FINAL REPORT

Feasibility Study Railroad Dry Cleaners (1-30-066) and Hercules Machine Sales (1-30-083) Sites Oceanside, New York

New York State Department of Environmental Conservation

November 2007

O'BRIEN & GERE

FINAL REPORT

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Feasibility Study
Railroad Dry Cleaners (1-30-066) and Hercules Machine Sales (1-30-083) Sites
Oceanside, New York

New York State Department of Environmental Conservation

November 2007

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DEC 04 2007
Hazardous Waste Remediation
NYSDEC Region 1

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New York State Department of Environmental Conservation
Division of Environmental Remediation
Remedial Bureau A, 11th Floor
625 Broadway, Albany, New York 12233-7015
Phone: (518) 402-9621 FAX: (518) 402-9627

Alexander B. Grannis
Commissioner

November 28, 2007

Mr. Bill Fonda
NYSDEC - Region 1
Loop Road, Bldg. 40
Stony Brook, New York 11790-2356

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DEC 04 2007
Hazardous Waste Remediation
NYSDEC Region 1

Re: Railroad Dry Cleaners Site (1-30-066)
Hercules Machine Sales Site (1-30-083)

Dear Mr. Fonda:

Enclosed is the Feasibility Study Report for the above mentioned sites. As the Region 1 office is a document repository for this site, please make this document available to the public.

Sincerely,

Jeffrey Dyber
Environmental Engineer 2
Remedial Section A

Enclosure

Job No. 10653/37556

FINAL REPORT

Feasibility Study
Railroad Cleaners and Hercules Machines Site
Oceanside, New York

New York State Department of Environmental Conservation

Douglas M. Crawford, Vice President
O'Brien & Gere Engineers, Inc.

November 2007

O'BRIEN & GERE

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1. Introduction

1.1. Purpose

The purpose of this report is to present the Feasibility Study for the Railroad Dry Cleaners (Railroad) Site and Hercules Machine Sales (Hercules) Site. The Railroad Site (1-30-066) and Hercules Site (1-30-083) are listed as Class 2 sites in the New York Registry of Inactive Hazardous Waste Sites. The sites are located in the Hamlet of Oceanside, Town of Hempstead, Nassau County, New York. A site map is provided as Figure 1.

1.2. Site Background

On behalf of the New York State Department of Environmental Conservation (NYSDEC), O'Brien & Gere Engineers, Inc. performed a Remedial Investigation (RI) to investigate the nature and extent of environmental contamination at the sites. The results of the RI were documented in a RI Report (O'Brien & Gere 2007). Following the RI, O'Brien & Gere performed a Feasibility Study (FS) to evaluate remedial alternatives for the sites. NYSDEC provided O'Brien & Gere several files and reports pertaining to previous investigations conducted at the Railroad and Hercules Sites. The previous investigations conducted at the sites, as depicted in the files supplied by NYSDEC, are also described briefly in the RI Report.

As documented in the RI Report, the Railroad Site has been operated as a dry cleaners and shirt laundry at 3180 Lawson Boulevard since 1963/1964 (EEA, 2003). Around 1988, the building and the interest in Hercules Laundry Machinery Co., Inc. was sold. Around 1995, a new corporation, Hercules Machinery Sales, Inc., was formed and operated at the 3188 Lawson Boulevard address. Hercules Machinery Sales supplied and repaired dry cleaning equipment at the site until 1999, when Hercules Dry Cleaning Equipment, Inc. was formed. Hercules Dry Cleaning Equipment operated at the site until April 2002, when the building was leased to Rightway Air Conditioning and Heating.

1.3. Summary of Remedial Investigation

1.3.1. Previous Investigations at the Railroad Site

Following removal of a fuel oil underground storage tank (UST), Richard D. Galli, P.E. (RDG) performed a Phase I RI at the Railroad Site in June 1989. Soil samples collected near the former tank location contained concentrations of tetrachloroethene (PCE) up to 1,100,000 micrograms per kilogram (ug/kg) and smaller amounts of trichloroethene (TCE). Soil and ground water was sampled as part of a Phase II RI in 1990. During the Phase II RI, PCE was detected at up to 265 ug/kg in soil and up to 10,000 micrograms per liter (ug/L) in ground water. Fuel oil constituents including toluene, ethylbenzene, and total xylene were also detected in soil borings. Benzene was also detected in ground water. In August 1990, Nassau County Department of Health (NCDOH) directed the facility to investigate and remediate the fuel oil and PCE contamination in and around the site. After the facility failed to complete the remedial activities requested by NCDOH, the County nominated the site to NYSDEC for inclusion in the New York State Registry of Inactive Hazardous Waste Disposal Sites. (NCDOH 1988, 1990; RDG 1989a, 1989b, 1990)

EEA, Inc. prepared a RI/FS Work Plan for further work at the Railroad Site in 2003. The first phase of the RI consisted of the collection of soil gas samples from 0 to 2 inches below ground surface (bgs) and analysis in the field by a flame ionization detector (FID) and organic vapor monitor (OVM). Air samples at the two locations with the highest field readings, located south and southwest of the former tank location, were collected via carbon/porpack cartridges and analyzed for volatile organic compounds (VOCs). High concentrations of PCE and PCE-degradation products were detected. (EEA 2003a, 2003b)

Based on results of the soil gas sampling, EEA performed a second phase of the RI in 2004 that consisted of further soil and ground water sampling. Soil samples collected south of the former UST contained high concentrations of PCE and degradation products (TCE and cis-1,2-DCE) in the shallow interval and much lower concentrations in the deeper interval. Elevated concentrations of PCE were found in ground water samples collected south of the former UST; TCE, cis-1,2-dichloroethene (DCE), and vinyl chloride were also present. PCE, TCE, and cis-1,2-DCE were present in the deeper soil samples collected west of the building. Remaining borings contained high levels of PCE in soil and shallow ground water, with lesser concentrations of degradation products. The presence of degradation products and distribution throughout the water column may indicate that the source of contamination west of the building may be older when compared to that found at other sample locations. (EEA 2004a, 2004b)

1.3.2. Previous Investigations at the Hercules Site

In 1992, NCDOH found activated carbon, likely from solvent recovery filters used in the dry cleaning process, on unpaved ground behind the Hercules building. Subsequent sampling indicated levels of PCE and degradation products in soil and ground water in excess of guidance values and ground water standards. These results initiated additional investigations at the Hercules Site.

In 1995, NCDOH collected and analyzed samples of activated carbon, soil, and ground water from the Hercules Site. Analytical results indicated PCE, TCE, and cis-1,2-DCE concentrations well above NYSDEC Technical Administrative Guidance Memorandum (TAGM) 4046 recommended soil cleanup objectives. PCE, TCE, cis-1,2-DCE, trans-1,2-DCE and vinyl chloride were detected in ground water samples collected from two downgradient monitoring wells. Based on these results, NYSDEC listed the Hercules Site in the New York State Registry of Inactive Hazardous Waste Disposal Sites as a Class 2 site. (NCDOH 1995)

Soil gas samples and soil samples were collected as part of a RI/FS Work Plan prepared for the Hercules Site by CA Rich Consultants, Inc. (CAR). To the west of the building, high concentrations of total organic vapor was measured by a PID. Laboratory analysis of soil samples confirmed high concentrations of PCE. Badge samples indicated interior and exterior air concentrations. Soil gas samples contained high concentrations of PCE, corresponding to soil boring locations where high PCE concentrations were encountered. No additional soil or ground water sampling was conducted as originally proposed in the RI/FS Work Plan. (CAR 2003, 2004)

1.3.3. O'Brien & Gere Remedial Investigation

O'Brien & Gere prepared a RI/FS Work Plan for both the Railroad and Hercules Sites in 2006, which was subsequently approved by NYSDEC. The RI consisted of the following activities:

- Literature search
- Well survey
- Base map development
- Monitoring well installation and development
- Water level monitoring
- Ground water sampling
- Soil vapor screening and sampling
- Soil vapor intrusion sampling
- Surveying

The RI concluded that, consistent with previous investigations, PCE, TCE, cis-1,2-DCE and vinyl chloride are the primary VOCs detected in ground water. The dissolved phase VOCs detected in the ground water above ground water standards are limited horizontally to a relatively narrow plume (i.e., 250 feet (ft) wide) extending lengthwise from the on-site source area west-southwest toward the East Rockaway Channel. The dissolved phase VOC plume was also found to thin and get deeper as it migrates to the west of the sites.

Based on results of the soil vapor intrusion (SVI) investigation and according to the NYSDOH guidelines for evaluating SVI, which are based on relationships between indoor air and sub-slab soil vapor samples collected at a given structure, the site building matches the criteria for mitigation. (NYSDOH 2006)

1.4. Conceptual Site Model

The Railroad Cleaners Site and the Hercules Site are located adjacent to each other and consist of two small building lots with a single story rectangular-shaped building occupying most of the sites. The building on the Hercules Site shares a common wall with the building on the Railroad Site to the north and with another business located to the south. The sites are located in a mixed-use neighborhood of retail businesses, houses, apartments, and commercial establishments. The topography of the sites and surrounding properties is relatively level, sloping gently from about 5 ft amsl at the sites westward to the East Rockaway Channel and southward to the Reed Channel which are located approximately 1,200 and 1,500 ft west and south of the sites, respectively.

Dry cleaning operations and dry cleaning equipment sales and repair operations have been conducted at the sites since 1963/1964. Historical data as well as data collected during this RI confirm that concentrations of PCE and related degradation products have been detected in soil and ground water at the Railroad and Hercules Sites. The nature of the release of contamination at the sites is unknown, however; soil vapor, soil and ground water quality data confirm that the probable source area is located beneath the buildings and along the western side of the properties.

The geology at the sites consists of three units of unconsolidated glaciofluvial deposits. These include in descending order, coarse to fine grained sand with some gravel (sand and gravel unit); discontinuous low permeability clay (clay unit); and medium to fine grained sand interbedded with varying amounts of clay, silt and organic material (sand unit). The sand and gravel unit was observed to range in thickness from approximately 66 to 117 ft. The clay unit encountered at the sites was observed to be thickest in the area of the sites and pinches out to the west and re-appears further west near the East Rockaway Channel. The observed thickness of the clay unit ranges from 3.5 ft to 18.0 ft where it is present.

The hydrogeologic system in the vicinity of the sites includes two hydrogeologic units: the shallow unconsolidated hydrogeologic unit and the deep unconsolidated hydrogeologic unit. The shallow unconsolidated unit is composed of coarse to fine grained sand and some gravel and is located within the Upper Glacial Aquifer. The deep unconsolidated hydrogeologic unit is composed of medium to fine grained sand inter-bedded with varying amounts of clay, silt and organic material and is located within the Magothy Aquifer. Depth to ground water ranges from about 1.4 ft to 6.2 ft bgs.

Ground water flow across the sites is generally to the west-southwest toward the East Rockaway Channel. Ground water levels in the uppermost part (*i.e.*, "A" Interval and "B" Interval) of the shallow unit are influenced by tidal fluctuations from the East Rockaway Channel. On average, a 0.5-foot water level fluctuation was observed with tidal fluctuations at monitoring wells MW-4 and MW-5 located approximately 500 ft east of the East Rockaway Channel and a 0.1-foot water level fluctuation was observed with tidal fluctuations at monitoring wells MW-1 and MW-2 located approximately 1,200 ft east of the East Rockaway Channel. A vertical influence from tidal fluctuations at the East Rockaway Channel was also observed between the "A" Interval and "B" Interval at monitoring wells located nearby the East Rockaway Channel (*i.e.*, MW-12, MW-19, MW-20, MW-21, and MW-23). Despite the vertical influences, tidal fluctuations do not alter the direction of ground water flow in the vicinity of the sites.

The four primary VOC constituents detected at the Railroad and Hercules sites are PCE, TCE, cis-1,2-DCE and vinyl chloride. Based on the hydrogeologic setting and distribution of COCs, three separate areas were identified: upgradient; on-site; and, off-site. No COCs were observed above ground water standards in the wells located upgradient of the sites., COCs were observed in the downgradient wells located on-site and off-site.. Similarly, PCE was observed in every soil sample collected from both the Hercules and the Railroad Sites, with several concentrations of TCE and cis-1,2-DCE detected as well.

As shown on Figure 3, the COCs detected in ground water above ground water standards are limited horizontally to a relatively narrow (*i.e.*, 250 ft wide) plume extending lengthwise from the on-site source area west-southwest toward the East Rockaway Channel. A geologic cross-section drawn along the axis of the VOC plume is presented in Figure 4 and shows the total concentration of the COCs detected in monitoring well Intervals A through H within the plane of the section. The cross-section of the COC plume shows that the highest combined concentrations of COCs are located in the vicinity of the sites and that COC concentrations decrease downgradient towards monitoring well MW-23. Also shown in the cross-section is that the core of the COC plume thins and gets deeper further to the west.

No potable water wells were identified within a 1-mile radius of the sites. The VOC ground water plume appears to be migrating to the west of the Site in the general direction of the East Rockaway Channel. The top of the VOC plume is deeper than the bottom of the East Rockaway Channel; therefore, the VOC plume does not appear to be discharging into the water body. No other sensitive receptors were identified immediately downgradient of the plume.

Based on the results of the soil vapor intrusion (SVI) investigation, conducted as part of the RI, and according to the NYSDOH guidelines for evaluating SVI which are based on relationships between indoor air and sub-slab soil vapor samples collected at a given structure, the on-site area (*i.e.*, the Hercules structure) matches the criteria for mitigation.

The qualitative human health exposure assessment evaluated the potential for receptors to be exposed to site-related constituents. The potential for receptors to be exposed to site-related constituents have been identified. The on-site receptors include patrons and workers at Railroad Dry Cleaners and Hercules Machine Sales, as well as utility or construction workers working on the sites. The off-site receptors include patrons, workers, and local residents (adults and children) occupying the nearby residential or commercial properties, as well as utility workers or other contractors working on or adjacent to the off-site properties. The potential exposure pathways identified for the sites are described in Section 1.5.

1.5. Human Health Risk Assessment

As part of the RI, a qualitative exposure pathway analysis was performed for the sites to evaluate the potential for human contact with site constituents. Following is a summary of the potentially complete pathways.

1.5.1. Potentially Complete Pathways

Potentially complete exposure pathways identified in the Exposure Pathway Analysis Report (EPAR) included the following:

Current and Future Potential On-Site Exposure Pathways

- Ingestion and dermal contact of subsurface soil by adult utility contractor or construction worker.
- Inhalation of air from open trenches/excavations by adult utility contractor or construction worker or patron.
- Inhalation of indoor air (vapor intrusion) by workers or patrons of Railroad Dry Cleaners and Hercules Machine Sales.
- Ingestion and dermal contact with site ground water by adult (utility contractor or construction worker).

Current and Future Potential Off-Site Exposure Pathways

- Ingestion and dermal contact with ground water by adult construction worker
- Inhalation of air from open trenches/excavations by adult utility contractor or construction worker or residents
- Inhalation of indoor air (vapor intrusion) by workers in commercial buildings and in adult, adolescent, and child residents.

2. Development of Remedial Alternatives

The objective of this phase of the FS was to develop a range of remedial alternatives for the sites. The process for development of alternatives consisted of six steps:

- identification of potential standards, criteria and guidance (SCGs)
- development of remedial action objectives (RAOs)
- identification of general response actions
- identification of areas or volumes of media
- identification, screening, and evaluation of remedial technologies and process options
- assembly of remedial alternatives.

2.1. Identification of Potential Standards, Criteria and Guidance (SCGs)

NYSDEC evaluates compliance with SCGs, as such, SCGs will be evaluated for these sites. There are three types of SCGs: chemical-, location-, and action-specific SCGs. Chemical-specific SCGs are health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to the ambient environment. Location-specific SCGs set restrictions on activities based on the characteristics of the sites or immediate environs. Action-specific SCGs set controls or restrictions on particular types of remedial actions once the remedial actions have been identified as part of a remedial alternative. The identification of potential SCGs is documented in Table 1.

2.2. Development of Remedial Action Objectives

Remedial action objectives are medium-specific goals for protecting human health and the environment. These remedial action objectives form the basis for the FS by providing overall goals for site remediation. The remedial action objectives are considered during the identification of appropriate remedial technologies and formulation of alternatives for the sites, and later during the evaluation of remedial alternatives.

Remedial action objectives are based on risk-based information established in the risk assessment, and potentially applicable or relevant and appropriate qualitative SCGs. Documentation of the rationale employed in the development of the RAOs for the sites is presented in the following sections.

2.2.1. Remedial Action Objectives for Soil

Soil was not investigated as part of the RI, but was investigated in previous investigations as summarized in Sections 1.3.1 and 1.3.2. Soil concentrations were compared to TAGM #4046 screening values in previous investigations. Since completion of the soil investigations, New York State has promulgated 6 NYCRR Part 375. 6 NYCRR Part 375-6 provides soil cleanup objectives for various different property uses that became effective on November 14, 2006. 6 NYCRR Part 375-6 "applies to the development and implementation of remedial programs" and provides soil cleanup objectives for the following re-uses: unrestricted, residential, restricted residential, commercial, industrial, and for the protection of ground water and ecological receptors. A comparison of COCs in soil to the soil cleanup objectives is presented on Figures 5 and 6.

The sites are currently used as commercial buildings located in a mixed-use neighborhood of retail businesses, houses, apartments, and commercial establishments. As such, site soil data collected from previous investigations were compared to soil cleanup objectives for unrestricted use. Analytical results for soil at the sites were above cleanup levels for unrestricted use in some samples.

As documented in the RI Report and summarized in Section 1.5, a potentially complete exposure pathway exists for ingestion and dermal contact of subsurface soil by adult utility contractor or construction worker.

Accordingly, the RAOs identified for soil consist of:

- Attain, to the extent practicable, Part 375 soil cleanup objectives for unrestricted use for subsurface soil on-site
- Minimize, to the extent practicable, direct contact with on-site subsurface soil that could result in unacceptable health risks.

2.2.2. Remedial Action Objectives for Ground Water

Analytical results indicate the presence of site-related COCs in samples collected from both on-site and off-site ground water wells. The NYS Class GA ground water standards and guidance values from NYSDEC TOGS 1.1.1 are identified as potential SCGs. COCs detected in ground water above ground water standards are limited horizontally; the plume is relatively narrow, extending lengthwise from the on-site source area west-southwest toward the East Rockaway Channel. No potable water wells were identified within a 1-mile radius of the sites. The top of the plume is deeper than the bottom of the East Rockaway Channel; therefore, the VOC plume does not appear to be discharging into the water body.

As documented in the RI Report and summarized in Section 1.5, a potentially complete exposure pathway exists for direct contact with ground water by construction workers performing excavation both on-site and off-site within the area of the ground water plume.

Accordingly, the RAOs identified for ground water consist of:

- Attain, to the extent practicable, Class GA ground water standards or guidance values from NYSDEC TOGS 1.1.1.
- Minimize, to the extent practicable, contact with ground water that would result in unacceptable health risks.

2.2.3. Remedial Action Objectives for Air

Results of indoor air and sub-slab samples for the eight studied structures were compared to the decision-making matrices presented in New York State Department of Health (NYSDOH) *Guidance for Evaluating Vapor Intrusion in the State of New York* (NYSDOH 2006), identified as a potentially applicable SCG for the sites. Comparison of data from these structures to the matrices indicated that the on-site Hercules building requires mitigation.

As documented in the RI Report and summarized in Section 1.5, a qualitative exposure pathway analysis was performed for the sites. This analysis identified inhalation of air from open trenches/excavations by adult utility or construction workers both on-site and off-site as a current and future potentially complete exposure pathway for construction or utility workers. In addition, the analysis identified the potential for occupants of both commercial and residential structures to inhale indoor air originating from ground water containing VOCs.

Accordingly, RAOs identified for soil vapor/indoor air consist of:

- Achieve, to the extent practicable, conformance with the NYSDOH vapor intrusion guidance values.
- Minimize, to the extent practicable, vapor intrusion from the subsurface.
- Minimize, to the extent practicable, inhalation of on-site and off-site air present in construction trenches/excavations that would result in unacceptable health risks.
- Minimize, the extent practicable, inhalation of indoor air by workers and visitors in commercial buildings.
- Minimize, to the extent practicable, potential inhalation of indoor air by occupants of residences.

2.3. Identification of Areas and Volumes of Media

Site conditions, the nature and extent of contamination, and preliminary remediation goals were taken into consideration to estimate the volumes and areas of media to be addressed by the general response actions.

The ground water plume is approximately 1,100 ft in length with an average width of about 250 ft, spanning nearly 6 acres. The maximum depth of the majority of plume is about 100 ft, with one detection around 110 ft below grade. As indicated on Figure 4, the plume contains one "hotspot" with ground water concentrations of total COCs in excess of 10,000 µg/L. Plume Area A ground water is defined as ground water west of the buildings with COC concentrations greater than 1,000 µg/L, as depicted on Figure 3. Plume Area B ground water is defined as ground water west of Plume Area A with COC concentrations less than 1,000 µg/L. Assuming a porosity of 30%, the estimated total volume of ground water exceeding the ground water standards is 62 million gallons.

The Railroad Site measures approximately 35 ft by 100 ft, with a rectangular-shaped building occupying most of the sites. The Hercules Site measures approximately 40 ft by 100 ft with a rectangular-shaped building. The building on the Hercules Site shares a common wall with the building on the Railroad Site to the north and with another building to the south. A paved parking lot is located between the buildings and the railroad tracks to the west. Based on historical soil data presented on Figures 5 and 6, it is estimated that approximately 280 cubic yards of soil down to the ground water table at approximately 3 ft below ground surface exhibit concentrations in excess of Part 375 soil cleanup objectives for unrestricted use. The area of impacted soil was assumed to extend just east of sample locations B-4 and B-5 and just west of B-3 (approximately 67 ft by 37 ft).

Eight structures that exist within the approximate area of the off-site plume were investigated for vapor intrusion. Based on the NYSDOH guidance, one of these structures (the on-site Hercules building) requires mitigation.

2.4. Identification of General Response Actions

General response actions are medium-specific actions that may be combined into alternatives to satisfy the remedial action objectives. General response actions that address the remedial action objectives related to the site media include institutional controls, containment, removal, disposal, reuse, and treatment. General response actions applicable to the sites are included in Table 2.

2.5. Physical and Technical Limits to Remediation

Site conditions present challenges to implementation of ground water and soil remediation at the sites. Specifically, the following physical characteristics exist at the sites:

- The ground water VOC plume extends under several blocks of residential areas. This presents challenges to the siting of injection or extraction wells, associated piping, and treatment systems.
- The depth to ground water is approximately 3 to 5 ft below grade. Additionally, much of the Site is covered by buildings. These present challenges to treatment of contaminated soil.

2.6. Identification and Screening of Remedial Technologies and Process Options

Potentially applicable remedial technology types and process options for each general response action were identified during this step. Process options were screened on the basis of technical implementability. The technical implementability of each identified process option was evaluated with respect to site contaminant information, site physical characteristics, and areas and volumes of affected media.

Descriptions and screening comments for technologies and process options identified for the sites are presented in Table 2. Process options that were viewed as not implementable for the sites were not considered further in the FS. Following are descriptions of technologies that were considered potentially implementable for the sites.

2.6.1. Air/Vapor

No action. The no action general response action must be considered in the FS, as specified in the NCP (40 CFR Part 300.430).

Institutional actions. The remedial technologies associated with the institutional general response action that was identified for the sites were monitoring and access restrictions. Access restrictions identified consist of environmental easements.

- **Air/vapor monitoring.** Monitoring of sub-slab vapor, indoor air, and ambient air sampling would be conducted to evaluate VOC concentrations in indoor air and sub-slab soil vapor. Air monitoring could also provide a means to detect changes in VOC concentrations to evaluate if existing mitigation systems are functioning as desired.

- **Environmental easement.** With respect to indoor air, land use restrictions would be reflected in the property deed. The environmental easement would preclude the use of a building influenced by vapor intrusion unless the building is proven to be in compliance with recommendations set forth in applicable guidance. Compliance status would be subject to review and approval by NYSDOH.

Control actions. The remedial technology related to the control of sub-slab vapors and vapor intrusion at the sites that was considered potentially applicable is described as follows.

- **Pumping/Ventilation (Sub-Slab Depressurization).** Pumping to ventilate the sub-slab of a building would involve the installation of a soil vapor extraction well through the slab and a blower to exert a vacuum to depressurize the sub-slab environment. Sub-slab depressurization is identified as the most effective means of mitigating vapor intrusion in the NYSDOH's *Guidance for Evaluating Soil Vapor Intrusion in the State of New York* (NYSDOH 2006).

Ex situ treatment actions. Physical treatment was identified as the potentially implementable remedial technology associated with the *ex situ* treatment general response action for soil vapor/indoor air. The process option considered potentially implementable for *ex situ* treatment was carbon adsorption.

Carbon adsorption. Activated carbon can readily adsorb organic contaminants from the vapor phase collected by a pumping/ventilation (sub-slab depressurization) system onto its surfaces during contact. The carbon must be periodically replaced, regenerated, treated, and/or disposed. Regeneration is accomplished off-site at a permitted commercial hazardous waste carbon regeneration facility. Spent carbon would be disposed of off-site at a permitted commercial hazardous waste facility.

2.6.2. Soil

No action. The no action general response action must be considered in the FS, as specified in the NCP (40 CFR Part 300.430).

Institutional actions. The remedial technology associated with the institutional general response action that was identified for the sites was access restrictions. Access restrictions identified consist of an environmental easement and fencing. The process options considered potentially applicable are described as follows.

- **Environmental easement.** With respect to contaminated soil, land use restrictions would be reflected in the property deed. The environmental easement would preclude activities that would potentially expose contaminated materials (and require health and safety precautions) without prior review and approval by NYSDEC.

- **Fencing**. Fencing at the sites would limit access to the source area and thereby minimize contact with contaminated soil.

Containment action. The remedial technology associated with the containment general response action that was identified for the sites was capping. The process option that is currently implemented is described below.

- **Asphalt cover.** The sites are currently completely covered by a parking lot, the building, and a sidewalk. Asphalt effectively minimizes contact with contaminated soils and stabilizes soil thereby limiting the spread of contaminants.

Removal action. The remedial technology associated with the removal general response action that was identified for the sites was excavation. The process option considered potentially applicable is described below.

- **Excavation.** Construction equipment, such as backhoes or bulldozers would be used to remove contaminated soil from the sites.

Disposal action. The remedial technology associated with the disposal general response action that was identified for the sites was land disposal. The process option considered potentially applicable is described below.

- **Off-site commercial landfill.** Excavated soil would be transported off-site and disposed of at a commercial landfill.

In situ and ex situ treatment actions. In situ physical, *in situ* biological, *ex situ* physical, *ex situ* chemical, *ex situ* biological, and *ex situ* thermal remedial technologies were identified as the potentially applicable for the treatment general response action. The process options considered potentially applicable are described below.

- **Soil Vapor Extraction (SVE).** SVE is an *in situ* unsaturated (vadose) zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile contaminants from the soil.

