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**CORRECTIVE MEASURES STUDY
ENVIRITE CORPORATION
198 OLD WATERBURY ROAD
THOMASTON, CONNECTICUT
RCRA DOCKET NO I-90-1032**

Prepared for

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern	HSWA	Hazardous and Solid Waste Amendments
ANPR	Advanced Notice of Proposed Rulemaking	HWCA	Hazardous Waste Control Act
RAR	Applicable or Relevant and Appropriate Requirements	I/C	Industrial/Commercial
bgs	Below Ground Surface	IPRB	Iron Permeable Reactive Barrier
CAA	Clean Air Act	LTR	Landfill Treatment Residue
CDA	Connecticut Development Authority	LTTD	Low Temperature Thermal Desorption
CFR	Code of Federal Regulations	mg/kg	milligrams per kilogram
CGS	Connecticut General Statutes	mg/l	milligrams per liter
CMS	Corrective Measures Study	Minges	Minges Associates
COPC	Chemical of Potential Concern	MIP	Membrane Interface Probe
CTDEP	Connecticut Department of Environmental Protection	MNA	Monitored Natural Attenuation
CTE	Central Tendency Exposure.	MPS	Media Protection Standards
CWA	Clean Water Act	NEPA	National Environmental Policy Act
DCE	Dichloroethylene	NPDES	National Pollution Discharge Eliminating System
DEC	Direct Exposure Criteria	O&M	Operation and Maintenance
ELUR	Environmental Land Use Restriction	OSHA	Occupational Safety and Health Administration
Envirite	Envirite Corporation	PAH	Polynuclear (or Polycyclic) Aromatic Hydrocarbons
ENVIRON	ENVIRON International Corporation	PCB	Polychlorinated Biphenyl
ERI	University of Connecticut Environmental Research Institute	PCE	Tetrachloroethylene (or Tetrachloroethene)
GAC	Granular Activated Carbon	PEWM-L	Pre-Envirite Waste Material beneath the Landfill Residues
GWPC	Ground Water Protection Criteria	PEWM-R	Pre-Envirite Waste Material adjacent to and beneath the Roadway
GZA	GZA GeoEnvironmental, Inc.		
HI	Hazard Index		

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PHERE	Public Health and Environmental Risk Evaluation	TBC	To-Be-Considered
PMC	Pollutant Mobility Criteria	TCE	Trichloroethylene (or Trichloroethene)
POTW	Publicly Owned Treatment Works	TMB	Trimethylbenzene
PVC	Polyvinyl chloride	TSCA	Toxic Substances Control Act
RAO	Remedial Action Objective	95% UCL	95 percent upper confidence limit on the mean concentration
RBCs	Risk-Based Concentrations	USDOE	United States Department of Energy
RBTC	Risk-Based Target Concentration	USEPA	United States Environmental Protection Agency
RCRA	Resource Conservation and Recovery Act	VC	Volatilization Criteria
RFI	RCRA Facility Investigation	VOC	Volatile Organic Compound
RL	Reporting Limit	WDR	Waste Discharge Requirements
RME	Reasonable Maximum Exposure	WQC	Water Quality Criteria
SARA	Superfund Amendments and Reauthorization Act	µg/l	micrograms per liter
SB	Statement of Basis	µg/kg	micrograms per kilogram
SDWA	Safe Drinking Water Act		
SPSH	Six Phase Soil Heating		
SVE	Soil Vapor Extraction		
SWMU	Solid Waste Management Units		
SWPC	Surface Water Protection Criteria		

EXECUTIVE SUMMARY

Overview

Envirite Inc. (Envirite) owns a former hazardous waste treatment facility and hazardous and solid waste disposal facility in Thomaston, Connecticut ("Site"), which was operated from 1975 until 1990. In November 1990, Envirite and the United States Environmental Protection Agency (USEPA) Region I entered into a Consent Agreement issued under Section 3008(h) of the Resource Conservation and Recovery Act (RCRA). Under the terms of the Consent Agreement, Envirite was required to evaluate the nature and extent of any releases of hazardous waste or hazardous constituents from the solid waste management units at the facility.

A RCRA facility investigation (RFI) was conducted by GZA GeoEnvironmental, Inc. (GZA) to characterize the Site and the surrounding area. To determine the nature, extent, and magnitude of chemicals present in various environmental media in the Site vicinity, samples of soil, ground water, and soil gas were collected from the Site. In addition, samples of surface water and sediment from Naugatuck River and Branch Brook were collected at locations both upstream and downstream of the Site. Based on data collected during and after the RFI, ENVIRON prepared a Public Health and Environmental Risk Evaluation (PHERE) of the Site. The purpose of the PHERE was to identify the human population and environmental systems that may be exposed to hazardous constituents released from the Site, and to assess potential risks to currently exposed populations and potential future populations. Subsequent to the PHERE, additional ground water monitoring data were collected to evaluate current conditions at the Site. A summary and evaluation of the most recent ground water monitoring results were presented by ENVIRON in a May 25, 2005 memorandum. The memorandum recommends further remediation of the Pre-Envirite Waste Material-Roadway (PEWM-R) pile, removal of the building, implementation of a land use restriction, and compliance of ground water with surface water protection criteria.

With completion of the RFI, the Corrective Measures Study (CMS) was conducted to determine the conceptual remedial alternative for the Site and provide a basis for the development of a Statement of Basis (SB) by the USEPA to inform the public and provide an opportunity for comment on the proposed remedy. The public comment will be evaluate and incorporated into USEPA's final remedy decision.

The CMS concludes that if the preferred remedial alternative for the Site is implemented, it will achieve the remedial objectives and provide a long-term, permanent solution for the Site. The

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preferred remedial alternative for the Site is removal of the PEWM-R, monitoring and natural attenuation for ground water, and establishing an Environmental Land Use Restriction (ELUR).

1.0 INTRODUCTION

1.1 Overview

ENVIRON International Corporation (ENVIRON) was retained by Envirite to prepare a CMS for the property located at 198 Old Waterbury Road in Thomaston, Connecticut (the Site), as shown on Figure 1. Based on the results of prior subsurface investigations and ENVIRON's Public Health and Environmental Risk Evaluation (PHERE), the CMS was prepared to address the soil and ground water issues at the Site.

The Site is a former hazardous waste treatment facility and hazardous and solid waste disposal facility, which was operated from 1975 until 1990. In November 1990, Envirite and the United States Environmental Protection Agency (USEPA) Region I entered into a Consent Agreement issued under Section 3008(h) of the Resource Conservation and Recovery Act (RCRA). Under the terms of the Consent Agreement, Envirite was required to evaluate the nature and extent of any releases of hazardous waste or hazardous constituents from the solid waste management units at the facility.

A RCRA facility investigation (RFI) was conducted by GZA GeoEnvironmental, Inc. (GZA) to characterize the Site and the surrounding area. To determine the nature, extent, and magnitude of chemicals present in various environmental media in the Site vicinity, samples of soil, ground water, and soil gas were collected from the Site. In addition, samples of surface water and sediment from Naugatuck River and Branch Brook were collected at locations both upstream and downstream of the Site.

Based on the results of the RFI, ENVIRON prepared a PHERE for the Site. The purpose of the PHERE was to identify the human population and environmental systems that may be exposed to hazardous constituents released from the Site, and to assess potential risks to currently exposed populations and potential future populations. Subsequent to the PHERE, additional ground water monitoring data were collected to evaluate current conditions at the Site. A summary and evaluation of the most recent ground water monitoring results were presented by ENVIRON in a May 25, 2005 memorandum. Following this memorandum, a request was made (and permission was granted) to perform additional quarterly rounds of expanded monitoring to evaluate up-gradient concentrations in ground water. Concurrent with this study, the CMS has been prepared.

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In addition to the ground water monitoring, closure activities for the former facility building are being coordinated. All bulk and containerized hazardous materials were removed from the Site, tanks were decontaminated, and the secondary containment areas were partially decontaminated.

1.2 Corrective Measures Study Objective and Approach

The CMS was prepared to evaluate remedial technologies for addressing remaining chemicals of potential concern (COPCs) in soil and ground water at the Site. In preparing the CMS, ENVIRON performed an evaluation and screening process in compliance with the May 1996 Advanced Notice of Proposed Rulemaking (ANPR) (61 FR 19432). ENVIRON generally followed the guidance prepared by the United States Department of Energy for preparing corrective measures studies (USDOE, 2003). Based on this guidance, regulatory compliance and the prior Site investigations were evaluated, and remedial action objectives (RAOs) and alternatives for the remediation of the chemicals detected in soil, waste material, and ground water were developed. These alternatives were then evaluated for the Site and a preferred remedy option was selected for the Site.

1.3 Report Organization

Following this introductory section, the remainder of this report is divided into the following sections:

- Section 2.0 - Site Background: presents an overview of the Site and surrounding area, identifies history of the Site that is relevant to the CMS, and provides detailed information on the Site topography, hydrology, and geology.
- Section 3.0 - Public Health and Environmental Risk Evaluation Summary: presents a summary of the PHERE.
- Section 4.0 - Remedial Action Objectives and Regulatory Requirements: presents the RAOs and regulatory considerations for the Site.
- Section 5.0 – Nature and Distribution of Impact: provides detailed information on the distribution of COPCs at the Site.
- Section 6.0 – Identification and Screening of Remedial Technologies: presents the methodology for the identification and screening of technologies for the impacted soil, waste material, and ground water at the Site.

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- Section 7.0 – Detailed Evaluation of the Alternatives: compares retained technologies from the preliminary screening to each other using nine evaluation criteria.
- Section 8.0 – Preferred Alternative for the Site: presents the selected remedial alternative for the Site and describes the preferred alternative in detail.
- Section 9.0 – Limitations: discusses limitations to this report.
- Section 10.0 – References: includes all references cited in this report.

2.0 SITE BACKGROUND

This chapter summarizes the portions of the Site description and history that are relevant to the CMS. More detailed descriptions of Site activities are presented in the RFI report (GZA 1995).

2.1 Site Description

The Site is located in the southern portion of the Town of Thomaston, Connecticut in Litchfield County, as shown on Figure 1. The southwestern portion of the Site is located in the Town of Watertown. The Site consists of a 12,000 square foot waste treatment and storage building and an approximately five-acre solid waste landfill, which includes a one-acre hazardous waste disposal area as shown on Figure 2. The Site is situated in a valley, approximately one half mile north of the confluence of Branch Brook and Naugatuck River. Branch Brook flows along the western edge of the Site, and Old Waterbury Road is situated to the east. Naugatuck River is located immediately east of Old Waterbury Road.

The area within a one half mile radius of the Site contains three major land uses. The areas to the west and south are mostly part of the Mattatuck State Forest. These areas are heavily wooded, with no commercial or residential activity. The Thomaston Publicly Owned Treatment Works (POTW), Thomaston dog pound, and a mixed solid waste transfer station are situated adjacent to the southern edge of the Site. Old Waterbury Road terminates at the POTW. To the east, north, and northwest, land use is a mix of industrial and residential. The properties north of the Site along Old Waterbury Road contain a number of light industries, including Summit Metals, Eyelets for Industry, and the T.A.D. Corporation. Other industries currently in the Site vicinity include Central Connecticut Cable Company, Stewart EFI, and Port-O-Let. Across from the Site on the eastern bank of Naugatuck River lie a major metal plating operation (Whyco Chromium Company) and sporadic residential uses.

The general topography of the Site vicinity consists of rolling hills with occasional steep valleys associated with Naugatuck River and its tributaries. In general, Site conditions include a bedrock highland that outcrops along the northern end of the Site and a sand and gravel aquifer that thickens from the bedrock outcrops in the north to 60 feet thick in the south and southeast portions of the Site. Surface water flow is from north to south, and stream flux measurements indicate the brook and river are likely recharging the aquifer (at least seasonally) adjacent to the Site (GZA

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1995). According to the RFI report, ground water in the overburden aquifer in the vicinity of the treatment building flows to the west towards Branch Brook; overburden ground water at the rest of the Site flows to the south and southwest. Flow directions in the bedrock are also generally to the south and southwest.

2.2 Site History

The Site history summarized below is based primarily on information presented in the RFI report (GZA 1995).

Prior to the construction of the Envirite facility in 1975, an investigation was conducted at the Site, during which time an "oily sludge" material that contained volatile organic compounds (VOCs) was discovered. This material was determined as likely being waste material from a solvent recovery operation, Solvents Recovery Service Corporation, which operated a facility across from the Site on the east bank of Naugatuck River from 1947 until 1955. Although the majority of this oily sludge ("Pre-Envirite Waste Material") reportedly was excavated and removed in 1975, similar waste material was discovered in 1981 in the same vicinity, approximately half of which is located off the Envirite property to the east. According to the RFI report, based on historical data, this PEWM was determined to be unrelated to Envirite's post-1975 operations.

According to the RFI report, the PEWM is believed to be the dominant source of organic constituents at the Site. High concentrations of certain VOCs (e.g., tetrachloroethylene [PCE], trichloroethylene [TCE]) were measured in samples collected from the PEWM, on the order of several thousand parts per million. Based on these high concentrations, potential exposures resulting from exposure to this waste material would be expected to be significant. The highest concentrations of organic constituents in the ground water were found in monitoring wells immediately downgradient of the PEWM.

Other potential sources of on-site contamination include two acid spills that occurred on-site in 1978 and 1983. The areas potentially impacted by these spills are located in the vicinity of soil samples F-1 through F-11 as shown on Figure 3. The first spill occurred on February 1, 1978 when a tank inside the storage and treatment building suffered a total failure and caused two other tanks to develop major leaks of hydrochloric and nitric acids. The second spill occurred on January 30, 1983 when a nitric acid storage tank failed. The leak damaged the plumbing and valves of some other tanks, causing the contents of several other tanks containing nitric, sulfuric, and hydrochloric acids to spill onto the floor. Additional details on the spills are provided in the RFI report (GZA 1995). These spills, particularly the 1983 spill, are believed to be the primary source of certain metals detected in environmental media. Concentrations of metals (e.g., copper, nickel, and zinc) are highest in well clusters along the southern boundary of the Site, immediately downgradient of areas

impacted by the 1983 on-site acid spill event. The spill is the likely source of these constituents in the wells since the observed metal constituents and depressed pH are typical of the composition of the material released, and constituent concentrations are decreasing over time. High concentrations of metals (e.g., barium, chromium, copper, lead, and zinc) were also detected in the PEWM.

From 1975 until 1990, the facility received inorganic acidic, alkaline, and neutral wastes from a variety of industrial clients. The wastes were batch treated on-site using cyanide destruction and hexavalent chromium reduction, followed by neutralization, precipitation, and stabilization. The treatment residues were deposited into a landfill, which forms a horseshoe-shaped ridge around the building. The landfill ranges from 15 to 30 feet above grade in height and approximately 150 to 200 feet wide. The landfill surface currently is completely vegetated, and landfill Cells 4 and 5 are capped with a 30 mil polyvinyl chloride (PVC) membrane cover installed in 1988.

2.2.1 Previous Uses and Pre-Existing Contamination

From approximately 1955 until 1975, the Site reportedly was used as a source of sand and gravel by Savin Brothers, a local construction contractor. The Site was also used to dispose of debris produced by the construction of Route 8, which runs parallel to the Site to the west. The debris consisted mostly of blast rubble that contained boulders and rock pieces (3 to 5 feet in diameter), and reportedly covered 85-90 percent of the Site.

In 1975, the Site was purchased from Savin Brothers by the Connecticut Development Authority (CDA), who financed the construction of the Envirite facility through the issuance of industrial development bonds. CDA held title to the property as security from 1975 until November 1994, at which time ownership transferred to Envirite.

Prior to the construction of the facility, Envirite retained Minges Associates (Minges) to investigate the suitability of the Site as a solid waste disposal area.¹ As part of its investigation, Minges completed a seepage test pit in the northeast portion of the Site to assess subsurface drainage, during which time a material described as an "oily sludge" (i.e. the PEWM) that apparently contained VOCs was discovered. Subsequent test pits determined the material to be approximately 2.5 to 4 feet thick.² The upper limit of the waste material found beneath the landfill residues (PEWM-L) ranges from 15 to 25.5 feet below

¹The report from the assessment conducted by Minges is included as Appendix A in the RFI Report (GZA 1995).

²Subsequent samples of the Pre-Envirite Waste Material collected by GZA during the RFI activities found the waste material thickness to range from 2 to 8.5 feet (GZA 1995).

ground surface (bgs). Based on a review of the RFI, this PEWM-L covers an area of approximately 30 feet by 40 feet as shown on Figure 4.

This material was determined as likely being waste material from a solvent recovery operation, Solvents Recovery Service Corporation, which operated a facility across from the Site on the east bank of Naugatuck River from 1947 until 1955. Historical records and aerial photographs reportedly indicate that a bridge across Naugatuck River was located directly across from Envirite's northern property line during this time, which could have facilitated transport and disposal from across the river. The majority of this oily sludge reportedly was excavated and removed in 1975 by CDA.

In 1981, during a hydrogeologic study, a one foot layer of rubbery "dried paint" material (PEWM-R) was encountered at a depth of 14 feet while an off-site monitoring well (MW-31) was being installed near the northern gate. This material was outside of the limits of the waste material delineated by Minges, and was assumed by ENVIRON to be a separate area from the PEWM found beneath the landfill residues (PEWM-L).³ Based on soil boring results, GZA (1995) determined that the upper limit of this waste material was found at a depth of 9 to 11.5 feet, and 55 percent of the known volume of the PEWM-R material is located off the Envirite property to the east. Based on a review of the RFI, the PEWM-R up to the edge of Old Waterbury Road covers an area of approximately 40 feet by 60 feet (i.e., 223 m²). According to the RFI report (GZA 1995); based on historical data, both areas of PEWM were determined to be unrelated to Envirite's post-1975 operations.

2.2.2 Waste Treatment and Disposal Operations

Following the construction of the facility, Envirite (then Liqwacon Corporation) began accepting acidic, alkaline, and neutral wastes from a variety of industrial clients, including electroplaters, electroless platers, surface finishers, steel producers, nonferrous metals manufacturers, and automobile, aircraft, hardware, jewelry, and electronics manufacturers. In general, the facility received liquid wastes and pumpable slurries that contained metals and cyanides.

The waste treatment process consisted of a batch process using cyanide destruction and hexavalent chromium reduction, followed by neutralization, precipitation, and stabilization. The treatment process produced a slurry with high water content that contained mostly insoluble metal-sulfide complexes. This slurry was filtered, with the

³Throughout this CMS, the PEWM present beneath the landfill residues will be referred to as "PEWM-L" and the PEWM present near the property boundary and roadway will be referred to as "PEWM-R."

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filtrate discharged to the sanitary sewer system under a Connecticut Department of Environmental Protection (CTDEP) permit for treatment at the adjacent Thomaston POTW. The filtered residues were placed in a permitted on-site landfill. The portions of the landfill used initially (Cells 1, 2, and 3) were located north of the building as shown in Figure 2. A description of the sections of the landfill, the materials disposed, and periods of usage are provided in Table 1. In 1980, the landfill area was expanded to the west of the building, Cell 4, to accommodate the volume of treatment residues being produced.

Following the effective date of the first RCRA regulations in November 1980, the waste residues being produced at the Site were considered hazardous because they were derived from listed hazardous wastes, and were required to be managed as such. The treatment residues that had been placed in Cell 4 prior to November 1980 (pre-RCRA residues) were removed and placed on top of the existing material in Cells 1, 2, and 3 as overfill, and Envirite began managing Cell 4 as a RCRA-regulated hazardous waste unit. RCRA-regulated residues were placed in a well defined area of the landfill separate from the nonhazardous pre-RCRA residues.

Because Envirite determined the treatment residues themselves were not hazardous, Envirite submitted a petition to USEPA in June 1981 asking that the residues produced at the Site be delisted, or classified as nonhazardous wastes. On December 16, 1981, USEPA granted Envirite a conditional temporary exclusion for the residues; a final exclusion was granted on November 14, 1982. In December 1982, the portion of Cell 4 containing hazardous wastes was capped with a one foot gravel blanket, and delisted nonhazardous wastes were placed over the gravel. In November 1985, Envirite submitted a final petition to USEPA for the exclusion of its treatment residues, which was granted on November 14, 1986.

Cell 4 continued to be used for delisted nonhazardous wastes until December 1985. Use of Cell 5 began after it was permitted by CTDEP in October 1984, and continued until May 1989, when the solid waste disposal capacity of the Site was reached. Wastes continued to be received and treated by the facility; treatment residues were transported to the Envirite facility in York, Pennsylvania for disposal. In May 1990, Envirite suspended all commercial treatment of hazardous wastes at the Site. In December 1990, Envirite submitted a notice of closure for the storage and treatment building to USEPA. The building subsequently was used solely for treatability demonstrations.

On May 10, 1996, Envirite sold to Pure-Etch Company of Connecticut a 1.9-acre portion of the Site, which included the 12,000 ft² treatment and storage building and

essentially all of the paved area surrounding the building. Two underground storage tanks that were excavated by Envirite in November 1996 were included in this parcel. On March 2, 2004, ownership of this portion of the site was returned to Envirite.

In correspondence dated December 12, 1996, Envirite apprised USEPA Region I of its plans to reorganize its legal and corporate structure such that the landfill property would be owned by a subsidiary wholly owned by a holding company which, in turn, would be wholly owned by Envirite Corporation.⁴ In its correspondence to Region I on February 24, 1997, Envirite confirmed its understanding that it continues to be bound by the Consent Order between Envirite Corporation and USEPA, which was finalized in November 1990 (RCRA Docket I-90-1032) as discussed below.

2.2.3 Permitting and Monitoring Activities

In October 1982, Envirite filed a RCRA Part A application with CTDEP and USEPA, which listed the Site as a treatment and storage facility, and a RCRA Part B application was submitted in 1983. In 1982, Envirite submitted a ground water monitoring program to CTDEP and USEPA, which was designed to monitor releases from Cell 4, the portion of the landfill that was being managed as a RCRA-regulated hazardous waste unit. Four monitoring wells were used for this program, in which statistically significant increases in certain parameters were detected. As a result, Envirite submitted a ground water quality assessment plan to USEPA in November 1986, which was designed to determine the rate, degree, and extent of ground water contamination. This plan was implemented in 1987 and has been maintained continuously thereafter.

Envirite submitted a series of closure and post-closure plans for the RCRA-regulated hazardous waste portion of the landfill (Cell 4) from 1983 through 1987, which were approved by CTDEP and USEPA on September 23, 1987. Closure of Cell 4 was completed in accordance with the approved plan in the summer of 1988, and closure was certified in December 28, 1988.

2.2.4 RCRA Facility Investigation

In November 1990,⁵ Envirite and USEPA Region I entered into a Consent Agreement under which Envirite was required to evaluate the nature and extent of any releases of hazardous waste or hazardous constituents from the solid waste management

⁴The subsidiary was eventually named "Thomaston Enterprises."

⁵The final Consent Order was signed by Envirite on October 22, 1990 and by USEPA on November 8, 1990.

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units (SWMUs) at the facility. Envirite submitted a RCRA Facility Investigation Proposal (RFI Report Proposal) that presented the scope of work for Phase I of the RFI in January 1991 (Fuss & O'Neill 1991), which was approved by USEPA on September 30, 1991. The RFI Report Proposal was subsequently modified in a March 22, 1994 submittal (Modified RFI Report Proposal) (GZA 1994), and work was initiated in April 1994. Monthly reports were submitted to USEPA documenting all investigation activities. Phase I field investigation activities conducted by GZA as part of the RFI included:

- Soil borings and bedrock coring;
- Monitoring well installations and sampling;
- Hydraulic tests;
- Stream measurements and surface water sampling;
- Sediment profiling and sampling;
- Biological survey of Branch Brook and Naugatuck River;
- Soil, treatment residue, and PEWM sampling; and
- Soil gas sampling.

These Phase I activities were completed in December 1994, and results were described in a report prepared by GZA (1995) and submitted to USEPA Region I. In response to comments from USEPA regarding the soil gas sampling results presented in the RFI, ENVIRON conducted a limited soil gas survey in August 1996 to supplement the results of the RFI. The results of this soil gas survey were submitted to USEPA Region I in October 1996 (ENVIRON 1996).

Phase II activities consisted primarily of additional soil sampling in the vicinity of two underground spill containment tanks. These tanks were used from 1975 to 1978 to collect spills from the acid and alkaline unloading pads on the south side of the treatment building. These tanks were removed by Envirite in November 1996, and soil sampling was conducted in this area by GZA (Envirite 1996a, 1996b).

2.2.5 Landfill Treatment Residue (LTR) Study

Additional sampling and analytical activities were conducted by the University of Connecticut Environmental Research Institute (ERI) between November 1997 and May 1998

to assess potential impacts to ground water from metals and VOCs in the landfill. The extent of, or potential for, ground water contact with the LTR were evaluated by measuring the elevation of both the landfill's base and ground water. The relative concentration and distribution of VOCs in the landfill was evaluated through the collection of soil core and soil gas samples from the landfill. The results of this study were submitted to USEPA Region I in December 1998 (Envirite 1998). The major findings of the report are as follows:

- The ground water table is consistently below the landfill cell's base elevation; thus, ground water contact with landfill materials at the base of each cell should not be considered as a potential exposure pathway for the Site.
- The VOC vapor distribution across the landfill and the physical characteristics of the landfill soils suggest that VOCs have been predominately released from the PEWM-R and have diffused throughout the landfill through soil layers used during the cell filling activities.

The landfill surface currently is completely vegetated, and landfill Cells 4 and 5 are capped with a 30 mil PVC membrane cover installed in 1988.

2.2.6 Public Health and Environmental Risk Evaluation

ENVIRON performed the PHERE to quantitatively evaluate potential risks to public health and the environment associated with the Site. The PHERE was submitted to the USEPA Region 1 on February 28, 2000. In the PHERE, Media Protection Standards (MPS) were developed for the primary COPCs in soil, ground water, surface water, sediment soil gas, and the PEWM. These protection standards were based on either the numerical criteria listed in the CTDEP Remediation Standard Regulations (RSRs) or alternative remediation criteria under the Regulations of Connecticut State Agencies, and were calculated in accordance with Connecticut state regulations based on the risks developed in the PHERE. The measured Site concentrations were then compared to the calculated MPS to identify potential areas needing further investigation and/or remediation. Further discussion of the PHERE is included in Section 3.0.

2.2.7 Closure Monitoring

Subsequent to the PHERE, additional ground water monitoring data were collected to evaluate current conditions at the Site. This monitoring was conducted in concurrence with the quarterly ground water sampling events. A summary of the ground water results including this monitoring data is included in Section 5.6.

2.3 Geology and Hydrology of the Site

A conceptual model of the Site has been developed based on the field observations and subsurface boring data described in the RFI report (GZA 1995) and additional analyses conducted by ERI (Envirite 1998) and XDD (1999). The conceptual model addresses the geology, hydrology, and fate and transport of COPC.

According to the RFI report (GZA 1995), the dominant geological feature of the Site is a bedrock highland that outcrops along the northern end of the Site and generally dips to the southwest to a maximum depth on-site of approximately 70 feet. The bedrock is overlain by overburden composed of fine to coarse alluvial sands and gravels ranging in thickness from zero feet near the bedrock outcrop to 60 feet in the south and southeast portions of the Site. Gravel and blast debris from the nearby construction of Route 8 have been placed as fill (10 to 20 feet thick) over most of the Site. Geologic cross-sections are presented in the RFI report.

The Site is bounded on the west by Branch Brook and on the east by the Naugatuck River. These streams merge approximately one half mile south of the Site, and both are thought to recharge the unconfined overburden aquifer at least seasonally. The water table is generally located in the upper portion of the overburden or the lower portion of the fill. There does not appear to be any confining or retarding layer separating the bedrock from the overburden, and the bedrock is thought to be essentially impermeable with the exception of the weathered zone that may be as much as 5 to 20 feet thick.

The predominant direction of flow over the Site in both the overburden and the bedrock appears to be from the north and east (where the aquifer is recharged by the Naugatuck River) to the south-southwest. Based on site-wide water table elevation data for 1993 and 1994, the south-southwest flow direction occurs from late spring (May) through early winter (December). Ground water flow in the overburden aquifer generally flows to the south and southwest. Flow directions in the bedrock are also generally to the south and southwest. Ground water flow in the northern portion of the Site is primarily horizontal. There is a downward component of flow in the southern portion of the Site in both the overburden and the bedrock. This component is most pronounced along the southwestern boundary, suggesting significant recharge from Branch Brook. The hydraulic conductivity of the bedrock is significantly lower than that of the overburden, in which the average horizontal linear ground water flow velocities are estimated to be 5 to 35 feet per day.

