FOCUSED FEASIBILITY STUDY
SCOBELL CHEMICAL – NYSDOT SITE
TOWN OF BRIGHTON, MONROE COUNTY
SITE NO. 828076

Prepared for:

New York State Department of Environmental Conservation
Division of Environmental Remediation

Prepared by:

MACTEC Engineering and Consulting, P.C.
Portland, Maine

PROJECT NO: 3612112226

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
cm/sec	centimeter(s) per second
COC	contaminant of concern
CSM	conceptual site model
DCE	dichloroethylene
DNAPL	dense non-aqueous phase liquid
EC	engineering control
EE	environmental easement
EZVI	emulsified zero-valence iron
FS	Feasibility Study
FFS	Focused Feasibility Study
HASP	Health and Safety Plan
IC	Institutional Control
IRM	Interim Remedial Measure
K	hydraulic conductivity
LTM	long term monitoring
MACTEC	MACTEC Engineering and Consulting, P.C.
msl	mean sea level
NPW	net present worth
NYCRR	New York Codes, Rules, and Regulations
NYS	New York State

GLOSSARY OF ACRONYMS AND ABBREVIATIONS (CONTINUED)

NYSDEC	New York State Department of Environmental Conservation
O&M	Operation and Maintenance
OM&M	Operation, Maintenance, and Monitoring
OU	Operable Unit
PCE	tetrachloroethene
ppb	parts per billion
PRR	Periodic Review Report
PVC	polyvinyl chloride
RAO	Remedial Action Objective
RD	remedial design
RI	Remedial Investigation
ROD	Record of Decision
SCG	standards, criteria and guidance values
SCO	Soil Cleanup Objectives
Site	Scobell Chemicals site, Brighton, NY
SMP	Site Management Plan
SSDS	Sub-Slab Depressurization System
SVE	soil vapor extraction
SVI	soil vapor intrusion
TCE	trichloroethene
TCH	thermal conductive heating
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
ZVI	zero-valence iron

EXECUTIVE SUMMARY

This report presents the findings of a Focused Feasibility Study (FFS) conducted for the Scobell Chemical – NYSDOT Site (Site No. 828076) in Brighton, New York (the Site) (Figure 1.1). This FFS evaluates remedial alternatives to reduce, control, or eliminate source area contamination which includes high concentrations of volatile organic compounds in groundwater and dense non-aqueous phase liquid located within a fractured zone of bedrock.

After identifying and screening technologies appropriate to Site and contaminant-limiting characteristics, technologies capable of treating the contaminant source area were assembled into remedial alternatives and analyzed in detail.

Four alternatives were selected for further evaluation.

1. No Further Action
2. Institutional Controls (ICs), Long Term Monitoring (LTM) and Additional Sub-Slab Depressurization Systems if Needed
3. ICs, In-Situ Thermal Treatment and LTM
4. ICs, In-Situ Chemical Reduction, and LTM

Based on the detailed analysis and comparison of alternatives, it is recommended that the New York State Department of Environmental Conservation select Alternative 4, ICs, In-Situ Chemical Reduction, and LTM, as the preferred remedy. Alternatives 1 and 2 are not practicable since they do not address the source area contamination and do not attempt to stabilize the downgradient plume. While Alternative 3 would provide a more certain degree of contaminant removal in the source area than Alternative 4, the higher capital costs associated with the source area size and the energy intensity of thermal remediation technologies are not feasible from a cost perspective. Alternative 4 has the greatest potential to cost-effectively reduce contaminant mass in the source area and reduce contaminant migration to the downgradient plume. Alternative 4 is also considered to be the most green remedial technology since it does not have high energy requirements and will not produce a significant quantity of remediation waste requiring transportation and disposal.