- ***In situ* soil flushing.** *In situ* soil flushing is the extraction of contaminants from the soil with water or other suitable aqueous solutions. The extraction fluid is passed through in-place soils using an injection or infiltration process. Extraction fluids are recovered from the underlying aquifer.

- ***In situ* enhanced biological treatment.** Natural degradation of VOCs in soil by biological organisms naturally present in the soil enhanced by external application of oxygen and/or nutrients.

- ***Ex situ* soil washing.** Soil washing is a physical treatment process that involves the separation/segregation and volumetric reduction of contaminants in soil. The process involves high energy contacting and mixing of excavated soil with an aqueous-based washing solution in a series of mobile washing units. The soil washing process separates fine-grained soil, which constituents are typically concentrated in, form coarser-grained soil. The aqueous-based washing solution would require further management.

- ***Ex situ* chemical extraction.** Waste contaminated soil and extractant are mixed in an extractor, thereby dissolving the contaminants. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use.

- **Biopiles.** Excavated soils are mixed with soil amendments and placed in aboveground enclosures. It is an aerated static pile composting process in which compost is formed into piles and aerated with blowers or vacuum pumps.

- ***Ex situ* thermal desorption.** Thermal desorption is a physical separation process and is not designed to destroy organics. Wastes are heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to the gas treatment system. The bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them.

- **Incineration.** Combustion of organic contaminants present in soil in on-site or off-site commercial incinerator.

2.6.3. Ground Water

No action. The no action general response action must be considered in the FS, as specified in the NCP (40 CFR Part 300.430).

Institutional controls. Monitoring and an environmental easement were identified as the potentially implementable remedial technologies associated with the institutional general response action for ground water.

- **Monitoring**. Ground water monitoring would involve periodic sampling and analysis of ground water. Ground water monitoring would provide a means of detecting changes in constituent concentrations in the ground water.

- **Environmental easement**. Currently, ground water is not used as a potable water source. An environmental easement could be implemented to prohibit the use of ground water, as well as to prohibit well drilling. In addition, an environmental easement could preclude excavation and construction activities that would expose workers without proper protective equipment to affected ground water.

Containment. A vertical barrier was identified as the potentially implementable remedial technology associated with the containment general response action for ground water. The process option considered potentially implementable for ground water containment was recovery wells.

- **Recovery wells.** Contaminated ground water would be pumped from the recovery wells for hydraulic containment. A pumping test would be required to identify locations for extraction wells and evaluate appropriate pumping rates and/or levels to minimize migration of contaminated ground water from source areas.

Collection. Ground water extraction was identified as the potentially implementable remedial technology associated with the collection general response action for ground water. The process option considered potentially implementable for ground water extraction was recovery wells.

- **Vertical recovery wells.** Contaminated ground water would be collected by pumping from recovery wells. A pumping test would be required to identify locations for extraction wells and evaluate appropriate pumping rates and/or levels to minimize migration of contaminated ground water from source areas.

In situ treatment. Physical, chemical and biological treatment and monitored natural attenuation were identified as the potentially implementable remedial technologies associated with the *in situ* treatment general response action for ground water. The potentially implementable process options are described below.

- **In-well air stripping.** In-well air stripping involves the injection of air into the water column to volatilize constituents. Air injected into the bottom of the well casing establishes a ground water circulation cell within the well, with groundwater entering the well at one screen and being discharged through a second screen. The recirculation cell continuously draws ground water into the well such that contaminants can be stripped from the aqueous to gaseous phase. Treated ground water is discharged back to the aquifer. Depending on the resulting characteristics of the effluent air stream, air pollution controls may be required.

- **Natural degradation.** Natural attenuation relies of the naturally occurring *in situ* biotic and abiotic processes to degrade organic constituents in the saturated zone. Baseline and ongoing monitoring is required to evaluate the effectiveness of this process option.

- **Bioremediation.** Natural *in situ* microbial degradation of organic contaminants can be enhanced through injection of microbial populations, nutrient sources, oxidants, and/or reductants into ground water through injection wells. A treatability study would be necessary to evaluate the effectiveness of biological treatment.

- **Chemical oxidation.** *In situ* chemical oxidation involves the addition of oxidation agents, such as hydrogen peroxide, ozone, or permanganate, into ground water through injection wells to oxidize/destroy organic contaminants.

Ex situ treatment. Physical and chemical treatment were identified as the potentially implementable remedial technologies associated with the *ex situ* treatment general response action for ground water. The potentially implementable process options are described below.

- **Air stripping.** Air stripping involves the contact of ground water with air in a countercurrent packed column, tray, or bulk reactor to transfer volatile organic contaminants from the ground water to the air. Depending on the resulting characteristics of the effluent air stream, air pollution controls may be required.

- **Carbon adsorption.** Activated carbon can readily adsorb organic contaminants from ground water onto its surfaces during contact. The carbon must be periodically replaced, regenerated, treated, and/or disposed. Regeneration may be accomplished on- or off-site at a permitted commercial hazardous waste carbon regeneration facility. Spent carbon would be disposed of off-site at a permitted commercial hazardous waste facility.

- **Adsorptive resin.** Commercial resins are available which can adsorb organic contaminants from the ground water during contact. Such resins are typically regenerated on-site on a periodic basis.

- **Chemical oxidation.** Chemical oxidation involves the addition of oxidation agents such as hydrogen peroxide or ozone to the ground water in the presence of ultraviolet light to oxidize organic contaminants to non-toxic byproducts. Chemical oxidation is typically performed in a closed reactor system.

Discharge. Discharge of treated ground water was identified as the potentially implementable remedial technology associated with the discharge GRA for ground water. The potentially implementable process options are described below.

- **Discharge to ground water.** Extracted and treated ground water would be re-injected to the aquifer pursuant to State Pollutant Discharge Elimination System (SPDES) requirements.

- **Discharge to POTW.** Extracted and treated ground water would be released to municipal sanitary sewers, and ultimately treated and discharged by a municipal treatment plant.

- **Discharge to surface water.** Extracted and treated ground water would be released to storm sewers pursuant to State Pollutant Discharge Elimination System (SPDES) requirements.

2.7. Evaluation of Remedial Technologies

The process options remaining after the initial screening were evaluated further according to the criteria of effectiveness, implementability, and cost. The effectiveness criterion included the evaluation of: potential effectiveness of the process options in meeting remedial objectives and handling the estimated volumes or areas of media; potential effects on human health and the environment during construction and implementation; and experience and reliability of the process options for site contaminants and conditions. Technical and institutional aspects of implementing the process options were assessed for the implementability criterion. The capital and operation and maintenance (O&M) costs of each process option were evaluated as to whether they were high, medium, or low relative to the other process options of the same technology type.

Based on the evaluation, the more favorable process options of each technology type were chosen as representative process options. The selection of representative process options simplifies the assembly and evaluation of alternatives, but does not eliminate other process options. The process option actually used to implement remediation may not be selected until the remedial design phase. A summary of the evaluation of process options and selected representative process options is presented in Table 3.

2.8. Assembly of Remedial Alternatives

Remedial alternatives were developed by assembling general response actions and representative process options into combinations that address the sites. Six alternatives were developed for the sites. A summary of the alternatives and their components is presented in Table 4. A description of each alternative is included in the following subsections.

2.8.1. Common Components of Alternatives

Environmental easements, a Site Management Plan, indoor air monitoring, and ground water monitoring are common elements to each of the alternatives being evaluated for the sites. Indoor air mitigation, maintenance of the asphalt cap, and additional vapor intrusion sampling are common elements to each alternative except for Alternative 1. Monitored natural attenuation (MNA) is a common element to Alternatives 2, 3A, and 4A. A description of these elements is included below.

Environmental easement. An institutional control, in the form of an environmental easement, would consist of on-site land use restrictions and ground water use restrictions. Land use restrictions would restrict activities that could result in unacceptable exposure to contaminated soil. Ground water use restrictions would preclude the use of ground water at the sites without prior notification and approval from NYSDEC. Restrictions related to soil and ground water would be implemented on the site properties. Ground water usage for off-site properties is subject to Title 6 New York Conservation Rules, and Regulations (NYCRR) Part 602, which states that a permit must be obtained to withdraw ground water above a rate of 45 gal/min for any purpose. For withdrawals of ground water below 45 gal/min, residents must notify NYSDEC. During the remedial design phase, a field survey of homes will be conducted to identify if private wells are installed in the contaminated plume and notify residents of the contaminated plume.

For Alternative 1, the environmental easement would consist of a requirement for continued ground water monitoring.

Site Management Plan. A Site Management Plan would guide future activities at the sites by addressing property and ground water use restrictions and by developing requirements for periodic site management reviews. The periodic site management reviews would focus on evaluating the sites with regard to the continuing protection of human health and the environment as provided by information such as indoor air and ground water monitoring results and documentation of field inspections. The Site Management Plan would also require that NYSDEC records be checked for new production wells that may have been installed since the last periodic review.

Additional vapor intrusion sampling. Though no off site structures were identified as requiring additional monitoring or vapor intrusion mitigation based on sampling to date, additional vapor intrusion sampling will be included in each active alternative. For cost estimate purposes, the vapor intrusion sampling is assumed for five buildings. The sampling would consist of sampling and analysis of indoor air, sub-slab vapor, and ambient air associated with these structures. Sampling would take place during remedial design and would be mitigated or monitored, if necessary. For cost estimate purposes, no further action was assumed for these five structures.

Ground water monitoring. Ground water monitoring would consist of sampling for VOCs at the locations and frequencies summarized in Table 6. Water levels will also be obtained from accessible monitoring wells on a quarterly basis.

Asphalt cover maintenance. The asphalt paving at the sites minimizes contact with contaminated soils. The asphalt will be inspected semi-annually for excessive rutting, potholes, or settlement. Should any of these conditions be observed, they will be corrected by filling with appropriate material.

Indoor air mitigation. Vapor intrusion conditions present in the Hercules building would be addressed in a manner consistent with NYSDOH guidance.. For cost estimate purposes, it is assumed that the common wall between the Railroad and Hercules buildings would be sealed and a sub-slab depressurization system would be installed in the Hercules building. For cost estimate purposes, it was assumed that ongoing indoor air monitoring and system operation and maintenance would be required in the Hercules building.

Monitored natural attenuation. The premise of MNA is to demonstrate with periodic ground water monitoring that natural conditions are effecting a decrease in VOCs via physical, chemical, and biological processes. These processes include intrinsic biodegradation, advection and hydrodynamic dispersion, and other chemical reactions (*e.g.*, abiotic transformation of VOCs). The effectiveness of MNA as a remediation process depends on the type and concentration of compounds present, and the physical, chemical, and biological characteristics of the soil and ground water at the sites. To this end, the rate of VOC mass reduction via natural process is a primary discriminator in determining the appropriateness of an MNA remedy.

Favorable scenarios for MNA include sites where VOC degradation is occurring in addition to advection and dispersion, affecting an overall decrease in the mass flux of VOCs at a site, and sites that have an overall low potential for VOC migration. Additionally, source control or remediation (natural or engineered) is an important component of MNA. The effectiveness of MNA would be evaluated as part of pre-design activities.

The conceptual approach for MNA at the sites would include characterization of ground water geochemistry (inorganic and organic) and the oxidation-reduction (redox) conditions. A baseline sampling event would be conducted in conjunction with the first quarterly sampling event. The baseline sampling event would include sampling of 22 existing monitoring wells and analysis for VOCs, dissolved oxygen, oxidation-reduction potential (ORP; via field methods), dissolved light hydrocarbons (methane, ethane, ethene), dissolved carbon dioxide gas, volatile fatty acids, sulfide, sulfate, nitrate, nitrite, and total iron.

Following the initial baseline monitoring event, ground water monitoring would be performed quarterly at eight existing monitoring wells and semi-annually at eleven existing monitoring wells located within the COC plume. These samples would be analyzed for VOCs, dissolved oxygen, and ORP (via field methods). Monitoring would continue until plume concentrations decline to below 5 µg/L.

2.8.2. Alternative 1 – No action with monitoring

Alternative 1 is the no action alternative, which includes ground water and air monitoring. The no action alternative is required by the NYSDEC DER-10, Technical Guidance for Site Investigation and Remediation (2002) and serves as a benchmark for the evaluation of action alternatives. This alternative provides for an assessment of the environmental conditions if no active remedial actions are implemented. The no action alternative includes ground water, air monitoring, environmental easements, and a Site Management Plan, as described in Section 2.8.1.

2.8.3. Alternative 2 – *In situ* ground water remediation

Alternative 2 consists of chemical oxidation and MNA for Plume Area A ground water in addition to Plume Area B ground water MNA, ground water monitoring, air monitoring, maintenance of the currently implemented asphalt cover, indoor air mitigation, environmental easements, and a Site Management Plan, as described in Section 2.8.1.

In situ chemical oxidation is a process of changing the oxidation-state of a contaminant through the introduction of liquid, slurry, or gaseous oxidants in the subsurface. Fenton's reagent, ozone injection, and potassium/sodium permanganate are commonly used chemical oxidants. The oxidants gain electrons that are lost by VOCs or other readily oxidized material. Subsequent to losing electrons, VOCs are reduced to benign products (*i.e.*, carbon dioxide and water). Oxidation reactions require contact between VOCs and the oxidant. Chlorinated ethenes, such as PCE, are oxidized because of their electrophilically favorable chemical structures. Electron pairs in the double carbon bond (pi bonds) of chlorinated VOCs are broken in the oxidation reactions, directly destroying the chlorinated molecule. Because most oxidants can be directly injected into the ground water aquifer, the approach is suited for *in situ* applications, without the expense of elaborate aboveground infrastructure or O&M for *ex situ* treatment.

Generally, the efficacy of *in situ* chemical oxidation is limited to the ability to maximize contact between the oxidant, the VOCs, and the naturally occurring mass of carbon in the subsurface. Given the scale of the downgradient ground water plume, a chemical oxidation approach would more appropriately be used as a destruction technology for the Plume Area A ground water where COC concentrations are greater than 1,000 ug/L. Ground water outside the treatment zone would be addressed through natural attenuation processes.

Permanganate injection technology is a natural extension of the use of (primarily) potassium permanganate in water purification. Both potassium permanganate and sodium permanganate supply the permanganate ion to initiate the dechlorination reaction with VOCs. Permanganate has been increasingly utilized as an *in situ* oxidant and possesses a specific gravity similar to that of PCE or TCE. Permanganate oxidation occurs by breaking the double carbon bond in a chlorinated ethene molecule. Potassium permanganate is produced as solid at 4% to 6% oxidant strength, and typically requires on-site mixing. Sodium permanganate is a liquid that is produced at 40% strength and typically requires only on-site dilution. The major difference between the two products (in addition to their respective cations) is that $NaMnO_4$ can be delivered to the subsurface at a higher strength (typically 10 to 15%) than $KMnO_4$, which can rarely exceed 3% strength in normal field conditions.

Given that the primary site compounds are TCE, PCE, cis-1,2-DCE, and vinyl chloride, permanganate is well suited for site application. For cost estimation purposes, sodium permanganate was selected for the *in situ* chemical oxidation approach. The remedy would be designed to reduce VOC concentrations in Plume Area A with COC concentrations greater than 1,000 µg/L. For cost estimation purposes, the chemical oxidation alternative would consist of an estimated 216 geoprobe injection points to treat the central portion of Plume Area A to depths ranging from 16 ft to 70 ft below grade (to an average depth of 33 ft), and an approximately 75 ft width. The depth of 70 ft and width of 75 ft were assumed in order to capture concentrations greater than 1,000 ug/L. Permanganate would be injected for a period of approximately 54 days. An estimated 110,000 lbs of sodium permanganate was assumed to be injected. This estimated quantity was based on a natural oxidant demand of 5 g/kg for a sand and gravel aquifer. Calculations were performed using estimation methods provided by Carus, Inc. and discussions with personnel from Carus, Inc. Two injection periods were assumed to be necessary to reduce concentrations to below 5 µg/L in the Plume Area A. Bench scale testing and ground water sampling should be performed during pre-design to ascertain which portion of Plume Area A is best addressed using chemical oxidation, or if chemical oxidation should be used in conjunction with another *in situ* technology such as *in situ* biological treatment to best address contamination in Plume Area A.

MNA as described above in Section 2.8.1, would be used to address ground water concentrations below 1,000 ug/L in Plume Area A (*i.e.*, ground water deeper than 70 ft and outside of 75 ft width along the plume center line within Plume Area B) and in Plume Area B. Attainment of plume concentrations below 5 ug/L is anticipated to take approximately 30 years, if Plume Area A ground water is successfully treated.

The conceptual approach for Alternative 2 is illustrated in Figures 7 and 8.

2.8.4. Alternative 3A – Plume Area A ground water extraction and treatment and *in situ* soil remediation

Alternative 3A consists of soil vapor extraction (SVE) for source area soil and extraction and treatment for Plume Area A ground water in addition to Plume Area B ground water MNA, air monitoring, ground water monitoring, maintenance of the currently implemented asphalt cover, environmental easements, and a Site Management Plan, as described in Section 2.8.1.

SVE is an *in situ* unsaturated (vadose) zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile contaminants from the soil. The gas leaving the soil would be treated to recover or destroy the contaminants as appropriate based on local and state air discharge regulations. Pre-design field studies would be necessary to identify the specific number, configuration, and locations of extraction wells and vacuum rates. Due to the shallow depth to ground water, it is anticipated that ground water may be extracted as well. This ground water would be separated from the air stream and directed to the ground water treatment system. For cost estimate purposes, two horizontal wells were assumed beneath each building. Due to the depth to ground water, these horizontal wells are anticipated to be located less than 4 ft below ground surface. The SVE system is assumed to influence soil vapor beneath both buildings, thus an indoor air mitigation system is not envisioned for this alternative.

Hydraulic control with *ex situ* treatment and discharge of treated ground water involves pumping impacted ground water to the surface from a system of ground water extraction wells for treatment and subsequent discharge of the treated ground water to surface water (*i.e.*, storm sewers). Hydraulic control would remove COCs from the subsurface and form a hydraulic barrier to minimize further off-site migration.

Preliminary estimates indicated that a total of two extraction wells, with a combined pumping rate of approximately 20 gallons per minute (gpm) (*i.e.*, 10 gpm per well), would be required to control Plume Area A ground water. The ground water extraction wells would be aligned with the apparent centerline of the plume and spaced approximately 225 ft apart, with the last well located along Royal Avenue. This extraction well distribution was selected to provide adequate capture of Plume Area A ground water. A description of the assumptions used in this estimate is provided in Appendix B. For cost estimating purposes, these wells were assumed to each be approximately 75 ft deep. It is anticipated that the ground water flow field to these recovery wells would extend beyond the depths of the extraction wells. Ground water outside the capture zone is anticipated to exhibit low VOC concentrations that would be addressed through natural attenuation processes. The exact depth of recovery wells would be verified during pre-design activities.

Pre-design field studies would be necessary to identify the specific number and locations of extraction wells and their discharge rates. The criteria for extraction well design and the extraction and treatment systems are dependent on the physical site characteristics, contaminant concentrations and the geochemistry of the ground water at the sites, which can affect the ground water treatment "train" (*i.e.*, treatment system) utilized to treat the extracted ground water. Ground water treatment would include the design of a "train" of processes, such as gravity segregation (*i.e.*, settling or equalization tank), metals pretreatment if necessary, filtration, air strippers, and carbon adsorption. For cost estimation purposes, it was assumed that extracted ground water would be treated using a low profile air stripper followed by activated carbon. Pretreatment using bag filters was also assumed for cost estimate purposes. The air stripper off-gas was assumed to be treated using activated carbon. The exact components of the treatment train would be refined during design. Treated ground water would be discharged to surface water through the storm sewer system. The ground water extraction/treatment/discharge system would be operated until plume concentrations decline to below 5 μg/L. For O&M cost estimate purposes, the extraction and treatment system is anticipated to be operational for 30 years. Attainment of Plume Area B concentrations below 5 ug/L is anticipated to take approximately 30 years, with continued hydraulic control for Plume Area A.

The conceptual approach for Alternative 3A is illustrated in Figures 9 and 10.

2.8.5. Alternative 3B – Ground water extraction and treatment and *in situ* soil remediation
Alternative 3B consists of SVE for source area soil and extraction and treatment for the contaminated ground water plume in addition to, air monitoring, ground water monitoring, indoor air mitigation, maintenance of the currently implemented asphalt cover, environmental easements, and a Site Management Plan, as described in Section 2.8.1.

SVE for source area soil would be implemented as described in Section 2.8.4.

Hydraulic control with *ex situ* treatment and discharge of treated ground water would be used to treat the contaminated ground water plume (*i.e.*, both Plume Area A and B). Preliminary estimates indicated that a total of five extraction wells, with a combined pumping rate of approximately 50 gallons per minute (gpm) (*i.e.*, 10 gpm per well), would be required to hydraulically control ground water. The ground water extraction wells would be aligned with the apparent centerline of the plume and spaced approximately 225 to 250 ft apart, with the last well located in the vicinity of the existing monitoring well MW-23. A description of the assumptions used in this estimate is provided in Appendix B. For cost estimation purposes it was assumed that two wells would be approximately 75 ft deep, two wells would be approximately 95 ft deep and one well would be approximately 90 ft deep. It is anticipated that the ground water flow field to these recovery wells would extend beyond the depths of the recovery wells. Ground water outside the capture zone is anticipated to exhibit low VOC concentrations that would be addressed through natural attenuation processes. The exact depth of recovery wells would be verified during pre-design activities.

Pre-design field studies would be necessary to identify the specific number and locations of extraction wells and their discharge rates. The criteria for extraction well design and the extraction and treatment systems are dependent on the physical site characteristics, contaminant concentrations and the geochemistry of the ground water at the sites, which can affect the ground water treatment "train" utilized to treat the extracted ground water. Ground water treatment would include the design of a "train" of processes, such as gravity segregation, metals pretreatment if necessary, filtration, air strippers, and carbon adsorption. For cost estimation purposes, it was assumed that extracted ground water would be treated using a low profile air stripper followed by activated carbon. Pretreatment using bag filters was also assumed for cost estimate purposes. The air stripper off-gas was assumed to be treated using activated carbon. The exact components of the treatment train would be refined during design. Treated ground water would be discharged to surface water through storm sewer system. The ground water extraction/treatment/discharge system would be operated until plume concentrations decline to below 5 µg/L. For O&M cost estimate purposes, the extraction and treatment system for Plume Area A is anticipated to be operational for 30 years. Attainment of Plume Area B concentrations below 5 µg/L is anticipated to take approximately 15 years, with continued hydraulic control of Plume Area A.

The conceptual approach for Alternative 3B is illustrated in Figures 10 and 11.

2.8.6. Alternative 4A – Plume Area A ground water extraction and treatment and Plume Area B ground water MNA

Alternative 4A consists of Plume Area A ground water extraction, treatment, and surface water discharge, in addition to Plume Area B ground water MNA, ground water monitoring, air monitoring, maintenance of the currently implemented asphalt cover, indoor air mitigation, environmental easements, and a Site Management Plan, as described in Section 2.8.1.

Hydraulic control with *ex situ* treatment and discharge of treated ground water involves pumping impacted ground water to the surface from a system of ground water extraction wells for treatment and subsequent discharge of the treated ground water to surface water (*i.e.*, storm sewers). Hydraulic control would effectively remove COCs from the subsurface and form a hydraulic barrier to minimize further off-site migration.

Preliminary estimates indicated that a total of two extraction wells, with a combined pumping rate of approximately 20 gallons per minute (gpm) (*i.e.*, 10 gpm per well), would be required to treat Plume Area A ground water. The ground water extraction wells would be aligned with the apparent centerline of the plume and spaced approximately 225 ft apart, with the last well located along Royal Avenue. A description of the assumptions used in this estimate is provided in Appendix B. For cost estimating purposes, these wells were assumed to each be approximately 75 ft deep. It is anticipated that the ground water flow field to these recovery wells would extend beyond the depth of the extraction wells. Ground water outside the capture zone is anticipated to exhibit low VOC concentrations that would be addressed through natural attenuation processes. The exact depth of recovery wells would be verified during pre-design activities.

Pre-design field studies would be necessary to identify the specific number and locations of extraction wells and their discharge rates. The criteria for extraction well design and the extraction and treatment systems are dependent on the physical site characteristics, contaminant concentrations and the geochemistry of the ground water at the sites, which can affect the ground water treatment "train" utilized to treat the extracted ground water. Ground water treatment would include the design of a "train" of processes, such as gravity segregation, metals pretreatment if necessary, filtration, air strippers, and carbon adsorption. For cost estimation purposes, it was assumed that extracted ground water would be treated using a low profile air stripper followed by activated carbon. Pretreatment using bag filters was also assumed for cost estimate purposes. The air stripper off-gas was assumed to be treated using activated carbon. The exact components of the treatment train would be refined during design.Treated ground water would be discharged to surface water through storm sewer system. The ground water extraction/treatment/discharge system would be operated until plume concentrations decline to below 5 µg/L. For O&M cost estimate purposes, the extraction and treatment system is anticipated to be operational for 30 years. Attainment of Plume Area B concentrations below 5 µg/L is anticipated to take approximately 30 years, with continued hydraulic control of Plume Area A.

The conceptual approach for Alternative 4A is illustrated in Figures 12 and 13.

2.8.7. Alternative 4B – Ground water extraction and treatment

Alternative 4B consists of ground water extraction, treatment, and surface water discharge for the contaminated ground water plume (*i.e.*, both Plume Areas A and B ground water), in addition to ground water monitoring, air monitoring, maintenance of the currently implemented asphalt cover, indoor air mitigation, environmental easements, and a Site Management Plan, as described in Section 2.8.1.

For hydraulic control of both Plume Area A and B ground water, preliminary estimates indicated that a total of five extraction wells, with a combined pumping rate of approximately 50 gallons per minute (gpm) (*i.e.,* 10 gpm per well), would be required. The ground water extraction wells would be aligned with the apparent centerline of the plume and spaced approximately 225 to 250 ft apart, with the last well located in the vicinity of the existing monitoring well MW-23. A description of the assumptions used in this estimate is provided in Appendix B. For cost estimation purposes it was assumed that two wells would be approximately 75 ft deep, two wells would be approximately 95 ft deep and one well would be approximately 90 ft deep. It is anticipated that the ground water flow field to these recovery wells would extend beyond the depth of the extraction wells. Ground water outside the capture zone is anticipated to exhibit low VOC concentrations that would be addressed through natural attenuation processes. The exact depth of recovery wells would be verified during pre-design activities.

Pre-design field studies would be necessary to identify the specific number and locations of extraction wells and their discharge rates. The criteria for extraction well design and the extraction and treatment systems are dependent on the physical site characteristics, contaminant concentrations and the geochemistry of the ground water at the sites, which can affect the ground water treatment "train" utilized to treat the extracted ground water. Ground water treatment would include the design of a "train" of processes, such as gravity segregation, metals pretreatment if necessary, filtration, air strippers, and carbon adsorption. For cost estimation purposes, it was assumed that extracted ground water would be treated using a low profile air stripper followed by activated carbon. Pretreatment using bag filters was also assumed for cost estimate purposes. The air stripper off-gas was assumed to be treated using activated carbon. The exact components of the treatment train would be refined during design. Treated ground water would be discharged to surface water through storm sewer system. The ground water extraction/treatment/discharge system would be operated until plume concentrations decline to below 5 µg/L. For O&M cost estimate purposes, the extraction and treatment system for Plume Area A is anticipated to be operational for 30 years. Attainment of Plume Area B concentrations below 5 µg/L is anticipated to take approximately 15 years, with continued hydraulic containment of Plume Area A.