According to XDD (1999), Branch Brook (which is located along the Site's western boundary) is a losing stream⁶ throughout the entire year, while the Naugatuck River (which runs

⁶Throughout this document, the term "losing stream" is meant to convey the notion that water migrates from the streambed into the aquifer.

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parallel and proximate to the Site's eastern boundary) is a losing stream for the period when the ground water flow direction through the Site is south-southwest (i.e., May through December). The 1993-94 data indicate that from mid-winter (January) through early spring (April), a mound in the water table level develops in the northeast corner of the Site, which creates an easterly ground water flow in the northern half (upgradient of the building) of the Site. The Naugatuck River experiences high water conditions during the winter (January) and early spring (April), and is a losing stream along three fourths of the Site's eastern boundary (running north to south). Consequently, the high water flow conditions in the Naugatuck River mitigate the easterly component of ground water flow across the northern part of the Site, ultimately causing ground water to flow south-southeast as it approaches the Naugatuck River, as illustrated in Figure 5 XDD (1999) indicated that the ground water flow direction along the southern quarter of the Site's eastern boundary near the Naugatuck River may range from south-southeast to south-southwest during the January-April time frame as the river becomes slightly gaining.

The RFI report (GZA 1995) indicates that Branch Brook intercepts and communicates with the upper regions of the shallow overburden aquifer, and that the overburden aquifer is recharged by Branch Brook at least seasonally, but does not provide potentiometric head data for locations to the west of Branch Brook. Although the available data are not conclusive, it seems likely that ground water flows off the Site to the southwest, then moves downstream in the overburden under Branch Brook. This ground water would eventually discharge to Branch Brook or the Naugatuck River some distance downstream from the Site. Flow patterns in the bedrock are more speculative, but may follow a similar pattern. However, insufficient data have been collected to determine whether ground water from the Site may migrate under Branch Brook at some depths and times.

3.0 PUBLIC HEALTH AND ENVIRONMENTAL RISK EVALUATION SUMMARY

ENVIRON performed the PHERE to quantitatively evaluate potential risks to public health and the environment associated with the Site. The PHERE was submitted to the USEPA Region 1 on February 28, 2000. In the PHERE, Media Protection Standards (MPS) were developed for the primary COPCs in soil, ground water, surface water, sediment soil gas, and the PEWM. These protection standards were based on either the numerical criteria listed in the CTDEP RSRs or alternative remediation criteria under the Regulations of Connecticut State Agencies, and were calculated in accordance with Connecticut state regulations based on the risks developed in the PHERE. The measured Site concentrations were then compared to the calculated MPS to identify potential areas needing further investigation and/or remediation.

3.1 Chemicals of Potential Concern

A total of 142 chemicals were detected during the RFI and other investigations. In order to focus the PHERE on these chemicals likely to represent the greatest risk, a series of screening steps were performed. Chemical contaminants that are infrequently detected may be artifacts in the data due to sampling, analytical, or other problems, and therefore, might not be related to Site operations (USEPA, 1989). Accordingly for the purposes of the PHERE, any chemical detected in less than five percent of the samples taken in each on-Site medium was eliminated from further consideration in the risk assessment. The following three exceptions to this rule were made 1) due to the relatively low number of constituents detected in the soil gas, all of these chemicals were retained for quantitative analysis in the PHERE, 2) all of the chemicals detected in the monitoring wells were retained due to the limited number of monitoring wells, and 3) all chemicals that exceed the standards specified in the Connecticut Remediation Standard Regulations (RSRs) were retained as COPCs. Chemicals that are considered trace nutrients were eliminated from the list of COPCs in accordance with the USEPA risk assessment guidance (USEPA 1989). The final screening was comparing the chemicals detected to risk-based concentrations (RBCs) developed by USEPA Region III. In summary, 105 of 142 chemicals were retained as COPC for consideration in the quantitative risk assessment through the chemical screening process.

3.2 Potential Exposure Pathways

The exposure pathways identified for quantitative evaluation in the PHERE include:

- Ingestion of on-site soil
- Industrial and residential use of off-site ground water
- Inhalation of chemicals volatilizing from soils into outdoor air
- Ingestion of surface water and sediment
- Dermal contact with surface water
- Ingestion of ground water
- Dermal contact with ground water while showering
- Inhalation of indoor air while showering
- Incidental

In addition to the pathways listed above, exposures are assessed for a hypothetical utility/construction worker scenario via the ingestion of soil and the inhalation of volatile chemicals during excavation activities involving the PEWM.

3.3 Cancer Risks and Noncancer Hazard Indices

Based on an evaluation of the risk estimates from exposure to chemicals for each of the modeled populations, the major results of the PHERE are summarized below. Both central tendency exposure (CTE) and reasonable maximum exposure (RME) scenarios were evaluated.

- For the populations modeled in the current use scenario, no excess cancer risks are above 1×10^{-6} with the exception of the on-site worker under the RME scenario. The cancer risk to the on-site worker under RME conditions is 2×10^{-6} . This is at the lower end of the risk range judged to be acceptable by USEPA. In addition, no hazard index values are above one for any of the populations modeled in the current use scenario. This indicates that the concentration levels present in the study area are acceptable for the exposures assessed under the current use scenario.
- Excess cancer risks under the future use scenario for off-site residents are between 4×10^{-4} (CTE) and 1×10^{-3} (RME). Under this hypothetical future use scenario, the

risks would exceed the upper end of the range of risk deemed acceptable by USEPA. The cancer risks are primarily attributable to polychlorinated biphenyls (PCBs). While PCBs were detected in many on-site media, PCBs were also detected in background soil and upstream sediment samples, and are unlikely to be site-related. Furthermore, because this area currently is part of the Mattatuck State Forest, the actual use of this location for residential purposes in the future is unlikely. Therefore, this situation clearly is a worst case estimate and in no way implies that this scenario is remotely likely in the future.

- Excess cancer risks under the future use scenario for off-site workers are between 6×10^{-6} (CTE) and 4×10^{-5} (RME). Under this hypothetical future use scenario, the risks would be within the range of risk deemed acceptable by USEPA. These risks are attributable to the incidental ingestion of ground water by a worker situated adjacent to the southern edge of the site. These risks are primarily attributable to N-nitrosodimethylamine, the source of which is unclear.
- Excess cancer risks under the future use scenario for on-site excavation activities are between 8×10^{-5} (utility worker) and 2×10^{-4} (construction worker). Under this hypothetical future use scenario, the risks would exceed the range of risk deemed acceptable by USEPA. In addition to the cancer risks, noncancer risks associated with this scenario were determined to be high and unacceptable. These risks are attributable to the inhalation of chemicals volatilizing during the excavation of the PEWM, which is situated over nine feet below ground level, for utility installation/maintenance or construction purposes.

3.4 Ecological Risk Assessment

The primary objectives of the ecological risk assessment were to: (1) determine the ecological resources present on the Site and in adjacent water bodies; and (2) identify any potential risks or existing impacts to these resources from chemicals present at, or migrating from, the Site.

The 13-acre Site consists of several buildings and a 5-acre landfill. Most of the Site is covered by mowed lawn. Branch Brook is the only wetland/water body which occurs on-site, flowing through the extreme western edge of the Site. The Naugatuck River occurs about 100 feet east of the Site. No special resources or significant habitats occur within the Site vicinity, although a state forest borders the Site to the west. Although the Site and surrounding area is utilized by a variety of aquatic and wildlife species, there are no known occurrences of rare and endangered species on the Site.

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Exposure of ecological receptors to Site-related chemicals was evaluated using data from the 1994 RFI sampling program pertaining to chemical concentrations in surface water, sediment, and surface soil. Data on benthic macroinvertebrate communities and fish populations were also collected in Branch Brook and the Naugatuck River during RFI studies. Based on a screening process using maximum measured concentrations and conservative toxicological benchmark values, eight inorganic and seven organic chemicals were retained for risk evaluation in surface soils and sediments; no chemicals were retained in surface water. The sediment chemicals were evaluated for potential impacts to lower trophic level aquatic biota using a comparison to toxicological benchmark values, the results of benthic macroinvertebrate surveys, and the results of fish surveys in a weight-of-the-evidence approach. In addition, the surface soils chemicals were evaluated using a comparison to toxicological benchmark values and food chain modeling to determine if these chemicals pose a risk to terrestrial receptors.

Upper trophic level receptor species used in food chain modeling included the meadow vole, red fox, American robin, and red-tailed hawk. These receptor species represent the most likely and/or significant exposure groups and pathways that may be present in on-site habitats. Population-level risks to these receptors were characterized using the quotient method. Effects were evaluated through a comparison of chronic toxicological benchmark values obtained from the literature for each selected receptor species to conservatively-derived benchmarks for ingestion exposure.

WATER BIRD SPECIES?

Based on the assessment endpoints evaluated and the weight-of-the evidence approach utilized in this assessment, significant adverse ecological effects are not likely to occur in Branch Brook and the Naugatuck River from site-related exposures. Based on the available assessment endpoints, there may be the potential for adverse impacts to lower trophic level soil biota in on-site terrestrial habitats. These potential risks are likely to have low ecological significance due to the limited nature and low quality of the habitats present on the landfill. In addition, the vegetation on the landfill was not visibly stressed. The risk evaluation indicates a low likelihood of adverse effects to populations of upper trophic level wildlife that might consume soil invertebrates, plants, and soil from the Site.

3.5 Media Protection Standards

In the PHERE, MPS were developed for the primary COPCs. These protection standards were intended to be used for measuring the necessity for and/or the degree of protection afforded by the corrective measures to be contemplated for the Site. The MPS proposed in the PHERE were based on either:

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- Numerical criteria listed in the CTDEP Remediation Standard Regulations (RSRs) (RSR-Based MPS) such as the Direct Exposure Criteria (DEC) and Pollutant Mobility Criteria (PMC) or
- Alternative Remediation Criteria under the Regulations of Connecticut State Agencies, and were calculated in accordance with Connecticut state regulations based on the risks developed in the PHERE (Risk-based MPS).⁷

For the purposes of this CMS, Envirite is modifying its MPS proposal to consist of only the numerical criteria listed in the RSRs. MPSs are proposed for each of the following environmental media: soil, PEWM, surface water, sediment, and ground water.

3.5.1 Soils

For surface soils, the proposed MPS are based on the DEC. Among the COPCs evaluated in the PHERE for soil, the most significant potential risks are associated with the ingestion of arsenic, benzo(a)pyrene, and beryllium in surficial soil:

<u>Contaminant</u>	<u>DEC (mg/kg)</u>	<u>95% UCL (mg/kg)</u>
Arsenic	3.8	1.5
Benzo(a)pyrene	0.78	0.35
Beryllium	1.3	0.74

The 95 percent upper confidence limits on the mean concentration (95% UCL) for all three of these contaminants are below the proposed MPS (i.e., the DEC).

For deep soil, the proposed MPS are based on the PMC. Among the COPCs evaluated in the PHERE for deep soil, the following chemicals were listed in the PHERE as having UCL levels that exceed the PMC:

<u>Contaminant</u>	<u>PMC (mg/kg)</u>	<u>95% UCL (mg/kg)</u>
Chlordane	0.066	0.19
Polychlorinated biphenyls	0.005	0.30

A discussion of the locations and extent of impacted deep soil for these above contaminants is included in Section 5.1.

⁷Sections 22a-133-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

3.5.2 Soil Gas

No soil gas samples were measured at levels that exceed the CTDEP volatilization criteria for soil gas.⁸ Therefore, soil gas levels were determined to be within an acceptable range and no MPS were developed for soil gas constituents.

3.5.3 Pre-Envirite Waste Material

Among the COPCs evaluated in the PHERE for the PEWM, the most significant potential risks are associated with benzene, PCE, and TCE. In the PHERE, the inhalation and waste material ingestion pathways were evaluated for a hypothetical utility worker. Based on the results for the on-site utility worker, the following MPS are proposed:

<u>Contaminant</u>	<u>MPS (mg/kg)</u>	<u>95% UCL (mg/kg)</u>
Benzene	0.002	30
PCE	860 to 86,000	3,100
TCE	97 to 9,700	3,300

It should be noted that these MPS for the PEWM are based on a hypothetical utility worker scenario. The MPS listed above for chemicals with noncarcinogenic health effects (i.e., benzene) are conservatively estimated from chronic and subchronic toxicity values.

Among the COPCs evaluated in the PHERE for PEWM leachate, the following chemicals were listed in the PHERE as having UCL levels that exceed the PMC:

<u>Contaminant</u>	<u>PMC (mg/kg)</u>	<u>95% UCL (mg/kg)</u>
<i>cis</i> -1,2-DCE	14	70
<i>trans</i> -1,2-DCE	20	70
2-Butanone	80	2,100
Benzene	0.2	30
Benzo[k]fluoranthene	1.0	38
Bis(2-ethylhexyl)phthalate	11	6,500
Butylbenzylphthalate	200	200

⁸Appendix F to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

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<u>Contaminant</u>	<u>PMC (mg/kg)</u>	<u>95% UCL (mg/kg)</u>
Cadmium (leachate)	0.05 mg/L	5.7 mg/L
Carbon tetrachloride	1.0	1.3
Dibutyl phthalate	140	3,100
Dieldrin	0.007	0.0071
- Ethylbenzene	10	3,100
Lead (leachate)	0.15 mg/L	11 mg/L
Naphthalene	56	160
PCBs	0.005	26
Pentachlorophenol	1.0	180
Styrene	20	2,300
PCE	1.0	3,100
Toluene	67	15,000
TCE	1.0	3,300
Xylenes	20	50

A discussion of the locations and extent of PEWM at concentrations above the PMC for these above contaminants is included in Section 5.3.

3.5.4 Surface Water

For surface water, the proposed MPS are based on the CTDEP Class A Surface Water Criteria. Among the COPCs evaluated in the PHERE for surface water, the most significant potential risks are associated with the ingestion of PCBs and PCE in surface water:

Contaminant	CTDEP Class A Surface Water Criteria				95% UCL (mg/kg)
	Aquatic Life Criteria		Human Health Criteria		
	Acute	Chronic	Consumption of Organisms Only	Consumption of Water and Organisms	
PCBs (total)	NE	0.014	0.0002	0.0002	0.0003
PCE	NE	NE	9	0.80	0.0007

It should also be noted that both of these chemicals were detected in both upstream and downstream surface water samples, and are unlikely to be site-related.

3.5.5 Sediment

No RSR criteria apply directly to sediment. Among the COPCs evaluated in the PHERE for sediment, the most significant potential risks are associated with the ingestion of benzo(a)pyrene in sediment. In the PHERE, the sediment ingestion pathway was evaluated for the recreational visitor populations. Based on the results for the recreational visitor, the following risk-based MPS were proposed:

<u>Contaminant</u>	<u>MPS (mg/kg)</u>	<u>95% UCL (mg/kg)</u>
Benzo(a)pyrene	1.8 to 180	0.75

The 95% UCL concentration for this chemical is below the proposed MPS. It should also be noted that this chemical was detected in both upstream and downstream sediment samples, and is unlikely to be site-related.

3.5.6 Ground Water

The ground water data provided in the PHERE was collected in 1994 and described in the 1995 RFI Report. In a memorandum dated November 25, 2002, ENVIRON compared these data with Media Protection Standards proposed in the PHERE, as well as numerical criteria provided by CTDEP's RSRs. ENVIRON subsequently collected additional ground water data in 2003. In a memorandum dated May 25, 2005, ENVIRON compared these data with numerical criteria provided by CTDEP's RSRs⁹. Based on this comparison, the following chemicals were identified that had concentrations that exceeded the RSR criteria. Many of the ground water constituents that exceeded MPS in the PHERE were found to now be in compliance with the RSR criteria. The ground water data are discussed further in Chapters 4 and 5 of this report.

⁹ It should be noted that Envirite's legal counsel had advised that, according to the Regulations of Connecticut State Agencies (RCSA) Section 22a-133k-1(b), the RSRs do not apply to areas that are affected by discharges allowed under a ground water discharge permit issued pursuant to Section 22a-430. Envirite has held a ground water discharge permit since 1984 at the Thomaston facility. Thus, while compliance with RSRs is one indicator of potential need for remediation to CTDEP, USEPA, and Envirite, these regulations are not strictly applicable to ground water constituent levels at the Thomaston facility.

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Contaminant	RSR Criteria	2003 Data
Vinyl Chloride	52 µg/L Industrial Volatilization Criteria (IVC)	195 µg/L (95% UCL)
TCE	67 µg/L (IVC)	139 µg/L (95% UCL)
Zinc	123 µg/L Surface Water Protection Criteria (SWPC)	244 µg/L (average)

4.0 REMEDIAL ACTION OBJECTIVES AND REGULATORY REQUIREMENTS

4.1 Remedial Action Objectives

VOCs present in the PEWM and ground water pose a potential threat to human health as indicated in the PHERE. Degradation of surface waters may occur via the migration of zinc in ground water. Therefore, the following remedial action objectives (RAOs) were developed for the Site:

- Preventing further degradation of ground water quality
- Preventing degradation of surface water from discharges of contaminated ground water
- Protecting human health
- Complying with institutional requirements

The regulatory requirements for remedial actions at the Site are discussed in Section 4.2. All remedial actions proposed in this CMS must comply with these regulatory requirements.

4.2 Overview of Regulatory Considerations

One of the evaluation factors for the CMS is institutional requirements such as state, local or public health regulations or permitting requirements that might impact the implementation of each alternative. Under the Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA) (40 CFR 264.525 (a)), the corrective measure must be protective of human health and the environment. In addition, the remedial actions must attain and be consistent with regulatory requirements, unless waived or granted a variance by the USEPA. A summary of the regulatory requirements, which are legally enforceable standards, criteria, or limits promulgated under federal or state law, is presented in Table 2. The corrective measure must also meet final media cleanup standards (MCS). The CTDEP RSRs have been identified as MCS for remedial action alternatives at the Site. Details and descriptions of each potential media-specific requirement are summarized in Table 2. A list of MCS for soil and ground water at the Site is presented in Tables 3 and 4, respectively.

4.2.1 Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA)¹⁰ and the regulations promulgated under RCRA¹¹ regulate the generation, management, and disposal of solid and hazardous waste. Certain remedial actions chosen for the Site may include the generation and disposal of solid or hazardous waste subject to RCRA requirements.

4.2.2 Connecticut's Remediation Standard Regulations

Connecticut's RSR's provide detailed guidance and standards that may be used at any site to determine whether or not remediation of contamination is necessary to protect human health and the environment. Generally, the RSR's apply to any action taken to remediate polluted soil, surface water or a ground water plume at or emanating from a release area, provided the remedial action is required pursuant to Chapter 445 or 446k of the Connecticut General Statutes (CGS), or voluntary remediation pursuant to Section 22a-133x or 22a-133y of the CGS.

Two remediation criteria must be met when remediating soil. These two criteria are the DEC and the PMC.

- **Direct Exposure Criteria:** These criteria are established to protect human health from exposure to contaminants in soil. With some exceptions, these criteria apply to soil located within 15 feet of the ground surface. Polluted soil must be remediated to a concentration that is consistent with the Residential DEC, unless the site is used exclusively for industrial or commercial purposes. In such a case, the less stringent Industrial/Commercial (I/C) DEC may be used, provided an ELUR is recorded to ensure that the site is not used for residential purposes in the future.
- **Pollutant Mobility Criteria:** These criteria are established to prevent the pollution of ground water caused by soil contamination that is available to migrate into ground water. With some exceptions, these criteria apply to soil located above the seasonal low water table. The PMC vary depending on the ground water quality classification of the site. The RSR's also specify when alternative PMC are appropriate. The RSR's also specify circumstances in which the PMC do not

¹⁰ 42 USC 6901 *et seq.*

¹¹ 40 CFR 240-271

apply. In general, these circumstances include cases where: polluted soil is located beneath a building, provided an ELUR is recorded to prohibit the building from being intentionally destroyed; widespread polluted fill exists, provided the ground water in the subject area is not used for drinking water purposes; an engineered control, such as an engineered cap, has been constructed to prevent the contamination of underlying ground water.

Three criteria apply to the remediation of impacted ground water: These criteria include Ground Water Protection Criteria (GWPC), Surface Water Protection Criteria (SWPC), and Volatilization Criteria (VC).

- Ground Water Protection Criteria: These criteria require that ground water plumes in high quality ground water areas be remediated to background quality, or, in certain instances, to levels that adequately protect existing and future uses of ground water as public or private drinking water supplies. In areas which have been classified as having degraded ground water quality due to historical land use practices, the ground water must be remediated to adequately protect any existing use of ground water. The RSR's also specify circumstances in which exemptions or variances from the GWPC are appropriate.
- Surface Water Protection Criteria: These criteria apply to a ground water plume at the point where the plume discharges to a surface water body. These criteria are established to ensure that surface water quality is not impaired by the discharge of contaminated ground water into a surface water body at contaminant concentrations above the Water Quality Standards.
- Volatilization Criteria: These criteria are established to protect human health from volatile substances in shallow ground water that may migrate from ground water and enter overlying buildings. The VC for ground water vary depending on whether the overlying building is used for residential or industrial/commercial purposes. In cases where the industrial/commercial VC are appropriate, an Environmental Land Use Restriction must be recorded.

The VC are only applicable if ground water is less than 30 feet below ground surface and a building is present within 30 feet of the exceedance area. ¹²

Under specific circumstances, an ELUR may be considered as an alternative to remediating contamination to a concentration that is consistent with specific criteria of the RSR's. The purpose of an ELUR is to prevent certain types of uses of a property, or limit specific activities on a contaminated property or in order to minimize the risk of exposure to the pollutants. For example, an ELUR may prohibit the destruction of a building located above contaminated soil to prevent the contamination from being exposed. An ELUR must be recorded on the municipal land records. The option of using an ELUR is at the discretion of the property owner.

4.2.3 Water Quality Criteria

CTDEP has developed Water Quality Criteria (WQC) for both aquatic life and human health criteria.¹³ The aquatic life criteria include acute and chronic standards for freshwater and saltwater. The human health criteria include standards for the consumption of water (i.e., for drinking water purposes) and organisms (e.g., fish) and consumption of organisms only. For aquatic life criteria, the chronic standards for freshwater were selected because they are more stringent than the acute standards. Naugatuck River is classified as a Class B surface water, while Branch Brook is classified as a Class B/A surface water. Designated uses of Class B waters are recreational use, fish and wildlife, fish and wildlife habitat, agricultural and industrial supply, and other legitimate uses (including navigation). Thus, only the consumption of organisms standards are required for human health criteria. Class B/A waters are those that may not be meeting Class A WQC, but have designated Class A criteria as a water quality goal. Designated uses of Class A waters are the same as Class B with the addition of potential drinking water supply. Because Branch Brook is classified as a B/A water, it is required to meet Class A WQC. Thus, the consumption of water and organisms standards apply for human health. The more stringent of the human health and aquatic life criteria were selected for each chemical for comparison.

¹² Sections 22a-133k-3(c)(5) of the RCSA; Volatilization Criteria for Ground Water – Exemption from volatilization criteria. “The volatilization criteria do not apply to ground water polluted with volatile organic substances...if no building exists over the ground water polluted with volatile organic substances at a concentration above the applicable volatilization criteria, and (i) it has been documented that best efforts have been made to ensure that each owner of any parcel of land or portion thereof overlying such polluted ground water records an environmental land use restriction which ensures that no building is constructed over such polluted ground water”.

¹³ Appendix D of Connecticut's Surface Water Quality Standards (CTDEP 1997), effective April 8, 1997.

4.2.4 Other Federal and State Laws

Other federal laws were reviewed as potential regulations pertinent to the RAOs at the Site. These laws include, but are not limited to, the Clean Water Act (CWA), the Clean Air Act (CAA), and Occupational Safety and Health Administration regulations (OSHA). Further detail on how these regulations may potentially be relevant to on-site activities is discussed in Table 2.

5.0 NATURE AND EXTENT OF IMPACT

GZA and ENVIRON have conducted site characterization work on behalf of Envirite as part of the RFI process (GZA 1995; ENVIRON 1996). Additional soil sampling has been conducted by Envirite following the removal of the underground spill containment tanks (Envirite 1996a, 1996b). Additional ground water monitoring has been conducted after the PHERE and as post-closure monitoring (ENVIRON 2005). The design and implementation of these investigative studies have been approved by USEPA Region I. These data form the basis for evaluating potential exposures to chemicals detected at the Site. Generally these investigations indicated that ground water and the PEWM are impacted with VOCs and metals. The following summarizes the nature and extent of COPC impact in each on-site media.

5.1 Nature and Extent of Soil Impact

Over 50 shallow and over 150 deep soil samples were collected at the Site. The primary areas of investigation were a drywell, the facility, the wastewater spill area, the perimeter of the landfill, the roadway areas, and the underground spill containment tank. The soil sampling locations are shown in Figure 3, and the sampling results are presented in the RFI. The results of the soil samples were evaluated in the PHERE, which found that the 95% UCL concentrations for all of these chemicals were below DEC. Therefore, shallow soil impact is not further evaluated in the CMS. Two constituents, PCBs and chlordane, exceeded the PMC for deep soils. The location of the maximum concentration of PCBs was found in R-12. The location of the maximum concentration of chlordane was found in W-25. These locations are associated with the PEWM-R and will be further discussed in Section 5.3.

5.2 Nature and Extent of Soil Gas Impact

CTDEP has developed volatilization criteria for soil gas, which protect against risks associated with the diffusion of soil gas constituents into industrial or residential buildings.¹⁴ The soil gas data collected by GZA (1995) and ENVIRON (1996) were compared to these criteria. The soil gas sampling locations are shown in Figure 7, and the sampling results are presented in the RFI. As discussed in Section 2.2.5, the VOC vapor distribution across the landfill and the physical

¹⁴ Appendix F to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

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characteristics of the landfill soils suggest that VOCs have been predominately released from the PEWM-R and have diffused throughout the landfill through soil layers used during the cell filling activities. No soil gas samples were measured at levels that exceed the CTDEP volatilization criteria for soil gas;¹⁵ therefore, soil gas levels were determined to be within an acceptable range.

5.3 Nature and Extent of Pre-Envirite Waste Material Impact

According to the RFI report (GZA 1995), the dominant source of organic constituents at the Site is believed to be the two piles of Pre-Envirite Waste Material PEWM-L and PEWM-R. The PEWM sampling locations are shown in Figure 4 and the sampling results are presented in Table 5. As discussed in Section 2.2.1, the PEWM has likely been situated on the eastern portion of the Site and the adjacent town property since 1955 prior to acquisition of the property by Envirite in 1975. According to the RFI, the PEWM has been characterized as "waste material from a solvent recovery operation". There is speculation that the PEWM may be associated with the operation of the former and now defunct, Solvents Recovery Service (SRS).

The RFI soil boring program revealed that the PEWM is comprised of two subsurface waste piles: the first pile is located on wholly on the Envirite property underneath the Envirite landfill (PEWM-L) and the second pile extends east of the Envirite property and underneath Old Waterbury Road.

The PEWM is located at depths exceeding nine feet, and is considered "inaccessible soil" by CTDEP. Inaccessible soil is defined as soil greater than four feet below ground surface, soil greater than two feet below paved surface, or soil beneath an existing building or structure.¹⁶ DEC standards do not apply to inaccessible soil. Therefore, the Pre-Envirite Waste Material was compared to the PMC for Class GB areas.

Based on the results of the PHERE, the most significant potential risks from the PEWM are from benzene, PCE and TCE. Figure 9 shows the concentrations of benzene, PCE, and TCE in the waste material samples. Among the COPCs evaluated in the PHERE for PEWM leachate, the following chemicals were listed in the PHERE as having UCL levels that exceed the PMC:

- *cis*-1,2-DCE
- *trans*-1,2-DCE
- 2-butanone (MEK)
- benzene
- benzo(k)fluoranthene
- bis(2-ethylhexyl)phthalate

¹⁵ Appendix F to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies.

¹⁶ Section 22a-133k-1(a)(28) of the Regulations of Connecticut State Agencies.

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- butylbenzylphthalate
- cadmium (leachate)
- carbon tetrachloride
- dibutyl phthalate
- dieldrin
- ethylbenzene
- lead (leachate)
- naphthalene
- PCBs
- pentachlorophenol
- styrene
- PCE
- toluene
- TCE
- xylenes

The impacts from these constituents in each pile, PEWM-L and PEWM-R, are discussed in further detail below.

5.3.1 PEWM-L

The location and extent of the PEWM-L pile as determined in the RFI and PHERE are shown in Figure 4. The PEWM-L pile is approximately 30 by 40 feet. The thickness of the waste material, up to 8 feet, is also shown in Figure 4. The soil boring results indicated that the upper limit of the waste material found beneath the landfill residues ranged from a depth of approximately 15 to 25.5 feet (322.48 to 331.08 MSL). The average ground water elevation in a nearby well, MW-31, is a depth of approximately 15.89 feet (324.11 ft MSL). This would place the PEWM-L pile in the saturated zone.

