural Heritage Program (letter to BBL dated March 2, 2000), there are two rare vascular plants (Hyssop-Skullcap and Southern Yellow Flax), a rare moth species (Coastal Barrens Buckmouth), and a rare butterfly species (Edwards' Hairstreak), in the vicinity of the site. The March 2, 2000 letter from the Natural Heritage Program did not identify any endangered species in the vicinity of the site. The USFWS reported to BBL in a March 21, 2000 letter that there are no federally-listed or proposed endangered or threatened species known to exist in the vicinity of the site. As indicated in the *Remedial Investigation Report* (BBL, 2002), the HWD site is a relatively small (0.5 acre) industrial site, and the entire site is covered with concrete and asphalt. Natural vegetative communities do not exist on site, and as such the site does not currently contain habitat required to support ecological receptors (including threatened/endangered species). Therefore, regulations pertaining to the protection of endangered species are not applicable for remedial activities at the HWD site.

3. Remedial Action Objectives

3.1 General

This section presents remedial action objectives (RAOs) developed for the HWD site to address constituents of interest in soil at the site and constituents of interest in groundwater beneath the site. The RAOs represent media-specific goals that result in the protection of human health and the environment. These objectives are, in general, developed by considering the results of the qualitative exposure assessment and the SCGs identified for the site. The RAOs developed for soil and groundwater are discussed below, followed by a description of the areas to be addressed to achieve the RAOs.

3.2 RAO Development Analysis

Based on the results of the previous investigation activities, PCE is the primary constituent of interest in soil and groundwater at the site. As summarized in Subsection 1.1, PCE has been identified in subsurface soil at concentrations exceeding potentially applicable guidance, including the guidance values presented in NYSDEC TAGM #4046. Five other VOCs, including trichloroethylene (TCE) and BTEX compounds, were detected in subsurface soil at concentrations exceeding the TAGM 4046 guidance values, but below the soil action levels presented in NYSDEC TAGM #3028 titled, *"Contained-In Criteria" for Environmental Media* (NYSDEC, 1997), the USEPA Region 3 RBCs for commercial/industrial soil, and the USEPA Region 9 PRGs for industrial soil. VOCs have also been identified in groundwater at the site at concentrations exceeding the standards/ guidance values presented in the NYSDEC TOGS 1.1.1 document titled, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations*, (NYSDEC, 2000). Site-related constituents of interest at the HWD site were not detected in surface water or sediment samples collected in the vicinity of the site.

As summarized in Subsection 1.4.1, the current land use at the HWD site is light industrial, and access to the site is limited by chain-link fencing and lockable gates. The site is covered with a concrete surface, and there is no use of groundwater at the site. Due to current site conditions, there are currently no exposure points present within the site property, and therefore no complete exposure pathways have been identified under current conditions at the site.

Given the commercial/industrial setting and small size of the HWD site, the lack of vegetation, and the traffic associated with current trucking activities at and in the vicinity of the site, the qualitative exposure assessment concluded that the site does not contain habitat capable of supporting ecological populations or communities. While potential ecological receptors typical of urban environs (rodents, common small birds) may occasionally be present at the site, the existing concrete pavement prevents any potential exposures to site soil. Therefore, no complete exposure pathways were identified for potential ecological receptors at or in the vicinity of the site.

As summarized in Subsection 1.5.3.3, under future conditions, complete exposure pathways could exist if the HWD site were developed for residential use and/or private water supply wells were installed at the site under a "no-action" scenario. If the concrete surface cover is removed, potentially complete exposure pathways may exist for excavation workers, commercial/industrial workers, trespassers, and ecological receptors. Under both hypothetical future scenarios, receptors could potentially be exposed to soil via incidental ingestion, dermal contact, and inhalation of particulates. In the unlikely event that a private well is installed at the site, hypothetical commercial/industrial workers or residents may be exposed to site-related constituents in groundwater via ingestion, dermal contact, and inhalation of vapors. Data presented in the *Remedial*

Investigation Report (BBL, 2002) suggests that it is highly unlikely that site-related constituents of interest would ever affect the municipal supply wells of the East Farmingdale Water District.

Potentially complete exposure pathways for commercial/industrial workers at the R&D building south of the HWD site (via migration of VOCs through soil vapor to indoor air) have been mitigated by the engineered upgrades made to the HVAC system, as described in Subsection 1.6. Potentially complete exposure pathways exist for commercial/industrial workers or hypothetical future residents at the HWD site if exposed to VOCs originating from groundwater beneath the site.

3.3 Soil and Groundwater RAOs

Based on the results of the previous investigation activities and qualitative exposure assessment, the overall goal of the remedial alternatives will be to mitigate potential future human exposure to PCE associated with the soil at the site and groundwater beneath the site. Therefore, the RAOs established for soil/groundwater include:

- minimize potential future exposure of workers at the site to soil containing VOCs;
- minimize potential migration of chemical constituents in onsite soil to stormwater at the site and groundwater beneath the site;
- control offsite migration of VOCs through soil vapor;
- mitigate potential groundwater quality impacts from the site; and
- minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards/guidance values.

These RAOs are used as the basis for identifying remedial technologies and for developing remedial action alternatives to address the constituents of interest identified in soil and groundwater at the HWD site.

The remedial performance goals for the alternatives identified in Section 4.0 that include soil removal or in-situ treatment are summarized below.

- *Excavation:* Soil would be removed from the area where VOCs have been identified at concentrations exceeding the 10 ppm NYSDEC soil guidance value for total VOCs as presented in TAGM #4046. Due to soil conditions (presence of sand and gravel materials), sheetpiling needed to support excavation sidewalls would prevent the collection of verification soil samples following excavation.
- *In-Situ Treatment (by In-Situ Soil Chemical Oxidation):* Verification soil samples would be collected following treatment (oxidant injection) events to compare VOC concentrations to the 10 ppm NYSDEC soil guidance value for total VOCs as presented in TAGM #4046. If the verification soil analytical results are not consistent with this 10 ppm performance goal, then additional treatment events would be conducted. The chemical oxidation concentrations, flow rates, delivery systems, etc., would be adjusted/modified, as appropriate, for the additional treatments. No further treatments would be made after VOC concentrations in the treatment area are generally consistent with the 10 ppm performance goal for total VOCs or if there is no discernible change in soil concentrations during repeat verification soil sampling events.

- *In-Situ Treatment (by Soil Vapor Extraction):* Field screening would be performed to evaluate the concentration of total VOCs in the extracted air conveyed to an SVE treatment system. When a point of no discernible change in VOC air concentrations is observed after an extended period of treatment (e.g., the concentration of VOCs in extracted air no longer decreases over time), then this asymptotic remedial performance result would be the remedial performance standard.

The remedial performance goal for groundwater beneath the site is to attain a 1 ppm total VOC concentration at monitoring wells MW-2 and MW-7. This 1 ppm performance goal is consistent with the remedial goal selected by the NYSDEC in the ROD for the Fairchild Republic Aircraft Main Plant Site. Based on the specific capacity testing completed as part of the additional groundwater investigation activities during April 2003, the groundwater yield at the site is considerable, and it would be technically and financially impractical in terms of constituent mass removed and associated cost to meet NYSDEC groundwater quality standards. Treating groundwater that contains greater than 1 ppm total VOCs would minimize the VOC contribution from the HWD site to groundwater.

3.4 Areas to be Addressed

The anticipated areas of soil and groundwater to be addressed in order to achieve the RAOs established for the site are summarized below.

- The area of soil to be addressed extends approximately 15 feet north, 12 feet south, 25 feet east, and 15 feet west of the reinforced concrete pad shown on Figure 4. The proposed area encompasses approximately 4,500 square feet and includes sampling locations SB-5, SB-8, SB-17, GP-1 through GP-10, and GP-15. The vertical extent of soil to be addressed in this area is in the vadose zone between approximately 6 and 13 feet bgs, depending on location and total VOC concentrations. This translates into a soil volume of approximately 1,300 cubic yards (CY).

- The area of groundwater to be addressed is approximately 100 feet wide (perpendicular to the groundwater flow direction) by 150 feet long (in the direction of groundwater flow), and extends from the northern limit of the former hazardous waste storage and treatment area (shown on Figure 4) southward to monitoring well MW-8, eastward to the fenceline on the eastern property boundary, and westward beyond monitoring well MW-2. The alternatives assume that the groundwater zone to be addressed extends from the water table (approximately 10 to 13 feet bgs) to the top of the screened interval for the deep groundwater monitoring wells (approximately 40 feet bgs), where constituents of interest have not been identified at concentrations exceeding NYSDEC groundwater quality standards.

The above-described areas are illustrated in figures that support the discussions within the detailed analysis of remedial alternatives in Section 5.0.

4. Technology Screening Summary and Development of Remedial Alternatives

4.1 General

This section of the FS Report presents the identification and screening of remedial technologies and the development of remedial alternatives for soil and groundwater. Each identified remedial technology is briefly described and evaluated against preliminary and secondary screening criteria, considering the characteristics of the HWD site. This approach is used to determine if a particular technology is appropriate for the remediation of the impacted soil and groundwater. Based on the preliminary and secondary screening, remedial technologies are eliminated or retained and subsequently combined into remedial alternatives for further evaluation in the detailed analysis of remedial alternatives presented in Section 5 of this FS Report.

4.2 Identification of Remedial Technologies

The identification of remedial technologies involved a focused review of available literature, including the following documents:

- NYSDEC TAGM #4030 titled, *Selection of Remedial Actions at Inactive Hazardous Waste Sites,* (NYSDEC, 1990);
- *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* (USEPA, 1988);
- *Presumptive Remedies: Policy and Procedures,* (USEPA, 1993a);
- *Presumptive Remedies: Site Characterization with Technology Selection of CERCLA Sites with Volatile Organic Compounds in Soils,* (USEPA, 1993b);
- *Treatment Technologies,* (USEPA, 1991);
- *Technology Screening Guide for Treatment of CERCLA Soils and Sludges,* (USEPA, 1988b);
- *Technology Briefs – Data Requirements for Selecting Remedial Action Technologies,* (USEPA, 1987); and
- *Remediation Technologies Screening Matrix and Reference Guide, Version 3* (Federal Remedial Technologies Roundtable [FRTR], 1997).

These documents, along with remedial technology vendor information and other available information, were reviewed to identify technologies that are potentially applicable for addressing VOC-impacted soil and groundwater at the site.

4.3 Technology Screening

Potentially applicable technologies and technology processes underwent preliminary and secondary screening to select the technologies that would most-effectively achieve the RAOs identified for the site. Technology refers to a general category of technologies, such as capping or immobilization, while the technology process is a specific process within each technology type. A "no-action" general response has been included and retained through the screening evaluation in accordance with 6 NYCRR Part 375, which incorporates the NCP by reference. The no-action response will serve as a baseline for comparing the potential overall effectiveness of the other technologies.

4.3.1 Preliminary Screening

The preliminary screening was performed to reduce the number of potentially applicable technologies and technology processes based on technical implementability. The results of the preliminary screening of soil and groundwater technologies/technology processes are presented in Tables 5 and 6, respectively. The technology processes are briefly described and screened in these tables.

4.3.2 Secondary Screening

A number of potentially applicable technologies and technology processes were retained through the preliminary screening for soil and groundwater. To further reduce the technology processes to be assembled into remedial alternatives, the technology processes retained through the preliminary screening were subjected to a secondary screening. The objective of the secondary screening was to choose, when possible, one representative remedial technology process for each remedial technology category to simplify the subsequent development and evaluation of the remedial alternatives. A description of the screening criteria is presented below.

- *Effectiveness* – This criterion evaluates the extent that the technology will mitigate potential threats to public health and the environment through the reduction in toxicity, mobility, and/or volume of constituents in the impacted soil and groundwater.

- *Implementability* – This criterion evaluates the ability to construct, reliably operate, and meet technical specifications or criteria associated with each technology. This evaluation also considers the operation and maintenance (O&M) required in the future, following completion of remedial construction.

The remedial technologies for soil and groundwater that were retained through secondary screening using the above-listed criteria are summarized in Tables 7 and 8, respectively, and identified below.

<u>Soil</u>

- No Action;
- Deed Restrictions;
- Asphalt/Concrete Cap;
- Soil Vapor Extraction;
- In-Situ Soil Chemical Oxidation;
- Soil Excavation;
- Offsite Incineration; and

- Offsite Disposal (RCRA Subtitle C Landfill and Subtitle D Landfill).

Groundwater

- No Action;
- Deed Restrictions/Groundwater Use Restrictions;
- Asphalt/Concrete Cap;
- In-Situ Chemical Oxidation (Focused Application);
- Monitored Natural Attenuation;
- Vertical Extraction Wells;
- Carbon Adsorption;
- Air Stripping;
- Discharge to a POTW;
- Discharge to Surface Water via Storm Sewer; and
- Reinsertion (Discharge to Groundwater).

The potential remedial technologies identified and screened above have been combined, as appropriate, to form comprehensive remedial alternatives capable of addressing the RAOs for the site. Consistent with the NCP (40 CFR Part 300.430), the following range of alternatives was developed to the extent practical:

- the no-action alternative;
- alternatives that remove constituents of interest to the maximum extent possible, thereby eliminating or minimizing the need for long-term management;
- alternatives that treat the constituents of interest but vary in the degree of treatment employed and long-term management needed; and
- alternatives that involve little or no treatment but provide protection of human health and the environment by preventing or minimizing exposure to the constituents of interest through the use of containment options and/or institutional controls.

The assembly and development of remedial activities is presented below.

4.4 Development of Remedial Alternatives

A total of five remedial alternatives have been assembled for further evaluation in the detailed analysis of remedial alternatives presented in Section 5.0. Each of the alternatives consists of one or more of the above-listed remedial technologies. The five remedial alternatives developed to address the soil and groundwater RAOs for the site are as follows:

- Alternative 1 – No-Action;
- Alternative 2 – In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation (Focused Application);
- Alternative 3 – Soil Vapor Extraction and In-Situ Groundwater Chemical Oxidation (Focused Application);

- Alternative 4 – Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment; and
- Alternative 5 – Soil Excavation and Offsite Incineration/Disposal and Groundwater Extraction/Onsite Treatment.

A brief description of each remedial alternative developed to address the soil and groundwater RAOs is presented below.

Alternative 1 – No-Action

This alternative involves no remedial actions to address impacted soil or groundwater at the site. This alternative relies on natural attenuation processes to potentially attain the RAOs.

Alternative 2 – In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation (Focused Application)

This alternative includes the same active treatment technology for both soil and groundwater (chemical oxidation). Chemical oxidation involves delivering oxidizing agents, such as potassium permanganate, hydrogen peroxide, ozone, etc., to impacted media to degrade organic constituents in the media to non-toxic byproducts. This alternative involves the construction of an oxidant delivery system, such as an infiltration gallery and groundwater injection well network, followed by oxidant application to treat VOCs in unsaturated/ saturated soil and groundwater. Components of the alternative include:

- Completing pre-design activities to further evaluate oxidant demand, potential infiltration/oxidant injection rates, and other parameters related to the design;
- Installing an oxidant delivery system. For example, an infiltration gallery consisting of parallel runs of perforated piping could be used to deliver oxidant solution to the unsaturated soil. A network of vertical injection wells at and hydraulically downgradient from the site could be used to deliver oxidant solution to groundwater;
- Injecting oxidant solution into the infiltration gallery and injection wells;
- Conducting verification sampling and analysis activities to evaluate the reduction of VOC concentrations in unsaturated soil; and
- Conducting groundwater sampling for VOCs to evaluate the reduction of VOC concentrations in groundwater.

Alternative 3 – Soil Vapor Extraction and In-Situ Groundwater Chemical Oxidation (Focused Application)

This alternative also includes active treatment remedies for both soil and groundwater. The soil remedy, in-situ SVE, is a proven technology that efficiently removes VOCs from unsaturated soil. The SVE process involves inducing a negative pressure gradient within the soil matrix through vapor extraction wells. As the induced vacuum propagates through the soil, VOCs in the soil vaporize. The VOC vapors are drawn to the extraction wells and through conveyance piping into a treatment system. Typically, the extracted vapors are treated by vapor-phase granular-activated carbon (GAC) prior to being discharged through an exhaust stack. Typical equipment used for implementation of SVE includes horizontal or vertical extraction wells, a vacuum unit (blower), a liquid/vapor separator (knock-out pot), a vapor treatment system, and system controls and instrumentation. The groundwater remedy, in-situ chemical oxidation (as discussed above) involves delivering an oxidizing agent to degrade organic constituents in the groundwater to non-toxic byproducts. Components of this alternative include:

- Completing a pilot study to further evaluate soil permeability, porosity, moisture content, and VOC mass removal rate;
- Installing vapor extraction wells, conveyance piping, and a skid-mounted treatment system at the site;
- Performing SVE system startup and operation and maintenance (O&M) activities;
- Conducting air monitoring activities to evaluate the reduction of total VOC concentrations in the influent air to the SVE system;
- Completing pre-design activities to further evaluate oxidant demand in groundwater and potential oxidant injection rates;
- Installing a network of vertical injection wells at and hydraulically downgradient from the site, and injecting oxidant into the wells; and
- Conducting groundwater sampling for VOCs to evaluate the reduction of VOC concentrations in groundwater.

Alternative 4 – Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment

This alternative includes an engineering control/containment remedy for soil and an active treatment remedy for groundwater. This alternative involves the construction of an engineered cap extending over the majority of the site, the construction/operation of a groundwater extraction and treatment system, and implementation of deed restrictions to limit future site activities. Although the existing concrete slab at the site currently isolates the underlying VOC-impacted soil from direct human contact, this surface is expected to continue to deteriorate. In addition, cracks in the slab allow precipitation to infiltrate into the underlying soil. The infiltration could result in the release of VOCs from soil to groundwater. Components of this alternative include:

- Constructing and maintaining a low-permeability engineered cap over an approximately 12,000 square foot area of the site. For purposes of this FS Report, it is assumed that the engineered cap would consist of asphalt top/base courses overlying a layer of dense-graded aggregate, a geosynthetic drainage composite, and a high-density polyethylene (HDPE) geomembrane with welded seams;
- Establishing a deed restriction to notify future property owners of the presence of VOCs in soil at the site and the need to inspect and maintain the cap over the soil, and the need for health and safety provisions/cap repairs in the event that excavation activities had to occur;
- Installing groundwater extraction wells in the shallow groundwater zone to remove groundwater containing VOCs at concentrations exceeding the remedial goal;
- Treating the groundwater onsite and subsequently discharging the treated water to the nearby POTW or storm water recharge basin. Alternatively, the treated water could potentially be re-injected into the groundwater at the site; and
- Implementing a periodic groundwater monitoring program to confirm that RAOs are being achieved.

Alternative 5 – Soil Excavation and Offsite Incineration/Disposal and Groundwater Extraction/Onsite Treatment

This alternative is presented in response to the NYSDEC's request in a November 26, 2002 letter to BBL for a conventional alternative that could meet both the NYSDEC-recommended cleanup objectives for soil and New York State water quality standards for groundwater.

- Removing the portion of the existing approximately 8-inch thick concrete slab at the site that overlies the area of soil to be excavated;
- Installing a sheetpile wall around the proposed excavation limits to stabilize excavation sidewalls (and to comply with OSHA requirements) and permit soil removal to a maximum depth of approximately 13 feet or the groundwater table (whichever is encountered first) in selected areas;
- Excavating approximately 1,300 CY of soil containing VOCs. The excavated soil would be transferred to a material staging area for characterization or would be direct-loaded for offsite transportation;
- Transporting the excavated soil offsite for incineration (if needed) and land disposal in accordance with applicable rules and regulations;
- Providing, placing, and grading a sand and gravel backfill material following completion of the excavation activities. The sheetpile wall would be removed and decontaminated in connection with the backfill placement;
- Installing groundwater extraction wells in the shallow groundwater zone to remove groundwater containing VOCs at concentrations exceeding the remedial goal;
- Treating the groundwater onsite and subsequently discharging the treated water to the nearby POTW or storm water recharge basin. Alternatively the treated water could potentially be re-injected into the groundwater at the site; and
- Implementing a periodic groundwater monitoring program to confirm that RAOs are being achieved.

5. Detailed Analysis of Remedial Alternatives

5.1 General

This section presents a detailed description and analysis of remedial alternatives developed to address VOCs in soil and groundwater related to the HWD site. The evaluation criteria used for analysis of the remedial alternatives are based on criteria specified in NYSDEC TAGM #4025, which incorporates the NCP by reference, and the USEPA guidance document titled, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988). The evaluation criteria are arranged in the order specified in NYSDEC TAGM #4030 titled *Selection of Remedial Actions at Inactive Hazardous Waste Disposal Sites* (NYSDEC, 1990). These criteria encompass statutory requirements and include other gauges of overall feasibility and acceptability of remedial options.

The detailed evaluation of each remedial alternative presented in this section consists of an assessment of the following seven criteria:

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

According to 6 NYCRR Part 375-1.109(c), another criterion to be considered when determining appropriate remedial alternatives is community acceptance. The community acceptance assessment will be completed by the NYSDEC after community comments on the PRAP are received. The results of the evaluation are typically considered when the NYSDEC selects a preferred remedial alternative and are typically presented in a Responsiveness Summary completed by the NYSDEC. The Responsiveness Summary is part of the ROD for the project and responds to all comments and questions raised during a public meeting associated with the PRAP, as well as comments received during the associated public comment period.

In addition to assessing each potential remedial alternative against the seven criteria presented above, the detailed analysis of the remedial alternatives presented in this section also includes a detailed technical description of each remedial alternative. In addition, unique engineering aspects (if any) of the physical components of the remedial alternative are discussed.

5.2 Description of Evaluation Criteria

A description of each of evaluation criterion used in this FS Report is presented below.

5.2.1 Compliance with SCGs

This criterion evaluates the compliance of the remedial alternative with appropriate SCGs. The evaluation will be based on compliance with:

- chemical-specific SCGs;
- action-specific SCGs; and
- location-specific SCGs.

5.2.2 Overall Protection of Human Health and the Environment

This criterion evaluates whether the remedial alternative provides adequate protection of human health and the environment. This evaluation relies on the assessment of other evaluation criteria, including long-term and short-term effectiveness and compliance with SCGs.

5.2.3 Short-Term Effectiveness

The short-term effectiveness of the remedial alternative is evaluated relative to its effect on human health and the environment during implementation of the alternative. The evaluation of each remedial alternative with respect to its short-term effectiveness will consider the following:

- short-term impacts to which the community may be exposed during implementation of the alternative;
- potential impacts to workers during implementation of the remedial alternative, and the effectiveness and reliability of protective measures;
- potential environmental impacts of the remedial alternative and the effectiveness of mitigative measures to be used during implementation; and
- amount of time until environmental concerns are mitigated.

5.2.4 Long-Term Effectiveness and Permanence

The evaluation of each remedial alternative relative to its long-term effectiveness and permanence is made by considering the risks that may remain following completion of the remedial alternative. The following factors will be assessed in the evaluation of the alternative's long-term effectiveness and permanence:

- potential environmental impacts from untreated waste or treatment residuals remaining at the completion of the remedial alternative;
- the adequacy and reliability of controls (if any) that will be used to manage treatment residuals or untreated waste remaining after the completion of the remedial alternative; and

- the ability of the remedial alternative to meet RAOs established for the site.

5.2.5 Reduction of Toxicity, Mobility, or Volume through Treatment

This criterion evaluates the degree to which remedial actions will permanently and significantly reduce the toxicity, mobility, or volume of the constituents present in the site media. The evaluation will be based on the:

- treatment process and the volume of materials to be treated;
- anticipated ability of the treatment process to reduce the toxicity, mobility, or volume of chemical constituents of interest;
- nature and quantity of treatment residuals that will remain after treatment;
- relative amount of hazardous substances and/or chemical constituents that will be destroyed, treated, or recycled; and
- degree to which the treatment is irreversible.

5.2.6 Implementability

This criterion evaluates the technical and administrative feasibility of implementing the remedial alternative, including the availability of the various services and materials required for implementation. The evaluation of implementability will be based on two factors, as described below.

- *Technical Feasibility* – This refers to the relative ease of implementing the remedial alternative based on site-specific constraints. In addition, the ease of construction, operational reliability, and ability to monitor the effectiveness of the remedial alternative are considered.
- *Administrative Feasibility* – This refers to the feasibility/time required to obtain necessary permits and approvals to implement the remedial alternative.

5.2.7 Cost

This criterion evaluates the estimated total cost to implement the remedial alternative. The total cost of each alternative represents the sum of the direct capital costs (materials, equipment, and labor), indirect capital costs (engineering, licenses/permits, and contingency allowances), and operation and maintenance (O&M) costs. O&M costs may include operating labor, energy, chemicals, and sampling and analysis. These costs will be estimated with an anticipated accuracy between -30% to +50% in accordance with the USEPA document titled *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988). A 25% contingency factor is included to cover unforeseen costs incurred during implementation of the remedial alternative. Present-worth costs are calculated for alternatives expected to last more than 2 years. In accordance with USEPA guidance presented in OSWER Directive 9355.3-20 as superseded by OSWER 9355.0-75, a 7% discount rate (before taxes and after inflation) is used to determine the present-worth factor.

5.3 Detailed Description and Analysis of Remedial Alternatives

This subsection presents the detailed description and analysis of each remedial alternative identified in Subsection 4.4 against the seven criteria described above in Subsection 5.2. The remedial alternatives to be evaluated include:

- Alternative 1 – No-Action;
- Alternative 2 – In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation (Focused Application);
- Alternative 3 – Soil Vapor Extraction and In-Situ Groundwater Chemical Oxidation (Focused Application);
- Alternative 4 – Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment; and
- Alternative 5 – Soil Excavation and Offsite Incineration/Disposal and Groundwater Extraction/Onsite Treatment.

The results of the detailed evaluation of remedial alternatives against the seven criteria will be used to aid in the recommendation of the appropriate alternative for implementation at the site.

5.3.1 Alternative 1 – No Action

Technical Description

The no-action alternative serves as a baseline for comparison of the overall effectiveness of the other remedial alternatives. The no-action alternative would not involve the implementation of any remedial activities to remove, treat, or contain the VOCs in soil and groundwater related to the HWD site. The alternative relies on natural attenuation processes to reduce the concentrations of VOCs in soil and groundwater. The site would be allowed to remain in its current condition, and no activities would be undertaken to change the current conditions.

Compliance with SCGs

Chemical-Specific SCGs

The Class GA groundwater quality standards presented in 6NYCRR Parts 700-705 and in the NYSDEC TOGS 1.1.1 document titled, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* (NYSDEC 2000) are applicable chemical-specific SCGs for this alternative. Because this alternative does not include any remedial actions associated with groundwater, natural attenuation processes are relied on to meet the requirement of these standards. However, this alternative does not include any monitoring to document groundwater quality and to confirm that VOCs at concentrations exceeding the NYSDEC Class GA Groundwater Quality Standards are migrating further south of the site.

Chemical-specific guidelines that are to be considered under this alternative are the soil guidance values presented in NYSDEC TAGM #4046 titled, *Determination of Soil Cleanup Objectives and Cleanup Levels* (NYSDEC, 1994). TAGM #4046 presents separate guidance values for protecting human health and groundwater quality at sites where cleanup to predisposal conditions is not practical or possible. TAGM

#4046 also presents a 10 ppm guidance value for total VOCs in soil. Natural degradation processes would not likely reduce VOC concentrations in soil at the site to below the TAGM #4046 guidance values.

The no-action alternative does not include the handling of any materials containing VOCs. Therefore, chemical-specific SCGs that regulate the subsequent management and disposal of these materials (and related residuals) are not applicable.

Action-Specific SCGs

Action-specific SCGs are not applicable because this alternative does not include any remedial actions.

Location-Specific SCGs

Location-specific SCGs are not applicable because this alternative does not include any remedial actions.

Overall Protection of Human Health and the Environment

Based on the RI results, the no-action alternative would be ineffective and would not meet the soil and groundwater RAOs for the HWD site. The alternative does not remove, treat, or contain VOCs in soil and groundwater. Although appropriate microorganisms for natural degradation of VOCs have been identified in groundwater hydraulically downgradient from the site, the historical VOC groundwater analytical data does not show an overall discernible decrease in VOC concentrations. Therefore, long-term environmental risks associated with the VOCs in groundwater would not likely be reduced under this alternative.

Short-Term Effectiveness

No remedial action would be implemented for the site. Therefore, there would be no short-term environmental impacts or risks posed to the community associated with implementation of this alternative.

Long-Term Effectiveness and Permanence

Under the no-action alternative, the VOCs identified in soil and groundwater would not be addressed. As a result, this alternative would not meet the RAOs identified for the site.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Under the no-action alternative, impacted soil and groundwater would not be removed, treated, recycled, contained, or destroyed. Therefore, the toxicity, mobility, and volume of the VOCs in the soil and groundwater would not be reduced (other than by natural passive in-situ processes).

Implementability

The no-action alternative does not involve any active remedial response and poses no technical or administrative implementability concerns.

Cost

There are no capital or O&M costs associated with implementation of the no-action alternative.

5.3.2 Alternative 2 – In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation (Focused Application)

Technical Description

In-situ chemical oxidation involves the subsurface introduction of oxidizing agents to degrade organic constituents present in soil or groundwater to less-toxic byproducts. This alternative includes the construction of an oxidant delivery system (such as an infiltration gallery and groundwater injection well network), followed by oxidant application to treat VOCs in unsaturated/saturated soil and groundwater.

Oxidant Selection

For cost estimation and remedial evaluation purposes in this FS Report, it has been assumed that potassium permanganate ($KMnO_4$) would be used as the oxidizing agent to address VOCs in soil and groundwater. Potassium permanganate has been shown effective at treating organic chemicals in laboratory, pilot, and full-scale applications in unconsolidated formations. Potassium permanganate is preferred for its relative stability, safety, ease of handling, and effectiveness over a wide range of pH. It is also more long-lived than other oxidants (persists in the subsurface for a longer period) and can be delivered over a larger area in the subsurface. Other oxidants such as hydrogen peroxide (Fenton's reagent) and ozone gas were also considered, but were not evaluated further because of a variety of concerns. Fenton's reagent is not preferred because of concerns regarding health and safety issues, chemical instability (explosion potential), limited pH applicability range (requiring acidification of the formation), substantial subsurface heat generation, and potential for pressure build-up and fugitive VOC emissions. Ozone gas was not evaluated further because of the difficulty in injecting the gas into the groundwater (ozone injection into the saturated zone involves the gas flow mechanisms of in-situ sparging). For instance, subsurface heterogeneity could lead to preferential gas flow, and ozone transport could be limited by mass transfer and aqueous-phase diffusions in areas that are water-saturated. Offgases generated from chemical oxidation via Fenton's reagent or ozone would likely need to be controlled by an SVE system.

Sodium permanganate was also considered, but was not favored because it is supplied in a highly concentrated solution (approximately 40% by weight) that would pose unnecessary health and safety concerns. Commercially-available potassium permanganate is supplied in the form of a powder that is relatively safe for handling. Potassium permanganate is generally delivered to the subsurface as a 1 to 6% solution during field applications.

Chemical Oxidation Using Permanganate

Permanganate has been used for over 50 years to oxidize organic chemicals in drinking water and wastewater treatment, including removal of iron and manganese, phenols, and more recently, chlorinated hydrocarbons related to industrial solvents (Schnarr, *et al.*, 1998; DOE, 1999). There has been considerable recent interest and use of permanganate for in-situ destruction of chlorinated solvents in the subsurface. During in-situ applications, oxidants are delivered to the subsurface to contact and react with target chemicals, which are either commonly oxidized to carbon dioxide or converted into innocuous compounds found in nature (Yin and Allen, 1999).

Potassium permanganate reacts with and oxidizes a wide range of common organic chemicals relatively quickly and completely. In particular, potassium permanganate reacts rapidly with the non-conjugated (non-aromatic) double bonds in chlorinated ethenes, such as PCE, TCE, DCE isomers, and vinyl chloride. The balanced chemical equations for potassium permanganate oxidation of PCE (C_2Cl_4) and TCE (C_2HCl_3) are as follows:

$$4KMnO_4 + 3C_2Cl_4 + 4H_2O \rightarrow 6CO_2 + 4MnO_2 + 4K^+ + 12Cl^- + 8H^+$$

$$2KMnO_4 + C_2HCl_3 \rightarrow 2CO_2 + 2MnO_2 + 2K^+ + 3Cl^- + H^+$$

Oxidation using potassium permanganate cleaves the carbon-carbon bonds of the ethenes and produces carbon dioxide, manganese dioxide solids, potassium, and chloride at non-toxic levels (DOE, 1999). Target compounds such as dissolved solvents react rapidly with permanganate. Half-lives for PCE and TCE are approximately 4.3 hours and 18 minutes, respectively, in the presence of excess permanganate ion (Yan and Schwartz, 1999).

Fate of Permanganate in the Subsurface

Permanganate would be injected into the subsurface at depths above and below the groundwater table. It is currently envisioned that subsurface delivery would be accomplished via an infiltration gallery (for soils) and vertical injection wells (for groundwater). Permaganate would be delivered in the aqueous phase (dissolved in water) and would infiltrate through the unsaturated soil and move through groundwater via advection and dispersion.

In addition to reacting with target substances such as chlorinated VOCs, potassium permanganate also reacts with a wide variety of organic and inorganic materials commonly present in the subsurface, such as:

- natural organic carbon;
- iron-bearing minerals;
- manganese-containing minerals; and
- other minerals.

Reaction with these non-target substances also consumes the oxidant. The mass of oxidant consumed per unit of geologic material is commonly expressed in terms of grams of oxidant per kilogram dry weight of soil (g/kg). Potassium permanganate consumption by target analytes follows the stoichiometry indicated in the balanced chemical equations listed above. The stoichiometric mass ratio of $KMnO_4$ to PCE is approximately 1.3:1 and the ratio of $KMnO_4$ to TCE is approximately 2.4:1. Potassium permanganate consumption in dry soil typically ranges from approximately 3 g/kg for relatively "clean" sand and gravel to 14 g/kg for clayey, organic soil and sediment.

MnO_4^- consumption by target compounds, organic carbon, and minerals follows second-order kinetics, in which the rate of a given reaction depends on the concentrations of both reactants. However, several studies have indicated that pseudo-first-order kinetics prevail for the less concentrated reactant when the other reactant is present in excess. MnO_4^- can react very quickly with organic carbon. Yan and Schwartz (1999) reported a half-life of approximately 5.5 hours for MnO_4^- consumption in the presence of excess dissolved total organic carbon. Seol, *et al.* (2000) reported half-lives ranging from 6 minutes to approximately 10 hours for MnO_4^- consumption in the presence of TCE or PCE, respectively.

Conceptual Approach for In-Situ Soil and Groundwater Chemical Oxidation

Under this alternative, pre-design activities would be performed to further evaluate oxidant demand, potential infiltration/oxidant injection rates, offgas generation, potential impacts on the biogeochemical environment, and the potential permeability reduction by manganese dioxide (MnO_2) colloids. Based on the findings of the pre-design activities, the remedial design would be prepared and implementation of in-situ oxidation would proceed on a full-scale application.

During full-scale implementation, a delivery system would be constructed to distribute oxidant solution to impacted soil and groundwater. For the purposes of cost estimating in this FS, it is assumed that the delivery system would include:

- an infiltration gallery consisting of parallel runs of perforated piping to deliver oxidant solution to the unsaturated soil. It is assumed that each run of piping would be no more than 100 feet long, and individual piping runs would be spaced evenly apart. It is also assumed that the piping would be installed just below grade; and

- a network of vertical injection wells at and hydraulically downgradient from the site to deliver oxidant solution to a focused area of the saturated zone. It is assumed that injection well clusters (two wells per cluster) would be installed within an approximately 150-foot-wide by 100-foot-long area, and clusters would be spaced routine intervals apart. As the oxidant solution is denser than groundwater, a significant depth of treatment could be realized by delivering oxidant into the upper 10 to 15 feet of the saturated zone, allowing the oxidant to descend as it migrates with groundwater flow. Delivery via wells straddling the water table would also aggressively treat the water table zone. Therefore, for cost estimating purposes, it is assumed that one of the two wells in each cluster would be screened across the groundwater table and the other well would be screened at a deeper interval.

The areas of soil and groundwater to be addressed by this alternative are shown on Figure 8. In order for in-situ chemical oxidation to be effective, it is necessary to deliver the oxidizing agents in a manner that promotes contact with the VOCs in the subsurface soil and groundwater. The radius of influence surrounding the infiltration gallery piping and individual injection wells would be evaluated during the pre-design phase. Results obtained for pre-design activities would be used to properly design the oxidant delivery parameters (e.g., oxidant concentration, injection rate, etc.) and spacing of oxidant injection locations.

At this time, for the purpose of developing a cost estimate for this alternative, it is assumed that a potassium permanganate solution would be injected into the infiltration gallery and injection wells on a quarterly basis. The number of injection events would be determined based on soil and groundwater sampling activities, as discussed further below. The oxidant would be batched from dry powder to concentrated stock solution, and subsequently mixed, diluted, filtered, and delivered to the individual injection points.

For cost estimating purposes, the total amount of oxidant needed under this alternative is assumed to be approximately 15 tons for soil treatment and 50 tons for groundwater treatment. Assuming the oxidant is delivered in a 3.5% solution, the total amount of oxidant solution would be 120,000 gallons for soil treatment and 350,000 gallons for groundwater treatment. The total amount of oxidant identified above was calculated based on the estimated total mass of VOCs in the subsurface areas to be addressed as part of the HWD site remedy and the stoichiometric relationship for the amount of oxidant required to destroy the estimated total mass of VOCs, taking into account potential oxidant demands by organic carbon and minerals. The volumes presented above are preliminary estimates only and may change based on results obtained for the pre-design activities and initial full-scale treatment. It is possible that treatment could be completed in a one year timeframe. As permanganate would likely be used as the oxidant, offgas recovery and treatment would not likely be required as part of this alternative.

Soil sampling would be conducted in connection with the soil treatment to evaluate the reduction of VOC concentrations in unsaturated soil and attainment of remedial goals. Additional injections would be performed, if needed, to treat the soil. Groundwater sampling for VOCs would be conducted prior to each injection event and approximately 6 months after the final injection event is completed to evaluate the reduction of VOC concentrations in groundwater and attainment of remedial goals. Additional injections would be performed, if needed, to treat the saturated zone. Existing groundwater use restrictions in place in Suffolk County Sanitary Code, Article 4 – Water Supply, Section 406.4, would continue to minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards.

Compliance with SCGs

Chemical-Specific SCGs

The Class GA groundwater quality standards presented in 6NYCRR Parts 700-705 and in the NYSDEC TOGS 1.1.1 document titled, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* (NYSDEC 2000) are applicable chemical-specific SCGs for this alternative. Groundwater quality would be assessed in connection with the in-situ soil and groundwater chemical oxidation treatment. In-situ groundwater chemical oxidation at other sites has been successful at reducing groundwater VOC concentrations to federal maximum contaminant levels (MCLs). It is anticipated that the concentrations of VOCs identified in groundwater at and downgradient from the HWD site would be reduced by this alternative. The ability of this alternative to result in attainment of groundwater quality standards is dependent on the amount of oxidant injected, the number of treatment applications, and the effect of other VOC sources in the vicinity of the HWD site. Groundwater monitoring would be performed to evaluate the reduction in groundwater VOC concentrations and provide data on concentration re-bounds (if any) following oxidant delivery.

Chemical-specific guidelines that are to be considered under this alternative are the soil guidance values presented in NYSDEC TAGM #4046 titled, *Determination of Soil Cleanup Objectives and Cleanup Levels* (NYSDEC, 1994).

The constituent values in TAGM #4046 are the lower of either a conservative human health risk-based value or a value calculated via soil/groundwater partitioning relationships to protect groundwater quality. Attainment of the TAGM #4046 values in soil allows for unrestricted use of a site. These guidelines, while considered, are not appropriate given the industrial/commercial zoning and use of the site and the presence of concrete/pavement materials on the ground surface. The intent of TAGM #4046 guidelines would be achieved by Alternative 2 as VOCs in soil would be chemically oxidized (lowering VOC concentrations an order of magnitude and approaching the 10 ppm total VOC cap value in TAGM #4046).

Action-Specific SCGs

Action-specific SCGs that apply to this alternative are the OSHA construction standards and health and safety requirements associated with the construction of the delivery system, handling of oxidant, and performance of onsite monitoring activities. Workers and worker activities that occur during implementation of this alternative must comply with OSHA requirements for training, safety equipment and procedures, monitoring, recordkeeping, and reporting as identified in 29 CFR Parts 1904, 1910, and 1926. Compliance with action-specific SCGs would be accomplished by following a NYSDEC-approved design and site-specific HASP.

NYSDEC Air Guide 1 will be evaluated during design to confirm that oxidation rates will not produce air emissions requiring restrictions.

Wastes generated by the installation of the infiltration gallery and injection wells (soil removed from trenching, soil cuttings, personal protective equipment [PPE], etc.) would be characterized to determine appropriate offsite disposal requirements. If any of the materials are characterized as a hazardous waste, then the RCRA, UTS/LDR, and United States Department of Transportation (USDOT) requirements for the packaging, labeling, transportation, and disposal of hazardous or regulated materials may be applicable. Compliance with these requirements would be achieved by utilizing licensed waste transporters and properly permitted disposal facilities.

Location-Specific SCGs

Remedial activities at the site would be conducted in accordance with local building/construction codes and ordinances, as appropriate.

Overall Protection of Human Health and the Environment

The in-situ soil and groundwater chemical oxidation alternative would meet the RAOs established for the site. Potential human exposure to the impacted soil and groundwater would be reduced following remedial activities, as impacted soil and groundwater would be treated in place to degrade VOCs into innocuous substances found in nature. Soil treatment activities would also address the potential migration of VOCs in onsite soil to stormwater at the site and groundwater beneath the site. Groundwater treatment activities would address potential groundwater quality impacts from the site and help control the migration of VOCs from groundwater to soil vapor. Oxidant delivered to the vadose zone soil under the in-situ soil chemical oxidation component would also react with and destroy VOCs in soil vapor, which would help control potential offsite VOC migration via soil vapor.

Existing groundwater use restrictions in place in Suffolk County Sanitary Code, Article 4 – Water Supply, Section 406.4, would continue to minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards.

Short-Term Effectiveness

As indicated above, the oxidant likely to be used under this alternative (potassium permanganate) reacts with and oxidizes PCE and TCE, the primary constituents of concern in soil and groundwater related to the HWD site, relatively quickly and completely. Reaction times for the destruction of these VOC constituents are on the order of minutes/hours. Treatment under this alternative can be completed in a relatively short timeframe without the need for significant construction activities or long-term maintenance/monitoring. Effective treatment is based on the ability to deliver the oxidant to the target constituents. A comprehensive infiltration gallery and injection well network is envisioned under this alternative to provide oxidant to the affected areas.

Under this alternative, onsite workers could be exposed to chemical constituents in soil during trenching activities to install the in-situ soil chemical oxidation infiltration gallery and during soil boring activities to install the in-situ groundwater chemical oxidation injection wells (via dermal contact, inhalation, and/or ingestion). However, this exposure would be of a relatively short duration and would be addressed via various health and safety precautions as discussed below. Onsite workers could also be exposed to potassium permanganate used for treatment. Inhalation of potassium permanganate can irritate the respiratory tract.

Potential exposure of onsite workers to chemical constituents and operational hazards would be mitigated by the use of PPE as specified in a site-specific HASP and through proper equipment and material handling procedures to be specified in the remedy design documents and site work plans. Air monitoring would be performed during implementation of this alternative to determine the need for engineering controls. Depending on the oxidant used, in-situ monitoring would be conducted during application of oxidizing agent to confirm that subsurface conditions do not become reactive or potentially explosive.

The community would not have access to the site during the remedial activities because the site is currently fenced and entry would be controlled through the main gate off Picone Boulevard. Potential risks to the community during treatment would also be mitigated by implementing an air monitoring plan and by implementing vapor control/dust control techniques to mitigate the offsite migration of unacceptable levels of VOC vapors and/or fugitive dust from the site.

Based on the remedial activities described herein, this remedial alternative may take up to 2 years to complete.

Long-Term Effectiveness and Permanence

Implementation of this alternative would be expected to permanently treat (via chemical oxidation) subsurface soil and groundwater containing VOCs. The soil and groundwater RAOs could be attained in a relatively short timeframe (e.g., as short as one year). However, additional treatment may be required to achieve the RAOs depending on the amount of oxidant consumed by natural organic material/minerals in both the unsaturated and saturated soil, and the total mass of VOCs present. Long-term operation, maintenance, and monitoring activities are not anticipated under this alternative.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Implementation of this alternative would reduce the toxicity, mobility, and volume of the VOC constituents in soil and groundwater. As indicated above, potassium permanganate reacts completely with (oxidizes) target chemicals to produce carbon dioxide and innocuous substances found in nature. This remedial alternative is an irreversible process because target VOCs would be permanently destroyed. Delivery of oxidant to the target VOCs is essential to achieve treatment goals.

Under this alternative, redox-sensitive metals (such as arsenic, chromium, and selenium) may potentially be oxidized to more mobile valence states. However, in most cases, metals naturally revert back to their reduced state after oxidation treatment is complete. In addition, post-treatment rebounds (temporary increases) in VOC concentrations may occur. Potential oxidant demands and VOC concentration rebounds would be further evaluated during pre-design activities and full-scale implementation, and oxidant concentrations/volumes would be adjusted accordingly.

Implementability

In-situ chemical oxidation has undergone extensive laboratory and pilot-scale testing and has been implemented to treat soil and groundwater at an increasing number of sites. The critical element for effectively and efficiently implementing in-situ chemical oxidation is the delivery of oxidizing agent to the impacted media/ target constituents. Regardless of the delivery system selected, it would be difficult to obtain a uniform distribution of oxidant throughout the vadose zone as the oxidant would follow preferential (permeable) pathways due to heterogeneity in the soil and gravity drainage. However, it is likely that the heterogeneity and gravity drainage would have similarly influenced the migration of VOCs released during historic site operations and the migration of VOCs in the subsurface following such a release. Pre-design activities would be completed prior to full-scale implementation of this alternative to:

- design an appropriate delivery system (currently anticipated to include an infiltration gallery for soil treatment and injection wells for groundwater treatment);
- identify the oxidant (potassium permanganate) concentration, injection rates, and duration/number of applications needed;

- determine the need for offgas recovery/treatment; and
- evaluate the potential significance of precipitate build-up (if any) from the treatment process.

The equipment and materials necessary to implement this alternative are available, as are several capable remedial contractors. Installation of a typical delivery system consisting of an infiltration gallery and injection wells is technically feasible. Potassium permanganate could be readily batched from dry powder to concentrated stock solution, and subsequently mixed, diluted, filtered, and delivered at accurate concentrations and flow rates to the individual injection points. A monitoring program would be developed to evaluate the effectiveness of the alternative.

Implementation of chemical oxidation for in-situ treatment of both soil and groundwater under this alternative provides an economy of scale in that one treatment technology addresses the two impacted media. For instance, excess oxidant delivered to treat the unsaturated overburden soil would migrate to groundwater and further degrade VOCs in groundwater. Implementation of this alternative would not result in large volumes of waste to be treated/disposed.

The timeframe associated with successful implementation of this remedial alternative is anticipated to range from one to two years (excluding pre-design activities and commencing with field construction). Long-term operation and maintenance activities would not be required. It is anticipated that treatment could be completed with a moderate disruption to current site activities.

Cost

The estimated cost associated with the in-situ soil chemical oxidation and in-situ groundwater chemical oxidation (focused application) alternative is $1,480,000. A detailed breakdown of the estimated cost associated with this alternative is presented in Table 9.

5.3.3 Alternative 3 – Soil Vapor Extraction and In-Situ Groundwater Chemical Oxidation (Focused Application)

Technical Description

This alternative involves the construction/operation of an SVE system to facilitate the removal and subsequent treatment of VOCs in soil, and the installation of an injection well network to inject oxidant into the saturated zone to facilitate in-situ treatment of VOCs in groundwater. As discussed above under Alternative 2, in-situ groundwater chemical oxidation involves delivering an oxidizing agent to degrade organic constituents in groundwater to non-toxic byproducts. SVE is a proven technology that has been successfully applied for VOC removal at numerous sites over a wide range of geologic and hydrogeologic conditions. The remainder of this technology description focuses on the soil remediation component of Alternative 3 – SVE. A summary of the groundwater remedial component (in-situ groundwater chemical oxidation) is also provided below, which references the detailed technical description and evaluation for chemical oxidation of VOCs in groundwater under Alternative 2.

As discussed in Subsection 4.4, the SVE process involves inducing a negative pressure gradient within the soil matrix through vapor extraction wells. As the induced vacuum propagates through the soil, VOCs in the soil vaporize. The VOC vapors are drawn to the extraction wells and through conveyance piping into a treatment system. Typically, the extracted vapors are treated by vapor-phase GAC prior to being discharged through an exhaust stack. Typical equipment used for implementation of SVE includes horizontal or vertical extraction wells, a vacuum unit (blower), a liquid/vapor separator (knock-out pot), a vapor treatment system, and system controls and instrumentation.

In order for SVE to be an effective remedial technology, design of the SVE system must take into consideration a number of parameters, including soil permeability, porosity, moisture content, stratigraphy, depth to groundwater, and chemical properties of the VOCs. The soil must have a sufficient air-filled porosity to allow the SVE system to strip the VOCs from the soil matrix. The soil type at the HWD site (sand/gravel extending to the water table) has sufficient air-filled porosity to allow the SVE system to strip the VOCs from the soil matrix. PCE and TCE, the primary constituents of concern in soil at the HWD site, are well-suited to SVE because of their high Henry's law constants (which means that these constituents can readily to partition to the atmosphere). These constituents have been successfully extracted via SVE at numerous sites.

Prior to designing the SVE system for this alternative, a pilot study would be performed to further evaluate soil permeability, porosity, moisture content, and VOC mass removal rate. Based on the results of the pilot study, the total number of extraction wells, spacing between wells, desired air flow rate, and treatment system specifications would be determined. The area of soil to be treated by SVE is shown on Figure 9. For purposes of cost estimating in this FS, it is assumed that six vertical SVE wells would be installed under this alternative. It is assumed that each well would have a radius of influence of greater than 20 feet with an induced vacuum of approximately 20-inches water column. Vapors extracted from the wells would be conveyed to an onsite treatment system through buried or aboveground piping. It is assumed that the treatment system would be constructed in the southwestern portion of the site and would consist of the following primary components:

- a blower to move an assumed 750 cubic feet per minute (CFM) of air. The air flow rate would be evaluated during design based on results of the pilot testing; and
- vapor-phase GAC filters/vessels equipped with piping/hoses.

Adjustments to the air flow rate from the individual extraction wells and troubleshooting (as needed) would be performed during treatment system startup. It is assumed that O&M activities would consist of routine site visits to inspect the treatment system components, evaluate the system performance (conduct field screening/ sampling for VOCs), and make necessary adjustments. The vapor-phase GAC would be changed out, as needed. The spent carbon would be transported for offsite regeneration (so that the VOCs adsorbed onto the carbon could be destroyed and the carbon could be reused) or for offsite incineration/disposal. It is also assumed that the air discharge from the SVE system would require a NYSDEC-issued air discharge permit (compliance with the substantive requirements of the permit). Once VOC concentrations in the extracted air are below NYSDEC allowable criteria (to be specified in the ROD), the GAC filters could be removed. Once the SVE system has treated soils to the remedial performance goal that would be determined during design (e.g., an asymptotic curve is reached and the concentration of VOCs in the extracted air stream does not appreciably diminish over time), the SVE system would be decommissioned. Based on the sand/gravel soil type, VOC concentrations identified in the RI soil samples, and anticipated air flow rate, it is assumed for purposes of this FS that the soil remedial goals could be attained in a five year timeframe and the treatment system would be decommissioned after five years of operation.

Prior to preparing the design for the in-situ groundwater chemical oxidation component of this alternative, pre-design activities would be performed as described under Alternative 2 – In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation (Focused Application).

The remedial component for groundwater under Alternative 3 is the same as Alternative 2. As described under Alternative 2, it is assumed that a network of vertical injection wells would be installed at and hydraulically downgradient from the HWD site to deliver oxidant solution to a focused area of the saturated zone. Injection well clusters (two wells per cluster) would be installed within the approximately 150-foot-wide by 100-foot-long area shown on Figure 9. Well clusters would be spaced routine intervals apart. One of the two wells in each cluster would be screened across the groundwater table and the other well would be screened at a deeper interval.