The conceptual approach for Alternative 4B is illustrated in Figures 13 and 14.

3. Detailed Analysis of Alternatives

The following section documents the detailed evaluation of the alternatives developed for the sites. The objective of the detailed analysis of alternatives was to analyze and present sufficient information to allow the alternatives to be compared and a remedy selected. The analysis consisted of an individual assessment of each alternative with respect to nine evaluation criteria that encompass statutory requirements and overall feasibility and acceptability. The detailed evaluation of alternatives also included a comparative evaluation designed to consider the relative performance of the alternatives and identify major trade-offs among them. The nine evaluation criteria are:

- Overall protectiveness of human health and the environment
- Compliance with SCGs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- Supporting agency acceptance
- Community acceptance

The preamble to the NCP (Federal Register 1990) indicates that, during remedy selection, these nine criteria should be categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria. The two threshold criteria, overall protection of human health and the environment, and compliance with SCGs, must be satisfied in order for an alternative to be eligible for selection. Long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost are primary balancing criteria that are used to balance the trade-offs between alternatives. The modifying criteria are supporting agency and community acceptance, which are formally considered after public comment is received on the Proposed Remedial Action Plan. The New York State TAGM entitled *Selection of Remedial Actions at Inactive Hazardous Waste Sites,* (NYSDEC 1990) and NYSDEC's Department of Environmental Restoration (DER)-10 draft guidance entitled *Technical Guidance or Site Investigation and Remediation* were also considered during this evaluation (NYSDEC 2002).

3.1. Individual Analysis of Alternatives

In the individual analysis of alternatives, each of the remedial alternatives was evaluated with respect to the evaluation criteria. A summary of the individual analysis of alternatives is presented in Table 5.

3.1.1. Overall Protection of Human Health and the Environment

The analysis of each alternative with respect to this criterion provides an evaluation of whether the alternative would achieve and maintain adequate protection and a description of how site risks would be eliminated, reduced, or controlled through treatment, engineering, or institutional controls. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.2. Compliance with SCGs

Potential SCGs for the sites are presented in Table 1 and the individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.3. Long-term Effectiveness and Permanence

This criterion assesses the magnitude of residual risk remaining from untreated material or treatment residuals at the sites. The adequacy and reliability of controls used to manage untreated material or treatment residuals are also evaluated. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.4. Reduction of Toxicity, Mobility or Volume Through Treatment

The evaluation of this criterion addressed the expected performance of treatment technologies in each alternative. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.5. Short-term Effectiveness

The evaluation of short-term effectiveness addressed the protection of workers and the community during construction and implementation of each alternative, and potential environmental effects resulting from implementation of each alternative. The time required to achieve remedial objectives was also evaluated under this criterion. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.6. Implementability

The analysis of implementability involved an assessment of the ability to construct and operate the technologies, the reliability of the technologies, the ease of undertaking additional remedial action, the ability to monitor the effectiveness of each remedy, and the ability to obtain necessary approvals from other agencies. Additionally, the availability of services, capacities, equipment, materials, and specialists necessary for implementation of the alternative was also assessed. The individual analysis of each remedial alternative with respect to this criterion is presented in Table 5.

3.1.7. Cost

For the cost analysis, cost estimates were prepared for each alternative based on vendor information and quotations, cost estimating guides, and experience. Cost estimates were prepared for the purpose of alternative comparison and were based on information currently known about the study area. The cost estimates include capital costs, annual operation and maintenance costs, and present worth cost. The present worth cost for these alternatives was calculated for the expected duration of the remedy at a 5% discount rate.

The individual cost estimates for the remedial alternatives are included in Tables 7 through 12. Assumptions for the cost estimates are included in Appendix A.

3.1.8. Support Agency Acceptance

Support agency acceptance will be addressed during development of the preferred alternative.

3.1.9. Community Acceptance

Community acceptance will be addressed during the preferred alternative public comment period prior to the ROD.

3.2. Comparative Analysis of Alternatives

In the comparative analysis of alternatives, the performance of each alternative relative to the others was evaluated for each criterion. As discussed in the following subsections, with the exception of Alternative 1, each alternative would satisfy the threshold criteria by providing protection to human health and the environment and by complying with the identified SCGs; therefore, each active alternative is eligible for selection as the final remedy. The primary balancing criteria (long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost) were used for balance in the comparative evaluation of alternatives.

3.2.1. Overall Protection of Human Health and the Environment

With respect to protection of human health, with the exception of Alternative 1, each alternative would provide protectiveness for ground water, soil, and indoor air potential impacts through institutional controls and for contact with soil through the currently implemented asphalt cover. Alternative 1 would not provide protectiveness for potential impacts from ground water or indoor air. While the existing asphalt cover included in Alternative 1 currently provides protectiveness from direct contact with soil, the absence of asphalt maintenance or institutional controls related to excavation in this alternative make this alternative less protective than the other alternatives with respect to soil.

In addition to the institutional controls, Alternatives 2, 3A, 3B, 4A, and 4B would provide protectiveness of human health and the environment for ground water through *in situ* treatment or pumping and treatment of ground water. The *in situ* treatment provided in Alternative 2 would make this alternative more protective than the others, as destruction of the VOCs afforded by this alternative is more protective than containment afforded by the remaining alternatives.

Alternatives 2, 3A, and 4A would be equally protective of human health and the environment by addressing potential future exposures to VOCs in downgradient ground water through natural attenuation. Alternatives 3B and 4B provide additional protectiveness through active pumping and treatment of downgradient ground water.

Alternatives 3A and 3B would be more protective of human health than the other alternatives for impacts due to contaminated soil through active treatment of soil above the ground water table.

Ground water monitoring included in each alternative would provide a means of evaluating the protectiveness of the alternatives.

3.2.2. Compliance with SCGs

As summarized in Table 1, chemical-specific SCGs were identified for ground water, soil, and indoor air. Alternatives 2, 3A, 3B, 4A and 4B would provide a means of addressing ground water SCGs through treatment, containment, and/or natural attenuation. Ground water monitoring included in each alternative would provide a means of evaluating the attainment of ground water SCGs. Alternative 1 would not address indoor air SCGs, while the remaining alternatives would attain indoor air SCGs through vapor control. Alternatives 2, 3A, 3B, 4A, and 4B would attain a level of performance that is equivalent to that required by the soil SCGs through institutional controls and the currently implemented asphalt cover, which would minimize contact with contaminated soil. Alternative 1 would attain a level of performance that is equivalent to that required by the soil SCGs through the currently implemented asphalt cover, which would minimize contact with contaminated soil. This would not be expected to be long-term, given that no cap maintenance is included in Alternative 1.

Location-specific SCGs would be achieved for each active alternative through compliance with requirements for construction within a floodplain. Action-specific SCGs related to OSHA requirements during construction activities were identified for Alternatives 2, 3A, 3B, 4A, and 4B and would be met during construction. Action-specific SCGs related to air emissions, waste management, and discharge of treated ground were identified for Alternatives 3A, 3B, 4A, and 4B and would be met during remedy implementation.

3.2.3. Long-term Effectiveness and Permanence

With the exception of Alternative 1, each alternative would provide some degree of long-term effectiveness and permanence through adequate and reliable controls of impacts from ground water, soil, and indoor air. With the exception of Alternative 1, the currently implemented asphalt cover included in each alternative would result in minimal residual risk from soil. Lesser long-term effectiveness and permanence are provided by Alternative 1 given that there is no provision for maintenance of the asphalt cover in this alternative. Ground water monitoring included in each alternative would provide a means of evaluating the reliability of controls. Alternatives 3A and 3B would provide a greater degree of long term effectiveness due to active treatment of contaminated on-site soils. Alternative 1 would provide no effectiveness or permanence for indoor air. Alternatives 2, 3A, 3B, 4A, and 4B would provide a greater degree of long-term effectiveness than Alternative 1 for impacts due to ground water through active treatment/hydraulic control.

3.2.4. Reduction of Toxicity, Mobility or Volume Through Treatment

Alternatives 2, 3A, 3B, 4A, and 4B, through natural attenuation or active treatment would attain reduction in VOC contamination of the ground water plume. Alternative 2 would provide a greater reduction in toxicity of ground water than Alternatives 3A, 3B, 4A, and 4B through active source area treatment included in Alternative 2. While pumping and treatment included in Alternatives 3A, 3B, 4A, and 4B is an effective method for reducing mobility of the contaminated ground water, this is not an effective method for reducing toxicity since it does not directly address source material, if present. Natural attenuation and active treatment are irreversible processes. Minimal residual contamination is anticipated from implementation of these alternatives.

3.2.5. Short-term Effectiveness

Alternative 1 could be implemented immediately. Alternatives 3A, 3B, 4A and 4B are anticipated to be constructable in a single construction season. Alternatives 3B and 4B would have the longest construction duration, as more extraction wells are included in these alternatives. For cost estimate purposes, it was assumed that injections of chemical oxidant would occur in phases over 1 year. The actual duration and frequency of injections would be estimated following pre-design studies. Based on preliminary modeling, assuming the source area is removed or contained, Alternatives 3B and 4B would likely achieve the ground water SCGs in the least amount of time. It is estimated that Alternatives 3B and 4B would likely attain ground water SCGs in Plume Area B ground water in approximately 15 years, while Alternatives 2, 3A, and 4A would likely attain ground water SCGs in Plume Area B ground water in approximately 30 years. It is anticipated that ground water extraction and treatment in Plume Area A ground water would not achieve ground water SCGs in the foreseeable future. Calculations related to estimation of timeframes to attain SCGs are included in Appendix B.

Engineering controls would be implemented during construction of the alternatives that would adequately protect the community and the environment.

3.2.6. Implementability

Each alternative would be implementable, however, Alternatives 3B and 4B present significant challenges to construct due to the size of the plume. Specifically, the 1,100-foot plume would require thousands of feet of piping to be installed through a very congested neighborhood to convey contaminated ground water to the treatment system. Implementation of Alternative 2 would require careful consideration of injection rates and pressures to minimize the likelihood of emergence of oxidant at the ground surface, given the very shallow ground water table.

The technologies being used in each alternative are reliable technologies. Each alternative would allow for additional remedial actions to be implemented, if necessary, and would be readily monitored for effectiveness of the remedy.

3.2.7. Cost

Detailed cost estimates for each alternative are included as Tables 7 through 12. Costs are summarized on Table 5.

3.2.8. Support Agency Acceptance

Support agency acceptance will be addressed during development of the preferred alternative.

3.2.9. Community Acceptance

Community acceptance will be addressed during the preferred alternative public comment period prior to the ROD.

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Table 1. *Evaluation of Potential SCGs*

Medium/Location/ Action	Citation	Requirements	Comments	PotentialSCG	Alternative
Potential chemical-specific SCGs					
Ground water	6 NYCRR 703 - Class GA ground water quality standards	Promulgated state regulation that requires that fresh ground waters of the state must attain Class GA standards.	Potentially applicable to site ground water.	Yes	1, 2, 3A, 3B, 4A, 4B
	NYSDEC TOGS 1.1.1 - Ambient Water Quality Standards and Guidance Values and Ground Water Effluent Limititations	This TOGS presents Division of Water ambient water quality standards and guidance values and groundwater effluent limitations. The authority for these values is derived from Article 17 of the Environmental Conservation Law and 6 NYCRR Parts 700-706, Water Quality	Potentially applicable to site ground water.	Yes	1, 2, 3A, 3B, 4A, 4B
Indoor Air	NYSDOH - Guidance for Evaluating Soil Vapor Intrusion.	Guidance that provides action levels for mitigation of indoor air influences	Potentially applicable for on-site residential and off-site buildings.	Yes	1, 2, 3A, 3B, 4A, 4B
Soil	NYSDEC 6 NYCRR Part 375-2 Inactive Hazardous Waste Disposal Site Remedial Program	Regulation that provides soil cleanup objectives for various property uses.	Potentially applicable to site soil.	Yes	1, 2, 3A, 3B, 4A, 4B
Potential location-specific SCGs					
Wetlands	6 NYCRR 663 - Freshwater wetland permit requirements	Actions occurring in a designated freshwater wetland (within 100 ft) must be approved by NYSDEC or its designee. Activities occurring adjacent to freshwater wetlands must: be compatible with preservation, protection, and conservation of wetlands and benefits; result in no more than insubstantial degradation to or loss of any part of the wetland; and be compatible with public health and welfare.	Not applicable or relevant and appropriate. No wetlands located at Site.	No	None
	Executive Order 11990 - Protection of Wetlands	Activities occurring in wetlands must avoid, to the extent possible, the long- and short-term adverse impacts associated with the destruction or modification of wetlands. The procedures also require USEPA to avoid direct or indirect support of new construction in wetlands wherever there are practicable alternatives or minimize potential harm to wetlands when there are no practicable alternatives.	Not applicable or relevant and appropriate. No wetlands located at Site.	No	None
100-year flood plain	6 NYCRR 373-2.2 - Location standards for hazardous waste treatment, storage, and disposal facilities -100-yr floodplain	Hazardous waste treatment, storage, or disposal facilities located in a 100-yr floodplain must be designed, constructed, operated and maintained to prevent washout of hazardous waste during a 100-yr flood.	Potentially applicable. Site is located in the 100-year floodplain.	Yes	2, 3A, 3B, 4A, 4B
	Executive Order 11988 - Floodplain Management	EPA is required to conduct activities to avoid, to the extent possible, the long- and short- term adverse impacts associated with the occupation or modification of floodplains. The procedures also require EPA to avoid direct or indirect support of floodplain development wherever there are practicable alternatives and minimize potential harm to floodplains when there are no practicable alternatives.	Not applicable. May be relevant and approproate as the site is location in the 100-year floodplain.	No	None
Within 61 meters (200 ft) of a fault displaced in Holocene time	40 CFR Part 264.18	New treatment, storage, or disposal of hazardous waste is not allowed.	Not applicable or relevant and appropriate. Site is not located within 200 ft of a fault displaced in Holocene time, as listed in 40 CFR 264 Appendix VI.	No	None
River or stream	16 USC 661 - Fish and Wildlife Coordination Act	Requires protection of fish and wildlife in a stream when performing activities that modify a stream or river.	Not applicable or relevant and appropriate. No rivers or streams located at Site.	No	None
Habitat of an endangered or threatened species	6 NYCRR 182	Provides requirements to minimize damage to habitat of an endangered species.	Not likely to be applicable or relevant and appropriate.	No	None

Table 1. *Evaluation of Potential SCGs*

Medium/Location/ Action	Citation	Requirements	Comments	PotentialSCG	Alternative
		Potential location-specific SCGs (cont.)			
Habitat of an endangered or threatened species	Endangered Species Act	Provides a means for conserving various species of fish, wildlife, and plants that are threatened with extinction.	Not likely to be applicable or relevant and appropriate.	No	None
Historical property or district	National Historic Preservation Act	Remedial actions are required to account for the effects of remedial activities on any historic properties included on or eligible for inclusion on the National Register of Historic Places.	Not likely to be applicable or relevant and appropriate.	No	None
		Potential action-specific SCGs			
Treatment actions	6 NYCRR 373 - Hazardous waste management facilities	Provides requirements for managing hazardous wastes.	Applicable for construction phase of remediation.	Yes	3A, 3B, 4A, 4B
Construction	29 CFR Part 1910 - Occupational Safety and Health Standards - Hazardous Waste Operations and Emergency Response	Remedial activities must be in accordance with applicable OSHA requirements.	Applicable for construction and monitoring phase of remediation.	Yes	2, 3A, 3B, 4A, 4B
	29 CFR Part 1926 - Safety and Health Regulations for Construction	Remedial construction activities must be in accordance with applicable OSHA requirements.	Applicable for construction phase of remediation.	Yes	2, 3A, 3B, 4A, 4B
Transportation	6 NYCRR 364 - Waste Transporter Permits	Hazardous waste transport must be conducted by a hauler permitted under 6 NYCRR 364.	Applicable for construction phase of remediation.	Yes	3A, 3B, 4A, 4B
	6 NYCRR Part 372 - Hazardous Waste Manifest System and Related Standards for Generators, Transporters, and Facilities	Substantive hazardous waste generator and transportation requirements must be met when hazardous waste is generated for disposal. Generator requirements include obtaining an EPA Identification Number and manifesting hazardous waste for disposal.	Applicable for construction phase of remediation.	Yes	3A, 3B, 4A, 4B
	49 CFR 172-174 and 177-179 - Department of Transportation Regulations	Hazardous waste transport to offsite disposal facilities must be conducted in accordance with applicable DOT requirements	Applicable for construction phase of remediation.	Yes	3A, 3B, 4A, 4B
Generation of air emissions	NYS Air Guide 1	Provides annual guideline concentrations (AGLs) and short-term guideline concentrations (SGCs) for specific chemicals. These are property boundary limitations that would result in no adverse health effects.	Applicable for construction phase of remediation.	Yes	3A, 3B, 4A, 4B
	NYS TAGM 4031 - Dust Suppressing and Particle Monitoring at Inactive Hazardous Waste Disposal Sites	Provides limitations on dust emissions.	Applicable for construction phase of remediation.	Yes	2, 3A, 3B, 4A, 4B
Construction storm water management	NYSDEC General permit for storm water discharges associated with construction activities. Pursuant to Article 17 Titles 7 and 8 and Article 70 of the Environmental Conservation Law.	The regulation prohibits discharge of materials other than storm water and all discharges that contain a hazardous substance in excess of reportable quantities established by 40 CFR 117.3 or 40 CFR 302.4, unless a separate NPDES permit has been issued to regulate those discharges. A permit must be acquired if activities involve the disturbance of 5 acres or more. If the project is covered under the general permit, the following are required: development and implementation of a storm water pollution prevention plan; development and implementation of a monitoring program; all records must be retained for a period of at least 3 years after construction is complete.	Not applicable. Construction disturbances will not exceed the limits.	No	None

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Air/Vapor				
No Action	None.	None.	No action.	Required for consideration by NCP (40 CFR Part 300.430).
Institutional Actions	Site Management Plan	Air/vapor monitoring	Periodic sampling for indoor and sub-slab air/vapor.	Potentially applicable.
	Access restrictions	Environmental easement	Restrictions to building uses and site activities that result in unprotected, unacceptable exposures to contaminated vapors. Requirements that mitigation systems be operated and monitored to maintain protectiveness from unacceptable exposures to contaminated vapors.	Potentially applicable.
Control Actions	Vapor control	Pumping/ventilation	Removal of subsurface soil vapors beneath the building slab to prevent intrusion of vapors to the building.	Potentially applicable.
Ex Situ Treatment Actions	Physical	Carbon adsorption	Adsorption of organic constituents from vapor phase to activated carbon.	Potentially applicable.
		Thermal oxidation	Destruction of organic constituents in a vapor phase by heating.	Not likely required for small vapor control systems.
		Catalytic oxidation	Destruction of organic constituents in a vapor phase by a combination heating and oxidation by solid media.	Not likely required for small vapor control systems.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
			Soil	
No Action	None.	Natural attenuation.	In place degradation of VOCs in soil by biological organisms and other abiotic processes naturally present in the soil.	Potentially applicable. Required for consideration by NCP (40 CFR Part 300.430).
Institutional Actions	Access restrictions	Environmental easement	Land use restriction for site.	Potentially applicable.
		Fencing	Installation of fencing surrounding area(s) of contamination.	Potentially applicable.
Containment Actions	Capping	Vegetated soil cover	Vegetated soil layer covering area(s) of contamination. Stabilizes soil and limits the spread of contaminants.	Not applicable as the surface of the Sites is completely covered by a building, a parking lot, and a sidewalk.
		Low-permeability cover	Soil layer used in conjunction with low permeability and protective layers to minimize infiltration.	Not applicable as the surface of the Sites is completely covered by a building, a parking lot, and a sidewalk.
		Asphalt cover	Asphalt minimizes contact with contaminated soil and stabilizes soil limiting the spread of contaminants.	Currently implemented.
Removal Actions	Excavation	Excavation	Use of construction equipment, such as backhoes, bulldozers, clamshells, draglines, or conveyors to remove site soils.	Potentially applicable for shallow soils (i.e., 1 – 3 feet) outside of the building footprint. Excavation of deeper site soils is not feasible due to site constraints (building locations, railroad) and the shallow ground water table.
Disposal Actions	Land disposal	Off-site commercial landfill	Off-site disposal hazardous soil would be disposed of at a hazardous commercial landfill. Soil characterized as non-hazardous would be disposed off-site at a non-hazardous commercial landfill.	Potentially applicable.
In situ Treatment Actions	Physical treatment	Soil Vapor Extraction (SVE)	Air stripping of VOCs from soil media by vapor extraction wells.	Potentially applicable.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In situ Treatment Actions (cont.)	Physical treatment	Multi-phase Extraction	SVE occurs while ground water is simultaneously recovered, thus removing VOCs from both the vadose zone and the saturated zone.	Not applicable due to the excessively permeable site soils (sand/gravel).
		Soil flushing	*In situ* soil flushing is the extraction of contaminants from the soil with water or other suitable aqueous solutions. The extraction fluid is passed through in-place soils using an injection or infiltration process. Extraction fluids are recovered from the underlying aquifer.	Potentially applicable.
		Solidification/stabilization	Solidification involves the formation of a solidified matrix that physically binds the contaminated material. Stabilization utilizes a chemical reaction to convert the contaminant to a less mobile form. Solidification and stabilization involve mixing treatment agents with the contaminated soil yielding a crystalline, glassy or polymeric framework around the contaminants. Mobile trenching/mixing units allow for this technology to be implemented *in situ*.	Not applicable for treatment of VOCs.
	Chemical treatment	Electrokinetics	A series of electrodes would be placed in a contaminant area to which a low voltage direct charge would be applied. Contaminant desorption and subsurface migration would occur and contaminants would be concentrated in a processing solution, which would then be extracted and treated.	Not applicable for treatment of VOCs.
	Biological treatment	*In situ* enhanced biological treatment	Natural degradation of VOCs in soil by biological organisms naturally present in the soil enhanced by external application of oxygen and/or nutrients.	Potentially applicable.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In situ Treatment Actions (cont.)	Biological treatment (cont.)	Bioventing	Introduction of low air flow rates to the subsurface to provide only enough oxygen to sustain microbial activity, thereby stimulating the natural *in situ* biodegradation of aerobically degradable compounds in the soil.	Not applicable due to shallow ground water table. Not favorable because it may enhance vapor intrusion. Limited unsaturated zone limits ability to install soil vapor extraction system.
		Phytoremediation	Use of plants to remove, transfer, stabilize, and destroy contaminants in soil.	Not applicable.
	Thermal Treatment	*In situ* vitrification	In place melting of soil into a solid, glass-like monolith using electrical power.	Not applicable due to shallow ground water table.
Ex situ Treatment Actions	Physical treatment	Soil washing	Separation/segregation of contaminant-bearing particles in soils.	Potentially applicable.
		Solidification/stabilization	Solidification involves the formation of a solidified matrix that physically binds the contaminated material. Stabilization utilizes a chemical reaction to convert the contaminant to a less mobile form. Solidification and stabilization involve mixing treatment agents with the contaminated soil yielding a crystalline, glassy or polymeric framework around the contaminants.	Not applicable for treatment of VOCs.
	Chemical treatment	Chemical extraction	Waste contaminated soil and extractant are mixed in an extractor, thereby dissolving the contaminants. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use.	Potentially applicable.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Ex situ Treatment Actions (cont.)	Chemical treatment (cont.)	Chemical reduction/oxidation	Waste contaminated soil and extractant are mixed in an extractor, thereby dissolving the contaminants. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use.	Not applicable for treatment of VOCs.
	Biological treatment	Biopiles	Excavated soils are mixed with soil amendments and placed in aboveground enclosures. It is an aerated static pile composting process in which compost is formed into piles and aerated with blowers or vacuum pumps.	Potentially applicable.
	Thermal treatment	Thermal desorption	*Ex situ* treatment of soils by volatilizing VOCs with low temperature heat processes.	Potentially applicable.
		Incineration	Combustion of organic contaminants present in soil in on-site or off-site commercial incinerator.	Potentially applicable.
Ground Water				
No Action	None	No action.	No action.	Required for consideration by NCP (40 CFR Part 300.430).
Institutional Actions	Site Management Plan	Ground water monitoring	Periodic sampling and analysis of ground water on-site and off-site to detect changes in constituent concentrations in ground water.	Potentially applicable.
	Environmental easement	Ground water use restrictions	Restriction of ground water use at the site, and off-site where ground water exceeds Class GA standards.	Potentially applicable.
Containment Actions	Vertical barrier	Slurry wall	Soil- or cement-bentonite slurry wall placed around the area of contamination to contain ground water.	Not applicable because clay confining layer is not continuous.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Containment Actions (cont.)	Vertical barrier	Sheet piles	Sheet piles installed around the area of contamination to contain ground water.	Not applicable because clay confining layer is not continuous.
		Recovery wells	Removal of ground water by pumping from recovery wells for hydraulic containment.	Potentially applicable.
		Permeable reactive barrier	Construction of an iron wall, boibarrier, or carbon wall to treat ground water as it flows through the treatment zone.	Not applicable due to depth of contamination.
Collection Actions	Ground water extraction	Vertical recovery wells	Removal of ground water by pumping from a series of recovery wells for mass removal.	Potentially applicable.
		Horizontal recovery well	Removal of ground water by pumping from a horizontal recovery well for mass removal.	Not applicable due to the length of the ground water plume in a residential area.
		Recovery trench	Removal of ground water by pumping from recovery trenches for hydraulic containment or mass removal.	Not applicable due to depth of contamination.
In Situ Treatment Actions	Physical	Air sparging	Injection of air into the saturated zone to volatilize constituents, which are collected in the unsaturated zone by an SVE system.	Not applicable due to depth of contamination. Not favorable because it may enhance vapor intrusion. Limited unsaturated zone limits ability to install soil vapor extraction system.
		In-well air stripping	Air is injected into the water column to volatilize constituents. Ground water is circulated *in situ*, with ground water entering the well at one screen and discharging through a second screen. Air is collected and treated if necessary.	Potentially applicable.
	Monitored natural attenuation	Natural degradation	Long-term monitoring of the natural biotic and abiotic degradation of organic constituents.	Potentially applicable.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
In Situ Treatment Actions (cont.)	Biological	Bioremediation	Injection of microbial populations, nutrient sources, oxidants, and/or reductants into ground water to enhance biological degradation of organic constituents.	Potentially applicable.
	Chemical	Chemical oxidation	Injection of oxidation agents such as hydrogen peroxide, ozone, or permanganate into ground water to oxidize/destroy organic contaminants.	Potentially applicable.
Ex Situ Treatment Actions	Physical	Air stripping	Contact of air with water in countercurrent column or bulk reactor to transfer VOCs from ground water to air.	Potentially applicable.
		Carbon adsorption	Adsorption of organic constituents from water to activated carbon.	Potentially applicable.
		Adsorptive resin	Adsorption of organic constituents from water to commercial adsorptive resin.	Potentially applicable.
		Settling	Retention of aqueous stream in tank to settle/separate light or heavy components.	Not applicable for dissolved VOC constituents.
		Filtration	Separation of solids from water phase using semipermeable filter medium.	Not applicable for dissolved VOC constituents.
	Chemical	Chemical oxidation	Addition of oxidation agents such as hydrogen peroxide and ultraviolet light to water to oxidize/destroy organic contaminants.	Potentially applicable.
		Precipitation	pH adjustment of ground water to separate out dissolved metal contaminants.	Not applicable for dissolved VOC constituents.
		Ion exchange	Chemical alternation of a hazardous to a non-hazardous constituent.	Not applicable for dissolved VOC constituents.