Concentrations of benzene, PCE, and TCE, which are associated with the most significant risks from the waste materials, are below the PMC. Concentrations in the PEWM samples above the PMC were found for bis(2-ethylhexyl)phthalate, ethylbenzene, dieldrin, PCBs, and pentachlorophenol. Leachate analysis¹⁷ results on samples of the PEWM-L reported only one VOC (2-butanone) and metals. The only metal concentration from the leachate samples above the PMC was cadmium.

5.3.2 PEWM-R

The location and extent of the PEWM-R pile as determined in the RFI and PHERE are shown in Figure 4. The PEWM-R pile is approximately 40 by 60 feet. This waste pile is also located near MW-31. Based on the RFI soil boring program it was estimated that as much as "55% of the volume of the second waste pile may span underneath Old Waterbury Road". The thickness of the waste material, up to 8.5 feet, is also shown in Figure 4. Soil boring results from the second waste pile indicated that PEWM was initially encountered at

depths of approximately 9 to 11.5 feet (330.58 to 324.25 MSL). Thus, the PEWM-R pile is mostly in the vadose or unsaturated zone. This result is consistent with ground water analytical data that indicates concentrations of VOCs in ground water may marginally increase/decrease with ground water elevation. Observation noted from a soil boring program conducted as part of RFI activities at the Site characterize the PEWM-L as an “oily sludge” and the PEWM-R as a oily rubbery material, “dried paint material, red, green and pink rubber-like material mixed with red or black oil”, and “rubbery waste with a hard, plastic-like texture”. In addition, it was noted that silty soil surrounding the waste also exhibited a rubbery texture.”

Concentrations of benzene, PCE, and TCE, which are associated with the most significant risks from the waste materials, are above the MPS and PMC in the PEWM-R pile. Maximum concentrations reported for benzene, PCE, and TCE were 30 mg/kg, 3,100 mg/kg, and 3,300 mg/kg, respectively. Concentrations in the PEWM samples above the PMC were found for *cis*-1,2-DCE, *trans*-1,2-DCE, 2-butanone (MEK), benzene, bis(2-ethylhexyl)phthalate, cadmium (leachate), dibutyl phthalate, ethylbenzene, lead (leachate), naphthalene, PCBs, styrene, PCE, toluene, TCE, and xylenes. Leachate analysis¹⁸ on samples of the PEWM-R detected VOCs, pesticides, and metals. The metal concentrations from the leachate samples above the PMC were cadmium and lead with a maximum concentrations reported of 5.1 mg/L and 11.2 mg/L. respectively.

5.4 Nature and Extent of Surface Water Impact

After completion of the PHERE, a monitoring program was conducted in 2003, 2004, and 2005 to evaluate the current compliance status of the Site’s surface water. Surface water samples were collected during each of the four quarters at locations upstream and downstream of the Envirite facility. No VOCs were detected in any of the surface water samples. Five metals were detected in both upstream and downstream samples – barium, iron, manganese, sodium, and zinc.

Based on samples of surface water collected by Aaron Environmental from several locations both upstream and downstream of the Site, the primary chemical constituents in the surface water are metals. Analyses of surface water samples collected from the Naugatuck River and Branch Brook at locations upstream and downstream of the Site are compared in Appendix B. Based on the similarity between the upstream and downstream measurements in the metals detected, the frequency of detection, and the mean concentrations, there does not appear to be any impact from the Site on surface water conditions.

¹⁷ Leachate extracted from soil samples using the synthetic precipitation leaching procedure (SPLP) for all samples.

¹⁸ Leachate extracted from soil samples using the synthetic precipitation leaching procedure (SPLP) for all samples.

5.5 Nature and Extent of Sediment Impact

Based on the results of the PHERE, the most significant potential risks from the sediment are from benzo(a)pyrene. No CTDEP criteria exist for sediment, so no comparisons were made between the sediment samples and any remediation standards. The sediment sampling locations are shown in Figure 6, and the sampling results are presented in the RFI. The 95% UCL concentrations for benzo(a)pyrene is below the MPS proposed in the PHERE. This chemical was reported in both upstream and downstream sediment samples, and is unlikely to be site-related.

5.6 Nature and Extent of Ground Water Impact

Subsequent to the PHERE, additional ground water monitoring data were collected to evaluate current conditions at the Site. The monitoring well locations are shown in Figure 5, the ground water monitoring data collected are presented in Appendix A. A memorandum prepared on May 25, 2005 titled "Summary of Recent Monitoring Results and Proposed Alternative Surface Water Protection Criteria" evaluated the data for four quarterly rounds of ground water sampling collected in 2003, as well as recent rounds of quarterly sampling conducted in 2004-05 as part of the Site's regular post-monitoring requirements.

Ground water quality classifications maps that designate the use of the ground water were developed for ground water in all areas of the State of Connecticut. On these maps, the ground water quality classes in the vicinity of the site are GA and GB. Class GA designates areas of existing, potential drinking water, or all ground waters not otherwise classified. Class GB is used where ground water is not suitable for drinking water.

Among the wells from which ground water data were collected and used in the CMS, only three wells are situated in a GA area. These wells (MW-36, MW-37B, and MW-37D) are located on the west side of the Branch Brook (a tributary of the Naugatuck River). Ground water in GA areas at the site is potentially subject to three RSR criteria:

- Residential Volatilization Criteria (RVC)¹⁹ – the 95% UCL of all sample locations must be less than the RVC for at least four consecutive quarterly sampling periods and each sample must be less than two times the RVC; if the ground water data exceed the RVC for ground water, the facility also has the option of meeting the RVC for soil vapor^{20, 21}

19 Appendix E to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies; Volatilization Criteria for Ground Water

20 Appendix F to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies; Volatilization Criteria for Soil Vapor

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- Ground Water Protection Criteria (GWPC)²² – each sample from four consecutive quarterly samples must be less than the GWPC; or the 95% UCL of all samples collected from all sampling locations over 12 consecutive monthly sampling periods must be less than the GWPC and each sample must be less than two times the GWPC
- Surface Water Protection Criteria (SWPC)²³ – the average concentration from all sample locations must be less than the SWPC for at least four consecutive quarterly sampling periods

The wells situated in the GB area include: MW-30, MW-31B, MW-31D, MW-31S, MW-41B, MW-41D, MW-41S, MW-42S, MW-43D, MW-43S, MW-44B, MW-44D, MW-51B, MW-52D, and MW-53D. Ground water in GB areas at the site (which will not be used for drinking purposes) is potentially subject to two RSR criteria:

- Industrial Volatilization Criteria (IVC)²⁴ – the 95% UCL of all sample locations must be less than the IVC for at least four consecutive quarterly sampling periods and each sample must be less than two times the IVC; if the ground water data exceed the IVC for ground water, the facility also has the option of meeting the IVC for soil vapor
- Surface Water Protection Criteria (SWPC)²⁵ – the average concentration from all sample locations must be less than the SWPC for at least four consecutive quarterly sampling periods

Compliance with the RSRs is evaluated by comparing ground water concentration data collected over four consecutive quarters with each applicable criteria. Major conclusions of this analysis of the ground water data included the following:

21 According to Section 22a-133k-3(c)(3)(A), remediation of a volatile organic substance to the volatilization criterion for ground water shall not be required if the concentration of such substance in soil vapors below a building is equal to or less than the applicable volatilization criterion for soil vapor.

22 Appendix C to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies; Ground Water Protection criteria for GA and GAA Areas

23 Appendix D to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies; Surface Water Protection Criteria for Substances in Ground Water

24 Appendix E to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies; Volatilization Criteria for Ground Water

25 Appendix D to Sections 22a-133k-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies; Surface Water Protection Criteria for Substances in Ground Water

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- The ground water in the GA wells, MW-36, MW-37B, and MW-37D, is likely in compliance with the RSRs. Only two VOCs were detected in 2003, bromoform and bis(2-ethylhexyl)phthalate, which were found to not represent statistically significant exceedances of the GWPC.
- Two COPC – vinyl chloride and TCE – exceeded the Industrial Volatilization Criteria (IVC). These volatilization criteria are only applicable if ground water is less than 30 feet below ground surface and a building is present within 30 feet of the VC exceedance area.
- Five COPC – vinyl chloride, *cis*-1,2-DCE, 1,2-DCA, TCE, and toluene – exceeded the Residential Volatilization Criteria (RVC).
- Five COPC, phenanthrene, heptachlor epoxide, PCBs, copper, and zinc, exceeded the Surface Water Protection Criteria in 2003. However, the concentrations of heptachlor epoxide and PCBs upgradient of the point at which ground water discharges to surface water are less than the SWPC, the SWPC are satisfied. In addition, phenanthrene was detected in only two out of 53 samples collected. Copper and zinc were continued to be monitored in 2004 and 2005, and concentrations of copper averaged over four quarters has declined to below the SWPC. Concentrations of zinc remain at concentrations above the SWPC.

Figure 10 shows the most recent ground water monitoring results for the ground water COPCs exceeding their RSRs during the 2003 evaluation including PCE, TCE, vinyl chloride, *cis*-1,2-DCE, 1,2-DCA, toluene, and zinc. The following summarizes the results for each constituent based on the 2005 Annual Report and the most recent quarterly monitoring:

- PCE was detected in the January 2006 sampling event only in MW44D at a concentration below the RSRs.
- TCE was detected at least once in five of the twelve wells sampled including MW-30, MW-41D, MW-43D, MW-44D, and MW-44B. The concentration was over two times the IVC and RVC for the January 2005 sampling event in MW-30. TCE was detected in four of the twelve wells samples in January 2006 including MW-30, MW-33, MW-44D, and MW-44B. The concentrations were below the IVC, and only MW-44D was over the RVC.
- The compound *cis*-1,2-DCE was detected in MW-30 during the January 2005 sampling event and in MW-31S in the August and November sampling events. The concentrations

were below the IVC; however, they were over two times the RVC. The compound *cis*-1,2-DCE was not detected in January 2006.

- Vinyl chloride was detected at least once in two of the twelve wells sampled during 2005. The concentration was over two times the RVC and IVC in MW-30 for the January 2005 sampling event, and over two times the RVC and IVC in MW-31S for all four quarters. Vinyl chloride was continued to be detected in MW-31S during the January 2006 sampling event, at a concentrations over two times the RVC and IVC.
- 1,2-Dichloroethane was detected at least once in two of the twelve wells sampled in 2005. The concentration was over the RVC in MW-30 and over the RVC in the January 2005 sampling event, and in MW-31S the concentration was over two times the RVC in August and November 2005 sampling events. 1,2-DCA was not detected in January 2006.
- Toluene was detected in MW-31S during all four sampling events for 2005. The concentrations were below the IVC for all four quarters; however, the concentrations were over two times the RVC during all four of the quarterly sampling events. Toluene was detected in two of the twelve wells sampled in January 2006, MW-31S and MW-30. The concentration was below the IVC in MW-31S; however, it was over two times the RVC.
- Zinc concentrations in 2005 and January 2006 remained consistent with levels detected over the last few years, and considerably lower than concentrations measured at the beginning of the monitoring program. The concentration was over the SWPC in MW-30, MW-31S, MW41S, MW-42S, MW-43S, MW43D, MW-44D, and MW-44B. The highest concentrations were found in MW-31S, which is downgradient of the PEWM-R.

5.6.1 Background Wells

The background wells, MW-32D, MW-32S, MW-55B, and MW-63, were last sampled during quarterly monitoring conducted in 2003. Among the four background wells monitored, three VOCs bis(2-ethylhexyl)phthalate, bromoform, and dibromochloromethane and three metals copper, lead, and zinc were detected. The average zinc concentration of in the background wells was 107 µg/L, and four of the eight samples exceed the SWPC of 123 µg/L. Additional background data are currently being collected.

5.6.2 Discussion of Results

According to the RFI report, the PEWM is believed to be the dominant source of organic constituents at the Site. High concentrations of certain VOCs (e.g., PCE, TCE were

measured in samples collected from the PEWM, on the order of several thousand parts per million). Based on these high concentrations, potential exposures resulting from exposure to this waste material would be expected to be significant. The highest concentrations of organic constituents in the ground water were found in monitoring wells immediately downgradient of the PEWM. In addition, the highest concentration of zinc at the site is now immediately downgradient of the PEWM pile as shown on Figure 10.

Other potential sources of on-site contamination include two acid spills that occurred on-site in 1978 and 1983. These spills, particularly the 1983 spill, are believed to be the primary source of certain metals detected in environmental media. Concentrations of metals (e.g., copper, nickel, and zinc) were highest in well clusters along the southern boundary of the Site, immediately downgradient of areas impacted by a 1983 on-site acid spill event. The spill was the likely source of these constituents in the wells since the observed metal constituents and depressed pH were typical of the composition of the material released, and constituent concentrations are decreasing over time. Concentrations of zinc in Well MW-42 were over 20,000 µg/L in the early 1990s; the January 2006 sampling event concentrations in MW-42 are 240 µg/L.

There is reason to believe that the low levels of COPCs found to date will generally decrease for the following reasons:

1. The ground water flow rates in the overburden aquifer are quite high, estimated at 5 to 35 feet per day,
2. The chemicals of concern were apparently released many years ago. The PEWM has apparently been on-site for at least 40 years, and the acid spill occurred in 1983.

In light of these facts, it is reasonable to assume that the concentrations of chemicals dissolved in the ground water immediately downgradient of the Site have reached or passed their maximum levels.

5.7 Nature and Extent of Landfill Treatment Residues

The treatment residues at the facility were deposited into a landfill, which forms a horseshoe-shaped ridge around the building. The landfill ranges from 15 to 30 feet above grade in height and approximately 150 to 200 feet wide. The landfill surface currently is completely vegetated, and landfill cells 4 and 5 are capped with a 30 mil PVC membrane cover installed in 1988.

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Additional sampling and analytical activities were conducted by ERI between November 1997 and May 1998 to assess potential impacts to ground water from metals and VOCs in the landfill. The extent of, or potential for, ground water contact with the LTR was evaluated by measuring the elevation of both the landfill's base and ground water. The relative concentration and distribution of VOCs in the landfill was evaluated through the collection of soil core and soil gas samples from the landfill. The results of this study were submitted to USEPA Region I in December 1998 (Envirite 1998). The major findings of the report are as follows:

- The ground water table is consistently below the landfill cell's base elevation; thus, ground water contact with landfill materials at the base of each cell should not be considered as a potential exposure pathway for the Site.
- The VOC vapor distribution across the landfill and the physical characteristics of the landfill soils suggest that VOCs have been predominately released from the PEWM-R and have diffused throughout the landfill through soil layers used during the cell filling activities.

Consistent with available information regarding the origins of the landfill residues and previous testing, the predominant compounds present in the treatment residues are metals with average mass concentrations between 1.0 mg/kg and 2,000 mg/kg. Results of landfill sampling is presented in the RFI. Maximum were typically in the 10,000 mg/kg range. In contrast the average concentrations for detected organic constituents typically ranged from 0.1 mg/kg to 1.0 mg/kg. Landfill treatment residues were observed to be located above the water table consistent with the design of the landfill.

Based on the type of waste treatment (neutralization, precipitation, and stabilization) conducted on-site prior to disposal of treatment residues into the landfill, it is unlikely that the landfill is a significant source of metals. Because the facility generally accepted inorganic liquid wastes for treatment and disposal, it is unlikely that the landfill is a significant source of organic compounds. No PCBs or pesticides are known to be associated with the wastes deposited in the landfill. In addition, based on a review of soil and ground water data, XDD (1999) concluded that "the water table elevations are consistently two feet or more below the LTR base elevations, based on annual records of rainfall for the last 64 years." As such, ground water contact with the LTR is not considered as a potential exposure pathway.

Because Cells 1 through 3 have not been capped with a plastic membrane; leaching of the LTR constituents in rainfall into the underlying aquifer was indicated as an issue to address upon completion of the LTR study in 1998. While there is not leachate data available for the LTR samples, MW-30 downgradient of cell 2 is situated to monitor the ground water for leachate from

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the LTR material as well as the PEWM-L. Concentrations of zinc in MW-30, immediately downgradient of cell 2, were lower than the background wells during the Site wide quarterly monitoring conducted in 2003. The distribution of elevated concentrations of zinc ground water does not appear to be associated with landfill cells without a membrane cover.

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6.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The purpose of this section of the CMS is to generate a list of potentially applicable treatment technologies and process options that can be used to develop remedial alternatives that can meet the RAOs discussed in Section 4.1. First, a preliminary screening was conducted to identify response actions that are appropriate for addressing the remediation of the PEWM and ground water at the Site. Second, for each response action, remedial technologies and their associated process options were evaluated based on effectiveness, implementability, and general cost as presented in Sections 6.3 and 6.4. Third, a detailed evaluation of the remedial alternatives was conducted using the nine criteria recommended by USEPA as presented in Section 7.0. Finally, based on a comparative analysis of the remedial alternatives, a preferred alternative was recommended for the Site as presented in Section 8.0.

6.1 Methodology

The potentially applicable treatment technologies and process options for COPC-impacted soil and ground water are identified for each potential response action. The preliminary screening is performed to select those treatment technologies and process options that are considered technically feasible based on the following:

- Detected chemical constituents;
- Chemical concentrations; and
- Site characteristics.

The secondary screening process consists of evaluating remedial technology processes in terms of effectiveness, implementability, and relative cost. The process options within a particular technology type are rated in relation to the other process options in the same category. A brief description of each secondary screening criteria is presented below.

Effectiveness: The effectiveness of each remaining process option is further evaluated based on:

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- The ability of the process option to handle or treat the estimated areas or volumes of media and meet the RAOs presented in Section 4.0.
- Documented success of the process option with respect to handling chemical constituents and Site conditions similar to those identified at the Facility.
- The potential impact on human health and the environment during the construction and implementation phase for each process option.

Implementability: The implementability of each remaining process option was evaluated based on:

- Technical implementability including on-site and off-Site space limitations, equipment availability, utility requirements, and requirements to mobilize, operate, maintain, monitor, and demobilize the proposed process.
- Administrative implementability including applicable federal, state and local regulations, and permitting requirements.
- Schedule implementability including time required to design, construct, and implement the process option.
- Effect on off-Site community.

Cost: The cost of each remaining process option is evaluated based on:

- The estimated relative capital cost for construction and initial implementation.
- The ongoing operation and maintenance costs.

Costs are estimated based on case histories, generic equipment costs, and vendor information, which are modified using best engineering judgment to consider site-specific conditions. The cost for each process option is ranked as high, moderate, or low cost, relative to the other process options in the same technology category.

Decisions regarding the effectiveness and implementability of each treatment technology and process option are based on professional experience, references, agency guidance documents, and other pertinent sources.

The remedial technologies and process options that are identified through the screening process and a summary of the preliminary and secondary screening processes are presented in

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Tables 7 and 8. Additional details, which support Tables 7 and 8, are provided in the remainder of this section.

In the remainder of this section, if a remedial technology is not retained after preliminary screening, it is so stated. If the technology is retained after the preliminary screening, the preliminary and secondary screening discussions are combined. After the secondary screening, each remedial technology or process option is either retained for consideration as part of a remedial alternative for the facility or it is rejected.

6.2 General Response Actions

Based on the RAOs presented in Section 4.1, a list of GRAs has been developed for the PEWM-R and ground water. The GRAs describe, in general terms, those actions that may achieve RAOs for the protection of human health and the environment. The lists of GRAs for soil and ground water are presented below.

PEWM

- No Action
- Limited Action
- Containment
- Removal
- Ex-situ Treatment
- In Situ Treatment

Ground Water

- No Action
- Limited Action
- Containment
- Extraction and Ex-situ Treatment
- In Situ Treatment

6.3 PEWM General Response Actions, Remedial Technologies and Process Options

The identified remedial technologies for the affected PEWM materials at the Site are discussed in the following sections. Table 6 presents the GRAs and remedial technologies and associated process options for the PEWM. In this section, remedial technologies and process options for PEWM are identified, described, and subjected to a preliminary and secondary screening.

6.3.1 No Action

No Action for the PEWM involves no active excavation, containment, monitoring, or treatment of PEWM containing COPCs. No Action would not result in achieving the RAOs

for PEWM where chemical concentrations do not already meet the RAOs and would therefore be considered ineffective at those locations. No Action is readily implementable. No Action is retained after preliminary and secondary screening for further evaluation to serve as a baseline for comparison with other treatment technologies and process options, as recommended in USEPA guidance documents.

6.3.2 Institutional Controls

Through the use of appropriate institutional controls, exposure to impacted soil is monitored, reduced, or eliminated. The remedial technology and associated process options identified for institutional controls include access control, deed restrictions, and regulatory control.

6.3.2.1 Access Control

Access control involves limiting access to the area under consideration using fencing, other physical barriers, and/or posting warning signs. The fencing, other physical barriers, or warning signs are installed around areas of the Site determined to not meet the RAOs.

Access control, such as the installation of fencing or other physical barriers, limit access to areas of the Site that contain COPCs at concentrations that cause the RAOs to be exceeded. The use of access control may restrict future property uses. Restrictions, if any, need to be negotiated with the current and future property owners. There are no apparent limitations regarding technical, administrative, or scheduling aspects that would limit the implementability of this process option.

The cost associated with the use of access control would be low.

Based on this preliminary and secondary screening, access control is retained for further evaluation.

6.3.2.2 Deed Restrictions and Regulatory Control

Deed restrictions and regulatory control reduce or eliminate exposure to soil containing COPC at concentrations that cause the RAOs to be exceeded. Deed restrictions include restrictions regarding the use of areas of the Site that contain COPCs. Deed restrictions involve the inclusion of specific legal restrictions in the property deed or title. Regulatory controls involve incorporating restrictions on the Site use through permitting processes and other regulations.

Under specific circumstances, an ELUR may be considered as an alternative to remediation of contamination to a concentration that is consistent with specific criteria of the RSR's. The purpose of an ELUR is to prevent certain types of uses of a property, or limit specific activities on a contaminated property or in order to minimize the risk of exposure to the pollutants. An ELUR must be recorded on the municipal land records. The option of using an ELUR is at the discretion of the property owner.

Regulatory controls imposed by local governments that involve a modification to community plans may require the approval of the city council and other governing bodies. Regulatory controls imposed by federal, state, and local governments may require the issuance of permits, which would potentially limit the use of the impacted areas. The legal personnel required to perform this work are readily available. There are no technical or administrative aspects that would limit the implementability of these Site restrictions and controls. Deed restrictions and regulatory control are proven and reliable methods for reducing or preventing contact with COPCs.

Major costs associated with the use of deed restrictions and regulatory controls include such items as legal and administrative fees. These costs are considered low for institutional controls.

Based on this preliminary and secondary screening, deed restrictions and regulatory control are retained for further evaluation.

6.3.3 Containment

Containment involves the installation of a physical barrier around PEWM identified as containing COPCs at concentrations that require remediation. The physical barriers could be designed to control the movement of COPCs from the soil column to ground water. The remedial technology and associated process options identified for containment include slurry wall and sheet pile wall.

6.3.3.1 Slurry Wall

This process option includes constructing a trench around areas of impacted soil that is subsequently filled with a soil or cement bentonite slurry to reduce or eliminate the lateral spread of the COPC. A slurry wall is generally anchored into an aquitard, bedrock, or other impermeable soil layer. To reduce the movement of COPC through the soil column, a slurry wall is used in conjunction with a low

permeability cap. There does not appear to be a continuous impermeable soil layer beneath the PEWM that would provide a reliable bottom seal for encapsulating impacted soil above the ground water level. Therefore, this process option is not retained based on preliminary screening criteria.

6.3.3.2. Sheet Pile Wall

This process option consists of driving interlocking sheet piles into the soil around the impacted area to form a physical barrier. As with the slurry wall, the sheet piles are generally anchored into an aquitard, bedrock, or other impermeable soil layer. To reduce the movement of COPC through the soil column, a sheet pile wall is used in conjunction with a low permeability cap. There does not appear to be a continuous impermeable soil layer beneath the PEWM that would provide a reliable bottom seal for encapsulating impacted soil above the ground water level. Therefore, this process option is not retained based on preliminary screening criteria.

6.3.4 Removal

Removal technologies employ physical removal of impacted soil for treatment on-site or transport off-Site for treatment or disposal. Removal technologies may require the use of personal protective equipment to reduce the potential for exposure to COPC. Removal requires disposal of the materials at an approved facility.

Excavation is used to remove soil that contains COPC at concentrations requiring remediation. Excavation is accomplished using construction equipment including loaders, backhoes, large diameter augers, and other appropriate equipment. The excavation operation may generate fugitive dust emissions and the release of volatile COPCs. Emission controls may be required during excavation and workers may use personal protective equipment to reduce exposure to COPC. The depth of excavations may be limited due to physical constraints associated with the location of the PEWM along the roadway. Shoring of the excavation sidewalls may be required. If excavation sidewall sloping is required it would increase the volume of soil requiring excavation, or may limit the potential source areas where it is feasible to excavate due to the roadway. Excavation requires additional areas for soil stockpiling prior to treatment or disposal. The implementation of this process could be limited by the city and other property owners due to the presence of the PEWM along and below the roadway. This may require additional administrative or scheduling coordination.

? No.

Major costs associated with excavating soil include such items as equipment and material costs, fuel, operator labor, oversight, material transport, and treatment/disposal. The limited existing SPLP analysis of the PEWM-R indicates that the PEWM may be characterized as a hazardous waste for disposal purposes because it fails to meet the regulatory levels for PCE and lead of 0.7 mg/L and 5.0 mg/L, respectively. Because the existing data for the PEWM were collected in 1995, waste approval analysis would be required prior to off-site treatment/disposal. Concentrations within the material may have decreased since this time. These costs are considered medium for removal.

Based on this preliminary and secondary screening, the excavation process option is retained.

6.3.5 Ex-situ Treatment

Ex-situ treatment technologies remediate impacted soil that has been excavated. Remedial technologies and associated process options identified for ex-situ treatment include treatment by low temperature thermal desorption (LTTD), ex-situ soil vapor extraction (SVE), ex-situ biodegradation, and off-Site disposal.

6.3.5.1 Low Temperature Thermal Desorption

The LTTD process removes VOCs and petroleum based compounds from excavated soil. LTTD is effective for removing volatile compounds from soil with high permeabilities. This treatment technology is not effective for PCBs and metals also found in the PEWM and surrounding soil. Under some conditions, this technology can be used in soil with low permeabilities such as clay; although, these soils may require longer treatment periods. The excavated soil would be fed into a pug mill (continuous feed) or treated in bins/trays (batch system). Soil placed in the LTTD would be subjected to temperatures up to approximately 800 °F, and the chemicals would be volatilized. The LTTD process could be implemented on-Site using portable mobile treatment units, or the impacted soil could be transported off-Site for treatment at permanent permitted facilities. Volatilized COPCs in the vapor exhaust stream can be recondensed for recycling, reuse, or disposal or destroyed using an afterburner.

Equipment that would be used for the LTTD Process is readily available, and there are multiple vendors that can provide this service. Onsite treatment using portable equipment would require a vapor control system such as scrubbers, activated carbon, or a thermal or catalytic oxidizer to meet air quality requirements.

Major costs associated with this process option include such items as permitting, trial treatment runs, equipment and materials, mobilization, fuel, utilities, operator labor, oversight, and demobilization. Due to permitting and mobilization/demobilization costs, LTTD is only cost effective when there are large volumes of soil to be treated. Costs are considered medium to high for ex-situ treatment depending on soil vapors.

Based on the preliminary and secondary screening, the LTTD process option is not retained for further evaluation. The needed landfill disposal of soil and the PEWM following treatment for VOCs due to the presence of PCBs and metals in the soil makes this alternative less desirable than removal and disposal without treatment.

6.3.5.2 Ex-Situ Soil Vapor Extraction

Ex-situ SVE applies an induced vacuum to an excavated soil stockpile to volatilize the VOCs in the soil. This treatment technology is not effective for PCBs and metals also found in the PEWM and surrounding soil. Emissions to the atmosphere from the soil are controlled by covering the stockpile with plastic sheeting or placing the soil in covered bins. The basic system components include extraction manifolds and vacuum pumps to remove vapors. The vapors extracted from the soil are treated using an appropriate vapor treatment system, such as vapor condensation and/or activated carbon adsorption. Ex-situ SVE is typically effective for removing VOCs from soil with moderate to high permeabilities.

If selected, equipment and materials that would be used to construct the treatment cell and implement the ex-situ SVE process are readily available, and there are multiple vendors that can provide this service. There are no other apparent limitations regarding technical, administrative, or scheduling aspects that would limit the implementability of this process option. Ex-situ SVE requires excavation of impacted soil, importation of fill materials for excavated areas, construction of soil treatment areas, soil treatment, and disposal of treated soil. In comparison, in situ SVE does not require most of these activities.