At this time, for the purpose of developing a cost estimate for this alternative, it assumed that a potassium permanganate solution would be delivered to the injection wells on a quarterly basis. The number of injection events would be determined based on groundwater sampling activities, as discussed further below. The oxidant would be batched from dry powder to concentrated stock solution, and subsequently mixed, diluted, filtered, and delivered to the individual injection points. For cost estimating purposes, it is assumed that approximately 350,000 gallons of oxidant solution (50 tons of potassium permanganate) would potentially be used for groundwater treatment. The amount of oxidant to be used and number of injection events are preliminary estimates only and may change based on results obtained for pre-design activities and initial full-scale treatment.

Groundwater sampling for VOCs would be conducted prior to each injection event and approximately 6 months after the final injection event is completed to evaluate the reduction of VOC concentrations in groundwater and attainment of remedial goals. Additional injections would be performed, if needed, to treat the saturated zone. Existing groundwater use restrictions in place in Suffolk County Sanitary Code, Article 4 – Water Supply, Section 406.4, would continue to minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards.

Under this alternative, the groundwater remedial goals could potentially be achieved within a one year timeframe following the start of groundwater treatment. As indicated above, the soil remedial goals could potentially be achieved in a five year timeframe. Based on the longer timeframe anticipated for soil treatment and the potential for constituents in soil to migrate to groundwater until the soil remedial goals are achieved, groundwater treatment would begin following completion of soil treatment. This approach would mitigate potential groundwater quality impacts that might otherwise occur if groundwater treatment were to be completed in advance of the soil treatment.

Compliance with SCGs

Chemical-Specific SCGs

The Class GA groundwater quality standards presented in 6NYCRR Parts 700-705 and in the NYSDEC TOGS 1.1.1 document titled, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* (NYSDEC 2000) are applicable chemical-specific SCGs for this alternative. Groundwater quality would be assessed in connection with the groundwater chemical oxidation treatment. In-situ groundwater chemical oxidation at other sites has been successful at reducing groundwater VOC concentrations to federal MCLs. It is anticipated that the concentrations of VOCs identified in groundwater at and downgradient from the HWD site would be reduced by this alternative. The ability of this alternative to result in attainment of groundwater quality standards is dependent on the amount of oxidant injected, number of treatment applications, and the effect of other VOC sources in the vicinity of the HWD site. Groundwater monitoring would be performed to evaluate the reduction in groundwater VOC concentrations and provide data on concentration re-bounds (if any) following oxidant delivery.

Another chemical-specific SCG that may apply to this alternative is related to air discharges from the SVE system. It is assumed that the air discharge from the SVE system would require a NYSDEC-issued air discharge permit (compliance with the substantive requirements of the permit).

Chemical-specific guidelines that are to be considered under this alternative are the soil guidance values presented in NYSDEC TAGM #4046 titled, *Determination of Soil Cleanup Objectives and Cleanup Levels* (NYSDEC, 1994). The intent of TAGM #4046 guidelines would be achieved by Alternative 3 as VOCs would be removed from the soil (lowering VOC concentrations an order of magnitude and approaching the 10 ppm total VOC cap value in TAGM #4046).

Action-Specific SCGs

Action-specific SCGs that apply to this alternative are the OSHA construction standards and health and safety requirements associated with the installation of the vapor extraction wells and conveyance piping, construction of the SVE treatment system, installation of the chemical oxidation injection wells, handling of oxidant, and performance of monitoring activities. Workers and worker activities that occur during implementation of this alternative must comply with OSHA requirements for training, safety equipment and procedures, monitoring, recordkeeping, and reporting as identified in 29 CFR Parts 1904, 1910, and 1926. Compliance with action-specific SCGs would be accomplished by following a NYSDEC-approved design and site-specific HASP.

Operation of the SVE system would result in the generation of air emissions. NYSDEC Air Guide 1, which incorporates by reference applicable federal and New York State regulations and requirements pertaining to air emissions, is an action-specific SCG for the SVE system. Vapor phase GAC would be provided, as needed, to treat air emissions in a manner that would not exceed allowable discharge limits and would comply with state and federal air emission requirements.

Wastes generated during the implementation of this alternative (soil cuttings generated by installation of the SVE wells and injection wells, soil removed during trenching to install the SVE conveyance piping, activated carbon used in the SVE system, PPE, etc.) would be characterized to determine appropriate offsite recycling/ disposal requirements. If any of the materials are characterized as a hazardous waste, then the RCRA, UTS/LDR, and USDOT requirements for the packaging, labeling, transportation, and disposal of hazardous or regulated materials may be applicable. Compliance with these requirements would be achieved by utilizing licensed waste transporters and properly permitted disposal facilities.

Location-Specific SCGs

Remedial activities at the site would be conducted in accordance with local building/construction codes and ordinances, as appropriate.

Overall Protection of Human Health and the Environment

The SVE and in-situ groundwater chemical oxidation alternative would meet the RAOs established for the site. The potential for unacceptable human exposure to site soil and groundwater would be reduced following remedial activities, as impacted soil and groundwater would be treated to remove VOCs. The SVE system operation would address the potential migration of VOCs in onsite soil to stormwater at the site and groundwater beneath the site by reducing the mass of VOCs in the soil. Groundwater treatment activities would address potential groundwater quality impacts from the site and help control the migration of VOCs from groundwater to soil vapor. The vacuum induced by the SVE system would create an induced soil vapor "zone" that would control soil vapor migration and reduce soil vapor concentrations toward neighboring properties before completion of SVE treatment. Existing groundwater use restrictions in place in Suffolk County Sanitary Code, Article 4 – Water Supply, Section 406.4, would continue to minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards.

Short-Term Effectiveness

The SVE system would result in a rapid decrease in VOC concentrations in soil following system startup. However, the rate of the decrease would likely become slower over time with continued operation of the SVE system. The decrease in VOC soil concentrations would coincide with the decrease in total VOC concentrations monitored in the influent air stream to the SVE treatment equipment, which would eventually reach an asymptotic level.

As previously discussed, the oxidant likely to be used for the groundwater treatment component of this alternative (potassium permanganate) reacts with and oxidizes PCE and TCE, the primary constituents of concern, relatively quickly and completely. Reaction times for the destruction of these VOC constituents are on the order of minutes/hours. Groundwater treatment under this alternative could be completed in a relatively short timeframe without the need for significant construction activities or long-term maintenance/monitoring. Effective treatment is based on the ability to deliver the oxidant to the target constituents. A comprehensive injection well network is envisioned under this alternative to provide oxidant to the affected areas. As discussed above, groundwater treatment would begin after the remedial performance goals for soil are achieved.

Under this alternative, onsite workers could be exposed to chemical constituents in soil during the soil boring/trenching activities to install the SVE wells, conveyance piping, and groundwater injection wells. Exposure routes would include dermal contact, inhalation, and/or ingestion. However, the exposure would be of a relatively short duration and would be addressed via various health and safety precautions as discussed below. Onsite workers could also be exposed to potassium permanganate used for treatment. Inhalation of potassium permanganate can irritate the respiratory tract.

Potential exposure of onsite workers to chemical constituents and operational hazards would be mitigated by the use of PPE as specified in a site-specific HASP and through proper equipment and material handling procedures to be specified in the remedy design documents and site work plans. Air monitoring would be performed during soil boring/trenching activities to determine the need for additional engineering controls (e.g., using water sprays to suppress dust, modifying the trenching rate, etc.) to confirm that dust or VOC vapors are within acceptable levels, as specified in the site-specific HASP.

The community would not have access to the site during the remedial activities because the site is currently fenced and entry would be controlled through the main gate off Picone Boulevard. Potential risks to the community during treatment would also be mitigated by implementing an air monitoring plan and by implementing vapor control/dust control techniques to mitigate the offsite migration of unacceptable levels of VOC vapors and/or fugitive dust from the site.

Based on the remedial activities described above, this remedial alternative may take up to seven years to complete.

Long-Term Effectiveness and Permanence

Implementation of this alternative would permanently treat subsurface soil and groundwater containing VOCs. The soil and groundwater RAOs could potentially be attained in a relatively short timeframe following commencement of remedial construction (e.g., five years for soil, and then under two years for groundwater). However, additional treatment could be required to achieve the groundwater RAOs depending on the amount of oxidant consumed by natural organic material and minerals in the saturated soil and total mass of VOCs present. Operation, maintenance, and monitoring activities related to the SVE system would continue until the remedial goals are attained. Operation of the SVE system would generate additional noise at the nearby properties even if the system were to be equipped with sound abatement devices.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Implementation of this alternative would reduce the toxicity, mobility, and volume of the VOC constituents in soil and groundwater. VOCs would be extracted from soil and treated through vapor-phase GAC. VOCs adsorbed by the vapor-phase GAC would be destroyed during regeneration or incineration of the spent carbon. The migration of VOCs through soil vapor would be controlled via the vacuum induced by the SVE system. VOCs in groundwater would react with potassium permanganate and be permanently destroyed via chemical oxidation. This remedial alternative consists of an irreversible process as target VOCs in soil would be permanently removed/destroyed and target VOCs in groundwater would be permanently destroyed.

Under this alternative, redox-sensitive metals in groundwater (such as arsenic, chromium, and selenium) may potentially be oxidized to more mobile valence states. However, in most cases, metals naturally revert back to their reduced state after oxidation treatment is complete. In addition, post-treatment rebounds (temporary increases) in VOC concentrations may occur. Potential oxidant demands and VOC concentration rebounds would be further evaluated during pre-design activities and full-scale implementation, and oxidant concentrations/volumes would be adjusted accordingly.

Implementability

SVE is a proven technology that has been successfully implemented at numerous sites for VOC removal and could easily be implemented at the HWD site. SVE is technically feasible and could be completed over a relatively short period.

In-situ chemical oxidation has undergone extensive laboratory and pilot-scale testing and has been implemented to treat groundwater at an increasing number of sites. The critical element for effectively and efficiently implementing in-situ chemical oxidation is the delivery of oxidizing agent to the impacted media/target constituents. Oxidant delivery methods would be evaluated during bench-scale and pilot testing prior to design/ full-scale implementation.

The equipment and materials necessary to implement this alternative are available, as are several capable remedial contractors. Installation of an SVE system and typical in-situ groundwater chemical oxidation delivery system (injection wells) is technically feasible. Potassium permanganate used for in-situ groundwater chemical oxidation could easily be batched from dry powder to concentrated stock solution, and subsequently mixed, diluted, filtered, and delivered at accurate concentrations and flow rates to the individual injection points. A monitoring program would be developed to evaluate the effectiveness of the alternative. Implementation of this alternative would not result in large volumes of waste to be treated/disposed.

The timeframe associated with successful implementation of this remedial alternative is anticipated to be approximately six to seven years (excluding pre-design activities and commencing with field construction). It is anticipated that treatment could be completed with a moderate disruption to current site activities.

Cost

The estimated cost associated with the SVE and in-situ groundwater chemical oxidation (focused application) alternative is $1,730,000. A detailed breakdown of the estimated cost associated with this alternative is presented in Table 10.

5.3.4 Alternative 4 – Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment

Technical Description

This alternative includes the construction of an engineered cap extending over the majority of the site, construction/operation of a groundwater extraction and onsite treatment system, and implementation of deed restrictions. It is assumed that the engineered cap would be installed over an approximately 12,000 square foot area of the site, and would extend beyond the locations where VOCs were identified in soil at concentrations exceeding the 10 ppm NYSDEC soil guidance value for total VOCs as presented in TAGM #4046. Potential horizontal limits of the engineered cap are shown on Figure 10.

The cap would be constructed directly over the existing concrete slab/asphalt pavement materials. For purposes of this FS Report, it is assumed that the cap would consist of a bituminous asphalt top (wearing) and base courses overlying a layer of dense-graded aggregate (interlocking stone), a geosynthetic drainage composite, a high-density polyethylene (HDPE) geomembrane with welded seams, and a non-woven geotextile. The geosynthetic drainage composite would be installed to convey water that seeps through the upper cap layers (bituminous asphalt top/base course material) away from the capped area. The HDPE liner would serve as a low-permeability barrier to minimize infiltration of water into the subsurface. The non-woven geotextile would provide a barrier between the existing concrete slab and the geomembrane to protect the geomembrane from puncture. A deed restriction would be established to notify future property owners of the presence of VOCs in soil at the site, the need to inspect and maintain the cap over the soil, and the need for health and safety provisions/cap repair in the event that excavation activities had to occur. Maintenance activities would be performed, as needed, and would consist of sealing and/or patching cracked areas of the cap, if present.

Under this alternative, groundwater extraction wells would be installed hydraulically downgradient from the site to capture the groundwater plume with total VOC concentrations exceeding 1 ppm for treatment. The actual locations and number of wells would be determined based on existing information and results of a pumping test conducted during a pre-design phase. The purpose of the pumping test would be to provide the necessary information to facilitate modeling of the capture zone created by pumping groundwater from the extraction wells and for estimating pumping rates. For cost estimation and remedial evaluation purposes in this FS Report, it is assumed that a total of three extraction wells would be installed (locations are shown on Figure 10) and the combined pumping rate from the wells would be 75 gpm. The pumping rates would be altered (as appropriate) during the design, construction, or operation of the groundwater withdrawal system to meet the RAOs in an efficient manner. It is assumed that each extraction well would be constructed using 6-inch diameter steel piping and would extend to a depth of approximately 40 feet below the ground surface.

Groundwater withdrawn from the extraction wells would be treated in an onsite water treatment system. The design of the system is dependent on the groundwater extraction rate and concentrations of VOCs in the extracted groundwater, which would be evaluated and determined during the pumping test (during remedial design). For the purposes of cost estimating in this FS, it is assumed that the groundwater treatment system would consist of the following components installed in a pre-engineered building enclosure:

- a polyethylene tank for flow equalization prior to treatment;
- two multi-media (sand) filters piped in parallel to filter particulates;
- a low-profile air stripper designed to treat the identified groundwater VOC concentrations at a flow rate of 75 gpm;
- a catalytic oxidizer to treat the exhaust from the air stripper to meet NYSDEC air discharge requirements; and
- two carbon vessels piped in parallel to serve as polishing units to treat VOCs unable to be treated by the air stripper in order to meet site-specific discharge requirements.

The treated water would be discharged either to the nearby POTW (via the sanitary sewer system) or the recharge basin northeast of the site (via storm sewer piping) or it would be re-injected into groundwater. Discharge to the POTW would require a POTW-issued discharge permit, while discharge to the recharge basin or re-injection to groundwater would require a NYSDEC-issued SPDES permit (compliance with the substantive requirements of the permit). Selection of the discharge location for the treated groundwater is primarily dependent upon the discharge flow rate and the ability of the existing storm/sanitary sewers to accommodate additional flow. For purposes of the FS, it is assumed that the water would be discharged to the POTW.

Water samples would be collected/analyzed as appropriate (e.g., weekly) during operation of the treatment system to evaluate system performance and compliance with discharge limits. Groundwater samples would be collected from the existing site monitoring well network on an annual basis to evaluate the potential reduction of VOC concentrations in groundwater.

Based on the limited space available at the site, the groundwater component of the remedial alternative would not be constructed until after the new engineered cap is in place (unless the groundwater treatment system could be constructed on vacant land south of the site). Construction of the engineered cap would require approximately 1 month to complete. Although the duration of the groundwater extraction/onsite treatment component cannot be accurately predicted, it is expected to take an extended period of time. For cost estimating purposes, a duration of 30 years for this alternative is assumed. The present worth of remedial actions further than 30 years into the future does not significantly affect the total present worth (this is consistent with the NYSDEC and NCP guidance).

Compliance with SCGs

Chemical-Specific SCGs

The Class GA groundwater quality standards presented in 6NYCRR Parts 700-705 and in the NYSDEC TOGS 1.1.1 document titled, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* (NYSDEC 2000) are applicable chemical-specific SCGs for this alternative. The groundwater extraction and onsite treatment system would hydraulically control VOCs in groundwater and reduce groundwater VOC concentrations over time. The low-permeability cap would minimize infiltration and mitigate the future migration of VOCs from soil to groundwater. Groundwater quality standards could potentially be achieved after a significant amount of groundwater has been extracted and treated over a period of many years.

Chemical-specific guidelines that are to be considered under this alternative are the soil guidance values presented in NYSDEC TAGM #4046 titled, *Determination of Soil Cleanup Objectives and Cleanup Levels* (NYSDEC, 1994). The VOC concentrations in soil would not be reduced by this alternative.

Action-Specific SCGs

Action-specific SCGs that apply to this alternative are the OSHA construction standards and health and safety requirements associated with the construction of the new engineered cap and groundwater treatment system, installation of the groundwater pumping wells and conveyance piping, and performance of onsite monitoring activities. Workers and worker activities that occur during implementation of this alternative must comply with OSHA requirements for training, safety equipment and procedures, monitoring, recordkeeping, and reporting as identified in 29 CFR Parts 1904, 1910, and 1926. Compliance with action-specific SCGs would be accomplished by following a NYSDEC-approved design and site-specific HASP.

Another action-specific SCG that would apply to this alternative is associated with re-injecting or discharging treated groundwater to the POTW or recharge basin. A discharge permit would need to be obtained from the local POTW and the treated water would need to meet influent requirements. If the treated groundwater were to be discharged to the recharge basin or re-injected, the discharge/re-injection would be conducted in compliance with SPDES requirements.

For the purpose of this FS, it is assumed that an air stripper would be used to treat the extracted groundwater. NYSDEC Air Guide 1, which incorporates by reference applicable federal and New York State regulations and requirements pertaining to air emissions, is an action-specific SCG for emissions from the air stripper. If needed, a catalytic oxidizer or vapor phase carbon would be used to treat the exhaust from the air stripper to meet NYSDEC air discharge requirements and comply with federal emission requirements.

Wastes generated during the implementation of this alternative (soil cuttings generated by installation of the pumping wells, soil removed during trenching to install the conveyance piping, PPE, etc.) would be characterized to determine appropriate offsite disposal requirements. If any of the materials are characterized as a hazardous waste, then the RCRA, UTS/LDR, and USDOT requirements for the packaging, labeling, transportation, and disposal of hazardous or regulated materials may be applicable. Compliance with these requirements would be achieved by utilizing licensed waste transporters and properly permitted disposal facilities.

Location-Specific SCGs

Remedial activities at the site would be conducted in accordance with local building/construction codes and ordinances, as appropriate.

Overall Protection of Human Health and the Environment

The asphalt cap/institutional controls and groundwater extraction/onsite treatment alternative would meet all but one of the RAOs for the site, as summarized herein. Potential human exposure to soil containing VOCs, which is currently minimal because the existing concrete slab physically isolates the soil from direct contact, would also be mitigated by the new cap. The deed restriction would further address the potential human exposure pathway by notifying future site owners of the presence of VOCs in the soil and the need to maintain the cap. The low-permeability materials used to construct the cap would address the potential migration of VOCs in onsite soil to stormwater at the site and groundwater beneath the site (cracks in the existing concrete slab allow precipitation to infiltrate the subsurface). The groundwater extraction and onsite treatment activities would address potential groundwater quality impacts from the site and help control the migration of VOCs from groundwater to soil vapor. However, this alternative would do little to address the offsite migration of VOCs in soil vapor originating from onsite soil.

Existing groundwater use restrictions in place in Suffolk County Sanitary Code, Article 4 – Water Supply, Section 406.4, would continue to minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards.

Short-Term Effectiveness

Hydraulic control of the VOCs in groundwater (at concentrations exceeding the remedial goal) would be attained in a relatively short timeframe. However, groundwater treatment under this alternative would take an extended period of time.

Potential short-term risks to public health and the environment are associated with air emissions from the groundwater treatment system. An analysis of potential air quality impacts from the air stripper is required and, if necessary, offgas treatment would be installed for compliance with air emissions standards.

Under this alternative, onsite workers could be exposed to chemical constituents in soil during the soil boring activities to install the pumping wells, trenching to install the conveyance piping, and surface disturbance activities in preparation for the cap construction. Exposure routes could include dermal contact, inhalation, and/or ingestion. However, the exposure would be of a relatively short duration and would be addressed via various health and safety precautions as discussed below.

Potential exposure of onsite workers to chemical constituents and operational hazards would be mitigated by the use of PPE as specified in a site-specific HASP and through proper equipment and material handling procedures to be specified in the remedy design documents and site work plans. Air monitoring would be performed during soil boring/trenching activities and during site preparation for the cap installation to determine the need for additional engineering controls (e.g., using water sprays to suppress dust, modifying the trenching rate, etc.) to confirm that dust or VOC vapors are within acceptable levels, as specified in the site-specific HASP.

The community would not have access to the site during the installation of the asphalt cap because the site is currently fenced and entry would be controlled through the main gate off Picone Boulevard. Potential risks to the community during excavation/trenching activities would also be mitigated by implementing an air monitoring plan and by implementing vapor control/dust control techniques to mitigate the offsite migration of unacceptable levels of VOC vapors and/or fugitive dust from the site.

Long-Term Effectiveness and Permanence

A maintained cap would effectively isolate the subsurface soil containing VOCs over the long term. Unlike the existing concrete slab, the new cap would minimize the potential migration of VOCs in onsite soil to stormwater at the site and groundwater beneath the site. Under this alternative, VOCs would remain in the onsite soil and could potentially generate vapors that migrate offsite.

The groundwater extraction and onsite treatment system would be effective over the long term as the system would be maintained in operation. The system would likely operate for as long as site-related VOCs remain in groundwater at concentrations exceeding the remedial goals. Annual operation, maintenance, and monitoring activities related to the groundwater treatment system would continue until the groundwater remedial goals are attained.

Reduction of Toxicity, Mobility, and Volume Through Treatment

Implementation of this alternative would not reduce the toxicity or volume of the VOC constituents in onsite soil. However, the mobility of VOCs in onsite soil would be reduced because the low-permeability materials of the cap would be a barrier to infiltration.

The mobility of VOCs in groundwater would be limited by the measure of hydraulic control achieved by the groundwater extraction system. VOC concentrations in groundwater would decrease over time by the continued operation of the groundwater extraction and onsite treatment system. VOCs in the extracted groundwater would be removed/destroyed by the groundwater treatment system equipment (e.g., air stripper and catalytic oxidizer). The groundwater treatment approach is an irreversible process as VOCs in groundwater would be permanently removed.

Implementability

Construction of an asphalt cap/institutional controls and groundwater extraction/treatment are technically feasible. The equipment and materials necessary to implement this alternative are available, as are several capable remedial contractors. A monitoring program would be developed to evaluate the effectiveness of the alternative. Implementation of this alternative would result in significant volumes of groundwater to be treated and discharged.

Groundwater extraction and onsite treatment could be effectively implemented at this site to remove VOCs from groundwater and provide hydraulic control of the groundwater VOC plume. Approval for discharge to the POTW would need to be obtained to confirm that the POTW would accept the treated water. An evaluation would also be needed to determine whether the sanitary sewer system could accommodate the additional flow from the onsite treatment system. In the event that discharge to the POTW is not feasible, treated groundwater could be discharged to the onsite storm sewer system (which conveys flow to the recharge basin) in accordance with SPDES requirements. Based on the location of the recharge basin, flow conveyed to the recharge basin may potentially facilitate hydraulic control of the groundwater plume of VOCs.

Treatability and pilot studies may be required to confirm that the water treatment system would meet necessary effluent requirements to satisfy POTW and/or SPDES requirements. In addition, pump tests and groundwater modeling would likely be required to confirm the groundwater extraction rates necessary to achieve hydraulic control.

The time associated with construction of the asphalt cap and the groundwater extraction/onsite treatment system would be approximately 4 to 5 months (excluding pilot and treatability studies), and the long-term O&M of the groundwater treatment system could last for an extended period of time.

Cost

The 30-year present worth estimated cost associated with the asphalt cap/institutional controls and groundwater extraction/onsite treatment alternative is $4,420,000. A detailed breakdown of the estimated cost associated with this alternative is presented in Table 11.

5.3.5 Alternative 5 – Soil Excavation and Offsite Incineration/Disposal and Groundwater Extraction/Onsite Treatment

<u>Technical Description</u>

This alternative includes the excavation of impacted soil at the HWD site, offsite transportation of the soil for incineration/disposal, and construction/operation of a groundwater extraction and onsite treatment system. Approximately 1,300 CY of unsaturated soil would be excavated from an approximately 4,500 square foot area at the HWD site. The excavation would extend to depths of between approximately 6 feet and up to 13 feet bgs, and would be discontinued prior to reaching the groundwater table. The approximate horizontal and vertical limits of the proposed excavation area are shown on Figure 11.

Based on the anticipated excavation depths, it is assumed that sheetpiling would be installed around the perimeter of the excavation area to support the excavation sidewalls. The sheetpile system would be designed by a Professional Engineer in the State of New York in accordance with the OSHA regulations set forth in 29 CFR Part 1926. For the purpose of cost estimating in this FS, it is assumed that the sheetpile wall would be approximately 300 feet long and would extend to a depth of approximately 40 feet below grade. Excavation sidewall benching, sloping, and/or shoring would be performed within the excavation area, as needed, to stabilize sidewalls between sub-areas where different removal depths are required. Excavation sidewall benching/sloping was considered around the excavation perimeter, but was not evaluated due to the limited space available at the site, the depth of excavation required (and subsequently the amount of lateral space needed), and the existing soil conditions (e.g., sand and gravel). The proposed sheetpile wall would be installed following the removal of concrete pavement covering the proposed excavation area.

The existing concrete pavement covering the excavation area and proposed sheetpile wall locations would be broken up using an excavator equipped with a hydraulic ram-hoe attachment and removed. Based on the anticipated limits of the excavation area and an average concrete thickness of 8-inches, an estimated 100 CY of concrete debris would be generated for disposal.

After the concrete pavement is removed and sheetpiling is installed, excavation activities would be performed. Excavation of impacted soil would generally be conducted using conventional construction equipment, such as excavators, front-end loaders, dump trucks, etc. The excavated soil would be stockpiled in lined material staging areas for waste characterization purposes and/or direct-loaded for offsite disposal. The handling approach would be determined remedial design based on results obtained for pre-excavation in-situ waste characterization sampling conducted during the test boring program. If a stockpiling approach is selected, soil would likely be placed in separate stockpiles for every 200 to 300 CY. Waste characterization samples would be collected from each stockpile to minimize the amount of soil potentially characterized as a hazardous waste requiring incineration. For cost estimation and remedial evaluation purposes in this FS Report, it is assumed that approximately:

- 350 tons of soil would be characterized as a nonhazardous waste and transported to the Waste Management (WM) High Acres Subtitle D landfill located in Fairport, New York for disposal as a nonhazardous waste;

- 900 tons of soil would be characterized as a RCRA hazardous waste that meets UTS/LDRs (>0.7 ppm PCE concentration in TCLP extract and <60 ppm total PCE concentration) and transported to the CWM Chemical Services LLC Subtitle C Landfill in Model, City New York for offsite disposal; and

- 900 tons of soil would be characterized as a RCRA hazardous waste that fails UTS/LDRs (>0.7 ppm PCE concentration in TCLP extract and >60 ppm total PCE concentration) and transported to the Von Roll incineration facility in East Liverpool, Ohio for offsite incineration/disposal.

Airborne monitoring for VOCs and particulate (dust) would be conducted during the excavation activities in accordance with the NYSDOH's Community Air Monitoring Program, dated June 2000. Based on the PCE concentrations identified in the RI soil samples (85 ppm average and 440 ppm maximum), engineering controls may be required to control VOC emissions during excavation activities to prevent the public from being exposed to VOC vapors at concentrations exceeding applicable criteria. For the purpose of this FS, it is assumed that a water-based vapor suppressant foam would be sprayed over the excavation area and soil stockpiles to control odors/reduce VOC emissions during excavation/handling activities. It is assumed that it would not be necessary to install a sprung structure under negative air pressure with vapor phase GAC for air emissions treatment. The potential need for a sprung structure would be evaluated during remedial design.

Depending on the final limits selected for the excavation area during design, it may be necessary to remove a portion of the existing onsite storm sewer system. Costs for the removal and replacement of two storm water catch basins and up to 75 feet of storm sewer piping are included in the cost estimate under this alternative.

Following completion of the excavation activities, the site would be restored by backfilling the excavation area with imported clean fill material, removing/decontaminating the sheetpiling, and re-paving the backfilled area. Based on the limited space available at the site, the groundwater component of the remedial alternative would not be constructed until after all excavated soil is transported for offsite treatment/disposal and the excavated area is restored (unless the treatment system could be constructed on vacant land south of the site).

The groundwater extraction and treatment system proposed under this alternative would consist of the same system described above for Alternative 4 – Asphalt Cap/Institutional Controls and Groundwater Extraction/ Onsite Treatment.

Compliance with SCGs

Chemical-Specific SCGs

The Class GA groundwater quality standards presented in 6NYCRR Parts 700-705 and in the NYSDEC TOGS 1.1.1 document titled, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* (NYSDEC 2000) are applicable chemical-specific SCGs for this alternative. The groundwater extraction and onsite treatment system would hydraulically control VOCs in groundwater and reduce groundwater VOC concentrations over time. The soil excavation activities would mitigate the potential future migration of VOCs from soil to groundwater. Groundwater quality standards could potentially be achieved after a significant amount of groundwater has been extracted and treated over a period of many years.

Chemical-specific guidelines that are to be considered under this alternative are the soil guidance values presented in NYSDEC TAGM #4046 titled, *Determination of Soil Cleanup Objectives and Cleanup Levels* (NYSDEC, 1994). The concentrations of VOCs in soil remaining following the excavation activities could potentially be consistent with the TAGM 4046 soil guidance values.

Action-Specific SCGs

Action-specific SCGs that apply to this alternative are the OHSA construction standards and health and safety requirements associated with the sheetpile wall installation, soil excavation, groundwater pumping well/

conveyance piping installation, treatment system construction, and performance of onsite monitoring activities. Workers and worker activities that occur during implementation of this alternative must comply with OSHA requirements for training, safety equipment and procedures, monitoring, recordkeeping, and reporting as identified in 29 CFR Parts 1904, 1910, and 1926. Compliance with action-specific SCGs would be accomplished by following a NYSDEC-approved design and site-specific HASP.

Another action-specific SCG that would apply to this alternative is associated with re-injecting or discharging treated groundwater to the POTW or recharge basin. A discharge permit would need to be obtained from the local POTW and the treated water would need to meet influent requirements. If the treated groundwater were to be discharged to the recharge basin or re-injected, the discharge/re-injection would be conducted in compliance with SPDES requirements.

For the purpose of this FS, it is assumed that an air stripper would be used to treat the extracted groundwater. NYSDEC Air Guide 1, which incorporates by reference applicable federal and New York State regulations and requirements pertaining to air emissions, is an action-specific SCG for emissions from the air stripper. If needed, a catalytic oxidizer or vapor phase carbon would be used to treat the exhaust from the air stripper to meet NYSDEC air discharge requirements and comply with federal emission requirements.

Wastes generated during the implementation of this alternative (soil removed from the excavation area, soil cuttings generated by installation of the pumping wells, soil removed during trenching to install the conveyance piping, PPE, etc.) would be characterized to determine appropriate offsite disposal requirements. If any of the materials are characterized as a hazardous waste, then the RCRA, UTS/LDR, and USDOT requirements for the packaging, labeling, transportation, and disposal of hazardous or regulated materials may be applicable. Compliance with these requirements would be achieved by utilizing licensed waste transporters and properly permitted disposal facilities.

Action-specific SCGs associated with the incineration and subsequent disposal of treated soil at a RCRA facility would include the RCRA standards for "Owners/Operators of Permitted Hazardous Waste Facilities" contained in 40 CFR Part 264, the air emissions standards contained in 40 CFR Part 60, the prevention of significant deterioration (PSD) air emission provisions contained in 40 CFR Part 51, relevant requirements under the Clean Air Act contained in 40 CFR Parts 1-99, and relevant state requirements.

Location-Specific SCGs

Remedial activities at the site would be conducted in accordance with local building/construction codes and ordinances, as appropriate.

Overall Protection of Human Health and the Environment

The soil excavation and offsite incineration/disposal and groundwater extraction/onsite treatment alternative would meet each of the RAOs for the site, as summarized herein. The soil excavation activities would mitigate potential human exposure to soil containing VOCs. These activities would also address the migration of VOCs in onsite soil to stormwater at the site and groundwater beneath the site. The excavation activities would also mitigate the offsite migration of VOCs in soil vapor originating from onsite soil. The groundwater extraction and onsite treatment activities would address potential groundwater quality impacts from the site and help control the migration of VOCs from groundwater to soil vapor. Existing groundwater use restrictions in place in Suffolk County Sanitary Code, Article 4 – Water Supply, Section 406.4, would continue to minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards.

Short-Term Effectiveness

In a relatively short timeframe, the excavation of soil containing VOCs would be completed and hydraulic control of the VOCs in groundwater (at concentrations exceeding the remedial goal) would be attained. However, groundwater treatment under this alternative would take an extended period of time.

Potential short-term risks to public health and the environment are associated with the excavation/handling of soil containing VOCs and potential air emissions from groundwater treatment. Water sprays and/or foam suppressants would be used during soil excavation/handling activities, as needed based on air monitoring activities, to mitigate potential risks (for inhalation) posed by fugitive dust or VOC vapors. An analysis of potential air quality impacts from the air stripper is required and, if necessary, offgas treatment would be installed for compliance with air emissions standards.

Under this alternative, onsite workers could be exposed to chemical constituents in soil during the excavation/ handling activities and soil boring activities. Exposure routes could include dermal contact, inhalation, and/or ingestion. However, the exposure would be of a relatively short duration and would be addressed via various health and safety precautions as discussed below.

Potential exposure of onsite workers to chemical constituents and operational hazards would be mitigated by the use of PPE as specified in a site-specific HASP and through proper equipment and material handling procedures to be specified in the remedy design documents and site work plans. Air monitoring would be performed during soil excavation/handling and boring activities to determine the need for additional engineering controls (e.g., using water sprays to suppress dust, modifying the excavation rate, etc.) to confirm that dust or VOC vapors are within acceptable levels, as specified in the site-specific HASP.

The community would not have access to the site during the excavation activities because the site is currently fenced and entry would be controlled through the main gate off Picone Boulevard. Potential risks to the community during excavation would also be mitigated by implementing an air monitoring plan and by implementing vapor control/dust control techniques to mitigate the offsite migration of unacceptable levels of VOC vapors and/or fugitive dust from the site.

Long-Term Effectiveness and Permanence

Implementation of this alternative would permanently remove subsurface soil containing VOCs. The soil RAOs could potentially be achieved in a relatively short timeframe (within a few weeks following installation of the sheetpile wall).

The groundwater extraction and onsite treatment system would be effective over the long term as the system would be maintained in operation. The system would likely operate for as long as site-related VOCs remain in groundwater at concentrations exceeding the remedial goals. Annual operation, maintenance, and monitoring activities related to the groundwater treatment system would continue until the groundwater remedial goals are attained.

Reduction of Toxicity, Mobility, and Volume Through Treatment

The soil excavation activities would reduce the toxicity, mobility, and volume of VOC constituents in the unsaturated zone at the HWD site as the soil would be permanently removed and replaced with clean backfill material. The toxicity, mobility, and volume of the VOC constituents in the excavated soil would be reduced by the offsite incineration/disposal activities.

The mobility of VOCs in groundwater would be limited by the measure of hydraulic control achieved by the groundwater extraction system. VOC concentrations in groundwater would decrease over time by the continued operation of the groundwater extraction and onsite treatment system. VOCs in the extracted groundwater would be removed/destroyed by the groundwater treatment system equipment (e.g., air stripper and catalytic oxidizer). The groundwater treatment approach is an irreversible process as VOCs in groundwater would be permanently removed.

Implementability

Excavation and offsite transportation of soils are commonly employed construction activities and are technically feasible. Soil that is characterized as hazardous and fails UTS/LDRs would be incinerated, which would destroy the VOC constituents in the soil, prior to landfill disposal. Soil that is characterized as hazardous and meets UTS/LDRs would be disposed of in a Subtitle C landfill. Soil that is characterized as nonhazardous would be disposed of in a Subtitle D landfill.

Groundwater extraction and onsite treatment could be effectively implemented at this site to remove VOCs from groundwater and provide hydraulic control of the groundwater VOC plume. Approval for discharge to the POTW would need to be obtained to confirm that the POTW would accept the treated water. An evaluation would also be needed to determine whether the sanitary sewer system could accommodate the additional flow from the onsite treatment system. In the event that discharge to the POTW is not feasible, treated groundwater could be discharged to the onsite storm sewer system (which conveys flow to the recharge basin) in accordance with SPDES requirements. Based on the location of the recharge basin, flow conveyed to the recharge basin may potentially facilitate hydraulic control of the groundwater plume of VOCs.

Treatability and pilot studies may be required to confirm that the water treatment system would meet necessary effluent requirements to satisfy POTW and/or SPDES requirements. In addition, pump tests and groundwater modeling would likely be required to confirm the groundwater extraction rates necessary to achieve hydraulic control.

Installation of the sheetpile wall and completion of soil excavation activities would require approximately 1 to 2 months to complete. The groundwater extraction and onsite treatment system could be constructed in a 3 to 4 month timeframe after backfilling activities are completed. Long-term O&M of the groundwater treatment system could last for an extended period of time.

Cost

The 30-year present worth estimated cost associated with the soil excavation and offsite incineration/disposal and groundwater extraction/onsite treatment alternative is $6,380,000. A detailed breakdown of the estimated cost associated with this alternative is presented in Table 12.

6. Comparative Analysis of Alternatives

6.1 General

While Section 5 presented an analysis of each alternative's ability to meet the evaluation criteria, this section presents a comparative analysis of the alternatives to each other with respect to the seven evaluation criteria identified in Section 5. This comparative analysis identifies the advantages and disadvantages of each alternative relative to each other and in consideration of the seven evaluation criteria. The results of the comparative analysis are used as a basis for recommending a remedial alternative to address the VOCs in soil and groundwater in Subsection 6.2. The comparative analysis of remedial alternatives is presented below.

6.1.1 Compliance with SCGs

Chemical-Specific SCGs

The Class GA groundwater quality standards presented in 6NYCRR Parts 700-705 and in the NYSDEC TOGS 1.1.1 document titled, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* (NYSDEC 2000) are applicable chemical-specific SCGs for each alternative. Alternative 1 (No Action) provides limited means to achieve the groundwater quality standards and no means to monitor the location and movement of site groundwater that exceeds the standards.

Alternatives 2 (In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation) and 3 (SVE and In-Situ Groundwater Chemical Oxidation) both involve the delivery of chemicals to react with and chemically oxidize VOCs in groundwater to innocuous byproducts. Under both alternatives, a significant depth of treatment could be realized as the oxidant (which is denser than water) descends through the saturated zone and migrates with groundwater flow. Under Alternative 2, oxidant applied for soil treatment that is not consumed in the unsaturated overburden would migrate to groundwater and help further degrade VOCs in groundwater. The groundwater extraction and treatment activities under Alternatives 4 (Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment) and 5 (Soil Excavation and Offsite Incineration/Disposal and Groundwater Extraction/Onsite Treatment) would result in the continued removal of groundwater containing VOCs and the reduction of groundwater VOC concentrations over time.

Groundwater quality would be assessed in connection with Alternatives 2 through 5. Groundwater quality standards could potentially be achieved in a relatively short timeframe under Alternatives 2 and 3 depending on the amount of oxidant injected and consumed by the targeted VOC constituents and formation, and the number of treatment applications provided. Under Alternative 2, groundwater treatment would be performed concurrently with soil treatment, and both the soil and groundwater treatment components could be completed in as little as one year (excluding pre-design activities and commencing with construction). As discussed above in Subsection 5.3.3, groundwater treatment under Alternative 3 would begin after soil treatment is completed, and Alternative 3 could be completed in approximately six to seven years. (excluding pre-design activities and commencing with construction). Under Alternatives 4 and 5, groundwater quality standards could potentially be achieved after a significant amount of groundwater has been extracted and treated over an extended period of time.

Chemical-specific guidelines that are to be considered under each alternative are the soil guidance values presented in NYSDEC TAGM #4046 titled, *Determination of Soil Cleanup Objectives and Cleanup Levels*

(NYSDEC, 1994). Alternative 1 would rely on natural degradation processes that would not likely reduce VOC concentrations in soil at the site to below the TAGM 4046 soil guidance values. The soil areas targeted for treatment under Alternatives 2 and 3 are based on the TAGM 4046 guidance values for soil remediation of VOCs. Therefore, these alternatives meet this SCG. VOC concentrations in soil would not be reduced by Alternative 4. However, the cap would mitigate infiltration (and hence partitioning of VOCs from soil to water) and would minimize unauthorized human contact with soils. Both of these results meet the intent of why the TAGM 4046 guidance values were developed (groundwater protection and human health protection). VOC concentrations in soil remaining following the excavation activities under Alternative 5 would be consistent with the TAGM 4046 soil guidance values.

Action-Specific SCGs

Action-specific SCGs are not applicable under Alternative 1. OSHA regulations (29 CFR Parts 1904, 1910, and 1926) would apply to construction/installation activities included under Alternatives 2 through 5.

SCGs related to air emissions (including relevant federal and New York State regulations/requirements incorporated by reference in NYSDEC Air Guide 1) would apply to the removal/treatment activities under Alternatives 3 through 5. As no point source (or other) emissions are expected under Alternative 2, there would not be a need to comply with air discharge SCGs under Alternative 2. SCGs related to packaging, labeling, transportation, and disposal of hazardous materials (including RCRA, UTS/LDR, and USDOT requirements) would apply to the removal activities under Alternatives 2 through 5. In addition, SCGs related to the discharge of treated groundwater to the POTW or recharge basin, or the reinjection of treated groundwater would apply under Alternatives 4 and 5.

All of the remedial activities would be designed and implemented to meet action-specific SCGs.

Location-Specific SCGs

Remedial activities under Alternatives 2 through 5 would be conducted in accordance with local building/construction codes and ordinances, as appropriate. However, depending on the outcome of the final design, Alternative 2 may not result in the construction of any permanent aboveground structures, mitigating the need for compliance with the identified location-specific SCGs.

6.1.2 Overall Protection of Human Health and the Environment

Alternative 1 (No Action) would be ineffective and would not meet the soil and groundwater RAOs for the HWD site. The capping, in-place treatment, or removal activities under Alternatives 2 through 5 would minimize potential future exposure of workers at the site to soil containing VOCs. These activities would also address potential migration of chemical constituents in onsite soil to stormwater at the site and groundwater beneath the site. The groundwater treatment activities under Alternatives 2 through 5 would mitigate groundwater quality impacts from the site and minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards/guidance values. Under each alternative, existing groundwater use restrictions in place in Suffolk County Sanitary Code, Article 4 – Water Supply, Section 406.4, would continue to minimize potential human exposure to VOCs in groundwater at concentrations exceeding groundwater quality standards.

The groundwater treatment activities under Alternatives 2 through 5 would also help control the migration of VOCs from groundwater to soil vapor. The migration of VOCs through soil vapor would be controlled by the soil treatment or removal activities under Alternatives 2, 3, and 5, but not by the capping activities under Alternative 4. Overall protection of human health and the environment could potentially be achieved fastest by Alternative 2 (In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation), provided the proper amount of oxidant reaches the target VOCs, because the oxidant reacts quickly with these VOCs to form innocuous products. Long-term operation and/or maintenance activities would not be required under Alternative 2. As compared to the other alternatives, Alternative 2 also offers the advantage that VOCs in soil and groundwater would be destroyed in-situ without the need to bring impacted soil or groundwater to the surface for treatment or disposal. As a result, VOC-impacted materials would not need to be transported offsite through commercial areas under Alternative 2.

6.1.3 Short-Term Effectiveness

There are no short-term negative impacts associated with Alternative 1. Potential short-term impacts under Alternatives 2 through 4 are primary associated with worker exposure to soil and groundwater containing VOCs during the installation of the in-situ chemical oxidation delivery systems, installation of the SVE extraction/ conveyance systems, and removal of the soil/base materials for the new cap construction. There would also be short-term risks to onsite workers associated with handling potassium permanganate under Alternatives 2 and 3 and spent carbon under alternatives 3, 4, and 5. Alternative 5 involves significant excavation activities, and as such presents a greater potential for short-term risks to onsite workers and the community during implementation. Under Alternatives 2 through 5, appropriate measures would be implemented to mitigate these risks including, but not limited to, implementing a HASP that includes an air monitoring program, using PPE, and instituting engineering controls to suppress dust or VOC emissions.

Alternative 2 could potentially achieve the soil and groundwater RAOs identified for the HWD site in the least amount of time of the alternatives evaluated. Considering that Alternative 2 may achieve the remedial goals much quicker than the other alternatives under consideration, there will be inherently less onsite labor hours, thereby reducing the probability of potential site accidents/worker injury.

6.1.4 Long-Term Effectiveness and Permanence

The no-action alternative would provide limited means to achieve and no method to monitor long-term effectiveness. Under Alternatives 2 and 3, VOCs in soil and groundwater would be permanently removed/ destroyed by in-situ technologies. The soil and groundwater RAOs could potentially be attained in a relatively short timeframe under both Alternatives 2 and 3 (e.g., as little as one year for Alternative 2 and an estimated six or seven years for Alternative 3). Depending on the amount of oxidant consumed by natural organic material/ minerals and the total mass of VOCs present in the target media, additional chemical oxidation treatments could be required under both Alternatives 2 and 3 to achieve the RAOs. Operation of the SVE system included under Alternative 3 would generate additional noise at the nearby properties for a period of several years, even if the system were to be equipped with sound abatement devices. Additional operation, maintenance, and monitoring activities relative to the SVE system could be required under Alternative 3 to achieve the RAOs.

Under Alternative 4, a maintained engineered cap would effectively isolate subsurface soil containing VOCs over the long term. However, the VOCs would be allowed to remain in onsite soil and could potentially migrate offsite via soil vapor. Under Alternative 5, soil containing VOCs would be permanently removed and transported for offsite incineration/disposal. The groundwater extraction and onsite treatment system identified under Alternatives 4 and 5 would be effective over the long term as the system would be maintained in operation resulting in the continued removal of VOCs from groundwater. The system would likely operate for as long as site-related VOCs persist in groundwater at concentrations exceeding the remedial goals. Annual operation, maintenance, and monitoring activities related to the groundwater treatment system would continue until the groundwater remedial goals are attained.

6.1.5 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 does not include implementation of active treatment processes to reduce the toxicity, mobility, or volume of VOCs in soil and groundwater. Alternatives 2, 3, and 5, which include in-situ soil chemical oxidation, soil vapor extraction and onsite vapor treatment, and excavation and offsite incineration/disposal (respectively), would reduce the toxicity, mobility, and volume of VOCs in onsite soil. Alternatives 2, 3, and 5 involve irreversible processes for soil as target VOCs would be permanently removed/destroyed. The cap under Alternative 4 would not reduce the toxicity and volume of VOCs in soil, but would reduce the mobility of the VOCs. The toxicity, mobility, and volume of VOCs in groundwater would be reduced by Alternatives 2 through 5. Each of these alternatives includes an irreversible treatment process for groundwater.

Alternative 2 would require the least amount of time to reduce the toxicity, mobility, and volume of VOCs in both soil and groundwater provided the proper amount of oxidant is delivered to the target VOCs in the subsurface. In addition, Alternative 2 would generate the least amount of waste materials. Under Alternative 2, there would not be any residuals that would remain after treatment, such as spent vapor-phase GAC associated with an SVE system or precipitates, filtrates/backwash, spent GAC, etc. from a groundwater treatment system. In addition, there would not be any large amounts of materials requiring offsite transportation and disposal, such as the soil excavated under Alternative 5.

6.1.6 Implementability

Each of the alternatives could be implemented at the site. Pre-design testing/pilot testing would be performed prior to implementing Alternatives 2 through 5, particularly to further evaluate final design parameters for in-situ chemical oxidation, SVE, and groundwater extraction/onsite treatment. Alternative 2 would be the simplest alternative to implement, as construction of onsite treatment systems requiring ongoing operation/maintenance is not needed, and only a small amount of waste (associated with installation of the delivery system) would need to be managed. Alternatives 3, 4, and 5 would each require ongoing operation, maintenance, and monitoring activities relative to operation of an SVE system or groundwater extraction and onsite treatment system. Operation, maintenance, and monitoring activities would be required for the longest period of time in connection with the groundwater extraction and onsite treatment systems under Alternatives 4 and 5. Alternative 5 would also present several technical challenges based on the depth/size of the soil excavation, such as maintaining excavation sidewalls and controlling the volatilization of VOCs from the excavation/material stockpiles.

6.1.7 Cost

The five remedial alternatives under consideration for the HWD site cover a wide range of capital and O&M costs. No capital or O&M costs are associated with the implementation of Alternative 1. The total costs to implement Alternatives 1 through 5 are presented in the table below.

Remedial Alternative		Estimated Capital Costs	Estimated O&M Costs	Total Costs (Rounded)
Alternative 1 –	No Action	$0	$0	$0
Alternative 2 –	In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation (Focused Application)	$1,430,650	$41,923	$1,480,000
Alternative 3 –	Soil Vapor Extraction and In-Situ Groundwater Chemical Oxidation (Focused Application)	$1,281,800	$448,110	$1,730,000
Alternative 4 –	Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment	$1,109,030	$3,308,315	$4,420,000
Alternative 5 –	Soil Excavation and Offsite Incineration/Disposal and Groundwater Extraction/Onsite Treatment	$3,359,785	$3,010,499	$6,380,000

6.2 Recommended Remedial Alternative

Based on the results of the comparative analysis presented above, Alternative 2 – In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation appears to be the most effective remedial alternative capable of meeting the RAOs for the site. This alternative will result in a significant and permanent reduction in the total mass of VOCs in soil and groundwater as the oxidant reaches and destroys the target VOCs. In addition, this alternative will be protective of human health and the environment, have minimal short-term negative impacts when compared to the other alternatives, be effective over the long term, and be implemented for a cost comparatively lower than the other alternatives. The key advantages of Alternative 2 over the other alternatives evaluated in this FS Report are summarized below.

- The soil RAOs would likely be achieved in less time under Alternative 2 than the other alternatives considered, because the oxidant reacts quickly and completely with VOCs to form innocuous products. A quicker remediation is desirable as there would be inherently less onsite labor hours, which would reduce the probability of potential site accidents/site worker injury.

- The groundwater RAOs would likely be achieved in less time under Alternative 2 than the other alternatives considered. Although the same groundwater treatment technology is included under both Alternatives 2 and 3 (in-situ groundwater chemical oxidation), groundwater treatment would be implemented concurrently with soil treatment under Alternative 2 and following completion of soil treatment under Alternative 3.

- Alternative 2 would not involve the extraction and subsequent aboveground onsite handling/treatment of large amounts of impacted soil, soil vapor, or groundwater that presents potential exposure scenarios requiring mitigation, such as under Alternatives 3, 4, and 5.

- There would not be the type of treatment residuals that would remain following treatment under Alternative 2, such as the spent vapor-phase GAC associated with the SVE system under Alternative 3, or precipitates, filtrates/backwash, spent GAC, etc. associated with a groundwater treatment system under Alternatives 4 and 5.

- Alternative 2 would not include a blower or other mechanical equipment that would continuously operate and generate added noise to the nearby properties like the SVE blower included under Alternative 3 or the groundwater treatment system components included under Alternatives 4 and 5 (air stripper blowers, pumps, alarms, etc.).

- There would be an economy-of-scale for Alternative 2 associated with the design and use of the same technology to treat both soil and groundwater. For instance, oxidant applied for soil treatment that is not consumed in the unsaturated overburden would migrate to groundwater and help further degrade VOCs in groundwater.

- Long-term operation, maintenance, and monitoring activities would not be required under this alternative like Alternatives 3, 4, and 5.

- Finally, Alternative 2 is the most cost-effective alternative evaluated.

Pre-design activities would be conducted in support of Alternative 2. If the findings of the pilot-scale testing indicate that in-situ chemical oxidation is not effective, a review of alternative remedial measures will be conducted and additional recommendations will be presented to the NYSDEC. Based on the information discussed above and the detailed and comparative analysis of remedial alternatives, in-situ soil and groundwater chemical oxidation is the recommended remedial alternative for the site.