Table 2. *Screening of Remedial Technologies and Process Options*

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Discharge Actions	Treated water discharge	Discharge to surface water	Discharge of extracted ground water to surface water features such as streams, ponds, culverts, *etc.*	Discharge to storm sewers is potentially applicable.
		Discharge to ground water	Re-injection of extracted and treated ground water back into the subsurface.	Potentially applicable.
		Discharge to POTW	Discharge of extracted ground water to sanitary.	Potentially applicable.

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Air/Vapor					
No Action	None	No action *	Effectiveness is uncertain.	Readily implementable.	No capital No O&M
Institutional Actions	Site Management Plan	Air/vapor monitoring *	Effective method for monitoring changes in VOC concentrations in air over time. Useful for evaluating remedy effectiveness.	Readily implementable.	Low capital Low O&M
	Access restrictions	Environmental easement *	Effectively control exposure to VOCs in indoor air by restricting use of affected building.	Readily implementable.	Low capital. No O&M
Control Actions	Vapor control	Pumping/ventilation *	Effective for control of vapor intrusion to indoor air.	Readily implementable.	Low capital Low O&M
Ex Situ Treatment Actions	Physical	Carbon adsorption	Effectively removes VOCs from vapor stream prior to discharge to atmosphere.	Readily implementable.	Low capital Medium O&M
Soil					
No Action	None.	No action*	Relies on long-term degradation. Effectiveness is not certain.	Readily implementable.	No capital No O&M
Institutional Actions	Access restrictions	Environmental easement *	Effectively minimizes access to the site.	Readily implementable.	Low capital No O&M
		Fencing	Effectively minimizes access to the site.	Readily implementable.	Low capital Low O&M
Containment Actions	Capping	Asphalt cover *	Effectively minimizes contact with contaminated soil	Currently implemented.	No capital Low O&M
Removal Actions	Excavation	Excavation	Effectively removes contaminated soil	May be difficult to implement due to site constraints (*i.e.*, building and railroad tracks, shallow ground water)	Medium capital No O&M

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Disposal Actions	Land disposal	Off-site commercial landfill	Effective disposal method. Minimizes contaminant migration.	Readily implementable for limited volumes of soil.	High capital No O&M
In Situ Treatment Actions	Physical treatment	Soil Vapor Extraction (SVE)	Effective for destruction of VOCs.	Implementable with a shallow horizontal extraction vent. Treatment for vapors and groundwater would be required. Pilot testing would be necessary.	Medium capital Medium O&M
		Soil flushing	Effective for separation/segregation and volumetric reduction of hazardous materials in soil. Contaminated fine particles and wash water require further management.	Readily implementable. Operation is labor intensive.	Medium capital No O&M
	Biological treatment	*In situ* enhanced biological treatment	Effective for destruction of VOCs.	Not implementable for a paved parking area. Treatment of shallow unsaturated soils would require construction of an infiltration gallery.	Medium capital Medium O&M
Ex Situ Treatment Actions	Physical treatment	Soil washing	Limited effectiveness for destruction of VOCs.	Readily implementable.	High capital No O&M
	Chemical treatment	Chemical extraction	Limited effectiveness for destruction of VOCs	Readily implementable.	High capital No O&M
	Biological treatment	Biopiles	Effective for destruction of VOCs.	May be difficult to implement due to site constraints (*i.e.*, building and railroad tracks)	Low capital Low O&M
	Thermal treatment	Thermal desorption	Effectively uses direct or indirect heat exchange to volatilize VOCs from soil. The volatilized contaminants are typically incinerated; an air emissions control system is employed to remove acid gasses and particulates in exhaust gas. Off-gas control is required.	May be difficult to implement due to site constraints (*i.e.*, building and railroad tracks)	Medium capital No O&M

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Ex Situ Treatment Actions (cont)		Incineration	Very effective. Off gas control and ash disposal required.	Off-site incineration would be readily implementable. On-site incineration may be difficult to implement due to site constraints.	High capital No O&M
Ground Water					
No Action	None.	No action *	Relies on natural biotic and abiotic degradation. RI results have shown that breakdown products of PCE exist in the off-site plume suggesting that natural attenuation is occurring.	Readily implementable.	No capital No O&M
Institutional Actions	Site Management Plan	Ground water monitoring *	Effective method for monitoring changes in VOCs. Useful for evaluating remedy effectiveness.	Readily implementable.	Low capital Low O&M
	Environmental easements	Ground water use restrictions *	Effectively controls exposure to VOCs in ground water by restricting ground water use.	Readily implementable.	Low capital No O&M
Containment Actions	Vertical barrier	Recovery wells *	Effectively controls contaminated ground water.	Implementable.	Medium capital High O&M
Collection Actions	Ground water extraction	Vertical recovery wells *	Effectively removes contaminated ground water.	Implementable.	Medium capital High O&M
In Situ Treatment Actions	Physical	In-well air stripping	Effective for removal of chlorinated VOCs. May encounter problems with inorganic fouling of the well screens. Potentially inefficient due to large size of plume.	May be difficult to implement due to limited accessibility for siting treatment equipment, piping, pumps, and appurtenances. Off gas control at each well head may be required. Community acceptance is questionable.	Medium capital Medium O&M

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
In Situ Treatment Actions (cont)	Monitored natural attenuation	Natural degradation *	Long-term ground water monitoring would be used to evaluate the effectiveness of natural biotic and abiotic degradation of organic constituents. RI results have shown that the breakdown products of PCE exist in the off-site plume, suggesting that natural attenuation is occurring.	Readily implementable.	Low capital Low O&M
	Biological	Bioremediation *	Likely effective for destruction of chlorinated VOCs in saturated zone. Treatability study would be necessary. Multiple applications would be necessary.	Readily implementable.	Medium capital Low O&M
	Chemical	Chemical oxidation *	Likely effective for destruction of chlorinated VOCs in saturated zone. Treatability study would be necessary. Multiple applications would be necessary.	Readily implementable.	Medium capital Low O&M
Ex Situ Treatment Actions	Physical	Air stripping *	Effective for removal of chlorinated VOCs.	May be difficult to implement due to limited accessibility for siting treatment equipment, piping, pumps, and appurtenances.	Low capital Medium O&M
		Carbon adsorption *	Effective for removal of chlorinated VOCs.	May be difficult to implement due to limited accessibility for siting treatment equipment, piping, pumps, and appurtenances.	High capital High O&M
		Adsorptive resin	Effective for removal of chlorinated VOCs.	May be difficult to implement due to limited accessibility for siting treatment equipment, piping, pumps, and appurtenances.	Medium capital Medium O&M

Table 3. *Evaluation of Process Options*

General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Costs
Ex Situ Treatment Actions (cont)	Chemical	Chemical oxidation	Effective for removal of chlorinated VOCs.	May be difficult to implement due to limited accessibility for siting treatment equipment, piping, pumps, and appurtenances.	Medium capital Medium O&M
Discharge Actions	Treated water discharge	Discharge to surface water *	Effective for disposal of treated ground water.	Readily implementable. Storm drains are located in the parking area.	Low capital Low O&M
		Discharge to ground water	Effective for disposal of treated ground water.	May be difficult to implement due to limited accessibility for siting treatment equipment, piping, pumps, and appurtenances.	High capital High O&M
		Discharge to POTW	Effective for disposal of extracted water.	May be implementable, depending on ground water extraction flow rates.	Low capital Medium O&M

Notes:
* Representative process option.

Table 4. *Components of Remedial Alternatives*

General Response Actions	Remedial Technology - Process Option	1	2	3A	3B	4A	4B
Institutional Actions	Access Restrictions - Environmental Easements		x	x	x	x	x
	Site Management Plan - Air and Ground Water Monitoring	x	x	x	x	x	x
Containment Actions	Asphalt Cover*	x	x	x	x	x	x
Control Actions	Indoor Air Mitigation		x	x	x	x	x
Collection Actions	Plume Area A Ground Water Extraction - Vertical Recovery Wells			x	x	x	x
	Plume Area B Ground Water Extraction - Vertical Recovery Wells				x		x
Ground WaterTreatment Actions	Monitored Natural Attenuation (Plume Area B Ground Water)		x	x		x	
	In situ Chemical Treatment - Chemical Oxidation		x				
	Ex situ Physical Treatment - Air stripping			x	x	x	x
	Ex situ Physical Treatment - Carbon Adsorption			x	x	x	x
Soil Treatment Actions	*In situ* Physical Treatment - Soil Vapor Extraction			x	x		
Disposal Actions	Discharge of Treated Ground Water to Municipal Sewer System			x	x	x	x

Alternative 1: No action with monitoring*.
Alternative 2: *In situ* ground water remediation
Alternative 3A: Plume Area A ground water extraction and treatment and *in situ* soil remediation
Alternative 3B: Plume Areas A & B ground water extraction and treatment and *in situ* soil remediation
Alternative 4A: Plume Area A ground water extraction and treatment
Alternative 4B: Plume Areas A & B ground water extraction and treatment
* No cover maintenance included.

Table 5. Detailed analysis of alternatives

Criterion	Alternative 1: No action with monitoring	Alternative 2: Plume Area A ground water remediation via chemical oxidation/MNA and Plume Area B ground water MNA	Alternative 3A: Source area soil remediation via SVE, Plume Area A ground water extraction/treatment and Plume Area B ground water MNA	Alternative 3B: Source area soil remediation via SVE and ground water plume remediation via extraction/treatment.	Alternative 4A: Plume Area A ground water remediation via extraction/treatment and Plume Area B ground water MNA	Alternative 4B: Ground water plume remediation via extraction/treatment.
	• Environmental easement • Asphalt cover • Ground water monitoring • Indoor air monitoring	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Plume Area A GW chem. Oxid. & MNA • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Source area soil SVE • Plume Area A GW extraction • Plume Area A GW treatment • Treated GW storm sewer discharge • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Source area soil SVE • Ground water plume extraction • Ground water plume treatment • Treated GW storm sewer discharge	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Plume Area A GW extraction • Plume Area A GW treatment • Treated GW storm sewer discharge • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Ground water plume extraction • Ground water plume treatment • Treated GW storm sewer discharge
Overall protection of human health and the environment						
Overall protection of human health	Short-term protection of human health would be provided through the currently implemented asphalt cover.	Protection of human health would be provided through institutional controls precluding ground water use, precluding contact with soil, and restricting building use. Active Plume Area A ground water remediation would address potential risks associated with future ground water use. Relies on natural attenuation to address potential risks associated with future Plume Area B ground water use. Indoor air mitigation would provide protection to human health from effects related to indoor air. Protection of human health would be provided through the currently implemented asphalt cover.	Protection of human health would be provided through institutional controls precluding ground water use, precluding contact with soil, and restricting building use. Active Plume Area A ground water remediation would address potential risks associated with future ground water use. Relies on natural attenuation to address potential risks associated with future Plume Area B ground water use. Active source area soil remediation would address potential risks with future contact with soil. Indoor air mitigation would provide protection to human health from effects related to indoor air. Protection of human health would be provided through the currently implemented asphalt cover.	Protection of human health would be provided through institutional controls precluding ground water use, precluding contact with soil, and restricting building use. Active ground water plume remediation would address potential risks associated with future ground water use. Active source area soil remediation would address potential risks with future contact with soil. Indoor air mitigation would provide protection to human health from effects related to indoor air. Protection of human health would be provided through the currently implemented asphalt cover.	Protection of human health would be provided through institutional controls precluding ground water use, precluding contact with soil, and restricting building use. Active Plume Area A ground water remediation would address potential risks associated with future ground water use. Relies on natural attenuation to address potential risks associated with future Plume Area B ground water use. Indoor air mitigation would provide protection to human health from effects related to indoor air. Protection of human health would be provided through the currently implemented asphalt cover.	Protection of human health would be provided through institutional controls precluding ground water use, precluding contact with soil, and restricting building use. Active ground water remediation would address potential risks associated with future ground water use. Indoor air mitigation would provide protection to human health from effects related to indoor air. Protection of human health would be provided through the currently implemented asphalt cover.
Overall protection of the environment	Short-term protection of the environment would be provided through the currently implemented asphalt cover.	Protection of the environment would be provided through active remediation of Plume Area A ground water. Relies on natural attenuation to protect Plume Area B ground water.	Protection of the environment would be provided through active remediation/control of source area soil and Plume Area A ground water.	Protection of the environment would be provided through active remediation/control of soil and ground water.	Protection of the environment would be provided through active remediation/control of ground water	Protection of the environment would be provided through active remediation/control of ground water.
Compliance with standards, criteria, and guidance (SCGs)						
Compliance with chemical-specific SCGs	Addresses soil SCGs in the short-term through capping.	Achieves compliance with Plume Area A ground water SCGs through active ground water treatment. Relies on natural attenuation to achieve Plume Area B ground water SCGs. Achieves compliance with indoor air SCGs through institutional controls and active indoor air mitigation. Addresses soil SCGs through institutional controls and capping.	Addresses Plume Area A ground water SCGs through active ground water treatment. Relies on natural attenuation to address Plume Area B ground water SCGs. Addresses soil SCGs through institutional controls and active treatment of source area soil and capping. Achieves compliance with indoor air SCGs through institutional controls and active vapor control.	Addresses ground water SCGs through active ground water treatment/control. Addresses soil SCGs through institutional controls and active treatment of source area soil and capping. Achieves compliance with indoor air SCGs through institutional controls and active vapor control.	Addresses Plume Area A ground water SCGs through active ground water treatment/control. Relies on natural attenuation to achieve Plume Area B ground water SCGs. Addresses soil SCGs through institutional controls and capping. Achieves compliance with indoor air SCGs through institutional controls and active vapor control.	Addresses ground water SCGs through active ground water treatment/control. Addresses soil SCGs through institutional controls and capping. Achieves compliance with indoor air SCGs through institutional controls and active vapor control.
Compliance with location-specific SCGs	No actions are part of this alternative.	Construction activities would be conducted consistent with requirements for construction within a flood plain .	Construction activities would be conducted consistent with requirements for construction within a flood plain .	Construction activities would be conducted consistent with requirements for construction within a flood plain .	Construction activities would be conducted consistent with requirements for construction within a flood plain .	Construction activities would be conducted consistent with requirements for construction within a flood plain .
Compliance with action-specific SCGs	No actions are part of this alternative.	Construction activities would be conducted consistent with OSHA safety requirements.	Construction activities would be conducted consistent with air quality standards and in accordance with OSHA safety requirements. Treatment systems would be operated consistent with applicable state and federal requirements. Wastes generated by the treatment process would be managed, transported and disposed of in accordance with applicable state and federal requirements.	Construction activities would be conducted consistent with air quality standards and in accordance with OSHA safety requirements. Treatment systems would be operated consistent with applicable state and federal requirements. Wastes generated by the treatment process would be managed, transported and disposed of in accordance with applicable state and federal requirements.	Construction activities would be conducted consistent with air quality standards and in accordance with OSHA safety requirements. Treatment systems would be operated consistent with applicable state and federal requirements. Wastes generated by the treatment process would be managed, transported and disposed of in accordance with applicable state and federal requirements.	Construction activities would be conducted consistent with air quality standards and in accordance with OSHA safety requirements. Treatment systems would be operated consistent with applicable state and federal requirements. Wastes generated by the treatment process would be managed, transported and disposed of in accordance with applicable state and federal requirements.

Table 5. Detailed analysis of alternatives

Criterion	Alternative 1: No action with monitoring	Alternative 2: Plume Area A ground water remediation via chemical oxidation/MNA and Plume Area B ground water MNA	Alternative 3A: Source area soil remediation via SVE, Plume Area A ground water extraction/treatment and Plume Area B ground water MNA	Alternative 3B: Source area soil remediation via SVE and ground water plume remediation via extraction/treatment.	Alternative 4A: Plume Area A ground water remediation via extraction/treatment and Plume Area B ground water MNA	Alternative 4B: Ground water plume remediation via extraction/treatment.
	• Environmental easement • Asphalt cover • Ground water monitoring • Indoor air monitoring	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Plume Area A GW chem. Oxid. & MNA • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Source area soil SVE • Plume Area A GW extraction • Plume Area A GW treatment • Treated GW storm sewer discharge • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Source area soil SVE • Ground water plume extraction • Ground water plume treatment • Treated GW storm sewer discharge	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Plume Area A GW extraction • Plume Area A GW treatment • Treated GW storm sewer discharge • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Ground water plume extraction • Ground water plume treatment • Treated GW storm sewer discharge
Long-term effectiveness and permanence						
Magnitude of residual risk	Potential risks related to ground water, soil and indoor air remain.	Minimal residual risk of exposure to ground water due to treatment and use controls. Minimal residual risk of exposure to contaminated soil due to institutional controls and currently implemented asphalt cover. Minimal residual risk of exposure to indoor air through mitigation and use controls.	Minimal residual risk of exposure to ground water due to treatment and use controls. Minimal residual risk of exposure to contaminated soil due to active treatment, institutional controls and currently implemented asphalt cover. Minimal residual risk of exposure to indoor air through mitigation and use controls.	Minimal residual risk of exposure to ground water due to treatment and use controls. Minimal residual risk of exposure to contaminated soil due to active treatment, institutional controls and currently implemented asphalt cover. Minimal residual risk of exposure to indoor air through mitigation and use controls.	Minimal residual risk of exposure to ground water due to treatment and use controls. Minimal residual risk of exposure to contaminated soil due to institutional controls and currently implemented asphalt cover. Minimal residual risk of exposure to indoor air through mitigation and use controls.	Minimal residual risk of exposure to ground water due to treatment and use controls. Minimal residual risk of exposure to contaminated soil due to institutional controls and currently implemented asphalt cover. Minimal residual risk of exposure to indoor air through mitigation and use controls.
Adequacy and reliability of controls	The currently implemented asphalt cover addresses risk associated with contact with soil. Lack of maintenance makes this an unreliable means of managing risk from soil.	Institutional controls are reliable means of managing risks due to ground water, soil, and indoor air. Vapor control would provide added control of risks to exposure to indoor air. Monitoring of ground water and air would provide effective means of evaluating potential risks. The currently implemented asphalt cover would be a reliable means to manage risk associated with contact with soil. Active treatment of ground water would provide added control of risks of exposure to ground water.	Institutional controls are reliable means of managing risks due to ground water, soil, and indoor air. Vapor control would provide added control of risks to exposure to indoor air. Monitoring of ground water and air would provide effective means of evaluating potential risks. The currently implemented asphalt cover is a reliable means to manage risk associated with contact with soil. Active treatment of soil and ground water would provide added control of risks of exposure to soil and ground water.	Institutional controls are reliable means of managing risks due to ground water, soil, and indoor air. Vapor control would provide added control of risks to exposure to indoor air. Monitoring of ground water and air would provide effective means of evaluating potential risks. The currently implemented asphalt cover would be a reliable means to manage risk associated with contact with soil. Active treatment of soil and ground water would provide added control of risks of exposure to soil and ground water.	Institutional controls are reliable means of managing risks due to ground water, soil, and indoor air. Vapor control would provide added control of risks to exposure to indoor air. Monitoring of ground water and air would provide effective means of evaluating potential risks. The currently implemented asphalt cover would be a reliable means to manage risk associated with contact with soil. Active treatment ground water would provide added control of risks of exposure to ground water.	Institutional controls are reliable means of managing risks due to ground water, soil, and indoor air. Vapor control would provide added control of risks to exposure to indoor air. Monitoring of ground water and air would provide effective means of evaluating potential risks. The currently implemented asphalt cover would be a reliable means to manage risk associated with contact with soil. Active treatment of ground water would provide added control of risks of exposure to ground water.
Reduction of toxicity, mobility, or volume through treatment						
Treatment process used and materials treated	No active treatment provided.	*In situ* chemical oxidation would be used to treat VOCs in Plume Area A ground water. Natural attenuation would be used for Plume Area B ground water.	Soil vapor extraction (SVE) would be used to treat soil above the ground water table. *Ex situ* air stripping and activated carbon would be used to treat VOCs in extracted Plume Area A ground water. Natural attenuation would be used for Plume Area B ground water.	Soil vapor extraction (SVE) would be used to treat soil above the ground water table. *Ex situ* air stripping and activated carbon would be used to treat VOCs in extracted ground water	*Ex situ* air stripping and activated carbon would be used to treat VOCs in extracted Plume Area A ground water. Natural attenuation would be used for Plume Area B ground water.	*Ex situ* air stripping and activated carbon would be used to treat VOCs in extracted ground water.
Amount of hazardous material destroyed or treated	None.	An approximately 6-acre ground water plume would be treated by a combination of *in situ* chemical oxidation and natural attenuation.	Approximately 280 cy of contaminated soil would be treated via SVE. An approximately 6-acre ground water plume would be remediated via a combination of active treatment and natural attenuation.	Approximately 280 cy of contaminated soil would be treated via SVE. An approximately 6-acre ground water plume would be extracted and treated.	An approximately 6-acre ground water plume would be remediated via a combination of active treatment and natural attenuation.	An approximately 6-acre ground water plume would be extracted and treated.
Degree of expected reduction in toxicity, mobility, or volume	None.	*In situ* chemical oxidation and natural attenuation would reduce ground water COC concentrations to meet ground water standards.	SVE would reduce COC concentrations in soil to below Part 375 cleanup objectives for unrestricted use. Plume Area A ground water extraction and treatment would reduce mobility and some degree of reduction of ground water toxicity would be achieved. It is not anticipated that ground water pump and treat would result in COC concentrations meeting ground water standards in the foreseeable future. Natural attenuation would reduce Plume Area B ground water COC concentrations to meet ground water standards.	SVE would reduce COC concentrations in soil to below Part 375 cleanup objectives for unrestricted use. Plume Area A ground water extraction and treatment would reduce mobility and some degree of reduction of ground water toxicity would be achieved. It is not anticipated that ground water pump and treat would result in COC concentrations meeting ground water standards in the foreseeable future. Plume Area B ground water extraction and treatment would reduce mobility and would reduce ground water COC concentrations to meet ground water standards.	Plume Area A ground water extraction and treatment would reduce mobility and some degree of reduction of ground water toxicity would be achieved. It is not anticipated that ground water pump and treat would result in COC concentrations meeting ground water standards in the foreseeable future. Natural attenuation would reduce Plume Area B ground water COC concentrations to meet ground water standards.	Plume Area A ground water extraction and treatment would reduce mobility and some degree of reduction of ground water toxicity would be achieved. It is not anticipated that ground water pump and treat would result in COC concentrations meeting ground water standards in the foreseeable future. Plume Area B ground water extraction and treatment would reduce mobility and would reduce ground water COC concentrations to meet ground water standards.
Degree to which treatment is irreversible	None.	Treatment of Plume Area A ground water would be irreversible. Natural attenuation of Plume Area B ground water would be irreversible.	Treatment of soil and Plume Area A ground water would be irreversible. Natural attenuation of Plume Area B ground water would be irreversible.	Treatment of soil and ground water would be irreversible.	Treatment of Plume Area A ground water would be irreversible. Natural attenuation of Plume Area B ground water would be irreversible.	Treatment of ground water would be irreversible.
Type and quantity of residuals remaining after treatment	None.	No residuals would remain after treatment.	No residuals would remain after treatment.	No residuals would remain after treatment.	No residuals would remain after treatment.	No residuals would remain after treatment.

Table 5. Detailed analysis of alternatives

Criterion	Alternative 1: No action with monitoring	Alternative 2: Plume Area A ground water remediation via chemical oxidation/MNA and Plume Area B ground water MNA	Alternative 3A: Source area soil remediation via SVE, Plume Area A ground water extraction/treatment and Plume Area B ground water MNA	Alternative 3B: Source area soil remediation via SVE and ground water plume remediation via extraction/treatment.	Alternative 4A: Plume Area A ground water remediation via extraction/treatment and Plume Area B ground water MNA	Alternative 4B: Ground water plume remediation via extraction/treatment.
	• Environmental easement • Asphalt cover • Ground water monitoring • Indoor air monitoring	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Plume Area A GW chem. Oxid. & MNA • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Source area soil SVE • Plume Area A GW extraction • Plume Area A GW treatment • Treated GW storm sewer discharge • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Source area soil SVE • Ground water plume extraction • Ground water plume treatment • Treated GW storm sewer discharge	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Plume Area A GW extraction • Plume Area A GW treatment • Treated GW storm sewer discharge • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Ground water plume extraction • Ground water plume treatment • Treated GW storm sewer discharge
Short-term effectiveness						
Protection of community during remedial actions	No remedial actions are considered under this alternative.	Proper health and safety measures would be established and implemented during remedial activities.	Proper health and safety measures would be established and implemented during remedial activities. Dust, if any, would be controlled during installation of system piping. Air stripper emissions would be monitored and controlled if necessary.	Proper health and safety measures would be established and implemented during remedial activities. Dust, if any, would be controlled during installation of system piping. Air stripper emissions would be monitored and controlled if necessary.	Proper health and safety measures would be established and implemented during remedial activities. Dust, if any, would be controlled during installation of system piping. Air stripper emissions would be monitored and controlled if necessary.	Proper health and safety measures would be established and implemented during remedial activities. Dust, if any, would be controlled during installation of system piping. Air stripper emissions would be monitored and controlled if necessary.
Protection of workers during remedial actions	No remedial actions are considered under this alternative.	Proper health and safety measures would be established and implemented during remedial activities.	Proper health and safety measures would be established and implemented during remedial activities.	Proper health and safety measures would be established and implemented during remedial activities.	Proper health and safety measures would be established and implemented during remedial activities.	Proper health and safety measures would be established and implemented during remedial activities.
Environmental impacts	No environmental impacts would be expected as a result of implementation of this alternative.	No environmental impacts would be expected as a result of implementation of this alternative.	Dust, volatile emissions, and surface runoff controls would be instituted to minimize impacts to the environment during implementation of this alternative.	Dust, volatile emissions, and surface runoff controls would be instituted to minimize impacts to the environment during implementation of this alternative.	Dust, volatile emissions, and surface runoff controls would be instituted to minimize impacts to the environment during implementation of this alternative.	Dust, volatile emissions, and surface runoff controls would be instituted to minimize impacts to the environment during implementation of this alternative.
Time until remedial action objectives are achieved	Natural attenuation is not anticipated to reduce COC concentrations to 5 ugh/L in the foreseeable future.	Assuming the source area is removed or controlled, Plume Area B ground water concentrations would be anticipated to decline to ground water SCGs in approximately 30 years through natural attenuation.	Assuming the source area is removed or controlled, Plume Area B ground water concentrations would be anticipated to decline to ground water SCGs in approximately 30 years through natural attenuation. SCGs may not be attainable in Plume Area A ground water in the foreseeable future, due to the potential presence of residual source material.	Assuming the source area is removed or controlled, Plume Area B ground water concentrations would be anticipated to decline to ground water SCGs in approximately 15 years through extraction and treatment. SCGs may not be attainable in Plume Area A ground water in the foreseeable future, due to the potential presence of residual source material.	Assuming the source area is removed or controlled, Plume Area B ground water concentrations would be anticipated to decline to ground water SCGs in approximately 30 years through natural attenuation. SCGs may not be attainable in Plume Area A ground water in the foreseeable future, due to the potential presence of residual source material.	Assuming the source area is removed or controlled, Plume Area B ground water concentrations would be anticipated to decline to ground water SCGs in approximately 15 years through extraction and treatment. SCGs may not be attainable in Plume Area A ground water in the foreseeable future, due to the potential presence of residual source material.