Major costs associated with this process option include such items as equipment, materials, utilities, operator labor, and oversight. These costs are considered medium to high for ex-situ treatment.

Based on this preliminary and secondary screening, the ex-situ SVE process option is not retained for further evaluation. The needed landfill disposal of soil and the PEWM following treatment for VOCs due to the presence of PCBs and metals in the soil makes this alternative less desirable than removal and disposal without treatment.

6.3.5.3 Ex-Situ Biodegradation

Ex-situ biodegradation treats soil using microbially mediated processes. Common ex-situ biodegradation applications include landfarming, composting, biopiles, and soil/water slurries. This treatment technology is not effective for PCBs and metals also found in the PEWM and surrounding soil. Landfarming is an aerobic process; whereas, composting and biopiles may be adapted to anaerobic or aerobic processes. Soil/water slurries are typically implemented to stimulate anaerobic biodegradation.

Landfarming involves spreading the excavated PEWM out in thin layers across a lined, bermed area and plowing the soil periodically to aerate it and to mix in additives. It is very commonly used for the treatment of soil impacted with petroleum hydrocarbons but is not practically applied for soil impacted by chlorinated solvents, PCBs, and metals. Therefore, landfarming is not retained after preliminary screening.

PCE, one of the primary COPCs in the PEWM, can only be biodegraded under anaerobic conditions by reductive dechlorination. Because PCE impacted soils coexist with TCE impacted soils, it is not practical to retain this process option for other compounds such as TCE. Therefore, aerobic processes are not retained after preliminary screening.

Depending on the soil geochemistry and the types of COPC present, amendments such as mineral nutrients, pH buffers, electron acceptors, surfactants, enzymes, and organic carbon sources are added to the soil to facilitate biodegradation. Organic carbon sources, such as potato starch or cellulose, are mixed into the soil as a food source when the COPC are the types of compounds that bacteria are unable to metabolize, such as PCE and TCE, or when the concentrations of COPC are so low that an auxiliary food source is required. Typically, these ex-situ site biodegradation applications rely on the degradative capabilities of the indigenous microbial populations, although, in some applications biodegradation may be enhanced or augmented through the addition of adapted or genetically-

engineered bacterial strains. Decisions regarding soil amendments, carbon sources, and bacterial populations are based on site-specific bench scale or pilot scale testing.

Composting involves mixing soil with mulch or other compost material in piles. Biopiles are similarly constructed, but do not contain the high percentage of compostable material. For anaerobic processes, the piles are not disturbed in order to avoid aerating them. Soil/water slurries are typically constructed in lined shallow ponds, and must be mixed periodically in a manner that does not disturb the anaerobic conditions.

All of these applications involve the use of significant land area, and must be constructed and closely monitored by highly trained personnel to maintain the processes to prevent volatilization of VOCs. Bench and/or pilot scale testing is required. Once soils are excavated, ex-situ SVE or transporting the soils off-Site is a more cost effective and reliable treatment remedy for chlorinated solvent impacted soil. In addition, there are many in situ soil remediation options that have been developed that can be practically and effectively implemented. Ex-situ biodegradation is not retained after preliminary and secondary screening.

6.3.5.4 Off-Site Disposal

Off-Site disposal involves containerizing and transporting excavated impacted soil from the Site to an appropriate facility for disposal. Prior to its transportation off-Site, soil samples would be collected and analyzed to characterize the soil. Soil containing COPC at concentrations greater than the applicable regulatory limits for hazardous waste are transported to and disposed at a permitted Class I or Class II hazardous waste facility. In addition, prior to landfilling, soil containing high concentrations of chemical constituents may require additional treatment to meet Land Ban Treatment Standards. Soil containing chemical constituents at concentrations less than these regulatory limits would be disposed at other appropriate off-Site facilities.

Earthmoving equipment, such as excavators and loaders are used to load the excavated soil in the containers for transportation. Depending on the contaminant type and concentration, specialized containers may be required. During the loading of impacted soil, special dust and vapor control procedures may be required. Equipment and materials used to conduct the loading process and provide transportation to the disposal site are readily available, and there are multiple vendors that can provide the equipment and service.

There are no apparent concerns regarding the technical, administrative, or scheduling aspects of this technology that would limit its implementability. The costs associated with the off-Site disposal include equipment and materials costs, transportation costs, operator labor, oversight, and disposal fees. The costs for off-Site disposal at a Class I or II facility would be considered high. Disposal at other facilities such as Class III or municipal landfills would be considered medium.

Off-Site disposal is retained after preliminary and secondary screening.

6.3.5.5 Solidification/Stabilization

Solidification/stabilization techniques lock the contaminants in the soil by physically encapsulating the COPC. These techniques are accomplished *ex situ* by mixing a cement or other binding material. This technology is typically used for the treatment of metals, but is not effective for the treatment of VOCs because mixing and heating associated with the cement may release the organic vapors. Therefore, solidification/stabilization is not retained after preliminary screening.

6.3.6 In Situ Treatment

In situ treatment technologies are used to remediate soil in place. Remedial technologies and associated process options identified for *in situ* treatment include monitored natural attenuation (MNA), bioremediation, in situ SVE, and thermal technologies.

6.3.6.1 Solidification/Stabilization

Solidification/stabilization techniques lock the contaminants in the soil by physically encapsulating the COPC. These techniques are accomplished *in situ* by injecting a cement or other binding material. This technology is typically used for the treatment of metals, but is not effective for the treatment of VOCs because mixing and heating associated with the cement may release the organic vapors. Therefore, solidification/stabilization is not retained after preliminary screening.

6.3.6.2 Monitored Natural Attenuation

Natural attenuation is "the combined effect of natural destructive and nondestructive processes to reduce a contaminant's mobility, mass, and associated risk" (Hinchee et al. 1996). The processes that comprise natural attenuation include physical processes (volatilization, sorption, advection, and dispersion), chemical transformation, and biodegradation. When natural attenuation is used as a site management strategy, a monitoring program is implemented to determine if natural

attenuation of COPC is occurring and is likely to be sustained based on the subsurface conditions. Since biodegradation is the only naturally occurring process in the subsurface that may destroy chlorinated solvents like PCE and TCE, parameters that indicate whether or not conditions will support biodegradation are included in the monitoring program. However, effective in situ biodegradation, one component of MNA, for vadose zone soils are aerobic processes and are not applicable for PCE which can only be biodegraded by anaerobic microbial processes. The physical processes that are applicable for PCE may further disperse the COC into the ground water or air. Further, MNA is typically found to be effective for addressing residual contamination following removal of the source area concentrations of the COPCs.

To date, Site monitoring has not included parameters to demonstrate biodegradation of COPCs in the PEWM and surrounding soil at the Site, and the rate of COPC reduction due to other natural attenuation processes has not been evaluated. These parameters could be evaluated through additional monitoring and bench scale or pilot scale testing. Based on current information, it is not possible to reliably estimate its ability to reduce COPC concentrations.

This alternative does not involve the implementation of engineering controls, the addition of amendments, or any manipulation of the soil. Sampling and analysis of the PEWM and surrounding soil could be conducted to determine if subsurface conditions are conducive to natural attenuation, and to confirm that chemical concentration reduction is proceeding at rates consistent with meeting remedial action objectives.

Handling large quantities of impacted soil and the PEWM is not required. Therefore, special procedures to control dust and/or vapors are not needed. Equipment to collect samples and laboratories to perform the required chemical analyses are readily available. There are no apparent concerns regarding the technical, administrative, or scheduling aspects of this technology that would limit its implementability.

The costs associated with MNA include those associated with sampling and analysis. These costs are considered low for in situ treatment.

MNA is not retained for soils and PEWM following preliminary and secondary screening.

6.3.6.3 *In Situ* Biodegradation

In situ biodegradation involves altering subsurface conditions through engineered applications to stimulate biodegradation. The goal of the application is typically to provide missing elements that may be limiting microbial processes. These elements may be mineral nutrients, an organic carbon source, and/or electron acceptors such as oxygen. For vadose zone soils, bioventing (injecting air at a rate that does not strip volatiles to the surface) is used to aerate the soil. This stimulates aerobic microbial processes when oxygen is the limiting factor. A similar application involving the injection of both air and methane has been used effectively to stimulate aerobic cometabolic transformation of chlorinated solvents by methanotrophic bacteria. This approach is effective for TCE, DCE, and vinyl chloride, but is not effective for PCE, which can only be biodegraded by anaerobic microbial processes.

Another approach used to stimulate biodegradation in unsaturated soils is the perfusion of the vadose zone with water containing additives using a surface-constructed infiltration gallery. This approach is also typically applied as an aerobic process, and it is highly unlikely that adapting the process in an attempt to maintain consistent, suitable anaerobic conditions in the vadose zone would be successful.

Effective in situ biodegradation applications for vadose zone soils are aerobic processes and are not applicable for PCE. Therefore, in situ biodegradation for vadose zone soils is not retained after preliminary screening. In situ biodegradation of saturated soils in ground water is a component of in situ ground water biodegradation and will be evaluated under that category.

6.3.6.4 *In Situ* Soil Vapor Extraction (SVE)

In situ SVE uses an induced vacuum to strip VOCs from unsaturated soil. System components consist of extraction wells, piping, vacuum pumps, injection or passive inlet wells, and a vapor treatment system. During operation, a vacuum is applied to subsurface soil and PEWM through a piping and vapor extraction well network causing a pressure gradient in the surrounding soil and inducing airflow. The induced airflow is used to volatilize and remove VOCs from the unsaturated soil and PEWM through the vapor extraction wells and extraction piping. Injection or passive inlet wells may be installed to aid the flow of fresh air through the soil. The vapor from the extraction wells is treated using an appropriate vapor treatment process, such as vapor condensation and/or carbon adsorption. This technology is

particularly effective removing VOCs, including halogenated aliphatic compounds, from soil with high permeability. Under some conditions, this technology can be applied in soil with low permeability, potentially such as the waste material, using higher vacuum for a longer period of time.

Equipment and materials used to construct an *in situ* SVE system are readily available, and there are multiple vendors that can provide this service. A vapor control system to treat extracted vapors and permits to construct and operate the system are required. The majority of the SVE system (extraction wells and pipelines) is constructed below grade, and the blowers and vapor control equipment are located above grade. Therefore, the *in situ* SVE system could be installed with minimal duration of impact to the adjacent roadway. There are no other apparent limitations regarding technical, administrative, or scheduling aspects that limit the implementability of this process option.

Major costs associated with this process option include such items as equipment (blowers, piping, off-gas treatment, etc.), materials, utilities, permits, operator labor, and oversight. These costs are considered medium for *in situ* treatment.

The *in situ* SVE process option is rejected after preliminary and secondary screening.

6.3.6.5 Thermal Technologies

Thermal technologies, including steam injection and six phase soil heating (SPSH), are processes where the soil is heated to enhance the removal of volatile and semi-volatile compounds.

When steam is injected into the subsurface soil through wells, volatile and semi-volatile compounds are vaporized and subsequently removed by SVE for treatment. The steam injection component requires installing injection wells and aboveground support equipment, such as a steam generator or boiler and pumping equipment. The vapor extraction component is comprised of extraction wells and piping, vacuum pumps, and a vapor treatment system. This technology is particularly effective removing VOCs, including halogenated aliphatic compounds, from soil with a high permeability. Condensation of steam in the soil matrix could cause migration of COPC.

Equipment and materials used to construct a system for providing the steam injection are readily available, and there are multiple vendors that can provide this service. A vapor control system is required to treat extracted vapors. The major portion of the steam injection treatment system (injection and extraction wells and pipelines) is constructed below grade.

The costs associated with steam injection include equipment and material for constructing the steam injection system and SVE component, fuel costs for producing steam, other utilities, operator labor, and oversight. These costs are considered high for in situ thermal treatment.

SPSH heats soil and the PEWM in situ, and water and COPC are removed from below the ground surface as steam. Each of the six phases are delivered to a single electrode, placed in a hexagonal pattern with approximately a 30-foot diameter. The vapor extraction well is located in the center of the hexagon. An offgas treatment system treats contaminated vapors removed from the subsurface. As the soil dries out, the electrical resistance increases and water may be added to maintain soil conductivity at the electrodes. SPSH is suited to sites with minimal site operations. The treated area needs to be defoliated and leveled with a bulldozer. Sites with underground metal objects such as pipes or underground storage tanks can short out the electrodes.

SPSH uses utility power transformers at a relatively low capital cost compared to other electrical heating techniques. However, costs would be high due to pavement, utilities, and improvements, which would need to be removed to implement SPSH. Also, operating costs are considered high.

Both technologies are effective for treating the VOC at the Site; however, the introduction of steam into the subsurface may modify the soil structure (addition of moisture) and could adversely affect roadway and underground pipes in the roadway could short out the electrodes. The introduction of steam could also mobilize the COPC, increasing migration to ground water. Therefore, steam injection and SPSH are not retained following the preliminary and secondary screening.

6.4 Ground Water General Response Actions, Treatment Technologies and Process Options

The identified remedial technologies for the affected ground water at the Site are discussed in the following sections. Table 7 presents the GRAs and remedial technologies and associated

process options for the ground water. In this section, remedial technologies and process options for PEWM are identified, described, and subjected to a preliminary and secondary screening.

6.4.1 No Action

A no action response provides a baseline assessment for comparison with other response actions that consist of greater levels of response. A no action response may be considered appropriate when the associated risk is within the acceptable range, or when an alternative response action may cause a greater environmental or health danger than the no-action response itself. An evaluation of the no action response is recommended in USEPA guidance documents as part of the CMS process. Under the no action alternative, no action will be taken to contain, treat, or remove the affected ground water present at the Site. Based on the results of the RFI and further ground water monitoring in 2003 to present as presented in Section 5.6, ENVIRON concluded that the Site does not meet its RAO for the protection of human health and preventing degradation of surface water from discharges of contaminated ground water. Although the no action alternative does not reduce risk at the Site, a detailed evaluation of the alternative was performed.

6.4.2 Institutional Controls

Through the use of institutional control, exposure to impacted ground water is monitored, reduced, or eliminated. The remedial technologies and associated process options identified for institutional controls include deed restrictions, regulatory control, and ground water monitoring.

6.4.2.1 Deed Restrictions and Regulatory Controls

Deed restrictions and regulatory controls are used to reduce or eliminate exposure to ground water containing COPCs. Deed restrictions such as establishing an ELUR for no residential activity allows the use of the industrial/commercial volatilization criteria for ground water. Establishing an ELUR for preventing building construction on the property, would allow an exemption for the Site from the volatilization criteria if no building exists over ground water which exceeds the volatilization criteria. Deed restrictions such as preventing the installation of wells and extraction of ground water limits the use of and exposure to impacted ground water. Regulatory control such as restricting the use of impacted ground water by incorporating restrictions in permits and plans. Existing regulatory controls on municipal water purveyors, which require governmental approval to install new water supply wells and also require periodic water quality testing and consumer notifications, would remain in force.

Deed restrictions involve including specific legal restrictions in the property deed or title. Regulatory control involves incorporating restrictions on ground water use in plans, permitting processes, and other regulations.

The expertise required to implement deed restrictions or other regulatory controls is readily available. There are no technical or administrative aspects that would limit the implementability of these site restrictions and controls. Deed restrictions and regulatory control are proven and reliable methods for reducing or preventing contact with COPCs.

Major costs associated with the use of deed restrictions and regulatory controls include such items as legal and administrative fees. These costs are considered low for ELURs.

Based on this preliminary and screening, this process option is retained for further evaluation.

6.4.2.2 Ground Water Monitoring

Ground water monitoring is used to generate information to allow evaluation of ground water and chemical compound movement and natural attenuation. Ground water monitoring is also effective for evaluating the progress of remediation efforts.

Ground water monitoring has been conducted at the Site. Therefore, the technical and administrative implementability of monitoring well installation and sampling has been addressed, and it is a dependable and reliable process option.

Major costs associated with this process option include such items as monitoring well installation and ground water sample collection and analysis. These costs are considered low for monitoring.

Based on this preliminary and secondary screening, ground water monitoring is retained for further evaluation.

6.4.2.3 Monitored Natural Attenuation

MNA consists of monitoring of ground water to track the progress of natural attenuation and to verify that concentrations decrease over time. The USEPA defines natural attenuation processes as those that include 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 and ground water. MNA as a remedial option relies on physical, chemical, and biological processes such as dispersion, degradation, volatilization, and sorption to attain remedial objectives (USEPA, 1998). With respect to VOCs and metals dissolved in ground water, natural attenuation may result in stabilization of a dissolved-phase plume, the reduction in the dissolved-phase concentration of VOCs, or a reduction in the overall mass of VOCs in the saturated zone.

The processes that comprise natural attenuation include physical processes (volatilization, sorption, advection, and dispersion), chemical transformation, and biodegradation. When natural attenuation is used as a site management strategy, a monitoring program is implemented to determine if natural attenuation of COPCs is occurring and if it is likely to be sustained, based on the subsurface conditions. Natural attenuation of chlorinated solvents has been demonstrated to occur and has been accepted as a site management strategy at numerous sites where soil and ground water are impacted with chlorinated solvents (USEPA, 2000b).

The volume of ground water that can be remediated using this process is not restricted. Natural attenuation is effective for the remediation of the aromatic hydrocarbons detected in ground water, and it can also be effective for halogenated hydrocarbons. The performance and reliability of MNA is dependent on subsurface conditions including water chemistry, microorganisms present, and the availability of nutrients and oxygen.

MNA requires using ground water monitoring to evaluate remediation effectiveness, ground water movement, chemical compound migration, and water quality. Ground water monitoring has been implemented at the Site; however, it has not included parameters needed for the evaluation of natural attenuation. The technical and administrative implementability for this process option is similar to ground water monitoring, which has been conducted at the Site. Wells would be monitored for VOC concentrations, as well as, other parameters (e.g., dissolved oxygen, methane, carbon dioxide, oxidation-reduction potential) to assess the rate of natural attenuation and VOC degradation in accordance with USEPA guidelines. Performance monitoring is an important component to this option due to the potentially longer remediation timeframe, potential for ongoing contaminant migration, and other uncertainties. MNA typically is recommended for sites where VOCs in ground water are not spreading too quickly and can be properly monitored.

Major costs associated with MNA include such items as characterizing the fate and transport of the chlorinated solvents, evaluating the processes that reduce the mass, toxicity, or mobility of the contamination, evaluating factors that affect the long-term performance of the natural attenuation process, and long-term monitoring to ensure continued effectiveness. This includes collecting and analyzing soil and ground water samples, fate and transport modeling, and possibly microcosm studies. These costs are considered low.

Based on this preliminary and secondary screening, this technology is retained for further evaluation.

6.4.3 Capping

Capping systems are used to provide an impermeable barrier to surface water infiltration to contaminated materials for prevention of further release of contaminants to the surrounding surface water or ground water. Capping also eliminates risks associated with dermal contact and or incidental ingestion of surface soils.

Capping systems can range in design from single layer caps to more complex multi layer caps. Local soils are often used in the design of the cap. Synthetic membranes such as high-density polyethylene are also available for incorporation into capping systems. Surface water controls such as dikes, drains, drainage nets, or gravel are usually included in the capping system. Multi layer caps may also have a layer of topsoil or hard cover to prevent damage to the synthetic membrane. The ground surface is then revegetated to reinforce the topsoil and to reduce erosion. Capping has already been implemented at the Site for landfill cells 4 and 5, with a layer of 30-mil PVC, soil, and revegetation.

Capping costs are typically high capital costs associated with the synthetic membrane, drainage net, and cover soil. Annual O&M costs are medium associated with the inspection of the cap and any repairs necessary.

Based on this preliminary and secondary screening, capping is retained for further evaluation.

6.4.4 Containment

Ground water containment technologies involve the use of physical barriers or controlling the hydraulic gradient to reduce or stop the migration of impacted ground water. Containment technologies are applicable to the COPCs in the Site's ground water. The remedial technologies and associated process options identified for containment include

hydraulic barriers such as vertical or horizontal extraction or injection wells and physical barriers such as funnel and gate systems, slurry wall, and sheet piling.

The physical barrier would require installation so that ground water would not flow around or below the barrier. A physical barrier at the Site would be difficult to implement due to the sloping bedrock zone at depths up to 70 feet and the presence of the Naugatuck River and Branch Brook at the Site boundaries. An hydraulic barrier could potentially be implemented at the Site. Hydraulic barriers require extraction and treatment of impacted ground water to contain the migration of the COPCs in ground water. Issues associated with hydraulic barriers and ground water extraction are discussed under Section 6.4.5.6.

Containment is not retained as a process option in this CMS due to low implementability due to the limited understanding of the vertical containment at the Site breadth of the impacted ground water along the Site boundary in proximity with surface water.

6.4.5 Treatment

Through the use of treatment technologies, the concentrations of COPCs in ground water are reduced. The remedial technologies evaluated were air sparging, *in situ* chemical oxidation, iron reactive permeable barriers, *in situ* bioremediation, enhanced bioremediation, pumping and treatment, and 2-PHASE™ extraction.

6.4.5.1 Air Sparging

The air sparging process uses ambient air injected under pressure through sparge points (wells) into the impacted ground water to promote the removal of VOCs. Air sparging has not been found to be effective for the treatment of dissolved zinc in ground water. It can be thought of as *in situ* air stripping. Air bubbles formed during the sparging process migrate laterally and vertically through the impacted ground water. Volatile compounds in the saturated zone and capillary fringe that are exposed to this injected air are volatilized and moved upwards through the unsaturated zone, where the volatilized organic compounds are collected using a SVE system and then treated using an appropriate vapor treatment technology.

The performance and reliability of air sparging may be impacted by the lithology within the area to be remediated. The volume of ground water that can be remediated using this process is not restricted, but depends on the radius of influence of the air injection and vapor extraction wells. Air sparging in the ground water is difficult to implement in multiple ground water zones and requires extensive

monitoring to assure that all of the VOCs removed from the ground water are effectively captured by vapor extraction wells.

An air sparging system is constructed using conventional drilling, excavating, and construction equipment. Air sparging systems are readily available through commercial vendors. There are no other significant limitations regarding technical, administrative, or scheduling aspects that would limit the implementation of this process option.

Major capital costs for use of an air sparging system include such items as the construction of vapor injection wells, SVE wells to capture vapors, and an aboveground vapor treatment system. This process option has moderate capital and moderate operations and maintenance costs.

Based on this preliminary and secondary screening, air sparging is not retained for further evaluation due to the process of volatilizing contaminants into the vadose zone and because it is not been found to be effective for the treatment of dissolved zinc in ground water.

6.4.5.2 *In Situ* Chemical Oxidation

Chemical oxidation is a process in which an oxidizing agent is used to convert or oxidize chemical constituents in the ground water. The application of this technology involves introducing an oxidant into the subsurface to create favorable conditions for the oxidation of VOCs. In situ chemical oxidation has not been found to be effective for the treatment of dissolved zinc in ground water. Metallic catalysts, stabilizers, and other constituents are sometimes used with the oxidants to increase their effectiveness. Oxidation of chlorinated compounds results in removal of the chlorine atoms from the compound and a corresponding increase in chloride concentration of the ground water. Other organic compounds are converted to carbon dioxide and water. Chemical oxidation is potentially applicable for the identified chemical types, chemical concentrations, and site characteristics.

Common oxidizers include modified Fenton's reagent (hydrogen peroxide based oxidants), ozone, potassium or sodium permanganate, and sodium hypochlorite, which would be injected into the impacted ground water zone. Bench scale tests using soil and ground water from obtained from areas requiring treatment at the Site and the selected oxidant are required to fully evaluate the effectiveness of the oxidant for the Site. Based on a review of available literature for chemical

oxidation and discussions with vendors, the oxidant most applicable to the Site conditions and concentrations of COPCs is potassium/sodium permanganate. Potassium/sodium permanganate is an oxidant that is persistent in ground water and will react with chlorinated ethenes (e.g. TCE and PCE). The permanganate oxidant progressively reacts with organic contaminants through a series of oxidation reactions. During the process, the oxidation reactions proceed by degrading the organic constituents ultimately to carbon dioxide and water. In the case of the chlorinated organics, as seen at this Site, the oxidation reactions proceed by degrading the chlorinated organic constituents to carbon dioxide, water and a chloride salt. Disadvantages of using potassium/sodium permanganate and other oxidants are that they may oxidize metals in saturated soils (such as reduced chromium in soils to hexavalent chrome) and has residual products. The residual products of the permanganate oxidant are manganese and manganese dioxide. These typically precipitate out of solution. Incomplete oxidation or formation of intermediate contaminants may limit the effectiveness of the technology.

The implementation of this process requires bench scale and pilot testing prior to full scale implementation. *In situ* chemical oxidation requires injection wells or temporary injection points. The implementation may be limited by the ability to transport the oxidizing reagent to the impacted area and ensure that the entire impacted area is treated. Additional characterization of the lithology utilizing membrane interface probes (MIP) facilitates the identification of areas of the subsurface to be treated and allows injection of the oxidant in these specific zones. Chemical oxidation involves the use of ground water monitoring to evaluate remediation effectiveness, ground water movement, chemical compound migration, and water quality.

Major capital costs for chemical oxidation include such items as bench scale testing, pilot testing, direct push borehole drilling, the oxidizing agent, potassium/sodium permanganate, and subsequent treatments. The overall cost is moderate to high depending on the number of injection points and treatments required.

Based on this preliminary and secondary screening, this process is not retained for further evaluation because it is not been found to be effective for the treatment of dissolved zinc in ground water.

6.4.5.3 Iron Reactive Permeable Barrier

A permeable reaction wall is created by placing reactive material (iron filings) in a treatment zone to treat dissolved-phase COPC through reductive dehalogenation. Typically the most effective installation of the iron permeable reactive barrier (IPRB) is perpendicular to the ground water flow path. However, with the ground water flow to the northeast and impacted ground water along the eastern Site boundary, effectively treating the impacted ground water at this Site may be difficult. The IPRB is installed by various excavating and trenching technologies, gas pressure to pneumatically inject the iron filings, or hydraulic pressure to inject an iron filings/guar mixture. The length and depth of the permeable reaction wall is dependent on the size of the area to be treated. The depth of impacted ground water at the Site of approximately 30 feet could be reached using trenching techniques to install the IPRB. The thickness of the reaction wall is dependent on the concentration of COPC in the ground water, the hydraulic conductivity, the ground water gradient, and resultant ground water velocity. Walls are designed to match or have a slightly greater permeability than the surrounding native soil. Chlorinated COPC in impacted ground water flowing through the wall would be converted to simple non-chlorinated hydrocarbons such as ethene. A permeable reaction wall is a potentially applicable process option for the identified chemical types, chemical concentrations, and Site characteristics.

Application of IRPB technology to treatment of the compounds that are the COPCs at the Site is a proven and well-documented technology. Bench scale testing and preliminary design would be required prior to installation. This technology is considered dependable and reliable. A field trial may be needed to determine final design parameters for an IPRB. The IRPB would be designed such that the ground water flows through the IRPB, the COPCs would react with the IRPB, and the COPCs would be reduced to less toxic and innocuous compounds. An IRPB would reduce COPC concentrations in any of the ground water that flows through the IRPB. The effectiveness of the IRPB technology in the ground water at the Site would be controlled primarily by the placement of the IRPB. The thickness and the permeability of the IRPB would need to be designed such that the average residence time of ground water flowing through the IRPB under ambient conditions would be adequate to ensure treatment for the COPCs. For this technology to be an effective component of the remedy, it would be equally important that the IRPB intercept as great a volume as possible of the TCE and vinyl chloride impact in the ground water.

If significant quantities of ground water are not intercepted by the IRPB, the technology would not meet the RAO for the ground water.

Major costs include items such as the pneumatically-driven or hydraulically-driven iron injection system, patent royalties, injection nozzles, bore hole casings, iron filings, iron- handling equipment, a nitrogen or guar feed source, and a hoist system to lift the nozzle. The installation cost is high, while the operation costs are low.

Due to placement constraints of the Site boundary and the direction of ground water flow, this technology is not retained for further evaluation.

6.4.5.4 *In Situ* Bioremediation

In situ bioremediation of ground water involves altering ground water conditions through engineered applications to stimulate biodegradation of COPCs in the dissolved phase. As dissolved phase COPCs are biodegraded, COPCs sorbed to soil in the saturated zone partition into the ground water and are biodegraded.

Bioremediation applications are generally designed to deliver amendments to the saturated zone. Depending on the ground water geochemistry and the types of COPC present, the amendments may include organic carbon sources (also termed "electron donors") electron acceptors, mineral nutrients, surfactants, enzymes, and inducers. Ground water is amended with organic carbon sources when the COPCs are the types of compounds that available bacteria cannot metabolize, such as chlorinated solvents like PCE and TCE, or when the concentrations of COPC are so low that an auxiliary food source is required. Organic carbon sources serve as "food" for microbial growth, as well as electron donors for microbial processes like reductive dechlorination.