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Tables

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Table 1

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Groundwater/Surface Water Elevations - April 22, 2003

Well ID	Reference Point (feet)	Depth to Water (feet)	Water Elevation (feet)
MW-1	80.63	28.36	52.27
MW-1D	81.54	29.26	52.28
MW-2	65.39	13.37	52.02
MW-2D	65.20	NA	NA
MW-3	67.55	15.06	52.49
MW-3D	64.89	NA	NA
MW-4	69.69	NA	NA
MW-5	79.22	NA	NA
MW-6	67.72	15.53	52.19
MW-7	65.31	13.31	52.00
MW-8	64.61	12.73	51.88
W-1	65.33	13.45	51.88
W-2	68.39	NA	NA
W-3	65.02	13.31	51.71
Staff Gauge	57.90	5.3 (estimated)	52.6 (estimated)

Notes:

1. Water level measurements obtained by Blasland, Bouck & Lee, Inc. (BBL) on April 22, 2003 between 7:30 a.m. and 9:30 a.m.
2. Water elevations provided in feet above mean sea level (AMSL) in relation to North American Vertical Datum (NAVD) 1988.
3. Surveyed reference point on the staff gauge is the 6.0-foot mark, which corresponds to an elevation of 57.90 feet.
4. The bottom of the staff gauge is at the 1.88-foot mark (elevation 53.78 feet), and the water level in the recharge basin was approximately 1.2 feet below this mark.
5. NA = Not available.

Table 2

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Groundwater Analytical Results for Detected Volatile Organic Compounds (ppb)

Detected Compound	NYSDEC Groundwater Standards	MW-1	MW-1D	MW-2	MW-3	BD042203 (MW-3)	MW-6	MW-7	MW-8
Benzene	1	< 0.3	< 0.3	< 2.6	2.0	1.8	< 0.3	< 6.5	< 2.6
Chlorobenzene	5	< 0.2	< 0.2	< 1.8	19	17	< 0.2	< 4.5	< 1.8
cis-1,2-Dichloroethene	5	< 0.2	< 0.2	21	2.3	1.9	< 0.2	38	27
1,1-Dichloroethane	5	< 0.2	1.8	< 2.4	< 0.5	< 0.5	< 0.2	< 6.0	< 2.4
1,1-Dichloroethene	5	< 0.4	1.3	< 4.3	< 0.9	< 0.9	< 0.4	< 11	< 4.3
Ethylbenzene	5	< 0.4	< 0.4	< 3.7	310	270	< 0.4	< 9.2	< 3.7
Tetrachloroethene	5	50	0.8	1,200	1.4	1.2	120	2,600	970
Trichloroethene	5	< 0.2	1.7	34	< 0.4	< 0.4	1.1	48	25
1,1,1-Trichloroethane	5	< 0.2	1.4	< 1.6	< 0.3	< 0.3	0.3	< 4.0	< 1.6
Toluene	5	< 0.2	< 0.2	< 1.5	9.6	8.2	< 0.2	< 3.8	< 1.5
Xylenes (Total)	5	< 0.2	< 0.2	< 1.8	40	35	< 0.2	< 4.5	< 1.8

Notes:

1. Samples collected by Blasland, Bouck & Lee, Inc. (BBL) on April 22-23, 2003.
2. Sample BD042203 is a blind duplicate of sample MW-3.
3. Samples analyzed by Severn Trent Laboratories, Inc. (STL) of Edison, New Jersey for Target Compound List (TCL) volatile organic compounds (VOCs) using United States Environmental Protection Agency (USEPA) Method 624.
4. Concentrations are reported in parts per billion (ppb), which are equivalent to micrograms per liter (μg/L).
5. Groundwater quality standards are from the New York State Department of Environmental Conservation (NYSDEC) Division of Water, Technical and Operational Guidance Series (TOGS 1.1.1) document entitled, "Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations," dated June 1998, revised April 2000.
6. < = Compound was not detected at a concentration exceeding the reported laboratory detection limit.
7. Shaded value indicates a VOC concentration exceeding the presented groundwater quality standard.

Table 3

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Groundwater Field/Laboratory Analytical Results for Key Indicator Parameters of In-Situ Biodegradation

Field/Laboratory Parameters	MW-1	MW-1D	MW-2	MW-3	MW-6	MW-7	MW-8
Field Parameters							
pH	6.2	6.2	6.3	6.8	7.7	6.5	6.0
Temperature (°C)	13.9	15.3	11.3	13.0	15.2	11.2	11.6
Specific Conductance (mS/cm)	0.20	0.27	0.28	0.39	0.17	0.24	0.25
Dissolved Oxygen (mg/L)	8.6	0.5	7.1	0.8	6.5	5.7	3.5
Turbidity (NTU)	0.0	10.1	0.0	17.5	0.0	8.3	2.2
Redox (mV)	135	116	156	-121	127	157	-40
Laboratory Analytical Parameters							
Geochemical Parameters							
Alkalinity as $CaCO_3$ (mg/L)	32	71	61	200	29	52	92
Ammonia as N (mg/L)	< 2.0	< 2.0	< 2.0	3.7	2.2	5.2	< 2.0
Chloride (mg/L)	20	36	35	9.4	14	22	15
Nitrate (mg/L)	17	< 0.50	15	< 0.50	10	14	8.6
Nitrite (mg/L)	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Phosphate (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Soluble Organic Carbon (mg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Sulfate (mg/L)	20	18	19	5.2	24	30	27
Sulfide (mg/L)	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Iron-dissolved (mg/L)	< 0.050	< 0.050	< 0.050	21	< 0.050	< 0.050	0.73
Carbon dioxide (mg/L)	34	76	26	71	26	28	38
Ethane (ng/L)	82	29	84	410	< 5.0	5.8	8,000
Ethene (ng/L)	23	32	25	340	11	8.4	180
Methane (ug/L)	0.71	14	0.73	780	0.08	0.13	160
Microbiological Parameters							
Biomass via PLFA (Cell/mL)	1.12E+04	2.23E+06	6.46E+03	1.34E+06	4.11E+03	8.81E+03	4.23E+05
Anaerobes via PLFA (% of population)	0.0	13.6	0.0	10.6	0.0	0.0	5.2
Metal reducers via PLFA (% of population)	0.0	1.3	0.0	2.1	0.0	0.0	1.4
Dehalococcoides Ethenogenes	ND	ND	ND	Detected	ND	ND	Detected

Notes:

1. Samples collected by Blasland, Bouck & Lee, Inc. (BBL) on April 22-23, 2003.
2. Field measurements obtained by BBL using a Horiba U-22 flow-through cell/water quality meter.
3. Laboratory analyses for key indicator parameters of in-situ biodegradation were performed by three laboratories, as summarized below:
   - Geochemical parameter analysis was performed by Microseeps, Inc. (University of Pittsburgh Applied Research Center) of Pittsburgh, Pennsylvania;
   - Phospholipid fatty acids (PLFA) analysis was performed by Microbial Insights, Inc. of Rockford, Tennessee; and
   - *Dehalococcoides ethenogenes* analysis was performed by Sirem Site Recovery & Management, Inc. (Sirem) of Guelph, Ontario.
4. Analyses were performed using the following methods:
   - United States Environmental Protection Agency (USEPA) Method 9056 for chloride, nitrate, nitrite, phosphate, and sulfate;
   - USEPA Method 310.1 for alkalinity;
   - USEPA Method 350.2 for ammonia;
   - USEPA Method 376.1 for sulfide;
   - USEPA Method 6010B for dissolved iron;
   - USEPA Method 9060 for dissolved organic carbon;
   - Laboratory-specific gas chromatography (GC) methods for carbon dioxide/methane (AM20GAX) and ethane/ethene (AM18);
   - A laboratory-specific gas chromatography/mass spectrometry (GC/MS) method for PLFA; and
   - A laboratory-specific polymerase chain-reaction (PCR) method for *dehalococcoides ethenogenes*.
5. Concentrations reported in the units identified above.

Table 3

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Groundwater Field/Laboratory Analytical Results for Key Indicator Parameters of In-Situ Biodegradation

6. S.U. = Standard units.
7. °C = Degrees Celcius.
8. mS/cm = milliSiemens per centimeter.
9. NTU = Nephelometric turbidity units.
10. mV = milliVolt.
11. mg/L = milligrams per liter, which is equivalent to parts per million (ppm).
12. ng/L = nanograms per liter.
13. < = Compound was not detected at a concentration exceeding the reported laboratory detection limit.
14. ND = not detected above the analytical method detection limit.

Table 4

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Potential Chemical, Action, and Location-Specific SCGs

Potential Federal/ State Requirements and Guidance	Citation/Reference	Potential Status	Summary of Requirements/Guidance	Considerations in Remedial Process/Action for Attainment
Chemical-Specific SCGs				
Identification and Listing of Hazardous Wastes	40 CFR Part 261 6 NYCRR Part 371	Applicable	Establishes procedures for identifying solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 260-266 and 6 NYCRR Parts 371-376.	Applicable to use for determining if soil that is removed from the site is a hazardous waste by characteristics or specific listing. These regulations do not set cleanup standards, but are considered when developing remedial alternatives.
Universal Treatment Standards/Land Disposal Restrictions (UTS/LDRs)	40 CFR Part 268	Applicable	Identifies hazardous wastes for which land disposal is restricted and provides a set of numerical constituents concentration criteria at which hazardous waste is restricted from land disposal.	Applicable to use if waste determined to be hazardous. These regulations will be used for remedial alternatives utilizing offsite land disposal.
Groundwater Quality Standards	6 NYCRR Part 703.5	Applicable	Establishes quality standards for groundwater.	These criteria are applicable in evaluating groundwater quality.
NYSDEC Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations	Division of Water Technical and Operational Guidance Series (TOGS 1.1.1, June 1998, revised April 2000)	Applicable	Provides a compilation of ambient water quality standards and guidance values for toxic and non-conventional pollutants for use in the NYSDEC programs.	These standards are applicable in evaluating groundwater quality.
NYSDEC Guidance on Determination of Soil Cleanup Objectives and Cleanup Levels	Technical and Administrative Guidance Memorandum (TAGM) #4046, January 24, 1994	To Be Considered	Provides a basis and a procedure to determine soil cleanup levels, as appropriate, for sites when cleanup to pre-disposal conditions is not possible or feasible. Contains generic soil cleanup objectives.	These guidance values are to be considered in evaluating soil quality.

Table 4
(cont'd)
Hazardous Waste Disposal, Inc.
11A Picone Boulevard
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Feasibility Study Report
Potential Chemical, Action, and Location-Specific SCGs

Potential Federal/ State Requirements and Guidance	Citation/Reference	Potential Status	Summary of Requirements/Guidance	Considerations in Remedial Process/Action for Attainment
Chemical-Specific SCGs (cont'd)				
USEPA Region 3 Risk-Based Concentrations (RBCs) for Commercial/Industrial Soil	USEPA Region 3 www.epa.gov/reg3hwmd/ risk/riskmenu.htm	To Be Considered	Provides RBCs for commercial/industrial soil ingestion based on adult occupational exposure, including an assumption that only 50% of total soil ingestion is work-related. Separate carcinogenic and non-carcinogenic risk-based concentrations are calculated for each pathway. The concentration in the USEPA Region 3 RBC table is the lower of the two values.	The RBCs are to be considered in evaluating soil quality.
USEPA Region 9 Preliminary Remediation Goals (PRGs) for Industrial Soil	USEPA Region 9 www.epa.gov/region09/ waste/sfund/prg/index. com	To Be Considered	Provides PRGs for industrial soil for screening purposes. Each PRG corresponds to an excess lifetime cancer risk of 1 x 10^{-6} or a non-cancer hazard quotient of 1.	The PRGs are to be considered in evaluating soil quality.
Action-Specific SCGs				
OSHA – General Industry Standards	29 CFR Part 1910	Applicable	These regulations specify the 8-hour time-weighted average concentration for worker exposure to various organic compounds. Training requirements for workers at hazardous waste operations are specified in 29 CFR 1910.120.	Proper respiratory equipment will be worn if it is not possible to maintain the work atmosphere below these concentrations.
OSHA – Safety and Health Standards	29 CFR Part 1926	Applicable	These regulations specify the type of safety equipment and procedures to be followed during site remediation.	Appropriate safety equipment will be onsite and appropriate procedures will be followed during any remedial activities.
OSHA – Recordkeeping, Reporting, and Related Regulations	29 CFR Part 1904	Applicable	These regulations outline recordkeeping and reporting requirements for an employer under OSHA.	These regulations apply to the company(s) contracted to install, operate, and maintain remedial actions at hazardous waste sites.

Table 4
(cont'd)
Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Potential Chemical, Action, and Location-Specific SCGs

Potential Federal/ State Requirements and Guidance	Citation/Reference	Potential Status	Summary of Requirements/Guidance	Considerations in Remedial Process/Action for Attainment
RCRA – General Standards	40 CFR 264	Relevant and Appropriate	General performance standards requiring minimization of need for further maintenance and control; minimization or elimination of post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products. Also requires decontamination or disposal of contaminated equipment, structures, and soils.	Proper design considerations will be implemented to minimize the need for future maintenance. Decontamination actions and facilities will be included.
RCRA – Regulated Levels for Toxic Characteristics Leaching Procedure (TCLP) Constituents	40 CFR Part 261	Applicable	These regulations specify the TCLP constituent levels for identification of hazardous waste that exhibit the characteristic of toxicity.	Excavated soil may be sampled and analyzed for TCLP constituents prior to disposal to determine if the materials are hazardous based on the characteristic of toxicity.
RCRA – Preparedness and Prevention	40 CFR Part 264 Subpart C	Relevant and Appropriate	These regulations outline requirements for safety equipment and spill control.	Safety and communication equipment will be installed at the site as necessary. Local authorities will be familiarized with the site.
Land Disposal Facility Notice in Deed	40 CFR Parts 264/265	Applicable	Establishes provisions for a deed notation for closed hazardous waste disposal units to prevent land disturbance by future owners.	The regulations are potentially applicable because closed areas may be similar to closed RCRA units.
RCRA – Contingency Plan and Emergency Procedures	40 CFR Part 264 Subpart D	Relevant and Appropriate	Provides requirements for outlining emergency procedures to be used following explosions, fires, etc.	Plans will be developed and implemented during remedial design, as appropriate. If necessary to develop, copies of the plan will be kept onsite.
Standards Applicable to Transporters of Applicable Hazardous Waste – RCRA Section 3003	40 CFR Parts 262 and 263 40 CFR Parts 170-179	Applicable	Establishes the responsibility of offsite transporters of hazardous waste in the handling, transportation, and management of the waste. Requires manifesting, recordkeeping, and immediate action in the event of a discharge.	These requirements would be applicable to any company(s) contracted to transport hazardous material from the site.

Table 4
(cont'd)
Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Potential Chemical, Action, and Location-Specific SCGs

Potential Federal/ State Requirements and Guidance	Citation/Reference	Potential Status	Summary of Requirements/Guidance	Considerations in Remedial Process/Action for Attainment
USEPA – Administered Permit Program: The Hazardous Waste Permit Program	40 CFR Part 270 RCRA Section 3005	Applicable	Covers the basic permitting, application, monitoring, and reporting requirements for offsite hazardous waste management facilities.	Any offsite facility accepting hazardous waste from the site would be properly permitted. Implementation of the site remedy would include consideration of these requirements.
Land Disposal Restrictions	40 CFR Part 268	Applicable	Restricts land disposal of hazardous wastes that exceed specific criteria. Establishes Universal Treatment Standards (UTS) to which hazardous waste must be treated prior to land disposal.	Excavated soils that exhibit the characteristics of a hazardous waste or that are decharacterized after generation must be treated to 90% constituent concentration reduction capped at 10 times the UTS.
New York Air Quality Classification System	6 NYCRR Part 256	Relevant and Appropriate	Outlines the air quality classifications for different land uses and population densities.	Air quality classification system will be referenced during the treatment process design.
National Emission Standards for Hazardous Air Pollutants (NESHAP)	40 CFR Part 61	Applicable	Provides emission standards for hazardous air pollutants.	Proper designs on air emissions controls will be implemented to meet these regulations.
New Source Performance Standards (NSPS)	40 CFR Part 60.52	Relevant and Appropriate	Provides particulate emission limits for incinerators.	Particulate emission limits should be specified for compliance.
Clean Air Act (CAA) - Ambient Air Quality Standards (NAAQS)	40 CFR Part 1 - 99	To be considered	Applies to major stationary sources such as treatment units that have the potential to emit significant amounts of pollutants.	The treatment system will be designed to meet these emission limits. If required, prevention of significant deterioration (PSD) procedures will be included in the remedial design/remedial action process.

Table 4
(cont'd)
Hazardous Waste Disposal, Inc.
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Farmingdale, New York

Feasibility Study Report
Potential Chemical, Action, and Location-Specific SCGs

Potential Federal/ State Requirements and Guidance	Citation/Reference	Potential Status	Summary of Requirements/Guidance	Considerations in Remedial Process/Action for Attainment
New York Permits and Certificates	6 NYCRR Part 201	Applicable	Provides instructions and regulations for obtaining a permit to operate an air emission source. Also provides instructions on what to do in case of malfunction.	Permits are not required for remedial actions implemented at hazardous waste sites; however, documentation for relevant and appropriate permit conditions would be provided to the NYSDEC prior to and during implementation of this alternative.
New York Emissions Testing, Sampling, and Analytical Determinations	6 NYCRR Part 202	Applicable	Outlines requirements for emissions testing for air emission sources. States that independent emissions tests can be ordered by the Commissioner of the NYSDEC.	Emissions from treatment procedure must be analyzed.
New York Regulations for General Process Emissions	6 NYCRR Part 212	Applicable	Outlines the procedure of environmental rating. The Commissioner determines a rating of emissions based on sampling.	The Commissioner will issue an environmental rating for emissions based on this regulation.
Protection of Significant Deterioration of Air Quality (PSD)	40 CFR Part 51.2	Applicable	New major stationary sources may be subject to PSD review [i.e., require best available control technology (BACT), lowest achievable detection limit (LAEL), and/or emission off-sets.	If necessary, PSD procedures will be included in the remedial design/remedial action process. The procedures could be expanded to BACT and LAEL evaluations.
New York Air Quality Standards	6 NYCRR Part 257	Applicable	Provides air quality standards for different chemicals (including those found at the site), particles, and processes.	Emissions from treatment processes will meet the air quality standards.
Clean Water Act (CWA) - Discharge to Waters of the U.S. National Pollution Discharge Elimination System (NPDES)	40 CFR Part 122, 125, 403, 230, and 402 33 USC 446 Section 404	To be considered	Establishes site-specific pollutant limitations and performance standards that are designed to protect surface water quality. Types of discharges regulated under CWA include discharge to surface water, indirect discharge to POTW, and discharges of dredged or fill material into U.S. waters.	May be relevant and appropriate for remedial alternatives that include discharging water to a POTW.

Table 4
(cont'd)
Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Potential Chemical, Action, and Location-Specific SCGs

Potential Federal/ State Requirements and Guidance	Citation/Reference	Potential Status	Summary of Requirements/Guidance	Considerations in Remedial Process/Action for Attainment
National Pollutant Discharge Elimination System (NPDES)	40 CFR Part 122	Applicable	These regulations detail the specific permit requirements for the discharge of pollutants to the waters of the U.S.	Any water discharged from the site would be treated and discharged in accordance with NPDES permit requirements.
New York State Pollution Discharge Elimination System (SPDES)	6 NYCRR Parts 750-758	Applicable	These regulations detail the specific permit requirements for the discharge of pollutants to the waters of New York State.	Any water discharged from the site would be treated and discharged in accordance with NYSDEC SPDES permit requirements.
New York Hazardous Waste Management System – General	6 NYCRR Part 370	Relevant and Appropriate	Provides definitions of terms and general instructions for the Part 370 series of hazardous waste management.	Hazardous waste is to be managed according to this regulation.
New York State - Identification and Listing of Hazardous Wastes	6 NYCRR Part 371	Applicable	Establishes procedures for identifying solid wastes that are subject to regulation as hazardous waste.	Materials excavated/removed from the site will be handled in accordance with RCRA and New York State hazardous waste regulations, if appropriate.
New York State - Hazardous Waste Manifest System and Related Standards for Generators, Transporters, and Facilities	6 NYCRR Part 372	Applicable	Provides requirements relating to the use of the manifest system and its recordkeeping requirements. Also establishes requirements for proper storage of hazardous waste. Applies to hazardous waste generators, transporters, and facilities in New York State.	This regulation will be applicable to the onsite storage of generated hazardous waste (if any) and to any company(s) contracted to do treatment work or to transport hazardous materials from the site.
Standards Applicable to Transporters of Applicable Hazardous Waste – RCRA Section 3003	40 CFR Parts 262 and 263 40 CFR Parts 170-179	Applicable	Establishes the responsibility of offsite transporters of hazardous waste in the handling, transportation, and management of the waste. Requires manifesting, recordkeeping, and immediate action in the event of a discharge.	These requirements will be applicable to any company(s) contracted to transport hazardous materials from the site.

Table 4
(cont'd)
Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Potential Chemical, Action, and Location-Specific SCGs

Potential Federal/ State Requirements and Guidance	Citation/Reference	Potential Status	Summary of Requirements/Guidance	Considerations in Remedial Process/Action for Attainment
New York State - Waste Transporter Permits	6 NYCRR Part 364	Applicable	Governs the collection, transport, and delivery of regulated waste within New York State.	Properly permitted haulers will be used if any waste materials are transported offsite.
USDOT Rules for Transportation of Hazardous Materials	49 CFR Parts 107, 171.1 – 172.558	Applicable	Outlines procedures for the packaging, labeling, manifesting, and transportation of hazardous materials.	Any company contracted to transport hazardous waste from the site will be required to follow these regulations.
New York Regulations for Hazardous Waste Management Facilities	6 NYCRR Parts 373-1.1 – 373-1.8	Applicable	Provides requirements and procedures for obtaining a permit to operate a hazardous waste treatment, storage, and disposal facility (TSDF). Also lists contents and conditions of permit.	Any offsite facility accepting waste from the site must be properly permitted.
NYSDEC Technical and Administrative Guidance Memorandums (TAGM)	NYSDEC TAGMs	To be considered	TAGMs are NYSDEC guidance that are to be considered during the remedial process.	Appropriate TAGMs will be considered during the remedial process.
Location-Specific SCGs				
Local Building Permits	Not Available	Applicable	Local authorities may require a building permit for any permanent or semi-permanent structure, such as an onsite water treatment system building or a retaining wall.	If remedial activities require construction of permanent or semi-permanent structures, necessary permits will be obtained.
Sewage Treatment Plant (STP) Influent Requirements	Not Available	Applicable	Treatment plant will have requirements for waters discharged to the plant, including discharge permits.	For alternatives involving the onsite treatment of water and discharge to a STP, a discharge permit will be obtained and treatment will be performed to meet the STP influent requirements.

Table 4
(cont'd)
Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Potential Chemical, Action, and Location-Specific SCGs

Potential Federal/ State Requirements and Guidance	Citation/Reference	Potential Status	Summary of Requirements/Guidance	Considerations in Remedial Process/Action for Attainment
National Historic Preservation Act	36 CFR Part 800	Applicable	Requirements for preservation of historic properties.	Activities taking place on a site on or under consideration for placement of the National Register of Historic Places must be planned to preserve the historic property and minimize harm.
Preservation of Area Containing Artifacts	36 CFR Part 65	Applicable	Requirements for preservation of historical/archeological artifacts.	Activities must be done to identify, preserve, and recover artifacts if the site has been identified as containing significant historical artifacts.
New York Preservation of Historic Structures or Artifacts	Section 14.09	Applicable	Requirements for preservation of historical/archeological artifacts.	Activities must be done to identify, preserve, and recover artifacts if the site has been identified as containing significant historical artifacts.

Table 5

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
No Action	No Action	No Action	Alternative would not include any remedial action.	Technically feasible.
Institutional Controls	Access Restrictions	Deed Restrictions	Deeds for the property would include restrictions on future site use and excavation of subsurface soils.	Potentially applicable.
In-Situ Containment/Control	Capping	Clay/Soil Cap	Placing and compacting clay material or soil material over areas containing constituents of concern.	Not retained. Not feasible for future site use in high traffic areas.
		Asphalt/Concrete Cap	Application of a layer of asphalt or concrete over areas containing constituents of concern.	Technically feasible.
		Multi-Media Cap	Application of clay material and a synthetic membrane over areas containing constituents of concern.	Not retained. Not feasible for future site use in high traffic areas.
	Physical Containment	Slurry Walls	Involves excavating a trench to the depth of a confining base layer while adding a slurry (e.g., soil/cement-bentonite mixture) to limit downgradient migration of constituents of interest.	Not retained. Excavation to confining base layer (located over 100 feet below grade) is not technically practical.

Table 5

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
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Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
In-Situ Containment/Control (cont'd)	Physical Containment (cont'd)	Steel Sheet Piles	Steel sheet piles are driven to the depth of a confining layer to limit downgradient migration of constituents of interest.	Not retained. Installation of sheet piling to confining base layer (located over 100 feet below grade) is not possible.
In-Situ Treatment	Immobilization	Stabilization/Solidification	Treatment process which immobilizes constituents of concern within a solid mass (monolith). A solid monolith is formed by injecting and mixing an immobilization agent into the media. A variety of agents (e.g., portland cement, lime, polymerics, proprietary agents, etc.) have been utilized and could be effective for immobilizing various constituents and media.	Not retained. Potential difficulties related to ability to provide adequate quality assurance/quality control (QA/QC) measures during implementation. Long-term stability and leaching characteristics of solidified material is unknown.
		Vitrification	Immobilizes or destroys constituents by melting the media utilizing electrical currents. The melted media then solidifies to form a glass-like monolith.	Not retained. Presence of underground utilities limits implementability.
	Extraction	Soil Flushing	Groundwater is extracted via extraction wells, passed through a treatment system (if required), extraction media is introduced into the water, and the water is then reinjected into the source areas to flush constituents from soil.	Not retained. This process is difficult to control.

Table 5

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
In-Situ Treatment (cont'd)	Extraction (cont'd)	Steam Stripping	Steam is used to remove VOCs from the media. The removed constituents are collected, recondensed, and treated.	Not retained. Presence of underground utilities and current site use inhibits this process.
		Soil Vapor Extraction	A vacuum is created to extract volatile constituents from vadose zone soils for treatment.	Technically feasible. Addresses management of soil vapors and off-site migration.
		Six-Phase Soil Heating	Electricity is applied to six subsurface electrodes to promote electrical resistive heating of soil and groundwater. This process is conducted in conjunction with soil vapor extraction (SVE) which is used to extract organic constituents volatilized by the heating process.	Not retained. Underground utilities would impede implementation of this process. Process requires large amount of surface area to implement.
		Dynamic Underground Stripping (DUS)/Hydrous Pyrolysis Oxidation (HPO)	Addition of heat (via steam injection and electrical resistive heating) to the subsurface to decrease the viscosity and increase the volitalization and mobility of residual contaminants to facilitate recovery. Process promotes in-situ biodegradation and in-situ hydrous pyrolysis oxidation (HPO).	Not retained. Presence of underground utilities limits implementability.

Table 5

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
In-Situ Treatment (cont'd)	Biodegradation	Enhanced In-Situ Aerobic Biodegradation	Degradation of constituents by utilizing micro-organisms in an aerobic environment with the addition of amendments and controls to enhance the process performance and decrease duration.	Not retained. Oxygen delivery to vadose zone soils is not readily accomplished due to site conditions.
		In-Situ Anaerobic Biodegradation	Degradation of constituents by utilizing micro-organisms in an anaerobic environment.	Not retained. May not effectively address VOCs. Nitrate injection (a regulated compound) would be required which may impair groundwater quality.
	Chemical Treatment	In-Situ Chemical Oxidation	Addition of oxidizing agents (e.g., ozone, hydrogen peroxide, potassium permanganate, etc.) to degrade organic constituents to less-toxic byproducts (e.g., carbon dioxide, water, etc.).	Technically feasible. Delivery of oxidizing agents to vadose zone soil could be accomplished by use of an infiltration gallery consisting of a series of horizontal, slotted or perforated pipes buried approximately 2 feet below the ground surface.

Table 5

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
Removal	Excavation	Excavation	Physical removal of media containing constituents of concern to prevent future migration and exposure. Typical excavation equipment includes backhoes, loaders, and/or dozers.	Technically feasible.
Ex-Situ On-Site Treatment	Extraction	Solvent Extraction	Organic constituents (typically oils) are chemically extracted from the media using various solvents. Constituents are typically separated from the solvent and concentrated in oil phase (which may require additional management). Typically the solvent is recycled and reused.	Not retained. Process is used to remove oil present in high percentages from sludges. Extensive pretreatment may be required.
		On-Site Low-Temperature Thermal Desorption (LTTD)	Process by which soils containing organics with boiling point temperatures less than 800 degrees Fahrenheit are heated in a mobile thermal desorption unit and the organic compounds are desorbed from the soils into an induced air flow. The resulting gas is treated either by condensation and filtration or by thermal destruction.	Technically feasible.
		Steam Stripping	Steam is used to remove volatile constituents from the media. The removed constituents are collected, recondensed, and treated.	Not retained. Space at the site is limited.

Table 5

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
Ex-Situ On-Site Treatment (cont'd)	Recycle/Reuse	On-Site Asphalt Batching (Cold-Mix/Hot-Mix)	Impacted soil is excavated and mixed at the site with a heated asphalt emulsion and Portland cement to stabilize the VOCs in the soil. The end product material may be used as structural fill above the groundwater table.	Technically feasible.
	Thermal Destruction	On-Site Incineration	Use of a mobile incineration unit installed on-site for high-temperature thermal destruction of the organic compounds present in the media.	Not retained. Potential emissions a concern based on site's location adjacent to a residential area.
	Ex-Situ Biodegradation	Biopile	Air and amendments are circulated throughout an engineered pile of covered soil to enhance biodegradation.	Not retained. Space at the site is limited.
		Bioreactor	Amendments are mixed in a reactor to enhance the degradation of organic compounds through the use of micro-organisms in an aerobic or anaerobic environment.	Not retained. Space at the site is limited.

Table 5

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
Ex-Situ On-Site Treatment (cont'd)	Ex-Situ Biodegradation (cont'd)	Land Farming	Media is typically mixed with moisture, nutrients, and oxygen to enhance aerobic biodegradation of organic compounds.	Not retained. Space at the site is limited.
		Composting	Piles of media are created to enable oxygen, moisture, and nutrient amendments to be added in order to enhance degradation by aerobic micro-organisms.	Not retained. Space at the site is limited. Large amounts of reducing amendments may be required.
	Chemical Treatment	Oxidation	Addition of oxidation agents to degrade organic constituents to less-toxic byproducts.	Technically feasible.
	On-Site Disposal	RCRA Landfill	Construction of a landfill that would meet RCRA requirements.	Not retained. Space at the site is limited.
		Solid Waste Landfill	Construction of a landfill that would meet NYSDEC solid waste requirements.	Not retained. Space at the site is limited.

Table 5

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
Off-Site Treatment/Disposal	Recycle/Reuse	Off-Site Asphalt Batching (Cold-Mix/Hot-Mix)	Impacted soil is excavated and mixed at an off-site facility with a heated asphalt emulsion and Portland cement to stabilize the VOCs in the soil. The end product material may be used as structural fill above the groundwater table.	Technically feasible.
		Brick/Concrete Manufacture	Soil is used as a raw material in manufacture of bricks or concrete. Heating in ovens during manufacture volatilizes organics and some inorganics. Other inorganics are bound into the product.	Not retained. Facilities capable of handling material are limited.
		Fuel Blending/Co-Burn in Utility Boiler	Soil is blended with feed coal to fire a utility boiler used to generate steam. Organics are destroyed.	Not retained. Facilities that accept residuals are limited.

Table 5

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
Off-Site Treatment/Disposal (cont'd)	Extraction	Low-Temperature Thermal Desorption (LTTD)	Process by which soils containing organics with boiling point temperatures less than 800 degrees Fahrenheit are heated and the organic compounds are desorbed from the soils into an induced airflow. The resulting gas is treated either by condensation and filtration or by thermal destruction.	Not retained. Identified LTTD treatment facilities are not permitted to treat soil containing PCE at the concentrations detected at the site.
	Thermal Destruction	Incineration	Process which uses high temperatures to thermally destruct organic compounds present in media.	Technically feasible.
	Chemical Treatment	Chemical Oxidation	Addition of oxidation agents to degrade organic constituents to less-toxic byproducts.	Technically feasible.
	Off-Site Disposal	RCRA Subtitle C Landfill	Disposal of media in an existing RCRA permitted landfill.	Technically feasible.
		Subtitle D Solid Waste Landfill	Disposal of media in an existing permitted non-hazardous landfill.	May be technically feasible for non-hazardous soil.

Note:

1. Shaded technologies have not been retained for further evaluation.

Table 6

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
No Action	No Action	No Action	Alternative would not include any remedial action.	Technically feasible.
Institutional Controls	Use Restrictions	Deed Restrictions/ Groundwater Use Restrictions	Deeds for the property and down gradient off-site properties may include restrictions on use of groundwater.	Potentially applicable.
In-Situ Containment/Control	Capping/Infiltration Control	Clay/Soil Cap	Placing and compacting clay material or soil material over areas containing constituents of concern to minimize infiltration of storm water.	Not retained. Not feasible for future site use in high traffic areas.
		Asphalt/Concrete Cap	Application of a layer of asphalt or concrete over areas containing constituents of concern to minimize infiltration of storm water.	Technically feasible.
		Multi-Media Cap	Application of clay material and a synthetic membrane over areas containing constituents of concern to minimize infiltration of storm water.	Not retained. Not practical for use in high traffic areas.
	Hydraulic Containment	Slurry Walls	Involves excavating a trench to the depth of a confining base layer while adding a slurry (e.g., soil/cement-betonies mixture) to limit down gradient migration.	Not retained. Excavation to confining base layer (located over 100 feet below grade) is not practical.
		Steel Sheet Piles	Steel sheet piles are driven to the depth of a confining layer to limit down gradient migration of groundwater.	Not retained. Installation of sheet piling to confining base layer (located over 100 feet below grade) is not practical.

Table 6

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
In-Situ Containment/Control (cont'd)	Hydraulic Containment (cont'd)	Grout Curtains	Holes are drilled around groundwater plumes. A grout is injected under pressure through the holes and allowed to cure to create a vertical barrier.	Not retained. Effectiveness to achieve and maintain desired permeability is limited.
In-Situ Treatment	Biodegradation	Enhanced In-Situ Aerobic Biodegradation	Degradation of constituents by utilizing aerobic micro-organisms with the addition of amendments and controls to enhance the process performance and decrease duration.	Technically feasible.
		Enhanced In-Situ Anaerobic Biodegradation	Degradation of constituents by utilizing anaerobic micro-organisms with the addition of amendments and controls to enhance the process performance and decrease duration.	Technically feasible.
	Chemical Treatment	In-Situ Chemical Oxidation (Focused Application)	Addition of oxidizing agents (e.g., ozone, hydrogen peroxide, etc.) below the water table to degrade organic constituents to less-toxic byproducts.	Technically feasible.
	Monitored Natural Attenuation	Monitored Natural Attenuation	Natural biological and physical processes that result in the reduction of concentration, toxicity, and mobility of chemical constituents. This process relies on long-term monitoring to demonstrate the reduction of impacts caused by chemical constituents.	Technically feasible.

Table 6

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
Extraction	Groundwater Extraction	Vertical Extraction Wells	Vertical wells are installed and utilized to recover groundwater for treatment/disposal.	Technically feasible.
		Horizontal Extraction Wells	Horizontal wells are utilized to replace conventional cluster wells in soils.	Technically feasible.
		Collection Trenches	A zone of higher permeability material is installed within the desired capture area with a perforated collection laterally placed along the base to direct groundwater to a collection area for treatment and/or disposal.	Technically feasible.
		Subsurface Drains	A high permeability channel is installed to provide groundwater collection and redirection of movement for treatment and/or disposal.	Not retained. Difficult to install due to depth to groundwater.
Ex-Situ On-Site Treatment	Chemical Treatment	Ion Exchange	Exchange of constituent cationic or anionic ions in the groundwater with ions held by an ion exchange material. Typically used to remove metallic elements and inorganic ions.	Not retained. Not proven to effectively treat organics.
		UV/Oxidation	Oxidation by subjecting groundwater to ultraviolet light and ozone.	Technically feasible.
		Chemical Oxidation	Addition of oxidizing agents to degrade organic constituents to less-toxic byproducts.	Not retained. Not practical to treat the volume of water to be extracted.

Table 6

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Preliminary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Description	Screening Comments
Ex-Situ On-Site Treatment (cont'd)	Physical Separation	Carbon Adsorption	Process by which organic constituents are adsorbed to the carbon as groundwater is passed through carbon units.	Technically feasible.
		Air Stripping	A process in which VOCs are removed through volatilization by increasing the contact between the groundwater and air.	Technically feasible.
		Precipitation/Coagulation/Flocculation	Process which transforms dissolved constituents into insoluble solids by adding coagulating agents to facilitate subsequent removal from the liquid phase by sedimentation/ filtration. The process usually uses pH adjustment, addition of a chemical precipitant, and flocculation.	Not retained. May not effectively treat organics.
Extraction with Off-Site Treatment/Disposal	Hydraulic Control	Discharge to a local Publicly Owned Treatment Works (POTW)	Treated or untreated water is discharged to a sanitary sewer and treated at a local POTW facility.	Technically feasible.
		Discharge to Surface Water via Storm Sewer	Treated or untreated water is discharged to a surface water, provided that quality and quantity meet the allowable discharge requirements for surface waters (NYSDEC SPDES compliance).	Technically feasible.
		Reinsertion	Groundwater is extracted via extraction wells, passed through a treatment system, and is then reinvested into the ground through injection wells.	Technically feasible.

Note:

1. Shaded technologies have not been retained for further evaluation.

Table 7

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Secondary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Effectiveness	Implementability
No Action	No Action	No Action	Does not achieve the RAOs for soil.	Not applicable.
Institutional Controls	Access Restrictions	Deed Restrictions	This option alone would not meet the RAOs. However, institutional controls could be used in conjunction with other remedial technologies to achieve RAOs.	Readily implementable.
In-Situ Containment/ Control	Capping	Asphalt/Concrete Cap	Effective for reducing infiltration of precipitation/surface water. Effective for reducing potential exposure to impacted surface soils. Long-term effectiveness requires ongoing maintenance and monitoring. Suitable for high-traffic areas.	The property is currently paved with an approximately 6-inch thick slab of concrete. Equipment and materials to construct a new or enhanced low-permeability asphalt/concrete cap are readily available.
In-Situ Treatment	Extraction	Soil Vapor Extraction	Effective for reducing VOC concentrations in soil.	Technically implementable.
	Chemical Treatment	In-Situ Chemical Oxidation	Effective for reducing VOC concentrations in soil provided the proper amount of oxidant reaches affected areas.	Technically implementable. Number of oxidant applications to achieve remedial goals is unknown.
Removal	Excavation	Excavation	Proven process for effectively removing unsaturated soil above the water table.	Technically implementable. Equipment capable of excavating the soil is readily available. Site conditions (i.e., presence of subsurface utilities) inhibits excavation in select areas of the site.

Table 7

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Secondary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Effectiveness	Implementability
Ex-Situ On-Site Treatment	Extraction	On-Site Low-Temperature Thermal Desorption (LTTD)	Proven process for effectively treating organic compounds.	Spatial limitations at the site are potentially a limiting factor.
	Recycle/Reuse	On-Site Asphalt Batching (Cold-Mix/Hot-Mix)	Effective for treating organics and inorganics through volatilization and encapsulation. Thermal pretreatment may be required to prevent leaching. No long-term data available. Bench-scale testing would be required to determine effectiveness.	Potentially implementable. However, may not be effective in the long-term for organic constituents.
	Chemical Treatment	Chemical Oxidation	Proven process for effectively treating organic compounds.	Spatial limitations at the site are potentially a limiting factor.
Off-Site Treatment/Disposal	Recycle/Reuse	Off-Site Asphalt Batching (Cold-Mix/Hot-Mix)	Effective for treating organics and inorganics through volatilization and encapsulation. Thermal pretreatment may be required to prevent leaching. No long-term data available. Bench-scale testing would be required to determine effectiveness.	Permitted facilities are limited.

Table 7

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Secondary Remedial Technology Screening Evaluation for Soil

General Response Action	Remedial Technology	Technology Process	Effectiveness	Implementability
Off-Site Treatment/Disposal (Cont'd)	Thermal Destruction	Incineration	Proven process for effectively addressing organic constituents.	Limited number of treatment facilities, but vendors indicate availability.
	Chemical Treatment	Chemical Oxidation	Proven process for effectively treating organic compounds.	Treatment facilities are limited.
	Disposal	RCRA Subtitle C Landfill	Proven process that can effectively disposal of RCRA hazardous solid waste.	Easily implemented.
		Subtitle D Solid Waste Landfill	Proven process that can effectively disposal of non-hazardous solid waste.	Easily implemented.

Note:

1. Shaded technologies have not been retained for development of remedial alternatives.

Table 8

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Secondary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Effectiveness	Implementability
No Action	None	None	Does not achieve the RAOs for groundwater.	Technically feasible.
Institutional Controls	Use Restrictions	Deed Restrictions/ Groundwater Use Restrictions	This option alone would not meet the RAOs. However, institutional controls could be used in conjunction with other remedial technologies to achieve RAOs.	Readily implementable. Would require coordination with off-site property owners for off-site impacts.
In-Situ Containment/ Control	Capping/Infiltration Control	Asphalt/Concrete Cap	Effective for reducing infiltration of precipitation/surface water to assist in maintaining hydraulic control. Long-term effectiveness requires ongoing maintenance and monitoring. Suitable for high-traffic areas.	The property is currently capped with an approximately 6-inch thick slab of concrete. Equipment and materials necessary to construct a new low permeability asphalt/concrete cap are readily available.
In-Situ Treatment	Biodegradation	Enhanced In-Situ Aerobic Biodegradation	Innovative technology. Process effective for addressing site-related constituents. Radius of influence surrounding injection points is uncertain. A delivery system could be designed based on available bio-geochemical data.	Not retained. Requires presence of appropriate microorganisms and nutrients, as well as appropriate environmental conditions. Microorganisms needed to break VOCs down into innocuous byproducts have not been identified at the site. Delivery of large amounts of supplemental nutrients would be required.

Table 8

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Secondary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Effectiveness	Implementability
In-Situ Treatment (Cont'd)	Biodegradation (Cont'd)	Enhanced In-Situ Anaerobic Biodegradation	Innovative technology. Process effective for addressing site-related constituents. Radius of influence surrounding injection points is uncertain. A delivery system could be designed based on available bio-geochemical data.	Not retained. Requires presence of appropriate microorganisms and nutrients, as well as appropriate environmental conditions. Microorganisms needed to break VOCs down into innocuous byproducts have not been identified at the site. Delivery of large amounts of supplemental nutrients would be required.
	Chemical Treatment	In-Situ Chemical Oxidation (Focused Application)	Innovative technology. Process effective for addressing site-related constituents. Radius of influence surrounding injection points is uncertain. This technology is most efficiently used to reduce chemical concentrations within "hot-spot" areas. Pilot-scale testing would be required to determine effectiveness and implementability.	Effectiveness is based on the ability to deliver oxidizing agents to impacted media.
	Monitored Natural Attenuation	Monitored Natural Attenuation	Potentially achieves RAOs for offsite groundwater in conjunction with other in-situ technology such as biodegradation or chemical oxidation.	Easily implemented. Appropriate microorganisms and environmental conditions have been identified offsite.

Table 8

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Secondary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Effectiveness	Implementability
Removal	Groundwater Removal	Vertical Extraction Wells	Proven process for effectively extracting groundwater. Implementation of this process along with treatment could effectively achieve the RAOs for groundwater.	Easily implemented.
		Horizontal Extraction Wells	Proven process for effectively extracting groundwater. Implementation of this process along with treatment could effectively achieve the RAOs for groundwater.	Not retained. Requires specialized horizontal drilling equipment. Not necessarily appropriate for the site.
		Collection Trenches	Proven process for effectively extracting groundwater. Implementation of this process along with treatment could effectively achieve the RAOs for groundwater.	Not retained. The required depth of the collection trench would likely be below the reach of excavation equipment.
Ex-Situ On-Site Treatment	Chemical Treatment	UV/Oxidation	Proven process for effectively treating organic compounds. Use of this process may effectively achieve the RAOs. May be implemented as part of process treatment train.	Not easily implemented due to limited space. Process equipment capable of performing UV/oxidation is available. A bench-scale treatability study may be required to evaluate the removal efficiency of this process and to make project-specific adjustments to the process. May require special provisions for the storage of process chemicals.

Table 8

Hazardous Waste Disposal, Inc.
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Feasibility Study Report
Secondary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Effectiveness	Implementability
Ex-Situ On-Site Treatment (cont'd)	Physical Separation	Carbon Adsorption	Effective at removing organic constituents. Use of this process may effectively achieve the RAOs. May be implemented as part of process treatment train.	Easily implemented. Carbon adsorption process equipment is readily available. This process can be preceded by other treatment technologies to reduce the amount of carbon used.
		Air Stripping	Effective at removing volatile organic constituents. Use of this process may effectively achieve the RAOs for groundwater. May be implemented as part of process treatment train.	Easily implemented. Air stripping process equipment is readily available.
Off-Site Treatment/Disposal	Hydraulic Control	Discharge to a local Publicly Owned Treatment Works (POTW)	Potentially available process for effectively handling groundwater. Impacted groundwater would require treatment to achieve water quality criteria established by the POTW. Treated groundwater would be subject to additional treatment at the POTW.	Can potentially be implemented, subject to approval by the POTW. Equipment and materials necessary to pretreat and discharge the water to the sanitary sewer system at the site are commercially available. Discharges to the sanitary sewer must meet POTW requirements.
		Discharge to Surface Water via Storm Sewer	Potentially available process for effectively handling groundwater. Impacted groundwater would require treatment to achieve water quality discharge limits.	Can potentially be implemented, subject to approval by the sewer authority. Equipment and materials to treat and discharge the water to the storm sewer system at the site are commercially available. Discharges to surface water must meet the requirements of a SPDES permit.

Table 8

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Secondary Remedial Technology Screening Evaluation for Groundwater

General Response Action	Remedial Technology	Technology Process	Effectiveness	Implementability
Off-Site Treatment/Disposal (cont'd)	Groundwater Discharge (cont'd)	Reinsertion	Proven process for effectively discharging treated groundwater. Prior to reinjection, impacted groundwater would require treatment to achieve water quality criteria established by the NYSDEC. Groundwater reinjection may affect the ability to maintain hydraulic control under groundwater extraction and containment scenarios.	Easily implemented. Equipment and materials to treat and reinject groundwater at the site are available.

Note:

1. Shaded technologies have not been retained for development of remedial alternatives.

Table 9

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 2 -
In-Situ Soil Chemical Oxidation and In-Situ Groundwater Chemical Oxidation (Focused Application)

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
CAPITAL COSTS					
Common Elements					
1	Treatability Study	1	LS	$35,000	$35,000
2	Engineering Design	1	LS	$75,000	$75,000
3	Mobilization/Demobilization	1	LS	$20,000	$20,000
4	Oversight	1	LS	$50,000	$50,000
5	Permitting	1	LS	$15,000	$15,000
6	Reporting	1	LS	$50,000	$50,000
7	Waste Disposal	1	LS	$40,000	$40,000
8	Site Restoration	1	LS	$10,000	$10,000
	Subtotal Common Elements				***$295,000***
In-Situ Soil Chemical Oxidation					
9	Infiltration Gallery Installation	500	LF	$50	$25,000
10	Quarterly Oxidant Injection	3	Each	$75,000	$225,000
11	Verification Soil Sampling and Analysis	3	Events	$12,000	$36,000
	Subtotal In-Situ Soil Chemical Oxidation				***$286,000***
In-Situ Groundwater Chemical Oxidation (Focused Application)					
12	Concrete Removal	1	LS	$7,500	$7,500
13	Injection Well Installation	42	Each	$1,000	$42,000
14	Quarterly Oxidant Injection	4	Each	$110,000	$440,000
15	Quarterly Groundwater Monitoring	4	Events	$7,500	$30,000
	Subtotal In-Situ Groundwater Chemical Oxidation				***$519,500***
	Subtotal Capital Cost				***$1,100,500***
	Engineering and Administration (10%)				***$110,050***
	Contingency (20%)				***$220,100***
	Estimated Capital Cost				**$1,430,650**
ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS					
16	Groundwater Monitoring and Reporting	1	LS	$40,000	$40,000
	Subtotal Annual O&M Cost				***$40,000***
	O&M Contingency (20%)				***$8,000***
	Estimated Annual O&M Cost				**$48,000**
	Present Worth Factor (Year 2, 7%)				**0.8734**
	Total Present Worth of Annual O&M				**$41,923**
	Total Estimated Cost				**$1,472,573**
	Rounded To				**$1,480,000**

General Comments:

1. ***Number of oxidant applications to achieve remedial goals is unknown.***
2. All costs include labor, equipment, and materials, unless otherwise noted.
3. Costs do not include legal fees, negotiations, or oversight by the New York State Department of Environmental Conservation (NYSDEC).

4. Unit costs are in 2003 dollars and are estimated from standard estimating guides, vendors, and professional judgment and experience from other projects.
5. Costs are based on current site information and project understanding.
6. Cost estimates for the FS are for the purpose of comparing relative costs for alternatives against each other and do not represent actual design or construction cost estimates. Following the remedy selection process, record of decision, and pre-design activities, a design/construction cost estimate can be prepared.

Assumptions:

1. Treatability study cost estimate includes costs to remove a small section of concrete pavement, excavate a test pit and perform testing to evaluate potential infiltration/oxidant injection rates, and collect soil samples from the pit for soil oxidant demand testing and laboratory analysis for volatile organic compounds (VOCs). Results of investigation would be used to provide a preliminary design specification for the chemical oxidation treatment alternative, including oxidant injection rate and total volume of oxidant needed.
2. Engineering design cost estimate includes costs to prepare a basis of design document and contract drawings/specifications.
3. Mobilization/demobilization cost estimate includes costs for the mobilization and demobilization of all labor, equipment, and materials necessary to implement this remedial alternative.
4. Oversight cost estimate includes costs for engineering oversight for 2 weeks of infiltration gallery construction and 2 weeks per quarterly injection event, for a total of 8 weeks.
5. Permitting cost estimate includes costs to demonstrate compliance with the substantive permitting requirements for a SPDES/ underground injection control permit for injecting oxidant into the groundwater. Assumes that permit-related efforts will not require more than 100 hours time and costs for travel/meetings/permit fees would not exceed $5,000.
6. Reporting cost estimate includes costs to prepare a report summarizing treatment activities and results obtained for laboratory analysis of verification soil samples and quarterly groundwater samples.
7. Waste disposal cost estimate includes costs for the offsite transportation and disposal of soil removed for trenching to install the infiltration gallery, soil cuttings generated by injection well installation activities, and personal protective equipment. Cost estimate is based on 75 cubic yards (CY) of material and assumes offsite disposal as a hazardous waste at the CWM Chemical Services, LLC facility in Model City, New York. Assumes a soil density of 1.6 tons/CY. Also includes costs for the offsite transportation and disposal of miscellaneous nonhazardous waste generated during the quarterly injection events, including personal protective equipment, disposable sampling equipment, miscellaneous containers, etc.
8. Site restoration cost estimate includes costs for general site cleanup following construction of the infiltration gallery. Does not include costs to remove the infiltration gallery piping following the final treatment or abandon the injection wells.
9. Infiltration gallery installation cost estimate includes costs for installing 6 parallel runs of 2-inch diameter perforated Schedule 80 polyvinyl chloride (PVC) piping to distribute oxidant solution to soil in the vicinity of the piping. Assumes that each run of piping would be between 40 and 95 feet long, and individual piping runs would be spaced 10 feet apart. Includes costs to excavate approximately 500 feet of 2-foot wide by 2-foot deep trench for the piping installation. Cost estimate includes costs to place bedding material beneath/around the piping, imported clean backfill material above the piping, and an asphalt pavement patch at the ground surface. Cost estimate assumes that 25 CY of concrete will be removed and transported to a recycler for crushing and future use as fill material. Assumes concrete does not contain detectable levels of VOC constituents. Assumes shoring/ bracing will not be required.
10. Quarterly oxidant injection cost estimate includes costs to inject a potassium permanganate solution (35 grams per liter KMNO4) into each of the 6 injection gallery lines at a rate of approximately 1.5 gallons per minute per line. Assumes that 9 days would be required for each quarterly injection event. The oxidant solution would be prepared in 5,000 gallon batches (in a 5,000 gallon) frac tank. Approximately 40,000 gallons of oxidant solution would be required for each quarterly injection event at a cost of approximately $16,500 per event. The estimated cost for labor and equipment for each quarterly injection event is $40,000. Assumes a total of 5 tons of potassium permanganate would be required for each quarterly injection event. Cost estimate also includes an additional $15,000 per injection event for uncertainties associated with oxidant demand.