1.0 INTRODUCTION

This report presents the findings of a Focused Feasibility Study (FFS) conducted for the New York State Department of Environmental Conservation (NYSDEC) Scobell Chemical – NYSDOT Site (Site No. 828076) in Brighton, New York (the Site) (Figure 1.1). MACTEC Engineering and Consulting, P.C. (MACTEC) performed this FFS to evaluate remedial alternatives capable of destroying or removing source area contamination. The primary contaminants of concern (COCs) in the source area are volatile organic compounds (VOCs), including dense non-aqueous phase liquid (DNAPL).

Feasibility studies (FSs) and respective Record of Decision (ROD) documents were completed for on-site contamination (Operable Unit 1 [OU1]) and off-site contamination (OU2) in the late 1990s and early 2000s. The identified remedial alternatives were not implemented due to complications associated with ownership at the time, lack of complete site characterization data, uncertainty related to the selected remedial actions, and the overall cost of implementation.

NYSDEC retained MACTEC to conduct a data gap investigation to better understand the extent of the source area and prepare a data gap report, including an updated Conceptual Site Model (CSM). MACTEC used the information obtained from the data gap investigation to conduct a FFS to identify potential remedial alternatives that would be effective at remediating source area contamination given new available technology and considering the recent data that has been collected.

The source area is located both on- and off-site; therefore, this FFS will help support the preparation of a ROD Amendment document that streamlines the remedial actions for the Site by combining OU1 and OU2 into one decision document.

1.1 REPORT ORGANIZATION

This FFS report is structured in general accordance with NYSDEC DER-10 (NYSDEC, 2010) guidance for remedy selection. Given the Site's previous FSs, certain sections of this FS have been modified, shortened or streamlined to combine alternatives to address source area contaminant removal located both on and off site (OU1 and OU2). An outline and summary of the FFS report sections follow:

Section 1.0 Introduction:

Discusses the purpose of the FFS report and briefly describes the Site, Site history, and previous Site investigations and FS evaluations.

Section 2.0 Physical Setting:

Briefly summarizes the physical characteristics of the Site as presented in the previous FSs.

Section 3.0 Nature and Extent of Contamination:

Briefly summarizes the nature and extent of contamination as presented in the previous FS and as revised in the 2013 Data Gap Analysis Report (MACTEC, 2013).

Section 4.0 Contaminant Fate and Transport:

Briefly summarizes the fate and transport of the Site contaminants.

Section 5.0 Human Health Exposure Assessment:

Briefly summarizes previous exposure evaluations and current receptors.

Section 6.0 Development of Remedial Action Objectives and General Response Actions for Source Area Contamination:

Presents the remedial action objectives (RAOs) and General Response Actions for the soil (surface and subsurface), groundwater, and DNAPL in the source area, and downgradient overburden groundwater, surface water, and soil vapor.

Section 7.0 Identification of Technologies and Alternatives:

Identifies potential remedial technologies and alternatives for the source area groundwater and DNAPL contamination. This FFS does not repeat the conventional FS process of comprehensively identifying and screening technologies, combining retained technologies into remedial alternatives, and then screening those alternatives. Instead, this FFS uses the prior FSs identification to help screen out technologies that were previously deemed impracticable and have likely not changed since this former evaluation, allowing the FFS to focus on a limited number of technologies and alternatives likely to reduce the mass of source area contamination.

Section 8.0 Development and Preliminary Screening of Alternatives:
Technologies retained from Section 7 are assembled into potential site-specific remedial alternatives capable of achieving the RAOs. Alternatives that cannot achieve RAOs are screened out.

Section 9.0 Detailed Analysis of Alternatives:
Presents the detailed analyses of remedial alternatives for the Site. The detailed analysis provides decision-makers with relevant information to aid in selecting a practicable remedy for the source area.

Section 10.0 Comparative Analysis of Alternatives:
Evaluates the relative performance of each alternative using the same criteria from the detailed analysis of alternatives. The comparative analysis identifies advantages and disadvantages of each alternative relative to one another to aid in selecting a practicable remedy for the source area.

Section 11.0 References
Presents a list of references used in the preparation of this report. Supporting information is included in the Appendices attached to this report.