Typically, ground water bioremediation relies on the degradative capabilities of the indigenous microbial populations; although, in some applications bioremediation may be enhanced or augmented through the addition of adapted or genetically engineered bacterial strains. Due to the complex lithology of the Site, it would be impractical to inject bacterial strains.

Both aerobic and anaerobic microbial processes are applicable for the bioremediation of chlorinated solvents like TCE, DCE, and vinyl chloride. PCE can only be biodegraded under anaerobic conditions by reductive dechlorination. At sites where PCE is among the COPCs, an anaerobic bioremediation approach alone may

be used, or a sequential anaerobic/aerobic approach may be used. Sequential anaerobic/aerobic approaches take advantage of the fact that PCE and TCE are biodegraded more rapidly by reductive dechlorination under anaerobic conditions; whereas, their transformation intermediates DCE and vinyl chloride are transformed more quickly by oxidative mechanisms under aerobic conditions.

To create anaerobic conditions in the subsurface and provide electron donors for the bacteria that carry out reductive dechlorination, ground water is amended with organic carbon sources such as molasses, volatile fatty acids, lactate, vegetable oil, or sugar. As microorganisms metabolize the added organic carbon, oxygen, and other electron acceptors such as nitrate, ferric iron, and sulfate are consumed, resulting in the type of anaerobic conditions under which reductive dechlorination occurs. To create aerobic conditions ground water is amended with oxygen. To stimulate aerobic transformation of the chlorinated compounds a compound such as methane, propane, or toluene is added to the ground water. These organic compounds serve a two-fold purpose: 1) they provide food for the microorganisms and 2) they induce the enzymes that cometabolically oxidize the chlorinated solvents.

Two main approaches are used to deliver the organic carbon compound(s) to the ground water to stimulate anaerobic conditions. One approach dissolves the organic carbon compound(s) and other additives into extracted ground water and reinjects the ground water through injection wells or infiltration galleries. The second approach is to inject organic carbon compounds and other additives into ground water through injection wells or temporary injection points. Both techniques can cause a mounding of the injected material at the delivery point, which could lead to flow of the injected material towards Naugatuck River if injected in the vicinity of MW-31. Materials that have been demonstrated to be effective through injection to the ground water include slow-release compounds such as proprietary lactic acid esters (sold commercially as Hydrogen Release Compound or HRC[®]) or vegetable oil. Once emplaced in the saturated zone, these compounds slowly dissolve releasing controlled amounts of organic carbon into the water. Installation of slow-release compounds into the subsurface does not involve surface equipment. In addition, ground water extraction to the surface is avoided. However, the slow-release compounds may have to be replaced as frequently as annually. Both approaches may be employed as part of a reactive barrier approach, in which ground water flows through a biologically active zone.

Effectiveness of *in situ* bioremediation may be limited by heterogeneity of the soils and bedrock which may restrict transport of amendments. Numerous points of injection may be required for the delivery of the organic carbon compound to the subsurface. Ground water flow rates also influence the effectiveness of both ground water extraction/reinjection and slow-release compound approaches. The success of anaerobic processes may be limited by the absence of bacteria that completely dechlorinate chlorinated solvents to ethene, and this may result in the build-up of cis-1,2-DCE and vinyl chloride. Ground water monitoring at the Site has not yet included parameters for biological monitoring to determine if the Site is conducive to biological degradation of the VOCs. However, some reduction of PCE and TCE to their breakdown product (cis-1,2-DCE) and vinyl chloride, a further breakdown product of cis-1,2-DCE were detected at the Site above the laboratory reporting limits.

Bioremediation for chlorinated hydrocarbons may take longer to achieve lower concentrations than other methods of remediation due to the time required for adaptation of microbes to degrade man-made contaminants and the slow degradation rates. Another limitation with the implementation of this treatment technology is the uncertainty about the efficiency of the process because it is difficult to verify with a small-scale treatability study.

Due to the above limitations at this Site, this process option is not retained for further evaluation.

6.4.5.5 Enhanced Biological Degradation

Enhanced biological degradation typically entails injection of nutrient or additional biota to accelerate or augment pre-existing biological degradation in ground water. Biological degradation, evidenced by the generation of TCE degradation products cis-1,2-DCE and vinyl chloride is likely occurring to a limited degree in the ground water. At this time it is not known that injection of nutrient or additional biota is necessary at this Site; therefore, this process option is not retained for further evaluation.

6.4.5.6 Extraction and Treatment

Extraction wells over long periods of time may reduce the mass and volume of the dissolved phase COPCs by removing ground water within the boundary of the dissolved phase COPC. Vertical extraction wells are used to create a capture zone towards which ground water flows for extraction. Horizontal extraction wells form a

horizontal line sink or hydraulic trough which ground water moves towards for extraction. The aerial extent of COPC in ground water dictates the number of wells required. The number and spacing of wells are also dependent upon the capture zone of the individual wells, which is dependent upon the pumping rate, the hydraulic properties of the aquifer, and the hydraulic gradient. The performance and reliability of an extraction system depends on site-specific conditions, system design and installation, and well development. Extracted water requires treatment prior to discharge with the needed pumping and piping systems to deliver extracted ground water from the wells to the treatment facility.

The success of ground water extraction for reduction of the COPC concentrations in ground water can be limited by several factors. In USEPA studies of ground water pump and treat systems, they have found the following factors that limit the effectiveness of these systems.

- The level of contamination measured in monitoring wells may be dramatically reduced in a moderate period of time, but low levels of contamination usually persist.
- The residual level of contaminants within the aquifer may cause the remediation to be continued indefinitely.
- An increase in the level of ground water contamination may follow cessation of the remediation if the remediation is discontinued prior to removal of all residual contaminants.

Depending on the residual level of contaminants within the aquifer, this may cause a remediation to be continued indefinitely, or it may lead to premature cessation of the remediation and closure of the Site. The latter is particularly troublesome because ground water contamination levels may increase if the remediation is discontinued prior to removal of all residual contaminants (USEPA, 1989).

These effects are observed because the release of contaminant residuals is a slow process relative to the induced water movement through the subsurface. The transport processes that cause this behavior include diffusion of contaminants in low permeability sediments, hydrodynamic isolation (areas not influenced by the extraction system), desorption of contaminants from sediment surfaces, and liquid-liquid partitioning of immiscible contaminants.

Site-specific factors that limit the viability of hydraulic plume reduction include: 1) bedrock and 2) sorption of COPC onto the soil matrix within the saturated zone. With these limiting factors, the duration for pumping to achieve hydraulic plume reduction cannot be accurately estimated.

The concentrations of COPCs documented in the ground water are within treatable ranges to meet typical limits for discharge either to a publicly owned treatment works (POTW) or surface water streams under the National Pollution Discharge Eliminating System (NPDES) permitting system. The overall effectiveness for this technology array to meet the RAO for the ground water would be affected adversely by the inability to demonstrate capture of the COPC impacted ground water. Qualified contractors for installation of vertical extraction wells are available to perform the work.

Major capital costs for extraction well systems include such items as bore hole drilling, construction of the wells, installation of pumps and piping systems, discharge permits, and easements on public and private property. The costs are proportional to the numbers of extraction wells needed. Since horizontal or directional wells are more difficult to install, capital costs are greater than costs for vertical extraction wells.

Because of the limited success of ground water extraction and treatment systems due to long operational duration to treat residual contamination, extraction and treatment of ground water is not retained for further evaluation following preliminary and secondary screening.

6.4.5.7 2-PHASE™ Extraction

2-PHASE™ Extraction uses high vacuum to extract VOCs in soil vapors and ground water simultaneously from ground water and vapor from the saturated zone and capillary fringe. 2-PHASE™ Extraction is potentially applicable to the VOC concentrations present at the Site; however, 2-PHASE™ extraction has not been found to be effective for the treatment of dissolved metals in ground water. The goal of 2-PHASE™ Extraction is to dewater portions of the saturated zone, so that VOCs associated with the soil and PEWM can be removed in extracted soil vapor. VOCs are more effectively removed in the vapor phase than in the dissolved phase, and greater VOC mass can be removed from the soil in a shorter amount of time if the soil is dewatered.

2-PHASE™ Extraction is effective in low permeability or moderately heterogeneous formations. The radius of influence (vapor and hydraulic) and mass removal rates are unique to each site and are greatly dependent on site conditions such as lithology, ground water conditions, and contaminant characteristics. The Site has high permeability sands and gravels.

Extracted soil vapors would be treated by granular activated carbon (GAC) and discharged to the atmosphere. Extracted ground water also would be treated by GAC and discharged under a NPDES permit. Installation is achieved through the use of conventional drilling and excavating equipment. Vendors are readily available to implement a 2-PHASE™ Extraction system.

Major capital costs for a 2-PHASE™ Extraction system include items such as the construction of ground water/vapor extraction wells, conveyance piping, a treatment pad, and aboveground auxiliary equipment. The system requires a high vacuum blower to extract the vapors from the wells, vapor and ground water conveyance systems, a vapor phase treatment system, and a ground water treatment system. This process option has moderate capital and moderate operations and maintenance costs.

This process option is not retained for further evaluation following preliminary and secondary screening.

7.0 DETAILED EVALUATION OF THE ALTERNATIVES

7.1 Development of Remedial Alternatives

ENVIRON performed an initial screening of the identified alternatives for the Site, based on effectiveness, implementability, and cost, which is presented in Section 6.0. Effectiveness was evaluated based on the proven reliability of the alternative to achieve the RAOs. Implementability was evaluated based on the availability of the technology and the ease of implementation and permitting. Relative cost was evaluated based on the total cost to implement the remedial alternative. The results of the screening based on effectiveness, implementability, and cost are presented in Tables 7 and 8. These tables describes the reasons for retaining or rejecting each process. The “no action” response presented in Tables 7 and 8 was retained as a baseline alternative (USEPA, 1988). Based on this initial screening, the following alternatives were developed using the remedial technologies screened for further consideration:

- Alternative 1 – No Action
- Alternative 2 – Monitoring and Natural Attenuation, Establish ELUR
- Alternative 3 –PEWM-R Removal (Partial or Complete), Monitoring and Natural Attenuation, Establish ELUR
- Alternative 4 – Cap Landfill, PEWM-R Removal (Partial or Complete), Monitoring and Natural Attenuation, Establish ELUR

7.2 Description of the Evaluation Criteria

USEPA notes in the ANPR that the system proposed in the July 1990 proposed Subpart S rule for remedy selection remains appropriate as general goals for cleanup and screening tools for the potential remedies (61 FR 19432). This recommends a detailed evaluation of the remedial alternatives, involving assessing each of the remedial alternatives against nine criteria and a comparison of the relative performance of the remedial alternatives against those criteria. The nine evaluation criteria are:

1. Overall protection of human health and the environment

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2. Meet Applicable Cleanup Standards
3. Control Sources of Future Releases
4. Compliance with Regulatory Requirements
5. Long-term reliability and Effectiveness
6. Reduction of toxicity, mobility, or volume through treatment
7. Short-term effectiveness
8. Implementability
9. Cost

An alternative must meet Criteria 1 through 4, known as "threshold criteria," in order to be recommended. Criteria 5 through 9, known as "balancing criteria," are evaluated to determine the best overall solution.

1. *Overall protection* of human health and the environment determines whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.
2. *Meet applicable cleanup standards* considers if an alternative meets these standards,
3. *Control sources of future releases* determines whether an alternative reduces or eliminates further releases of hazardous wastes and hazardous constituents that may pose a threat to human health and the environment,
4. *Compliance with regulatory requirements* evaluates whether the alternative meets state and federal environmental laws, regulations, and other requirements that pertain to the Site and, if not, whether a waiver is justified.
5. *Long-term reliability and effectiveness* considers the ability of an alternative to maintain protection of human health and the environment over time, and the reliability of such protection.
6. *Reduction of toxicity, mobility, or volume* evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of residual contamination remaining.
7. *Short-term effectiveness* considers how fast the alternative reaches the cleanup goal and the risks the alternative poses to workers, residents, and the environment during construction or implementation of the alternative.
8. *Implementability* considers the technical and administrative feasibility of implementing the alternative, such as relative availability of goods and services and permitting requirements. Also, considers if the technology has been used successfully on other similar sites.

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9. *Cost* includes estimated capital and operations and maintenance (O&M) costs, as well as present worth costs.

Application of these criteria to the four alternatives retained after the preliminary and secondary screening is presented in Table 8.

7.3 Comparative Evaluation of the Alternatives

The purpose of the comparative evaluation presented in Table 8 was to select a preferred remedial alternative that will be most suitable for the Site, based on the criteria. In Table 8, the alternative remedies are listed, and the comparative ranks of low, medium, and high are applied for each criterion to indicate the desirability of the alternatives under consideration. The rankings of low, medium, and high are relative rankings. In the comparative analysis, low costs are considered more desirable than high costs; therefore, low costs are given a desirability ranking of high, and high costs are given a desirability ranking of low. The estimated cost for the application of the alternatives is also included in Table 8. Costs for all alternative remedies for each area are summarized in Table 9, and more detailed line-item cost estimates for ground water and PEWM remedies are included in Appendix C. The costs listed in Table 9 are the total present value costs for the alternatives that include capital costs (design, construction, startup, and other initial costs) and operations and maintenance costs (including monitoring and closure costs). It is expected that monitoring will be included in all alternatives except the No Action alternative.

7.3.1 Overall Protection of Human Health and the Environment

This criterion ranks the alternative relative to each other on whether the alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment. Alternative 4 and Alternative 3 rank high because these alternatives reduce or eliminate further degradation of ground water. Alternative 2 ranks medium for the overall protection of human health and the environment because it controls threats through documenting ground water conditions to assure the protection of human health and the environment. However, Alternative 2 does not reduce or eliminate the further degradation of ground water. Alternative 1 ranks low for overall protection of human health and the environment because it does not include monitoring to document ground water conditions to assure human health and the environment are protected and does not reduce or eliminate further degradation of ground water.

7.3.2 Control Sources of Future Releases

This criterion evaluates whether the alternative controls sources of future releases. Alternative 4 and Alternative 3 rank high for compliance with the regulatory requirements in particular because the objective or reducing further degradation of ground water. Alternative

2 ranks medium because the monitoring incorporates parameters to evaluate natural attenuation to document if natural conditions will meeting the CTDEP ground water criteria.

Alternative 1 ranks low for compliance with the regulatory requirements because it does not reduce the concentrations of COPCs in ground water to meet the water quality criteria, which was identified as a regulatory consideration.

7.3.3 Meet Applicable Cleanup Standards

This criterion evaluates whether the alternative meets applicable cleanup standards to the Site and, if not, whether a waiver is justified. Alternative 4 and Alternative 3 rank high for compliance with the cleanup standards in particular because they remove the PEWM-R that exceeds cleanup standards for VOCs. Alternative 2 ranks medium because the monitoring incorporates parameters to evaluate natural attenuation to document if natural conditions will meeting the cleanup standards. Alternative 1 ranks low for compliance with the cleanup standards because it does not reduce the concentrations of COPCs in soil or ground water to meet the standards.

7.3.4 Compliance with Regulatory Requirements

This criterion evaluates whether the alternative meets state and federal environmental laws, regulations, and other requirements that pertain to the Site and, if not, whether a waiver is justified. Alternative 4 and Alternative 3 rank high for compliance with regulatory requirements in particular because the objective or reducing further degradation of ground water. Alternative 2 ranks medium because the monitoring incorporates parameters to evaluate natural attenuation to document if natural conditions will meeting the CTDEP ground water criteria. Alternative 1 ranks low for compliance with regulatory requirements because it does not reduce the concentrations of COPCs in ground water to meet the water quality criteria, which was identified as a regulatory requirement.

7.3.5 Long-term Reliability and Effectiveness

This criterion considers the ability of an alternative to maintain protection of human health and the environment over time, and the reliability of such protection. Alternative 4 and Alternative 3 rank high for long-term reliability and effectiveness because they remove the concentrations of COPCs in the PEWM, which should be a permanent reduction in contribution to the dissolved phase COPCs in ground water over the long-term. Alternative 2 ranks medium because the monitoring incorporates parameters to evaluate natural attenuation of VOCs to document if natural conditions reduce the concentrations of COPCs in the long term. Alternative 1 ranks low for long-term protection of human health

and the environment because there is no protection of the ground water and human health in the long-term.

7.3.6 Reduction of Toxicity, Mobility, or Volume

This criterion evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment, and the amount of residual contamination remaining. Alternative 4 ranks high for reduction of toxicity, mobility, or volume through treatment due to the removal of PEWM-R and the reduction of mobility of metals from surface water infiltration into the landfill material. Alternative 3 ranks medium for reduction of toxicity, mobility, or volume through treatment due to the removal and disposal of PEWM-R. Alternative 2 and Alternative 1 rank low because no reduction of toxicity, mobility, or volume actively occurs under these alternatives.

7.3.7 Short-term Effectiveness

This criterion considers how fast the alternative reaches the cleanup goal and the risks the alternative poses to workers, residents, and the environment during construction or implementation of the alternative. Alternative 4 and Alternative 3 ranks medium because the estimated time frame for removal of the PEWM-R is short, less than one year; however, these alternatives have higher risk to workers during the implementation of the PEWM-R removal. Alternative 2 also ranks medium for short term effectiveness because MNA may require a much longer time period to reach the cleanup criteria and may require long term monitoring; however, it poses minimal short term risk to workers and the environment during implementation. Alternative 1 ranks low for short-term effectiveness because there is no reduction in short term risks or time to reach cleanup criteria.

7.3.8 Implementability

This criterion considers the technical and administrative feasibility of implementing the alternative, such as relative availability of goods and services and permitting requirements. Also, this criterion considers if the technology has been used successfully at other similar sites. Alternative 1 ranks high for implementability because it does not require any action to implement. Alternative 2 ranks high for implementability because the installation of wells and monitoring at the Site has already been proven to be readily implementable. Alternative 3 and 4 rank medium for implementability due to the presence of PEWM on the edge of the Site along the roadway, which may make it challenging to excavate and provide additional administrative difficulties for coordination of the excavation along the roadway with the city and other property owners. The capping of landfill material,

Alternative 4, has already been conducted for landfill cells 4 and 5 at the Site and is readily implementable.

7.3.9 Cost

This criterion includes estimated capital and operations and maintenance (O&M) and closure costs, as well as the net present worth of these costs. The net present value of the O&M and closure costs were estimated using an interest rate of 7 percent. These costs were based on the following estimated project durations:

- 10 years for ground water monitoring
- Removal of the PEWM-R for the first year
- Capping of the landfill material for the first year

Alternative 1 ranked high for lowest estimated cost. Alternative 2 also ranked high for an estimated cost of approximately \$448,000. Alternative 3 ranked medium with an estimated cost of approximately \$695,000. Alternative 4 ranked low with an estimated cost of approximately \$963,000.

7.3.10 Summary

Based on the above comparative analysis, Alternative 3 ranked the highest out of the criteria evaluated. PEWM-R removal, monitoring and natural attenuation, and establishing an ELUR is the best apparent alternative based on less short-term impact and lower total present value cost. A description of how the excavation and monitoring is incorporated into an overall Site remedy is included in the Section 8.0.

8.0 PREFERRED ALTERNATIVE FOR THE SITE

8.1 Introduction

Based on the screening and the detailed analysis, Alternative 3 PEWM-R removal, monitoring and natural attenuation, and establishing an ELUR was considered as the best apparent remedial alternative for the Site based on less short-term impact and lower total present value cost. The key elements of the implementation schedule after regulatory agency acceptance of this corrective measures study and approval of the alternative to be implemented are:

- Removal of the existing facility building (see attached site plan)
- Establishment of an ELUR preventing future building construction on the property
- Removal of the PEWM-R
- Ground Water Monitoring
- Closure Report Preparation/Approval
- Site Closure ?

Selection of alternatives other than those identified as the best apparent alternatives herein could have a significant impact on the project schedule. Ground water monitoring will continue as established for the closure monitoring. The main components of the schedule are discussed in further detail below.

8.1.1 Implementation

Prior to initiation of excavation activities, ENVIRON will contact DigAlert and retain a geophysical survey contractor in order to identify any utilities and underground debris in the proposed excavation. ENVIRON will prepare a Site-specific Health and Safety Plan (HASP) for the fieldwork. The HASP is designed to minimize exposure of ENVIRON's field personnel to potentially hazardous materials. All field personnel involved in the project will be required to implement the procedures presented in the HASP while conducting the planned field work.

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Soils in the PEWM-R area have not been recently or sufficiently characterized for disposal purposes. Precharacterization samples could be collected prior to the excavation activities, which will allow for the soils to be loaded directly into trucks or other containers for transport to the appropriate disposal facility, unless unusual conditions such as odors or gross staining are encountered.

Soil excavation and associated confirmation soil sampling will be conducted in the area of the PEWM-R at the Site. During excavation activities, soil impacted with VOCs and metals exceeding their respective MCS will be excavated and transported to an off-Site disposal facility. Confirmatory samples will be obtained from below the final depths of excavation. Soils above the PEWM-R with concentrations below the MCS will be used as backfill for the excavation. If the soils have been precharacterized, the soils will be excavated and loaded directly into trucks for transport off site to the appropriate disposal / recycling facility. During excavation, if any visual, olfactory, or other evidence suggests the presence of additional contamination, an on-site determination will be made regarding whether to discontinue excavation activities until such time as the material in question can be tested or otherwise characterized. In the event that further contamination is identified, this material will be excavated for appropriate disposal or recycling, and following removal, additional confirmatory samples will be obtained to establish that residual level left in place do not exceed regulatory standards.

In general, all excavation activities must be performed in accordance with OSHA requirements (Subpart P, Excavations, 29 CFR 1926.650, .651 and .652). If the excavation is greater than 4 feet deep, a ladder, ramp or other means of safe egress must be located within the excavation if workers are present. Excavations greater than 5 feet deep will be adequately sloped or benched, or be adequately shored to protect workers from cave-ins. Workers should be protected from materials and equipment that could pose a hazard by falling or rolling into excavations by placing and keeping such materials or equipment at least 2 feet from the edge of the excavation or by providing retaining devices. Excavations left open overnight will be barricaded and/or fenced to isolate the area.

The excavation contractor shall properly load, and transport the regulated under bill of lading or manifest to the selected treatment/disposal facility.

ENVIRON will prepare a report for USEPA Region 1. The reports will include field procedures, the volume of soil removed, and confirmation sample analytical results.

MNA will be continued to be conducted along with the closure monitoring. The duration of MNA requires that documentation of conditions that show historical trends in

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contamination showing plume stabilization and/ or loss of contaminant mass over time and analytical data showing that geochemical conditions are suitable for biodegradation and that active biodegradation has occurred.

8.1.2 Conclusion

The CMS concludes that if the preferred remedial alternative for the Site, Alternative 3 - PEWM-R Removal, Monitoring and Natural Attenuation, and establish an ELUR, is implemented, it will achieve the remedial objectives for the Site. It will further provide a long-term, permanent solution for the Site.

9.0 LIMITATIONS

The judgments, conclusions, and recommendations described in this CMS report pertain to the conditions judged to be currently present or applicable at the Site. This CMS report was prepared solely for the use of the USEPA, CTDEP, Envirite, and Envirite's affiliates, agents, and legal counsel, as it pertains to the Site. Any reliance on, or use of, this CMS report by any third party shall be at such party's sole risk.

Certain information contained in this CMS report was excerpted by ENVIRON from reports and documents prepared by third parties or other outside sources. ENVIRON does not make any warranties or representations, whether expressed or implied, regarding the accuracy of such information, and shall not be held accountable or responsible in the event that any such inaccuracies are present.

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TABLES

Table 1
Description of Landfill Cells
Former Envirite RCRA Facility
Thomaston, Connecticut

Cell	Dimensions	Regulatory Status of Contents	Fill Dates	Method of Closure	Volume of Residues
1	170 feet by 130 feet	nonregulated (pre-RCRA)	11/76 - 8/79	1 foot gravel drainage layer; 6 inch loam and seeded.	5,100 c.y. to grade
			overfill added 10/80 ^a		5,000 c.y. overfill
2	165 feet by 130 feet	nonregulated (pre-RCRA)	11/76 - 8/79	1 foot gravel drainage layer; 6 inch loam and seeded.	6,300 c.y. to grade
			overfill added 10/80 ^a		6,000 c.y. overfill
3	150 feet by 140	nonregulated (pre-RCRA)	11/76 - 8/79	1 foot gravel drainage layer; 6 inch loam and seeded.	6,300 c.y. overfill
			overfill added 10/80 ^a		
4 ^a	250 feet by 180 feet	hazardous	11/80 - 11/82	Hazardous waste capped with 1 foot gravel drainage layer. Residues placed above cap. Cell capped with 30 mil PVC liner, drainage net, 42 inch cover, 6 inch loam and seeded.	19,000 c.y.
	550 feet by 170 feet	nonregulated (delisted)	11/82 - 6/87		47,600 c.y.
5	400 feet by 165 feet	nonregulated (delisted)	6/87 - 5/89	30 mil PVC liner, drainage net, 24 inch cover, 6 inch loam and seeded.	21,000 c.y.

Notes:

Source: Fuss & O'Neill (1989)

^a Envirite began placing nonregulated pre-RCRA waste treatment residues in Cell 4 in August 1979. In October 1980, prior to the effective date of the first RCRA regulations (i.e., November 1980), these materials were removed from Cell 4 and placed on top of the existing material in Cells 1, 2, and 3 as overfill. Following the removal of these wastes, Cell 4 began being used for RCRA hazardous wastes.

Table 2
Regulatory Requirements
Former Envirote RCRA Facility
Thomaston, Connecticut

Requirement	Description
Clean Water Act	The Clean Water Act regulates the discharge of non-toxic and toxic pollutants into surface water by specific and non-specific sources. Includes requirements applicable to obtaining New Pollutant Discharge Elimination System (NPDES) Permit if ground water is to be discharged to surface water. The general requirements of a permit include 1) development and implementation of a Storm Water Pollution and Prevention Plan, 2) elimination of non-storm water discharge to storm water conveyances, and 3) monitoring of the quality and quantity of stormwater discharges. Certain remedial alternatives for the site could potentially trigger storm water discharge; therefore, these requirements are potentially applicable.
Connecticut Water Pollution Control Regulations - Permitting (22a-430 1-8)	Establishes permitting requirements for discharges to surfacewater, ground water, and POTWs.
Connecticut Air Pollution Regulations - Control of Odors (CGS 22a-174-23).	Site remediation activities will be planned to control the release of objectionable odors from the Site.
Connecticut Air Pollution Regulations - Fugitive Dust Emissions (CGS 22a-174-18[b])	Activities involving building demolition and site remediation (excavation, landfill cap, etc.) will be conducted in a manner to minimize fugitive dust emissions from the Site.
Connecticut Water Quality Standards (WQS) (CGS 22a-174-29)	Establishes numeric antidegradation criteria for ground water and surface water.
Federal Drinking Water Standards (40 CFR Part 141)	Chemical -specific drinking water standards have been promulgated under the federal Safe Drinking Water Act as Maximum Contaminant Levels (MCLs). Connecticut has also promulgated drinking water standards under the RSRs. Since the ground water is not currently used for drinking or other domestic purposes, the Ground Water Protection Criteria do not apply (Appendix C to Sections 22a-133-1 through 22a-133k-3 of the Regulations of Connecticut State Agencies).
Hazardous Materials Transportation Regulations (49 CFR Parts 107, 171-177)	Applicable if hazardous materials are shipped off-site.
Manifest System, Record Keeping, and Reporting (40 CFR Part 264.70 wt seq.)	Applicable since hazardous waste would be transported off-site for treatment and disposal under certain remedial scenarios.
National Pretreatment Standards (40 CFR Part 403)	The remedial alternatives evaluated may include discharge of COPC-impacted water to a Publicly Owned Treatment Works (POTW).
Occupational Safety and Health Administration (29 CFR Part 1910.120)	Health and safety training requirements for on-site workers; regulations regarding employee safety standards relating to hazardous waste operations and emergency response.
RCRA On-Site Treatment Requirements (40 CFR Part 264.190-196, Treatment of Hazardous Waste in a Unit)	Tanks (i.e. any portable device in which a material is stored, transported, disposed of, or handled) must have sufficient structural strength to ensure that they do not collapse, rupture, or fail; waste must not be incompatible with tank material unless protected by a liner; design and operating standards for units in which hazardous waste is related; inspection and repair requirements; storage provisions; and closure requirements.
RCRA Treatment Requirements (40 CFR Part 264.601-603, Part 264 Subpart X, Part 268 Subpart D; Clean Air Act Section 101; and 40 CFR Part 52.04.	New "miscellaneous units", potentially including temporary on-site treatment equipment, must satisfy environmental performance standards; monitoring, analysis, and reporting requirements; post-closure care for units; fugitive odor and emissions control plan for remedial action; and filing of notices with State to include estimate of emissions rate for each pollutant expected.
Resource Conservation and Recovery Act (RCRA) (42 USC 6901 et seq.)	Regulates the generation, management, and disposal of solid and hazardous waste. Certain remedial actions chosen for the Site may include the generation and disposal of solid or hazardous waste subject to RCRA requirements, which are, therefore, potentially applicable or relevant and appropriate to the Site.