11. Verification soil sampling and analysis cost estimate includes costs for soil boring and sampling activities after each injection event to evaluate the reduction in VOC soil concentrations. Assumes the installation of 12 soil borings to a depth of approximately 15 feet and the collection of two soil samples per boring for laboratory analysis for VOCs following each injection event.
12. Concrete removal cost estimate includes costs to saw cut and remove concrete at proposed injection well cluster locations. Assumes concrete debris would be transported for offsite use as fill material. Assumes concrete does not contain detectable levels of VOCs.
13. Injection well installation cost estimate includes costs to install injection well clusters (2 wells per cluster) in a 100-foot-wide by 150-foot-long area. Assumes well clusters would be arranged in 6 rows with up to 4 well clusters per row. Spacing between well clusters is assumed to be approximately 25 feet. Individual wells would be a maximum of 40 feet deep. Includes costs for concrete curb boxes at each well cluster location.
14. Quarterly oxidant injection cost estimate includes costs to inject a potassium permanganate solution (35 grams per liter $KMnO4$) into each injection well at a rate of approximately 5 gallons per minute per well for a total of 5.5 hours per well per event. Assumes that 8 days would be required for each quarterly injection event. The oxidant solution would be prepared in 5,000 gallon batches (in a 5,000 gallon frac tank). Approximately 85,500 gallons of oxidant solution would be required for each quarterly injection event at a cost of approximately $45,000 per event. The estimated cost for labor and equipment for each quarterly injection event is $35,000. Assumes a total of 12.5 tons of potassium permanganate would be required for each quarterly injection event. Cost estimate includes an additional $30,000 per injection event for uncertainties associated with oxidant demand.
15. Quarterly groundwater monitoring cost estimate includes costs for collecting groundwater samples for field screening and laboratory analysis for VOCs on a quarterly basis for a period of one year at a cost of $7,500 per monitoring event. Assumes sampling would be conducted immediately prior to each treatment.
16. Annual groundwater monitoring and reporting cost estimate includes costs for collecting groundwater samples at the site groundwater monitoring well network approximately 6 months following the final oxidant injection event for field parameters and laboratory analysis for VOCs. Includes preparation of one annual groundwater monitoring report.

Additional Assumptions:

1. Cost estimate assumes an average total organic carbon concentration of 1,000 to 2,000 ppm, a total mass of VOCs in the soil of less than 500 pounds, and no non-aqueous phase liquid (NAPL) in the soil/groundwater.
2. Assumes the oxidant demand for the sand and gravel soil at the HWD site does not exceed 3 grams per kilogram (g/Kg).
3. Cost estimate also assumes groundwater plume of VOCs is 100 feet wide (perpendicular to the groundwater flow direction) by 150 feet long (parallel to groundwater flow direction) and is 30 feet thick. Assumes that the average organic carbon fraction is 0.001.
4. Cost estimate assumes that treatment can be completed in a one year timeframe based on the estimated mass of VOCs assumed to be present in the vadose-zone soil/dissolved phase and the stoichiometric relationship for the amount of oxidant required to destroy the estimated total mass of VOCs. Assumes an oxidant efficiency of under 20% and an oxidant loading factor of safety of 1.25. Assumes there would be no re-bound in groundwater VOC concentrations after the final (fourth) treatment.
5. Assumes that redox-sensitive metals such as arsenic, chromium, and selenium will not be identified in groundwater at concentrations exceeding groundwater quality standards following the oxidant injection events.
6. Cost estimate assumes a soil infiltration rate of 10 inches per hour.
7. Cost estimate assumes that off-gas treatment would not be required in connection with treatment.

Table 10

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 3 -
Soil Vapor Extraction and In-Situ Groundwater Chemical Oxidation (Focused Application)

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
CAPITAL COSTS					
Common Elements					
1	Engineering Design	1	LS	$75,000	$75,000
2	Mobilization/Demobilization	1	LS	$25,000	$25,000
3	Oversight	1	LS	$55,000	$55,000
4	Permitting	1	LS	$30,000	$30,000
5	Waste Disposal	1	LS	$40,000	$40,000
6	Site Restoration	1	LS	$10,000	$10,000
Subtotal Common Elements					***$235,000***
Soil Vapor Extraction					
7	Soil Vapor Extraction System Pilot Study	1	LS	$30,000	$30,000
8	Soil Vapor Extraction System Wells	6	Each	$2,500	$15,000
9	Conveyance Piping	250	LF	$50	$12,500
10	Soil Vapor Extraction System Equipment and Installation	1	LS	$85,000	$85,000
11	Soil Vapor Extraction System Startup	1	LS	$12,000	$12,000
Subtotal Soil Vapor Extraction					***$154,500***
In-Situ Groundwater Chemical Oxidation (Focused Application)					
12	Treatability Study	1	LS	$35,000	$35,000
13	Concrete Removal	1	LS	$7,500	$7,500
14	Injection Well Installation	42	Each	$1,000	$42,000
15	Engineering Observation	8	Days	$1,500	$12,000
16	Quarterly Oxidant Injection	4	Each	$110,000	$440,000
17	Quarterly Groundwater Monitoring	4	Events	$7,500	$30,000
18	Reporting	1	LS	$30,000	$30,000
Subtotal Groundwater Chemical Oxidation					***$596,500***
Subtotal Capital Cost					***$986,000***
Engineering and Administration (10%)					***$98,600***
Contingency (20%)					***$197,200***
Estimated Capital Cost					**$1,281,800**
ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS					
Soil Vapor Extraction					
19	Soil Vapor Extraction System O&M	1	LS	$65,000	$65,000
20	Annual Reporting	1	LS	$20,000	$20,000
Subtotal Annual O&M Cost					***$85,000***
O&M Contingency (20%)					***$17,000***
Estimated Annual O&M Cost					**$102,000**
Present Worth Factor (5 yrs., 7%)					**4.1002**

Table 10

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 3 -
Soil Vapor Extraction and In-Situ Groundwater Chemical Oxidation (Focused Application)

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
	Total Present Worth of Annual O&M				**$418,220**
In-Situ Groundwater Chemical Oxidation (Focused Application)					
21	Groundwater Monitoring and Reporting	1	LS	$40,000	$40,000
	Subtotal Annual O&M Cost				***$40,000***
	O&M Contingency (20%)				***$8,000***
	Estimated Annual O&M Cost				**$48,000**
	Present Worth Factor (Year 7, 7%)				**0.6227**
	Total Present Worth of Annual O&M				**$29,890**
	Total Estimated Cost				**$1,729,910**
	Rounded To				**$1,730,000**

General Comments:

1. All costs include labor, equipment, and materials, unless otherwise noted.
2. Costs do not include legal fees, negotiations, or oversight by the New York State Department of Environmental Conservation (NYSDEC).
3. Unit costs are in 2003 dollars and are estimated from standard estimating guides, vendors, and professional judgment and experience from other projects.
4. Costs are based on current site information and project understanding.
5. Cost estimates for the FS are for the purpose of comparing relative costs for alternatives against each other and do not represent actual design or construction cost estimates. Following the remedy selection process, record of decision, and pre-design activities, a design/construction cost estimate can be prepared.

Assumptions:

1. Engineering design cost estimate includes costs to prepare a basis of design document and contract drawings/specifications.
2. Mobilization/demobilization cost estimate includes costs for the mobilization and demobilization of all labor, equipment, and materials necessary to implement this remedial alternative.
3. Oversight cost estimate includes costs for engineering oversight of remedial construction activities and quarterly injection activities for this alternative. Cost estimate is based on 3 weeks of field time for the soil vapor extraction (SVE) system construction. Cost estimate is also based on field time for four quarterly groundwater chemical oxidation injection events at 100 hours per event.
4. Permitting cost estimate includes costs to obtain an air discharge permit from the NYSDEC for the SVE system. Also includes costs to demonstrate compliance with the substantive permitting requirements for a SPDES/underground injection control permit for injecting oxidant into the groundwater. Assumes that permit-related efforts will not require more than 100 hours time and costs for travel/meetings/permit fees would not exceed $5,000.
5. Waste disposal cost estimate includes costs for the offsite transportation and disposal of soil removed for trenching to install the SVE conveyance piping, soil cuttings generated by well installation activities, and personal protective equipment. Cost estimate is based on 75 cubic yards (CY) of material and assumes offsite disposal as a hazardous waste at the CWM Chemical Services, LLC facility in Model City, New York. Assumes a soil density of 1.6 tons/CY. Also includes costs for the offsite transportation and disposal of miscellaneous nonhazardous waste generated during the quarterly injection events, including personal protective equipment, disposable sampling equipment, miscellaneous containers, etc.
6. Site restoration cost estimate includes costs for general site cleanup following construction of the SVE treatment system. Does not include costs to abandon the SVE wells, remove the conveyance piping, and remove all treatment system components. Also does not include costs to abandon the chemical oxidation injection wells.

7. Soil vapor extraction system pilot study and design cost estimate includes costs for a pilot study that would include the use of a rented blower to extract vapors from one or two SVE wells to further evaluate the soil permeability and volatile organic compound (VOC) mass removal rate. Costs for the SVE wells are included under Item No. 8.
8. Soil vapor extraction system wells cost estimate includes costs for 6 vertical SVE wells, placed in two rows and spaced approximately 30 feet apart. Assumes each well would be approximately 12 feet deep and be constructed using 4-inch diameter polyvinyl chloride (PVC) piping. Assumes a radius of influence of greater than 20-feet per well.
9. Conveyance piping cost estimate includes costs for excavating approximately 250 feet of 2-foot wide by 4-foot deep trench and installing 4-inch diameter PVC conveyance piping in the trench to convey extracted soil vapor to an SVE treatment system in the southwest corner of the site. Cost estimate includes costs for placing bedding material beneath/around the piping, imported clean backfill material above the piping, and an asphalt pavement patch at the ground surface. Cost estimate assumes approximately 25 CY of concrete will be removed and transported to a recycler for crushing and future use as fill material. Assumes concrete does not contain detectable levels of VOC constituents. Does not include costs for providing temporary shoring/bracing in the trench.
10. Soil vapor extraction system equipment and installation cost estimate includes costs for a 10 to 15 horsepower rotary lobe blower to deliver an estimated air flow rate of 750 cubic feet per minute (CFM) at approximately 20-inches water column, a vapor/liquid separator module (knock-out pot), control panel, and 8-foot wide by 20-foot long skid-mounted steel framed enclosure for approximately $40,000. Cost estimate also includes two 2,000 pound skid-mounted vapor-phase granular-activated carbon filters/vessels equipped with piping/flex hoses and sample ports for approximately $15,000. Includes approximately $5,000 for establishing electrical service, $15,000 for mechanical installation, and $10,000 for miscellaneous expenses.
11. Soil vapor extraction system startup cost estimate includes costs to startup the treatment system, including making any necessary adjustments to air flow rates from header lines and performing troubleshooting, as needed. Cost estimate is based on 3 site visits during the first week of operation, 2 site visits during the second week of operation, and 1 site visit during the third and fourth weeks of operation at $1,200 per visit.
12. Treatability study cost estimate includes costs to conduct a treatability study to evaluate oxidant demand and provide a preliminary design specification for oxidant application.
13. Concrete removal cost estimate includes costs to saw cut and remove concrete at proposed injection well cluster locations. Assumes concrete debris would be transported for offsite use as fill material. Assumes concrete does not contain detectable levels of VOCs.
14. Injection well installation cost estimate includes costs to install injection well clusters (2 wells per cluster) in a 100-foot-wide by 150-foot-long area. Assumes well clusters would be arranged in 6 rows with up to 4 well clusters per row. Spacing between well clusters is assumed to be approximately 25 feet. Individual wells would be a maximum of 40 feet deep. Includes costs for concrete curb boxes at each well cluster location.
15. Engineering observation cost estimate includes costs for an onsite engineer/geologist to characterize soil encountered during well installation activities and coordinate the installation of the injection wells.
16. Quarterly oxidant injection cost estimate includes costs to inject a potassium permanganate solution (35 grams per liter $KMnO_4$) into each injection well at a rate of approximately 5 gallons per minute per well for a total of 5.5 hours per well per event. Assumes that 8 days would be required for each quarterly injection event. The oxidant solution would be prepared in 5,000 gallon batches (in a 5,000 gallon frac tank). Approximately 85,500 gallons of oxidant solution would be required for each quarterly injection event at a cost of approximately $45,000 per event. The estimated cost for labor and equipment for each quarterly injection event is $35,000. Assumes a total of 12.5 tons of potassium permanganate would be required for each quarterly injection event. Cost estimate includes an additional $30,000 per injection event for uncertainties associated with oxidant demand.
17. Quarterly groundwater monitoring cost estimate includes costs for collecting groundwater samples for field screening and laboratory analysis for VOCs on a quarterly basis for a period of one year at a cost of $7,500 per monitoring event. Assumes sampling would be conducted immediately prior to each treatment.

18. Reporting cost estimate includes costs to prepare an annual report documenting the groundwater treatment and results for the quarterly groundwater monitoring.
19. Soil vapor extraction system O&M cost estimate includes costs for bi-monthly site visits to inspect treatment system components, evaluate treatment system performance (i.e., conduct screening using a photoionization detector), and make necessary adjustments. Cost estimate includes 24 site visits per year at a cost of $1,200 per visit ($30,000 per year). Cost estimate also includes annual changeout of 2,000 pounds of carbon at $1.50 per pound ($3,000 per year), electricity to operate the treatment sytem ($10,000 per year), and coordination/miscellaneous repairs ($20,000 per year). It is assumed that carbon changeout will not be required more than once per year based on the estimated total mass of VOCs in the soil (less than 500 pounds) and a conservative estimated carbon adsorption efficiency of 10%.
20. Annual reporting cost estimate includes costs to prepare annual reports to summarize treatment system operation and maintenance activities performed, and results obtained for performance monitoring and final verification sampling.
21. Annual groundwater monitoring and reporting cost estimate includes costs for collecting groundwater samples at the site groundwater monitoring well network approximately 6 months following the final oxidant injection event for field parameters and laboratory analysis for VOCs. Includes preparation of one annual groundwater monitoring report.

Additional Assumptions:

1. Cost estimate is based on SVE system operating for 5 years.
2. Cost estimate assumes that the in-siu groundwater chemical oxidation treatment can be completed in a one year timeframe based on the estimated mass of VOCs assumed to be present in the dissolved phase and sorbed phase and the stoichiometric relationship for the amount of oxidant required to destroy the estimated total mass of VOCs. Assumes an oxidant efficiency of under 20% and an oxidant loading factor of safety of 1.25. Assumes there would be no re-bound in VOC concentrations after the final (fourth) treatment.
3. Cost estimate assumes that there is no non-aqueous phase liquid (NAPL) in the soil/groundwater. Also assumes that redox sensitive metals such as arsenic, chromium, and selenium will not be identified in groundwater at concentrations exceeding groundwater quality standards following the oxidant injection events.
4. Cost estimate also assumes groundwater plume of VOCs is 100 feet wide (perpendicular to the groundwater flow direction) by 150 feet long (parallel to groundwater flow direction) and is 30 feet thick. Assumes that the average organic carbon fraction is 0.001.
5. Assumes the oxidant demand for the saturated soil does not exceed 1 gram per kilogram (g/Kg).

Table 11

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 4 -
Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
CAPITAL COSTS					
Common Elements					
1	Engineering Design	1	LS	$50,000	$50,000
2	Mobilization/Demobilization	1	LS	$25,000	$25,000
3	Oversight	1	LS	$75,000	$75,000
4	Site Restoration	1	LS	$10,000	$10,000
				Subtotal Common Elements	***$160,000***
Asphalt Cap/Institutional Controls					
5	Geotextile	12,000	SF	$0.20	$2,400
6	Geomembrane	12,000	SF	$0.75	$9,000
7	Geosynthetic Drainage Composite	12,000	SF	$0.60	$7,200
8	Dense Graded Aggregate (6-inches)	225	CY	$30	$6,750
9	Bituminous Asphalt Base Course (4-inches)	12,000	SF	$1.25	$15,000
10	Bituminous Asphalt Top Course (2-inches)	12,000	SF	$0.75	$9,000
11	Storm Sewer Manhole Modifications	1	LS	$3,000	$3,000
12	Institutional Controls	1	LS	$5,000	$5,000
				Subtotal Asphalt Cap/Institutional Controls	***$57,350***
Groundwater Extraction/Onsite Treatment					
13	Permitting	1	LS	$30,000	$30,000
14	Extraction Wells	3	Each	$6,000	$18,000
15	Extraction Pumps and Controls	3	Each	$3,000	$9,000
16	Extraction Transfer Piping	125	LF	$70	$8,750
17	Pre-Engineered Building Enclosure	1,600	SF	$75	$120,000
18	5,000 Gallon Equalization Tank	1	Each	$5,000	$5,000
19	Multi-Media Filter	1	Each	$15,000	$15,000
20	Air Stripper and Effluent Discharge Pump	1	Each	$60,000	$60,000
21	Catalytic Oxidizer	1	Each	$175,000	$175,000
22	Carbon Adsorption System	1	Each	$20,000	$20,000
23	Miscellaneous Mechanical	1	LS	$40,000	$40,000
24	Miscellaneous Electrical & Controls	1	LS	$60,000	$60,000
25	System Startup	1	LS	$50,000	$50,000
26	Miscellaneous Waste Disposal	1	LS	$25,000	$25,000
				Subtotal Groundwater Extraction/Onsite Treatment	***$635,750***
				Subtotal Capital Cost	***$853,100***
				Engineering and Administration (10%)	***$85,310***
				Contingency (20%)	***$170,620***
				Estimated Capital Cost	**$1,109,030**

Table 11

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 4 -
Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS					
Annual O&M					
27	Annual Cap Maintenance	1	LS	$5,000	$5,000
28	Treatment System O&M	1	LS	$130,000	$130,000
29	Utilities	1	LS	$25,000	$25,000
30	Groundwater Monitoring and Reporting	1	LS	$30,000	$30,000
31	Waste Disposal	1	LS	$20,000	$20,000
	Subtotal Annual O&M Cost				***$210,000***
	O&M Contingency (20%)				***$42,000***
	Estimated Annual O&M Cost				**$252,000**
	Present Worth Factor (30 years, 7%)				**12.4090**
	Total Present Worth of Annual O&M				**$3,127,068**
5-Year Equipment Changeout					
32	Pumps and Blowers	1	LS	$20,000	$20,000
33	Catalytic Oxidizer Catalyst	1	LS	$50,000	$50,000
	Subtotal 5-Year Equipment Changeout Cost				***$70,000***
	Changeout Contingency (20%)				***$14,000***
	Estimated 5-Year Equipment Changeout Cost				**$84,000**
	Present Worth Factor (Years 5, 15, 20, 25, 30, 7%)				**2.1577**
	Total Present Worth of 5-Year Changeout				**$181,247**
	Total Estimated Cost				**$4,417,345**
	Rounded To				**$4,420,000**

General Comments:

1. All costs include labor, equipment, and materials, unless otherwise noted.
2. Costs do not include legal fees, negotiations, or oversight by the New York State Department of Environmental Conservation (NYSDEC).
3. Unit costs are in 2003 dollars and are estimated from standard estimating guides, vendors, and professional judgment and experience from other projects.
4. Costs are based on current site information and project understanding.
5. Cost estimates for the FS are for the purpose of comparing relative costs for alternatives against each other and do not represent actual design or construction cost estimates. Following the remedy selection process, record of decision, and pre-design activities, a design/construction cost estimate can be prepared.

Assumptions:

1. Design cost estimate includes costs for all labor and materials necessary to design and prepare contract documents for the remedial elements of this alternative. Assumes that existing surface water drainage structures will need to be replaced. Assumes that a storm water runoff evaluation will not be required.
2. Mobilization/demobilization cost estimate includes costs for the mobilization and demobilization of all labor, equipment, and materials necessary to implement this remedial alternative.
3. Oversight cost estimate includes costs for engineering oversight of remedial construction activities for this alternative. Cost estimate is based on 10 weeks time in the field and includes rental of air monitoring equipment.

Table 11

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 4 -
Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment

4. Site restoration cost estimate includes costs for general site cleanup following installation of the cap and installation of the treatment system.
5. Geotextile cost estimate includes costs to install an 8-ounce non-woven geotextile over the existing concrete pavement surface within the limits to be capped.
6. Geomembrane cost estimate includes costs to install a 40-mil thick high-density polyethylene geomembrane with welded seams over the geotextile.
7. Geosynthetic drainage composite cost estimate includes costs to install a composite drainage layer to convey water that seeps through the upper cap layers (bituminous asphalt top course/base material) away from the capped area.
8. Dense graded aggregate cost estimate includes costs to install an approximately 6-inch thick layer of interlocking stone to serve as a subbase for the bituminous asphalt top and base courses.
9. Bituminous asphalt base course cost estimate includes costs for a 4-inch thick layer of bituminous asphalt to serve as a base layer.
10. Bituminous asphalt top course cost estimate includes costs for a 2-inch thick layer of bituminous asphalt to serve as the wearing course.
11. Storm sewer manhole modifications cost estimate includes costs to install additional riser materials to match the new final grade established by construction of the engineered cap.
12. Institutional controls cost estimate includes costs for a deed restriction to notify future property owners of the presence of chemical constituents in soil at the site, the need to maintain the cap over the soil, and the need for health and safety provisions/ cap repair in the event that excavation activities had to occur.
13. Permitting cost estimate includes costs to obtain a permit for discharge of treated groundwater to the municipal sanitary sewer system. Assumes that permitting will require no more than 100 hours time and and for travel/meetings/permit fees would not exceed $5,000.
14. Extraction wells cost estimate includes costs to install three 6-inch diameter stainless steel extraction wells to a depth of approximately 40 feet below the ground surface. Cost estimate includes a concrete curb boxes, totalizing flow meters, pressure gauges, and valves. Also includes well development and survey activities to document the well locations/elevations.
15. Extraction pumps and controls cost estimate includes costs for submersible extraction pumps capable of pumping 25 gallons per minute (gpm) each and related water level sensors/flow controllers.
16. Extraction transfer piping cost estimate includes costs to excavate approximately 125 feet of 2-foot wide by 4-foot deep trench and installing 4- to 6-inch diameter high density polyetheylene (HDPE) dual-containment piping in the trench. Cost estimate includes costs for placing bedding material beneath/around the piping, imported clean backfill material above the piping, and an asphalt pavement patch at the ground surface.
17. Pre-engineered building enclosure cost estimate includes costs to provide and erect an approximately 40-foot long by 40-foot wide pre-engineered building system, including the foundation, concrete slab, and heating/ventilation.
18. 5,000 gallon equalization tank cost estimate includes costs to provide and install a 5,000 gallon capacity polyethylene tank for flow equalization prior to treatment.
19. Multi-media filters cost estimate includes costs for providing two sand filters in parallel to filter particles greater than 10 to 20 microns in size.
20. Air stripper and effluent discharge pump cost estimate includes costs to provide and install a low-profile (i.e., shallow-tray type) air stripper to treat groundwater containing volatile organic compounds (VOCs) at a maximum flow rate of 75 gpm. Also includes an effluent discharge pump to convey water to the municipal sanitary sewer system. Assumes that the existing sanitary sewer system can accommodate an additional flow of 75 gpm.
21. Catalytic oxidizer cost estimate includes costs to provide and install a catalytic oxidizer to treat the exhaust from the air stripper to meet requirements of the NYSDEC.
22. Carbon adsorption system cost estimate includes costs to provide and install two 2,000 pound skid-mounted carbon vessels piped in parallel to serve as polishing units to treat VOCs unable to be treated by the air stripper in order to meet site-specific discharge requirements.

Table 11

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 4 -
Asphalt Cap/Institutional Controls and Groundwater Extraction/Onsite Treatment

23. Miscellaneous mechanical cost estimate includes costs to provide and install pumps, piping and valves, fittings, gauges, pipe supports, etc.
24. Miscellaneous electrical & controls cost estimate includes costs to provide and install conduits and wiring, electrical panels, instrumentation, lights, receptacles, programmable logic controller, and other electrical components.
25. System startup cost estimate includes costs to conduct hydraulic testing, groundwater pumping tests, sampling and analysis activities, and troubleshooting during the startup of the treatment system.
26. Miscellaneous waste disposal cost estimate includes costs to dispose of concrete/soil removed for trenching to install extraction transfer piping, soil cuttings generated by well installation activities, treatment residuals, disposable equipment, and personal protective equipment at a facility permitted to accept the materials.
27. Annual cap maintenance cost estimate includes costs for sealing cracks in the bituminous asphalt pavement and performing other minor repairs that may be needed.
28. Treatment system O&M cost estimate includes costs for weekly site visits to inspect treatment system components, evaluate treatment system performance (i.e., collect influent and treated effluent samples for laboratory analysis for VOCs), and make necessary adjustments. Cost estimate assumes 52 site visits per year at a cost of $1,200 per visit ($62,500), analysis of four water samples for VOCs per event plus quality assurance quality controls samples (7 samples @ $125/sample = $875 per sampling event and $45,500 per year), photoionization detector (PID) monitoring of the air discharge ($5,000 per year). Also includes $10,000 per year for labor and expenses to make repairs to the treatment system and $5,000 per year for carbon changeout.
29. Utilities cost estimate includes costs for electricity to operate the submersible well pump, effluent discharge pump, air stripper blowers, and electrical controls. Also includes natural gas for the catalytic oxidizer.
30. Groundwater monitoring and reporting cost estimate includes costs to collect groundwater samples at the site groundwater monitoring well network on an annual basis for field parameters and laboratory analysis for VOCs. Includes preparation of annual groundwater monitoring reports.
31. Waste disposal cost estimate includes costs to dispose of miscellaneous wastes generated by O&M activities, including disposable sampling equipment and personal protective equipment, and costs to discharge treated groundwater to a local POTW.
32. Pumps and blowers 5-year equipment changeout cost estimate includes costs to replace the submersible well pump, effluent discharge pump, and air stripper blowers every 5 years.
33. Catalytic oxidizer catalyst cost estimate includes costs to replace the catalyzer in the oxider used to treat emissions from the air stripper.

Table 12

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 5 -
Soil Excavation and Offsite Incineration/Disposal and Groundwater Extraction/Onsite Treatment

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
CAPITAL COSTS					
Common Elements					
1	Engineering Design	1	LS	$90,000	$90,000
2	Mobilization/Demobilization	1	LS	$25,000	$25,000
3	Oversight	1	LS	$100,000	$100,000
4	Site Restoration	1	LS	$10,000	$10,000
				Subtotal Common Elements	***$225,000***
Soil Excavation and Offsite Incineration/Disposal					
5	Material Staging Area Construction	1	LS	$10,000	$10,000
6	Concrete Pavement Removal	100	CY	$45	$4,500
7	Sheetpile Wall Installation	12,000	SF	$30	$360,000
8	Soil Excavation/Handling	1,300	CY	$20	$26,000
9	Vapor Suppressant Foam	1	LS	$10,000	$10,000
10	Waste Characterization Sample Analyses	6	Each	$1,000	$6,000
11	Transportation and Offsite Disposal of Nonhazardous Waste	550	tons	$150	$82,500
12	Transportation and Offsite Disposal of Hazardous Waste	900	tons	$275	$247,500
13	Transportation and Offsite Incineration of Hazardous Waste	900	tons	$1,000	$900,000
14	Storm Sewer Replacement	1	LS	$15,000	$15,000
15	Sand/Gravel Backfill Material Placement	1,250	CY	$25	$31,250
16	Dense Graded Aggregate (6-inches)	80	CY	$30	$2,400
17	Bituminous Asphalt Base Course (4-inches)	4,500	SF	$1.25	$5,625
18	Bituminous Asphalt Top Course (2-inches)	4,500	SF	$0.65	$2,925
19	Reporting	1	LS	$20,000	$20,000
	Subtotal Soil Excavation and Offsite Incineration/Disposal				***$1,723,700***
Groundwater Extraction/Onsite Treatment					
20	Permitting	1	LS	$30,000	$30,000
21	Extraction Wells	3	Each	$6,000	$18,000
22	Extraction Pumps and Controls	3	Each	$3,000	$9,000
23	Extraction Transfer Piping	125	LF	$70	$8,750
24	Pre-Engineered Building Enclosure	1,600	SF	$75	$120,000
25	5,000 Gallon Equalization Tank	1	Each	$5,000	$5,000
26	Multi-Media Filter	1	Each	$15,000	$15,000
27	Air Stripper and Effluent Discharge Pump	1	Each	$60,000	$60,000
28	Catalytic Oxidizer	1	Each	$175,000	$175,000
29	Carbon Adsorption System	1	Each	$20,000	$20,000
30	Miscellaneous Mechanical	1	LS	$40,000	$40,000
31	Miscellaneous Electrical & Controls	1	LS	$60,000	$60,000
32	System Startup	1	LS	$50,000	$50,000

Table 12

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Cost Estimate for Alternative 5 -
Soil Excavation and Offsite Incineration/Disposal and Groundwater Extraction/Onsite Treatment

Item #	Description	Estimated Quantity	Unit	Unit Price	Estimated Amount
33	Miscellaneous Waste Disposal	1	LS	$25,000	$25,000
				Subtotal Groundwater Extraction/Onsite Treatment	*$635,750*
				Subtotal Capital Cost	*$2,584,450*
				Engineering and Administration (10%)	*$258,445*
				Contingency (20%)	*$516,890*
				Estimated Capital Cost	**$3,359,785**
ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS					
Annual O&M					
34	Treatment System O&M	1	LS	$130,000	$130,000
35	Utilities	1	LS	$25,000	$25,000
36	Groundwater Monitoring and Reporting	1	LS	$30,000	$30,000
37	Waste Disposal	1	LS	$5,000	$5,000
				Subtotal Annual O&M Cost	*$190,000*
				O&M Contingency (20%)	*$38,000*
				Estimated Annual O&M Cost	**$228,000**
				Present Worth Factor (30 years, 7%)	**12.4090**
				Total Present Worth of Annual O&M	**$2,829,252**
5-Year Equipment Changeout					
38	Pumps and Blowers	1	LS	$20,000	$20,000
39	Catalytic Oxidizer Catalyst	1	LS	$50,000	$50,000
				Subtotal 5-Year Equipment Changeout Cost	*$70,000*
				Changeout Contingency (20%)	*$14,000*
				Estimated 5-Year Equipment Changeout Cost	**$84,000**
				Present Worth Factor (Years 5, 15, 20, 25, 30, 7%)	**2.1577**
				Total Present Worth of 5-Year Changeout	**$181,247**
				Total Estimated Cost	**$6,370,284**
				Rounded To	**$6,380,000**

General Comments:

1. All costs include labor, equipment, and materials, unless otherwise noted.
2. Costs do not include legal fees, negotiations, or oversight by the New York State Department of Environmental Conservation (NYSDEC).
3. Unit costs are in 2003 dollars and are estimated from standard estimating guides, vendors, and professional judgment and

experience from other projects.
4. Costs are based on current site information and project understanding.
5. Cost estimates for the FS are for the purpose of comparing relative costs for alternatives against each other and do not represent actual design or construction cost estimates. Following the remedy selection process, record of decision, and pre-design activities, a design/construction cost estimate can be prepared.

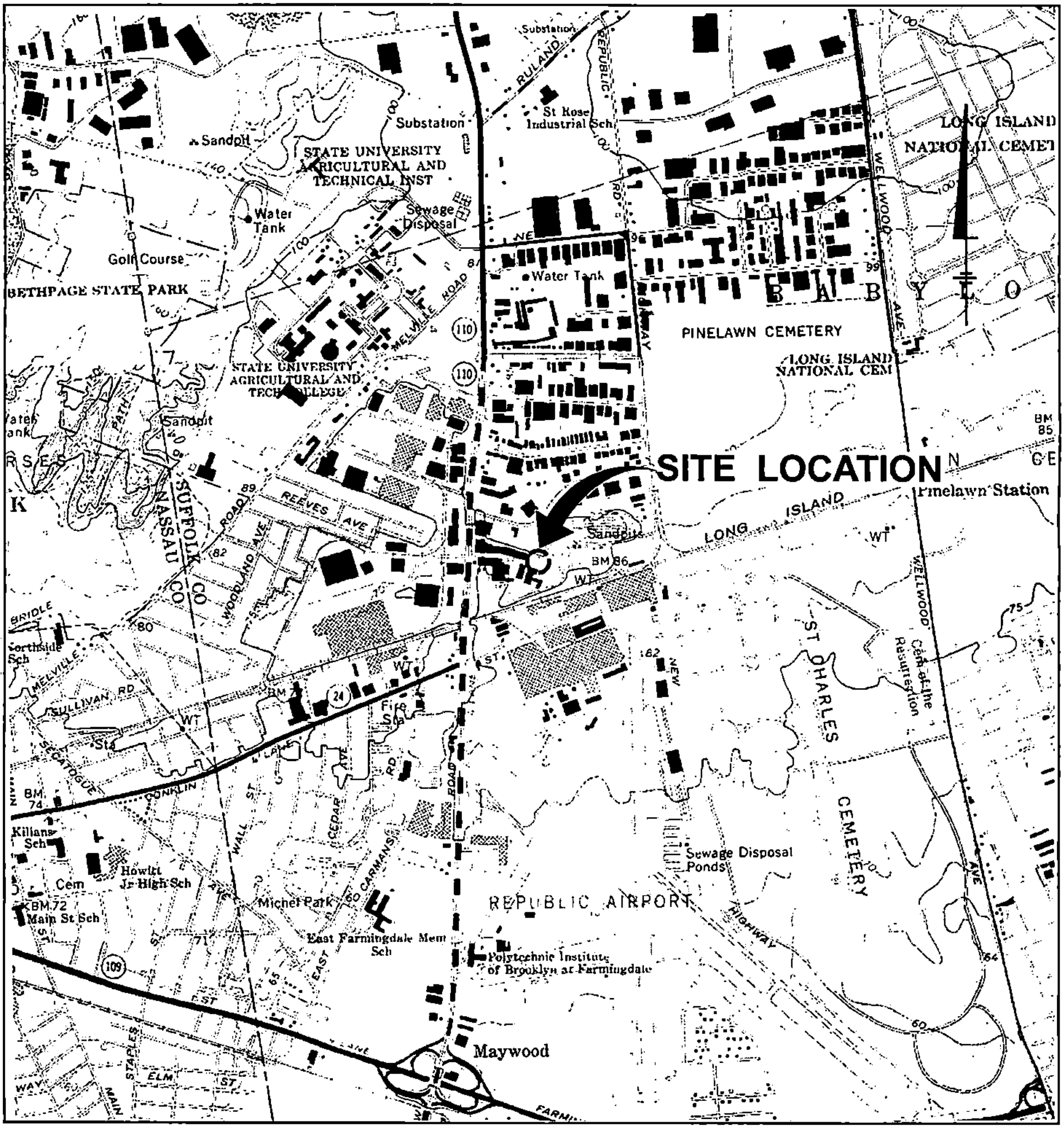
Assumptions:
1. Engineering design cost estimate includes costs for all labor and materials necessary to design and prepare contract documents for the remedial elements of this alternative. Also includes additional sampling to verify final excavation limits prior to sheetpile wall installation.
2. Mobilization/demobilization cost estimate includes costs for the mobilization and demobilization of all labor, equipment, and materials necessary to implement this remedial alternative.
3. Oversight cost estimate includes costs for engineering oversight of remedial construction activities for this alternative. Cost estimate is based on 15 weeks time in the field and includes rental of air monitoring equipment.
4. Site restoration cost estimate includes costs for general site cleanup following completion of excavation/backfilling activities and following installation of the groundwater treatment system.
5. Material staging area construction cost estimate includes costs to construct a 70-foot long by 60-foot wide lined pad for temporary staging/characterization of excavated soil. It is assumed that the staging area would consist of a 4-inch thick granular fill base layer (interlocking stone), a 40-mil high-density polyethylene (HDPE) liner over the base layer and bermed sidewalls formed using granular fill, and an 8-inch thick sacrificial sand layer over the liner.
6. Concrete pavement removal cost estimate includes costs for removing the existing concrete pavement over the approximately 4,500 square foot soil excavation area. Assumes that the average concrete thickness is 8 inches and that the concrete would be transported for offsite crushing/use as hard fill. Assumes concrete does not contain detectable levels of VOCs.
7. Sheetpile wall installation cost estimate includes costs for installing sheetpile wall around the proposed excavation limits. Assumes that the wall would be approximately 300 feet long and would extend to a depth of 40 feet below grade to permit excavation to a maximum depth of approximately 13 feet.
8. Soil excavation/handling cost estimate includes costs for excavating approximately 1,300 cubic yards of soil containing volatile organic compounds (VOCs) and transferring the excavated soil to the material staging area for characterization. Cost estimate assumes that soil would be excavated to depths ranging from 6 to 13 feet below grade from a 4,500 square foot area. Includes costs for measures to suppress vapors (adding lime, covering soil, etc.).
9. Vapor suppressant foam cost estimate includes costs for spraying a water-based suppressant foam over the excavation area and soil stockpiles to control odors/reduce VOC emissions during excavation/handling activities. Cost estimate is based on 20 drums of foam @ $275/drum ($5,500), sprayer rental ($2,000 for one month), and labor. Assumes it will not be necessary to provide a sprung structure under negative air pressure with vapor phase carbon for air emissions treatment. The potential need for a sprung structure would be evaluated during remedial design.
10. Waste characterization sample analyses cost estimate includes costs for collecting waste characterization soil samples at a frequency of one sample per approximately 250 CY of excavated soil. Assumes that each sample would be analyzed for Toxicity Characteristic Leaching Procedure (TCLP) VOCs, TCLP semi-volatile organic compounds (SVOCs), TCLP metals, ignitability, corrosivity, reactivity, polychlorinated biphenyls (PCBs), and total VOCs.
11. Transportation and offsite disposal of nonhazardous waste cost estimate assumes that approximately 350 tons of soil will be characterized as nonhazardous (i.e., based on the analytical results obtained for one waste characterization sample) and transported to the Waste Management (WM) High Acres Subtitle D landfill located in Fairport, New York for disposal as a nonhazardous waste. Also assumes that materials used to construct the soil staging pads (an estimated 200 tons) will be transported for offsite disposal as a nonhazardous waste. Soil density is assumed to be 1.6 tons per cubic yard.
12. Transportation and offsite disposal of hazardous waste cost estimate includes costs for transportation of 900 tons of soil anticipated to be characterized as a RCRA hazardous waste that meets land disposal restrictions (i.e., total PCE concentrations assumed

to be below 60 ppm) to the CWM Chemical Services LLC Subtitle C landfill located in Model City, New York for offsite disposal.

13. Transportation and offsite incineration of hazardous waste cost estimate includes costs for transportation of 900 tons of soil anticipated to be characterized as a RCRA hazardous waste that fails land disposal restrictions (i.e., total PCE concentrations at or above 60 ppm) to the VonRoll incineration facility in East Liverpool, Ohio.
14. Storm sewer replacement cost estimate includes costs to replace 2 storm sewer catch basins and up to 75 feet of piping removed as part of the soil excavation activities. Assumes that the sewer system is above the water table and sheeting is not required.
15. Sand/gravel backfill material placement cost estimate includes costs for providing, placing, and compacting a general sand and gravel backfill material in the excavated area to a height of 1-foot below the surrounding grade.
16. Dense graded aggregate cost estimate includes costs to install an approximately 6-inch thick layer of interlocking stone to serve as a subbase for bituminous asphalt top and base courses.
17. Bituminous asphalt base course cost estimate includes costs for a 4-inch thick layer of bituminous asphalt to serve as a base layer.
18. Bituminous asphalt top course cost estimate includes costs for a 2-inch thick layer of bituminous asphalt to serve as the top (wear) layer.
19. Reporting cost estimate includes costs for a certification report to summarize the soil removal and waste handling activities.
20. Permitting cost estimate includes costs to obtain a permit for discharge of treated groundwater to the municipal sanitary sewer system. Assumes that permitting will require no more than 100 hours time and and for travel/meetings/permit fees would not exceed $5,000.

Figures

BLASLAND, BOUCK & LEE, INC.
engineers & scientists



REFERENCE: AMITYVILLE, NEW YORK USGS QUAD. 1969 PR 1979, HUNTINGTON, NEW YORK USGS QUAD 1967 PR 1979

2000' 0 2000'

APPROXIMATE SCALE: 1" = 2000'

HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK

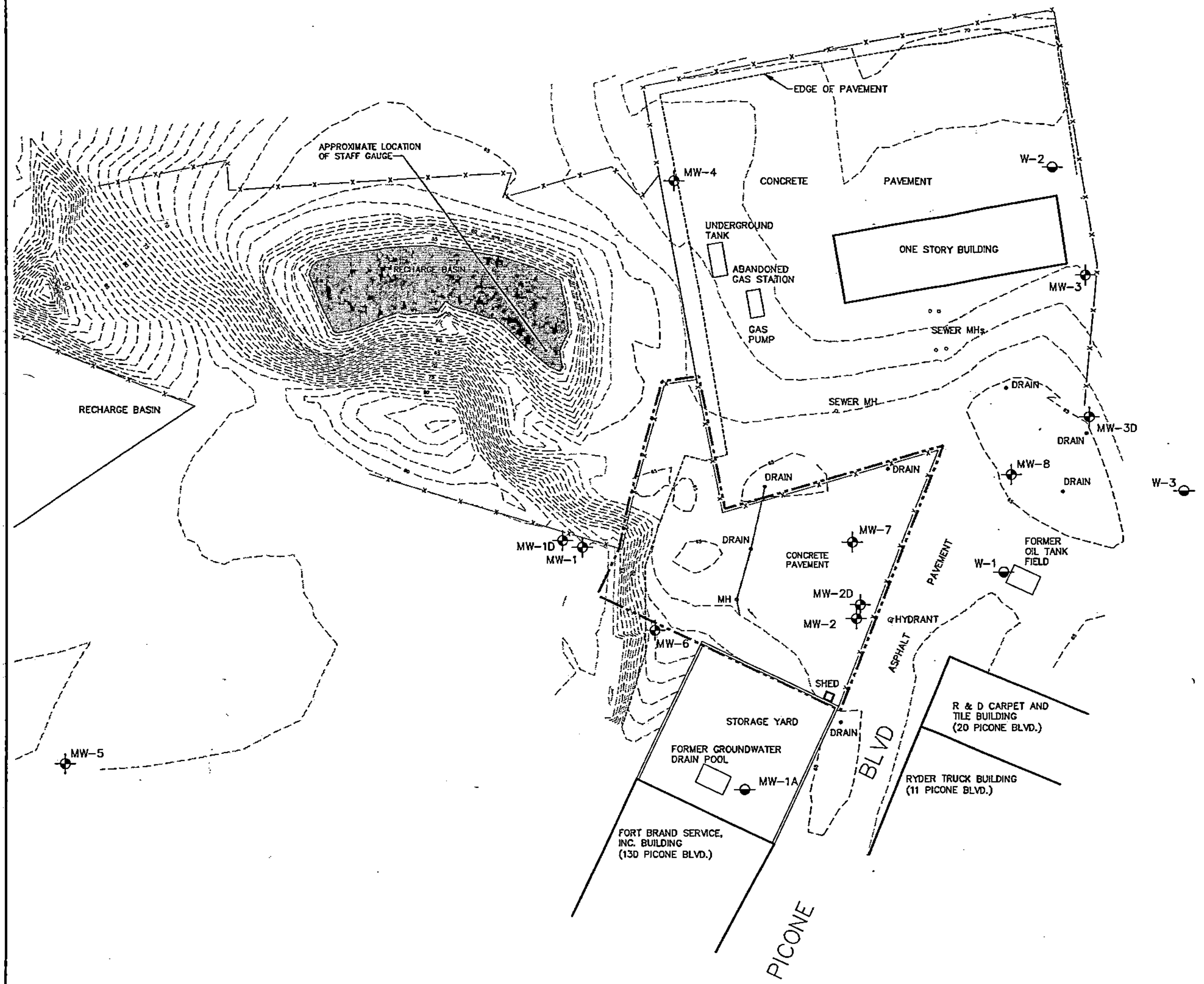
FEASIBILITY STUDY REPORT

SITE LOCATION MAP

BBL
BLASLAND, BOUCK & LEE, INC
engineers & scientists

FIGURE
1

07/24/03 SYR-D85-DJH
60405021/60405n01.CDR



LEGEND:

—·—·— SITE BOUNDARY LOCATION (11A PICONE BOULEVARD)

——x——x—— FENCE LINE

⌖ EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)

⊖ EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF OTHER SITES)

NOTES:

1. WELLS MW-1 THROUGH MW-4 INSTALLED BY GIBBS & HILL, INC. IN SEPTEMBER 1990.
2. WELLS MW-5 AND MW-6 WERE INSTALLED IN JUNE 1994 BY FANNING, PHILIPS & MOLNAR.
3. WELLS W-1, W-2 AND W-3 INSTALLED BY TYREE BROTHERS ENVIRONMENTAL SERVICES, INC., SOURCE IS MAP PROVIDED BY GIBBS & HILL, INC. DATED 6/17/94 (NOT TO SCALE).
4. WELLS MW-1D THROUGH MW-3D INSTALLED BY BLASLAND, BOUCK & LEE, INC. (BBL) IN DECEMBER 1999. WELLS MW-7 AND MW-8 INSTALLED BY BBL DURING FEBRUARY 2001 AND APRIL 2003, RESPECTIVELY.
5. THE LOCATION OF THE OLD TANK FIELD IS APPROXIMATE. THE SOURCE IS A MAP PRODUCED BY TYREE BROTHERS ENVIRONMENTAL SERVICES, INC. (NOT TO SCALE, NO DATE PROVIDED).
6. THE LOCATIONS OF THE FORMER GROUNDWATER DRAINPOOL AND MONITORING WELL MW-1A AT 13D PICONE BOULEVARD ARE APPROXIMATE. THE SOURCE IS FIGURE 2 – GROUNDWATER SAMPLING LOCATIONS PREPARED BY FANNING, PHILLIPS & MOLMAR (FPM) DATED 8/23/96.
7. THE LOCATION OF THE ABANDONED GAS STATION (GAS PUMP AND UNDERGROUND TANK) IS APPROXIMATE. THE SOURCE IS A MAP PROVIDED IN THE GIBBS & HILL, INC. DECEMBER 1991 PHASE II INVESTIGATION REPORT (NOT TO SCALE).

SOURCE:

ALL BASE MAP INFORMATION UNLESS OTHERWISE NOTED WAS TAKEN FROM A MAP ENTITLED "MONITORING WELL AND SOIL BORING LOCATION PLAN, HWD SITE-PICONE BOULEVARD, FARMINGDALE NEW YORK, PROJECT No. 604.05 #2". PREPARED BY ALBERT W. TAY. FILE No. 99390-3.DWG. SURVEYED 11/22/99 THROUGH 11/29/99. SURVEY REVISED 2/9/2000 AND 5/13/2003.

0 40' 80'
GRAPHIC SCALE

HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK
FEASIBILITY STUDY REPORT

SITE PLAN

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
2

X: 60405X01.DWG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
9/2/03 ROC-85-SLM,SYR-85-GMS RCB
60405021/60405B01.DWG

LEGEND:

— · · — · · —	SITE PROPERTY BOUNDARY LOCATION (11A PICONE BOULEVARD)
⬚	APPROXIMATE FORMER DRUM STORAGE AREA BOUNDARY
▭	APPROXIMATE AREA BOUNDARY FOR HAZARDOUS WASTE STORAGE AND TREATMENT AREA, AND HAZARDOUS WASTE HANDLING AND ABOVE GROUND TANK STORAGE AREA

SOURCE:

UNDISTORTED APRIL 7, 1980 AERIAL PHOTOGRAPH PROVIDED BY AEROGRAPHICS, INC.

NOTE:

AREA BOUNDARIES DEPICTED ARE BASED ON SKETCHES OF SITE INSPECTIONS CONDUCTED ON JUNE 30, 1982 AND SEPTEMBER 14, 1982, BY SCHD, AND FIGURES 1-2 AND 1-3 OF THE NYSDEC 1991 PHASE II REPORT BY GIBBS & HILL.

0 40' 80'
GRAPHIC SCALE

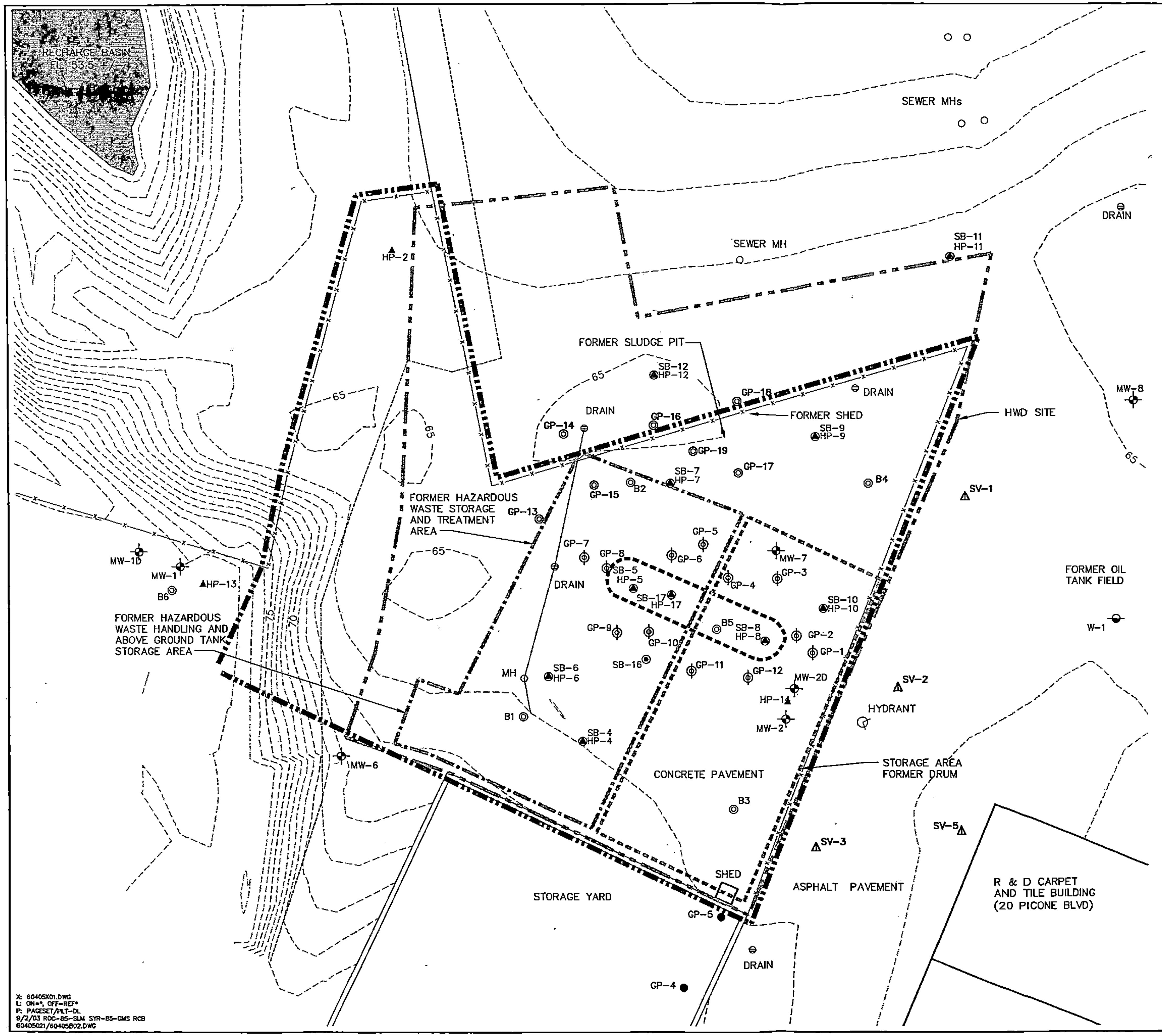
HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK
FEASIBILITY STUDY REPORT

HISTORICAL SITE OPERATION FEATURES (APRIL 7, 1980)

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
3

X: 60405X01, 60405X02.JPG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
8/6/03 CRA-54-SY SYR-85-KMD GMS
60405021/60405N01.DWG



LEGEND:

▬ ▪ ▪ ▬ ▪ ▪ ▬	SITE BOUNDARY LOCATION (11A PICONE BOULEVARD)
—x——x—	FENCE LINE
◎	SOIL VOC DELINEATION BORING (AUGUST 2002)
△	SOIL VAPOR SAMPLE LOCATION (AUGUST 2002)
⌖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)
◒	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF OTHER SITES)
◬	SOIL BORING/HYDROPUNCH™ LOCATION
▲	HYDROPUNCH™ LOCATION ONLY
◉	SOIL BORING LOCATION ONLY
⏀	GEOPROBE® SOIL BORING LOCATION
⬭	LOCATION OF REINFORCED CONCRETE PAD
●	GEOPROBE® GROUNDWATER SAMPLING LOCATION (APPROXIMATE)
◎	PHASE II SOIL BORING LOCATION (APPROXIMATE)

NOTES:

1. SOIL VOC DELINEATION BORINGS AND SOIL VAPOR SAMPLE LOCATIONS WERE SURVEYED BY BBL DURING AUGUST 2002.
2. THE LOCATION OF THE FORMER OIL TANK FIELD IS APPROXIMATE. THE SOURCE IS A MAP PRODUCED BY TYREE BROTHERS ENVIRONMENTAL SERVICES, INC. (NOT TO SCALE, NO DATE PROVIDED).
3. SOIL BORINGS B-1 THROUGH B-6 WERE INSTALLED BY GIBBS & HILL, INC. AT THE APPROXIMATE LOCATIONS SHOWN, SOURCE IS FIGURE 2 PROVIDED IN THEIR REPORT ENTITLED "ENGINEERING INVESTIGATIONS AT INACTIVE HAZARDOUS WASTE SITES IN THE STATE OF NEW YORK – PHASE II INVESTIGATION, DECEMBER 1991".
4. THE LOCATIONS OF GEOPROBE GROUNDWATER SAMPLING LOCATIONS (GP-4 AND GP-5) AT 130 PICONE BOULEVARD ARE APPROXIMATE. THE SOURCE IS FIGURE 2 – GROUNDWATER SAMPLING LOCATIONS PREPARED BY FANNING, PHILLIPS & MOLMAR (FPM) DATED 8/23/95.
5. HISTORICAL SITE OPERATION FEATURES ARE BASED ON AN UNDISTORTED APRIL 7, 1980 PHOTOGRAPH PROVIDED BY AEROGRAPHICS, INC., SKETCHES OF SITE INSPECTIONS CONDUCTED ON JUNE 30, 1982 AND SEPTEMBER 14, 1982 BY THE SUFFOLK COUNTY HEALTH DEPARTMENT, AND FIGURES 1-2 AND 1-3 OF THE NYSDEC 1991 PHASE II REPORT BY GIBBS & HILL.