Table 5. Detailed analysis of alternatives

Criterion	Alternative 1: No action with monitoring	Alternative 2: Plume Area A ground water remediation via chemical oxidation/MNA and Plume Area B ground water MNA	Alternative 3A: Source area soil remediation via SVE, Plume Area A ground water extraction/treatment and Plume Area B ground water MNA	Alternative 3B: Source area soil remediation via SVE and ground water plume remediation via extraction/treatment.	Alternative 4A: Plume Area A ground water remediation via extraction/treatment and Plume Area B ground water MNA	Alternative 4B: Ground water plume remediation via extraction/treatment.
	• Environmental easement • Asphalt cover • Ground water monitoring • Indoor air monitoring	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Plume Area A GW chem. Oxid. & MNA • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Source area soil SVE • Plume Area A GW extraction • Plume Area A GW treatment • Treated GW storm sewer discharge • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Source area soil SVE • Ground water plume extraction • Ground water plume treatment • Treated GW storm sewer discharge	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Plume Area A GW extraction • Plume Area A GW treatment • Treated GW storm sewer discharge • Plume Area B ground water MNA	• Environmental easement • Asphalt cover & maintenance • Ground water monitoring • Indoor air monitoring • Indoor air mitigation • Ground water plume extraction • Ground water plume treatment • Treated GW storm sewer discharge
Implementability						
Ability to construct and operate the technology	No technologies would be constructed in this alternative.	Installation of injection wells for *in situ* chemical oxidation treatment would be readily constructable. Installation of vapor control systems would be readily constructable. Careful design considerations would be necessary to address injection of oxidant in the presence of a shallow ground water table.	A horizontal soil vapor extraction vent could be constructed. Installation of a treatment system for *ex situ* treatment of ground water would be readily constructable. Construction of extraction wells to collect ground water would be readily constructable. Installation of piping necessary to convey water related to this alternative would be difficult due to the large size of the plume and the highly congested nature of the area. Installation of a vapor control system would be readily constructable.	A horizontal soil vapor extraction vent could be constructed. Installation of a treatment system for *ex situ* treatment of ground water would be readily constructable. Construction of extraction wells to collect ground water would be readily constructable. Installation of piping necessary to convey water related to this alternative would be difficult due to the large size of the plume and the highly congested nature of the area. Installation of vapor control systems would be readily constructable.	Installation of a treatment system for *ex situ* treatment of ground water would be readily constructable. Construction of extraction wells to collect ground water would be readily constructable. Installation of piping necessary to convey water related to this alternative would be difficult due to the large size of the plume and the highly congested nature of the area. Installation of a vapor control system would be readily constructable.	Installation of a treatment system for *ex situ* treatment of ground water would be readily constructable. Construction of extraction wells to collect ground water would be readily constructable. Installation of piping necessary to convey water related to this alternative would be difficult due to the large size of the plume and the highly congested nature of the area. Installation of a vapor control system would be readily constructable.
Reliability of technology	No technologies included in this alternative.	*In situ* chemical oxidation treatment would be a reliable means of reducing VOC concentrations in ground water. Ground water sampling and analysis would be a reliable means to monitor the effectiveness of ground water treatment. Vapor control would be a reliable technology for controlling risks due to indoor air.	SVE would be a reliable means of reducing VOC concentrations in soil. Ground water extraction would be a reliable means of reducing VOC concentrations in ground water. Ground water sampling and analysis would be a reliable means to monitor the effectiveness of ground water extraction. Vapor control would be a reliable technology for controlling risks due to indoor air.	SVE would be a reliable means of reducing VOC concentrations in soil. Ground water extraction would be a reliable means of reducing VOC concentrations in ground water. Ground water sampling and analysis would be a reliable means to monitor the effectiveness of ground water extraction. Vapor control would be a reliable technology for controlling risks due to indoor air.	Ground water extraction would be a reliable means of reducing VOC concentrations in ground water. Ground water sampling and analysis would be a reliable means to monitor the effectiveness of ground water extraction. Vapor control would be a reliable technology for controlling risks due to indoor air.	Ground water extraction would be a reliable means of reducing VOC concentrations in ground water. Ground water sampling and analysis would be a reliable means to monitor the effectiveness of ground water extraction. Vapor control would be a reliable technology for controlling risks due to indoor air.
Ease of undertaking additional remedial actions, if necessary	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.	Additional remedial actions, if necessary, would be readily implementable.
Ability to monitor effectiveness of remedy	Ground water and indoor air would be monitored as part of this alternative.	Effectiveness of the remedy could be monitored through sampling of indoor air and ground water.	Effectiveness of the remedy could be monitored through sampling of indoor air and ground water. Effectiveness of SVE could be monitored through confirmatory soil sampling.	Effectiveness of the remedy could be monitored through sampling of indoor air and ground water. Effectiveness of SVE could be monitored through confirmatory soil sampling.	Effectiveness of the remedy could be monitored through sampling of indoor air and ground water.	Effectiveness of the remedy could be monitored through sampling of indoor air and ground water.
Coordination with other agencies and property owners	Coordination with local authorities would be necessary to implement monitoring restrictions.	Coordination with local authorities would be necessary to implement use and access restrictions. Coordination with property owners would be necessary to implement indoor air investigations.	Coordination with local authorities would be necessary to implement use and access restrictions. Coordination with property owners would be necessary to implement indoor air investigations. Coordination with local authorities and support agencies would be necessary for to implement discharge of treated ground water.	Coordination with local authorities would be necessary to implement use and access restrictions. Coordination with property owners would be necessary to implement indoor air investigations. Coordination with local authorities and support agencies would be necessary for to implement discharge of treated ground water.	Coordination with local authorities would be necessary to implement use and access restrictions. Coordination with property owners would be necessary to implement indoor air investigations. Coordination with local authorities and support agencies would be necessary for to implement discharge of treated ground water.	Coordination with local authorities would be necessary to implement use and access restrictions. Coordination with property owners would be necessary to implement indoor air investigations. Coordination with local authorities and support agencies would be necessary for to implement discharge of treated ground water.
Availability of off-site treatment storage and disposal services and capacities	None required.	None required.	Disposal services would be readily available for management of treatment residuals.	Disposal services would be readily available for management of treatment residuals.	Disposal services would be readily available for management of treatment residuals.	Disposal services would be readily available for management of treatment residuals.
Availability of necessary equipment, specialists, and materials	None required.	None required.	Readily available.	Readily available.	Readily available.	Readily available.
Costs						
Capital cost	$170,000	$3,510,000	$1,108,000	$181,900	$1,050,000	$1,760,000
Present worth of operation and maintenance cost (1)	$890,000	$2,270,000	$3,820,000	$4,660,000	$3,670,000	$4,510,000
Approximate total net present worth cost (1)	$1,060,000	$5,780,000	$4,928,000	$6,479,000	$4,720,000	$6,270,000

(1) Present worth is calculated based on a 5% discount rate.

Table 6
Ground Water Monitoring Requirements

NYSDEC Railroad Dry Cleaners and Hercules Machine Sales Sites
Oceanside, New York

Monitoring Well ID/Sample Location	Sampling Frequency for VOCs					
	First Year			Following First Year		
	Quarterly	Semi-Annually	Annually	Quarterly	Semi-Annually	Annually
Background Monitoring Wells						
MW-7A			X			X
MW-7B			X			X
MW-7C			X			X
Perimeter Monitoring Wells						
MW-10B			X			X
MW-10C			X			X
MW-16A			X			X
MW-16B			X			X
MW-16C			X			X
MW-16D			X			X
MW-16E			X			X
MW-18A		X				X
MW-18B	X				X	
MW-18C		X				X
MW-19B			X			X
MW-19C			X			X
MW-19D			X			X
Plume Monitoring Wells						
Replacement MW-1	X					X
Replacement MW-3	X				X	
MW-8A	X			X		
MW-8B	X			X		
MW-8C	X				X	
MW-8D	X				X	
MW-8E	X				X	
MW-8F	X				X	
MW-9B	X			X		
MW-9C	X			X		
MW-9D	X			X		
MW-9E		X				X
MW-9F		X				X
MW-9G		X				X
MW-9H		X				X
MW-12A	X				X	
MW-12B		X				X
MW-12C	X			X		
MW-12D		X				X
MW-12E		X				X
MW-14A	X				X	
MW-14B		X				X
MW-14C	X			X		
MW-14D		X				X
MW-14E		X				X

Table 6
Ground Water Monitoring Requirements

NYSDEC Railroad Dry Cleaners and Hercules Machine Sales Sites
Oceanside, New York

Monitoring Well ID/Sample Location	Sampling Frequency for VOCs					
	First Year			Following First Year		
	Quarterly	Semi-Annually	Annually	Quarterly	Semi-Annually	Annually
MW-14F		X				X
MW-17A	X				X	
MW-17B	X			X		
MW-17C	X			X		
MW-17D		X				X
MW-21A			X			X
MW-21B		X			X	
MW-21C		X			X	
MW-21D	X			X		
MW-21E		X			X	
MW-23A			X			X
MW-23B		X				X
MW-23C	X			X		
MW-23D		X			X	
MW-23E		X				X

Notes:

1. Groundwater samples will be analyzed for VOCs using USEPA SW-846 Methods 8021 or 8260.
2. Water levels will be obtained from all accessible monitoring wells on a quarterly basis. Water levels will be measured manually in the field to the nearest 0.01 foot using an electronic water level probe.

Table 7
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 1 Cost Estimate – No action with monitoring

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Environmental Easement						
Ground water & indoor air monitoring	LS	1	$15,000	$15,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	$40,000	
2) Site management plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	$20,000	
3) Ground Water Monitoring - VOCs	LS	1	$55,000	$55,000		Sampling schedule as defined in the Ground Water Monitoring Table.
				SUBTOTAL:	$55,000	
			TOTAL DIRECT CAPITAL COST:		$115,000	
Indirect Capital Costs						
1) Contingency (25% of Direct Capital Costs)		1	$28,750	$28,750		
				SUBTOTAL:	$28,750	
2) Engineering (15% of Direct Capital Costs)		1	$17,250	$17,250		
				SUBTOTAL:	$17,250	
3) Legal Fees (5% of Direct Capital Costs)		1	$5,750	$5,750		
				SUBTOTAL:	$5,750	
			TOTAL INDIRECT CAPITAL COSTS (rounded):		$52,000	
			TOTAL CAPITAL COSTS (rounded):		$170,000	
Operation & Maintenance Costs						
1) Periodic Review	LS	1	$10,000	$10,000		Assumes reviews are conducted every 5 years.
2) Ground Water Monitoring, Years 2 to 30 - VOCs Only	LS	1	$43,000	$43,000		Sampling schedule as defined in the Ground Water Monitoring Table.
3) Vapor Intrusion Monitoring, Years 1 to 30	Event	4	$4,000	$16,000		Assumes Hercules building requires quarterly monitoring.
		PRESENT WORTH OF O&M COSTS (rounded):			$890,000	Assumes 30 years of O&M and a discount rate of 5%.
		APPROXIMATE TOTAL PRESENT WORTH COST (rounded):			$1,060,000	

Table 8
REMEDIAL ALTERNATIVE COST SUMMARY
Alternative 2 Cost Estimate –Plume Area A ground water chemical oxidation and MNA

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	$50,000	
2) Site Management Plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	$20,000	
3) Vapor Intrusion Mitigation System Installation	LS	1	$25,000	$25,000		Installation of a sub-slab depressurization system and sealing common wall.
				SUBTOTAL:	$25,000	
4) Additional Vapor Intrusion Sampling	LS	1	$13,000	$13,000		Vapor intrusion sampling is assumed for five buildings
				SUBTOTAL:	$13,000	
5) *In Situ* Chemical Oxidation Testing						
Bench Scale Test	LS	1	$10,000	$10,000		Oxidant demand testing and report.
Pilot Study	LS	1	$128,000	$128,000		Oxidant injection pilot for 40 injection points.
				SUBTOTAL:	$138,000	
6) *In Situ* Chemical Oxidation Injections Using Permanganate	LS	1	$2,000,000	$2,000,000		Two events of continuous injection for 86 days. Includes materials and labor.
				SUBTOTAL:	$2,000,000	
7) MNA Baseline Sampling	Per event	4	$27,000	$108,000		Assumes quarterly sampling events at 22 wells.
				SUBTOTAL:	$108,000	
8) Ground Water Monitoring - VOCs	LS	1	$46,000	$46,000		Sampling schedule as defined in the Ground Water Monitoring Table.
Well installation	EA	2	$10,000	$20,000		Up to two 100-ft on site monitoring wells replaced.
				SUBTOTAL:	$66,000	
			TOTAL DIRECT CAPITAL COST:		$2,420,000	
Indirect Capital Costs						
1) Contingency (25% of Direct Capital Costs)	LS	1	$605,000	$605,000		
				SUBTOTAL:	$605,000	
2) Engineering (15% of Direct Capital Costs)	LS	1	$363,000.00	$363,000		
				SUBTOTAL:	$363,000	
3) Legal Fees (5% of Direct Capital Costs)	LS	1	$121,000.00	$121,000		
				SUBTOTAL:	$121,000	
4) Construction Performance Bond (1.25% Direct Capital Costs - Construction Costs Only)	LS	1	$562.50	$563		
				SUBTOTAL:	$563	
			TOTAL INDIRECT CAPITAL COSTS:		$1,089,563	
			TOTAL CAPITAL COSTS (rounded):		$3,510,000	

Table 8
REMEDIAL ALTERNATIVE COST SUMMARY
Alternative 2 Cost Estimate -Plume Area A ground water chemical oxidation and MNA

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST	NOTES
Operation & Maintenance Costs					
1) Periodic Review	LS	1	$10,000	$10,000	Assumes reviews are conducted every 5 years.
2) Ground Water Monitoring, Years 2 to 30 - MNA parameters	LS	1	$61,000	$61,000	Sampling schedule as defined in the Ground Water Monitoring Table.
3) Ground Water Monitoring, Years 2 to 30 - VOCs Only	LS	1	$24,000	$24,000	Sampling schedule as defined in the Ground Water Monitoring Table.
4) Vapor Intrusion Monitoring, Years 1 to 30	Event	4	$4,000	$16,000	Assumes Hercules building requires quarterly monitoring.
5) Vapor Intrusion Mitigation System Operation and Maintenance, Years 1 to 30	LS	1	$1,500	$1,500	Assumes O&M for 1 mitigation system.
6) Asphalt Maintenance	LS	1	$500	$500	Covers sealing cracks in the asphalt on an annual basis.
7) Insurance (1% Direct Capital Cost)	LS	1	$24,200	$24,200	
8) Reserve Fund (1% Direct Capital Cost)	LS	1	$24,200	$24,200	
		PRESENT WORTH OF O&M COSTS (rounded):		$2,270,000	Assumes 30 years of O&M and a discount rate of 5%
		APPROXIMATE TOTAL PRESENT WORTH COST (rounded):		**$6,780,000**	

Table 9
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 3A Cost Estimate – Source area soil remediation via SVE, Plume Area A ground water remediation via extraction/treatment, and Plume Area B ground water MNA

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	$50,000	
2) Site management plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	$20,000	
3) Vapor intrusion mitigation	LS	1	$5,000	$5,000		Includes sealing common wall.
				SUBTOTAL:	$5,000	
4) Additional Vapor Intrusion Sampling	LS	1	$13,000	$13,000		Vapor intrusion sampling is assumed for five buildings
				SUBTOTAL:	$13,000	
5) Soil Vapor Extraction System	LS	1	$60,000	$60,000		
				SUBTOTAL:	$60,000	
6) Ground Water Collection/Treatment/Discharge Systems						
Pre-design field studies	LS	1	$25,000	$25,000		Includes pump testing.
Permitting (Air, NPDES, etc.)	LS	1	$15,000	$15,000		
Mobilization	LS	1	$25,000	$25,000		
Extraction wells	LS	1	$13,000	$13,000		Installation of 2 extraction wells.
Treatment system	LS	1	$310,000	$310,000		
Electrical	LS	1	$25,000	$25,000		
Restoration	LS	1	$10,000	$10,000		
Surveying	LS	1	$15,000	$15,000		
				SUBTOTAL:	$438,000	
7) MNA Baseline Sampling	Per event	4	$27,000	$108,000		Assumes quarterly sampling events at 22 wells.
				SUBTOTAL:	$108,000	
8) Ground Water Monitoring - VOCs	LS	1	$46,000	$46,000		Sampling schedule as defined in the Ground Water Monitoring Table.
Well installation	EA	2	$10,000	$20,000		Up to two 100-ft on site monitoring wells replaced.
				SUBTOTAL:	$66,000	
				TOTAL DIRECT CAPITAL COST:	$760,000	
Indirect Capital Costs						
1) Contingency (25% of Direct Capital Costs)	LS	1	$190,000	$190,000		
				SUBTOTAL:	$190,000	
2) Engineering (15% of Direct Capital Costs)	LS	1	$114,000	$114,000		
				SUBTOTAL:	$114,000	
3) Legal Fees (5% of Direct Capital Costs)	LS	1	$38,000	$38,000		
				SUBTOTAL:	$38,000	
4) Construction Performance Bond	LS	1	$6,288	$6,288		
(1.25% Direct Capital Costs - Construction Costs Only)				SUBTOTAL:	$6,288	
				TOTAL INDIRECT CAPITAL COSTS:	$348,288	
				TOTAL CAPITAL COSTS (rounded):	$1,108,000	

Table 9
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 3A Cost Estimate – Source area soil remediation via SVE, Plume Area A ground water remediation via extraction/treatment, and Plume Area B ground water MNA

O'BRIEN & GERE — COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST	NOTES
Operation & Maintenance Costs					
1) Periodic Review	LS	1	$10,000	$10,000	Assumes reviews are conducted every 5 years.
2) Ground Water Monitoring, Years 2 to 30 - MNA parameters	LS	1	$61,000	$61,000	Sampling schedule as defined in the Ground Water Monitoring Table.
3) Ground Water Monitoring, Years 2 to 30 - VOCs Only	LS	1	$24,000	$24,000	Sampling schedule as defined in the Ground Water Monitoring Table.
4) Vapor Intrusion Monitoring, Years 1 to 30	Event	4	$4,000	$16,000	Assumes Hercules building requires quarterly monitoring.
5) Vapor Intrusion Mitigation System Operation and Maintenance, Years 1 to 30	LS	1	$1,500	$1,500	Assumes O&M for 1 mitigation system.
6) Ground Water Treatment System Operation and Maintenance, Years 1 to 30	LS	1	$125,000	$125,000	Includes electricity, maintenance, disposal, discharge sampling.
7) Soil Vapor Extraction System Operation and Maintenance, Years 1 to 5	LS	1	$30,000	$30,000	Includes electricity, maintenance, disposal, effluent sampling.
8) Asphalt Maintenance	LS	1	$500	$500	Covers sealing cracks in the asphalt on an annual basis.
9) Insurance (1% Direct Capital Cost)	LS	1	$7,600	$7,600	
10) Reserve Fund (1% Direct Capital Cost)	LS	1	$7,600	$7,600	
		PRESENT WORTH OF O&M COSTS (rounded):		$3,820,000	Assumes 30 years of O&M and a discount rate of 5%
		APPROXIMATE TOTAL PRESENT WORTH COST (rounded):		**$4,928,000**	

Table 10
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 3B Cost Estimate -- Source are soil remediation via SVE, ground water plume remediation via extraction/treatment

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	$50,000	
2) Site management plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	$20,000	
3) Vapor intrusion mitigation system installation	LS	1	$5,000	$5,000		Includes sealing common wall.
				SUBTOTAL:	$5,000	
4) Additional Vapor Intrusion Sampling	LS	1	$13,000	$13,000		Vapor intrusion sampling is assumed for five buildings
				SUBTOTAL:	$13,000	
5) Soil Vapor Extraction System	LS	1	$60,000	$60,000		
				SUBTOTAL:	$60,000	
6) Ground Water Collection/Treatment/Discharge Systems						
Pre-design field studies	LS	1	$25,000	$25,000		Includes pump testing.
Permitting (Air, NPDES, etc.)	LS	1	$15,000	$15,000		
Mobilization	LS	1	$25,000	$25,000		
Extraction wells	LS	1	$27,000	$27,000		Installation of 5 extraction wells.
Treatment system	LS	1	$780,000	$780,000		
Electrical	LS	1	$25,000	$25,000		
Restoration	LS	1	$110,000	$110,000		
Surveying	LS	1	$15,000	$15,000		
				SUBTOTAL:	$1,022,000	
7) Ground Water Monitoring - VOCs	LS	1	$55,000	$55,000		Sampling schedule as defined in the Ground Water Monitoring Table.
Well installation	EA	2	$10,000	$20,000		Up to two 100-ft on site monitoring wells replaced.
				SUBTOTAL:	$75,000	
				TOTAL DIRECT CAPITAL COST:	$1,245,000	
Indirect Capital Costs						
1) Contingency (25% of Direct Capital Costs)	LS	1	$311,250	$311,250		
				SUBTOTAL:	$311,250	
2) Engineering (15% of Direct Capital Costs)	LS	1	$186,750	$186,750		
				SUBTOTAL:	$186,750	
3) Legal Fees (5% of Direct Capital Costs)	LS	1	$62,250	$62,250		
				SUBTOTAL:	$62,250	
4) Construction Performance Bond (1.25% Direct Capital Costs - Construction Costs Only)	LS	1	$13,588	$13,588		
				SUBTOTAL:	$13,588	
				TOTAL INDIRECT CAPITAL COSTS:	$573,838	
				TOTAL CAPITAL COSTS (rounded):	$1,819,000	

Table 10
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 3B Cost Estimate -- Source are soil remediation via SVE, ground water plume remediation via extraction/treatment

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST	NOTES
Operation & Maintenance Costs					
1) Periodic Review	LS	1	$10,000	$10,000	Assumes reviews are conducted every 5 years.
2) Ground Water Monitoring, Years 2 to 30 - VOCs Only	LS	1	$43,000	$43,000	Sampling schedule as defined in the Ground Water Monitoring Table.
3) Vapor Intrusion Monitoring, Years 1 to 30	Event	4	$4,000	$16,000	Assumes Hercules building requires quarterly monitoring.
4) Vapor Intrusion Mitigation System Operation and Maintenance, Years 1 to 30	LS	1	$1,500	$1,500	Assumes O&M for 1 mitigation system.
5) Ground Water Treatment System Operation and Maintenance, Years 1 to 15	LS	1	$250,000	$250,000	For Plume Area B. Includes electricity, maint., disp., disch. sampling.
6) Ground Water Treatment System Operation and Maintenance, Years 16 to 30	LS	1	$125,000	$125,000	For Plume Area A. Includes electricity, maint., disp., disch. sampling.
7) Soil Vapor Extraction System Operation and Maintenance, Years 1 to 5	LS	1	$30,000	$30,000	Includes electricity, maintenance, disposal, effluent sampling.
8) Asphalt Maintenance	LS	1	$500	$500	Covers sealing cracks in the asphalt on an annual basis.
9) Insurance (1% Direct Capital Cost)	LS	1	$12,450	$12,450	
10) Reserve Fund (1% Direct Capital Cost)	LS	1	$12,450	$12,450	
	PRESENT WORTH OF O&M COSTS (rounded):			$4,660,000	Assumes 30 years of O&M and a discount rate of 5%
	APPROXIMATE TOTAL PRESENT WORTH COST (rounded):			$6,479,000	

Table 11
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 4A Cost Estimate – Plume Area A ground water remediation via extraction/treatment and Plume Area B ground water MNA

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	$50,000	
2) Site management plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	$20,000	
3) Vapor intrusion mitigation system installation	LS	1	$25,000	$25,000		Installation of a sub-slab depressurization system and sealing wall.
				SUBTOTAL:	$25,000	
4) Additional Vapor Intrusion Sampling	LS	1	$13,000	$13,000		Vapor intrusion sampling is assumed for five buildings
				SUBTOTAL:	$13,000	
5) Ground Water Collection/Treatment/Discharge Systems						
Pre-design field studies	LS	1	$25,000	$25,000		Includes pump testing.
Permitting (Air, NPDES, etc.)	LS	1	$15,000	$15,000		
Mobilization	LS	1	$25,000	$25,000		
Extraction wells	LS	1	$13,000	$13,000		Installation of 2 extraction wells.
Treatment system	LS	1	$310,000	$310,000		
Electrical	LS	1	$25,000	$25,000		
Restoration	LS	1	$10,000	$10,000		
Surveying	LS	1	$15,000	$15,000		
				SUBTOTAL:	$438,000	
6) MNA Baseline Sampling	Event	4	$27,000	$108,000		Assumes quarterly sampling events at 22 wells.
				SUBTOTAL:	$108,000	
7) Ground Water Monitoring - VOCs	LS	1	$46,000	$46,000		Sampling schedule as defined in the Ground Water Monitoring Table.
Well installation	EA	2	$10,000	$20,000		Up to two 100-ft on site monitoring wells replaced.
				SUBTOTAL:	$66,000	
				TOTAL DIRECT CAPITAL COST:	$720,000	
Indirect Capital Costs						
1) Contingency (25% of Direct Capital Costs)	LS	1	$180,000	$180,000		
				SUBTOTAL:	$180,000	
2) Engineering (15% of Direct Capital Costs)	LS	1	$108,000	$108,000		
				SUBTOTAL:	$108,000	
3) Legal Fees (5% of Direct Capital Costs)	LS	1	$36,000	$36,000		
				SUBTOTAL:	$36,000	
4) Construction Performance Bond (1.25% Direct Capital Costs - Construction Costs Only)	LS	1	$5,788	$5,788		
				SUBTOTAL:	$5,788	
				TOTAL INDIRECT CAPITAL COSTS:	$329,788	
				TOTAL CAPITAL COSTS (rounded):	$1,050,000	