**Table 2
Regulatory Requirements
Former Envirite RCRA Facility
Thomaston, Connecticut**

Requirement	Description
Regulations of Connecticut State Agencies (RCSA) Appendix D to Sections 22a-133-1 through 22a-133-3	Ground water that discharges to surface water must also meet Surface Water Protection Criteria (SWPC).
Regulations of Connecticut State Agencies (RCSA) Appendix E to Sections 22a-133k-1 through 22a-133k-3	To protect against the potential volatilization of ground water constituents into soil gas, CTDEP has also developed volatilization criteria for ground water. According to Section 22a-133k-3(c)(3)(A), remediation of a volatile organic substance to the volatilization criterion for ground water shall not be required if the concentration of such substance in soil vapors below a building is equal to or less than the applicable volatilization criterion for soil vapor.
Regulations of Connecticut State Agencies (RCSA) Section 22a-133k-1(b)	Regulations of Connecticut State Agencies (RCSA) Section 22a-133k-1(b), the RSRs do not apply to areas that are affected by discharges allowed under a ground water discharge permit issued pursuant to Section 22a-430.
Regulations of Connecticut State Agencies (RCSA) Section 22a-133k-1(b)	Regulations of Connecticut State Agencies (RCSA) Section 22a-133k-1(b), the RSRs do not apply to areas that are affected by discharges allowed under a ground water discharge permit issued pursuant to Section 22a-430.
USEPA Ambient Water Quality Criteria, Quality Criteria for Water, 1986, EPA 440/5-86-00.	The remedial alternatives evaluated may include discharge of water to surface water criteria.

ELI
 A
 (water discharge to surface water)

**Table 3
Media Cleanup Standards for Soil
Former Envirite RCRA Facility
Thomaston, Connecticut**

Contaminant	CTDEP DEC	CTDEP PMC	Risk Based MPS		Media Cleanup Standards
			Min	Max	
Surface Soils (mg/kg)					
Arsenic	3.80	NA	3.80	380	3.80
Benzo[a]pyrene	0.78	NA	0.78	78	0.78
Beryllium	1.30	NA	1.30	130	1.30
Deep Soils (mg/kg)					
Chlordane	NR	0.07	NE	NE	0.07
Polychlorinated biphenyls	NR	0.01	NE	NE	0.01
Sediment (mg/kg)					
Benzo[a]pyrene	NA	NA	1.80	180	1.80
Pre-Envirite Waste Material (mg/kg)					
Benzene	NA	NA	0.002	0.002	0.002
Tetrachloroethylene	NA	NA	860	86,000	860
Trichloroethene	NA	NA	97	9,700	97
Pre-Envirite Waste Material Leachate (mg/kg)					
cis-1,2-DCE	NA	14	NA	NA	14
trans-1,2-DCE	NA	20	NA	NA	20
2-Butanone	NA	80	NA	NA	80
Benzene	NA	0.2	NA	NA	0.2
Benzo[k]fluoranthene	NA	1	NA	NA	1
Bis(2-ethylhexyl)phthalate	NA	11	NA	NA	11
Butylbenzylphthalate	NA	200	NA	NA	200
Cadmium (leachate)	NA	0.05 mg/L	NA	NA	0.05 mg/L
Carbon tetrachloride	NA	1	NA	NA	1
Dibutyl phthalate	NA	140	NA	NA	140
Dieldrin	NA	0.007	NA	NA	0
Ethylbenzene	NA	10	NA	NA	10
Lead (leachate)	NA	0.15 mg/L	NA	NA	0.15 mg/L
Naphthalene	NA	56	NA	NA	56
PCBs	NA	0.005	NA	NA	0
Pentachlorophenol	NA	1	NA	NA	1
Styrene	NA	20	NA	NA	20
PCE	NA	1	NA	NA	1
Toluene	NA	67	NA	NA	67
TCE	NA	1	NA	NA	1
Xylenes	NA	20	NA	NA	20

DEC: CTDEP Remediation Standard Regulations Direct Exposure Criteria

PMC: CTDEP Remediation Standard Regulations Pollutant Mobility Criteria

CTDEP: Connecticut Department of Environmental Protection

NA: Not applicable

NE: Not established

**Table 4
Media Protection Standards for Ground Water
Former Envirite RCRA Facility
Thomaston, Connecticut**

Analyte	GB Wells CTDEP CRITERIA (ug/L) ¹		GA Wells CTDEP CRITERIA (ug/L) ¹			SWPC ug/L	CTDEP Class A Surface Water Criteria ³			
	RVC ug/L	IVC ug/L	GWPC ug/L	RVC ug/L	IVC ug/L		Aquatic Life Criteria	Human Health Criteria	Consumption of Water and Organisms	
							Acute ug/L			Chronic ug/L
Volatile Organic Compounds										
1,1,1,2-Tetrachloroethane	2	64	1	2	64	NE	NE	NE	NE	NE
1,1,1-Trichloroethane	6,500	16,000	200	6,500	16,000	62,000	NE	NE	NE	NE
1,1,2,2-Tetrachloroethane	1.8	54	0.5	1.8	54	110	NE	NE	11	0.17
1,1,2-Trichloroethane	220	29,000	5	220	29,000	1,260	NE	NE	42	0.60
1,1-Dichloroethane	3,000	41,000	70	3,000	41,000	NE	NE	NE	NE	NE
1,1-Dichloroethene	190	920	7	190	920	96	NE	NE	3	0.1
1,1-Dichloropropene	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1,2,3-Trichlorobenzene	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1,2,3-Trichloropropane	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1,2,4-Trichlorobenzene	NE	NE	70	NE	NE	NE	NE	NE	940	70
1,2,4-Trimethylbenzene	NE	NE	350	NE	NE	NE	NE	NE	NE	NE
1,2-Dibromo-3-Chloropropane	NE	NE	in review	NE	NE	NE	NE	NE	NE	NE
1,2-Dibromoethane	NE	NE	in review	NE	NE	NE	NE	NE	NE	NE
1,2-Dichlorobenzene	30,500	50,000	600	30,500	50,000	170,000	NE	NE	17,000	2,700
1,2-Dichloroethane	6.5	68	1	6.5	68	2,970	NE	NE	99	0.38
1,2-Dichloropropene	7.4	58	5	7.4	58	NE	NE	NE	39	0.52
1,3,5-Trimethylbenzene	280	3,900	350	280	3,900	NE	NE	NE	NE	NE
1,3-Dichlorobenzene	24,200	50,000	600	24,200	50,000	26,000	NE	NE	2,600	400
1,3-Dichloropropane	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1,3-Dichloropropene	11	360	0.5	11	360	34,000	NE	NE	1,700	10
1,4-Dichlorobenzene	50,000	50,000	75	50,000	50,000	26,000	NE	NE	2,600	400
2,2-Dichloropropane	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2-Butanone	50,000	50,000	400	50,000	50,000	NE	NE	NE	NE	NE
2-Chloroethyl vinyl ether	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2-Chlorotoluene	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
2-Hexanone	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4-Chlorotoluene	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4-Methyl-2-Pentanone	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Acetone	50,000	50,000	700	50,000	50,000	NE	NE	NE	NE	NE
Acrolein	NE	NE	NE	NE	NE	NE	NE	NE	780	320
Acrylonitrile	NE	NE	0.5	NE	NE	20	NE	NE	0.66	0.06
Benzene	130	310	1	130	310	710	NE	NE	71	1.20
Benzo[a]pyrene	NE	NE	0.2	NE	NE	0.3	NE	NE	0.05	0.00
Benzo[b]fluoranthene	NE	NE	0.1	NE	NE	0.3	NE	NE	0.49	0.04
Benzo[k]fluoranthene	NE	NE	0.5	NE	NE	0.3	NE	NE	0.49	0.04
Bis(2-ethylhexyl)phthalate	NE	NE	2	NE	NE	59	NE	NE	NE	NE
Bromobenzene	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

**Table 4
Media Protection Standards for Ground Water
Former Envirite RCRA Facility
Thomaston, Connecticut**

	GB Wells CTDEP CRITERIA (ug/L) ¹		GA Wells CTDEP CRITERIA (ug/L) ¹			SWPC	CTDEP Class A Surface Water Criteria ³				
	RVC	IVC	GWPC	RVC	IVC		Aquatic Life Criteria	Chronic	Human Health Criteria		
							Acute		Consumption of Organisms Only	Consumption of Water and Organisms	
Bromochloromethane	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
Bromodichloromethane	2.3	73	0.6	2.3	73	NE	NE	NE	NE	NE	
Bromoform	75	2,300	4	75	2,300	10,800	NE	NE	360	4	
Bromomethane	NE	NE	10	NE	NE	NE	NE	NE	NE	NE	
Carbon Tetrachloride	5.3	14	5	5.3	14	132	NE	NE	4	0.25	
Chlorobenzene	1,800	23,000	100	1,800	23,000	420,000	NE	NE	21,000	100	
Chloroethane	12,000	29,000	NE	12,000	29,000	NE	NE	NE	NE	NE	
Chloroform	26	62	6	26	62	14,100	NE	NE	470	6	
Chloromethane	390	5,500	3	390	5,500	NE	NE	NE	NE	NE	
cis-1,2-Dichloroethene	830	11,000	70	830	11,000	NE	NE	NE	NE	NE	
Dibromochloromethane	NE	NE	0.5	NE	NE	1,020	NE	NE	NE	NE	
Dibromomethane	NE	NE	in review	NE	NE	NE	NE	NE	NE	NE	
Dichlorodifluoromethane	93	1,200	NE	93	1,200	NE	NE	NE	NE	NE	
Ethylbenzene	2,700	36,000	700	2,700	36,000	580,000	NE	NE	29,000	700	
Hexachlorobutadiene	NE	NE	0.5	NE	NE	NE	NE	NE	50	0.44	
Isopropylbenzene	2,800	6,800	30	2,800	6,800	NE	NE	NE	NE	NE	
Methylene Chloride	160	2,200	5	160	2,200	48,000	NE	NE	1,600	5	
Methyl-tert-butyl-ether	21,000	50,000	100	21,000	50,000	NE	NE	NE	NE	NE	
Naphthalene	NE	NE	280	NE	NE	NE	NE	NE	20,513	677	
n-Butylbenzene	1,500	21,000	61	1,500	21,000	NE	NE	NE	NE	NE	
N-nitrosodimethylamine	NE	NE	NE	NE	NE	NE	NE	NE	16	5	
n-Propylbenzene	NE	NE	61	NE	NE	NE	NE	NE	NE	NE	
Phenanthrene ⁵	NE	NE	200	NE	NE	0.1	NE	NE	49	4	
p-Isopropyltoluene	NE	NE	70	NE	NE	NE	NE	NE	NE	NE	
sec-Butylbenzene	1,500	20,000	61	1,500	20,000	NE	NE	NE	NE	NE	
Styrene	3,100	42,000	100	3,100	42,000	NE	NE	NE	NE	NE	
tert-Butylbenzene	NE	NE	61.0	NE	NE	NE	NE	NE	NE	NE	
Tetrachloroethylene	340	810	5	340	810	88	NE	NE	9	0.80	
Toluene	7,100	41,000	1,000	7,100	41,000	4,000,000	NE	NE	200,000	1,000	
trans-1,2-Dichloroethene	1,000	13,000	100	1,000	13,000	NE	NE	NE	140,000	100	
Trichloroethene	27	67	5	27	67	2,340	NE	NE	81	3	
Trichlorofluoromethane	1,300	4,200	1,300	1,300	4,200	NE	NE	NE	NE	NE	
Vinyl Chloride	1.6	52	2	1.6	52	15,750	NE	NE	525	2	
Xylenes (total)	8,700	48,000	530	8,700	48,000	NE	NE	NE	NE	NE	
Pesticides and PCBs											
4,4'-DDE	NE	NE	0.1	NE	NE	NE	NE	NE	0.0006	0.0006	
4,4'-DDT	NE	NE	0.1	NE	NE	NE	0.55	0.001	0.0006	0.0006	
Aldrin	NE	NE	in review	NE	NE	NE	1.5	NE	0.0001	0.0001	
beta-BHC	NE	NE	in review	NE	NE	NE	NE	NE	NE	NE	

**Table 4
Media Protection Standards for Ground Water
Former Envirite RCRA Facility
Thomaston, Connecticut**

	GB Wells CTDEP CRITERIA (ug/L) ¹		GA Wells CTDEP CRITERIA (ug/L) ¹				SWPC	CTDEP Class A Surface Water Criteria ³			
	RVC	IVC	GWPC	RVC	IVC	Aquatic Life Criteria		Human Health Criteria			
						Acute		Chronic	Consumption of Organisms Only	Consumption of Water and Organisms	
Dieldrin	NE	NE	0.002	NE	NE	0.1	0.24	0.056	0.0001	0.0001	
Endosulfan sulfate	NE	NE	42.0	NE	NE	NE					
Heptachlor	NE	NE	0.4	NE	NE	0.05	0.26	0.038	0.0002	0.0002	
Heptachlor Epoxide	NE	NE	0.2	NE	NE	0.05	0.26	0.038	0.0001	0.0001	
PCBs (total)	NE	NE	0.5	NE	NE	0.5	NE	0.014	0.0002	0.0002	
Metals											
Arsenic-Low Level, Dissolved	NE	NE	50	NE	NE	4	340 (Arsenic III)	150 (Arsenic III)	0.021 (Arsenic III)	0.011 (Arsenic III)	
Barium, Dissolved	NE	NE	1,000	NE	NE	NE	NE	NE	NE	NE	
Beryllium-Dissolved	NE	NE	4	NE	NE	4	NE	NE	0.1300	0.0077	
Cadmium, Dissolved	NE	NE	5	NE	NE	6	2.02	1.35	10,769	5	
Chromium, Dissolved	NE	NE	50 (Cr Total)	NE	NE	110 (Cr VI)	16 (Cr VI)	11 (Cr VI)	2019 (Cr VI)	100 (Cr VI)	
Copper, Dissolved	NE	NE	1,300	NE	NE	48	14.3	4.8	NE	1,300	
Iron, Dissolved	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
Lead, Dissolved	NE	NE	15	NE	NE	13	30	1.2	NE	15	
Manganese, Dissolved	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
Mercury, Dissolved	NE	NE	2	NE	NE	0.4	1.4	0.77	0.05	0.05	
Nickel, Dissolved	NE	NE	100	NE	NE	880	260.5	28.9	4,600	610	
Silver, Dissolved	NE	NE	36	NE	NE	12	1.02	NE	107,692	175	
Sodium, Dissolved	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	
Zinc, Dissolved	NE	NE	5,000	NE	NE	123	65	65	68,740	9,100	

Notes:

IVC = Industrial Volatization Criteria¹

RVC = Residential Volatization Criteria¹

SWPC = Surface Water Protection Criteria²

NE = Not established

GA = Class of groundwater designated as an area of existing or potential drinking water

GB = Class of groundwater designated as not suitable for drinking water

Blue = Indicates parameters sampled for the post-Closure Monitoring Program

Footnotes:

¹ Compliance with the IVC and RVC is demonstrated when the 95% UCL of the arithmetic mean of sample concentrations (for a minimum of 4 consecutive quarters) is less than or equal to the standard AND no single sample exceeds twice the standard.

² Compliance with the SWPC is demonstrated when the AVG of sample concentrations is less than or equal to the standard.

³ Samples collected from Branch Brook, a Class B/A surface water are required to meet CTDEP Class A surface water quality standards.

Table 5
Summary of Pre-Envirite Waste Material Analytical Results
Former Envirite RCRA Facility
Thomaston, Connecticut

Location	Envirite Sample ID	matrix_used	Collection Date	Collection Depth	PEWM - L Samples				PEWM -R Samples	
					W-09	W-09	W-11	W-19	W-25	W-30
PMC	W-SL	W-SL	W-SL	W-SL	W-SL	W-SL	W-SL	W-SL	W-SL	
			10/26/1994	10/26/1994	10/31/1994	11/9/1994	11/21/1994	12/7/1994		
			23.5-25.5	Not specified	26-28'	20-22.5'	9-11'	13-15'		
Volatile Compounds										
Benzene	0.2	N (1.3)	N (1.3)	0.002	0.15	30	N (94)			
2-Butanone	80	N (1.3)	N (1.3)	N (0.011)	N (1.3)	2100	N (94)			
Carbon tetrachloride	1	1.3	1.3	N (0.011)	N (1.3)	N (900)	N (94)			
4-Chloroaniline	NE	74	38	7.6	N (89)	N (240)	N (25)			
Chlorobenzene	20	N (1.3)	N (1.3)	N (0.011)	0.15	N (900)	N (94)			
Chloroform	1.2	N (1.3)	0.24	N (0.011)	N (1.3)	N (900)	N (94)			
1,1-Dichloroethene	1.4	N (1.3)	N (1.3)	N (0.011)	0.07	N (900)	N (94)			
1,2-Dichloroethylene (cis)	14	N (1.3)	N (1.3)	0.002	N (1.3)	70	26			
1,2-Dichloroethylene (trans)	20	N (1.3)	N (1.3)	0.002	N (1.3)	70	26			
4,6-Dinitro-2-methylphenol	NE	N (180)	91	N (18)	N (220)	N (570)	N (61)			
Ethylbenzene	10.1	8.6	14	0.047	N (1.3)	3100	700			
4-Methyl-2-pentanone	NE	N (1.3)	N (1.3)	N (0.011)	N (1.3)	7900	540			
Styrene	20	N (1.3)	N (1.3)	N (0.011)	N (1.3)	2,300	620			
Tetrachloroethylene (PCE)	1	N (1.3)	N (1.3)	0.015	0.1	3,100	440			
Toluene	67	0.6	0.92	0.005	0.28	15,000	2,000			
Trichloroethene	1	N (1.3)	N (1.3)	N (0.011)	0.2	3,300	250			
Xylenes (total)	19.5	27	50	0.018	0.23	16,000	2,600			
Semivolatile Compounds										
Acenaphthylene	84	N (74)	38	N (7.6)	N (89)	N (240)	N (25)			
Benzo[b]fluoranthene	1	N (74)	N (38)	N (7.6)	N (89)	N (240)	0.59			
Benzo[k]fluoranthene	1	N (74)	38	N (7.6)	N (89)	N (240)	0.82			
Bis(2-chloro-1-methylethyl)ether	NE	N (74)	38	N (7.6)	N (89)	N (240)	N (25)			
Bis(2-ethylhexyl)phthalate	11	N (340)	N (210)	N (38)	610	6,500	190			
Butylbenzylphthalate	NE	200	N (120)	N (7.6)	N (89)	N (240)	N (25)			
Butylbenzylphthalate	200	200	N (120)	N (7.6)	N (89)	N (240)	N (25)			
Dibutyl phthalate	140	N (74)	N (38)	N (7.6)	200	3100	74			
2,4-Dinitrophenol	NE	180	91	18	N (220)	N (570)	N (61)			
Di-n-Octyl phthalate	20	N (74)	N (38)	N (7.6)	7	N (240)	N (25)			
Fluoranthene	56	N (74)	N (38)	N (7.6)	N (89)	N (240)	1.2			
Hexachlorocyclopentadiene	NE	74	38	7.6	N (89)	N (240)	N (25)			
Isophorone	NE	N (74)	N (38)	N (7.6)	N (89)	68	1.9			
Methoxychlor	8	N (0.094)	N (0.094)	N (0.02)	0.036	N (0.24)	N (0.13)			

Table 5
Summary of Pre-Envirite Waste Material Analytical Results
Former Envirite RCRA Facility
Thomaston, Connecticut

Location	Envirite Sample ID	matrix_used	Collection Date	Collection Depth	PEWM - L Samples			PEWM -R Samples		
					W-09	W-09	W-11	W-19	W-25	W-30
PMC	W-09	W-09	W-11	W-19	W-25	W-30	W-SL	W-SL	W-SL	
10/26/1994	10/26/1994	10/31/1994	11/9/1994	11/21/1994	12/7/1994					
23.5-25.5	Not specified	26-28'	20-22.5'	9-11'	13-15'					
2-Methylnaphthalene	NE	N (74)	2.1	N (7.6)	4.5	N (240)	0.93			
Naphthalene	56	12	6.8	N (7.6)	18	160	6.9			
3-Nitroaniline	NE	N (180)	91	N (18)	N (220)	N (570)	N (61)			
2-Nitrophenol	NE	N (74)	38	N (7.6)	N (89)	N (240)	N (25)			
Pentachlorophenol	1	180	N (91)	18	N (220)	N (570)	N (61)			
Phenanthrene	40	N (74)	N (38)	N (7.6)	N (89)	N (240)	0.93			
Phenol	800	N (74)	N (38)	N (7.6)	N (89)	170	5.7			
Pyrene	40	N (74)	N (38)	N (7.6)	N (89)	N (240)	1.2			
PCBs/Pesticides										
Aldrin	NE	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
Aroclor 1254	NE	9.5			0.071					
BHC, beta	NE	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
BHC, delta	NE	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
Chlordane	0.066	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
4,4'-DDD	NE	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
4,4'-DDE	NE	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
4,4'-DDT	NE	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
Dieldrin	0.007	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
Endosulfan I	NE	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
Endosulfan II	NE	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
Endosulfan sulfate	NE	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
Endrin	NE	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
Endrin aldehyde	NE	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
Endrin ketone	NE	N (0.018)	N (0.018)	N (0.0038)	0.0071	N (0.047)	N (0.025)			
HCH (alpha)	NE	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
HCH (gamma) Lindane	0.04	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
Heptachlor	0.013	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
Heptachlor epoxide	0.02	N (0.0094)	N (0.0094)	N (0.002)	0.0036	N (0.024)	N (0.013)			
PCBs (total)	0.005	12.3 N (0.18)	12.3 N (0.18)	1.22 N (0.038)	17.424	26 N (0.46)	16.1 N (0.25)			
Toxaphene	0.6	N (0.94)	N (0.94)	N (0.2)	0.36	N (2.4)	N (1.3)			
Inorganic Compounds										
Antimony	0.06	8.5	8.6	9.1	N (8.4)	96.3	N (9.9)			
Arsenic	0.5	1.2	1.2	1.9	2.3	2.8	2.8			

Table 5
Summary of Pre-Envirite Waste Material Analytical Results
Former Envirite RCRA Facility
Thomaston, Connecticut

Location	Envirite Sample ID	matrix_used	Collection Date	Collection Depth	PEWM - L Samples			PEWM -R Samples		
					W-09	W-09	W-11	W-19	W-25	W-30
	PMC				W-09	W-09	W-11	W-19	W-25	W-30
					W-SL	W-SL	W-SL	W-SL	W-SL	W-SL
					10/26/1994	10/26/1994	10/31/1994	11/9/1994	11/21/1994	12/7/1994
					23.5-25.5	Not specified	26-28'	20-22.5'	9-11'	13-15'
Barium	10		69.5	63.9	45.6	32.7	1710	260		
Beryllium	0.04		0.87	0.33	N (0.24)	0.28	N (0.29)	0.43		
Cadmium	0.05		8.1	4.3	0.56	N (0.43)	394	29.1		
Chromium	0.5		48.8	34.3	25.7	15.5	1240	220		
Cobalt	NE		10.5	9.7	7.6	9.5	24.8	11		
Copper	13		162	62.3	135	26.5	3340	1070		
Lead	0.15		25.9	13	21	12.7	5900	541		
Mercury	0.02		0.098	0.11	0.096	N (0.1)	2.4	0.3		
Nickel	1		44.5	29.2	26.3	17	58.8	25		
Selenium	0.5		N (0.22)	0.23	0.24	N (0.22)	47.5	6.3		
Silver	0.36		1.1	N (0.68)	N (0.72)	36.5	10.8	0.94		
Thallium	0.05		0.22	0.25	N (0.24)	N (0.22)	0.59	0.26		
Tin	NE		3.8	N (3)	N (3.1)	2.8	35.4	N (3.4)		
Vanadium	0.5		28.3	38.8	27.3	19.8	10.7	23.9		
Zinc	50		188	185	50.1	50.9	5570	838		

Notes:

- 1 All concentrations are presented in mg/kg (ppm).
- 2 Only compounds with at least one detection are shown.
- 3 Concentrations that exceed the PMC are **boldfaced**.
- 4 Concentrations that exceed the MCS are highlighted.

Abbreviations:

- U -- Not Detected.
- J -- Estimated Concentration.
- () -- Detection Limit.
- NE -- Not Established
- PMC -- Connecticut Department of Environmental Protection Pollutant Mobility Criteria
- MCS -- Media Cleanup Standards
- PEWM-L -- Pre-Envirite Waste Material found beneath the landfill materials.
- PEWM-R -- Pre-Envirite Waste Material found adjacent to the Roadway

**Table 6
Initial Screening of PEWM Remedial Action Alternatives
Former Envirite RCRA Facility
Thomaston, Connecticut**

General Response Actions	Remedial Technology	Process Options	Description	Effectiveness	Implementability	Cost	Initial Screening Comments
No Action	None	Not Applicable	Assumes no remedial action will ever be taken at the site.	Does not meet remedial action objectives (RAOs).	May not be acceptable to public or agencies.	None	Rejected.
Institutional Control	Access Restrictions	Access Control	Limiting access using fencing, other physical barriers, and/or posting warning signs.	Does not meet remedial action objectives (RAOs).	May not be acceptable to public or agencies.	Low capital, low O&M.	Retained for further evaluation.
		Deed Restrictions and Regulatory Control	Restrict building and residential use at the site.	Not effective in evaluating, meeting, reducing, or containing concentrations of COPCs.	Easily implementable.	Low capital, low O&M.	Retained for further evaluation.
Containment	Physical Barrier	Slurry or Sheet Pile Wall	Vertical barrier constructed of a slurry or grout injected into soil mass, or steel sheet piling driven into the soil.	Requires an aquitard or other impermeable soil layer to be effective in reducing vertical mobility of COPCs.	Difficult to implement due to no known site feature to prevent vertical migration of the COPCs in the PEWM.	High capital, medium O&M	Rejected.
Removal	Removal	Excavation and off-site treatment or disposal	Excavation uses construction equipment including loaders, backhoes, large diameter augers, and other appropriate equipment. Off-Site disposal involves containerizing and transporting excavated impacted soil to an appropriate facility for disposal.	Effective at removing the COPCs from the site, may not result in a reduction in concentration depending on off site disposal options.	Easily implementable. The depth of excavations may be limited due to physical constraints and maintaining roadway access.	Moderate capital low O&M.	Retained for further evaluation.
Ex-situ Treatment	Treatment	Low Temperature Thermal Desorption (LTTD)	LTTD uses high temperatures to volatilize VOCs and petroleum based compounds in the soil.	The LTTD process removes VOCs and petroleum based compounds from excavated soil. This is not effective at reducing concentrations of metals and PCBs, which would be required for depositing of the soil at the site.	Easily implementable. The depth of excavations may be limited due to physical constraints and maintaining roadway access.	Moderate capital, moderate O&M.	Rejected.
		Ex-situ Soil Vapor Extraction	Vapor extraction to strip VOCs from excavated soils. VOCs are volatilized and treated with an off gas treatment system.	Potentially effective for treatment of VOCs; however, not effective at removing PCBs or metals, which would be required for depositing of the soil at the site.	Easily implementable. The depth of excavations may be limited due to physical constraints and maintaining roadway access.	Moderate capital, moderate O&M.	Rejected.
		Ex-situ Biodegradation	Application of nutrients into the excavated soils to break down COPCs in PEWM.	Potentially effective for treatment of VOCs; however, not effective at removing PCBs or metals, which would be required for depositing of the soil at the site.	Potentially difficult to implement due to metals concentrations in the soil. In addition, the depth of excavations may be limited due to physical constraints and maintaining roadway access.	Moderate capital, moderate O&M.	Rejected.