SOURCE:

ALL BASE MAP INFORMATION UNLESS OTHERWISE NOTED WAS TAKEN FROM A MAP ENTITLED "MONITORING WELL AND SOIL BORING LOCATION PLAN, HWD SITE-PICONE BOULEVARD, FARMINGDALE, NEW YORK, PROJECT No. 604.05 #2", PREPARED BY ALBERT W. TAY, FILE No. 99390-3.DWG, SURVEYED 11/22/99 THROUGH 11/29/99. SURVEY REVISED 2/9/2000 AND 5/13/2003.

0 15' 30'
GRAPHIC SCALE

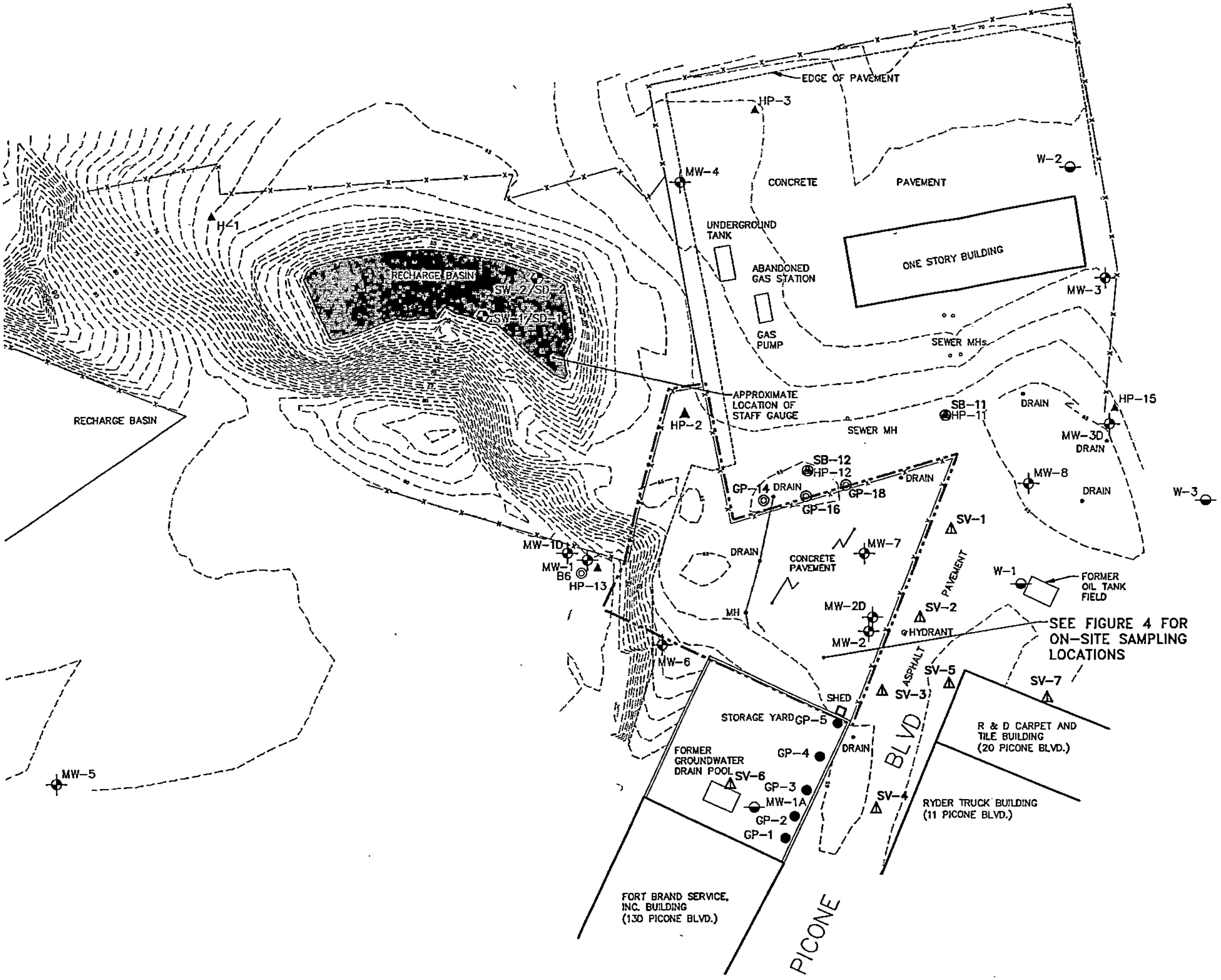
HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK
FEASIBILITY STUDY REPORT

ONSITE SAMPLING LOCATIONS

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
4

X: 60405X01.DWG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
9/2/03 ROC-85-SLM SYR-85-GMS RCB
60405021/60405B02.DWG



LEGEND:

—·—··—	SITE BOUNDARY LOCATION (11A PICONE BOULEVARD)
—x——x—	FENCE LINE
◎	SOIL VOC DELINEATION BORING (AUGUST 2002)
⚠	SOIL VAPOR SAMPLE LOCATION (AUGUST 2002)
⌖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)
◒	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATIONS OF OTHER SITES)
◬	SOIL BORING/HYDROPUNCH™ LOCATION
▲	HYDROPUNCH™ LOCATION ONLY
◉	SOIL BORING LOCATION ONLY
●	GEOPROBE® GROUNDWATER SAMPLING LOCATION
◎	PHASE II SOIL BORINGS
⊕	SURFACE WATER/SEDIMENT SAMPLING LOCATION (APPROXIMATE LOCATION)

NOTES:

1. SOIL VOC DELINEATION BORINGS AND SOIL VAPOR SAMPLE LOCATIONS WERE SURVEYED BY BBL DURING AUGUST 2002.
2. THE LOCATION OF THE FORMER OLD TANK FIELD IS APPROXIMATE. THE SOURCE IS A MAP PRODUCED BY TYREE BROTHERS ENVIRONMENTAL SERVICES, INC. (NOT TO SCALE, NO DATE PROVIDED).
3. APPROXIMATE LOCATIONS OF SOIL BORINGS B-1 THROUGH B-6 AND SURFACE WATER AND SEDIMENT SAMPLES (SW-1/SD-1 AND SW-2/SD-2) WERE INSTALLED BY GIBBS & HILL, INC., SOURCE IS FIGURE 2 PROVIDED IN THEIR REPORT ENTITLED "ENGINEERING INVESTIGATIONS AT INACTIVE HAZARDOUS WASTE SITES IN THE STATE OF NEW YORK – PHASE II INVESTIGATION, DECEMBER 1991".
4. THE LOCATION OF THE ABANDONED GAS STATION (GAS PUMP AND UNDERGROUND TANK) IS APPROXIMATE. THE SOURCE IS A MAP PROVIDED IN THE GIBBS & HILL, INC. DECEMBER 1991 PHASE II INVESTIGATION REPORT (NOT TO SCALE).
5. THE LOCATIONS OF THE FORMER GROUNDWATER DRAINPOOL, MONITORING WELL MW-1A AND GEOPROBE GROUNDWATER SAMPLING LOCATIONS (GP-3 THROUGH GP-5) AT 13D PICONE BOULEVARD ARE APPROXIMATE. THE SOURCE IS FIGURE 2 – GROUNDWATER SAMPLING LOCATIONS PREPARED BY FANNING, PHILLIPS & MOLMAR (FPM) DATED 8/23/96.

SOURCE:

ALL BASE MAP INFORMATION UNLESS OTHERWISE NOTED WAS TAKEN FROM A MAP ENTITLED "MONITORING WELL AND SOIL BORING LOCATION PLAN, HWD SITE–PICONE BOULEVARD, FARMINGDALE NEW YORK, PROJECT No. 604.05 #2". PREPARED BY ALBERT W. TAY, FILE No. 99390-3.DWG. SURVEYED 11/22/99 THROUGH 11/29/99. SURVEY REVISED 2/9/2000 AND 5/13/2003.

0 40' 80'
GRAPHIC SCALE

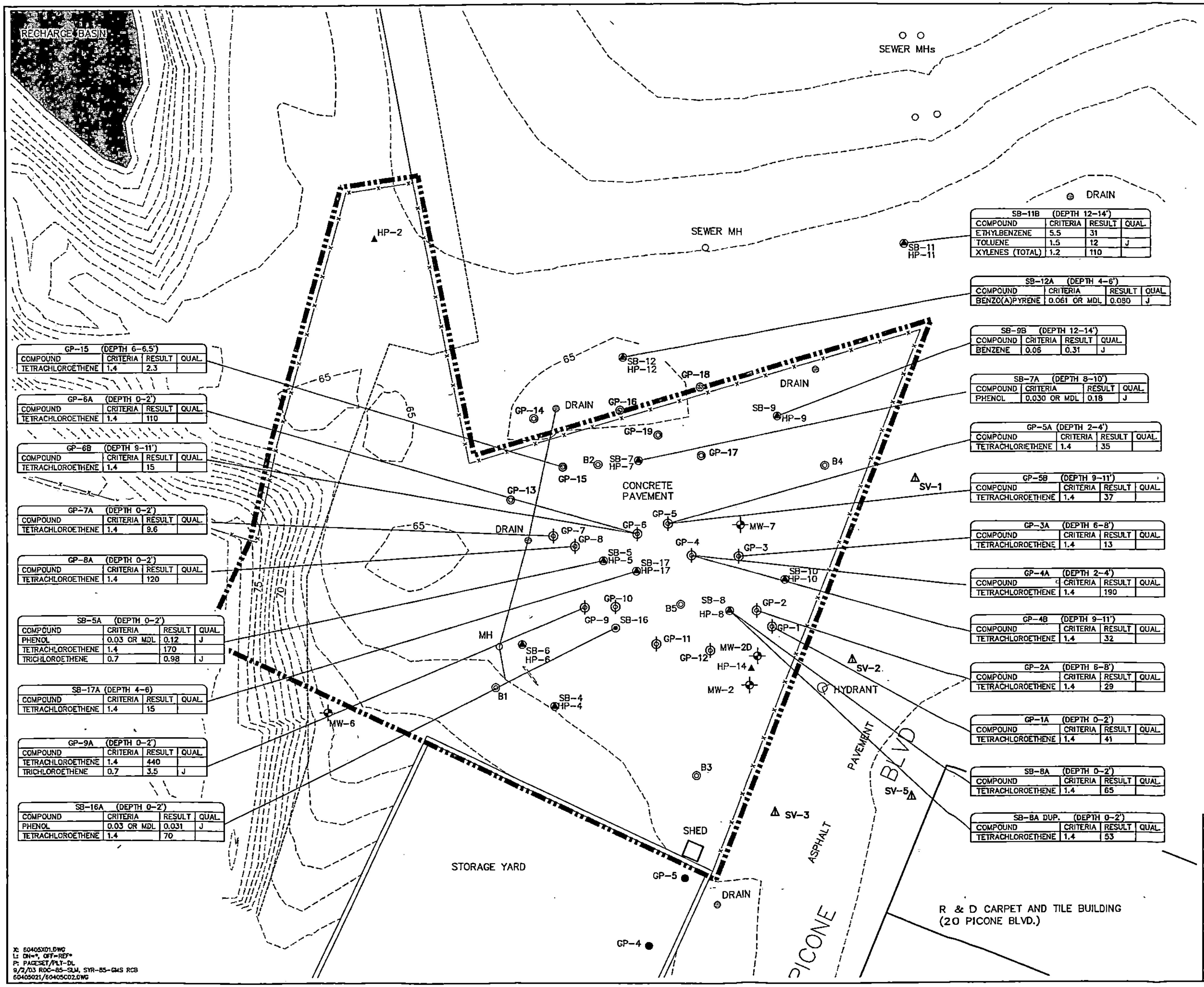
HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK
FEASIBILITY STUDY REPORT

SAMPLING LOCATIONS NEAR THE HWD SITE

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
5

X: 60405X01.DWG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
9/2/03 ROC-85-SLM SYR-85-GMS RCB
60405021/60405B03.DWG



GP-15 (DEPTH 6-6.5')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	2.3	

GP-6A (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	110	

GP-6B (DEPTH 9-11')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	15	

GP-7A (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	9.6	

GP-8A (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	120	

SB-5A (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
PHENOL	0.03 OR MDL	0.12	J
TETRACHLOROETHENE	1.4	170	
TRICHLOROETHENE	0.7	0.98	J

SB-17A (DEPTH 4-6)

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	15	

GP-9A (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	440	
TRICHLOROETHENE	0.7	3.5	J

SB-16A (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
PHENOL	0.03 OR MDL	0.031	J
TETRACHLOROETHENE	1.4	70	

SB-11B (DEPTH 12-14')

COMPOUND	CRITERIA	RESULT	QUAL.
ETHYLBENZENE	5.5	31	
TOLUENE	1.5	12	J
XYLENES (TOTAL)	1.2	110	

SB-12A (DEPTH 4-6')

COMPOUND	CRITERIA	RESULT	QUAL.
BENZO(A)PYRENE	0.061 OR MDL	0.080	J

SB-9B (DEPTH 12-14')

COMPOUND	CRITERIA	RESULT	QUAL.
BENZENE	0.06	0.31	J

SB-7A (DEPTH 8-10')

COMPOUND	CRITERIA	RESULT	QUAL.
PHENOL	0.030 OR MDL	0.18	J

GP-5A (DEPTH 2-4')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLORIETHENE	1.4	35	

GP-5B (DEPTH 9-11')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	37	

GP-3A (DEPTH 6-8')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	13	

GP-4A (DEPTH 2-4')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	190	

GP-4B (DEPTH 9-11')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	32	

GP-2A (DEPTH 6-8')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	29	

GP-1A (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	41	

SB-8A (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	65	

SB-8A DUP. (DEPTH 0-2')

COMPOUND	CRITERIA	RESULT	QUAL.
TETRACHLOROETHENE	1.4	53	

LEGEND:

▬ ▪ ▪ ▬	SITE BOUNDARY LOCATION (11A PICONE BOULEVARD)
—x—x—	FENCE LINE
◎	SOIL VOC DELINEATION BORING (AUGUST 2002)
⚠	SOIL VAPOR SAMPLE LOCATION (AUGUST 2002)
⌖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)
◬	SOIL BORING/HYDROPUNCH™ LOCATION -
▲	HYDROPUNCH™ LOCATION ONLY
◉	SOIL BORING LOCATION ONLY
⦶	GEOPROBE® SOIL BORING LOCATION
●	GEOPROBE® GROUNDWATER SAMPLING LOCATION (APPROXIMATE)
◎	PHASE II SOIL BORING LOCATION (APPROXIMATE)

NOTES:

1. SOIL VOC DELINEATION BORINGS AND SOIL VAPOR SAMPLE LOCATIONS WERE SURVEYED BY BBL DURING AUGUST 2002.
2. THE LOCATION OF THE FORMER OIL TANK FIELD IS APPROXIMATE. THE SOURCE IS A MAP PRODUCED BY TYREE BROTHERS ENVIRONMENTAL SERVICES, INC. (NOT TO SCALE, NO DATE PROVIDED).
3. SOIL BORINGS B-1 THROUGH B-6 WERE INSTALLED BY GIBBS & HILL, INC. AT THE APPROXIMATE LOCATIONS SHOWN, SOURCE IS FIGURE 2 PROVIDED IN THEIR REPORT ENTITLED "ENGINEERING INVESTIGATIONS AT INACTIVE HAZARDOUS WASTE SITES IN THE STATE OF NEW YORK – PHASE II INVESTIGATION, DECEMBER 1991".
4. THE LOCATIONS OF GEOPROBE GROUNDWATER SAMPLING LOCATIONS (GP-4 AND GP-5) AT 13D PICONE BOULEVARD ARE APPROXIMATE. THE SOURCE IS FIGURE 2 – GROUNDWATER SAMPLING LOCATIONS PREPARED BY FANNING, PHILLIPS & MOLMAR (FPM) DATED 8/23/96.

SOURCE:

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0 15' 30'
GRAPHIC SCALE

HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK

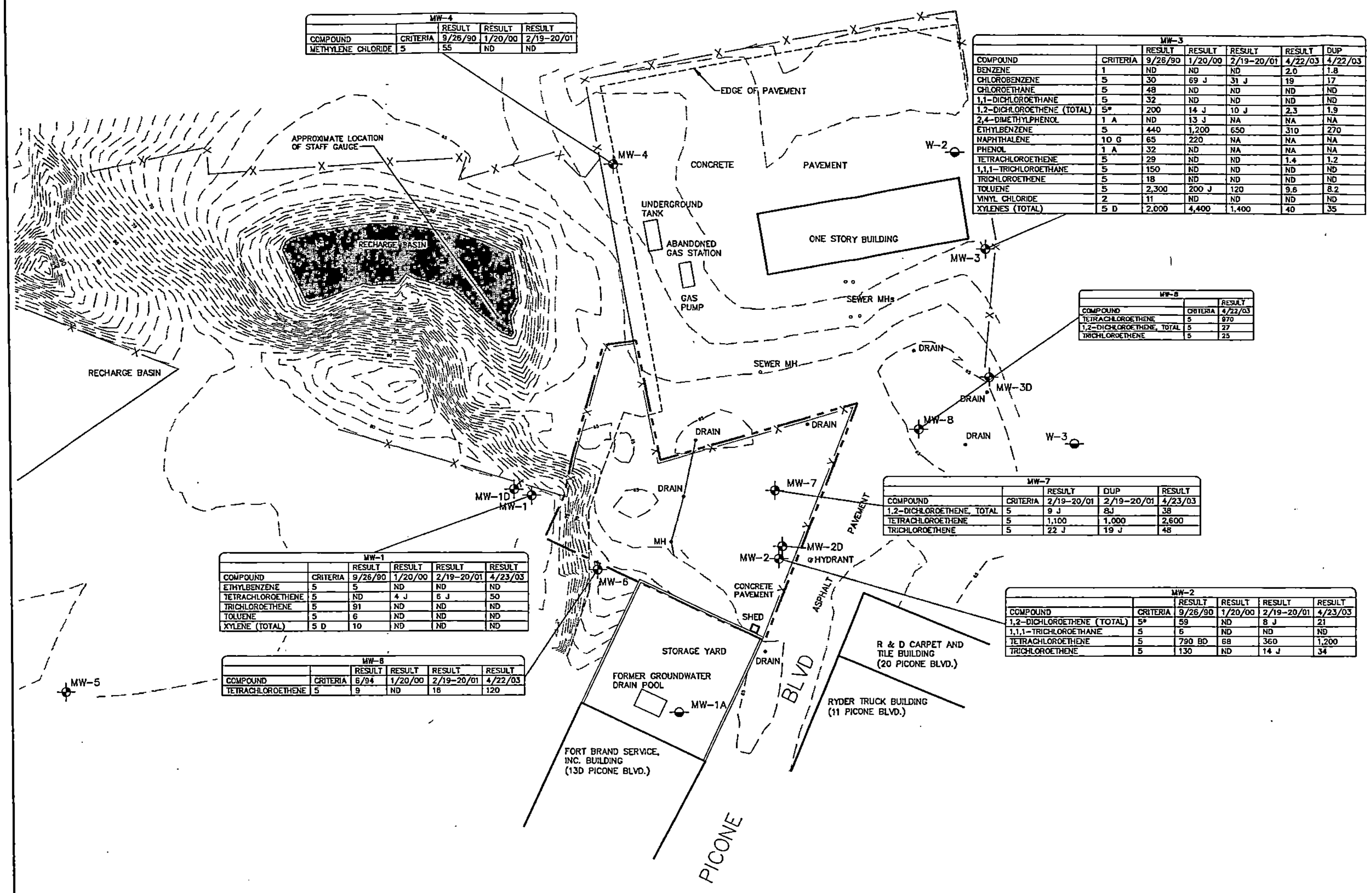
FEASIBILITY STUDY REPORT

DISTRIBUTION OF ORGANIC COMPOUNDS IN SOIL ABOVE NYSDEC TAGM 4046 GUIDANCE VALUES (ppm)

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
6

X: 60405X01.DWG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
9/2/03 ROC-85-SLM, SYR-85-GMS RCB
60405021/60405C02.DWG



MW-4

		RESULT	RESULT	RESULT
COMPOUND	CRITERIA	9/26/90	1/20/00	2/19-20/01
METHYLENE CHLORIDE	5	55	ND	ND

MW-3

		RESULT	RESULT	RESULT	RESULT	DUP
COMPOUND	CRITERIA	9/26/90	1/20/00	2/19-20/01	4/22/03	4/22/03
BENZENE	1	ND	ND	ND	2.0	1.8
CHLOROBENZENE	5	30	69 J	31 J	19	17
CHLOROETHANE	5	48	ND	ND	ND	ND
1,1-DICHLOROETHANE	5	32	ND	ND	ND	ND
1,2-DICHLOROETHENE (TOTAL)	5*	200	14 J	10 J	2.3	1.9
2,4-DIMETHYLPHENOL	1 A	ND	13 J	NA	NA	NA
ETHYLBENZENE	5	440	1,200	650	310	270
NAPHTHALENE	10 G	65	220	NA	NA	NA
PHENOL	1 A	32	ND	NA	NA	NA
TETRACHLOROETHENE	5	29	ND	ND	1.4	1.2
1,1,1-TRICHLOROETHANE	5	150	ND	ND	ND	ND
TRICHLOROETHENE	5	18	ND	ND	ND	ND
TOLUENE	5	2,300	200 J	120	9.6	8.2
VINYL CHLORIDE	2	11	ND	ND	ND	ND
XYLENES (TOTAL)	5 D	2,000	4,400	1,400	40	35

MW-8

		RESULT
COMPOUND	CRITERIA	4/22/03
TETRACHLOROETHENE	5	970
1,2-DICHLOROETHENE, TOTAL	5	27
TRICHLOROETHENE	5	25

MW-7

		RESULT	DUP	RESULT
COMPOUND	CRITERIA	2/19-20/01	2/19-20/01	4/23/03
1,2-DICHLOROETHENE, TOTAL	5	9 J	8J	38
TETRACHLOROETHENE	5	1,100	1,000	2,600
TRICHLOROETHENE	5	22 J	19 J	48

MW-1

		RESULT	RESULT	RESULT	RESULT
COMPOUND	CRITERIA	9/26/90	1/20/00	2/19-20/01	4/23/03
ETHYLBENZENE	5	5	ND	ND	ND
TETRACHLOROETHENE	5	ND	4 J	6 J	50
TRICHLOROETHENE	5	91	ND	ND	ND
TOLUENE	5	6	ND	ND	ND
XYLENE (TOTAL)	5 D	10	ND	ND	ND

MW-6

		RESULT	RESULT	RESULT	RESULT
COMPOUND	CRITERIA	6/94	1/20/00	2/19-20/01	4/22/03
TETRACHLOROETHENE	5	9	ND	16	120

MW-2

		RESULT	RESULT	RESULT	RESULT
COMPOUND	CRITERIA	9/26/90	1/20/00	2/19-20/01	4/23/03
1,2-DICHLOROETHENE (TOTAL)	5*	59	ND	8 J	21
1,1,1-TRICHLOROETHANE	5	6	ND	ND	ND
TETRACHLOROETHENE	5	790 BD	68	360	1,200
TRICHLOROETHENE	5	130	ND	14 J	34

LEGEND:

— — — —	SITE BOUNDARY LOCATION (11A PICONE BOULEVARD)
——X——	FENCE LINE
⌖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)
⊖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF OTHER SITES)

NOTES:

1. ALL CONCENTRATIONS ARE REPORTED IN MICROGRAMS PER LITER (ug/L) EQUIVALENT TO PARTS PER BILLION (ppb).
2. G = GUIDANCE VALUE
3. * = CRITERIA VALUE LISTED FOR 1,2-DICHLOROETHENE (Total) APPLIES TO THE Cis AND Trans- ISOMERS INDIVIDUALLY.
4. D = VALUE LISTED APPLIES TO EACH ISOMER INDIVIDUALLY.
5. A = VALUE LISTED APPLIES TO THE SUM OF THESE SUBSTANCES.
6. J = THE RESULT IS LESS THAN THE QUANTITATION LIMIT BUT GREATER THAN ZERO. CONCENTRATION GIVEN IS AN APPROXIMATE VALUE.
7. BD = CONTAMINANT ALSO DETECTED IN METHOD BLANK. DILUTED SAMPLE ANALYSIS.
8. ND = NOT DETECTED.
9. NA = NOT ANALYZED.
10. CRITERIA REFERENCE: NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION (NYSDEC) DIVISION OF WATER TECHNICAL AND OPERATIONAL GUIDANCE SERIES (1.1.1), DOCUMENT TITLED AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES AND GROUNDWATER EFFLUENT LIMITATIONS, DATED JUNE 1998, UPDATED APRIL 2000.

SOURCE:

ALL BASE MAP INFORMATION UNLESS OTHERWISE NOTED WAS TAKEN FROM A MAP ENTITLED "MONITORING WELL AND SOIL BORING LOCATION PLAN, HWD SITE-PICONE BOULEVARD, FARMINGDALE NEW YORK, PROJECT No. 604.05 #2". PREPARED BY ALBERT W. TAY. FILE No. 99390-3.DWG. SURVEYED 11/22/99 THROUGH 11/29/99. SURVEY REVISED 2/9/2000 AND 5/13/2003.

0 40' 80'
GRAPHIC SCALE

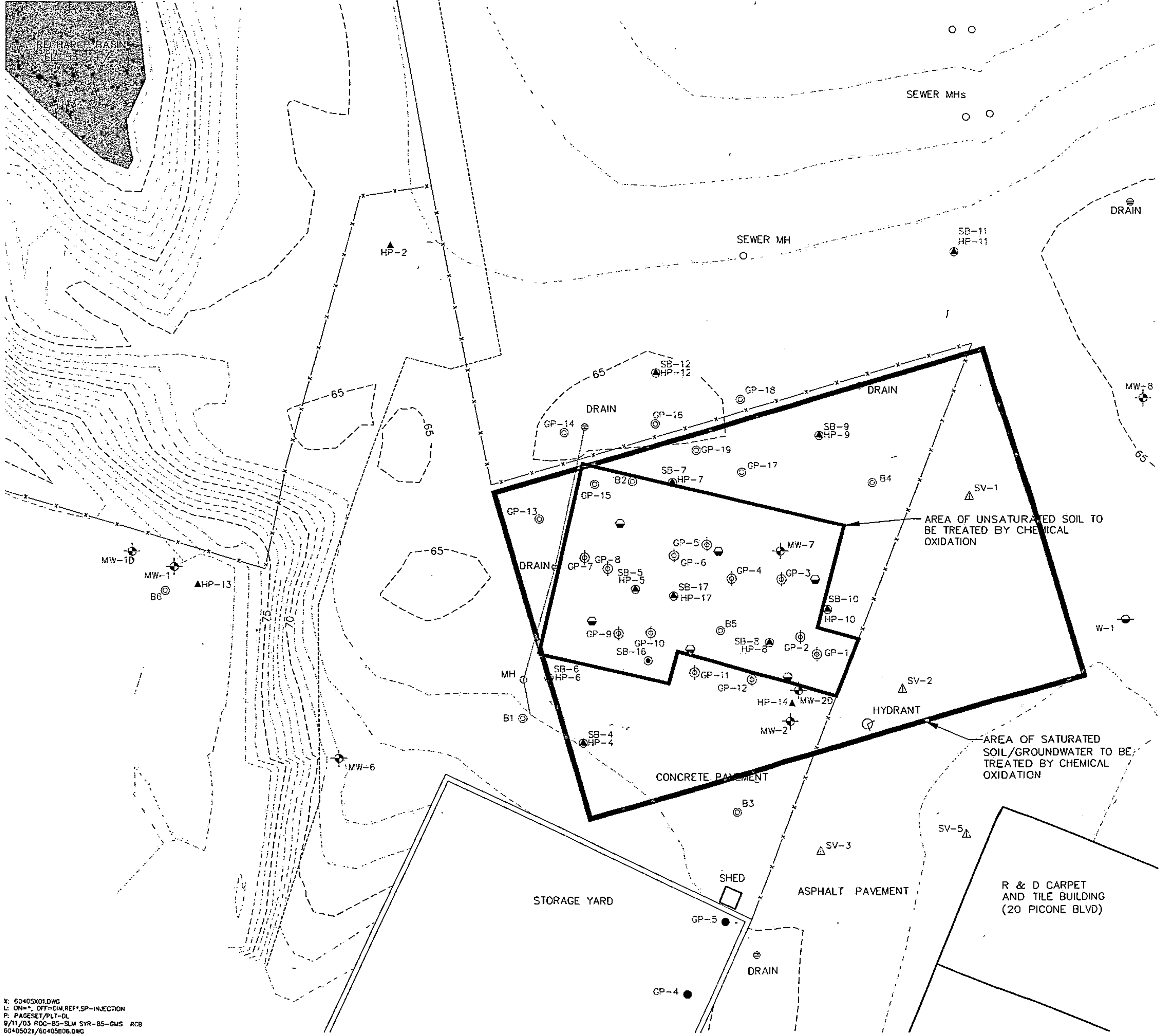
HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK
FEASIBILITY STUDY REPORT

DISTRIBUTION OF ORGANIC COMPOUNDS IN GROUNDWATER ABOVE NYSDEC CRITERIA (ppb)

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
7

X: 60405X01.DWG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
9/18/03 ROC-85-SLM SYR-85-GMS RCB
60405021/60405C01.DWG



LEGEND:

—x—x—	FENCE LINE
◎	SOIL VOC DELINEATION BORING (AUGUST 2002)
△	SOIL VAPOR SAMPLE LOCATION (AUGUST 2002)
⊕	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)
⊖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF OTHER SITES)
◬	SOIL BORING/HYDROPUNCH™ LOCATION
▲	HYDROPUNCH™ LOCATION ONLY
◉	SOIL BORING LOCATION ONLY
⦶	GEOPROBE® SOIL BORING LOCATION
●	GEOPROBE® GROUNDWATER SAMPLING LOCATION (APPROXIMATE)
©	PHASE II SOIL BORING LOCATION (APPROXIMATE)

NOTES:

1. SOIL VOC DELINEATION BORINGS AND SOIL VAPOR SAMPLE LOCATIONS WERE SURVEYED BY BBL DURING AUGUST 2002.
2. APPROXIMATE LOCATIONS OF SOIL BORINGS B-1 THROUGH B-6 WERE INSTALLED BY GIBBS & HILL, INC., SOURCE IS FIGURE 2 PROVIDED IN THEIR REPORT ENTITLED "ENGINEERING INVESTIGATIONS AT INACTIVE HAZARDOUS WASTE SITES IN THE STATE OF NEW YORK - PHASE II INVESTIGATION, DECEMBER 1991".

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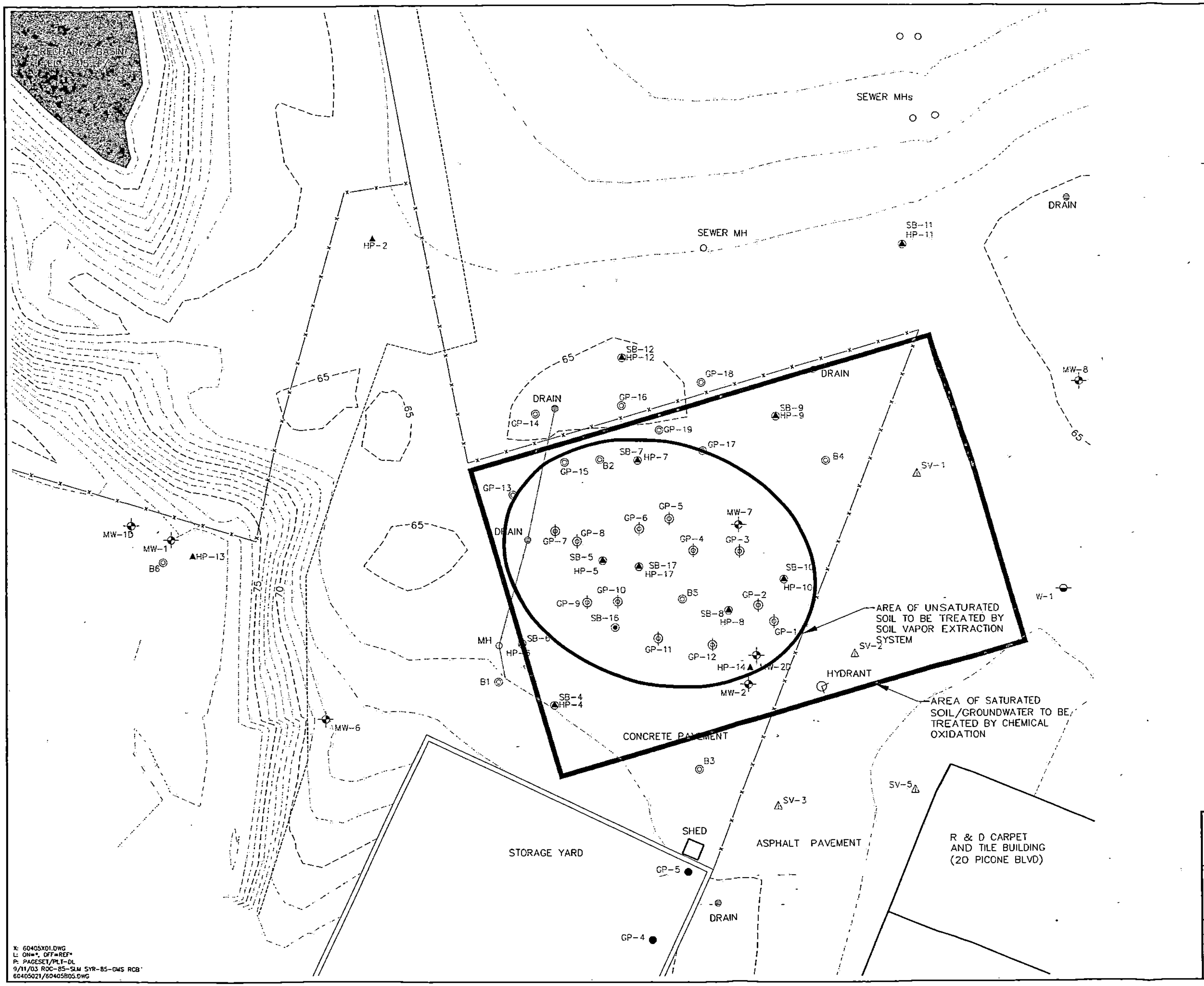
HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK
FEASIBILITY STUDY REPORT

ALTERNATIVE 2 - IN-SITU SOIL CHEMICAL OXIDATION AND IN-SITU GROUNDWATER CHEMICAL OXIDATION (FOCUSED APPLICATION)

BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
8

X: 60405X01.DWG
L: ON=*, OFF=DIM,REF*,SP-INJECTION
P: PAGESET/PLT-DL
9/11/03 ROC-85-SLM SYR-85-GMS RCB
60405021/60405B06.DWG



X: 60405X01.DWG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
9/11/03 ROC-85-SLM SYR-85-GMS RCB
60405021/60405B05.DWG

LEGEND:

—x——x—	FENCE LINE
◎	SOIL VOC DELINEATION BORING (AUGUST 2002)
△	SOIL VAPOR SAMPLE LOCATION (AUGUST 2002)
⊕	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)
⊖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF OTHER SITES)
◬	SOIL BORING/HYDROPUNCH™ LOCATION
▲	HYDROPUNCH™ LOCATION ONLY
◉	SOIL BORING LOCATION ONLY
⌽	GEOPROBE® SOIL BORING LOCATION
●	GEOPROBE® GROUNDWATER SAMPLING LOCATION (APPROXIMATE)
©	PHASE II SOIL BORING LOCATION (APPROXIMATE)

NOTES:

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0 15' 30'
GRAPHIC SCALE

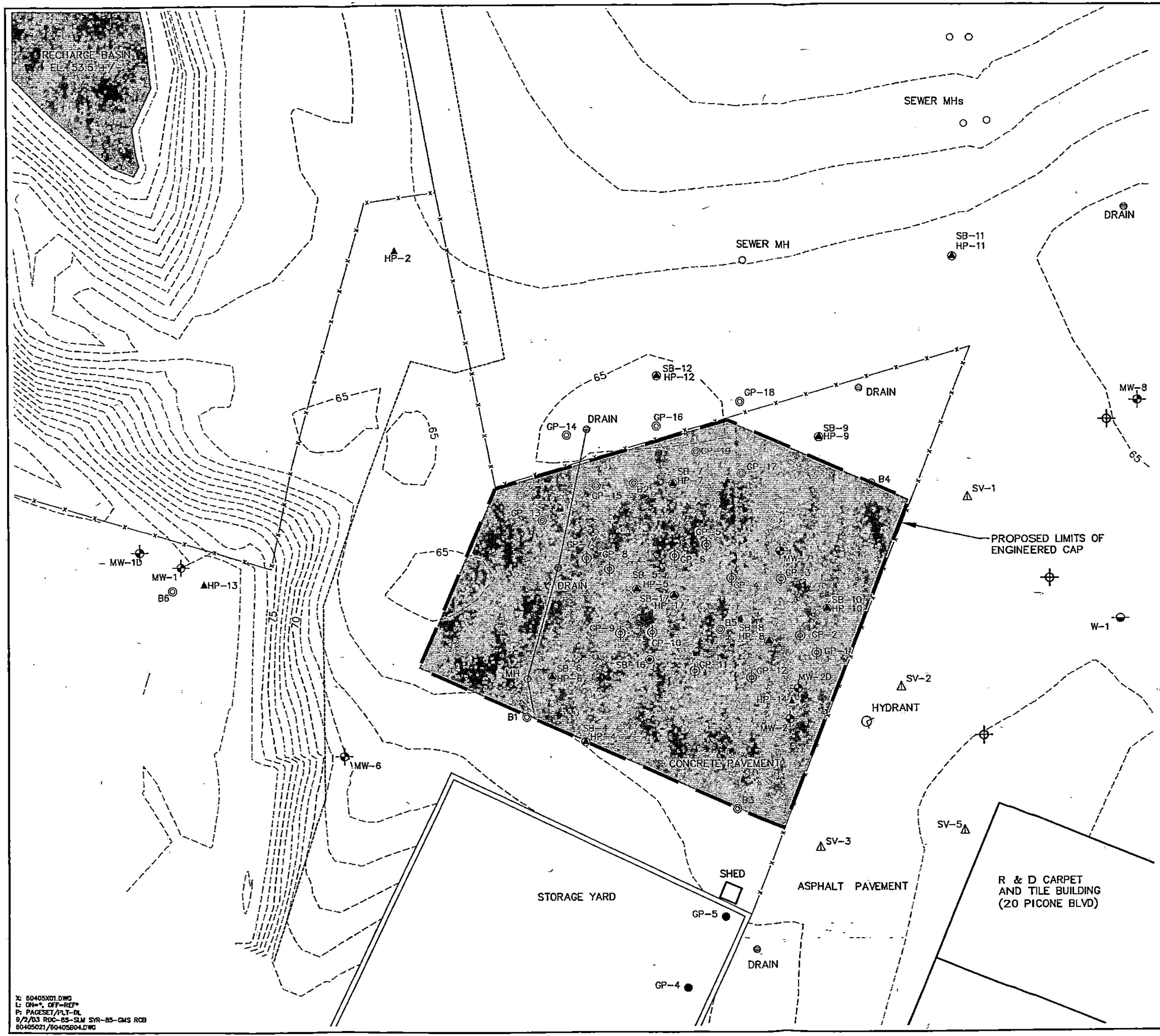
HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK

FEASIBILITY STUDY REPORT

ALTERNATIVE 3 - SOIL VAPOR EXTRACTION AND IN-SITU GROUNDWATER CHEMICAL OXIDATION (FOCUSED APPLICATION)

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
9



LEGEND:

- ▨ PROPOSED LIMITS OF ENGINEERED CAP
- ⊕ PROPOSED GROUNDWATER PUMPING WELL
- —x—x— FENCE LINE
- ◎ SOIL VOC DELINEATION BORING (AUGUST 2002)
- △ SOIL VAPOR SAMPLE LOCATION (AUGUST 2002)
- ⊕ EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)
- ⊖ EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF OTHER SITES)
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- ▲ HYDROPUNCH™ LOCATION ONLY
- ◉ SOIL BORING LOCATION ONLY
- ⦶ GEOPROBE® SOIL BORING LOCATION
- ● GEOPROBE® GROUNDWATER SAMPLING LOCATION (APPROXIMATE)
- ◎ PHASE II SOIL BORING LOCATION (APPROXIMATE)

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0 15' 30'
GRAPHIC SCALE

HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK

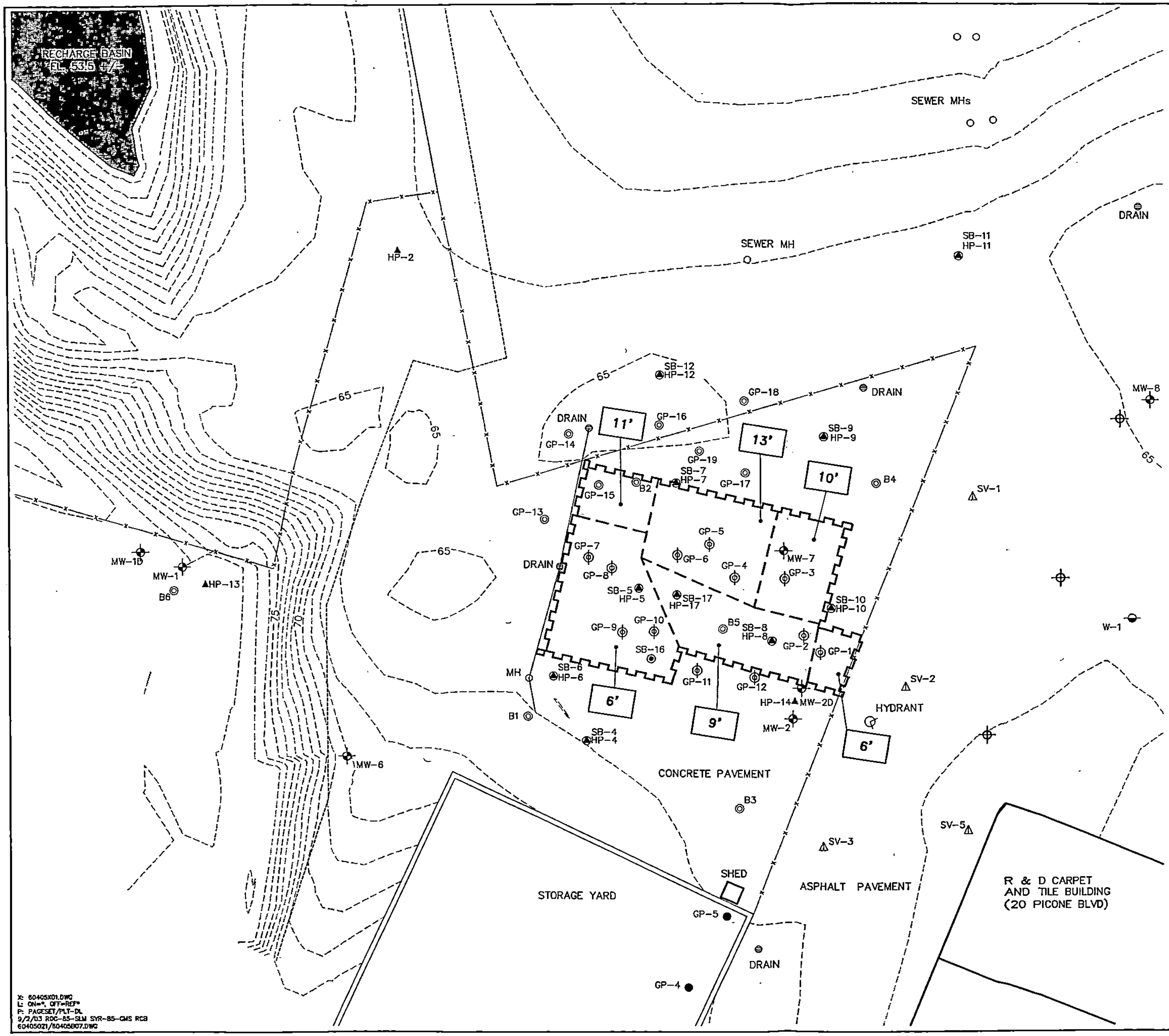
FEASIBILITY STUDY REPORT

ALTERNATIVE 4 - ASPHALT CAP/ INSTITUTIONAL CONTROLS AND GROUNDWATER EXTRACTION/ONSITE TREATMENT

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
10

X: 60405X01.DWG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
9/2/03 ROC-85-SLM SYR-85-GMS RCB
60405021/60405B04.DWG



LEGEND:

⊓⊔⊓⊔	PROPOSED SHEETPILE WALL ALONG BOUNDARY OF SOIL EXCAVATION
⌖	PROPOSED GROUNDWATER PUMPING WELL
10'	PROPOSED DEPTH OF SOIL EXCAVATION
—x—x—	FENCE LINE
◎	SOIL VOC DELINEATION BORING (AUGUST 2002)
△	SOIL VAPOR SAMPLE LOCATION (AUGUST 2002)
⌖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF THE HWD SITE)
⊖	EXISTING GROUNDWATER MONITORING WELL LOCATION (INSTALLED FOR INVESTIGATION OF OTHER SITES)
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●	GEOPROBE® GROUNDWATER SAMPLING LOCATION (APPROXIMATE)
◎	PHASE II SOIL BORING LOCATION (APPROXIMATE)

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X: 60405X01.DWG
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
9/2/03 ROC-85-SLM SYR-85-GMS RCB
60405021/60405B07.DWG

HAZARDOUS WASTE DISPOSAL, INC.
11A PICONE BOULEVARD
FARMINGDALE, NEW YORK

FEASIBILITY STUDY REPORT

ALTERNATIVE 5 - SOIL EXCAVATION AND OFFSITE INCINERATION/DISPOSAL AND GROUNDWATER EXTRACTION/ONSITE TREATMENT

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
11

Appendix A

Groundwater Monitoring Well Completion Log

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Date Start/Finish: 4/10/03
Drilling Company: Delta Well and Pump Co.
Driller's Name: Charles Blumberg Jr.
Drilling Method: Hollow Stem Auger
Auger Size:
Rig Type: Failing F-10
Sampling Method: 2-inch split spoon

Northing:
Easting:
Casing Elevation:

Borehole Depth: 23.0 feet
Surface Elevation:

Geologist: Kiersten Robbins

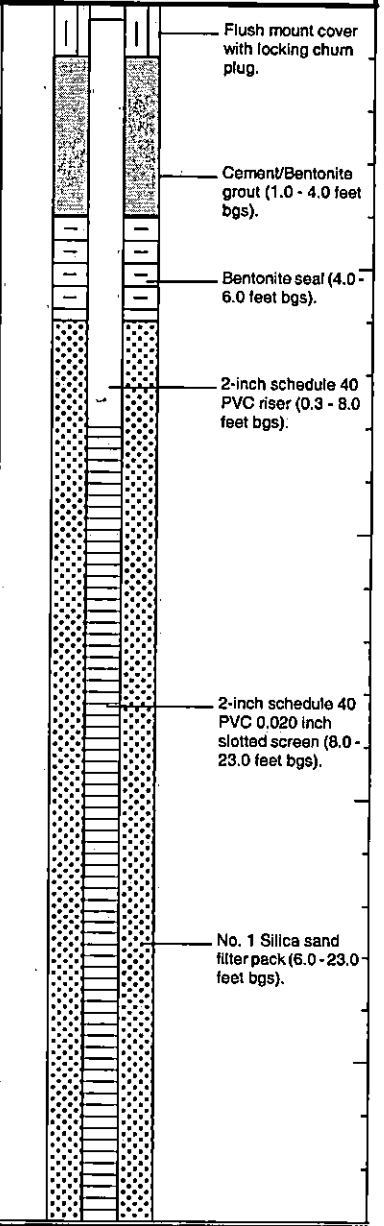
Well/Boring ID: MW-8

Client: HWD Site Group

Location: Hazardous Waste Disposal Site
Farmingdale, New York

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	Blows / 6 Inches	N - Value	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level
0	0	NA	NA							Asphalt. Concrete. Debris.	
				0.6feet	7 22 16 13	38	0.0 0.0			Brown fine to medium, subrounded SAND and GRAVEL, moist.	
				0.2feet	6 7		0.0				
5	5			0.0feet	refu					Concrete.	
				0.7feet	5 11 26 37	37	0.0 0.0			Brown fine to medium, subrounded SAND and GRAVEL, moist. Wood and brick debris. Dark brown to black fine SAND, little very fine sand, dry.	
				0.5feet	9 14 16 15	30	0.0			Brown to light brown fine SAND, little subangular gravel, dry.	
10	10			0.0feet	refu					Concrete.	
				0.8feet	9 12 15 13	27	11.4 64.9			Tan to brown, medium to coarse, subrounded SAND and GRAVEL, moist. Tan to brown, medium to coarse, subrounded SAND and GRAVEL, wet.	
				0.6feet	6 8 8 11	16	152			Petroleum-like odor.	▼
15	15			1.0feet	10 6 7 4	13	4.8 33.6			Tan to brown, medium to coarse, subrounded SAND, some gravel, wet.	
				0.5feet	5 4 6 8	10	57.0				
20	20			0.6feet	10 40 34 16	74	32.3				
				0.5feet	15 53 41	94	9.4			Tan medium to coarse, subrounded SAND, some gravel, wet.	