Table 11
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 4A Cost Estimate -- Plume Area A ground water remediation via extraction/treatment and Plume Area B ground water MNA

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Operation & Maintenance Costs						
1) Periodic Review	LS	1	$10,000	$10,000		Assumes reviews are conducted every 5 years.
2) Ground Water Monitoring, Years 2 to 30 - MNA parameters	LS	1	$61,000	$61,000		Sampling schedule as defined in the Ground Water Monitoring Table.
3) Ground Water Monitoring, Years 2 to 30 - VOCs Only	LS	1	$24,000	$24,000		Sampling schedule as defined in the Ground Water Monitoring Table.
4) Vapor Intrusion Monitoring, Years 1 to 30	Event	4	$4,000	$16,000		Assumes Hercules building requires quarterly monitoring.
5) Vapor Intrusion Mitigation System Operation and Maintenance, Years 1 to 30	LS	1	$1,500	$1,500		Assumes O&M for 1 mitigation system.
6) Ground Water Treatment System Operation and Maintenance, Years 1 to 30	LS	1	$125,000	$125,000		Includes electricity, maintenance, disposal, discharge sampling.
7) Asphalt Maintenance	LS	1	$500	$500		Covers sealing cracks in the asphalt on an annual basis.
8) Insurance (1% Direct Capital Cost)	LS	1	$7,200	$7,200		
9) Reserve Fund (1% Direct Capital Cost)	LS	1	$7,200	$7,200		
		PRESENT WORTH OF O&M COSTS (rounded):			$3,670,000	Assumes 30 years of O&M and a discount rate of 5%
		APPROXIMATE TOTAL PRESENT WORTH COST (rounded):			**$4,720,000**	

Table 12
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 4B Cost Estimate – Ground water plume remediation via extraction/treatment

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
Direct Capital Costs						
1) Environmental Easement						
Ground water use restrictions	LS	1	$15,000	$15,000		
Building/property use restrictions	LS	1	$10,000	$10,000		
Site information database	LS	1	$25,000	$25,000		
				SUBTOTAL:	**$50,000**	
2) Site management plan	LS	1	$20,000	$20,000		
				SUBTOTAL:	**$20,000**	
3) Vapor intrusion mitigation system installation	LS	1	$25,000	$25,000		Installation of a sub-slab depressurization system and sealing wall.
				SUBTOTAL:	**$25,000**	
4) Additional Vapor Intrusion Sampling	LS	1	$13,000	$13,000		Vapor intrusion sampling is assumed for five buildings
				SUBTOTAL:	**$13,000**	
5) Ground Water Collection/Treatment/Discharge Systems						
Pre-design field studies	LS	1	$25,000	$25,000		Includes pump testing.
Permitting (Air, NPDES, etc.)	LS	1	$15,000	$15,000		
Mobilization	LS	1	$25,000	$25,000		
Extraction wells	LS	1	$27,000	$27,000		Installation of 5 extraction wells.
Treatment system	LS	1	$780,000	$780,000		
Electrical	LS	1	$25,000	$25,000		
Restoration	LS	1	$110,000	$110,000		
Surveying	LS	1	$15,000	$15,000		
				SUBTOTAL:	**$1,022,000**	
6) Ground Water Monitoring - VOCs	LS	1	$55,000	$55,000		Sampling schedule as defined in the Ground Water Monitoring Table.
Well installation	EA	2	$10,000	$20,000		Up to two 100-ft on site monitoring wells replaced.
				SUBTOTAL:	**$75,000**	
			TOTAL DIRECT CAPITAL COST:		**$1,205,000**	
Indirect Capital Costs						
1) Contingency (25% of Direct Capital Costs)	LS	1	$301,250	$301,250		
				SUBTOTAL:	**$301,250**	
2) Engineering (15% of Direct Capital Costs)	LS	1	$180,750	$180,750		
				SUBTOTAL:	**$180,750**	
3) Legal Fees (5% of Direct Capital Costs)	LS	1	$60,250	$60,250		
				SUBTOTAL:	**$60,250**	
4) Construction Performance Bond (1.25% Direct Capital Costs - Construction Costs Only)	LS	1	$13,088	$13,088		
				SUBTOTAL:	**$13,088**	
			TOTAL INDIRECT CAPITAL COSTS:		**$555,338**	
			TOTAL CAPITAL COSTS (rounded):		**$1,760,000**	

Table 12
REMEDIAL ALTERNATIVE COST SUMMARY

Alternative 4B Cost Estimate – Ground water plume remediation via extraction/treatment

O'BRIEN & GERE

COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST	NOTES
Operation & Maintenance Costs					
1) Periodic Review	LS	1	$10,000	$10,000	Assumes reviews are conducted every 5 years.
2) Ground Water Monitoring, Years 2 to 30 - VOCs Only	LS	1	$43,000	$43,000	Sampling schedule as defined in the Ground Water Monitoring Table.
3) Vapor Intrusion Monitoring, Years 1 to 30	Event	4	$4,000	$16,000	Assumes Hercules building requires quarterly monitoring.
4) Vapor Intrusion Mitigation System Operation and Maintenance, Years 1 to 30	LS	1	$1,500	$1,500	Assumes O&M for 1 mitigation system.
5) Ground Water Treatment System Operation and Maintenance, Years 1 to 15	LS	1	$250,000	$250,000	For Plume Area B. Includes electricity, maint., disp., disch. sampling.
6) Ground Water Treatment System Operation and Maintenance, Years 16 to 30	LS	1	$125,000	$125,000	For Plume Area A. Includes electricity, maint., disp., disch. sampling.
7) Asphalt Maintenance	LS	1	$500	$500	Covers sealing cracks in the asphalt on an annual basis.
8) Insurance (1% Direct Capital Cost)	LS	1	$12,050	$12,050	
9) Reserve Fund (1% Direct Capital Cost)	LS	1	$12,050	$12,050	
		PRESENT WORTH OF O&M COSTS (rounded):		**$4,610,000**	Assumes 30 years of O&M and a discount rate of 5%
		APPROXIMATE TOTAL PRESENT WORTH COST (rounded):		**$6,270,000**	

Table 13
REMEDIAL ALTERNATIVE ANNUAL COST SUMMARY

O'BRIEN & GERE

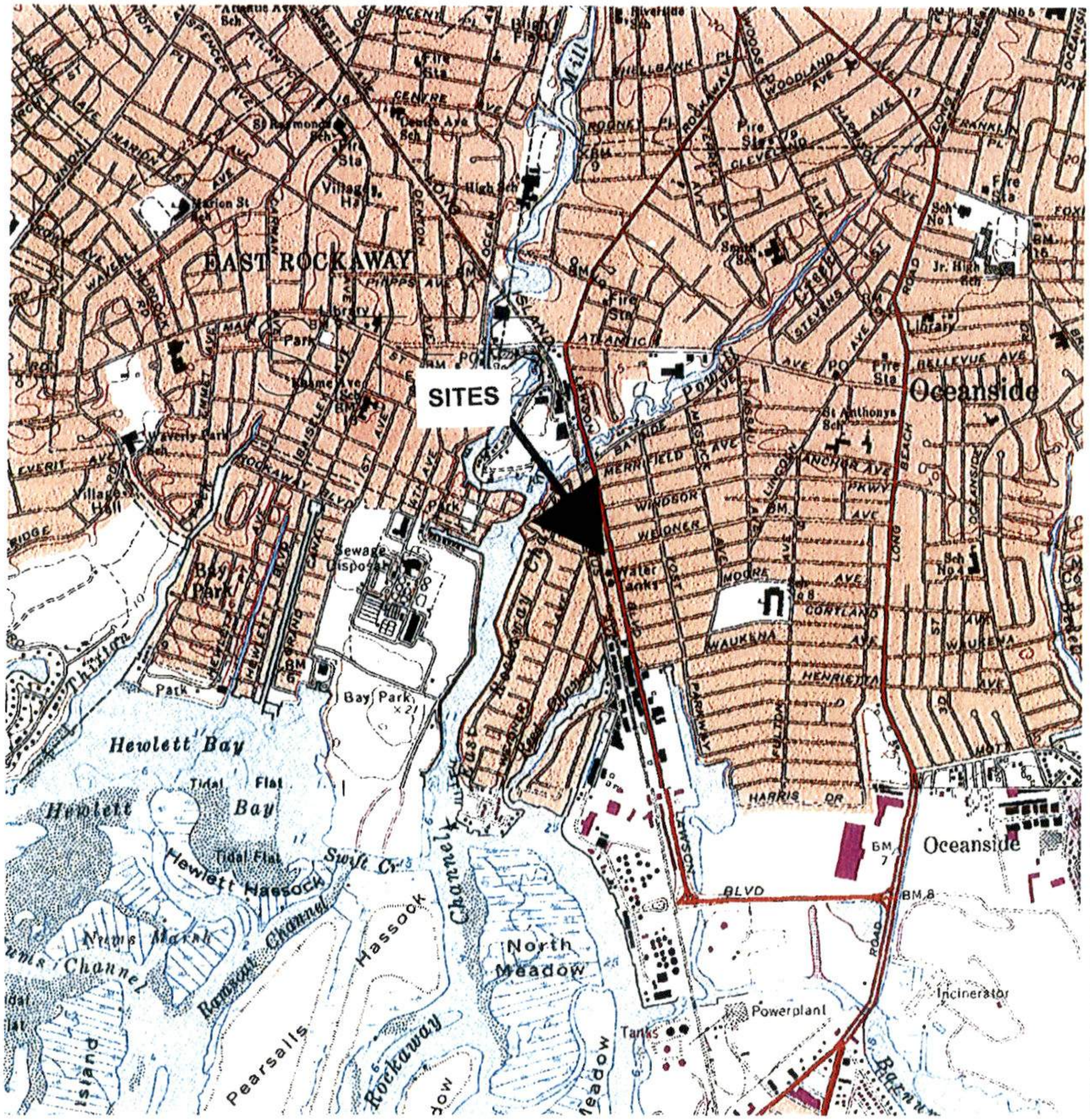
COST ESTIMATE SUMMARY

Site: Railroad Dry Cleaners and Hercules Machine Sales Sites
Location: 3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase: Feasibility Study (-30% to +50%)
Base Year: 2007

	Year(s)	Annual Cost
Alternative 1	Year 1	$16,000
	Years 5, 10, 20, 25 and 30	$69,000
	All other years (2 - 30)	$59,000
Alternative 2	Year 1	$66,400
	Years 5, 10, 20, 25 and 30	$161,400
	All other years (2 - 30)	$151,400
Alternative 3A	Year 1	$188,200
	Years 2, 3 and 4	$273,200
	Year 5	$283,200
	Years 10, 15, 20, 25 and 30	$253,200
	All other years (6 - 30)	$243,200
Alternative 3B	Year 1	$322,900
	Years 2, 3 and 4	$365,900
	Year 5	$375,900
	Years 10 and 15	$345,900
	All other years (6 - 14)	$335,900
	Years 20, 25, and 30	$220,900
	All other years (16 - 30)	$210,900
Alternative 4A	Year 1	$157,400
	Years 5, 10, 20, 25 and 30	$252,400
	All other years (2 - 30)	$242,400
Alternative 4B	Year 1	$292,100
	Years 5, 10 and 15	$345,100
	All other years (2 - 15)	$335,100
	Years 20, 25 and 30	$220,100
	All other years (16 - 30)	$210,100

Notes: Period review costs of $10,000 occurring every 5 years (*i.e.,* year 5, 10, 15, 20, 25, and 30).

FIGURE 1



ADAPTED FROM: USGS 7.5 MIN. quad., LYNBROOK (SOUTH), NEW YORK
AND USGS 7.5 MIN. quad., LAWRENCE, NEW YORK

QUADRANGLE LOCATION

NYS DEPT. OF ENVIRONMENTAL CONSERVATION
OCEANSIDE, NEW YORK RAILROAD DRY CLEANERS AND
HERCULES MACHINE SALES

SITE LOCATION MAP

1   1/2   0   1 MILE

1000   0   1000   2000   3000   4000   5000   6000   7000 FEET

1   .5   0   1 KILOMETER

FILE NO. 10653.37556.001
SEPTEMBER 2007

SCALE: 1:24000

O'BRIEN & GERE

Friday, August 05, 2005 9:58:42 AM

I:\NYSDEC.10653\37556.RAILROAD-CL-HER\DOCUMENTS\DRAWINGS\FS_FIGURES\1-SITE LOCATION MAP.DWG

FIGURE 2

Adapted from: NYS Statewide Digital Orthoimagery Program - 2004 Annual Lot, Nassau County; NYS GIS Clearinghouse

Friday, August 05, 2005 9:58:42 AM

\\ALBANY_FS2\ALT\PROJECTS\NYSDEC.10653\37556.RAILROAD-CL-HER\DOCUMENTS\DRAWINGS\FS FIGURES\2-SITE PLAN.DWG

LEGEND

MW-18 MONITORING WELL

RAILROAD DRY CLEANERS
AND
HERCULES MACHINE SALES
OCEANSIDE, NEW YORK

SITE PLAN

0 150 300

SCALE IN FEET

FILE NO. 10653.37556
SEPTEMBER 2007

O'BRIEN & GERE ENGINEERS INC.

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Adapted from: NYS Statewide Digital Orthoimagery Program - 2004 Annual Lot, Nassau County; NYS GIS Clearinghouse

FIGURE 3

Legend

- Monitoring Well Locations
- Extent of COCs Above GW Standard
- Plume Area A
- Plume Area B

RAILROAD DRY CLEANERS
AND
HERCULES
MACHINE SALES
OCEANSIDE, NEW YORK

HORIZONTAL EXTENT OF COCS ABOVE GROUND WATER STANDARDS

0 75 150 300
Feet

November 2007

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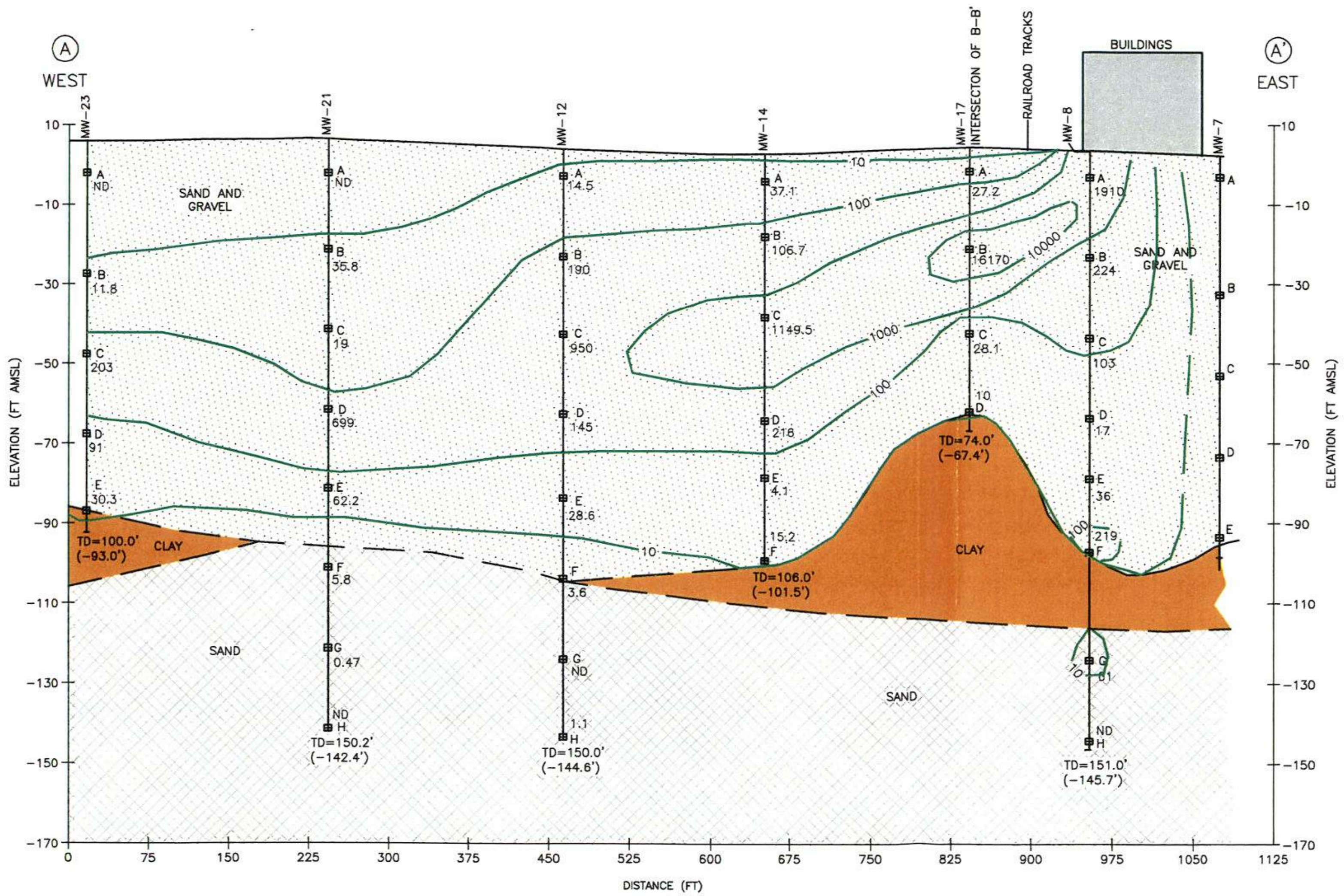
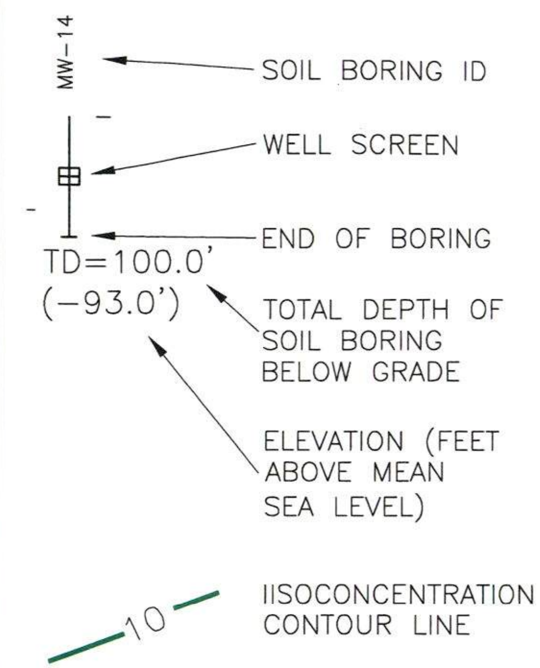


FIGURE 4

LEGEND



NOTE: TOTAL CONCENTRATION OF COCS LISTED AT EACH SCREEN

RAILROAD DRY CLEANERS
AND
HERCULES MACHINE SALES
OCEANSIDE, NEW YORK

CROSS SECTION
OF COC PLUME

0 150 300
HORIZONTAL SCALE IN FEET

0 40 80
VERTICAL SCALE IN FEET

FILE NO. 10653.37556
SEPTEMBER 2007

O'BRIEN & GERE

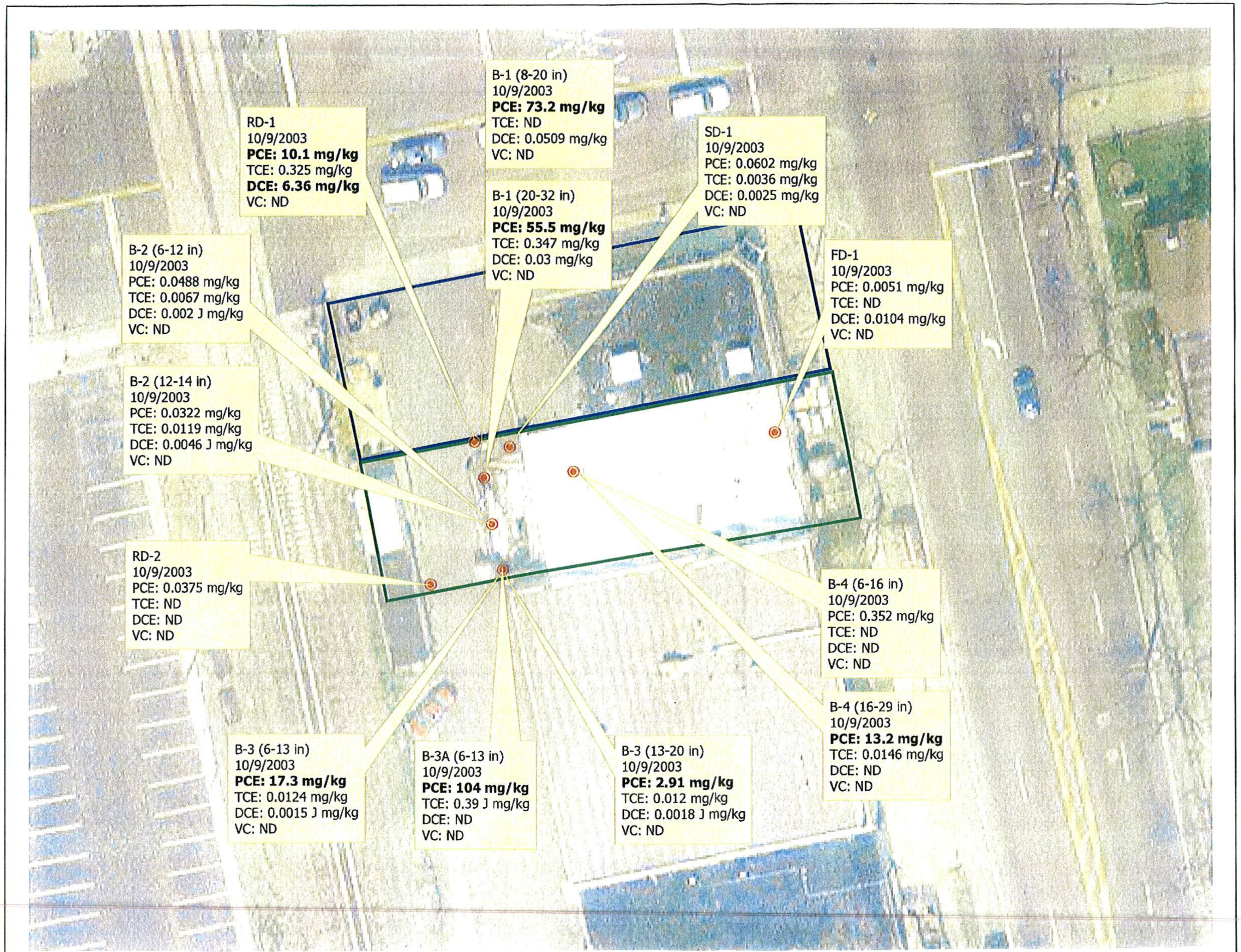


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FIGURE 5

Legend

- Subsurface Soil Sample
- Hercules Machine Sales
- Railroad Dry Cleaners

Notes:
PCE: Tetrachloroethene
TCE: Trichloroethene
DCE: cis-1,2-Dichloroethene
VC: Vinyl chloride
ND: Not detected
Concentrations that exceed NYCRR Part 375-6 unrestricted soil cleanup objectives are bolded.

Miligrams per kilogram (mg/kg) is equivalent to parts-per-million (ppm).

RAILROAD DRY CLEANERS
AND
HERCULES
MACHINE SALES
OCEANSIDE, NEW YORK

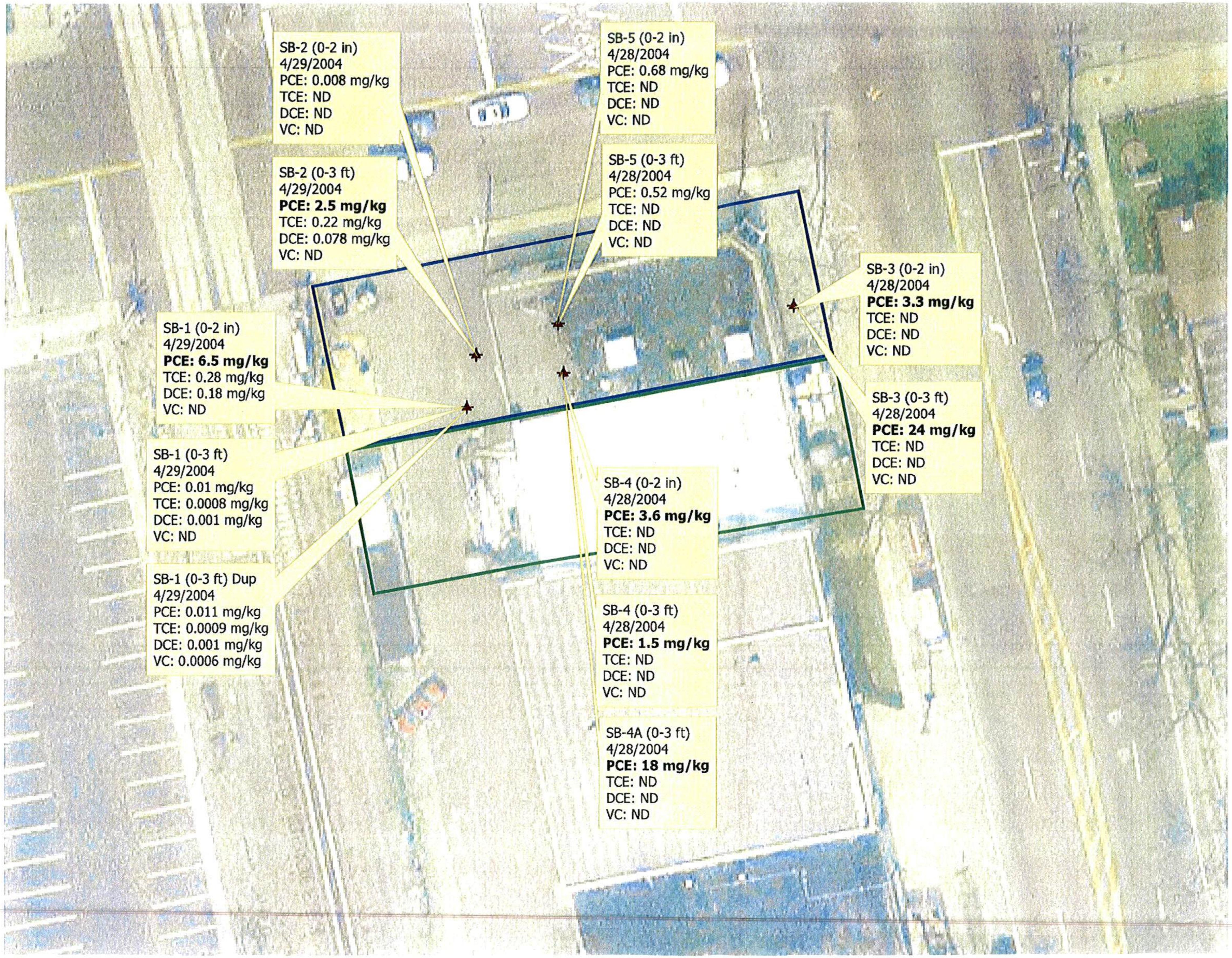
HISTORICAL SOIL COC RESULTS AT HERCULES SITE

0 12.5 25 50
Feet

September 2007
Figure 2-4 hist SO.mxd

O'BRIEN & GERE ENGINEERS, INC.