**Table 6
Initial Screening of PEWM Remedial Action Alternatives
Former Envirite RCRA Facility
Thomaston, Connecticut**

General Response Actions	Remedial Technology	Process Options	Description	Effectiveness	Implementability	Cost	Initial Screening Comments
	Stabilization	Solidification/Stabilization	Solidification/stabilization techniques lock the contaminants in the soil by physically encapsulating the COPC. This technique is accomplished by excavating the materials, machine-mixing with a cement-based agent, and depositing the solidified mass in a designated area.	Effective for the treatment of metals, but not effective for the treatment of VOCs. May cause the release of organic vapors from the mixing and heating associated with the binding material.	Effective for the treatment of metals, but not effective for the treatment of VOCs.	High capital, low O&M.	Rejected.
In Situ Treatment	Stabilization	Solidification/Stabilization	Solidification/stabilization techniques lock the contaminants in the soil by physically encapsulating the COPC. These techniques are accomplished insitu by injecting a cement.	Effective for the treatment of metals, but not effective for the treatment of VOCs.	Effective for the treatment of metals, but not effective for the treatment of VOCs.	High capital, low O&M.	Rejected.
	Treatment	Monitored Natural Attenuation	Routine PEWM monitoring for COPCs and biogeochemical data to evaluate the natural biodegradation process. Natural subsurface processes (i.e., Dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials) are allowed to reduce contaminant concentrations.	Potentially effective for treatment of VOCs. Dispersion processes may allow further migration of COPCs into groundwater. PCE biodegradation not effective in the aerobic zone.	Easily implementable. May require long term monitoring. Requires extensive site characterization and monitoring are usually necessary.	Low capital, low O&M.	Rejected.
		In Situ Soil Vapor Extraction	Air extraction from the vadose zone to strip VOCs for treatment.	Potentially effective for treatment of VOCs.	Potentially difficult to implement due to permeability of PEWM and consequently likely low effective radius from extraction wells.	Low to moderate capital, moderate O&M.	Rejected.
In Situ Treatment (Continued)	Treatment (Continued)	In Situ Biodegradation	Application of nutrients into the subsurface to break down VOCs in PEWM.	Uncertainty associated with understanding if appropriate types of microorganisms and nutrients are present in the subsurface, their effectiveness in biodegrading the COPCs, and the effective delivery of nutrients to appropriate subsurface areas. A bench scale test is required to determine required nutrient concentrations and determine bioremediation rates.	Potentially difficult to implement due to low permeability of the waste material, and proximity to the Naugatuck River.	Low capital, low O&M.	Rejected.

Table 6
Initial Screening of PEWM Remedial Action Alternatives
Former Envirite RCRA Facility
Thomaston, Connecticut

General Response Actions	Remedial Technology	Process Options	Description	Effectiveness	Implementability	Cost	Initial Screening Comments
		Thermal Technologies	Thermal technologies, including steam injection and six phase soil heating (SPSH), are processes where the soil is heated to enhance the removal of volatile and semi-volatile compounds	Effective for treatment of VOCs, SVOCs, and petroleum products.	Potentially difficult to implement due to the presence of Old Waterbury Road and utilities in the road that can short out electrodes for the SPSH.	Moderate capital, moderate O&M.	Rejected.

Table 7
Screening of Ground Water Remedial Action Alternatives
Former Envirite RCRA Facility
Thomaston, Connecticut

General Response Actions	Remedial Technology	Process Options	Description	Effectiveness	Implementability	Cost	Initial Screening Comments
No Action	None	None	Assumes no remedial action will ever be taken at the site.	Does not meet remedial action objectives (RAOs).	May not be acceptable to public or agencies.	None	Retained; to establish baseline for comparison.
Limited Action	Ground Water Monitoring	Routine Monitoring for COPCs	Conduct routine sampling and analysis for COPCs.	Effective if reduction of COPCs is observed.	Easily implementable. May require long term monitoring.	Low capital, low O&M.	Retained for further evaluation.
		Monitored Natural Attenuation	Routine ground water monitoring for COPCs and biogeochemical data to evaluate the natural biodegradation process. Natural subsurface processes (i.e., Dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials) are allowed to reduce contaminant concentrations.	Proven technology to effectively demonstrate degradation of VOCs in ground water. (Needs to be proven at this site). Present degradation rate unknown.	Easily implementable. May require long term monitoring.	Low capital, low O&M.	Retained for further evaluation.
	Institutional Controls	Deed Restrictions	Restrict ground water use at the site, restrict residential development of the site, restrict building construction.	Not effective in evaluating, meeting, reducing, or containing concentrations of COPCs. Reduces potential exposure to volatilization of	Easily implementable. Requires removal of existing building.	Low capital, low O&M.	Retained for further evaluation.
Containment	Vertical Barriers	Slurry Walls, Grout Curtains, or Sheet Piling	Vertical barrier constructed of a slurry or grout injected into soil mass, or steel sheet piling driven into the soil.	Effective in containing the VOC-impacted ground water. Does not reduce the concentrations of COPCs beneath the Site.	Difficult to implement due COPCs in bedrock.	High costs in constructing deep enough barrier walls to contain VOCs and metals in ground water.	Rejected.
	Horizontal Barriers	Capping	Horizontal barrier constructed of PVC or other impervious material to prevent infiltration of storm water into contaminated material and leaching into ground water.	Effective at reducing storm water into through the landfill materials. Marginally effective in the long term protection of ground water.	Capping has already been implemented at the site for landfill cells 4 and 5, with a layer of 30-mil PVC, soil, and revegetation.	High capital, low O&M.	Retained for further evaluation.

**Table 7
Screening of Ground Water Remedial Action Alternatives
Former Envirite RCRA Facility
Thomaston, Connecticut**

General Response Actions	Remedial Technology	Process Options	Description	Effectiveness	Implementability	Cost	Initial Screening Comments
Treatment Actions	<i>In Situ</i> Technologies	Air sparging/SVE	Air injection into saturated zone to strip VOCs into unsaturated zone for removal by SVE.	Potentially effective for treatment of VOCs. Not effective for the treatment of zinc.	Potentially implementable in shallow zones. Difficult to implement in bedrock.	Low to moderate capital, moderate O&M.	Rejected.
	<i>In Situ</i> Technologies	<i>In Situ</i> Chemical Oxidation	An oxidizing agent (ozone, sodium or potassium permanganate, or Fenton's Reagent) is injected into the ground water to oxidize the VOCs.	Potentially effective for treatment of VOCs. Not effective for the treatment of zinc. A bench scale test is required to determine if the oxidizing agent is effective for site specific ground water conditions.	Potentially implementable in shallow zones. May be difficult to inject into PEWM due to low permeability of the material. Difficult to implement in bedrock and in proximity of the river and brook.	Moderate capital, low O&M.	Rejected.
		Permeable Reactive Barrier	Construction of permeable reactive barrier to react with VOC-impacted ground water to degrade VOCs.	Potentially effective for treatment of VOCs, not effective for the treatment of zinc. Limited information regarding the long term effectiveness/fouling of the iron permeable reactive barrier.	Potentially implementable in shallow zones. Difficult to implement in bedrock and in proximity of the river and brook.	Moderate capital, low O&M.	Rejected.
		<i>In Situ</i> Bioremediation	Application of nutrients into the subsurface to break down VOCs in ground water.	Uncertainty associated with understanding if appropriate types of microorganisms and nutrients are present in the subsurface, their effectiveness in biodegrading VOCs, and the effective delivery of nutrients to appropriate subsurface areas. Not effective for the treatment of zinc. A bench scale test is required to determine required nutrient concentrations and determine bioremediation rates.	Potentially implementable in shallow zones; however, vertical and horizontal migration around the barrier is difficult to prevent. Difficult to implement in bedrock and in proximity of the river and brook.	Low capital, low O&M.	Rejected.

Table 7
Screening of Ground Water Remedial Action Alternatives
Former Envirite RCRA Facility
Thomaston, Connecticut

General Response Actions	Remedial Technology	Process Options	Description	Effectiveness	Implementability	Cost	Initial Screening Comments
Treatment Actions	<i>In Situ</i> Technologies	Enhanced Biodegradation	Injection of HRC, molasses, vegetable oil, or other "food" into ground water to degrade VOCs.	Potentially effective for biodegradation of VOCs. May result in the formation of breakdown products including cis-1,2-DCE and vinyl chloride. A bench scale test is required to determine required nutrient concentrations and determine bioremediation rates.	Potentially difficult to implement due to bedrock, and proximity of the river and brook.	Low capital, low O&M.	Rejected.
	Ground Water Extraction	Ground Water Pumping and Treatment	Ground water pumped from existing or additional wells, treated at the surface, and discharged under permit to appropriate discharge location.	Ground water extraction feasible but not typically effective in mass reduction.	Implementable using new wells. Performance of ground water pumping may be compromised by aquifer heterogeneity.	Moderate capital, moderate O&M.	Rejected.
	Multi-Phase Extraction	2-PHASE™ Extraction and Treatment	Extraction of soil vapor and ground water at high vacuums from extraction wells.	Potentially effective for soil vapor and ground water extraction. May not be effective for the PEWM due to the permeability of the material. Extracted ground water would require treatment for both VOCs and metals.	Implementable using new and/or existing wells. Potentially difficult to implement due to low permeability of the PEWM. Difficult to dewater the formation due to the high permeability of the saturated zone. A pilot test is required to determine the radius of influence of extraction wells.	Moderate capital, moderate O&M.	Rejected.

Table 8
Comparative Analysis of Remedial Action Alternatives
Former Envirite RCRA Facility
Thomaston, Connecticut

Alternative		Threshold Criteria				Balancing Criteria				
		Overall Protection of Human Health and the Environment	Meet Applicable Cleanup Standards	Control Sources of Future Releases	Compliance with Regulatory Requirements	Long-term Reliability and Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short-term Effectiveness	Implementability	Cost ¹
1	No Action	Low	Low	Low	Low	Low	Low	Low	High	High
2	Monitoring and Natural Attenuation and Establish ELUR	Medium	Medium	Low	Medium	Medium	Low	Medium	High	High
3	PEWM-R Removal, Monitoring and Natural Attenuation, and Establish ELUR	High	High	High	High	High	Medium	Medium	Medium	Medium
4	Cap Landfill, PEWM-R Removal, Monitoring and Natural Attenuation, and Establish ELUR	High	High	High	High	High	High	Medium	Medium	Low

Notes:

¹In the comparative analysis, low costs alternatives are ranked as high and high cost alternatives are ranked as low because low costs are considered more desirable than high costs.

ELUR - Environmental Land Use Restriction

PEWM-R - Pre Envirite Waste Material by Roadway

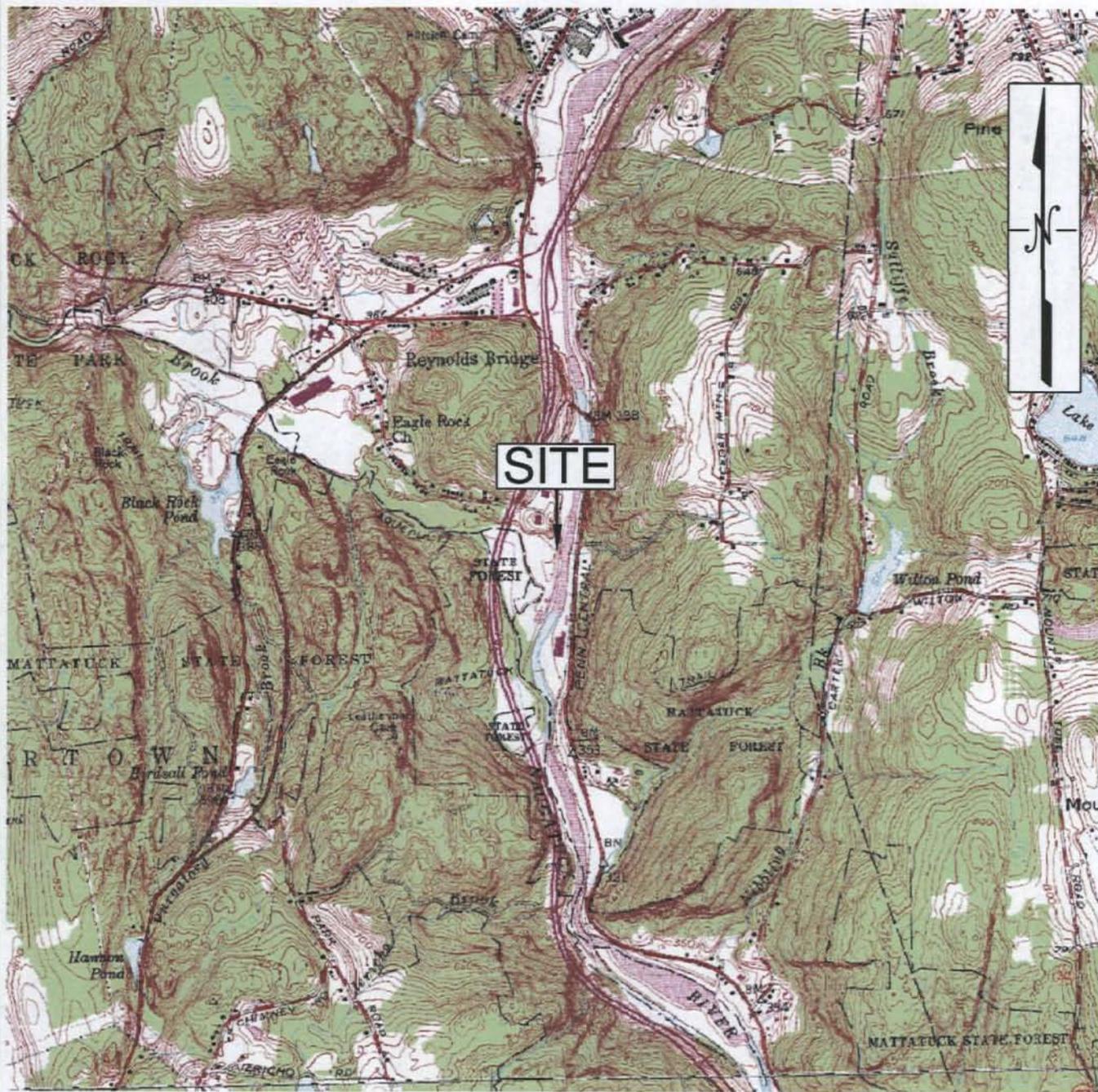
Table 9
Cost Summaries for Remedial Action Alternatives
Former Envirite RCRA Facility
Thomaston, Connecticut

Cost Breakdown	Alternative 1 No Action	Alternative 2 ELUR and MNA	Alternative 3 and PEWM Excavation	Alternative 4 and Capping
<u>CAPITAL COSTS</u>				
Capital Costs	\$0	\$5,000	\$185,300	\$359,100
Engineering Design (15%)	\$0	\$0	\$0	\$26,100
Project Management (20%)	\$0	\$1,000	\$37,100	\$71,900
Contingency (20%)	\$0	\$1,000	\$37,100	\$71,900
Subtotal Capital Costs	\$0	\$7,000	\$260,000	\$529,000
<u>ANNUAL O&M COSTS</u>				
Annual Costs	\$0	\$36,624	\$36,624	\$73,324
Reporting (20%)	\$0	\$14,000	\$14,000	\$14,000
Project Management (20%)	\$0	\$10,200	\$10,200	\$17,600
Subtotal Annual O&M Costs	\$0	\$61,000	\$61,000	\$105,000
<u>CLOSURE COSTS</u>				
Closure Costs	\$0	\$15,000	\$15,000	\$15,000
Reporting (15%)	\$0	\$2,300	\$2,300	\$2,300
Project Management (20%)	\$0	\$3,000	\$3,000	\$3,000
Subtotal Closure Costs	\$0	\$21,000	\$21,000	\$21,000
NET PRESENT VALUE OF TOTAL COSTS (Rounded)	\$0	\$500,000	\$744,000	\$1,360,000

Assumptions:

The discount rate used for calculation of the net present value was 5%.
MNA assumes 10 years of monitoring.

FIGURES



c:\acad\ 01-14443A\SLM THOMASTON CT.DWG

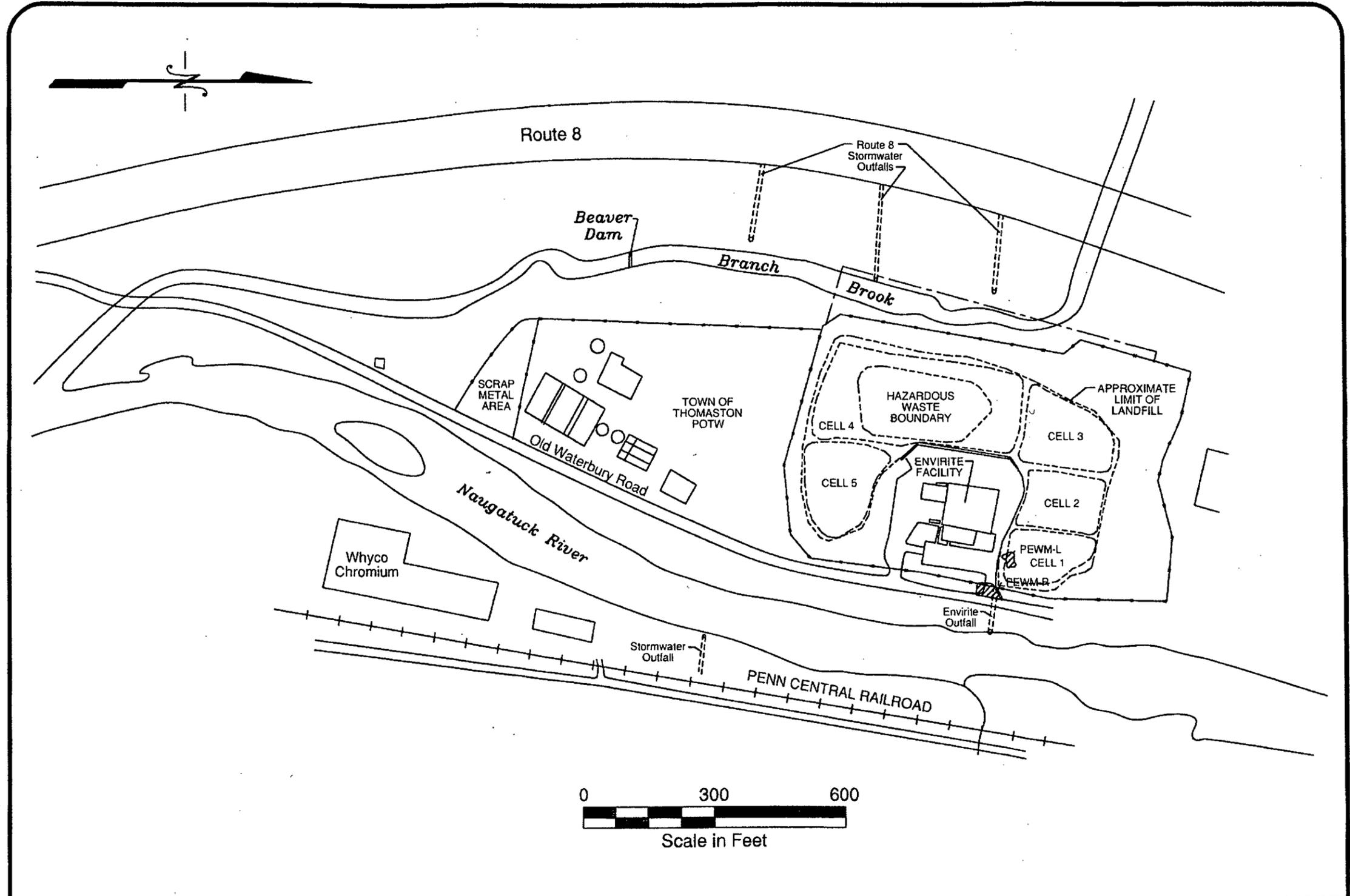
SOURCE: WWW.TOPOZONE.COM; MAPS A LA CARTE, INC.

ENVIRON

SITE LOCATION MAP
 ENVIRITE CORPORATION
 THOMASTON, CONNECTICUT

Figure

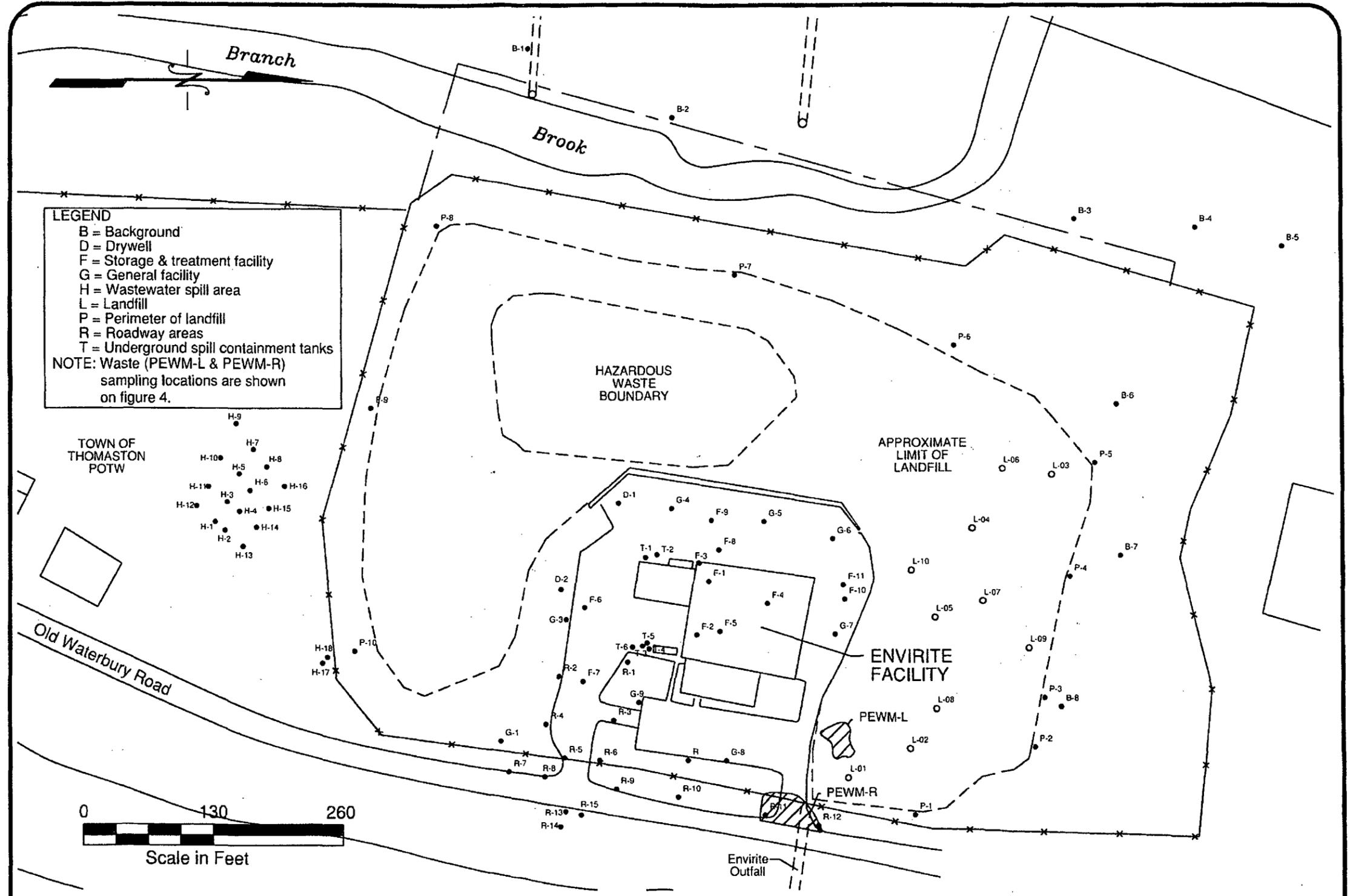
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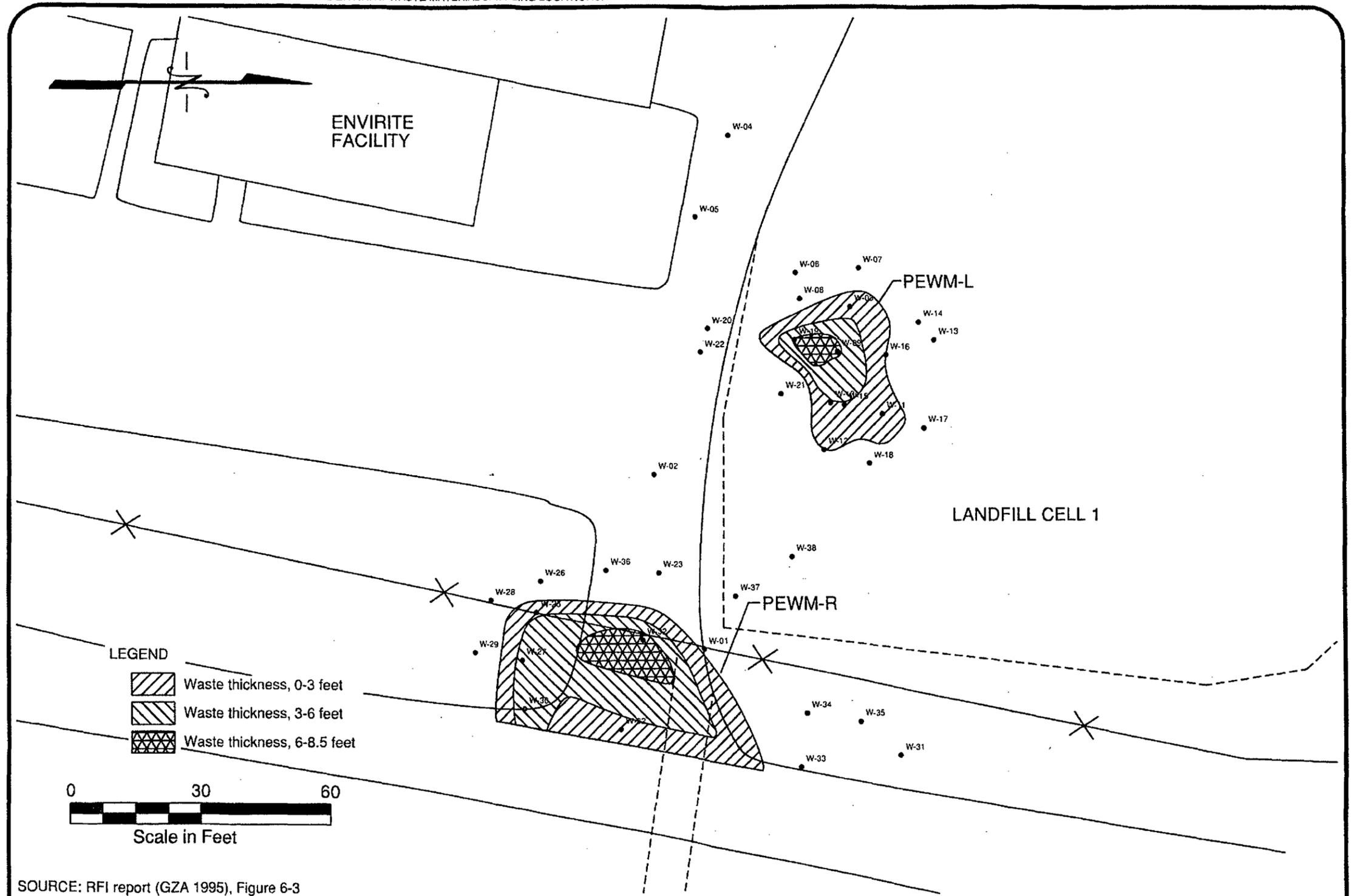