1.2 PURPOSE OF REPORT

This FFS Report presents changes to the CSM since the 1999 and 2002 ROD documents for OU1 and OU2, develops RAOs to protect human health and the environment, and develops remedial alternatives to satisfy the RAOs.

1.3 SITE BACKGROUND

The Site is located at 1 Rockwood Place in a mixed commercial, industrial, and residential area in the northern section of the Town of Brighton and immediately east of the City of Rochester boundary. The Site occupies approximately 2 acres and is positioned along the north-side of New

York State (NYS) Highway 590. The Site is approximately 1,000 feet east of the intersection of Rockwood Place and East Avenue.

The Site contains no structures, is covered with grass and scrub growth, and is surrounded by a chain link fence. A small surface water drainage ditch parallels the New York Central Railroad Line that is present immediately north of the property. The Grass Creek is located north of the Site beyond the railroad line.

The Site is currently undeveloped, zoned for industrial use, and is part of the right-of-way bordering the NYS Highway 590 and 490 exchanges. This Site is located in an industrial zoned area. The properties west of the Site along Rockwood Place are located in the City of Rochester and are also zoned industrial. The surrounding parcels are currently used for a combination of industrial, commercial, transportation, and utility right-of-ways. The nearest residential area is located along Blossom Road approximately 600 feet north of the Site.

The Site is the location of a former chemical repackaging company that operated at this location from the 1920s until 1986. During this time, assorted chemicals were purchased by the company in bulk and repackaged into smaller containers for resale. Four above ground storage tanks were reportedly located at the Site. The overall quantity and type of materials handled is unclear but significant subsurface soil and groundwater contamination has resulted from past operations. In 1988 the NYS Department of Transportation conducted an interim remedial measure (IRM) removal action. The IRM included decontamination and demolition of the structures, removal of containers, drums and above ground storage tanks, and excavation and disposal of contaminated soil. The site was divided into two OUs: OU1 for on-site contamination and OU2 for off-site contamination.

Several investigations have been conducted at the Site to date including. The 2002 remedial investigation (RI) report includes both OUs (NYSDEC, 2002a). Findings indicate the primary COCs include trichloroethene (TCE), tetrachloroethene (PCE), 1,1-dichloroethene (DCE), cis-1,2-DCE, vinyl chloride, 1,1,1-trichloroethane, benzene, toluene, and xylene. The highest concentrations of site contaminants in soil were detected in the central and western/northwestern portions of the Site. Specifically, TCE, PCE, and toluene were detected at concentrations above the soil cleanup objectives (SCOs) for the protection of groundwater. TCE, along with its associated breakdown products, and toluene are also found in groundwater in the central and western/northwestern portions of the Site. The maximum groundwater concentrations of TCE at 1,000,000 parts per billion (ppb) and toluene at 300,000 ppb exceed their associated groundwater standard of 5 ppb. DNAPL was also present in a groundwater monitoring well located near the northwest corner of the Site (MW-3D) containing primarily TCE. On-site groundwater contamination is present in both overburden and bedrock. Figure 1.2 shows on-site and off-site groundwater monitoring locations.

ROD documents have been completed for both OU1 (NYSDEC, 1999a and b) and OU2 (NYSDEC, 2002b and c). The ROD documents present the selected remedial actions which were chosen in accordance with the NYS Environmental Conservation Law.

The 1999 selected remedy for OU1 includes:

- Soil vapor extraction (SVE) for subsurface soils
- Excavation and offsite disposal of surface soils
- Groundwater extraction and treatment (via carbon) for shallow overburden
- Low flow DNAPL recovery for shallow bedrock
- Long term monitoring (LTM)
- Institutional Controls (ICs)
- Maintenance of the soil cover over the Site

The 2002 selected remedy for OU2 includes:

- In-situ thermal treatment to address the concentrated source area located in the bedrock/groundwater north of the onsite OU (north of the railroad tracks)
- In-situ remediation technologies, such as surfactant flushing, for contamination located under the railroad tracks
- After source treatment either enhanced in-situ bioremediation or pump and treat for groundwater downgradient of the Site
- Installation of a downgradient groundwater extraction and treatment and/or in-situ treatment system
- LTM

Reader should refer to the previous ROD documents, FSs, and RI reports for a more detailed history of the Site.