FIGURE 6



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Legend

- Surface Soil Sample
- Hercules Machine Sales
- Railroad Dry Cleaners

Notes:
PCE: Tetrachloroethene
TCE: Trichloroethene
DCE: cis-1,2-Dichloroethene
VC: Vinyl chloride
ND: Not detected
Concentrations that exceed NYCRR Part 375-6 unrestricted soil cleanup objectives are bolded.

Miligrams per kilogram (mg/kg) is equivalent to parts-per-million (ppm).

RAILROAD DRY CLEANERS
AND
HERCULES
MACHINE SALES
OCEANSIDE, NEW YORK

HISTORICAL SOIL COC RESULTS AT RAILROAD SITE

0 12.5 25 50
Feet

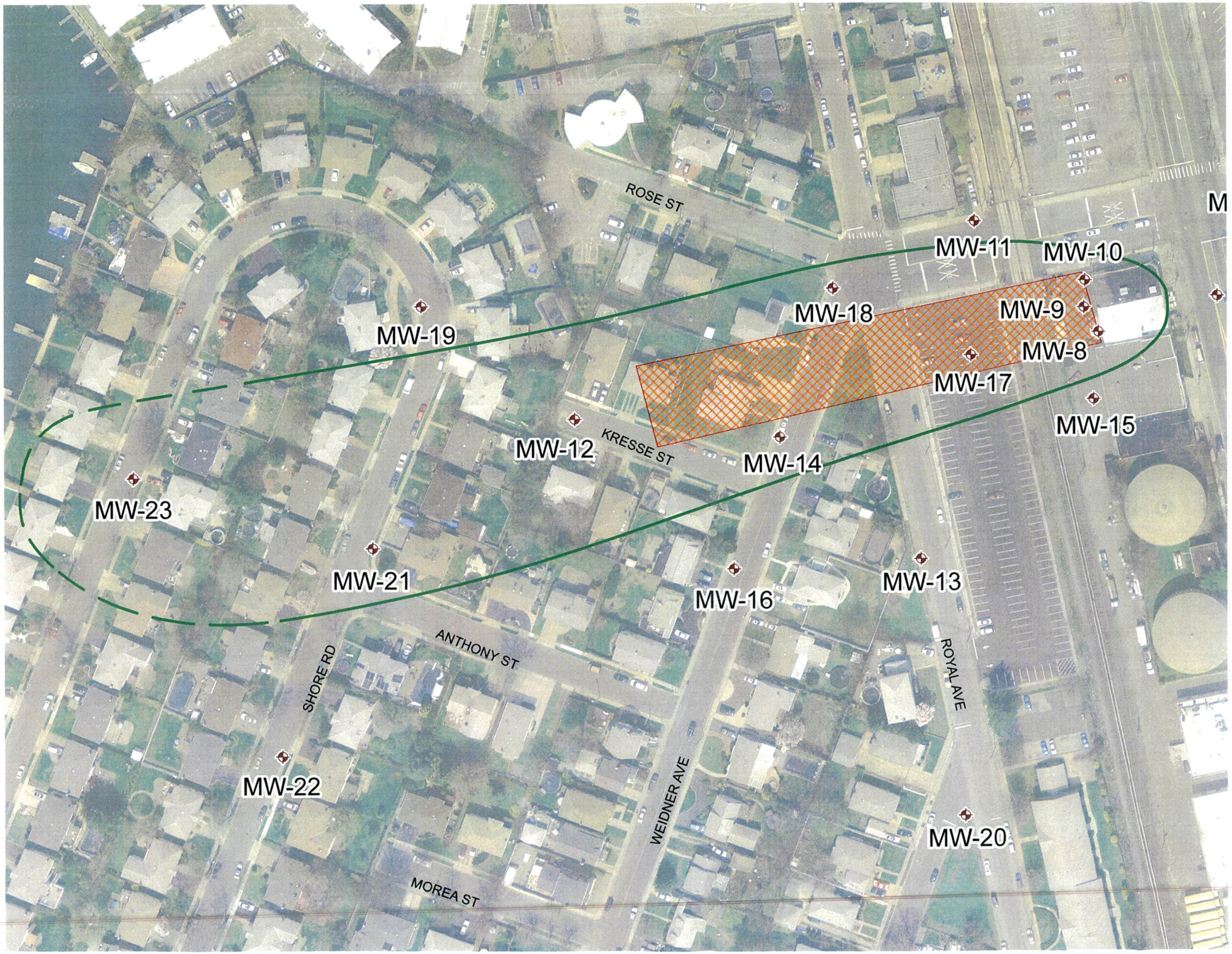
September 2007
Figure 2-5 hist SS.mxd

O'BRIEN & GERE ENGINEERS, INC.

OMPUEBUF: Bvhvtu3118

11/8/2007

FIGURE 7



Legend

- Extent of COCs Above GW Standard
- Monitoring Well Locations
- Chemical Oxidation Injection Area

RAILROAD DRY CLEANERS
AND
HERCULES
MACHINE SALES
OCEANSIDE, NEW YORK

ALTERNATIVE 2 CONCEPTUAL PLAN

0 50 100 200
Feet

November 2007

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Figure 8. Schematic Diagram of Alternative 2

- Environmental easement
- Asphalt cover and maintenance
- Ground water monitoring
- Indoor air monitoring
- Indoor air mitigation (via sub-slab depressurization)
- Plume Area A ground water chemical oxidation and MNA
- Plume Area B ground water MNA

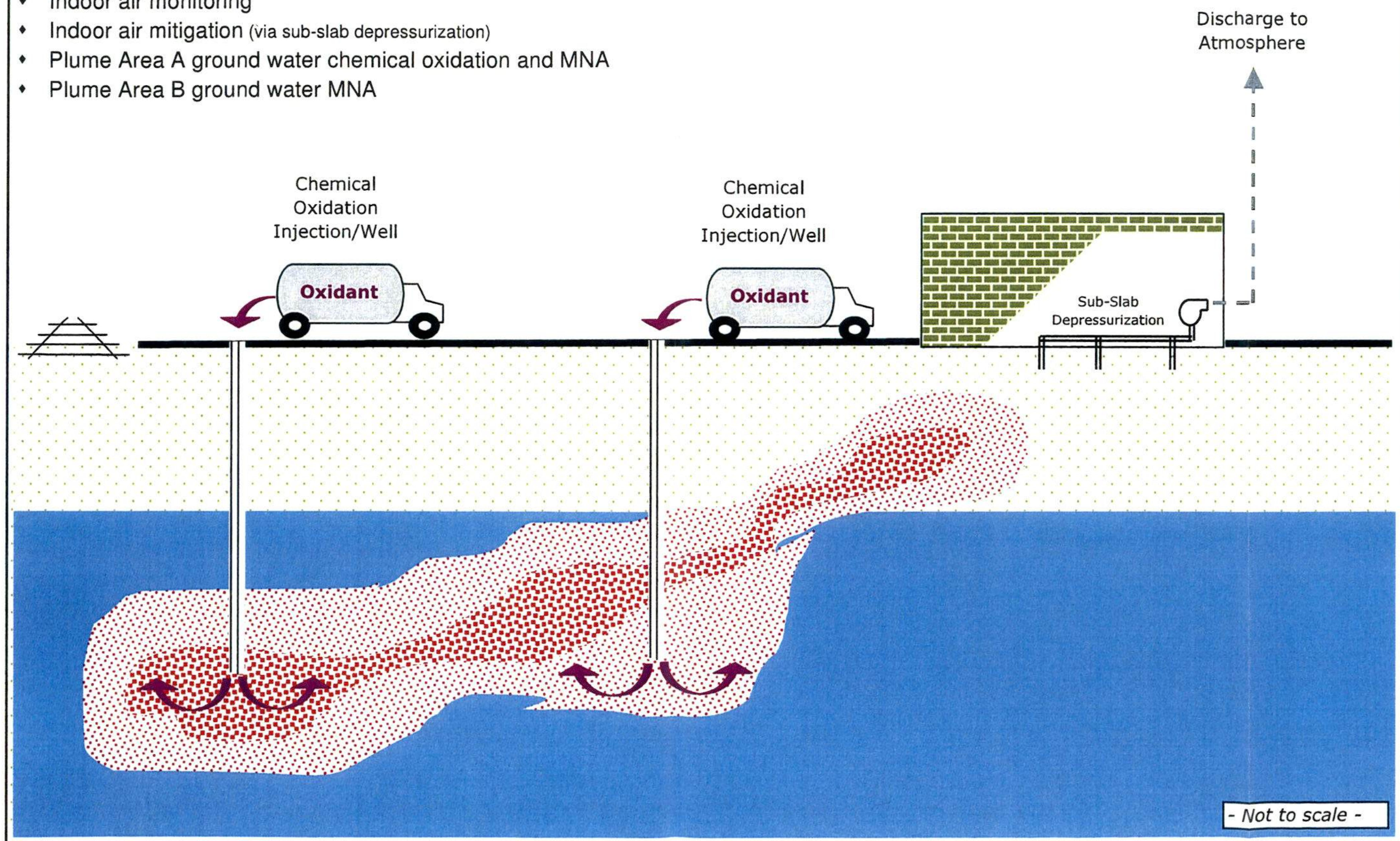

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FIGURE 9

Legend

- Proposed Extraction Wells
- Ground Water Extraction Piping
- SVE System
- Monitoring Well Locations
- Extent of COCs Above GW Standarc
- SVE and GW Treatment System

RAILROAD DRY CLEANERS
AND
HERCULES
MACHINE SALES
OCEANSIDE, NEW YORK

ALTERNATIVE 3A CONCEPTUAL PLAN

0 50 100 200
Feet

November 2007

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Figure 10. Schematic Diagram of Alternative 3 A/B

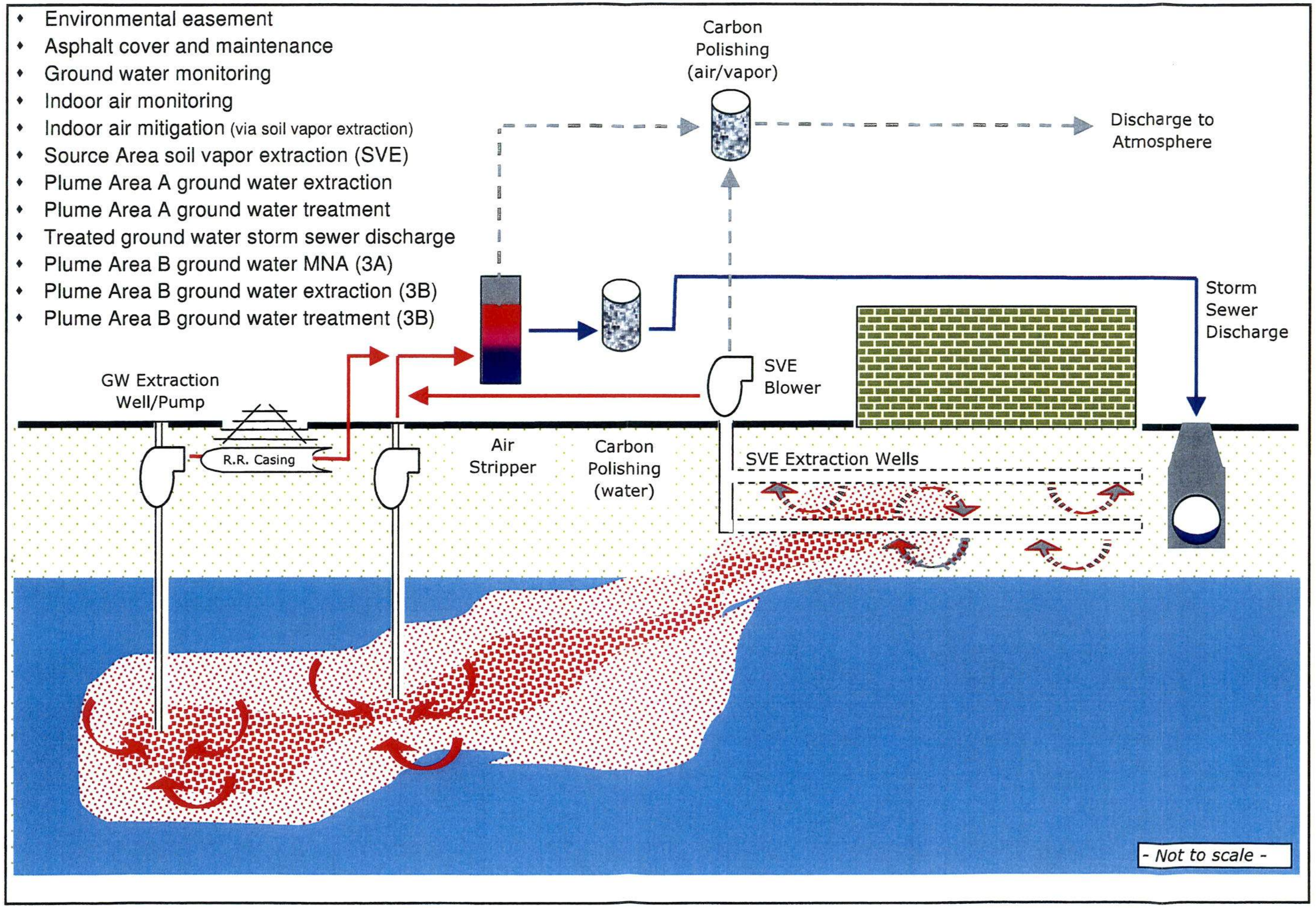

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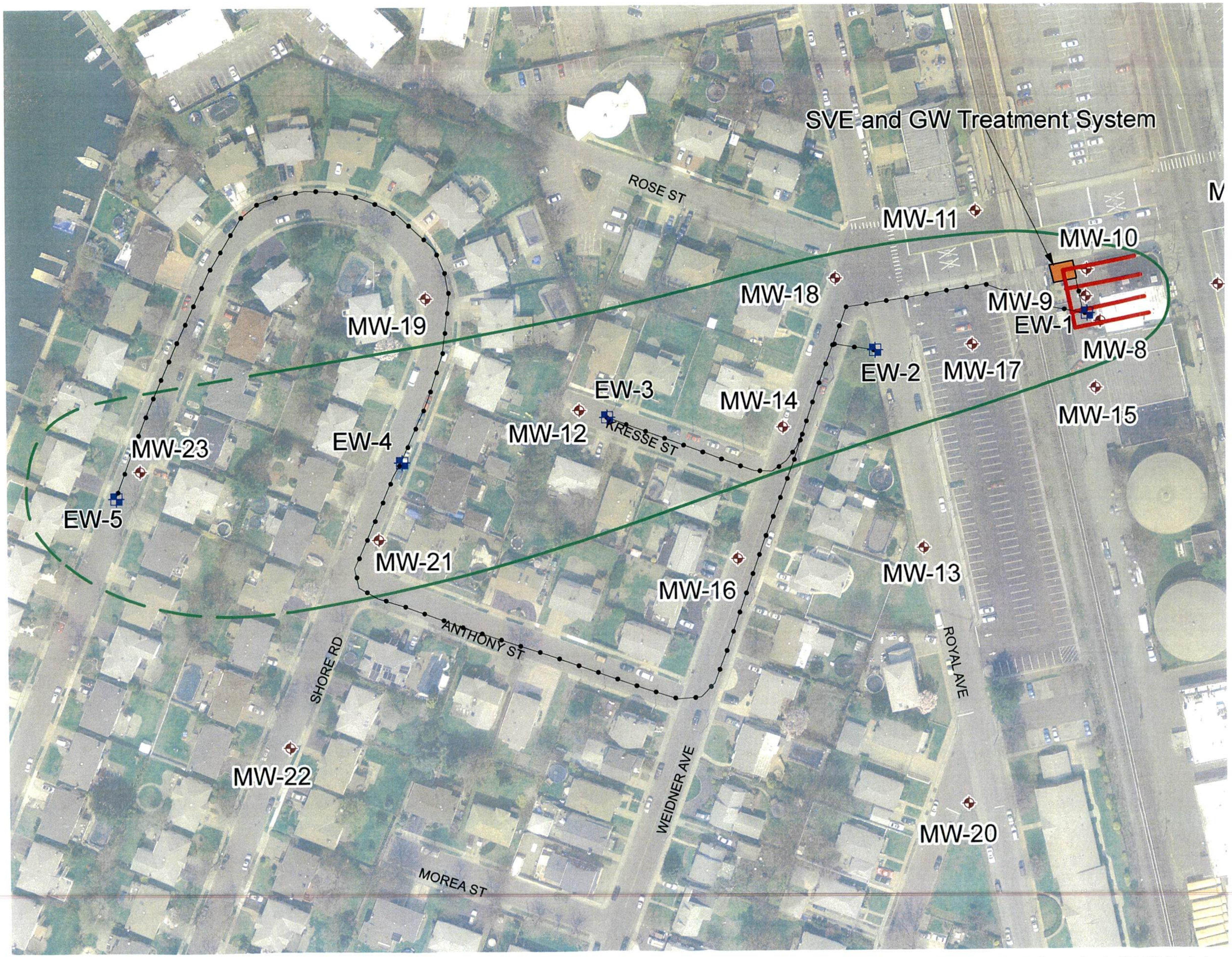
FIGURE 11



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Legend

- Proposed Extraction Wells
- Ground Water Extraction Piping
- SVE System
- Monitoring Well Locations
- Extent of COCs Above GW Standard
- SVE and GW Treatment System

RAILROAD DRY CLEANERS
AND
HERCULES
MACHINE SALES
OCEANSIDE, NEW YORK

ALTERNATIVE 3B CONCEPTUAL PLAN

0 50 100 200
Feet

November 2007

O'BRIEN & GERE ENGINEERS, INC.

11/8/2007

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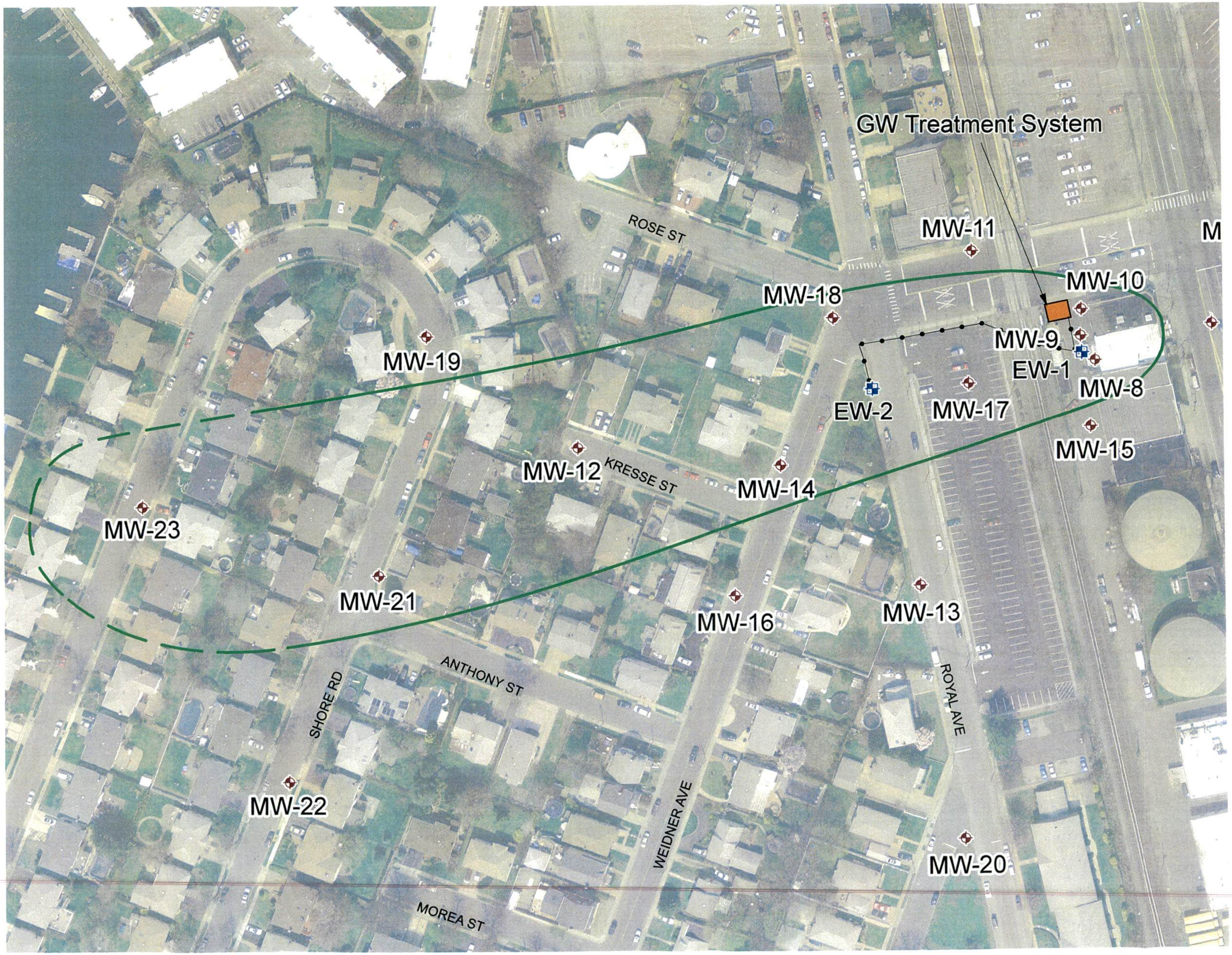

FIGURE 12

RAILROAD DRY CLEANERS
AND
HERCULES
MACHINE SALES
OCEANSIDE, NEW YORK

ALTERNATIVE 4A CONCEPTUAL PLAN

November 2007

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Figure 13. Schematic Diagram of Alternative 4 A/B

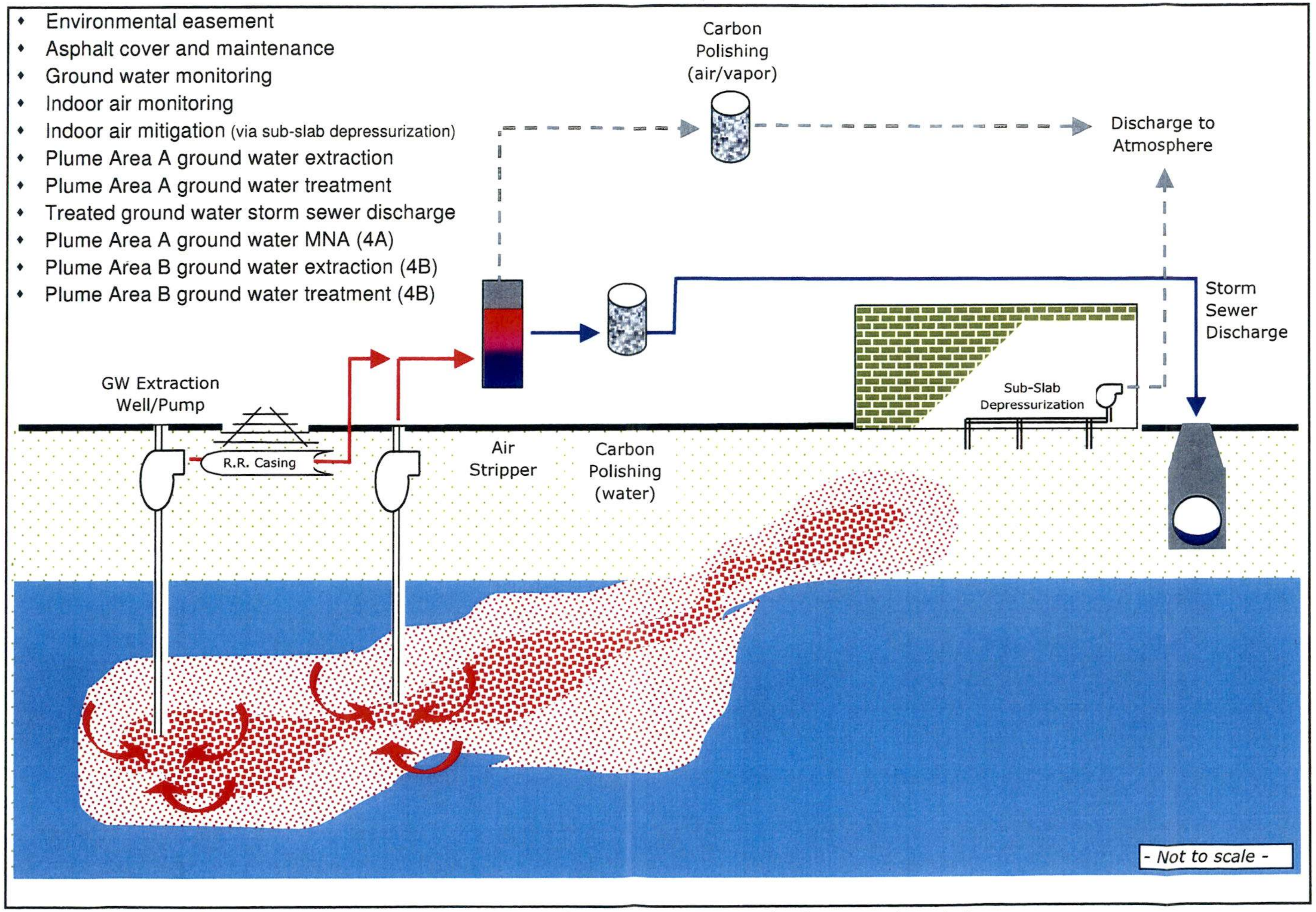

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FIGURE 14

Legend

- Proposed Extraction Wells
- Ground Water Extraction Piping
- Monitoring Well Locations
- Extent of COCs Above GW Standard
- GW Treatment System

RAILROAD DRY CLEANERS AND HERCULES MACHINE SALES
OCEANSIDE, NEW YORK

ALTERNATIVE 4B CONCEPTUAL PLAN

0 50 100 200
Feet

November 2007

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Cost Estimate Assumptions

Appendix A.

Assumptions for Feasibility Study Cost Estimates - Conceptual Estimates	
Site:	Railroad Dry Cleaners and Hercules Machine Sales Sites
Location:	3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase:	Feasibility Study (-30% to +50%)
Base Year:	2007

Alternative 1 - No Action

Alternative #1 consists of ground water and indoor air monitoring

Ground water monitoring:

Sampling schedule as defined in the Ground Water Monitoring Table.

112 ground water samples for VOCs at $100/sample

Analytical:	$	11,200.00
Labor and perdiem:	$	22,000.00
Equipment rental:	$	5,050.00
Reporting:	$	4,500.00
Total:	$	42,750.00
Total rounded:	**$**	**43,000.00**

Indoor Air Sampling:

Assumes Hercules building requires quarterly monitoring.