Well/Boring Construction



BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

Remarks:

Project: 60405.024 Template: F:\PROJECTS\HWD\SB_well.ldf
Data File:F:\PROJECTS\HWD\logs\MW-8.dat Date:4/11/03

Appendix B

Groundwater Sampling Logs

Appendix B

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Additional Groundwater Sampling Activities
Groundwater Sampling Log

Well Number: ***MW-1D***	**Well Depth (ft BTIC):** 68.30	
Date: 4/23/2003	**Screen Length (ft):** 10	**Initial Water Level (ft BTIC):** 29.26
Sampling Device: Perstaltic Pump	**Pump Intake Depth (ft BTIC):** 63.30	**Pre-Pumping Water Level (ft BTIC):** 29.25
Sampling Personnel: GCP	**Well Diameter (in):** 4	**Tubing Type:** Polyethylene

Time	**pH**	**Temp.** (degrees C)	**Specific Cond.** (mS/cm)	**Dissolved Oxygen** (mg/l)	**Turbidity** (NTU)	**Redox** (mV)	**Depth to Water** (feet)	**Purge Rate** (mL/min)	**Comments**
10:30	6.39	13.58	0.260	7.48	35.8	122	29.26	500	Colorless / Odorless
10:35	6.21	15.15	0.268	0.77	7.5	129	29.26	500	Colorless / Odorless
10:40	6.20	15.24	0.268	0.56	1.1	126	29.26	500	Colorless / Odorless
10:45	6.19	15.35	0.268	0.51	2.8	123	29.26	500	Colorless / Odorless
10:50	6.19	15.35	0.268	0.47	7.2	121	29.26	500	Colorless / Odorless
10:55	6.18	15.37	0.267	0.48	10.3	120	29.26	500	Colorless / Odorless
11:00	6.20	15.38	0.267	0.46	10.0	117	29.26	500	Colorless / Odorless
11:05	6.19	15.33	0.267	0.45	10.1	116	29.26	500	Colorless / Odorless
11:10									Sample Collected

Sample collected using a Persistaltic Pump for: Alkalinity, Dissolved Iron, Dissolved Organic Carbon, Ammonia, Nitrate, Nitrite, Phosphate, Chloride, Sulfate, Sulfide, Carbon Dioxide, Ethane, Ethene, Methane, Phospholipid Fatty Acids, Dehalococcoides Ethenogenes

Sample collected using bailer for : VOC

Notes:

BTIC - Below top of inner casing

Appendix B

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Additional Groundwater Sampling Activities
Groundwater Sampling Log

Well Number: *MW-1*	**Well Depth (ft BTIC):** 30.97	
Date: 4/23/2003	**Screen Length (ft):** 15	**Initial Water Level (ft BTIC):** 28.36
Sampling Device: Perstaltic Pump	**Pump Intake Depth (ft BTIC):** 29.66	**Pre-Pumping Water Level (ft BTIC):** 28.36
Sampling Personnel: GCP	**Well Diameter (in):** 2	**Tubing Type:** Polyethylene

Time	**pH**	**Temp.** (degrees C)	**Specific Cond.** (mS/cm)	**Dissolved Oxygen** (mg/l)	**Turbidity** (NTU)	**Redox** (mV)	**Depth to Water** (feet)	**Purge Rate** (mL/min)	**Comments**
8:50	6.15	13.28	0.216	9.05	56.2	113	28.45	500	Colorless / Odorless
8:55	6.12	13.52	0.205	8.74	0.0	125	28.45	500	Colorless / Odorless
9:00	6.15	13.58	0.200	8.61	0.0	130	28.45	500	Colorless / Odorless
9:05	6.17	14.19	0.200	7.98	0.0	131	28.45	500	Colorless / Odorless
9:10	6.20	14.09	0.202	8.39	0.0	132	28.45	500	Colorless / Odorless
9:15	6.12	16.30	0.198	8.35	6.1	133	28.45	500	Colorless / Odorless
9:20	6.18	14.07	0.198	8.63	0.0	134	28.45	500	Colorless / Odorless
9:25	6.16	13.98	0.196	8.57	0.0	135	28.45	500	Colorless / Odorless
9:30	6.15	13.94	0.196	8.59	0.0	135	28.45	500	Colorless / Odorless
9:35									Sample Collected

Sample collected using a Persistaltic Pump for:	Alkalinity, Dissolved Iron, Dissolved Organic Carbon, Ammonia, Nitrate, Nitrite, Phosphate, Chloride, Sulfate, Sulfide, Carbon Dioxide, Ethane, Ethene, Methane, Phospholipid Fatty Acids, Dehalococcoides Ethenogenes
Sample collected using bailer for :	VOC

Notes:
BTIC - Below top of inner casing

Appendix B

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Additional Groundwater Sampling Activities
Groundwater Sampling Log

Well Number:	*MW-2*	**Well Depth (ft BTIC):**	21.85		
Date:	4/23/2003	**Screen Length (ft):**	15	**Initial Water Level (ft BTIC):**	13.37
Sampling Device:	Perstaltic Pump	**Pump Intake Depth (ft BTIC):**	18.51	**Pre-Pumping Water Level (ft BTIC):**	13.35
Sampling Personnel:	GCP	**Well Diameter (in):**	2	**Tubing Type:**	Polyethylene

Time	**pH**	**Temp.** (degrees C)	**Specific Cond.** (mS/cm)	**Dissolved Oxygen** (mg/l)	**Turbidity** (NTU)	**Redox** (mV)	**Depth to Water** (feet)	**Purge Rate** (mL/min)	**Comments**
8:32	6.13	10.42	0.419	8.86	15.1	113	13.35	375	Odorless / Colorless
8:37	6.44	10.72	0.406	7.49	15.5	134	13.35	425	Odorless / Colorless
8:42	6.41	10.86	0.386	7.13	4.1	144	13.35	425	Odorless / Colorless
8:47	6.38	10.92	0.346	7.28	0.0	149	13.35	425	Odorless / Colorless
8:52	6.37	11.00	0.331	7.14	0.0	150	13.35	400	Odorless / Colorless
8:57	6.34	11.07	0.312	7.19	0.0	152	13.35	400	Odorless / Colorless
9:02	6.32	11.10	0.293	7.21	0.0	153	13.35	400	Odorless / Colorless
9:07	6.31	11.04	0.298	7.22	0.0	154	13.35	400	Odorless / Colorless
9:12	6.29	11.14	0.279	7.20	0.0	156	13.35	400	Odorless / Colorless
9:17	6.30	11.19	0.280	7.15	0.0	156	13.35	400	Odorless / Colorless
9:22	6.29	11.27	0.278	7.13	0.0	156	13.35	400	Odorless / Colorless
9:25									Sample Collected

Sample collected using a Persistaltic Pump for: Alkalinity, Dissolved Iron, Dissolved Organic Carbon, Ammonia, Nitrate, Nitrite, Phosphate, Chloride, Sulfate, Sulfide, Carbon Dioxide, Ethane, Ethene, Methane, Phospholipid Fatty Acids, Dehalococcoides Ethenogenes

Sample collected using bailer for : VOC

Notes:

BTIC - Below top of inner casing

Appendix B

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Additional Groundwater Sampling Activities
Groundwater Sampling Log

Well Number: *MW-3*	**Well Depth (ft BTIC):** 21.54	
Date: 4/22/2003	**Screen Length (ft):** 15	**Initial Water Level (ft BTIC):** 15.06
Sampling Device: Peristaltic Pump	**Pump Intake Depth (ft BTIC):** 18.30	**Pre-Pumping Water Level (ft BTIC):** 15.33
Sampling Personnel: GVS	**Well Diameter (in):** 2	**Tubing Type:** Polyethylene

Time	**pH**	**Temp.** (degrees C)	**Specific Cond.** (mS/cm)	**Dissolved Oxygen** (mg/l)	**Turbidity** (NTU)	**Redox** (mV)	**Depth to Water** (feet)	**Purge Rate** (mL/min)	**Comments**
10:05	6.90	12.75	0.366	3.02	363.0	-84	16.04	200	Slight odor
10:10	6.86	12.94	0.385	1.47	276.0	-113	15.95	120	Slight odor / Slight sheen
10:15	6.88	12.96	0.395	1.33	158.0	-122	15.95	120	Slight odor / Slight sheen
10:20	6.86	12.05	0.397	0.74	118.0	-124	15.95	120	Slight odor / Slight sheen
10:25	6.80	12.90	0.393	0.10	89.1	-122	15.94	120	Slight odor / Slight sheen
10:30	6.81	12.95	0.391	0.84	62.7	-123	15.94	120	Slight odor / Slight sheen
10:35	6.79	12.89	0.391	0.54	56.7	-121	15.94	120	Slight odor / Slight sheen
10:40	6.79	12.94	0.387	0.90	39.9	-121	15.94	120	Slight odor / Slight sheen
10:45	6.75	12.91	0.387	0.74	28.1	-121	15.94	120	Slight odor
10:50	6.76	12.88	0.387	0.76	12.4	-120	15.94	120	Slight odor
10:55	6.76	12.88	0.336	0.75	17.5	-121	15.94	120	Slight odor
11:00	6.77	12.95	0.385	0.75	17.5	-121	15.94	120	Slight odor
11:05									Sample Collected

Sample collected using a Persistaltic Pump for:	Alkalinity, Dissolved Iron, Dissolved Organic Carbon, Ammonia, Nitrate, Nitrite, Phosphate, Chloride, Sulfate, Sulfide, Carbon Dioxide, Ethane, Ethene, Methane, Phospholipid Fatty Acids, Dehalococcoides Ethenogenes
Sample collected using bailer for :	VOC

Notes:
BTIC - Below top of inner casing
BD042203 collected here

Appendix B

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Additional Groundwater Sampling Activities
Groundwater Sampling Log

Well Number:	*MW-6*	**Well Depth (ft BTIC):**	27.54		
Date:	4/23/2003	**Screen Length (ft):**	10	**Initial Water Level (ft BTIC):**	15.53
Sampling Device:	Perstaltic Pump	**Pump Intake Depth (ft BTIC):**	22.54	**Pre-Pumping Water Level (ft BTIC):**	15.50
Sampling Personnel:	GVS	**Well Diameter (in):**	4	**Tubing Type:**	Polyethylene

Time	**pH**	**Temp.** (degrees C)	**Specific Cond.** (mS/cm)	**Dissolved Oxygen** (mg/l)	**Turbidity** (NTU)	**Redox** (mV)	**Depth to Water** (feet)	**Purge Rate** (mL/min)	**Comments**
13:25	7.43	14.26	0.209	8.59	8.8	121	15.50	475	Colorless / Odorless
13:30	6.21	14.80	0.185	6.93	7.5	136	15.51	500	Colorless / Odorless
13:35	6.17	15.01	0.181	6.91	7.6	135	15.52	500	Colorless / Odorless
13:40	6.21	14.99	0.179	6.88	4.5	134	15.51	500	Colorless / Odorless
13:45	6.25	15.01	0.176	6.87	3.7	133	15.51	500	Colorless / Odorless
13:50	6.30	15.13	0.175	6.68	3.0	132	15.51	500	Colorless / Odorless
13:55	6.40	15.11	0.174	6.81	2.0	131	15.51	500	Colorless / Odorless
14:00	6.51	15.21	0.173	6.67	1.1	130	15.51	500	Colorless / Odorless
14:05	6.61	15.21	0.172	6.79	0.4	129	15.51	500	Colorless / Odorless
14:10	6.73	15.22	0.171	6.64	0.0	128	15.51	500	Colorless / Odorless
14:15	6.79	15.18	0.170	6.75	0.0	128	15.51	500	Colorless / Odorless
14:20	6.92	15.24	0.170	6.74	0.0	128	15.51	500	Colorless / Odorless
14:25	7.07	15.28	0.170	6.59	0.0	127	15.51	500	Colorless / Odorless
14:30	7.23	15.24	0.169	6.66	0.0	126	15.51	500	Colorless / Odorless
14:35	7.31	15.24	0.169	6.56	0.0	127	15.51	500	Colorless / Odorless
14:40	7.59	15.21	0.169	6.73	0.0	127	15.51	500	Colorless / Odorless
14:45	7.73	15.25	0.169	6.66	0.0	126	15.51	500	Colorless / Odorless
14:50	7.69	15.23	0.168	6.64	0.0	126	15.51	500	Colorless / Odorless
14:55	7.71	15.24	0.168	6.54	0.0	127	15.51	500	Colorless / Odorless
14:59									Sample Collected

Sample collected using a Persistaltic Pump for:	Alkalinity, Dissolved Iron, Dissolved Organic Carbon, Ammonia, Nitrate, Nitrite, Phosphate, Chloride, Sulfate, Sulfide, Carbon Dioxide, Ethane, Ethene, Methane, Phospholipid Fatty Acids, Dehalococcoides Ethenogenes
Sample collected using bailer for :	VOC

Notes:

BTIC - Below top of inner casing

Appendix B

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Additional Groundwater Sampling Activities
Groundwater Sampling Log

Well Number:	*MW-7*	**Well Depth (ft BTIC):**	21.40		
Date:	4/22/2003	**Screen Length (ft):**	10	**Initial Water Level (ft BTIC):**	13.31
Sampling Device:	Perstaltic Pump	**Pump Intake Depth (ft BTIC):**	17.35	**Pre-Pumping Water Level (ft BTIC):**	13.31
Sampling Personnel:	GCP	**Well Diameter (in):**	2	**Tubing Type:**	Polyethylene

Time	**pH**	**Temp.** (degrees C)	**Specific Cond.** (mS/cm)	**Dissolved Oxygen** (mg/l)	**Turbidity** (NTU)	**Redox** (mV)	**Depth to Water** (feet)	**Purge Rate** (mL/min)	**Comments**
13:35	7.63	11.05	0.232	6.19	34.2	127	13.31	500	Colorless / Odorless
13:40	6.70	11.10	0.233	5.65	8.5	148	13.31	500	Colorless / Odorless
13:45	6.57	11.12	0.242	5.65	7.9	153	13.31	500	Colorless / Odorless
13:50	6.53	11.17	0.234	5.65	7.8	157	13.31	500	Colorless / Odorless
13:55	6.52	11.16	0.238	5.71	8.3	157	13.31	500	Colorless / Odorless
14:05									Sample Collected

Sample collected using a Persistaltic Pump for:	Alkalinity, Dissolved Iron, Dissolved Organic Carbon, Ammonia, Nitrate, Nitrite, Phosphate, Chloride, Sulfate, Sulfide, Carbon Dioxide, Ethane, Ethene, Methane, Phospholipid Fatty Acids, Dehalococcoides Ethenogenes
Sample collected using bailer for :	VOC

Notes:
BTIC - Below top of inner casing

Appendix B

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Additional Groundwater Sampling Activities
Groundwater Sampling Log

Well Number: *MW-8*	**Well Depth (ft BTIC):** 23.45	
Date: 4/22/2003	**Screen Length (ft):** 15	**Initial Water Level (ft BTIC):** 12.73
Sampling Device: Perstaltic Pump	**Pump Intake Depth (ft BTIC):** 18.45	**Pre-Pumping Water Level (ft BTIC):** 12.75
Sampling Personnel: GCP	**Well Diameter (in):** 2	**Tubing Type:** Polyethylene

Time	**pH**	**Temp.** (degrees C)	**Specific Cond.** (mS/cm)	**Dissolved Oxygen** (mg/l)	**Turbidity** (NTU)	**Redox** (mV)	**Depth to Water** (feet)	**Purge Rate** (mL/min)	**Comments**
9:50	6.27	11.55	0.247	3.95	6.1	30	12.79	500	Colorless / Odorless
10:00	6.02	11.55	0.252	3.45	1.9	-40	12.79	500	Colorless / Odorless
10:10	5.99	11.55	0.249	3.31	2.0	-41	12.79	500	Colorless / Odorless
10:15	6.01	11.54	0.246	3.34	1.0	-43	12.79	500	Colorless / Odorless
10:20	6.01	11.55	0.249	3.45	2.2	-40	12.79	500	Colorless / Odorless
10:25									Sample Collected

Sample collected using a Persistaltic Pump for:	Alkalinity, Dissolved Iron, Dissolved Organic Carbon, Ammonia, Nitrate, Nitrite, Phosphate, Chloride, Sulfate, Sulfide, Carbon Dioxide, Ethane, Ethene, Methane, Phospholipid Fatty Acids, Dehalococcoides Ethenogenes
Sample collected using bailer for :	VOC

Notes:
BTIC - Below top of inner casing

Appendix C

Laboratory Analytical Data Reports (Form 1 Results)

BBL®
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engineers & scientists

Severn Trent Laboratories, Inc.

BBL®
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engineers & scientists

Client ID: **MW-1D**
Site: HWD Farmingdale

Lab Sample No: **424031**
Lab Job No: I092

Date Sampled: 04/23/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47647.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 1.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	0.5
Bromomethane	ND	0.4
Vinyl Chloride	ND	0.5
Chloroethane	ND	0.5
Methylene Chloride	ND	0.8
Acetone	ND	1.0
Carbon Disulfide	ND	0.2
1,1-Dichloroethene	1.3	0.4
1,1-Dichloroethane	1.8	0.2
trans-1,2-Dichloroethene	ND	0.2
cis-1,2-Dichloroethene	ND	0.2
Chloroform	ND	0.2
1,2-Dichloroethane	ND	0.3
2-Butanone	ND	2.5
1,1,1-Trichloroethane	1.4	0.2
Carbon Tetrachloride	ND	0.2
Bromodichloromethane	ND	0.4
1,2-Dichloropropane	ND	0.2
cis-1,3-Dichloropropene	ND	0.2
Trichloroethene	1.7	0.2
Dibromochloromethane	ND	0.2
1,1,2-Trichloroethane	ND	0.3
Benzene	ND	0.3
trans-1,3-Dichloropropene	ND	0.2
Bromoform	ND	0.3
4-Methyl-2-Pentanone	ND	0.6
2-Hexanone	ND	1.0
Tetrachloroethene	0.8	0.3
1,1,2,2-Tetrachloroethane	ND	0.3
Toluene	ND	0.2
Chlorobenzene	ND	0.2
Ethylbenzene	ND	0.4
Styrene	ND	0.3
Xylene (Total)	ND	0.2

Client ID: **MW-1D**
Site: HWD Farmingdale

Lab Sample No: **424031**
Lab Job No: I092

Date Sampled: 04/23/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47647.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 1.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. Propane, 2-methoxy-2-methyl-	6.69	9.7	
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
18.			
19.			
20.			
21.			
22.			
23.			
24.			
25.			
26.			
27.			
28.			
29.			
30.			

TOTAL ESTIMATED CONCENTRATION 9.7

Client ID: **MW-1**
Site: HWD Farmingdale

Lab Sample No: **424030**
Lab Job No: I092

Date Sampled: 04/23/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47649.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 1.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	0.5
Bromomethane	ND	0.4
Vinyl Chloride	ND	0.5
Chloroethane	ND	0.5
Methylene Chloride	ND	0.8
Acetone	ND	1.0
Carbon Disulfide	ND	0.2
1,1-Dichloroethene	ND	0.4
1,1-Dichloroethane	ND	0.2
trans-1,2-Dichloroethene	ND	0.2
cis-1,2-Dichloroethene	ND	0.2
Chloroform	ND	0.2
1,2-Dichloroethane	ND	0.3
2-Butanone	ND	2.5
1,1,1-Trichloroethane	ND	0.2
Carbon Tetrachloride	ND	0.2
Bromodichloromethane	ND	0.4
1,2-Dichloropropane	ND	0.2
cis-1,3-Dichloropropene	ND	0.2
Trichloroethene	ND	0.2
Dibromochloromethane	ND	0.2
1,1,2-Trichloroethane	ND	0.3
Benzene	ND	0.3
trans-1,3-Dichloropropene	ND	0.2
Bromoform	ND	0.3
4-Methyl-2-Pentanone	ND	0.6
2-Hexanone	ND	1.0
Tetrachloroethene	50	0.3
1,1,2,2-Tetrachloroethane	ND	0.3
Toluene	ND	0.2
Chlorobenzene	ND	0.2
Ethylbenzene	ND	0.4
Styrene	ND	0.3
Xylene (Total)	ND	0.2

Client ID: **MW-1**
Site: HWD Farmingdale

Lab Sample No: **424030**
Lab Job No: I092

Date Sampled: 04/23/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47649.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 1.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. NO VOLATILE ORGANIC COMPOUNDS FOUND			
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TOTAL ESTIMATED CONCENTRATION 0.0

Client ID: **MW-2**
Site: HWD Farmingdale

Lab Sample No: **424029**
Lab Job No: I092

Date Sampled: 04/23/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47653.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 10.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	4.6
Bromomethane	ND	4.4
Vinyl Chloride	ND	5.3
Chloroethane	ND	4.6
Methylene Chloride	ND	8.1
Acetone	ND	9.7
Carbon Disulfide	ND	2.4
1,1-Dichloroethene	ND	4.3
1,1-Dichloroethane	ND	2.4
trans-1,2-Dichloroethene	ND	2.5
cis-1,2-Dichloroethene	21	2.4
Chloroform	ND	1.9
1,2-Dichloroethane	ND	2.6
2-Butanone	ND	25
1,1,1-Trichloroethane	ND	1.6
Carbon Tetrachloride	ND	1.9
Bromodichloromethane	ND	3.6
1,2-Dichloropropane	ND	2.3
cis-1,3-Dichloropropene	ND	2.4
Trichloroethene	34	1.8
Dibromochloromethane	ND	2.5
1,1,2-Trichloroethane	ND	3.4
Benzene	ND	2.6
trans-1,3-Dichloropropene	ND	2.1
Bromoform	ND	3.4
4-Methyl-2-Pentanone	ND	5.5
2-Hexanone	ND	9.7
Tetrachloroethene	1200	3.1
1,1,2,2-Tetrachloroethane	ND	2.8
Toluene	ND	1.5
Chlorobenzene	ND	1.8
Ethylbenzene	ND	3.7
Styrene	ND	2.8
Xylene (Total)	ND	1.8

Client ID: **MW-2**
Site: HWD Farmingdale

Lab Sample No: **424029**
Lab Job No: I092

Date Sampled: 04/23/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47653.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 10.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. NO VOLATILE ORGANIC COMPOUNDS FOUND			
2.			
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TOTAL ESTIMATED CONCENTRATION 0.0

Client ID: **MW-3**
Site: HWD Farmingdale

Lab Sample No: **424026**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47650.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 2.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	0.9
Bromomethane	ND	0.9
Vinyl Chloride	ND	1.1
Chloroethane	ND	0.9
Methylene Chloride	ND	1.6
Acetone	ND	1.9
Carbon Disulfide	ND	0.5
1,1-Dichloroethene	ND	0.9
1,1-Dichloroethane	ND	0.5
trans-1,2-Dichloroethene	ND	0.5
cis-1,2-Dichloroethene	2.3	0.5
Chloroform	ND	0.4
1,2-Dichloroethane	ND	0.5
2-Butanone	ND	4.9
1,1,1-Trichloroethane	ND	0.3
Carbon Tetrachloride	ND	0.4
Bromodichloromethane	ND	0.7
1,2-Dichloropropane	ND	0.5
cis-1,3-Dichloropropene	ND	0.5
Trichloroethene	ND	0.4
Dibromochloromethane	ND	0.5
1,1,2-Trichloroethane	ND	0.7
Benzene	2.0	0.5
trans-1,3-Dichloropropene	ND	0.4
Bromoform	ND	0.7
4-Methyl-2-Pentanone	ND	1.1
2-Hexanone	ND	1.9
Tetrachloroethene	1.4	0.6
1,1,2,2-Tetrachloroethane	ND	0.6
Toluene	9.6	0.3
Chlorobenzene	19	0.4
Ethylbenzene	310	0.7
Styrene	ND	0.6
Xylene (Total)	40	0.4

Client ID: **MW-3**
Site: HWD Farmingdale

Lab Sample No: **424026**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47650.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 2.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. Unknown	3.10	31	
2. Chlorotrifluoroethene isomer	3.28	45	
3. Ethylmethylbenzene isomer	14.37	8.1	
4. Benzene, propyl-	14.81	29	
5. Ethylmethylbenzene isomer	14.93	11	
6. Ethylmethylbenzene isomer	15.21	28	
7. Trimethylbenzene isomer	15.37	110	
8. Trimethylbenzene isomer	15.83	43	
9. Unknown Aromatic	16.07	50	
10. Benzene, 1,2-dichloro-/Unknown Aromati	16.22	7.5	
11. Methylpropylbenzene isomer	16.30	10	
12. Ethyldimethylbenzene isomer	16.37	10	
13. Methyl-methylethylbenzene isomer	16.47	12	
14. 2,3-dihydro-methyl-1H-Indene isomer/C1	16.65	10	
15. Tetramethylbenzene isomer	16.91	11	
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TOTAL ESTIMATED CONCENTRATION	416

Client ID: **BD042203** (MW-3)
Site: HWD Farmingdale

Lab Sample No: **424028**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47651.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 2.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	0.9
Bromomethane	ND	0.9
Vinyl Chloride	ND	1.1
Chloroethane	ND	0.9
Methylene Chloride	ND	1.6
Acetone	ND	1.9
Carbon Disulfide	ND	0.5
1,1-Dichloroethene	ND	0.9
1,1-Dichloroethane	ND	0.5
trans-1,2-Dichloroethene	ND	0.5
cis-1,2-Dichloroethene	1.9	0.5
Chloroform	ND	0.4
1,2-Dichloroethane	ND	0.5
2-Butanone	ND	4.9
1,1,1-Trichloroethane	ND	0.3
Carbon Tetrachloride	ND	0.4
Bromodichloromethane	ND	0.7
1,2-Dichloropropane	ND	0.5
cis-1,3-Dichloropropene	ND	0.5
Trichloroethene	ND	0.4
Dibromochloromethane	ND	0.5
1,1,2-Trichloroethane	ND	0.7
Benzene	1.8	0.5
trans-1,3-Dichloropropene	ND	0.4
Bromoform	ND	0.7
4-Methyl-2-Pentanone	ND	1.1
2-Hexanone	ND	1.9
Tetrachloroethene	1.2	0.6
1,1,2,2-Tetrachloroethane	ND	0.6
Toluene	8.2	0.3
Chlorobenzene	17	0.4
Ethylbenzene	270	0.7
Styrene	ND	0.6
Xylene (Total)	35	0.4

Client ID: **BD042203** (MW-3)
Site: HWD Farmingdale

Lab Sample No: **424028**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47651.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 2.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. Unknown	3.10	23	
2. Chlorotrifluoroethene isomer	3.28	40	
3. Ethylmethylbenzene isomer	14.37	7.0	
4. Benzene, propyl-	14.82	24	
5. Ethylmethylbenzene isomer	14.92	9.9	
6. Ethylmethylbenzene isomer	15.21	24	
7. Trimethylbenzene isomer	15.37	99	
8. Coeluting Aromatics	15.56	6.8	
9. Trimethylbenzene isomer	15.83	38	
10. Unknown Aromatic	16.08	45	
11. Benzene, 1,2-dichloro-/Unknown Aromati	16.23	8.8	
12. Ethyldimethylbenzene isomer	16.38	8.9	
13. Methyl-methylethylbenzene isomer	16.47	10	
14. 2,3-dihydro-methyl-1H-Indene isomer	16.65	8.7	
15. Tetramethylbenzene isomer	16.90	9.2	
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TOTAL ESTIMATED CONCENTRATION 362

Client ID: **MW-6**
Site: HWD Farmingdale

Lab Sample No: **424025**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47648.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 1.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	0.5
Bromomethane	ND	0.4
Vinyl Chloride	ND	0.5
Chloroethane	ND	0.5
Methylene Chloride	ND	0.8
Acetone	ND	1.0
Carbon Disulfide	ND	0.2
1,1-Dichloroethene	ND	0.4
1,1-Dichloroethane	ND	0.2
trans-1,2-Dichloroethene	ND	0.2
cis-1,2-Dichloroethene	ND	0.2
Chloroform	ND	0.2
1,2-Dichloroethane	ND	0.3
2-Butanone	ND	2.5
1,1,1-Trichloroethane	0.3	0.2
Carbon Tetrachloride	ND	0.2
Bromodichloromethane	ND	0.4
1,2-Dichloropropane	ND	0.2
cis-1,3-Dichloropropene	ND	0.2
Trichloroethene	1.1	0.2
Dibromochloromethane	ND	0.2
1,1,2-Trichloroethane	ND	0.3
Benzene	ND	0.3
trans-1,3-Dichloropropene	ND	0.2
Bromoform	ND	0.3
4-Methyl-2-Pentanone	ND	0.6
2-Hexanone	ND	1.0
Tetrachloroethene	120	0.3
1,1,2,2-Tetrachloroethane	ND	0.3
Toluene	ND	0.2
Chlorobenzene	ND	0.2
Ethylbenzene	ND	0.4
Styrene	ND	0.3
Xylene (Total)	ND	0.2

Client ID: **MW-6**
Site: HWD Farmingdale

Lab Sample No: **424025**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47648.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 1.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. NO VOLATILE ORGANIC COMPOUNDS FOUND			
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TOTAL ESTIMATED CONCENTRATION 0.0

Client ID: **MW-7**
Site: HWD Farmingdale

Lab Sample No: **424024**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47654.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 25.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	12
Bromomethane	ND	11
Vinyl Chloride	ND	13
Chloroethane	ND	12
Methylene Chloride	ND	20
Acetone	ND	24
Carbon Disulfide	ND	6.0
1,1-Dichloroethene	ND	11
1,1-Dichloroethane	ND	6.0
trans-1,2-Dichloroethene	ND	6.2
cis-1,2-Dichloroethene	38	6.0
Chloroform	ND	4.8
1,2-Dichloroethane	ND	6.5
2-Butanone	ND	62
1,1,1-Trichloroethane	ND	4.0
Carbon Tetrachloride	ND	4.8
Bromodichloromethane	ND	9.0
1,2-Dichloropropane	ND	5.8
cis-1,3-Dichloropropene	ND	6.0
Trichloroethene	48	4.5
Dibromochloromethane	ND	6.2
1,1,2-Trichloroethane	ND	8.5
Benzene	ND	6.5
trans-1,3-Dichloropropene	ND	5.2
Bromoform	ND	8.5
4-Methyl-2-Pentanone	ND	14
2-Hexanone	ND	24
Tetrachloroethene	2600	7.8
1,1,2,2-Tetrachloroethane	ND	7.0
Toluene	ND	3.8
Chlorobenzene	ND	4.5
Ethylbenzene	ND	9.2
Styrene	ND	7.0
Xylene (Total)	ND	4.5

Client ID: **MW-7** Lab Sample No: **424024**
Site: HWD Farmingdale Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47654.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 25.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. NO VOLATILE ORGANIC COMPOUNDS FOUND			
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TOTAL ESTIMATED CONCENTRATION 0.0

Client ID: **MW-8**
Site: HWD Farmingdale

Lab Sample No: **424027**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47652.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 10.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	4.6
Bromomethane	ND	4.4
Vinyl Chloride	ND	5.3
Chloroethane	ND	4.6
Methylene Chloride	ND	8.1
Acetone	ND	9.7
Carbon Disulfide	ND	2.4
1,1-Dichloroethene	ND	4.3
1,1-Dichloroethane	ND	2.4
trans-1,2-Dichloroethene	ND	2.5
cis-1,2-Dichloroethene	27	2.4
Chloroform	ND	1.9
1,2-Dichloroethane	ND	2.6
2-Butanone	ND	25
1,1,1-Trichloroethane	ND	1.6
Carbon Tetrachloride	ND	1.9
Bromodichloromethane	ND	3.6
1,2-Dichloropropane	ND	2.3
cis-1,3-Dichloropropene	ND	2.4
Trichloroethene	25	1.8
Dibromochloromethane	ND	2.5
1,1,2-Trichloroethane	ND	3.4
Benzene	ND	2.6
trans-1,3-Dichloropropene	ND	2.1
Bromoform	ND	3.4
4-Methyl-2-Pentanone	ND	5.5
2-Hexanone	ND	9.7
Tetrachloroethene	970	3.1
1,1,2,2-Tetrachloroethane	ND	2.8
Toluene	ND	1.5
Chlorobenzene	ND	1.8
Ethylbenzene	ND	3.7
Styrene	ND	2.8
Xylene (Total)	ND	1.8

Client ID: **MW-8**
Site: HWD Farmingdale

Lab Sample No: **424027**
Lab Job No: I092

Date Sampled: 04/22/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47652.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 10.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. NO VOLATILE ORGANIC COMPOUNDS FOUND			
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TOTAL ESTIMATED CONCENTRATION	0.0

Client ID: **TB042303**
Site: HWD Farmingdale

Lab Sample No: **424032**
Lab Job No: I092

Date Sampled: 04/14/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47646.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 1.0

VOLATILE ORGANICS - GC/MS
METHOD 624

Parameter	Analytical Result Units: ug/l	Method Detection Limit Units: ug/l
Chloromethane	ND	0.5
Bromomethane	ND	0.4
Vinyl Chloride	ND	0.5
Chloroethane	ND	0.5
Methylene Chloride	ND	0.8
Acetone	ND	1.0
Carbon Disulfide	ND	0.2
1,1-Dichloroethene	ND	0.4
1,1-Dichloroethane	ND	0.2
trans-1,2-Dichloroethene	ND	0.2
cis-1,2-Dichloroethene	ND	0.2
Chloroform	ND	0.2
1,2-Dichloroethane	ND	0.3
2-Butanone	ND	2.5
1,1,1-Trichloroethane	ND	0.2
Carbon Tetrachloride	ND	0.2
Bromodichloromethane	ND	0.4
1,2-Dichloropropane	ND	0.2
cis-1,3-Dichloropropene	ND	0.2
Trichloroethene	ND	0.2
Dibromochloromethane	ND	0.2
1,1,2-Trichloroethane	ND	0.3
Benzene	ND	0.3
trans-1,3-Dichloropropene	ND	0.2
Bromoform	ND	0.3
4-Methyl-2-Pentanone	ND	0.6
2-Hexanone	ND	1.0
Tetrachloroethene	ND	0.3
1,1,2,2-Tetrachloroethane	ND	0.3
Toluene	ND	0.2
Chlorobenzene	ND	0.2
Ethylbenzene	ND	0.4
Styrene	ND	0.3
Xylene (Total)	ND	0.2

Client ID: **TB042303**
Site: HWD Farmingdale

Lab Sample No: **424032**
Lab Job No: I092

Date Sampled: 04/14/03
Date Received: 04/24/03
Date Analyzed: 04/28/03
GC Column: DB624
Instrument ID: VOAMS6.i
Lab File ID: f47646.d

Matrix: WATER
Level: LOW
Purge Volume: 5.0 ml
Dilution Factor: 1.0

VOLATILE ORGANICS - GC/MS
TENTATIVELY IDENTIFIED COMPOUNDS
METHOD 624

COMPOUND NAME	RT	EST. CONC. ug/l	Q
1. NO VOLATILE ORGANIC COMPOUNDS FOUND			
2.			
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TOTAL ESTIMATED CONCENTRATION 0.0

EDISON
w Durham Road
Edison, New Jersey 08817
Phone: (732) 549-3900 Fax: (732) 549-3679

CHAIN OF CUSTODY / ANALYSIS REQUEST

PAGE 1 OF 1

Name (for report and invoice) John Brussel
Company BBL
Address
City Syracuse State NY
Phone 315-446-2570 Fax

Samplers Name (Printed) Glenn Palmer
P.O. #

Site/Project Identification HWD Farmingdale
State (Location of site): NJ: ☐ NY: ☒ Other:
Regulatory Program:

Analysis Turnaround Time
Standard ☒
Rush Charges Authorized For:
2 Week ☐
1 Week ☐
Other ☐

ANALYSIS REQUESTED (ENTER "X" BELOW TO INDICATE REQUEST)

LAB USE ONLY
Project No:
Job No: E092

Sample Identification	Date	Time	Matrix	No. of Cont.	voc 624	ms/msD 624										Sample Numbers
Mw-7	4/22/03	1405	GW	9	✓	✓										424024
mw-6	↓	1459	↓	3	✓											424025
mW-3		1104		3	✓											424026
mW-8		1025		3	✓											424027
BD042203				3	✓											424028
mw-2	4/23/05	0925	↓	3	✓											424029
mw-1	↓	0935		3	✓											424030
mW-1D		1110		3	✓											424031
TB042303	Gm 4/24/03	X	W	2	✓											424032

Preservation Used: 1 = ICE, 2 = HCl, 3 = H_2SO_4, 4 = HNO_3, 5 = NaOH
6 = Other ________, 7 = Other ________

Soil:	2	2									
Water:	2	2									

Special Instructions

Water Metals Filtered (Yes/No)?

Relinquished by	Company	Date / Time	Received by	Company
1) Glenn Palmer	BBL	4/24/03 / 10:30 Am	1) K. CHALOKA	STL
2) K CHALOKA	STL Edison Ken Chaloka	4/24/03 / 12:00 Pm	2) Gm	STL
3)			3)	
4)			4)	

Laboratory Certifications: New Jersey (12028), New York (11452), Pennsylvania (68-522), Connecticut (PH-0200), Rhode Island (132).

STL-6003

STL Edison

Microseeps, Inc.

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engineers & scientists

MICROSEEPS

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Page 1 of 2
Order #: P0304416
Report Date: 05/12/03
Client Proj Name: Farmingdale NY
Client Proj #: Farmingdale NY

Laboratory Results

Lab Sample #	Client Sample ID
P0304416-01	MW-1D

Approved By: Debbie Hallo

NOTES:

Order #: P0304416
Report Date: 05/12/03
Client Proj Name: Farmingdale NY
Client Proj #: Farmingdale NY

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Lab Sample #: P0304416-01

Sample Description	Matrix	Sampled Date/Time	Received
MW-1D	Water	23 Apr. 03 11:10	24 Apr. 03

Analyte(s)	Result	PQL	Units	Method #	Analyst	Analysis Date
WetChem						
Water						
Alkalinity as CaCO3	71	4.0	mg/L	310.1	js	4/25/03
Ammonia as N	<2.0	2.0	mg/L	350.2	js	5/2/03
Chloride	36	1.0	mg/L	9056	md	4/25/03 04:39
Nitrate	<0.50	0.50	mg/L	9056	md	4/25/03 04:39
Nitrite	<0.50	0.50	mg/L	9056	md	4/25/03 04:39
Phosphate	<0.10	0.10	mg/L	9056	md	4/25/03 04:39
SolubleOrganic Carbon	<5	5	mg/L	9060	md	5/6/03
Sulfate	18	1.0	mg/L	9056	md	4/25/03 04:39
Sulfide	< 2.0	2.0	mg/L	376.1	am	4/28/03
Metals						
ter						
-dissolved	<0.050	0.050	mg/L	6010B	ak	4/30/03
RiskAnalysis						
Water						
Carbon dioxide	76	0.60	mg/L	AM20GAX	mm	5/9/03
Ethane	29	5.0	ng/L	AM18	mm	5/9/03
Ethene	32	5.0	ng/L	AM18	mm	5/9/03
Methane	14	0.015	ug/L	AM20GAX	mm	5/9/03

P0304416

CHAIN - OF - CUSTODY RECORD

Phone: (412) 826-5245 **Microseeps, Inc. - 220 William Pitt Way - Pittsburgh, PA 15238** Fax No.: (412) 826-3433

Company : BBL
Co. Address : Tow Path Rd
Proj. Manager: John Brussel
Proj. Location: Farmingdale NY
Proj. Number:
Phone # : 315-446-2570 **Fax # :**

Sampler's signature :

Results to :

Invoice to :

Cooler ID	Cooler Temp.

	Sample ID	Sample Description	Date	Time	Comp.	Grab	# Cont.	Alkalinity	Ammonia	Sulfide	Dissolved Organic Carbon	chloride, nitrate, nitrite, sulfate, phosphate	methane, ethane, ethene, CO_2	Dissolved Iron		Remarks
01	MW-1D		4/23/03	1110		X	15	X	X	X	X	X	X	X		

Relinquished by :	Company :	Date :	Time :	Received by : CWashlash	Company : Microseeps	Date : 4/24/03	Time : 1407
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :
Relinquished by :	Company :	Date :	Time :	Received by :	Company :	Date :	Time :

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MICROSEEPS

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Order #: P0304415
Report Date: 05/09/03
Client Proj Name: Farmingdale NY
Client Proj #: Farmingdale NY

Laboratory Results

Lab Sample #	Client Sample ID
P0304415-01	MW-2
P0304415-02	MW-1

Approved By:
NOTES:

Order #: P0304415
Report Date: 05/09/03
Client Proj Name: Farmingdale NY
Client Proj #: Farmingdale NY

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Lab Sample #: P0304415-01

Sample Description	Matrix	Sampled Date/Time	Received
MW-2	Water	23 Apr. 03 9:25	24 Apr. 03

Analyte(s)	Result	PQL	Units	Method #	Analyst	Analysis Date
WetChem						
Water						
Alkalinity as CaCO3	61	4.0	mg/L	310.1	js	4/25/03
Ammonia as N	<2.0	2.0	mg/L	350.2	js	5/2/03
Chloride	35	1.0	mg/L	9056	md	4/24/03 18:51
Nitrate	15	0.50	mg/L	9056	md	4/24/03 18:51
Nitrite	<0.50	0.50	mg/L	9056	md	4/24/03 18:51
Phosphate	<0.10	0.10	mg/L	9056	md	4/24/03 18:51
SolubleOrganic Carbon	<5.0	5.0	mg/L	9060		5/7/03
Sulfate	19	1.0	mg/L	9056	md	4/24/03 18:51
Sulfide	<2.0	2.0	mg/L	376.1	am	4/28/03
Metals						
Water						
Iron-dissolved	<0.050	0.050	mg/L	6010B	ak	4/30/03
RiskAnalysis						
Water						
Carbon dioxide	26	0.60	mg/L	AM20GAX	mm	5/8/03
Ethane	84	5.0	ng/L	AM18	mm	5/8/03
Ethene	25	5.0	ng/L	AM18	mm	5/8/03
Methane	0.73	0.015	ug/L	AM20GAX	mm	5/8/03

Page 3 of 3
Order #: P0304415
Report Date: 05/09/03
Client Proj Name: Farmingdale NY
Client Proj #: Farmingdale NY

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Lab Sample #: P0304415-02

Sample Description	Matrix	Sampled Date/Time	Received
MW-1	Water	23 Apr. 03 9:35	24 Apr. 03

Analyte(s)	Result	PQL	Units	Method #	Analyst	Analysis Date
WetChem						
Water						
Alkalinity as CaCO3	32	4.0	mg/L	310.1	js	4/25/03
Ammonia as N	<2.0	2.0	mg/L	350.2	js	5/2/03
Chloride	20	1.0	mg/L	9056	md	4/24/03 19:16
Nitrate	17	0.50	mg/L	9056	md	4/24/03 19:16
Nitrite	<0.50	0.50	mg/L	9056	md	4/24/03 19:16
Phosphate	<0.10	0.10	mg/L	9056	md	4/24/03 19:16
SolubleOrganic Carbon	<5.0	5.0	mg/L	9060		5/7/03
Sulfate	20	1.0	mg/L	9056	md	4/24/03 19:16
Sulfide	<2.0	2.0	mg/L	376.1	am	4/28/03
Metals						
[illegible]ter						
[illegible]-dissolved	<0.050	0.050	mg/L	6010B	ak	4/30/03
RiskAnalysis						
Water						
Carbon dioxide	34	0.60	mg/L	AM20GAX	mm	5/8/03
Ethane	82	5.0	ng/L	AM18	mm	5/8/03
Ethene	23	5.0	ng/L	AM18	mm	5/8/03
Methane	0.71	0.015	ug/L	AM20GAX	mm	5/8/03

PO 304415

CHAIN - OF - CUSTODY RECORD

Phone: (412) 826-5245 **Microseeps, Inc. - 220 William Pitt Way - Pittsburgh, PA 15238** Fax No.: (412) 826-3433

Company : BBL
Co. Address : Tow Path Rd
Proj. Manager: John Brussel
Proj. Location: Farmingdale NY
Proj. Number:
Phone # : 315-446-2570 **Fax # :**

Sampler's signature :

Results to : John Brussel
Syracuse

Invoice to : John Brussel
Syracuse

Cooler ID	Cooler Temp.

Parameters Requested

	Sample ID	Sample Description	Date	Time	Comp.	Grab	# Cont.	Alkalinity	Ammonia	Sulfide	Dissolved Organic Carb	chloride, nitrate, nitrite, sulfate, phosphate	methane, ethane, ethene, CO2	Dissolved Iron		Remarks
01	MW-2		4/23/05	0925		X	15	X	X	X	X	X	X	X		
02	MW-1		↓	0935		X	15	X	X	X	X	X	X	X		
	~~MW-1D~~		~~X~~													

Relinquished by :	**Company :** BBL	**Date :** 4/23/05	**Time :** 1300	**Received by :**	**Company :** Microseeps	**Date :** 4/24/05	**Time :** 12:45
Relinquished by :	**Company :**	**Date :**	**Time :**	**Received by :**	**Company :**	**Date :**	**Time :**
Relinquished by :	**Company :**	**Date :**	**Time :**	**Received by :**	**Company :**	**Date :**	**Time :**

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MICROSEEPS

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Page 1 of 5
Order #: P0304389
Report Date: 05/08/03
Client Proj Name: HWD 02
Client Proj #: 6040524

Laboratory Results

Lab Sample #	Client Sample ID
P0304389-01	MW-7
P0304389-02	MW-6
P0304389-03	MW-3
P0304389-04	MW-8

Approved By: Rebecca J Stevens

NOTES:

Order #: P0304389
Report Date: 05/08/03
Client Proj Name: HWD 02
Client Proj #: 6040524

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Lab Sample #: P0304389-01

Sample Description	Matrix	Sampled Date/Time	Received
MW-7	Water	22 Apr. 03 14:05	23 Apr. 03

Analyte(s)	Result	PQL	Units	Method #	Analyst	Analysis Date
WetChem						
Water						
Alkalinity as CaCO3	52	4.0	mg/L	310.1	js	4/25/03
Ammonia as N	5.2	2.0	mg/L	350.2	am	4/29/03
Chloride	22	1.0	mg/L	9056	md	4/23/03 20:14
Nitrate	14	0.50	mg/L	9056	md	4/23/03 20:14
Nitrite	<0.50	0.50	mg/L	9056	md	4/23/03 20:14
Phosphate	<0.10	0.10	mg/L	9056	md	4/23/03 20:14
SolubleOrganic Carbon	<5.0	5.0	mg/L	9060	md	4/29/03
Sulfate	30	1.0	mg/L	9056	md	4/23/03 20:14
Sulfide	<2.0	2.0	mg/L	376.1	am	4/25/03
Metals						
Water						
Iron-dissolved	<0.050	0.050	mg/L	6010B	ak	4/30/03
RiskAnalysis						
Water						
Carbon dioxide	28	0.60	mg/L	AM20GAX	mm	5/7/03
Ethane	5.8	5.0	ng/L	AM18	mm	5/7/03
Ethene	8.4	5.0	ng/L	AM18	mm	5/7/03
Methane	0.13	0.015	ug/L	AM20GAX	mm	5/7/03

Order #: P0304389
Report Date: 05/08/03
Client Proj Name: HWD 02
Client Proj #: 6040524

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Lab Sample #: P0304389-02

Sample Description	Matrix	Sampled Date/Time	Received
MW-6	Water	22 Apr. 03 14:59	23 Apr. 03

Analyte(s)	Result	PQL	Units	Method #	Analyst	Analysis Date
WetChem						
Water						
Alkalinity as CaCO3	29	4.0	mg/L	310.1	js	4/25/03
Ammonia as N	2.2	2.0	mg/L	350.2	am	4/29/03
Chloride	14	1.0	mg/L	9056	md	4/23/03 20:39
Nitrate	10	0.50	mg/L	9056	md	4/23/03 20:39
Nitrite	<0.50	0.50	mg/L	9056	md	4/23/03 20:39
Phosphate	<0.10	0.10	mg/L	9056	md	4/23/03 20:39
SolubleOrganic Carbon	< 5.0	5.0	mg/L	9060	md	4/29/03
Sulfate	24	1.0	mg/L	9056	md	4/23/03 20:39
Sulfide	<2.0	2.0	mg/L	376.1	am	4/25/03
Metals						
ter						
-dissolved	<0.050	0.050	mg/L	6010B	ak	4/30/03
RiskAnalysis						
Water						
Carbon dioxide	26	0.60	mg/L	AM20GAX	mm	5/7/03
Ethane	<5.0	5.0	ng/L	AM18	mm	5/7/03
Ethene	11	5.0	ng/L	AM18	mm	5/7/03
Methane	0.080	0.015	ug/L	AM20GAX	mm	5/7/03

Order #: P0304389
Report Date: 05/08/03
Client Proj Name: HWD 02
Client Proj #: 6040524

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Lab Sample #: P0304389-03

Sample Description	Matrix	Sampled Date/Time	Received
MW-3	Water	22 Apr. 03 11:04	23 Apr. 03

Analyte(s)	Result	PQL	Units	Method #	Analyst	Analysis Date
WetChem						
Water						
Alkalinity as CaCO3	200	4.0	mg/L	310.1	js	4/25/03
Ammonia as N	3.7	2.0	mg/L	350.2	am	4/29/03
Chloride	9.4	1.0	mg/L	9056	md	4/23/03 21:03
Nitrate	<0.50	0.50	mg/L	9056	md	4/23/03 21:03
Nitrite	<0.50	0.50	mg/L	9056	md	4/23/03 21:03
Phosphate	<0.10	0.10	mg/L	9056	md	4/23/03 21:03
SolubleOrganic Carbon	<5.0	5.0	mg/L	9060	md	4/29/03
Sulfate	5.2	1.0	mg/L	9056	md	4/23/03 21:03
Sulfide	<2.0	2.0	mg/L	376.1	am	4/25/03
Metals						
ter						
-dissolved	21	0.050	mg/L	6010B	ak	4/30/03
RiskAnalysis						
Water						
Carbon dioxide	71	0.60	mg/L	AM20GAX	mm	5/7/03
Ethane	410	5.0	ng/L	AM18	mm	5/7/03
Ethene	340	5.0	ng/L	AM18	mm	5/7/03
Methane	780	0.015	ug/L	AM20GAX	mm	5/7/03

Order #: P0304389
Report Date: 05/08/03
Client Proj Name: HWD 02
Client Proj #: 6040524

Client Name: Blasland Bouck & Lee
Contact: John Brussel
Address: 6723 Towpath Road
Box 66
Syracuse, NY 13214-0066

Lab Sample #: P0304389-04

Sample Description	Matrix	Sampled Date/Time	Received
MW-8	Water	22 Apr. 03 10:25	23 Apr. 03

Analyte(s)	Result	PQL	Units	Method #	Analyst	Analysis Date
WetChem						
Water						
Alkalinity as CaCO3	92	4.0	mg/L	310.1	js	4/25/03
Ammonia as N	< 2.0	2.0	mg/L	350.2	am	4/29/03
Chloride	15	1.0	mg/L	9056	md	4/23/03 21:28
Nitrate	8.6	0.50	mg/L	9056	md	4/23/03 21:28
Nitrite	<0.50	0.50	mg/L	9056	md	4/23/03 21:28
Phosphate	<0.10	0.10	mg/L	9056	md	4/23/03 21:28
SolubleOrganic Carbon	<5.0	5.0	mg/L	9060	md	4/29/03
Sulfate	27	1.0	mg/L	9056	md	4/23/03 21:28
Sulfide	<2.0	2.0	mg/L	376.1	am	4/25/03
Metals						
ter						
[illegible]-dissolved	0.73	0.050	mg/L	6010B	ak	4/30/03
RiskAnalysis						
Water						
Carbon dioxide	38	0.60	mg/L	AM20GAX	mm	5/7/03
Ethane	8000	5.0	ng/L	AM18	mm	5/7/03
Ethene	180	5.0	ng/L	AM18	mm	5/7/03
Methane	160	0.015	ug/L	AM20GAX	mm	5/7/03

P0304389

CHAIN - OF - CUSTODY RECORD

Phone: (412) 826-5245 **Microseeps, Inc. - 220 William Pitt Way - Pittsburgh, PA 15238** Fax No. : (412) 826-3433

Company : BBL

Co. Address : TowPath Rd Syracuse NY

Proj. Manager: John Brussel

Proj. Location: HWD

Proj. Number:

Phone # : 315-[illegible]-2570 **Fax # :**

Sampler's signature :

Results to : John Brussel

Invoice to : John Brussel

Cooler ID	**Cooler Temp.**

	Sample ID	**Sample Description**	**Date**	**Time**	**Comp.**	**Grab**	**# Cont.**	Alkalinity	Ammonia	Sulfide	Dissolved Organic Carb	chloride, nitrate, nitrite, su Phosphate	methane, ethane, ethene, CO2	Dissolved Iron		**Remarks**
01	mw-7	GW	4/22/05	1405		x	15	✓	✓	✓	✓	✓	✓	✓		
02	mw-6		↓	1459		↓	15	↓	↓	↓	↓	↓	↓	↓		
03	mw-3			1104			15									
04	mw-8			1025			15									

Relinquished by :	**Company :** BBL	**Date :** 4/22/05	**Time :** 1600	**Received by :** R. Welch	**Company :** Microseeps	**Date :** 4/23/05	**Time :** 1100
Relinquished by :	**Company :**	**Date :**	**Time :**	**Received by :**	**Company :**	**Date :**	**Time :**
-d by :	**Company :**	**Date :**	**Time :**	**Received by :**	**Company :**	**Date :**	**Time :**

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Microbial Insights, Inc.