2.0 SITE PHYSICAL SETTING

The physical characteristics relevant to remediation of the contamination source area are presented in this section. Additional information on site physical characteristics is available in historic documents.

2.1 GEOLOGY

Surficial deposits at the Scobell site consists of a silty clay cover placed during the 1988 IRM (0.4 to 3 feet) over a fill of sand, silt and gravel with coal, cinders, brick and glass to approximately 4.5 feet deep. Native silt and clay with some sand extends down to 7.5 feet, and finally an oxidized basal sand unit up to 3.5 feet thick overlies the bedrock. Bedrock at the Site begins at a depth range of 7-10.5 feet deep.

The bedrock is primarily competent dolomite that becomes more competent and less fractured at depth. Although numerous horizontal fractures were noted along bedding planes in boring logs, the primary mass of contamination was noted to be present in an approximate 4 foot wide fracture zone ranging from 15 to 25 feet below ground surface (bgs). The bedrock is interpreted to dip slightly towards the north in the vicinity of the Site. Additional details on the geology of the Site were provided in the RI reports for OU1 and OU2 dated February 1999 and February 2002 and updates were provided in the Data Gap Analysis Report (MACTEC, 2013).

2.2 HYDROGEOLOGY

Depth to groundwater across the source area ranges from 6 to 15 feet deep, located in the overburden layer. Most of the on-site overburden groundwater flows to the south towards the highway ramps, while most of the off-site (north of the railroad tracks) overburden groundwater flows to the northeast. Groundwater in the bedrock appears to flow to the northeast.

Hydraulic conductivity (K) tests were conducted as part of the original RI at the Site, and additional tests were conducted during the 2012 data gap investigation with focus on K values within the bedrock fracture zone of noted higher contamination. K values for the three wells measured in 2012 ranged from 1.1 x 10-2 centimeter per second (cm/sec) to 1.98 x 10-1 cm/sec.

Due to the nature of fractured bedrock, wells at the Site likely intercept fractures of varying conductivity, with some potentially intercepting multiple fractures, and others located in zones where the fractures are less frequent and the fracture apertures smaller. As a result, K values varied from location to location. K values measured in 2012 were higher than those measured during previous investigations. Assuming similar horizontal gradients for groundwater, higher K values would indicate higher groundwater flow/seepage velocities than those calculated previously (i.e. higher than the one to ten feet per day noted in the 2002 RI).

3.0 NATURE AND EXTENT OF CONTAMINATION

This section summarizes the current understanding of the nature and extent of groundwater and DNAPL contamination in the source area. For additional information on the nature and extent of contamination on Site, refer to the Data Gap Analysis Report (MACTEC, 2013) or the previous ROD documents for OU1 and OU2. The Site and surrounding area are zoned for industrial use.

3.1 SOURCE AREA

The source area for this Site is defined as the DNAPL present within bedrock fractures at the Site and approximately 300 feet downgradient of the Site. Figure 3.1 shows the estimated extent of DNAPL in bedrock. Figure 3.2 shows a cross-section of the DNAPL source area. TCE is the primary contaminant in the source area and is assumed to represent total VOC contamination. As described in the updated CSM in the Data Gaps Report (MACTEC, 2013), the majority of DNAPL contamination within the bedrock is present within the bedrock fractures, with additional mass diffused in the bedrock matrix and dissolved in groundwater. The diffused DNAPL will act as a long term groundwater contaminant source even after DNAPL leaves or is removed from the fractures unless the source area remedy also targets the bedrock matrix. Estimates of contaminant mass within the source area range from approximately 900 to 15,500 pounds over an area between 100,000 to 180,000 square feet (180,000 square feet was used for cost estimating purposes).

Surface soil at the Site does not exceed industrial use SCOs.