Three samples at $425 per sample

Analytical:	$	1,275.00
Labor and perdiem:	$	2,200.00
Reporting:	$	450.00
Total:	$	3,925.00
Total rounded:	**$**	**4,000.00**

Assumptions for Feasibility Study Cost Estimates - Conceptual Estimates	
Site:	Railroad Dry Cleaners and Hercules Machine Sales Sites
Location:	3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase:	Feasibility Study (-30% to +50%)
Base Year:	2007

Alternative 2 - In situ chemical oxidation
Alternative #2 consists of treating Plume Area A via *in situ* chemical oxidation and MNA and Plume Area B ground water via MNA.

Vapor Intrusion Mitigation System
Assumed $20,000 for design and installation of a commercial mitigation system
Assumed $5,000 for sealing the common wall.

Additional Vapor Intrusion Sampling
Vapor intrusion sampling is assumed for five buildings and would consist of indoor air, sub-slab vapor, and ambient air samples.
No further action was assumed for these five structures.

Analytical:	$	6,375.00
Labor and perdiem:	$	3,300.00
Reporting:	$	3,600.00
Total:	$	13,275.00
Total rounded:	**$**	**13,000.00**

In situ chemical oxidation:
Area to be treated assumed to be 475 by 75 ft and an average thickness of 33 ft.
30% porosity assumed.
Total treatment volume: 44,600 cubic yards
Total treatment pore volume: 2.6 million gallons
Assume natural oxidant demand for sand and gravel aquifer: 5 g/kg
Assumed chemical oxidant demant: 50,000 lb.
Estimated NaMnO3 usage: 230,000 lb (40 %)
Estimated cost 40% NaMNO3 per lb: $2.40/lb + $0.20/lb in freight
Estimated number of geoprobe injection points: 216 (Source: Carus)
Estimated injection points per day: 4 (Source Carus)
Estimated injection cost per day: $7,000 (Source Carus)
Number of phases: 2 (Source: Carus)

Phase I Injection:	$ 976,000.00
Phase II Injection	$ 976,000.00
Total:	$ 1,952,000.00
Total rounded:	**$ 2,000,000.00**

Bench Scale Testing

Oxidant demand testing:	$	5,000.00
Labor:	$	3,000.00
Reporting:	$	2,000.00
Total:	$	10,000.00
Total rounded:	**$**	**10,000.00**

Chemical Oxidation Pilot Study

40 point, 2 wk test:	$	91,666.67
Sampling:	$	6,000.00
Labor:	$	15,000.00
Reporting:	$	15,000.00
Total:	$	127,666.67
Total rounded:	**$**	**128,000.00**

Baseline Monitored Natural Attenuation
Baseline event assumed 26 samples (22 wells and 4 QA/QC) at $700 per sample

Analytical:	$	18,200.00
Labor and perdiem:	$	5,500.00
Equipment:	$	1,500.00
Reporting:	$	1,300.00
Total:	$	26,500.00
Total rounded:	**$**	**27,000.00**

Assumptions for Feasibility Study Cost Estimates - Conceptual Estimates		
Site:	Railroad Dry Cleaners and Hercules Machine Sales Sites	
Location:	3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY	
Phase:	Feasibility Study (-30% to +50%)	
Base Year:	2007	
Baseline Ground Water Monitoring - VOCs		
Baseline event assumed 127 samples (113 wells and 14 QA/QC) at $100 per sample		
Analytical:	$	12,700.00
Labor and perdiem:	$	22,000.00
Equipment:	$	5,050.00
Reporting:	$	5,400.00
Total:	$	45,150.00
Total rounded:	**$**	**46,000.00**
Annual Monitored Natural Attenuation		
60 samples (54 wells and 6 QA/QC) at $700 per sample		
Analytical:	$	42,000.00
Labor and perdiem:	$	13,200.00
Equipment:	$	3,650.00
Reporting:	$	1,350.00
Total:	$	60,200.00
Total rounded:	**$**	**61,000.00**
Annual Ground Water Monitoring - VOCs		
Baseline event assumed 127 samples (113 wells and 14 QA/QC) at $100 per sample		
Analytical:	$	5,200.00
Labor and perdiem:	$	11,000.00
Equipment:	$	2,550.00
Reporting:	$	4,500.00
Total:	$	23,250.00
Total rounded:	**$**	**24,000.00**
Indoor Air Sampling:		
Assumes Hercules building requires quarterly monitoring.		
Three samples p at $425 per sample		
Analytical:	$	1,275.00
Labor and perdiem:	$	2,200.00
Reporting:	$	450.00
Total:	$	3,925.00
Total rounded:	**$**	**4,000.00**

Assumptions for Feasibility Study Cost Estimates - Conceptual Estimates	
Site:	Railroad Dry Cleaners and Hercules Machine Sales Sites
Location:	3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase:	Feasibility Study (-30% to +50%)
Base Year:	2007

Alternative 3A - SVE with Source Area Pump and Treat
Alternative 3A consists of SVE for treatment of source area soil along with extraction and treatment of source area ground water and downgradient ground water MNA.

Vapor Intrusion Mitigation System
Assumed $5,000 for sealing the common wall.
Commercial mitigation system not included because soil vapor extraction system in place.

Additional Vapor Intrusion Sampling
Vapor intrusion sampling is assumed for five buildings and would consist of indoor air, sub-slab vapor, and ambient air samples.
No further action was assumed for these five structures.

Analytical:	$	6,375.00
Labor and perdiem:	$	3,300.00
Reporting:	$	3,600.00
Total:	$	13,275.00
Total rounded:	**$**	**13,000.00**

Soil Vapor Extraction
Assumes horizontal vapor extraction wells.
Assumes 2-inch piping installed below building slab and adjoining paved areas to a depth of 2 feet below grade.
Assumes two east-west wells per building (approx. 70 LF each) and one north-south header (approx. 300 LF) parallel to railroad tracks.
Assumes 4-inch thickness of slab and 6-inch thickness of pavement.
Assumes skid mounted package SVE unit, misc piping and equipment, costing $30,000.
Interior trenching estimated to cost $20,000 and exterior trenching estimated to cost $10,000.
Total cost of SVE system estimated at $60,000.

Plume Area A Extraction Wells
Assumed 2 extraction wells each 75 vertical linear feet (VLF) at $28/VLF
Disposal of cuttings: assumed 8 drums at $350 per drum
Location and placement of extraction wells based on evaluation of aquifer recovery rate using the Theis Equation.
Estimated capture zone and pumping rate using Todd Equation.

Extraction well:	$	4,200.00
Disposal of cuttings:	$	2,800.00
Mobilization:	$	2,500.00
Labor:	$	3,000.00
Total:	$	12,500.00
Total rounded:	**$**	**13,000.00**

Ground Water Treatment System
Assumed 25 gpm air stripper (with carbon effluent and off-gas treatment, tankage, appurtenances)
Assumed 250 LF of piping at $117/LF installed
Assumed 500 SF treatment building at $137/SF

Air stripper:	$	200,000.00
Building:	$	68,500.00
Piping:	$	29,250.00
Mobilization:	$	7,000.00
Total:	$	304,750.00
Total rounded:	**$**	**310,000.00**

Baseline Monitored Natural Attenuation
Baseline event assumed 26 samples (22 wells and 4 QA/QC) at $700 per sample

Analytical:	$	18,200.00
Labor and perdiem:	$	5,500.00
Equipment:	$	1,500.00
Reporting:	$	1,300.00
Total:	$	26,500.00
Total rounded:	**$**	**27,000.00**

Baseline Ground Water Monitoring - VOCs
Baseline event assumed 127 samples (113 wells and 14 QA/QC) at $100 per sample

Analytical:	$	12,700.00
Labor and perdiem:	$	22,000.00
Equipment:	$	5,050.00
Reporting:	$	5,400.00
Total:	$	45,150.00
Total rounded:	**$**	**46,000.00**

Assumptions for Feasibility Study Cost Estimates - Conceptual Estimates		
Site:	Railroad Dry Cleaners and Hercules Machine Sales Sites	
Location:	3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY	
Phase:	Feasibility Study (-30% to +50%)	
Base Year:	2007	
Annual Monitored Natural Attenuation		
60 samples (54 wells and 6 QA/QC) at $700 per sample		
Analytical:	$	42,000.00
Labor and perdiem:	$	13,200.00
Equipment:	$	3,650.00
Reporting:	$	1,350.00
Total:	$	60,200.00
Total rounded:	**$**	**61,000.00**
Annual Ground Water Monitoring - VOCs		
Baseline event assumed 127 samples (113 wells and 14 QA/QC) at $100 per sample		
Analytical:	$	5,200.00
Labor and perdiem:	$	11,000.00
Equipment:	$	2,550.00
Reporting:	$	4,500.00
Total:	$	23,250.00
Total rounded:	**$**	**24,000.00**
Indoor Air Sampling:		
Assumes Hercules building requires quarterly monitoring.		
Three samples p at $425 per sample		
Analytical:	$	1,275.00
Labor and perdiem:	$	2,200.00
Reporting:	$	450.00
Total:	$	3,925.00
Total rounded:	**$**	**4,000.00**

Assumptions for Feasibility Study Cost Estimates - Conceptual Estimates

Site:	Railroad Dry Cleaners and Hercules Machine Sales Sites
Location:	3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase:	Feasibility Study (-30% to +50%)
Base Year:	2007

Alternative 3B - SVE with Pump and Treat for Contaminated Ground Water Plume

Alternative 3B consists of SVE for treatment of source area soil along with extraction and treatment of contaminated goumd water.

Vapor Intrusion Mitigation System

Assumed $5,000 for sealing the common wall.
Commercial mitigation system not included because soil vapor extraction system in place.

Additional Vapor Intrusion Sampling

Vapor intrusion sampling is assumed for five buildings and would consist of indoor air, sub-slab vapor, and ambient air samples.
No further action was assumed for these five structures.

Analytical:	$	6,375.00
Labor and perdiem:	$	3,300.00
Reporting:	$	3,600.00
Total:	$	13,275.00
Total rounded:	**$**	**13,000.00**

Soil Vapor Extraction

Assumes horizontal vapor extraction wells.
Assumes 2-inch piping installed below building slab and adjoining paved areas to a depth of 2 feet below grade.
Assumes two east-west wells per building (approx. 70 LF each) and one north-south header (approx. 300 LF) parallel to railroad tracks.
Assumes 4-inch thickness of slab and 6-inch thickness of pavement.
Assumes skid mounted package SVE unit, misc piping and equipment, costing $30,000.
Interior trenching estimated to cost $20,000 and exterior trenching estimated to cost $10,000.
Total cost of SVE system estimated at $60,000.

Plume Areas A & B Extraction Wells

Assumed 5 extraction wells (75 ft, 90ft, and two 95 ft) or total 355 vertical linear feet (VLF 355
Disposal of cuttings: assumed19 drums at $350 per drum
Location and placement of extraction wells based on evaluation of aquifer recovery rate using the Theis Equation.
Estimated capture zone and pumping rate using Todd Equation.

Extraction well:	$	9,940.00
Disposal of cuttings:	$	6,650.00
Mobilization:	$	3,000.00
Labor:	$	7,000.00
Total:	$	26,590.00
Total rounded:	**$**	**27,000.00**

Ground Water Treatment System

Assumed 50 gpm air stripper (with carbon effluent and off-gas treatment, tankage, appurtenances)
Assumed 250 LF of piping at $117/LF installed
Assumed 500 SF treatment building at $137/SF

Air stripper:	$	300,000.00
Building:	$	205,500.00
Piping:	$	245,700.00
Mobilization:	$	25,000.00
Total:	$	776,200.00
Total rounded:	**$**	**780,000.00**

Baseline Ground Water Monitoring - VOCs

Baseline event assumed 153 samples (139 wells and 14 QA/QC) at $100 per sample

Analytical:	$	15,300.00
Labor and perdiem:	$	27,500.00
Equipment:	$	6,300.00
Reporting:	$	5,400.00
Total:	$	54,500.00
Total rounded:	**$**	**55,000.00**

Annual Ground Water Monitoring - VOCs

Baseline event assumed 112 samples (102 wells and 10 QA/QC) at $100 per sample

Analytical:	$	11,200.00
Labor and perdiem:	$	22,000.00
Equipment:	$	5,050.00
Reporting:	$	4,500.00
Total:	$	42,750.00
Total rounded:	**$**	**43,000.00**

Indoor Air Sampling:

Assumes Hercules building requires quarterly monitoring.
Three samples p at $425 per sample

Analytical:	$	1,275.00
Labor and perdiem:	$	2,200.00
Reporting:	$	450.00
Total:	$	3,925.00
Total rounded:	**$**	**4,000.00**

Assumptions for Feasibility Study Cost Estimates - Conceptual Estimates	
Site:	Railroad Dry Cleaners and Hercules Machine Sales Sites
Location:	3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase:	Feasibility Study (-30% to +50%)
Base Year:	2007

Alternative 4A - Source area ground water pump and treat with downgradient ground water MNA

Alternative 4A consists of source area ground water extraction and treatment with downgradient ground water MNA.

Vapor Intrusion Mitigation System

Assumed $20,000 for design and installation of a commercial mitigation system

Assumed $5,000 for sealing the common wall.

Additional Vapor Intrusion Sampling

Vapor intrusion sampling is assumed for five buildings and would consist of indoor air, sub-slab vapor, and ambient air samples.

No further action was assumed for these five structures.

Analytical:	$	6,375.00
Labor and perdiem:	$	4,000.00
Reporting:	$	450.00
Total:	$	10,825.00
Total rounded:	**$**	**11,000.00**

Plume Area A Extraction Wells

Assumed 2 extraction wells each 75 vertical linear feet (VLF) at $28/VLF

Disposal of cuttings: assumed 8 drums at $350 per drum

Location and placement of extraction wells based on evaluation of aquifer recovery rate using the Theis Equation.

Estimated capture zone and pumping rate using Todd Equation.

Extraction well:	$	4,200.00
Disposal of cuttings:	$	2,800.00
Mobilization:	$	2,500.00
Labor:	$	3,000.00
Total:	$	12,500.00
Total rounded:	**$**	**13,000.00**

Ground Water Treatment System

Assumed 25 gpm air stripper (with carbon effluent and off-gas treatment, tankage, appurtenances)

Assumed 250 LF of piping at $117/LF installed

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Building:	$	68,500.00
Piping:	$	29,250.00
Mobilization:	$	7,000.00
Total:	$	304,750.00
Total rounded:	**$**	**310,000.00**

Baseline Monitored Natural Attenuation

Baseline event assumed 26 samples (22 wells and 4 QA/QC) at $700 per sample

Analytical:	$	18,200.00
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Total:	$	26,500.00
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Baseline event assumed 127 samples (113 wells and 14 QA/QC) at $100 per sample

Analytical:	$	12,700.00
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Phase:	Feasibility Study (-30% to +50%)	
Base Year:	2007	
Annual Monitored Natural Attenuation		
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Indoor Air Sampling:		
Assumes Hercules building requires quarterly monitoring.		
Three samples p at $425 per sample		
Analytical:	$	1,275.00
Labor and perdiem:	$	2,200.00
Reporting:	$	450.00
Total:	$	3,925.00
Total rounded:	**$**	**4,000.00**

Assumptions for Feasibility Study Cost Estimates - Conceptual Estimates	
Site:	Railroad Dry Cleaners and Hercules Machine Sales Sites
Location:	3180 and 3188 Lawson Boulevard, Hamlet of Oceanside, Town of Hempstead, Nassau County, NY
Phase:	Feasibility Study (-30% to +50%)
Base Year:	2007

Alternative 4B - Pump and Treat Contaminated Ground Water

Alternative 4B consists of extraction and treatment of contaminated ground water.

Vapor Intrusion Mitigation System

Assumed $20,000 for design and installation of a commercial mitigation system

Assumed $5,000 for sealing the common wall.

Additional Vapor Intrusion Sampling

Vapor intrusion sampling is assumed for five buildings and would consist of indoor air, sub-slab vapor, and ambient air samples.

No further action was assumed for these five structures.

Analytical:	$	6,375.00
Labor and perdiem:	$	3,300.00
Reporting:	$	3,600.00
Total:	$	13,275.00
Total rounded:	**$**	**13,000.00**

Plume Areas A & B Extraction Wells

Assumed 5 extraction wells (75 ft, 90ft, and two 95 ft) or total 355 vertical linear feet (VLF) at $28/VLF

Disposal of cuttings: assumed19 drums at $350 per drum

Location and placement of extraction wells based on evaluation of aquifer recovery rate using the Theis Equation.

Estimated capture zone and pumping rate using Todd Equation.

Extraction well:	$	9,940.00
Disposal of cuttings:	$	6,650.00
Mobilization:	$	3,000.00
Labor:	$	7,000.00
Total:	$	26,590.00
Total rounded:	**$**	**27,000.00**

Ground Water Treatment System

Assumed 50 gpm air stripper (with carbon effluent and off-gas treatment, tankage, appurtenances)

Assumed 250 LF of piping at $117/LF installed

Assumed 500 SF treatment building at $137/SF

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Building:	$	205,500.00
Piping:	$	245,700.00
Mobilization:	$	25,000.00
Total:	$	776,200.00
Total rounded:	**$**	**780,000.00**

Baseline Ground Water Monitoring - VOCs

Baseline event assumed 153 samples (139 wells and 14 QA/QC) at $100 per sample

Analytical:	$	15,300.00
Labor and perdiem:	$	27,500.00
Equipment:	$	6,300.00
Reporting:	$	5,400.00
Total:	$	54,500.00
Total rounded:	**$**	**55,000.00**

Annual Ground Water Monitoring - VOCs

Baseline event assumed 112 samples (102 wells and 10 QA/QC) at $100 per sample

Analytical:	$	11,200.00
Labor and perdiem:	$	22,000.00
Equipment:	$	5,050.00
Reporting:	$	4,500.00
Total:	$	42,750.00
Total rounded:	**$**	**43,000.00**

Indoor Air Sampling:

Assumes Hercules building requires quarterly monitoring.

Three samples p at $425 per sample

Analytical:	$	1,275.00
Labor and perdiem:	$	2,200.00
Reporting:	$	450.00
Total:	$	3,925.00
Total rounded:	**$**	**4,000.00**

Appendix B

Hydrologic Assumptions

To:	File	*cc:*	
From:	Paul D'Annibale		
Re:	Oceanside Ground Water Calculations		
File:	37556		
Date:	October 19, 2007		

This memo presents the ground water calculations related to conceptual design of a ground water pump and treat system as detailed in the Feasibility Study Report for Railroad Dry Cleaners and Hercules Machine Sales Sites (FS report).

Objective

As discussed in the FS report, several remedial options are being evaluated for VOC contaminated ground water at the Site. Options related to ground water recovery are supported by these ground water calculations. There are two objectives of these ground water calculations: 1) the first objective is to estimate the volume of ground water flowing through the source area of the contaminant plume; and 2) the second objective is to evaluate the number of extraction wells required to capture the volume of VOC impacted ground water. These ground water calculations were generated using data previously presented in the Remedial Investigation Report for Railroad Dry Cleaners and Hercules Machine Sales Sites (RI report).

Methodology

The approximate volume of ground water flowing through the source area of the contaminant plume can be determined using the Darcy Equation as follows:

$$Q = KIA$$

where Q is the discharge (ft^3/day), K is hydraulic conductivity [estimated to be 53 feet/day (RI report, pg. 29)], I is the average hydraulic gradient within the A, B, and C Intervals [0.0015 feet/feet (RI report, pgs. 30-31)], and A is the cross-sectional area of the aquifer through the source area of the contaminant plume [assumed to be approximately 16,000 ft^2 (RI report, Figure 4-3)].

Based on the hydraulic gradient calculated for the April 23, 2007 water level measurements, the estimated volume of ground water flowing through the source area of the contaminant plume was approximately 1,300 ft^3/day or 9,900 gallons per day (gpd).

Based on these results, an extraction well with a pumping rate of approximately 7 gpm would be required to cut off the source area contaminant plume. Applying a safety factor of 30% to this flow rate an extraction well with a pumping rate of approximately 10 gpm is recommended. To assess the ability of the aquifer to accommodate an extraction well with a pumping rate of 10 gpm, an evaluation of the aquifer characteristics was performed using the Theis Equation modified as follows:

$$s = (Q/(4\pi T))^* W(u)$$

where: s is the confined drawdown of the extraction well (feet), Q is the pumping rate of the extraction well (approximately 14,400 gpd), T is the transmissivity of the aquifer [assumed to be 20,000 gpd/ft, based on the hydraulic conductivity and saturated thickness of the aquifer (RI report, pg. 29 Figure 9-2)], and W(u) is the well function (dimensionless, approximated by Excel spreadsheet).

Assuming an extraction well with a radius of 0.25 feet, pumping continuously, the confined drawdown is calculated to be approximately 1.5 feet. This drawdown is determined to be within typical well construction criteria for the Site.

The ability of an extraction well with a pumping rate of approximately 10 gpm to create a capture zone wide enough to contain the horizontal extent of the VOC plume can be determined using the Capture Zone Equation as follows:

y = Q / (K*b*I)

where y is the maximum total width of capture zone upgradient from the extraction well (feet), Q is the pumping rate of the extraction well (10 gpm or 1,930 ft^3/day), K is hydraulic conductivity [estimated to be 53 feet/day (RI report, pg. 29)], b is the thickness of the aquifer [estimated to be 90 feet (RI report, Figure 9-2)], and I is the average hydraulic gradient within the A, B, and C Intervals [0.0015 feet/feet (RI report, pgs. 30-31)].

Based on the parameters presented above, the horizontal capture zone of an extraction well pumping at 10 gpm is approximately 250 feet. The horizontal extent of the source area and downgradient contaminant plume is approximately 200 ft and 230 ft, respectively (RI report, Figure 9-1).

Further, the distance downgradient from extraction well to the stagnation point can be calculated as follows:

x = Q / (2*Pi*K*b*I)

where x is the distance to the stagnation point downgradient of the extraction well (feet), Q is the pumping rate of the extraction well (10 gpm or 1,930 ft^3/day), K is hydraulic conductivity [estimated to be 53 feet/day (RI report, pg. 29)], b is the thickness of the aquifer [estimated to be 90 feet (RI report, Figure 9-2)], and I is the average hydraulic gradient within the A, B, and C Intervals [0.0015 feet/feet (RI report, pgs. 30-31)].

Based on these data, the stagnation point downgradient of the extraction well is approximately 40 feet. Given the limited effective distance downgradient from an extraction well with a pumping rate of 10 gpm, it is recommended that two to five extraction wells be installed as part of the remedial effort of the source area (Plume Area A) and downgradient contaminant plume (Plume Area B) respectively.

Oceanside FS
Pumping Pore Flushing

Objective: Estimate the time required for the existing plume, downgradient of the RR tracks, to decline to Class GA ground water standards under ground water extraction conditions. This estimate is based upon the assumption that the source of the organics is upgradient of the RR tracks and will be completely removed or contained.

First we will estimate the number of pore flushes required to meet Class GA ground water standards. We will use PCE since it reflect the greatest exceedance of standards.

Estimate number of pore flushes required

$NPV = -R \ln(C_{wt}/C_{wo})$

Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites (OSWER Directive 9238.1-02, December 1988)

Where

NPV = number of pore volumes

1 R = chemical specific retardation

5 C_{wt} = chemical specific cleanup goal (ug/l) (PCE used for conservative estimate)

13,000 C_{wo} = initial chemical concentration (ug/l) (PCE used for conservative estimate)

7.9 NPV = number of pore volumes

Now we will estimate the ground water travel time in the vicinity of an extraction well. The extraction well pumping rate was selected to capture the full width of the plume.

Ground Water Velocity and Travel Times Near a Pumping Well

(Regional velocity not included)

v = Q/(2*Pi*b*n*r)

Q = Pumping Rate (ft3/day)	1,925	Pumping rate of 10 gpm per well
b = Saturated Thickness (ft)	90	
n = Porosity	0.25	(within range presented in RI Report)

Radius (ft)	Velocity (ft/day)	Incremental Travel Time (days)	Approximate Total Travel Time (days)
1	13.62	0	0
5	2.72	1	2
10	1.36	4	5
15	0.91	6	11
20	0.68	7	18
25	0.54	9	27
40	0.34	44	71
50	0.27	37	108
75	0.18	138	246
100	0.14	184	429
110	0.12	81	510
120	0.11	88	598
130	0.10	95	**694**
140	0.10	103	797

The estimated radius of the plume is about 130 ft.

Now we will estimate the time required to complete the pore flushings necessary
to meet ground water standards.

Estimate time required to complete pore flushing

t = Pt*NPV

694 Pt = travel time from edge of plume to extraction well (days)
7.9 NPV = number of pore volumes

5,457 t = time required to flush NPV through area of concern (days)
15.0 t = time required to flush NPV through area of concern (years)

Summary

This evaluation indicates that it will require about 15 years for the highest VOC concentrations in the plume to decline to Class GA ground water standards under ground water extraction conditions.

file: Oceanside_PoreFlush.xls

Appendix B

Oceanside FS
Non Pumping Pore Flushing

Objective: Estimate the time required for the existing plume, downgradient of the RR tracks to decline to Class GA ground water standards.
This estimate is based upon the assumption that the source of the organics is upgradient of the RR tracks and will be completely removed or contained.

First we will estimate the number of pore flushes required to meet Class GA ground water standards. We will use PCE since it reflect the greatest exceedance of standards.

Estimate number of pore flushes required

$NPV = -R \ln(C_{wt}/C_{wo})$

Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites (OSWER Directive 9238.1-02, December 1988)

Where

	NPV = number of pore volumes
1	R = chemical specific retardation
5	C_{wt} = chemical specific cleanup goal (ug/l) (PCE used for conservative estimate)
1,000	C_{wo} = initial chemical concentration (ug/l) (PCE used for conservative estimate)
5.3	NPV = number of pore volumes

Now we will estimate the volume of water in the plume between the RR and the downgradient extent of the plume.

Estimate volume of water aquifer in area to be flushed

V = LWbn

650	L = length of plume (ft)
230	W = width of area (ft)
90	b = saturated thickness of aquifer (ft)
0.25	n = aquifer porosity (within range presented in RI Report)
3,363,750	V = volume of water (ft^3)
25,160,850	V = volume of water (gallons)

Now we will estimate the time required to complete the pore flushings necessary to meet ground water standards.

Estimate time required to complete pore flushing

t = (V/Q)NPV

3,363,750	V = volume of water (ft^3)
1,646	Q = Darcy flux for plume width (ft^3/day)
5.3	NPV = number of pore volumes

Q = KiWb

53	K = Hydraulic conductivity (ft/day)
0.0015	I = hydraulic gradient (average)
230	W = width (ft)
90	b = saturated thickness (ft)

10,830	t = time required to flush NPV through area of concern (days)
29.7	t = time required to flush NPV through area of concern (years)

Summary

This evaluation indicates that it will require about 30 years for the highest VOC concentrations in the plume to decline to Class GA ground water standards under natural attenuation conditions.

file: Oceanside_PoreFlush.xls