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

microbial insights

2340 Stock Creek Blvd.
Rockford TN 37853-3044
Phone (865) 573-8188
Fax: (865) 573-8133
Email: microbe@microbe.com

Microbial Analysis Report

Client: John Brussel
BBL
Tow Path Rd.
Syracuse, NY

Phone: 315.446.2570

Fax:

MI Identifier: 84bbl **Date Rec.:** 4/24/03 **Report Date:** 5/20/03

Analysis Requested: PLFA

Project: HWD

Comments:

All samples within this data package were analyzed under U.S. EPA Good Laboratory Practice Standards: Toxic Substances Control Act (40 CFR part 790). All samples were processed according to standard operating procedures. Test results submitted in this data package meet the quality assurance requirements established by Microbial Insights, Inc.

Reported by:

Susan Reynolds

Reviewed by:

Microbial Analysis Report

Executive Summary

The microbial communities from seven groundwater samples were analyzed and characterized according to their phospholipid fatty acid composition (PLFA analysis). Results from this study revealed the following key observations:

- Biomass estimates, as determined by the total concentration of PLFA, were shown to be highest in sample MW-1D. Overall, biomass concentrations varied between ~10^3 to ~10^6 cells/mL water among sampling locations.
- PLFA profiles revealed that the complexity and composition of the community structure varied among sampling locations. Samples MW-1 and MW-2 were shown to contain simple community structures in comparison to the other samples submitted for analysis. High proportions of terminally branched saturated PLFA (indicative of anaerobes) were found in samples MW-3 and MW-1D. Samples MW-6 and MW-1D were shown to contain high proportions of polyenoic PLFA (characteristic of eukaryotic organisms). The biomarker 18:2ω6, indicative of fungi, was the most prevalent in the polyenoic group.
- Physiological status biomarkers indicated that the Gram negative bacteria in all samples other than MW-1 and MW-6 were stressed and at least borderline starved. MW-2 and MW-1D were shown to be the most starved.

Overview of Approach:

Phospholipid Fatty Acid Analysis

Determination of the phospholipid fatty acids (PLFA) in environmental samples is an effective tool for monitoring microbial responses to their environment. They are essential components of the membranes of all cells (except for the Archea, a minor component of most environments), so their sum includes all important actors of most microbial communities. There are four different types of information in PLFA profiles – biomass, community structure, diversity, and physiological status.

Biomass: PLFA analysis is the most reliable and accurate method available for the determination of viable microbial biomass. Since phospholipids break down rapidly upon cell death (21, 23), the PLFA biomass does not contain 'fossil' lipids of dead cells. The sum of the PLFA, expressed as picomoles (1 picomole = 1×10^{-12} mole), is proportional to the number of cells. The proportion used in this report, 20,000 cells/pmole, is taken from cells grown in laboratory media, and varies somewhat with type of organism and environmental conditions. Starving bacterial cells have the lowest cells/pmol, and healthy eukaryote cells have the highest.

Community Structure:. The PLFA in an environmental sample is the sum of the microbial community's PLFA, and reflects the proportions of different organisms in the sample. PLFA profiles are routinely used to classify bacteria and fungi (19) and are one of the characteristics used to describe new bacterial species (25). Broad phylogenic groups of microbes have different fatty acid profiles, making it possible to distinguish between them (4, 5, 22, 24). Table 1 describes the six major structural groups employed in this report.

Table 1. Description of PLFA structural groups.

PLFA Structural Group	General classification
Monoenoic (Monos)	Abundant in Proteobacteria (Gram negative bacteria), typically fast growing, utilize many carbon sources, and adapt quickly to a variety of environments.
Terminally Branched Saturated (TerBrSats)	Characteristic of Firmicutes (Low G+C Gram-positive bacteria), and also found in Bacteriodes, and some Gram-negative bacteria.
Branched Monoenoic (BrMonos)	Found in the cell membranes of micro-aerophiles and anaerobes, such as sulfate- or iron-reducing bacteria
Mid-Chain Branched Saturated (MidBrSats)	Common in Actinobacteria (High G+C Gram-positive bacteria), and some sulfate-reducing bacteria.
Normal Saturated (Nsats)	Found in all organisms.
Polyenoic	Found in Eukaryotes such as fungi, protozoa, algae, higher plants, and animals.

Diversity: The diversity of a microbial community is a measure of the number of different organisms and the evenness of their distribution. Natural communities in an undisturbed environment tend to have high diversity. Contamination with toxic compounds will reduce the diversity by killing all but the resistant organisms. The addition of a large amount of a food source will initially reduce the diversity as the opportunists (usually Proteobacteria) over-grow organisms less able to reproduce rapidly. The formulas used to calculate microbial community diversity from PLFA profiles have been adapted from those applied to communities of macro-organisms (8).

Physiological status: The membrane of a microbe must adapt to the changing conditions of it's environment, and these changes are reflected in the PLFA. Toxic compounds or environmental conditions that disrupt the membrane cause some bacteria to make trans fatty acids from the usual cis fatty acids (7). Many Proteobacteria and others respond to starvation or highly toxic conditions by making cyclopropyl (7) or mid-chain branched fatty acids (20). The physiological status biomarkers for Toxic Stress and Starvation/Toxicity are formed by dividing the amount of the stress-induced fatty acid by the amount of it's biosynthetic precursor.

PLFA were analyzed by extraction of the total lipid (21) and then separation of the polar lipids by column chromatography (6). The polar lipid fatty acids were derivatized to fatty acid methyl esters, which were quantified using gas chromatography (15). Fatty acid structures were verified by chromatography/mass spectrometry and equivalent chain length analysis.

Results and Discussion

Phospholipid Fatty Acid Analysis

Biomass estimates, as determined by the total concentration of PLFA, were shown to be highest in sample MW-1D. Biomass concentrations varied between ~10^3 to ~10^6 cells/mL water.

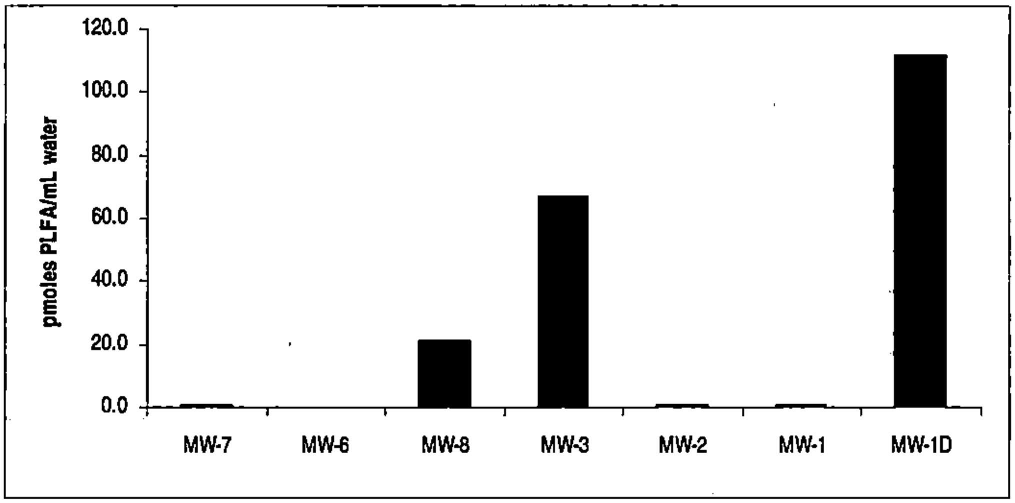

Figure 1. Biomass content is presented as the total amount of phospholipid fatty acids (PLFA) extracted from a given sample. Total biomass is calculated based upon PLFA attributed to both bacterial and eukaryotic biomass (characteristic of higher organisms).

PLFA profiles revealed that the complexity and composition of community structure varied with sampling location. Samples MW-2 and MW-1 contained simple community structures (few PLFA groups were detectable, Figure 2). MW-2 was composed primarily of monoenoic PLFA (characteristic of Proteobacteria), while MW-1 contained mostly normally saturated PLFA. Proteobacteria are of particular interest in contaminated sites in that they have the ability to utilize a wide range of carbon sources and adapt quickly to environmental changes. Normally saturated PLFA are common to both prokaryotic and eukaryotic organisms and therefore do not give much insight into the structure of the community. High proportions are usually indicative of a simple community structure.

The other samples submitted for analysis exhibited a fairly diverse community structure. Samples MW-8 and MW-3 had the most similar community structures. In comparison to the other samples, MW-3 and MW-1D contained high proportions of terminally branched saturated PLFA, which are primarily attributed to Firmicutes (*Clostridia*-like anaerobes). An increase can indicate the presence of anaerobes. Samples MW-6 and MW-1D contained high proportions of polyenoic PLFA, compared to the other samples, (characteristic of eukaryotic organisms). The biomarker 18:2ω6, indicative of fungi, was the most prevalent fatty acid in the polyenoic group.

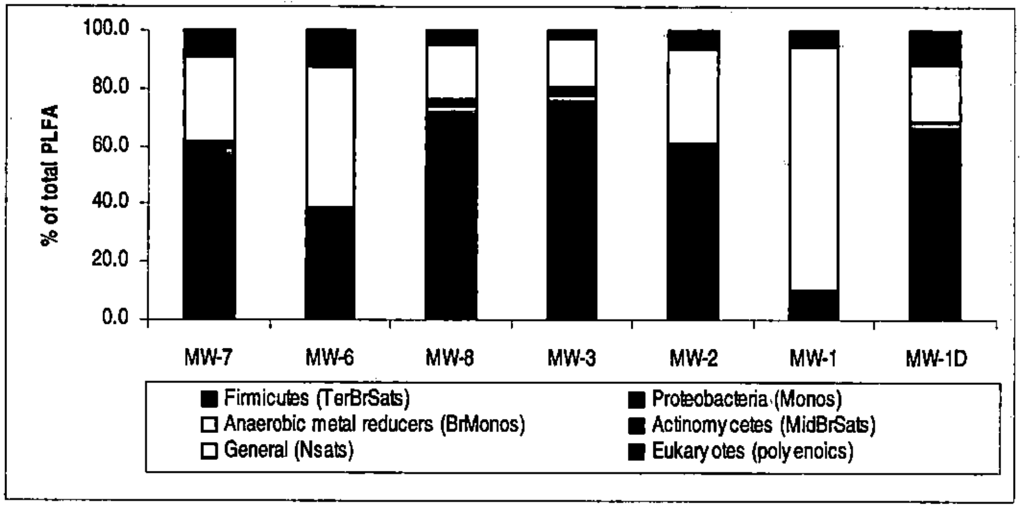

Figure 2. Relative percentages of total PLFA structural groups in the samples analyzed. Structural groups are assigned according to PLFA chemical structure, which is related to fatty acid biosynthesis. See Table 1 for detailed descriptions of structural groups. An "X" indicates samples with insufficient biomass for community structure to be determined.

Physiological status biomarkers indicated that only samples MW-6 and MW-1 were not starved or stressed. MW-2 and MW-1D were the most starved.

In the other samples showing signs of stress, the Group A bacteria contributed, almost exclusively, to the stress biomarker ratio. This indicated that the Group B bacteria were responding more favorably than the Group A bacteria to the specific environmental conditions at this site.

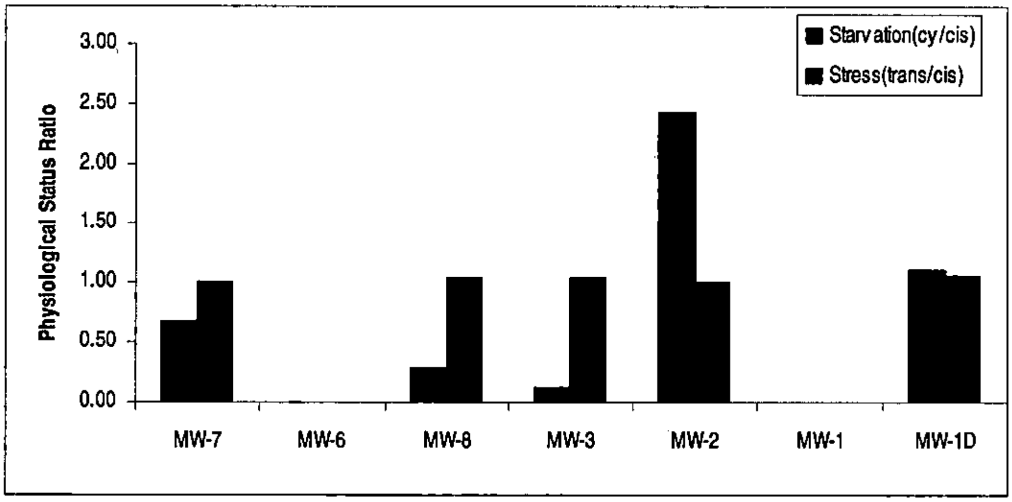

Figure 3. Microbial physiological stress markers. Starvation biomarker for the Gram-negative community is assessed by the ratio cyclopropyl fatty acids to their metabolic precursor. Adaptation of the Gram-negative community to toxic stress is determined by the ratio of ω7t/ω7c fatty

acids. Gram-negative bacteria generate *trans* fatty acids to minimize the permeability of their cellular membranes as an adaptation to a less favorable environment. Ratios (16:1ω7t/16:1ω7c and 18:1ω7t/18:1ω7c) greater than 0.1 have been shown to indicate an adaptation to a toxic or stressful environment, resulting in decreased membrane permeability. An "X" indicates samples with insufficient biomass for metabolic status markers to be determined.

Table 2. Values below are: viable microbial biomass expressed as picomoles of PLFA per mL of sample and as cells per mL of sample, fatty acid structural groups as percent of total PLFA, and physiological status biomarkers as mole ratio. "-" indicates data not available.

Samples		**Biomass**		**Community Structure (% of total PLFA)**						**Physiological Status**	
Sample Name	Sample Date	pmol/mL	cells/mL	Fimicutes (TerBrSats)	Proteobacteria (Monos)	Anaerobic metal reducers (BrMonos)	Actinomycetes/ SRB (MidBrSats)	General (Nsats)	Eukaryotes (polyenoics)	Starved cy/cis	Membrane Stress, trans/cis
MW-7	4/22/2003	0.4	8.81E+03	0.0	57.8	0.0	3.9	29.5	8.8	0.67	1.00
MW-6	4/22/2003	0.2	4.11E+03	0.0	33.0	0.0	5.9	48.5	12.6	0.00	0.00
MW-8	4/22/2003	21	4.23E+05	5.2	67.1	1.4	3.0	18.3	5.2	0.28	1.03
MW-3	4/22/2003	67	1.34E+06	10.6	64.9	2.1	3.2	16.5	2.7	0.12	1.03
MW-2	4/23/2003	0.3	6.46E+03	0.0	61.1	0.0	0.0	32.8	6.2	2.43	1.00
MW-1	4/23/2003	1	1.12E+04	0.0	10.1	0.0	0.0	84.3	5.6	0.00	0.00
MW-1D	4/23/2003	112	2.23E+06	13.6	53.3	1.3	0.7	19.3	11.8	1.10	1.06

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Phone: (519) 822-2265
Fax: (519) 822-3151

16 May 2003 SiREM Ref: TL0035

John Brussel
BBL Inc.
6723 Towpath Road
PO Box 66
Syracuse NY 13214-0066

Reference: Gene-Trac *Dehalococcoides* Assays - DT-0075
Invoice #813197

Dear Mr. Brussel:

This letter transmits the final test results for 7 samples submitted for *Dehalococcoides* testing. Invoice # 813197 in the amount of $2359.57 has been applied against your PO # BBL-PS-14099 for this work.

If you have any questions or concerns regarding the attached results or invoice, please contact me toll free by telephone at 1-866-251-1747 ext. 238, or by email at pdennis@siremlab.com.

We appreciate your business and look forward to serving you again in the future.

Sincerely,
SiREM Laboratory

Philip

Phil Dennis, M.A.Sc.
Director

/att.

SiREM
Site Recovery & Management
www.siremlab.com

130 Research Lane, Suite 2
Guelph, Ontario N1G 5G3
Phone: (519) 822-2265
Fax: (519) 822-3151

Test Results for Gene-Trac *Dehalococcoides* Assay

Client Name: BBL Inc.	**Test Reference Number:** DT-0075
Contact: John Brussel	**Report Issued:** 07-May-03
Site Location: HWD Farmingdale, NY	**Site Sampling:** 22-Apr-03, 23-Apr-03 **Sample(s) Received:** 28-Apr-03 **DNA Extraction:** 29-Apr-03
Telephone: (315) 446-9120	**Gel Image Number :** AG-0099a&b /DHC-UP-0038
E-mail: jcb@bbl-inc.com	**Positive Control (+ve control):** Assay with Cloned *Dehalococcoides* 16S rRNA gene
Fax:	**Negative Control (-ve control):** Assay with DNA extraction blank

Test Results:

Client Sample ID	SiREM ID	Non-*Dehalococcoides* Bacterial DNA	*Dehalococcoides* Test, Intensity (% of Positive Control)	Intensity Score	Test Result: *Dehalococcoides* DNA
MW-7	DHC-0404	Detected	0%	-	Not Detected
MW-6	DHC-0405	Detected	0%	-	Not Detected
MW-3	DHC-0406	*Not Tested	100%	+++	Detected (3 of 3 primer sets)
MW-8	DHC-0407	*Not Tested	52%	++	Detected (3 of 3 primer sets)
MW-2	DHC-0408	Detected	0%	-	Not Detected
MW-1	DHC-0409	Not Detected	0%	-	Not Detected
MW-1D	DHC-0410	Detected	0%	-	Not Detected
Not applicable	+ve control	Not applicable	100%	+++	Detected (3 of 3 primer sets)
Not applicable	-ve control	Not applicable	0%	-	Not Detected

* Universal bacterial primer test not performed where *Dehalococcoides* test is positive

The above results refer only to that portion of the sample tested with the Gene-Trac assay. The test is based on a polymerase chain reaction (PCR) test with three primer sets specific to DNA sequences in the 16S rRNA gene of *Dehalococcoides* organisms. A positive (+ to ++++) result indicates that genetic material (DNA) from a member of the *Dehalococcoides* group was detected. *Dehalococcoides* organisms are the only microorganisms proven to possess the necessary enzymes for the complete dechlorination of tetrachloroethene or trichloroethene to ethene. The presence of *Dehalococcoides* genetic material has been positively correlated to complete dechlorination of chlorinated ethenes at contaminated sites.

"Dehalococcoides Test Intensity" = quantitative assessment of electrophoresis band intensity of PCR product as a percentage of the corresponding positive control reaction. This value provides a semi-quantitative assessment of the amount of *Dehalococcoides* genetic material present in the sample. While band intensity might reflect actual concentration of the target organism, Gene-Trac is a semi-quantitative method and is only recommended to determine the presence or absence of *Dehalococcoides* genetic material in the sample.

"Intensity Score", categorizes PCR product quantity based on the "intensity (% of positive control)": ++++ = Very high band intensity (greater than 100% of positive control), +++ = high band intensity (67-100%), ++ moderate band intensity (34-66%) + = low band intensity (4-33%), -/+ = inconclusive (1-3%), - = no detectable band (0%)

Analyst: ________ **Authorized by:** ________ **Date:** May 15/03

Jaimee Mariani
Laboratory Technologist

Philip Dennis, M.A.Sc.,
Director, SiREM

Gene-Trac *Dehalococcoides* Case Narrative, Test DT-0075

Sample Condition:

SiREM received 7 – 2*1000 ml ground water samples from HWD Farmingdale, NY, on April 28, 2003. The samples arrived in a cooler with a measured temperature of 16°C and were stored at 4°C upon arrival in the laboratory. Each sample was vacuum filtered for the preparation of the genomic DNA.

Test Particulars:

Client Designation	SiREM Designation	*"Debris Description"	**Volume of Groundwater Utilized
MW-7	DHC-0404	No debris	900 mL
MW-6	DHC-0405	Light Brown Debris	900 mL
MW-3	DHC-0406	Red/Brown Debris	800 mL
MW-8	DHC-0407	Yellow/Brown Debris	900 mL
MW-2	DHC-0408	Yellow	900 mL
MW-1	DHC-0409	No debris	900 mL
MW-1D	DHC-0410	Brown Debris w/ Black Flecks	900 mL

Notes:

*"Debris" refers to solid material (including biomass) remaining after vacuum filtration of groundwater through a 0.45 μM filter

** Varying amounts of groundwater are utilized depending on the volume of debris collected, or the capacity of the filter prior to clogging, maximum is 1L.

Genomic DNA extraction was performed on the above noted samples on April 29, 2003. A PCR reaction using a universal bacterial primer was performed on all sample(s) not testing positive for *Dehalococcoides* DNA.

This test is used to determine if the samples contained PCR amplifiable bacterial DNA (other than that belonging to *Dehalococcoides* organisms) and is reported on the Test Certificate under "non-*Dehalococcoides* Bacterial DNA". This test confirmed that the DNA extraction from every sample except MW-1 was successful, which increases confidence that negative *Dehalococcoides* results are true negatives and not due to sampling biases. The negative result of sample MW-1 suggests that we were unable to extract PCR amplifiable bacterial DNA from this sample, most likely due to a lack of biomass.

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Site Recovery & Management

Chain-of-Custody Form

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No. 0001

Lab # S-0003

Page 1 of 1

Project Name: HWD Farmingdale
Project #:
Project Manager: John Brussel
Company: BBL
Address: Tow Path Rd
Syracuse NY
Phone #: 315-446-2570
Fax #: 315-446-2570
Sampler's Signature:
Sampler's Printed Name: Glenn Palmer

Analysis

						Preservative	0										
						Dehalococcoides Ethenogenes											
Client Sample ID	**Lab ID**	**Sampling Date**	**Sampling Time**	**Matrix**	**# of Containers**												**Other Information**
mw-7		4/22/03	1405	GW	2	x											
mw-6		↓	1459	↓	↓	↓											
mw-3		↓	1104	↓	↓	↓											
mw-8		↓	1025	↓	↓	↓											
mw-2		4/23/03	925	GW	2	x											
mw-1		↓	935	↓	↓	↓											
MW-1D		↓	1110	↓	↓	↓											

Preservative Key
0. None
1. HCL
2. Other ______
3. Other ______
4. Other ______
5. Other ______
6. Other ______

Sample Receipt
Cooler Condition:
Cooler Temperature:
Custody Seals: Yes ☐ No ☐

Invoice Information
P.O. #
Bill To:

For Lab Use Only
3 sample bottles broken in transit

Relinquished By:	**Received By:**	**Relinquished By:**	**Received By:**	**Relinquished By:**	**Received By:**
Signature	Signature Rita Schofield	Signature	Signature	Signature	Signature
Printed Name	Printed Name Rita Schofield	Printed Name	Printed Name	Printed Name	Printed Name
Firm BBL	Firm Sirem Lab	Firm	Firm	Firm	Firm
Date/Time 4/22/03 1600	Date/Time April 28/03	Date/Time	Date/Time	Date/Time	Date/Time

Distribution: White - Return to Originator; Yellow - Lab Copy; Pink - Retained by Client

In the absence of an executed agreement, submission of samples to SiREM implies consent for performance of analyses specified on this Chain-of-Custody form and agreement with the terms and conditions of the SiREM Laboratory Services Agreement. The entity submitting samples shall be responsible for payment in full for said analyses.

Appendix D

Memorandum Summarizing Evaluation of Natural Attenuation

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Appendix D

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Feasibility Study Report
Evaluation of Natural Attenuation

1.0 Introduction

This appendix presents an evaluation of monitored natural attenuation (MNA) of chemicals of concern (COCs) in groundwater at the site. The purpose of this evaluation is to determine the feasibility of using MNA for site remediation, and to help assess what role MNA may play in groundwater remedial activities. Methods used to evaluate MNA in this section are consistent with appropriate United States Environmental Protection Agency (USEPA) technical guidance (USEPA, 1998) and USEPA's Office of Solid Waste and Emergency Response (OSWER) Directive 9200.4-17P (USEPA, 1999). The Directive states that MNA implementation depends on "...a variety of physical, chemical or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation or destruction of contaminants."

This evaluation is based on COC groundwater analytical results and certain MNA indicator parameters measured during a groundwater sampling event performed in April 2003. As discussed in detail below, these data support the general conclusion that dissolved COCs in groundwater are being naturally attenuated at some sampling locations due to a variety of processes including dispersion, dilution, hydrophobic sorption, and in-situ biodegradation. Based on this conclusion, MNA is feasible as a component of the site groundwater remedy and could be used to treat some portions of the residual dissolved-phase COC plume.

2.0 Technical Basis for MNA

This section discusses the technical basis for monitored natural attenuation (MNA) in groundwater at the site, and provides a general framework for evaluating site-specific data. This is important because chemical migration and attenuation in groundwater can be complicated due to the presence of heterogeneous flowpaths, non-aqueous phase liquids (NAPLs), and transient groundwater flow conditions. After the theoretical context in this section has been developed, site-specific data are reviewed in Section 3 in an effort to elucidate predominant transport mechanisms.

2.1 Groundwater Flow and Chemical Transport

The key transport and attenuation mechanisms for groundwater and chemical migration in saturated soils at the site include advection, hydrophobic sorption, hydrodynamic dispersion, dilution, and naturally occurring in-situ biodegradation (ISBIO). Hydrophobic sorption of COCs onto solid organic matter present in saturated soils may retard the migration rate of chemicals relative to the average linear groundwater velocity. Hydrodynamic dispersion and dilution may cause decreasing chemical concentrations in groundwater during transport. ISBIO is a biologically-mediated destructive process that decreases the total mass of chemicals in groundwater. Each of these transport and attenuation mechanisms is described in greater detail in the following sections.

2.2 Advection

Advective transport of chemicals in groundwater, or advection, refers to the transport of chemicals by the bulk movement of groundwater. In granular soils such as those found at the site, advection can be the most important process resulting in the downgradient migration of dissolved chemicals. Groundwater advection in saturated soils can be approximated by Darcy's Law as follows (Freeze and Cherry, 1979):

$$v = KI / n_e$$

where v is the average linear groundwater velocity, K is the horizontal hydraulic conductivity of the soil, I is the hydraulic gradient, and n_e is the effective porosity of the soil. Using this formula, an average hydraulic conductivity of 272 feet per day (ft/d), a hydraulic gradient of 0.004, and an assumed effective porosity of 0.3, the average linear groundwater velocity in saturated soils at the site is approximately 3.5 ft/d. Although this value seems high, it is characteristic of the glacial outwash sand and gravel deposits present beneath the site.

2.3 Hydrodynamic Dispersion and Dilution

Hydrodynamic dispersion is a combination of mechanical mixing and diffusion, and results in chemical plumes spreading laterally outward from the main direction of groundwater flow along a flowpath. Because groundwater flow in some porous media may exhibit a high degree of heterogeneity due to the natural variability of soil texture and structure, groundwater flowpaths can be tortuous resulting in mechanical mixing of COC-laden groundwater with unimpacted groundwater. Mechanical mixing during advective groundwater flow thus leads to lowering of COC concentrations with time and distance along a given flowpath. Chemical diffusion is considered negligible during advective transport in granular soils such as those present at the site. With time, chemical plumes in saturated soils will disperse longitudinally and laterally as different portions of the chemical mass are transported at different velocities.

Dilution of chemicals in groundwater can occur at the site due to the addition of water through recharge of infiltrating precipitation. Recharge from infiltrating precipitation is the result of a complex series of processes in the unsaturated zone that results in the downward transport of water, chemicals, and perhaps naturally occurring organic matter (NOM) to the water table. NOM in recharging groundwater may be very important for supporting natural ISBIO of site COCs, which is described in Section 2.5. Although much of the area near the site is relatively impermeable due to the presence of asphalt, concrete, and buildings, some infiltration of precipitation and resulting dilution of chemical plumes is likely to occur. Furthermore, the recharge basin located approximately 80 feet north-northeast of the site is a likely source of groundwater recharge in the area and probably results in some dilution of chemical plumes in groundwater near the site.

2.4 Hydrophobic Sorption and COC Retardation

Hydrophobic sorption refers to the chemical transport process whereby nonpolar, hydrophobic chemicals such as chlorinated solvents dissolved in groundwater partition preferentially to solid organic matter present within soils. The quantity of chemicals that can partition to solid organic matter is directly proportional to the amount of solid organic matter. The result of this process is that some quantity of the chemical mass is removed from groundwater during transport, and the rate of COC migration in groundwater can be less than the average linear groundwater velocity. Hydrophobic sorption is therefore an attenuation process which results in the COC plume velocity being retarded relative to the average linear groundwater velocity.

To more accurately evaluate the role that hydrophobic sorption may play in retarding the COC plume migration rate relative to the average linear groundwater velocity in site soils, COC-specific retardation factors were estimated based on the following equation (Freeze and Cherry, 1979):

$$R_c = \rho_b \times K_{oc} \times f_{oc} / n$$

where R_c is the hydrophobic-based retardation factor for a specific chemical (c), ρ_b is the bulk density of the soil, K_{oc} is the chemical-specific organic carbon partition coefficient, f_{oc} is the fraction of solid organic carbon in the soil, and n is the soil porosity. The following table calculates site-specific retardation factors for the site COCs and their intermediate byproducts based on this equation:

Site COC	K_{oc}	R_c
Tetrachloroethene	363	4.3
Trichloroethene	104	1.9
Cis-1,2-Dichloroethene	50	1.5
Vinyl chloride	29.5	1.3
1,1,1-Trichloroethane	179	2.6
1,1-Dichloroethane	40	1.4
1,1-Dichloroethene	343	4.1

Note: Calculations based on a soil bulk density of 99 pounds per cubic foot (assumed) and fraction of organic carbon of 0.0017 (average of site measurements for soils sampled between 4 and 14 feet below the ground; n=18). K_{oc} values are Syracuse Research Corporation (SRC) recommended values based on their Chemfate database, which may be found at http://esc.syrres.com/efdb/Chemfate.htm. R_c values calculated according to above equation.

As shown, site-specific COC retardation factors ranged from about 1.3 for vinyl chloride (little retardation) to 4.3 for PCE (moderate retardation). This information indicates that hydrophobic-based retardation of COCs in saturated site soils may account for some of the observed COC plume attenuation.

2.5 In-Situ Biodegradation

In-situ biodegradation (ISBIO) is a naturally occurring, biologically mediated destructive process that decreases chemical mass in groundwater with time and distance. To carry out their life functions, naturally occurring microorganisms require electron donors (organic carbon), electron acceptors, water, mineral nutrients, and appropriate environmental conditions (e.g., pressure, temperature, pH). Natural ISBIO is the process by which organic chemicals are degraded or transformed by naturally occurring microorganisms through the use of an organic chemical as a carbon source or electron acceptor. By evaluating the biogeochemistry of groundwater at contaminated sites, it is possible to demonstrate that biodegradation is occurring and to determine which biogeochemical reactions are predominant.

Organic chemicals can be biodegraded in-situ in groundwater by means of naturally occurring aerobic and anaerobic microorganisms that oxidize organic compounds. Aerobic oxidation of organic chemicals requires the presence of molecular oxygen (O_2) as an electron acceptor, as well as appropriate microorganisms, nutrients (e.g., phosphorus, potassium, and nitrogen), and environmental conditions (e.g., circumneutral pH conditions and adequate temperature). Anaerobic oxidation of organic chemicals can occur via oxidation-reduction (redox) processes including nitrate reduction, iron reduction, sulfate reduction, and methanogenesis, and requires the presence of an alternate electron acceptor such as nitrate, ferric iron, sulfate, and/or carbon dioxide, as well as the presence of appropriate microorganisms, nutrients, and environmental conditions. These processes are described in greater detail below.

Most of the site COCs can be naturally biodegraded in groundwater by means of sequential decay reactions in which secondary COCs are produced as intermediate byproducts. These intermediate byproducts can undergo further biodegradation reactions until final byproducts are produced. A classic example of a sequential decay reaction that is well documented at hazardous waste sites is *reductive dechlorination* of chlorinated ethenes (Vogel et al., 1987):

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{DCE} \rightarrow \text{VC} \rightarrow \text{Ethene} + CO_2 + Cl^-$$

In reductive dechlorination of PCE, certain microorganisms utilize chloride ions as electron acceptors, and strip them from ethene molecules in a stepwise process resulting in the formation of lesser-chlorinated molecules as intermediate byproducts until finally only ethene molecules and chloride ions are remaining. This reaction requires appropriate microorganisms to be present, reducing geochemical conditions, and a sufficient supply of organic carbon and nutrients. In addition, the intermediate byproducts DCE, VC, and ethene can be further degraded by oxidative processes (requiring oxygen) resulting in the formation of carbon dioxide and chloride ions as final byproducts:

$$\text{DCE} + O_2 \rightarrow CO_2 + Cl^-$$

$$\text{VC} + O_2 \rightarrow CO_2 + Cl^-$$

$$\text{Ethene} + O_2 \rightarrow CO_2 + Cl^-$$

These chemical equations are presented here for illustrative purposes and to provide a framework for evaluating the site natural attenuation data which included analysis of many of the reactants, intermediates, and final byproducts of these and other reactions.

The general approach to evaluating groundwater data for ISBIO assessments typically involves comparing analytical results for COCs and select biogeochemical indicator parameters from groundwater samples collected within the COC plume with background groundwater samples collected hydraulically upgradient from the source area. This is known as the "background comparison approach." Changes in concentrations of COCs and biogeochemical parameters between background groundwater and plume groundwater can provide insights into the predominant biogeochemical processes that are occurring in the vicinity of the sampling points. Biogeochemical indicator parameters include electron acceptors such as nitrate, sulfate, solid forms of iron; electron donors such as total and dissolved carbon; nutrients such as nitrogen and phosphorus; and degradation byproducts such as carbon dioxide, ethene, ethane, and methane. Parameter selection is typically based on the biologic principle that microorganisms consume electron acceptors, organic carbon, and nutrients, and generate byproducts while metabolizing organic pollutants (Chappelle, 1993). ISBIO indicator parameters are discussed in greater detail in the following subsections.

Environmental Conditions

Environmental conditions of groundwater that affect microbial growth and ISBIO include groundwater pH, temperature, alkalinity, and oxidation reduction potential (ORP). Circumneutral pH values (i.e., $6 < \text{pH} < 8$) indicate favorable pH conditions for microbiologic growth and biodegradation. Alkalinity can buffer organic acids that may be generated during some biogeochemical reactions, and well-buffered groundwater is therefore favorable for microbial growth and biodegradation. An optimal groundwater temperature range for microbial growth is generally between about 10°C and 30°C. ORP values provide a gross measure of whether groundwater conditions are generally oxidizing or reducing. Reducing geochemical conditions are favorable for anaerobic oxidation and reductive dechlorination of site-specific COCs.

Electron Acceptors

Microorganisms require the presence of electron acceptors during metabolic reactions involving ISBIO of site-related COCs. Naturally occurring electron acceptors typically monitored in groundwater include dissolved oxygen (DO), nitrate, nitrite, ferric iron, sulfate, and carbon dioxide. Each of these electron acceptors is associated with a different oxidation reduction (redox) process known to degrade organic pollutants, as follows.

- Aerobic degradation is a biologically mediated redox reaction in which aerobic microorganisms use oxygen as an electron acceptor, oxidize organic compounds, and produce carbon dioxide and other inorganic compounds as byproducts.
- Denitrification is an anaerobic redox reaction in which denitrifying microorganisms use nitrate and nitrite as electron acceptors, oxidize organic carbon compounds, and produce carbon dioxide, ammonia, and other inorganic compounds as byproducts.
- Iron reduction is an anaerobic redox reaction in which iron reducing microorganisms use ferric iron (Fe^{3+}) as an electron acceptor, oxidize organic carbon compounds, and produce carbon dioxide, ferrous iron (Fe^{2+}), and other inorganic compounds as byproducts.
- Sulfate reduction is an anaerobic redox reaction in which sulfate reducing microorganisms use sulfate as an electron acceptor, oxidize organic carbon compounds, and produce carbon dioxide, sulfides, and other inorganic compounds as byproducts.
- Methanogenesis is an anaerobic redox reaction in which methanogenic bacteria use carbon dioxide as an electron acceptor, ferment organic compounds, and produce carbon dioxide, methane, and other inorganic compounds as byproducts.

Each of these redox reactions requires certain electron acceptors. Electron acceptor availability and usage can be evaluated by comparing on-site concentrations with background groundwater conditions.

Electron Donors

Organic carbon is required for microbiologic growth and ISBIO of site COCs. For reductive dechlorination of chlorinated solvents to occur, alternative carbon sources such as NOM or anthropegenically-introduced organic carbon (e.g., petroleum chemicals) are required. Sources of organic carbon in site groundwater can be indicated by detectable concentrations of Soluble Organic Carbon (SOC) and other organic chemicals. SOC concentrations of 20 mg/L or greater are considered optimal for dechlorination processes (Wiedemeier, 1998). In addition to these geochemical indicators, some intermediate breakdown products such as ethane and ethene can also serve as alternative organic carbon sources for reductive dechlorination reactions.

Nutrients

Nitrogen and phosphorus are macronutrients required by microorganisms for cell growth and maintenance. The availability of these nutrients can be evaluated along with naturally occurring carbon sources to determine whether sufficient quantities of macronutrients are available to support ISBIO of site COCs. Deficiencies of these macronutrients can limit microbiological growth and ISBIO.

2.6 Summary

There are several naturally occurring fate and transport processes that potentially contribute to naturally attenuating peak concentrations of COCs in site groundwater, including hydrophobic sorption, hydrodynamic dispersion, dilution, and natural ISBIO. These fate and transport processes provide a general framework against which site-specific data may be compared in an effort to assess the relative importance of each process.

3.0 Evaluation of In-Situ Biodegradation

This section evaluates the nature and extent of naturally occurring ISBIO of COCs in groundwater beneath the site, and what roles natural ISBIO may play in the overall groundwater remedy for the site. It includes descriptions of the types of data used to evaluate ISBIO, VOC concentration trends with time and distance, site geochemical conditions, and site microbiological conditions.

3.1 Data Types and Quantities

Groundwater samples were collected at select site monitoring wells and analyzed for Target Compound List (TCL) VOCs and ISBIO indicator parameters during the April 2003 sampling event. Groundwater monitoring wells sampled in support of this evaluation include MW-1, MW-1D, MW-2, MW-3, MW-6, MW-7, and MW-8. VOCs identified during this sampling event are listed in Table 1. ISBIO indicator parameters analyzed for during this sampling event are listed in Table 2, and generally include indicators of environmental conditions (e.g., pH, temperature, oxidation-reduction potential [ORP]) and concentrations of key electron acceptors, electron donors, and metabolic byproducts of biologically-mediated redox reactions associated with in-situ reductive dehclorination reactions. These data constitute the primary data set utilized to evaluate ISBIO conditions at the site.

To facilitate evaluation of the ISBIO data, a conceptual groundwater flowpath was identified for the shallow groundwater zone. This flowpath originates in an area hydraulically upgradient from the site, extends through the probable source location, and terminates in an area hydraulically downgradient from the probable source location. Use of this conceptual flowpath can show changes in VOC and ISBIO indicator parameter concentrations with distance along the flowpath. The premise of this method is that biogeochemical changes in groundwater associated with ISBIO will manifest themselves as measurable changes in the indicator parameters along a flowpath. This is commonly called the "background comparison approach." Although groundwater flow can be complex and heterogeneous, the background comparison approach can be appropriate in such settings. The shallow groundwater flowpath consists of the following groundwater monitoring wells:

- MW-1 (background);
- MW-2 (probable source area);
- MW-7 (probable source area); and
- MW-8 (downgradient location).

3.2 VOC Concentration Trends

Concentration trends of VOCs in groundwater samples collected at site monitoring wells with time and distance were evaluated for evidence of ISBIO and other natural attenuation processes (e.g., dilution). COC concentration trends with time and distance can also be used to evaluate plume stability, which is a suggested component of natural attenuation evaluations based on regulatory guidance documents (USEPA, 1998).

3.2.1 VOC Concentration Trends with Time

Figure 1 shows current and historical groundwater VOC concentrations measured at site monitoring wells in February 1990, January 2000, February 2001, and April 2003. As shown, since 1990 PCE concentrations have increased with time in groundwater sampled at monitoring wells MW-1, MW-2, MW-6, and MW-7, and decreased with time in groundwater sampled at monitoring well MW-3. Also as shown on Figure 1, since 1990 TCE concentrations have decreased with time in groundwater sampled at monitoring wells MW-1, MW-2, and MW-3, and increased with time at monitoring well MW-7. The data also show that since 1990 1,2-DCE concentrations have decreased with time in groundwater sampled at monitoring wells MW-2 and MW-3, and increased with time at monitoring well MW-7.

The presence of 1,2-DCE, which is an intermediate byproduct of ISBIO of PCE and TCE, can be considered evidence that ISBIO is naturally occurring in groundwater at some locations of the site. However, the VOC concentration trends with time are inconclusive regarding the stability of the VOC groundwater plume.

3.2.2 VOC Concentration Trends with Distance

Figure 1 shows the distribution of VOCs detected in groundwater with distance at the site, and Figure 2 illustrates concentrations of select VOCs measured at monitoring wells along the shallow groundwater flowpath described above during the April 2003 sampling event. As shown, detectable concentrations of PCE and TCE were present in recent and historic background groundwater samples collected at hydraulically upgradient monitoring well MW-1. The highest VOC concentrations generally have been detected in groundwater sampled at monitoring well MW-7. VOC concentrations in groundwater appears to decrease between monitoring wells MW-7 and MW-2. It is notable that the relative concentrations of VOCs do not appear to change significantly with distance, indicating that dispersion and dilution are contributing to the attenuation of peak VOC concentrations with distance.

3.3 Geochemical Conditions

The April 2003 groundwater monitoring data were used to evaluate geochemical conditions at the site (Table 2). General geochemical conditions are discussed first, followed by the implications of site geochemistry on naturally occurring ISBIO.

3.3.1 General

Generic indicators of geochemical conditions in site groundwater include groundwater pH, temperature, and oxidation-reduction potential (ORP). As shown in Table 2, groundwater pH ranged from about 6.0 to 7.8 standard units at all wells sampled during the April 2003 sampling event. This pH range is considered to be optimal for ISBIO reactions to occur. Furthermore, site groundwater appeared to be moderately to well buffered in April 2003, as indicated by alkalinity measurements that ranged from about 29 to 200 mg/L (Table 2). Groundwater temperatures ranged from about 11°C to 15°C during the April 2003 sampling event (Table 2), indicating that the groundwater temperature at the site was adequate for ISBIO at the time of sampling.

Groundwater ORP ranged from -121 to 157 millivolts (mV) at wells sampled during the April 2003 sampling event (Table 2). As shown, the lowest ORP measurements (indicated by negative values) were recorded at monitoring wells MW-3 and MW-8, which indicates that groundwater near these sampling conditions was under strongly reducing conditions at the time of sampling. This observation is supported in part by the dissolved oxygen (DO) measurement recorded at monitoring well MW-3 which was less than 1.0 mg/L (Table 2). The elevated DO measurement recorded at monitoring well MW-8 (3.5 mg/L) may be a false positive result due to the ample opportunities for atmospheric oxygen to be introduced into the sample during field sampling and analytical procedures. At best, the DO measurement recorded at MW-8 in April 2003 is inconclusive regarding geochemical conditions in groundwater at this location. Based on this information, there appears to be at least one and possibly two geochemically reducing zones in shallow groundwater near the site, located near monitoring well MW-3 and possibly MW-8, that were conducive to reductive dechlorination ISBIO reactions at the time of sampling.

3.3.2 Implications for Natural ISBIO

The groundwater monitoring data were also used to evaluate the implications of site geochemical conditions for naturally occurring ISBIO of site COCs. This was accomplished by reviewing the site data for indicator parameters of electron acceptor availability, electron donor availability, nutrient availability, and the presence of metabolic byproducts.

Electron Acceptor Availability

Naturally occurring microorganisms known to participate in reductive dechlorination and ISBIO reactions require an adequate supply of electron acceptors such as nitrate, sulfate, and carbon dioxide to carry out their life functions. Electron acceptor availability was evaluated at the site by plotting measured indicator parameters with distance along the shallow groundwater flowpath discussed above (Figures 3 through 5). The basic premise of this approach is that naturally occurring ISBIO reactions consume electron acceptors while COCs are being degraded, and that these reactions result in measurable and observable patterns along groundwater flowpaths.

For example, nitrate is the electron acceptor associated with denitrification, which is an important redox process that destroys organic matter in groundwater and causes reducing geochemical conditions. Therefore, concentrations of nitrate measured in site samples can be used to indicate the presence and magnitude of denitrification. Nitrate concentrations measured along the shallow groundwater flowpath in April 2003 are shown on Figure 3. As shown, nitrate concentrations ranged from 8.6 to 17 mg/l. The highest nitrate concentration observed along the flowpath was detected in groundwater sampled at background monitoring well MW-1 and the lowest nitrate concentration was detected at downgradient monitoring well MW-8. These data suggest that nitrate was available as an electron acceptor in groundwater hydraulically upgradient from the site, and that nitrate was being consumed at some locations along the shallow groundwater flowpath at the time of sampling. This information indicates that denitrification likely was occurring in groundwater near monitoring wells MW-2 and MW-7. The non-detect nitrate concentration measured in groundwater sampled at monitoring well MW-3 (Table 2) indicates that nitrate was almost fully depleted at this sampling location.

Nitrite concentrations can also be used to indicate the presence, absence, and magnitude of dentrification in groundwater at some sites. However, nitrite concentrations were non-detect at all sampling locations in April 2003 and, therefore, the data are inconclusive.

Sulfate is the electron acceptor associated with sulfate reduction, which is an important redox process that may be associated with reductive dechlorination and ISBIO of chlorinated solvents in groundwater. Concentrations of sulfate measured in site samples can therefore be used to indicate the presence and magnitude of sulfate reduction. Sulfate concentrations measured along the shallow groundwater flowpath in April 2003 are shown on Figure 4. As shown, sulfate concentrations ranged from about 19 mg/l to 30 mg/l along this flowpath. The lowest sulfate concentration observed along the flowpath was detected at monitoring well MW-2 and the highest sulfate concentration was detected at monitoring well MW-7. These data suggest that sulfate was available as an electron acceptor in groundwater hydraulically upgradient from the site, and that sulfate was being consumed at some locations along the shallow groundwater flowpath at the time of sampling. This information indicates that sulfate reduction likely was occurring in groundwater near monitoring well MW-2. The low sulfate concentration measured in groundwater sampled at monitoring well MW-3 (5.2 mg/L; Table 2) indicates that sulfate was depleted (compared with background) at this sampling location.

Carbon dioxide is the electron acceptor associated with methanogenesis, which is an important redox process associated with reductive dechlorination and ISBIO of chlorinated solvents in groundwater. Concentrations of carbon dioxide measured in site samples can therefore be used to indicate the presence and magnitude of methanogenesis. Carbon dioxide concentrations along flowpath A-A' are shown on Figure 5. As shown, carbon dioxide concentrations ranged from about 26 to 76 mg/L along this flowpath. The lowest carbon dioxide concentration observed along the flowpath was detected at monitoring well MW-2 and the highest carbon dioxide concentrations were detected at monitoring wells MW-1 (background) and MW-8 (hydraulically downgradient). This information suggests that carbon dioxide was available as an electron acceptor in groundwater hydraulically upgradient from the site at the time of sampling. The elevated carbon dioxide concentration detected in groundwater sampled at monitoring well MW-3 (71 mg/L; Table 2) is inconclusive with regard to the presence and magnitude of methanogenesis in groundwater at this sampling location, and is more thoroughly discussed below.

Electron Donor Availability

Naturally occurring microorganisms known to participate in reductive dechlorination and ISBIO reactions require an adequate supply of electron donors such as naturally-occurring organic matter (NOM) to carry out their life functions. Anthropogenically introduced sources of organic carbon, such as petroleum chemicals, can also serve as electron donors during reductive dechlorination and ISBIO of chlorinated solvents in groundwater. Electron donor availability was evaluated at the site by measuring concentrations of soluble organic carbon in site samples (Table 2). Similar to electron acceptors, the basic premise of this approach is that naturally occurring ISBIO reactions consume electron donors while COCs are being degraded, and this results in measurable and observable patterns along groundwater flowpaths.

As shown in Table 2, concentrations of soluble organic carbon measured in site groundwater samples during the April 2003 sampling event were non-detect at all locations sampled. This information indicates that a suitable supply of electron donors was not available in hydraulically upgradient groundwater at the time of sampling, and that a lack of biologically available organic carbon in site groundwater may be an ISBIO rate-limiting factor.

As mentioned above, in addition to NOM, petroleum chemicals can also serve as electron donors during reductive dechlorination reactions. The April 2003 analytical results plotted on Figure 1 suggest that low levels (i.e., less than 1 mg/L) of petroleum chemicals such as benzene, toluene, ethylbenzene, and xylene isomers were detected in groundwater sampled at monitoring well MW-3. This information suggests that a limited quantity of electron donors may have been available for reductive dechlorination and ISBIO of chlorinated solvents in groundwater near the MW-3 sampling location in April 2003.

Nutrient Availability

Naturally occurring microorganisms known to participate in reductive dechlorination and ISBIO reactions also require an adequate supply of macronutrients such as nitrogen and phosphorus to carry out their life functions. Anthropogenically introduced sources of nutrients, such as fertilizers, can also serve as macronutrients during reductive dechlorination and ISBIO of chlorinated solvents in groundwater. Nutrient availability was evaluated at the site by measuring concentrations of ammonia and nitrate to indicate the potential availability of nitrogen, and concentrations of phosphate to indicate the potential availability of phosphorus.

As shown in Table 2, concentrations of nitrate measured in site groundwater samples during the April 2003 sampling event ranged from non-detect to 17 mg/L. This data shows that a suitable supply of nitrogen was available at some sampling locations at the time of sampling. However, nitrogen was depleted at other sampling locations (i.e., MW-3). Furthermore, phosphate concentrations were everywhere non-detect above the method detection limit of 0.1 mg/L. This information suggests that a lack of biologically available macronutrients, particularly nitrogen and phosphorus, in site groundwater may be an ISBIO rate-limiting factor.

ISBIO Metabolic Byproducts

In addition to serving as an electron acceptor, carbon dioxide is also a metabolic byproduct of a variety of ISBIO reactions, including aerobic respiration, denitrification, iron reduction, sulfate reduction, and methanogenesis. Therefore, carbon dioxide concentrations can be a good generic indicator for the presence and magnitude of ISBIO reactions in groundwater. Carbon dioxide concentrations along flowpath A-A' are shown on Figure 5. As shown, the highest carbon dioxide concentration observed along the flowpath (38 mg/L) was detected at hydraulically downgradient monitoring well MW-8. This information confirms the presence of ISBIO in site groundwater near monitoring well MW-8 at the time of sampling. The elevated carbon dioxide concentration detected in groundwater sampled at monitoring well MW-3 (71 mg/L; Table 2) confirms the presence of ISBIO in site groundwater near monitoring well MW-3 at the time of sampling.

Ammonia is a metabolic byproduct associated with denitrification, which was discussed above. Concentrations of ammonia measured in site samples can therefore also be used to indicate the presence and magnitude of denitrification. As shown in Table 2, concentrations of ammonia measured in site groundwater samples during the April 2003 sampling event ranged from non-detect to 5.2 mg/L. The lowest ammonia concentrations observed in site groundwater samples were at monitoring wells MW-1, MW-2, and MW-8, and the highest ammonia concentration was detected at monitoring well MW-7. These data suggest that ammonia was being produced as a metabolic byproduct in site groundwater at the time of sampling. This information indicates that denitrification likely was occurring in groundwater near monitoring wells MW-3, MW-6, and MW-7 in April 2003.