ENVIRON

SITE PLAN
ENVIRITE CORPORATION, THOMASTON, CONNECTICUT

Figure
2



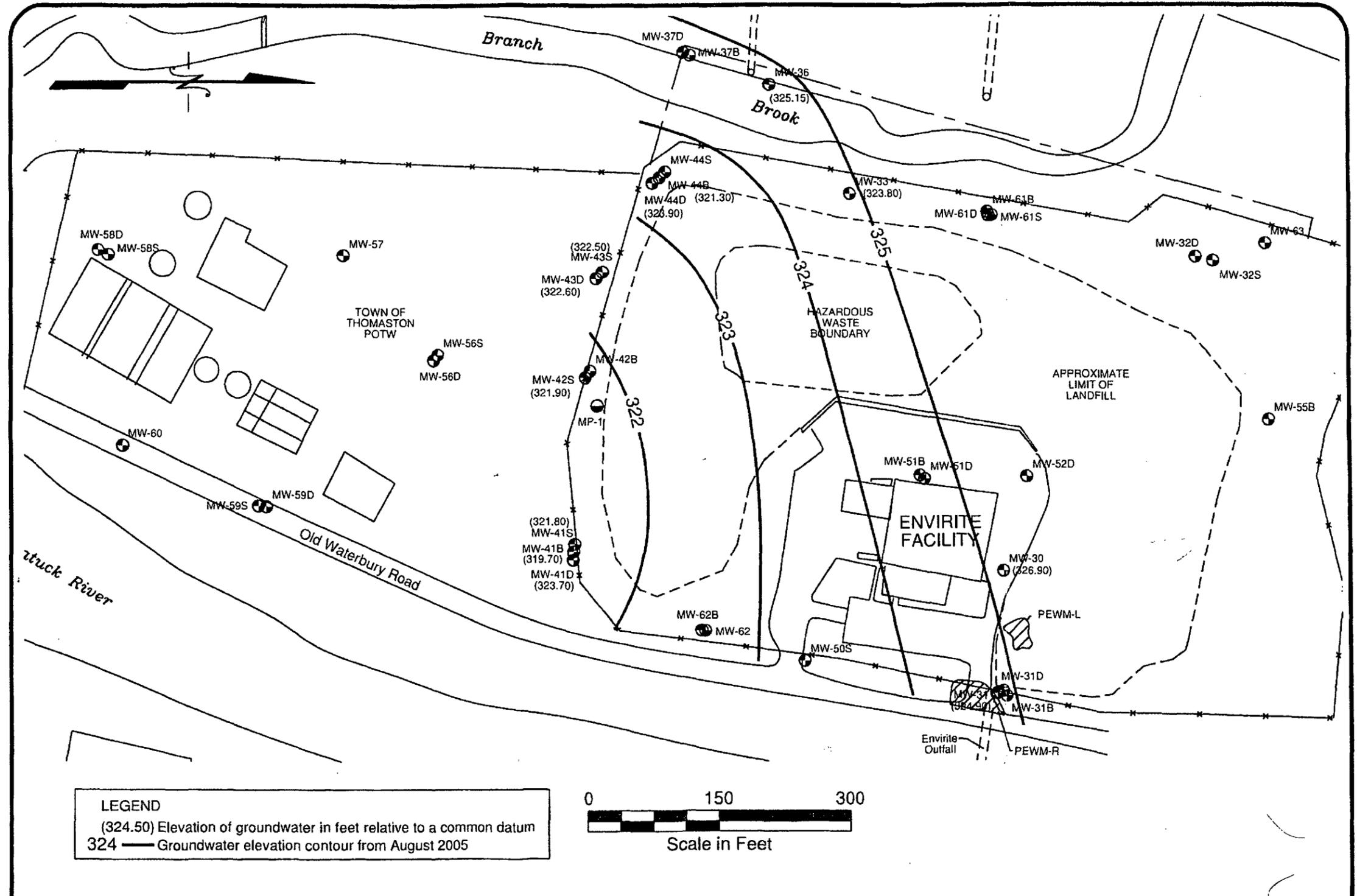


SOURCE: RFI report (GZA 1995), Figure 6-3

ENVIRON

PRE-ENVIRITE WASTE MATERIAL SAMPLING LOCATIONS
AND APPROXIMATE WASTE LOCATIONS
ENVIRITE CORPORATION, THOMASTON, CONNECTICUT

Figure
4



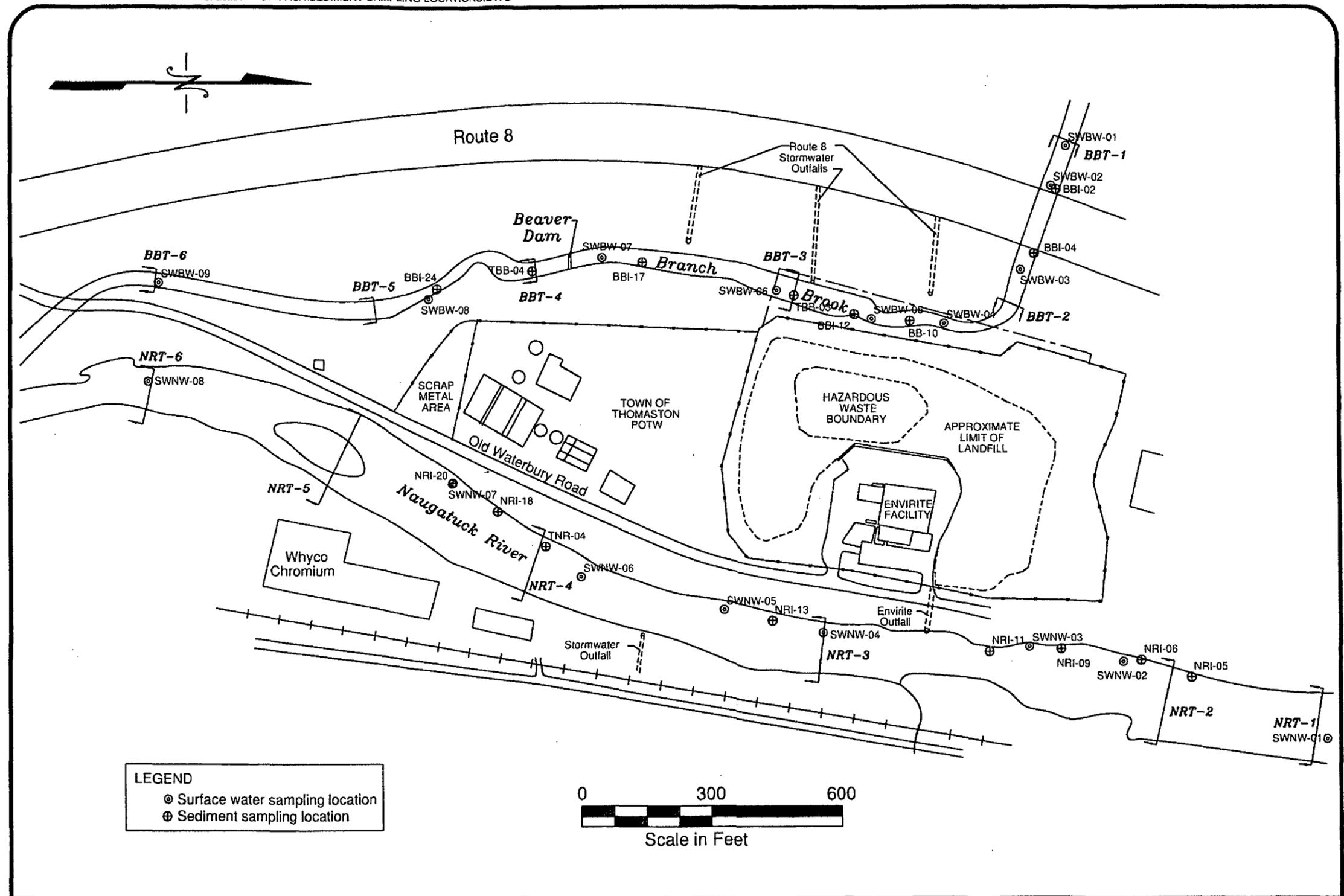
LEGEND
 (324.50) Elevation of groundwater in feet relative to a common datum
 324 — Groundwater elevation contour from August 2005

0 150 300
 Scale in Feet

ENVIRON

GROUND WATER SAMPLING LOCATIONS
 ENVIRITE CORPORATION, THOMASTON, CONNECTICUT

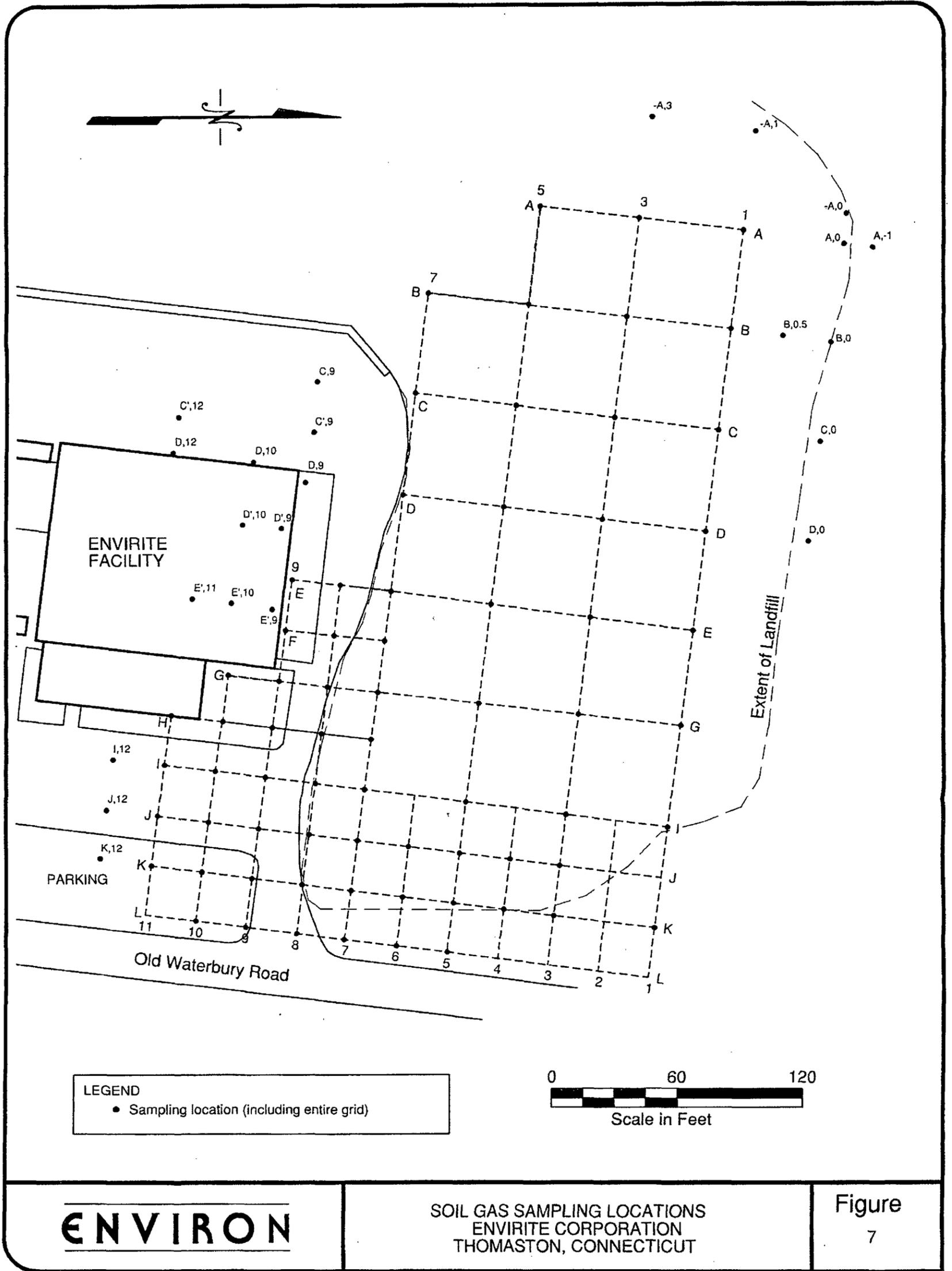
Figure
 5



ENVIRON

SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS
ENVIRITE CORPORATION, THOMASTON, CONNECTICUT

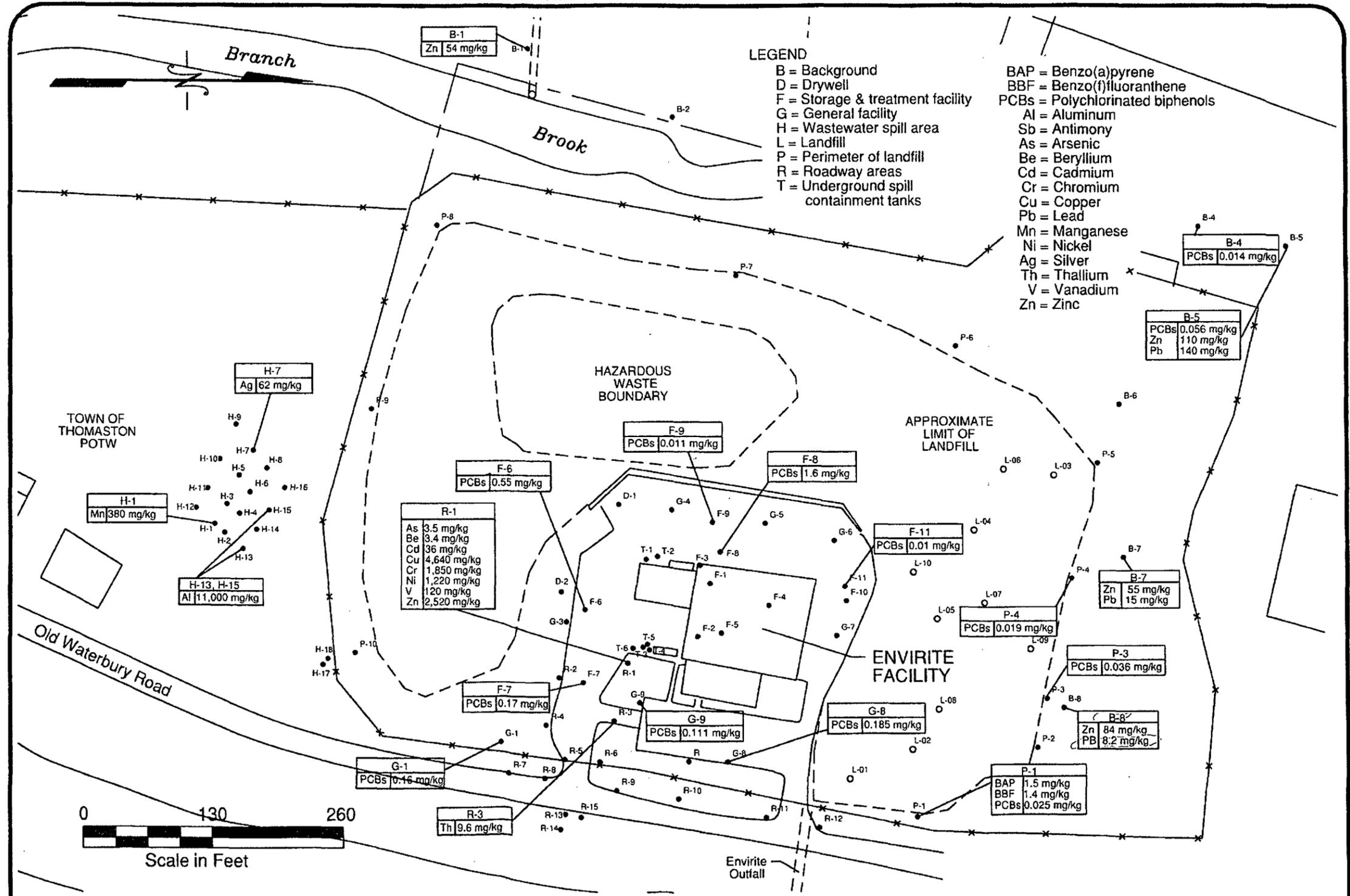
Figure



ENVIRON

SOIL GAS SAMPLING LOCATIONS
 ENVIRITE CORPORATION
 THOMASTON, CONNECTICUT

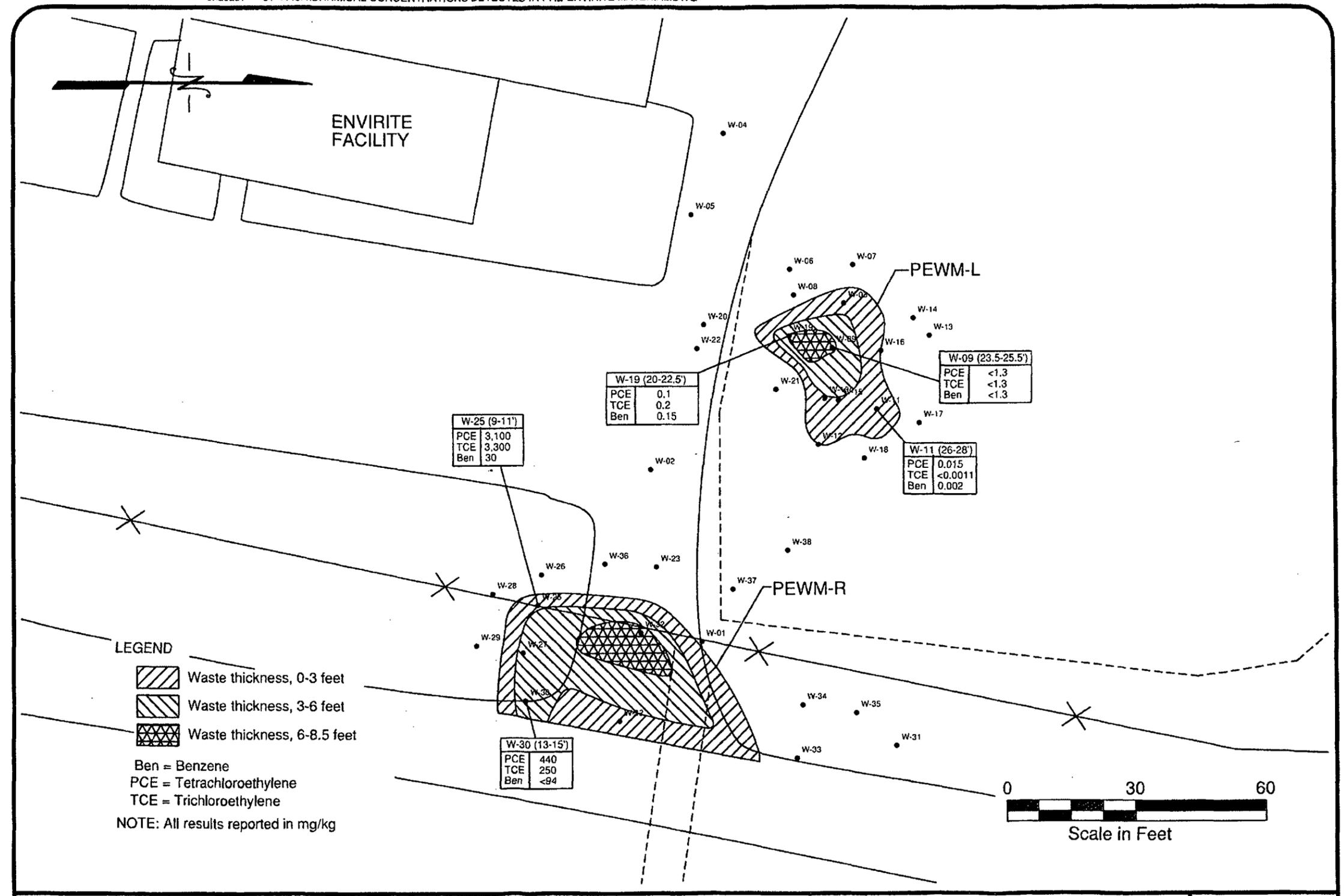
Figure
 7

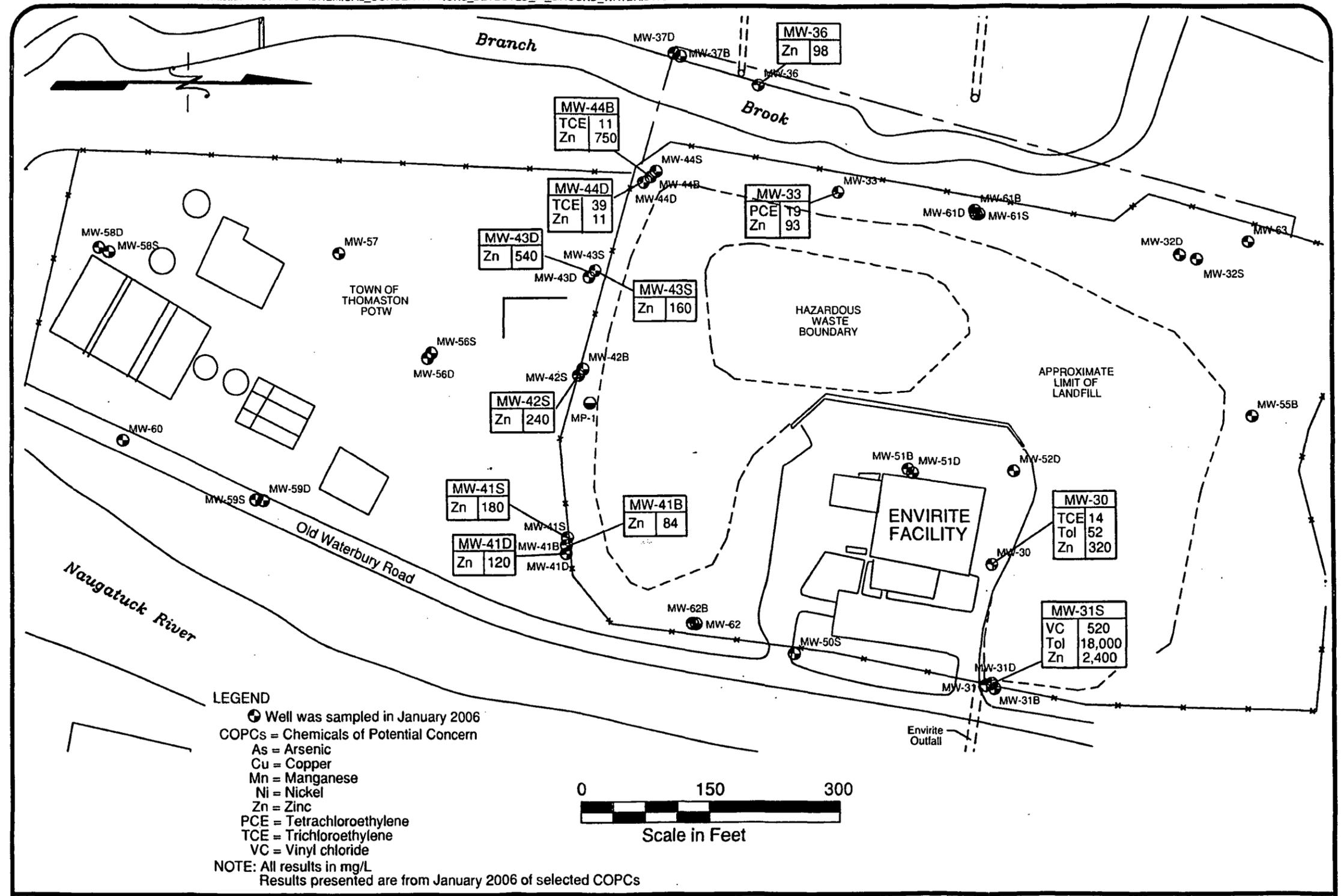


ENVIRON

MAXIMUM CHEMICAL CONCENTRATIONS DETECTED IN SURFICIAL SOIL
 ENVIRITE CORPORATION, THOMASTON, CONNECTICUT

Figure 8





APPENDIX A

Summary of Ground Water Analytical Results

APPENDIX B

Summary of Surface Water Analytical Results

APPENDIX C

Cost Breakdown of Removal Action Alternatives

Appendix C – Cost Breakdown of Remedial Action Alternatives

Former Envirite RCRA Facility
Thomaston, Connecticut

ELUR and Monitored Natural Attenuation					
Item Description	Unit	Quantity	Unit Rate	Subtotal	Assumptions/Notes:
Capital Costs:					
ELUR	LS	5,000	1.00	\$5,000	
SUBTOTAL				\$5,000	Rounded
Project Management (20%)				\$1,000	Rounded
Contingency (20%)				\$1,000	Rounded
CAPITAL COSTS				\$7,000	Rounded
Annual O&M Costs:					
Equipment Rental (pH, temp, conductivity, DO, ORP meters and dissolved gases collection equipment)	EA	4	300	\$1,200	Equipment rental for four quarters of sampling per year
VOCs by USEPA Method 624	EA	60	98	\$5,880	Laboratory Costs - Analysis of 12 wells and QC samples
Dissolved Metals	EA	60	136	\$8,160	Laboratory Cost - Analysis of select wells
Labor	HR	24	110	\$2,640	
General Minerals	EA	44	147	\$6,468	Laboratory Cost - Analysis of select wells
Sulfate, Sulfide, Nitrate and Nitrite by USEPA Method 300.0	EA	44	58	\$2,552	Laboratory Cost - Analysis of select wells
Total Dissolved Iron by USEPA Method 6010	EA	44	13	\$572	Laboratory Cost - Analysis of select wells
TOC by USEPA Method 415.1	EA	44	28	\$1,232	Laboratory Cost - Analysis of select wells
Dissolved Gases by Method RSK-175 (LHC, Ethylene, Ethane, Hydrogen)	EA	44	180	\$7,920	Laboratory Cost - Analysis of select wells
Reporting	EA	4	3500	\$14,000	
SUBTOTAL				\$50,700	Rounded
Project Management (20%)				\$10,200	Rounded
ANNUAL O&M COSTS				\$61,000	Rounded
Closure Costs					
Well Abandonment	EA	12	1,250	\$15,000	
SUBTOTAL				\$15,000	Rounded
Closure Reporting (15%)				\$2,300	Rounded
Project Management (20%)				\$3,000	Rounded
CLOSURE COSTS				\$21,000	Rounded
NET PRESENT VALUE OF TOTAL COSTS				\$489,000	Rounded, Assuming 10 Years of Monitoring, 7% discount rate

Appendix C – Cost Breakdown of Remedial Action Alternatives

Excavation of PEWM					
Item Description	Unit	Quantity	Unit Rate	Subtotal	Assumptions/Notes:
Capital Costs:					
Agency Coordination	EA	1	5,000	\$5,000	City Permits
Fencing	EA	3	65	\$195	Subcontractor's Estimate
Geophysical Survey	LS	1	2,750	\$2,750	Subcontractor's Estimate
Mobilization of Equipment	ELS	1	3,500	\$3,500	Subcontractor's Estimate
Hay Bales	EA	50	6	\$300	Subcontractor's Estimate
Water Truck	DAY	5	350	\$1,750	Subcontractor's Estimate
Heavy Equipment	DAY	5	3,850	\$19,250	Subcontractor's Estimate
Logging by Geologist	HR	75	80	\$6,000	Oversight and sampling during excavation
Sampling for Metals	EA	10	132	\$1,320	Laboratory Estimate
Sampling for VOCs	EA	10	80	\$800	Laboratory Estimate
Polyethylene sheeting	Roll	5	85.00	\$425	Subcontractor's Estimate
Asphalt Restoration	SF	2,400	6	\$14,400	
Waste Approval Analysis	EA	10	880	\$8,800	Subcontractor's Estimate
Asphalt transportaion and disposal	TON	54	85	\$4,590	Subcontractor's Estimate
Hazardous soil transportaion and disposal	TON	450	225	\$101,250	Subcontractor's Estimate, for disposal in the US (assuming waste fails TCLP for lead and PCE). Disposal in Canada \$195/ton. If the waste tests as non hazardous, the disposal price is \$85/ton.
Backfilling	TON	450	22.00	\$9,900	Subcontractor's Estimate
SUBTOTAL				\$180,300	Rounded
Project Management (20%)				\$36,100	Rounded
Contingency (20%)				\$36,100	Rounded
CAPITAL COSTS				\$253,000	Rounded

Appendix C – Cost Breakdown of Remedial Action Alternatives

Capping					
Item Description	Unit	Quantity	Unit Rate	Subtotal	Assumptions/Notes:
Capital Costs:					
Geotextile Filter (Cost & Installation)	SY	7,172	2.00	\$14,344	Landfill cost model 2002
Synthetic Membrane 30 mil PVC (Cost & Installation)	SY	7,172	3.00	\$21,517	Landfill cost model 2002
Drainage Net (Cost & Installation)	SY	7,172	6.00	\$43,033	Landfill cost model 2002
Filter fabric (Cost & Installation)	EA	2	3,000	\$6,000	Landfill cost model 2002
Cover Soil	CY	4,781	14.00	\$66,934	Landfill cost model 2002
Loam	CY	1,245	14.00	\$17,430	Landfill cost model 2002
Seeding & Mulch	AC	2	3,000.00	\$4,500	Landfill cost model 2002
SUBTOTAL				\$173,800	Rounded
Engineering Design (15%)				\$26,100	Rounded
Project Management (20%)				\$34,800	Rounded
Contingency (20%)				\$34,800	Rounded
CAPITAL COSTS				\$270,000	Rounded
Annual O&M Costs:					
Labor & Equipment Cost to Mow	AC	2	65	\$130	
Labor & Equipment Cost to Fertilize	AC	60	100	\$6,000	
Cap Repair	%	0.1	\$270,000	\$27,000	As 1% of cap installation
Cap Inspection	HR	32	110	\$3,520	
SUBTOTAL				\$36,700	Rounded
Project Management (20%)				\$7,400	Rounded
ANNUAL O&M COSTS				\$45,000	Rounded
NET PRESENT VALUE OF TOTAL COSTS				\$962,000	Rounded, Assuming 30 Years of O&M, 5% discount rate

Appendix C – Cost Breakdown of Remedial Action Alternatives

Acronyms:

CY: cubic yard

EA: each

g/kg: grams per kilogram

HRS: hours

LB: pound

LF: linear foot

LS: lump sum

PVC: poly vinyl chloride

RA: remedial alternative

TOC: total organic carbon

TPH: total petroleum hydrocarbons

USEPA: United States Environmental Protection Agency

VOCs: volatile organic compounds