Dissolved iron is a metabolic byproduct associated with iron reduction, which is an important redox process associated with reductive dechlorination and ISBIO of chlorinated solvents in groundwater. Concentrations of dissolved iron measured in site samples can therefore be used to indicate the presence and magnitude of iron reduction. Dissolved iron concentrations measured along the shallow groundwater flowpath in April 2003 are shown on Figure 6. As shown, dissolved iron concentrations ranged from non-detect to about 21 mg/l along this flowpath. The lowest dissolved iron concentrations observed along the flowpath were at monitoring wells MW-1, MW-2, and MW-7, and the highest dissolved iron concentration was detected at monitoring well MW-8. These data indicate that dissolved iron was being produced as a metabolic byproduct in groundwater hydraulically downgradient from the site at the time of sampling. This information indicates that iron reduction likely was occurring in groundwater near monitoring well MW-8 in April 2003. The elevated dissolved iron concentration measured in groundwater sampled at monitoring well MW-3 (21 mg/L; Table 2) indicates that iron reduction also was occurring at this sampling location.

Sulfide is a metabolic byproduct associated with sulfate reduction, which is an important redox process discussed above. Concentrations of sulfide measured in site samples can therefore be used to indicate the presence and magnitude of sulfate reduction in some cases. Sulfide concentrations were non-detect at all sampling locations (Table 2). Because sulfide can participate in a variety of geochemical reactions, the site data are inconclusive with regard to the presence, absence, and magnitude of sulfate reduction.

Methane is a metabolic byproduct associated with methanogenesis, which is an important redox process associated with reductive dechlorination and ISBIO of chlorinated solvents in groundwater as discussed above. Concentrations of methane measured in site samples can therefore be used to indicate the presence and magnitude of methanogenesis. Methane concentrations measured along the shallow groundwater flowpath in April 2003 are shown on Figure 7. As shown, methane concentrations ranged from about 0.001 to 0.16 mg/l along this flowpath. The lowest methane concentration observed along the flowpath was detected at monitoring well MW-7, and the highest methane concentration was detected at monitoring well MW-8. These data indicate that methane was being produced as a metabolic byproduct in groundwater hydraulically downgradient from the site at the time of sampling. This information indicates that methanogenesis likely was occurring in groundwater near monitoring well MW-8 in April 2003. The elevated methane concentration measured in groundwater sampled at monitoring well MW-3 (~0.8 mg/L; Table 2) indicates that methanogenesis also was occurring at this sampling location.

Ethane is one of the final byproducts of reductive dechlorination of some chlorinated solvents in groundwater, and therefore concentrations of ethane measured in site samples can be used to verify the presence of complete reductive dechlorination reactions. Ethane concentrations measured along the shallow groundwater flowpath in April 2003 are shown on Figure 8. As shown, ethane concentrations ranged from about 0.006 to 8 micrograms per liter (ug/L) along this flowpath. The lowest ethane concentration observed along the flowpath was detected at monitoring well MW-7, and the highest ethane concentration was detected at monitoring well MW-8. These data indicate that ethane was being produced as a metabolic byproduct in groundwater hydraulically downgradient from the site at the time of sampling. This information indicates that reductive dechlorination was occurring in groundwater near monitoring well MW-8 in April 2003. The elevated ethane concentration measured in groundwater sampled at monitoring well MW-3 (~0.4 ug/L; Table 2) indicates that reductive dechlorination also was occurring at this sampling location.

Ethene is also a final byproduct of reductive dechlorination of some chlorinated solvents in groundwater, and therefore concentrations of ethene measured in site samples can be used to verify the presence of complete reductive dechlorination reactions. As shown in Table 2, concentrations of ethene measured in site groundwater samples during the April 2003 sampling event ranged from about 0.008 to 0.34 ug/L. The lowest ethene concentrations observed in site groundwater samples were detected at monitoring wells MW-6 and MW-7, and the highest ethene concentrations were detected at monitoring wells MW-3 and MW-8. These data indicate that ethene was being produced as a metabolic byproduct in groundwater hydraulically downgradient from the site at the time of sampling. This information indicates that reductive dechlorination was occurring in groundwater near monitoring wells MW-3 and MW-8 in April 2003.

Chloride concentrations can be used to indicate the presence and magnitude of ISBIO of chlorinated solvents in groundwater because chloride is final byproduct of most naturally occurring and enhanced ISBIO reactions involving chlorinated solvents. In other words, chloride concentrations can be a good, generic indicator of the extent of ISBIO of chlorinated solvents at some sites. Chloride concentrations measured along the shallow groundwater flowpath in April 2003 are shown on Figure 9. As shown, chloride concentrations ranged from about 15 to 35 mg/L. The lowest chloride concentration observed along the flowpath was detected at monitoring well MW-8 and the highest chloride concentration was detected at monitoring well MW-2. These data indicate that chloride was being produced along the shallow groundwater flowpath at the time of sampling, and that ISBIO of chlorinated solvents likely was occurring in groundwater near monitoring well MW-2 at the time of sampling. Chloride concentrations measured in groundwater at other downgradient monitoring wells such as MW-3 and MW-8 are inconclusive due to the low resolution of the analytical method.

3.4 Microbiological Conditions

The presence, type, and metabolic status of indigenous microorganisms in the subsurface beneath the site were evaluated by analyzing groundwater samples collected at monitoring wells located upgradient, near the middle, and downgradient of the site for concentrations of phospholipid fatty acids (PLFAs) during the April 2003 sampling event. Phospholipids are part of intact cell membranes and, therefore, identification and quantification of PLFAs in groundwater samples can provide information regarding the in-situ biomass, community structure, and metabolic status of indigenous microbial populations.

The PLFA data indicate that the in-situ biomass of site groundwater samples ranged from about 10^3 to 10^6 cells per milliliter (cells/mL) during the April 2003 sampling event (Table 2). As shown, the maximum biomass concentrations were detected at monitoring wells MW-1D, MW-3, and MW-8. The PLFA data also indicate that groundwater samples collected at monitoring wells MW-1D, MW-3, and MW-8 contained relatively high proportions of terminally branched saturated PLFAs, which indicate the presence of anaerobic microorganisms, and branched monoenoic PLFAs which indicate the presence of metal-reducing microorganisms such as sulfate- and iron-reducing bacteria. These trends correlate well with the presence of increased concentrations of metabolic byproducts (i.e., carbon dioxide, methane, ethane, and ethene) at the MW-3 and MW-8 sampling locations, as well as the presence of petroleum chemicals in the sample collected at monitoring well MW-3. On balance, the PLFA and biogeochemical data suggest that indigenous groundwater microorganisms at some locations beneath the site have adapted to the presence of dissolved petroleum chemicals and chlorinated solvents and are able to incorporate these substances into their metabolic processes.

Groundwater samples were also analyzed for the presence of a specific microorganism known to reductively dechlorinate chlorinated solvents, namely *Dehalococcoides Ethenogenes*. *D. Ethenogenes* is the only microorganisms species isolated to date capable of complete reductive dechlorination of PCE, TCE, DCE isomers, and vinyl chloride, and therefore confirming its presence in groundwater can be used to verify that reductive dechlorination reactions are in fact causing the geochemical changes noted above. As shown in Table 2, detectable concentrations of *D. Ethenogenes* were measured in groundwater samples collected at monitoring wells MW-3 and MW-8, which confirms that appropriate types of microorganisms were present at these sampling locations to support complete ISBIO or enhanced ISBIO of COCs in groundwater. Although *D. Ethenogenes* was not detected above the method detection limit in samples collected at the remainder of the monitoring wells sampled, it is important to remember that non-detect microbiologic measurements do not indicate that microorganisms are not present in a sample, only that the microorganisms were not present above the method detection limit.

3.5 Summary

Based on the above discussion, there is ample evidence that ISBIO and complete reductive dechlorination of chlorinated solvents was occurring in shallow groundwater near the downgradient portion of the site-related COC plume during the April 2003 sampling event, specifically near the MW-3 and MW-8 sampling locations. This conclusion is supported by the groundwater analytical data, which demonstrate that a population of anaerobic microorganisms, including *D. Ethenogenes*, was present in the subsurface capable of complete reductive dechlorination of dissolved chlorinated solvents. The data indicate that a lack of organic carbon and macronutrients such as nitrogen and phosphorus may be limiting the rate of naturally occurring ISBIO reactions at some areas of the site.

4.0 Conclusions

This evaluation of natural attenuation has yielded the following conclusions:

- The key transport and attenuation mechanisms for COC migration in groundwater at the site include advection, hydrodynamic dispersion, dilution, hydrophobic sorption, and naturally occurring ISBIO.

- Dispersion and dilution are expected to result in attenuation of peak COC concentrations in site groundwater.

- The COC plume migration rate is likely retarded compared with the average linear groundwater velocity due to hydrophobic sorption onto solid aquifer materials. Sorption-based COC retardation factors ranging between about 1.3 and 4.3 have been estimated for the site.

- ISBIO and complete reductive dechlorination of site COCs through ethene and ethane appear to be occurring in at least two naturally occurring "bioreactive zones" located near the MW-3 and MW-8 sampling locations, which are situated near the downgradient portion of the COC plume.

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Tables

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Table 1

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Evaluation of Natural Attenuation
Groundwater Analytical Results for Detected Volatile Organic Compounds (ppb)

Detected Compound	**NYSDEC Groundwater Standards**	**MW-1**	**MW-1D**	**MW-2**	**MW-3**	**BD042203 (MW-3)**	**MW-6**	**MW-7**	**MW-8**
Benzene	1	< 0.3	< 0.3	< 2.6	**2.0**	**1.8**	< 0.3	< 6.5	< 2.6
Chlorobenzene	5	< 0.2	< 0.2	< 1.8	**19**	**17**	< 0.2	< 4.5	< 1.8
cis-1,2-Dichloroethene	5	< 0.2	< 0.2	**21**	2.3	1.9	< 0.2	**38**	**27**
1,1-Dichloroethane	5	< 0.2	1.8	< 2.4	< 0.5	< 0.5	< 0.2	< 6.0	< 2.4
1,1-Dichloroethene	5	< 0.4	1.3	< 4.3	< 0.9	< 0.9	< 0.4	< 11	< 4.3
Ethylbenzene	5	< 0.4	< 0.4	< 3.7	**310**	**270**	< 0.4	< 9.2	< 3.7
Tetrachloroethene	5	**50**	0.8	**1,200**	1.4	1.2	**120**	**2,600**	**970**
Trichloroethene	5	< 0.2	1.7	**34**	< 0.4	< 0.4	1.1	**48**	**25**
1,1,1-Trichloroethane	5	< 0.2	1.4	< 1.6	< 0.3	< 0.3	0.3	< 4.0	< 1.6
Toluene	5	< 0.2	< 0.2	< 1.5	**9.6**	**8.2**	< 0.2	< 3.8	< 1.5
Xylenes (Total)	5	< 0.2	< 0.2	< 1.8	**40**	**35**	< 0.2	< 4.5	< 1.8

Notes:

1. Samples collected by Blasland, Bouck & Lee, Inc. (BBL) on April 22-23, 2003.
2. Sample BD042203 is a blind duplicate of sample MW-3.
3. Samples analyzed by Severn Trent Laboratories, Inc. (STL) of Edison, New Jersey for Target Compound List (TCL) volatile organic compounds (VOCs) using United States Environmental Protection Agency (USEPA) Method 624.
4. Concentrations are reported in parts per billion (ppb), which are equivalent to micrograms per liter (µg/L).
5. Groundwater quality standards are from the New York State Department of Environmental Conservation (NYSDEC) Division of Water, Technical and Operational Guidance Series (TOGS 1.1.1) document entitled, "Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations," dated June 1998, revised April 2000.
6. < = Compound was not detected at a concentration exceeding the reported laboratory detection limit.
7. Shaded value indicates a VOC concentration exceeding the presented groundwater quality standard.

Table 2

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
Groundwater Field/Laboratory Analytical Results for Key Indicator Parameters of In-Situ Biodegradation

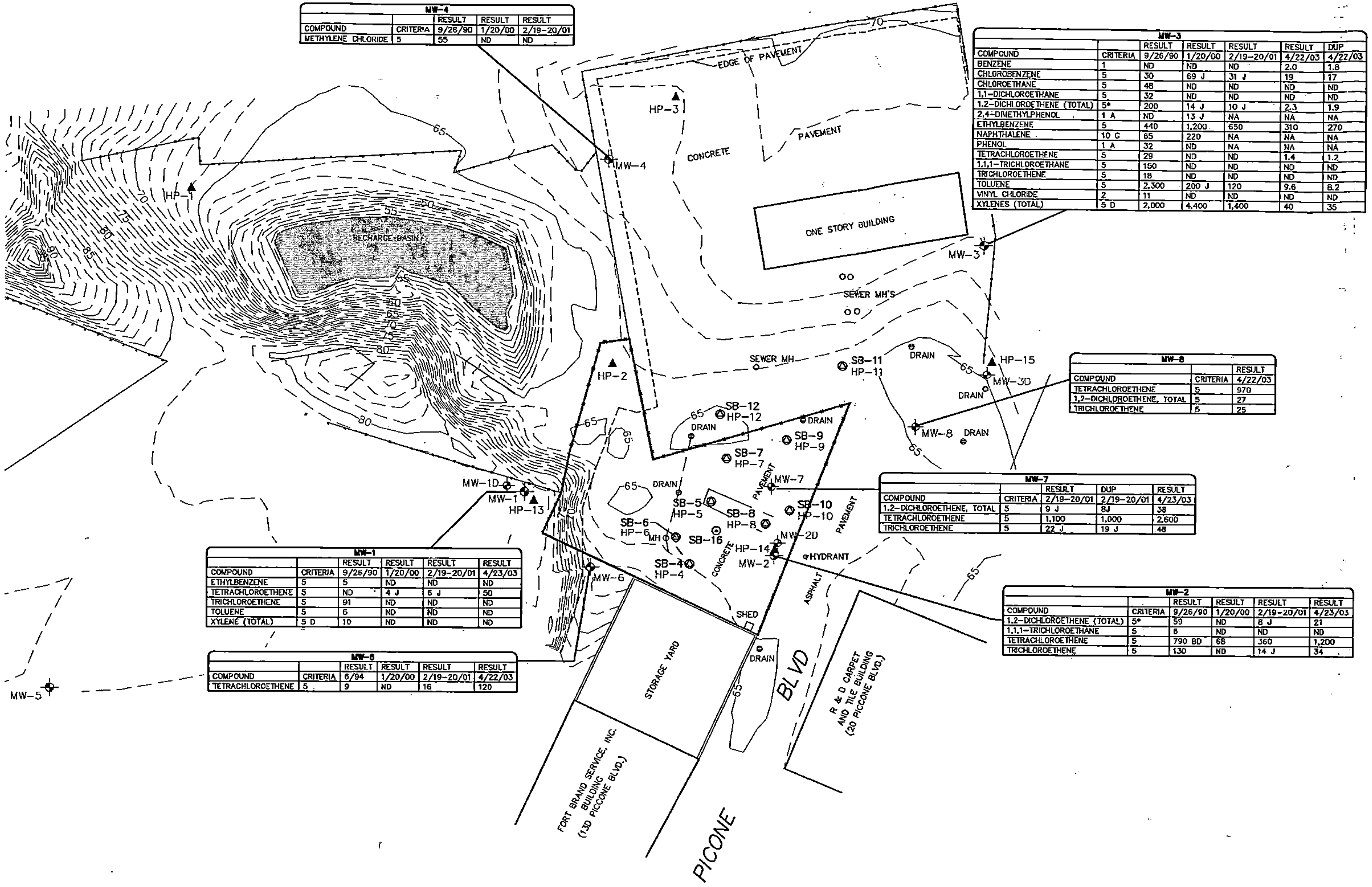
Field/Laboratory Parameters	MW-1	MW-1D	MW-2	MW-3	MW-6	MW-7	MW-8
Field Parameters							
pH	6.2	6.2	6.3	6.8	7.7	6.5	6.0
Temperature (°C)	13.9	15.3	11.3	13.0	15.2	11.2	11.6
Specific Conductance (mS/cm)	0.20	0.27	0.28	0.39	0.17	0.24	0.25
Dissolved Oxygen (mg/L)	8.6	0.5	7.1	0.8	6.5	5.7	3.5
Turbidity (NTU)	0.0	10.1	0.0	17.5	0.0	8.3	2.2
Redox (mV)	135	116	156	-121	127	157	-40
Laboratory Analytical Parameters							
Geochemical Parameters							
Alkalinity as $CaCO_3$ (mg/L)	32	71	61	200	29	52	92
Ammonia as N (mg/L)	< 2.0	< 2.0	< 2.0	3.7	2.2	5.2	< 2.0
Chloride (mg/L)	20	36	35	9.4	14	22	15
Nitrate (mg/L)	17	< 0.50	15	< 0.50	10	14	8.6
Nitrite (mg/L)	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Phosphate (mg/L)	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Soluble Organic Carbon (mg/L)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Sulfate (mg/L)	20	18	19	5.2	24	30	27
Sulfide (mg/L)	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Iron-dissolved (mg/L)	< 0.050	< 0.050	< 0.050	21	< 0.050	< 0.050	0.73
Carbon dioxide (mg/L)	34	76	26	71	26	28	38
Ethane (ng/L)	82	29	84	410	< 5.0	5.8	8,000
Ethene (ng/L)	23	32	25	340	11	8.4	180
Methane (ug/L)	0.71	14	0.73	780	0.08	0.13	160
Microbiological Parameters							
Biomass via PLFA (Cell/mL)	1.12E+04	2.23E+06	6.46E+03	1.34E+06	4.11E+03	8.81E+03	4.23E+05
Anaerobes via PLFA (% of population)	0.0	13.6	0.0	10.6	0.0	0.0	5.2
Metal reducers via PLFA (% of population)	0.0	1.3	0.0	2.1	0.0	0.0	1.4
Dehalococcoides Ethenogenes	ND	ND	ND	Detected	ND	ND	Detected

Notes:

1. Samples collected by Blasland, Bouck & Lee, Inc. (BBL) on April 22-23, 2003.
2. Field measurements obtained by BBL using a Horiba U-22 flow-through cell/water quality meter.
3. Laboratory analyses for key indicator parameters of in-situ biodegradation were performed by three laboratories, as summarized below:
   - Geochemical parameter analysis was performed by Microseeps, Inc. (University of Pittsburgh Applied Research Center) of Pittsburgh, Pennsylvania;
   - Phospholipid fatty acids (PLFA) analysis was performed by Microbial Insights, Inc. of Rockford, Tennessee; and
   - *Dehalococcoides ethenogenes* analysis was performed by Sirem Site Recovery & Management, Inc. (Sirem) of Guelph, Ontario.
4. Analyses were performed using the following methods:
   - United States Environmental Protection Agency (USEPA) Method 9056 for chloride, nitrate, nitrite, phosphate, and sulfate;
   - USEPA Method 310.1 for alkalinity;
   - USEPA Method 350.2 for ammonia;
   - USEPA Method 376.1 for sulfide;
   - USEPA Method 6010B for dissolved iron;
   - USEPA Method 9060 for dissolved organic carbon;
   - Laboratory-specific gas chromatography (GC) methods for carbon dioxide/methane (AM20GAX) and ethane/ethene (AM18);
   - A laboratory-specific gas chromatography/mass spectrometry (GC/MS) method for PLFA; and
   - A laboratory-specific polymerase chain-reaction (PCR) method for *dehalococcoides ethenogenes*.
5. Concentrations reported in the units identified above.

6. S.U. = Standard units.
7. °C = Degrees Celcius.
8. mS/cm = milliSiemens per centimeter.
9. NTU = Nephelometric turbidity units.
10. mV = milliVolt.
11. mg/L = milligrams per liter, which is equivalent to parts per million (ppm).
12. ng/L = nanograms per liter.
13. < = Compound was not detected at a concentration exceeding the reported laboratory detection limit.
14. ND = not detected above the analytical method detection limit.

Figures



MW-4

COMPOUND	CRITERIA	RESULT 9/26/90	RESULT 1/20/00	RESULT 2/19-20/01
METHYLENE CHLORIDE	5	55	ND	ND

MW-3

COMPOUND	CRITERIA	RESULT 9/26/90	RESULT 1/20/00	RESULT 2/19-20/01	RESULT 4/22/03	DUP 4/22/03
BENZENE	1	ND	ND	ND	2.0	1.8
CHLOROBENZENE	5	30	69 J	31 J	19	17
CHLOROETHANE	5	48	ND	ND	ND	ND
1,1-DICHLOROETHANE	5	32	ND	ND	ND	ND
1,2-DICHLOROETHENE (TOTAL)	5*	200	14 J	10 J	2.3	1.9
2,4-DIMETHYLPHENOL	1 A	ND	13 J	NA	NA	NA
ETHYLBENZENE	5	440	1,200	650	310	270
NAPHTHALENE	10 G	65	220	NA	NA	NA
PHENOL	1 A	32	ND	NA	NA	NA
TETRACHLOROETHENE	5	29	ND	ND	1.4	1.2
1,1,1-TRICHLOROETHANE	5	150	ND	ND	ND	ND
TRICHLOROETHENE	5	18	ND	ND	ND	ND
TOLUENE	5	2,300	200 J	120	9.6	8.2
VINYL CHLORIDE	2	11	ND	ND	ND	ND
XYLENES (TOTAL)	5 D	2,000	4,400	1,400	40	35

MW-8

COMPOUND	CRITERIA	RESULT 4/22/03
TETRACHLOROETHENE	5	970
1,2-DICHLOROETHENE, TOTAL	5	27
TRICHLOROETHENE	5	25

MW-7

COMPOUND	CRITERIA	RESULT 2/19-20/01	DUP 2/19-20/01	RESULT 4/23/03
1,2-DICHLOROETHENE, TOTAL	5	9 J	8J	38
TETRACHLOROETHENE	5	1,100	1,000	2,600
TRICHLOROETHENE	5	22 J	19 J	48

MW-1

COMPOUND	CRITERIA	RESULT 9/26/90	RESULT 1/20/00	RESULT 2/19-20/01	RESULT 4/23/03
ETHYLBENZENE	5	5	ND	ND	ND
TETRACHLOROETHENE	5	ND	4 J	6 J	50
TRICHLOROETHENE	5	91	ND	ND	ND
TOLUENE	5	6	ND	ND	ND
XYLENE (TOTAL)	5 D	10	ND	ND	ND

MW-2

COMPOUND	CRITERIA	RESULT 9/26/90	RESULT 1/20/00	RESULT 2/19-20/01	RESULT 4/23/03
1,2-DICHLOROETHENE (TOTAL)	5*	59	ND	8 J	21
1,1,1-TRICHLOROETHANE	5	6	ND	ND	ND
TETRACHLOROETHENE	5	790 BD	68	360	1,200
TRICHLOROETHENE	5	130	ND	14 J	34

MW-6

COMPOUND	CRITERIA	RESULT 6/94	RESULT 1/20/00	RESULT 2/19-20/01	RESULT 4/22/03
TETRACHLOROETHENE	5	9	ND	16	120

LEGEND

───	SITE BOUNDARY LOCATION (11-A PICONE BOULEVARD)
─·─	FENCE LINE
⊕	MONITORING WELL LOCATION
⊗	SOIL BORING/HYDROPUNCH(TM) LOCATION
▲	HYDROPUNCH(TM) LOCATION ONLY
⊙	SOIL BORING LOCATION ONLY

Notes:

1. ALL CONCENTRATIONS ARE REPORTED IN MICROGRAMS PER LITER (ug/L) EQUIVALENT TO PARTS PER BILLION (ppb).
2. G = GUIDANCE VALUE
3. * = CRITERIA VALUE LISTED FOR 1,2-DICHLOROETHENE (Total) APPLIES TO THE Cis AND Trans- ISOMERS INDIVIDUALLY.
4. D = VALUE LISTED APPLIES TO EACH ISOMER INDIVIDUALLY.
5. A = VALUE LISTED APPLIES TO THE SUM OF THESE SUBSTANCES.
6. J = THE RESULT IS LESS THAN THE QUANTITATION LIMIT BUT GREATER THAN ZERO. CONCENTRATION GIVEN IS AN APPROXIMATE VALUE.
7. BD = CONTAMINANT ALSO DETECTED IN METHOD BLANK. DILUTED SAMPLE ANALYSIS.
8. ND = NOT DETECTED.
9. NA = NOT ANALYZED.
10. CRITERIA REFERENCE: NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION (NYSDEC) DIVISION OF WATER TECHNICAL AND OPERATIONAL GUIDANCE SERIES (1.1.1), AMBIENT WATER QUALITY STANDARDS AND GUIDANCE VALUES, JUNE 1998.

40' 0 40' 80'
SCALE IN FEET

SOURCE:
ALL BASE MAP INFORMATION UNLESS OTHERWISE NOTED WAS TAKEN FROM A MAP ENTITLED "MONITORING WELL AND SOIL BORING LOCATION PLAN, HWD SITE-PICONE BOULEVARD, FARMINGDALE NEW YORK, PROJECT No. 604.05 #2". PREPARED BY ALBERT W. TAY. FILE No. 99390-3.DWG. SURVEYED 11/22/99 THROUGH 11/29/99. SURVEY REVISED 2/9/2000 AND 5/13/2003.

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P: STD PCP-DBL
5/23/03 CRA-54-IY, TLF, IY SYR-85-RCB
60405025\60405C01.DWG

HAZARDOUS WASTE DISPOSAL, INC. SITE
FARMINGDALE, NEW YORK
FEASIBILITY STUDY REPORT

HISTORIC DISTRIBUTION OF ORGANIC COMPOUNDS IN GROUNDWATER MONITORING WELLS ABOVE NYSDEC CRITERIA

BBL®
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
1

Figure 2

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
VOC Concentration Trends Along Flowpath A-A'

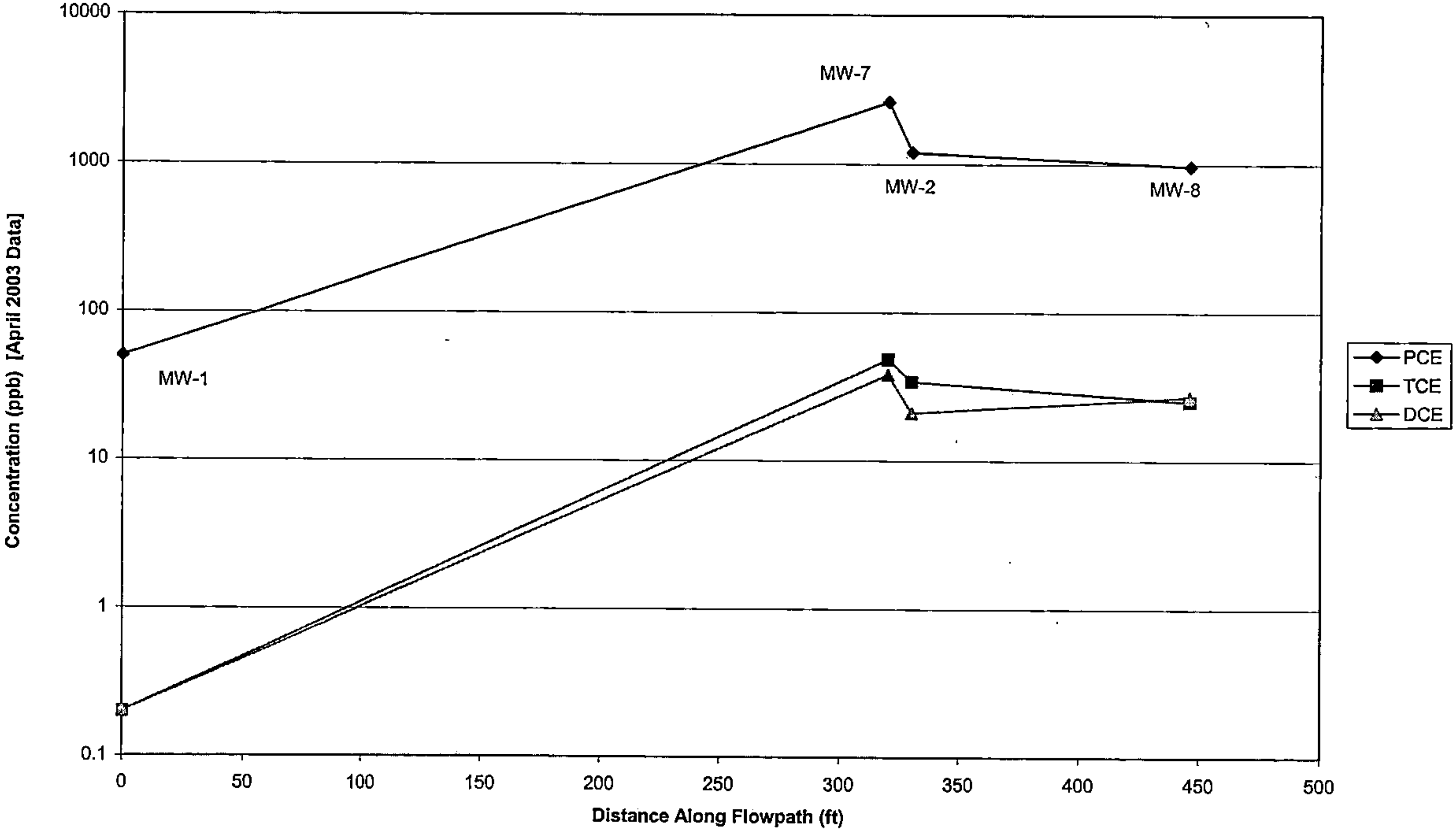


Figure 3

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
<u>Nitrate Concentration Trends Along Flowpath A-A'</u>

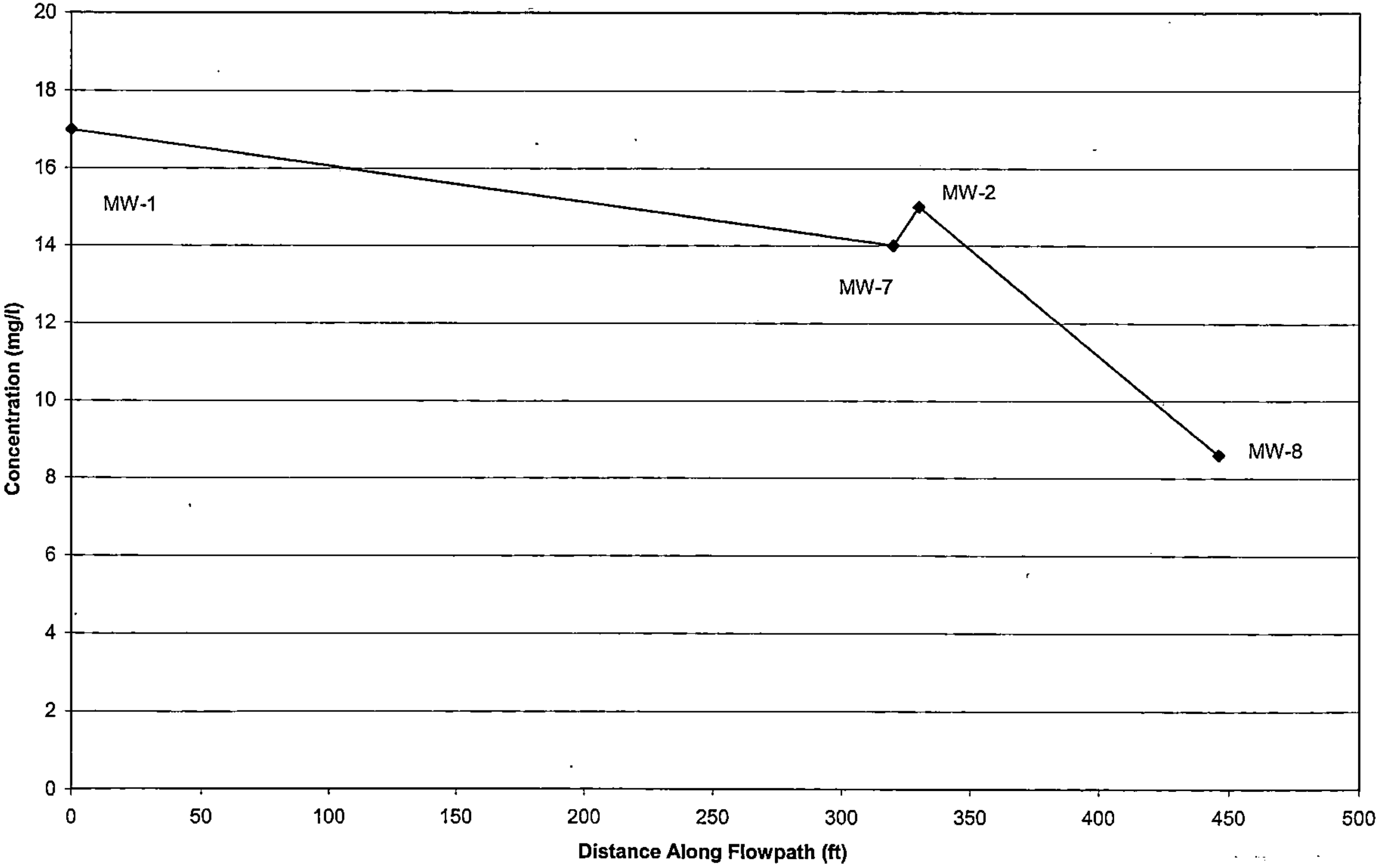
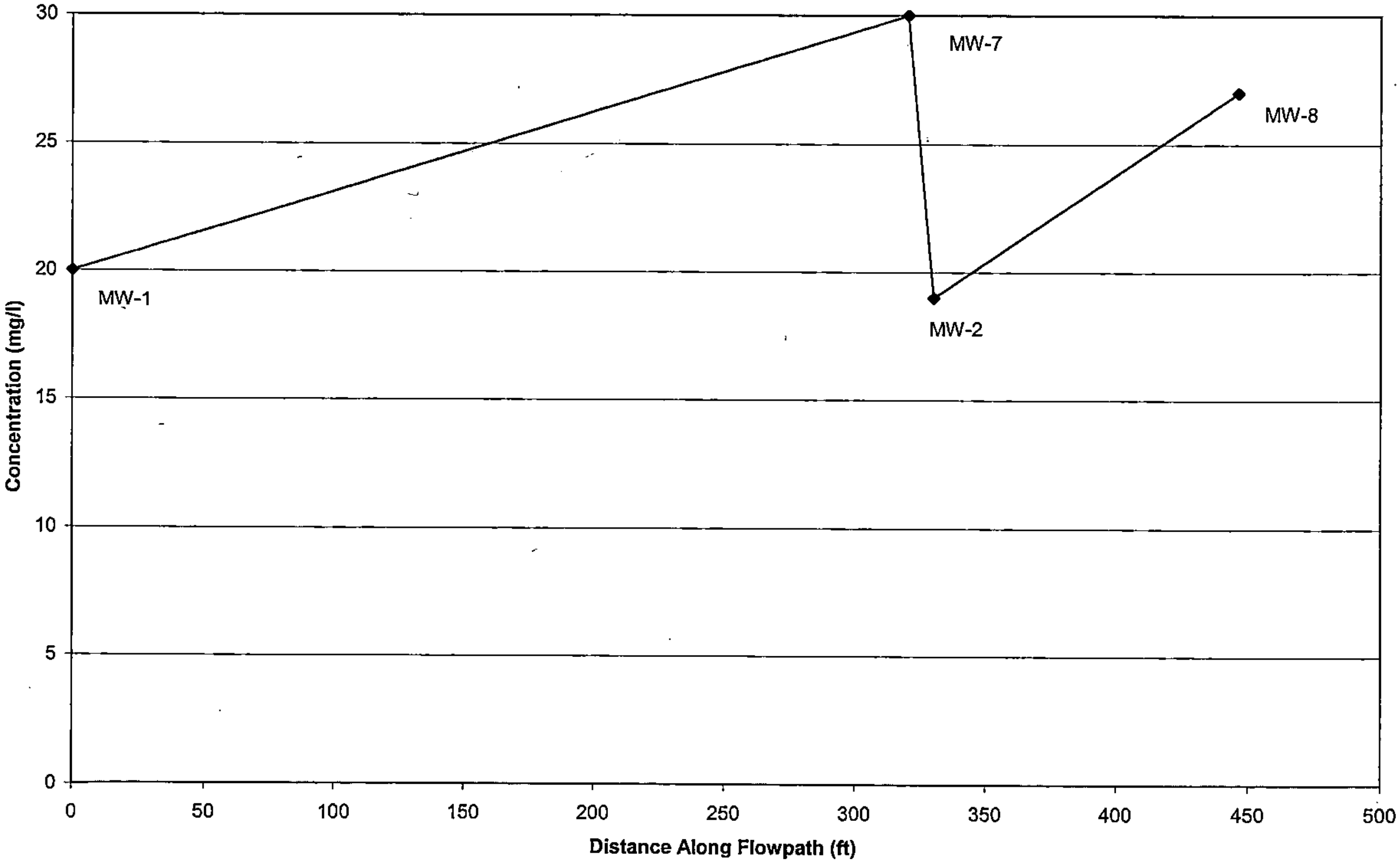


Figure 4

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
Sulfate Concentration Trends Along Flowpath A-A'



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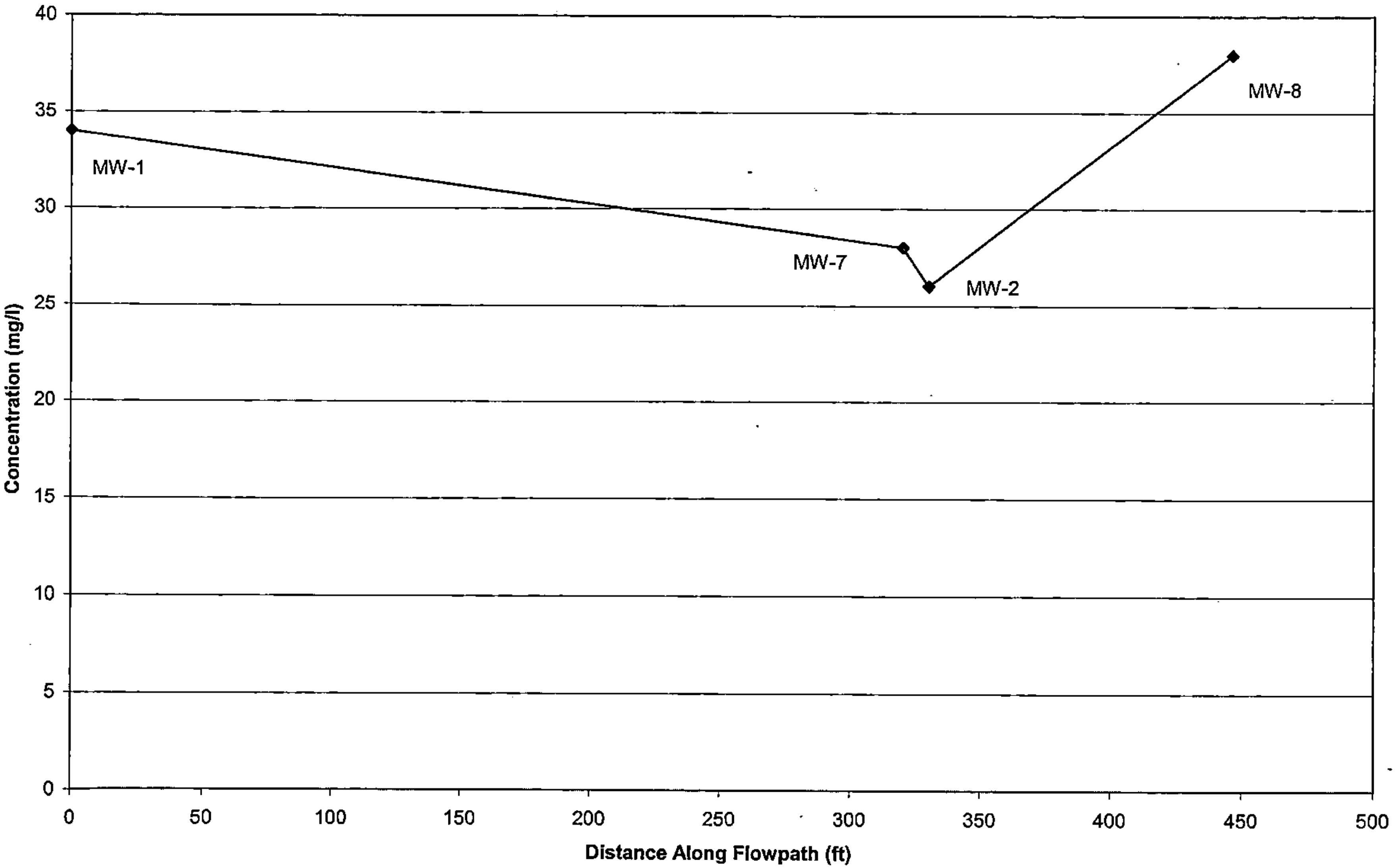
9/18/2003

Figure 5

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
Carbon Dioxide Concentration Trends Along Flowpath A-A'



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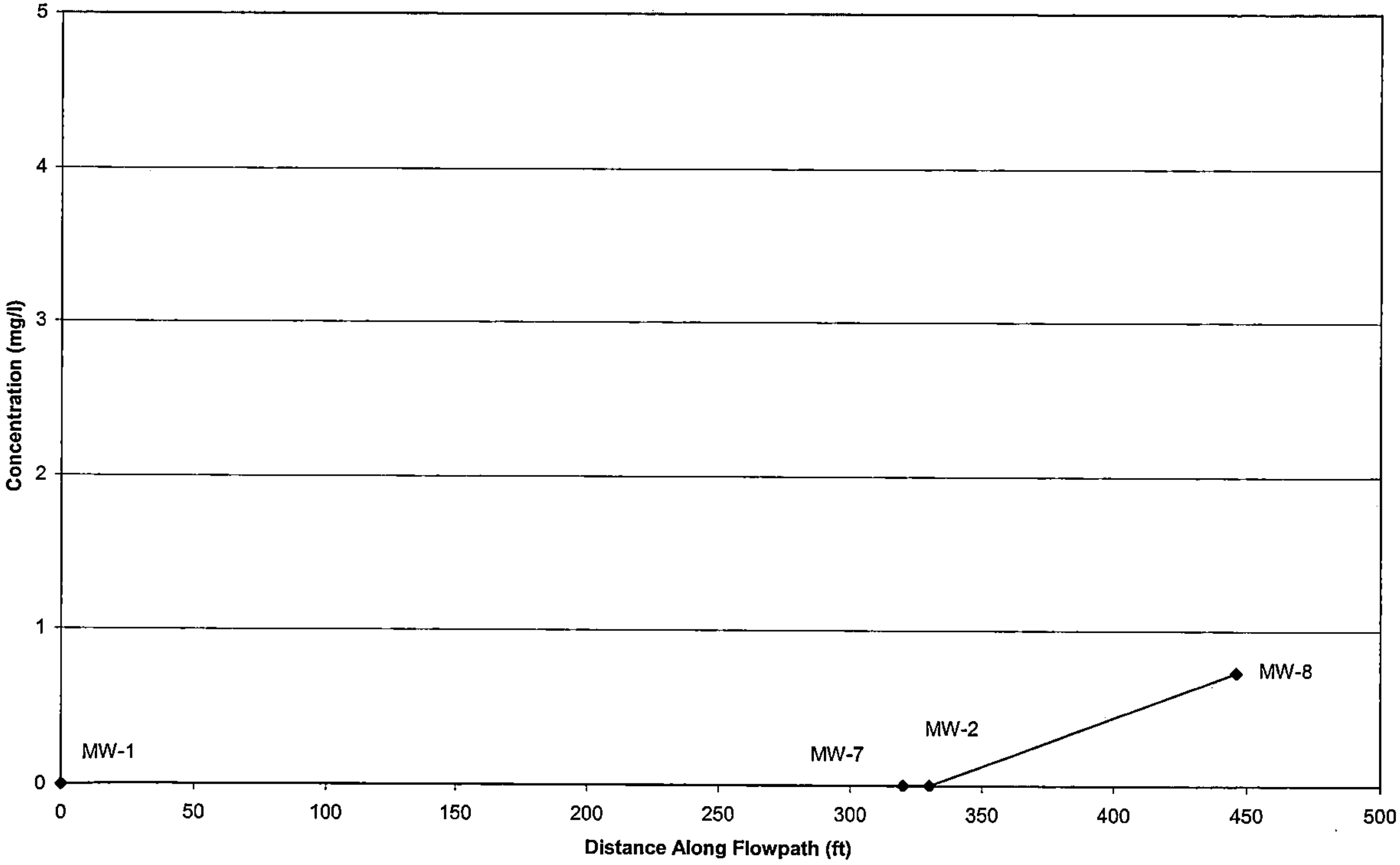
9/18/2003

Figure 6

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
<u>Dissolved Iron Concentration Trends Along Flowpath A-A'</u>



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9/18/2003

Figure 7

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
Methane Concentration Trends Along Flowpath A-A'

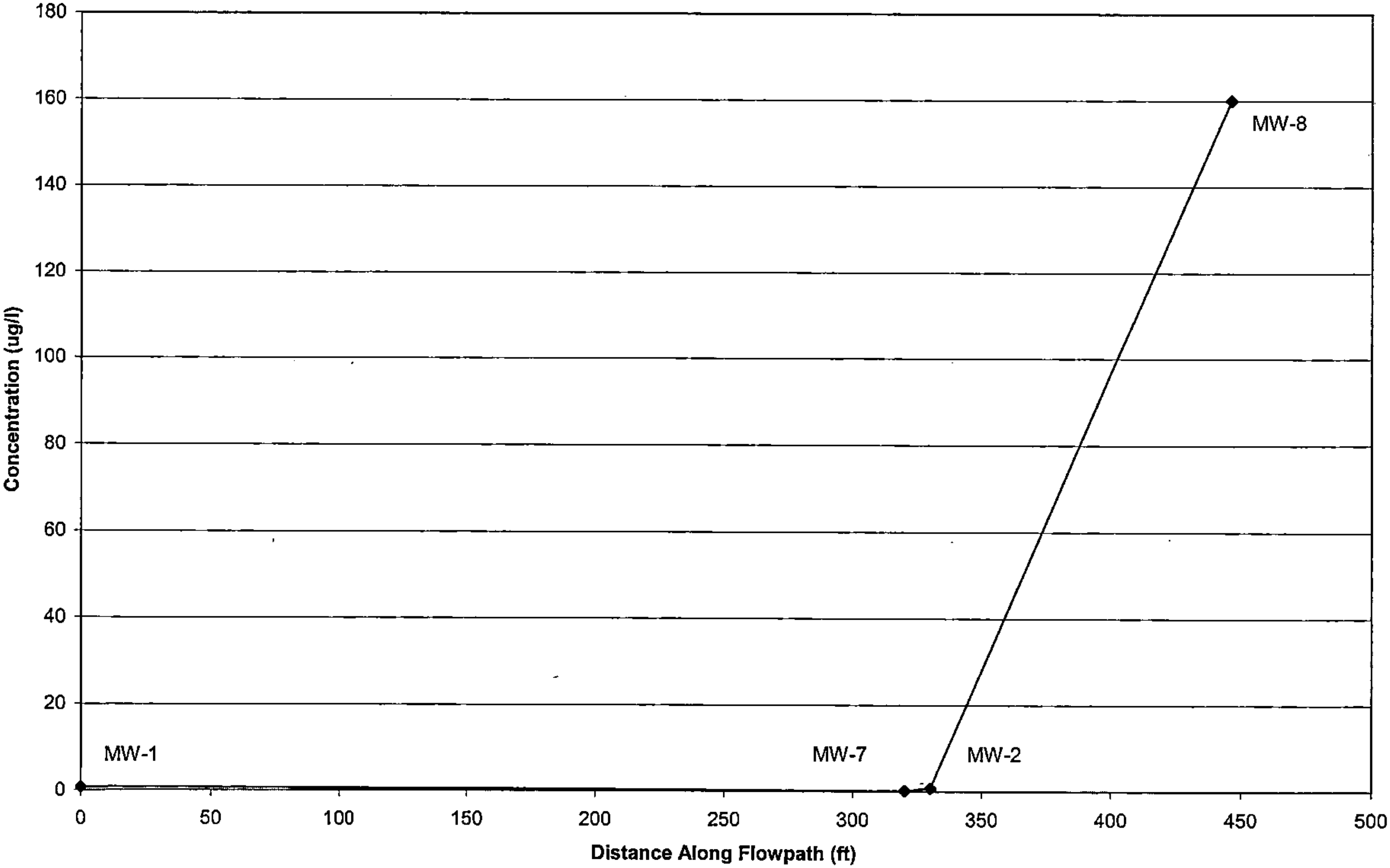

Figure 8

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
Ethane Concentration Trends Along Flowpath A-A'

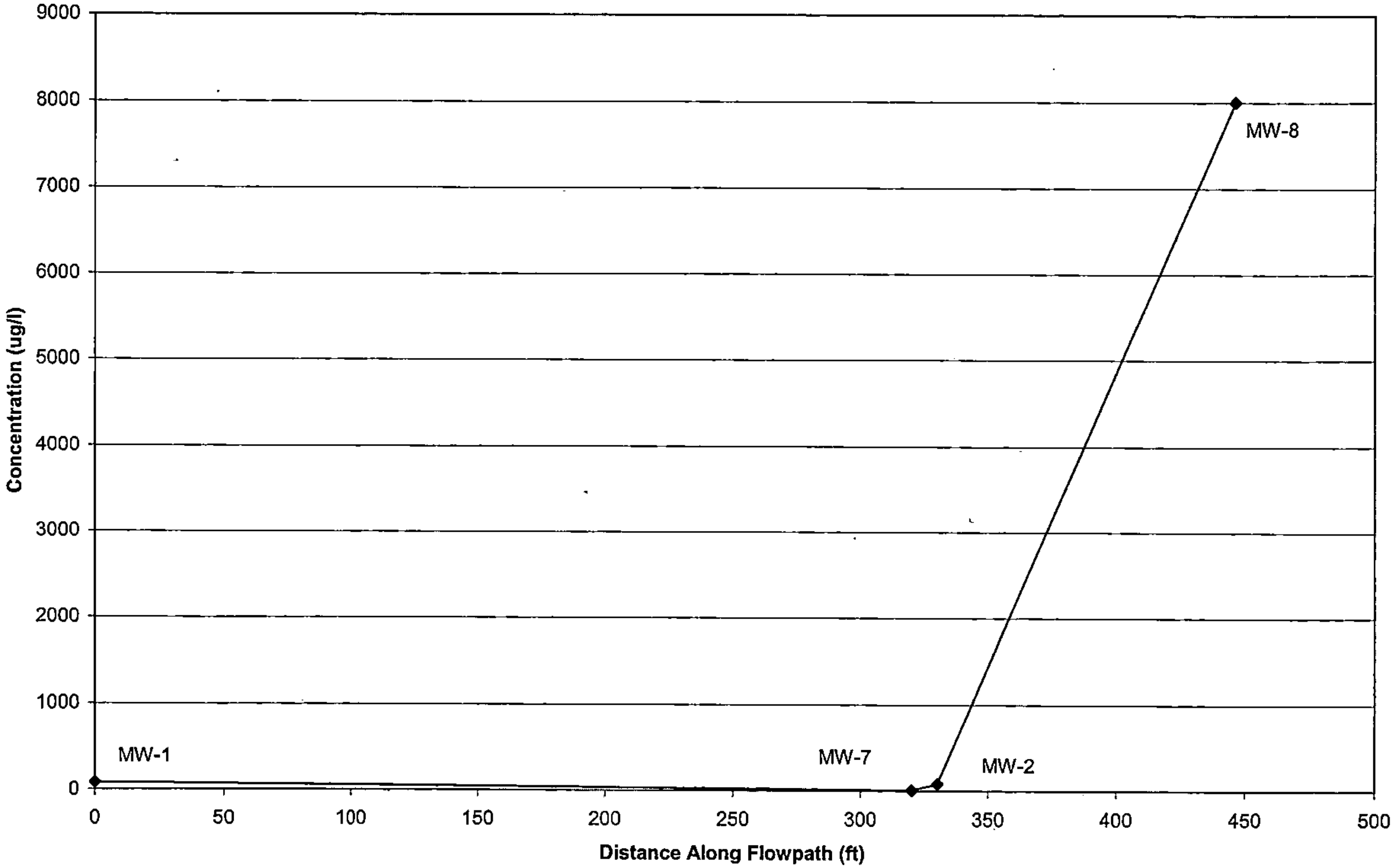

Figure 9

Hazardous Waste Disposal, Inc.
11A Picone Boulevard
Farmingdale, New York

Evaluation of Natural Attenuation
<u>Chloride Concentration Trends Along Flowpath A-A'</u>