Subsurface soil contamination is limited to on-site areas and is predominantly made up of VOCs. There is contamination present across the Site, but the most significant concentrations are present in the central and west/northwestern sections of the Site. Although these concentrations exceed the protection of groundwater SCOs, they do not exceed the SCOs for industrial use.

3.2 DOWNGRADIENT GROUNDWATER

Site contaminants have been detected in overburden and bedrock groundwater down to depths of 70 feet bgs (approximately 60 feet below bedrock surface). The primary migration pathway downgradient occurs between 10 and 20 feet bgs within horizontal bedrock fractures. The extent of groundwater contamination downgradient of the Site has not been fully characterized.

4.0 CONTAMINANT FATE AND TRANSPORT

This section summarizes the fate and transport of source area contaminants.

4.1 FATE OF VOCS

The physical-chemical properties of Site VOCs were evaluated during previous Site evaluations to assess the importance of fate processes such as degradation, adsorption, volatilization, and dissolution for Site contaminants. Adsorption and degradation are the most significant fate processes for VOCs, given the high fraction of organic carbon measured in the bedrock (905 milligrams per kilogram) and the high concentrations of TCE daughter products in groundwater samples. However, given the existing DNAPL source area and high groundwater concentrations, these fate processes would likely require hundreds of years to satisfy class GA groundwater standards for contaminated groundwater.

4.2 MIGRATION OF VOCS

Based on the physical-chemical properties of contaminants and observed contaminant concentrations in groundwater during investigations, migration of DNAPL in horizontal bedrock fractures is the primary migration pathway for the majority of contaminant mass. Dissolved-phase transport in groundwater is the primary migration pathway for contamination extending farther off-site to potential downgradient receptors. Vapor intrusion from sub-slab soil to indoor air may also be a complete exposure pathway within the source area and downgradient groundwater contaminant plume.

5.0 QUALITATIVE EXPOSURE ASSESSMENT

Human and environmental exposure pathways at the Site were identified by evaluating the following:

- populations of receptors that may be present at and in the vicinity of the Site;
- means by which receptors may be exposed to Site contamination (e.g., direct contact, ingestion, inhalation); and
- significance of exposure that may occur through the potential exposure pathways.

Contaminated groundwater is not being used for drinking water because the area is served by a public water supply that is not affected by Site-related contamination. Unless the ground is disturbed, direct contact with Site-related soil or groundwater contamination is unlikely because the Site has been covered with a clay cap. Contaminants identified in surface water do not pose a risk to ecological receptors, or to humans that might consume fish in the area (NYSDEC, 2002a) (surface water is not used for drinking water).

Soil vapor intrusion (SVI) from VOC contaminated soil and/or groundwater into overlying buildings may affect the indoor air quality. The Site is currently vacant; therefore, the inhalation of Site-related contaminants due to SVI does not represent a complete exposure pathway for the Site in its current condition. However, the potential exists for people to inhale Site contaminants in indoor air due to SVI for any future on-site redevelopment and occupancy. In addition, SVI sampling conducted in the vicinity of the Site has indicated that actions are necessary to address SVI concerns at off-site properties that overly the groundwater contamination plume.

While the focus of this FFS is to evaluate remedial alternatives to address potential exposures from the DNAPL source area, this FFS will also recommend methods to control remaining exposure pathways as components of the DNAPL source area remedy.

6.0 DEVELOPMENT OF REMEDIAL ACTION GOALS AND OBJECTIVES, AND GENERAL RESPONSE ACTIONS FOR SOURCE AREA CONTAMINATION

6.1 IDENTIFICATION OF REMEDIAL ACTION GOALS AND OBJECTIVES

RAOs are the specific goals that must be achieved by the remedial actions selected in this FFS. RAOs therefore form the basis for identifying remedial technologies and developing remedial alternatives. Conventionally, RAOs are medium-specific or OU-specific goals established to protect public health and the environment. The RAOs are exposure-based in that they are selected to address specific potential exposure pathways for each of the identified media of concern, as identified in the qualitative exposure assessment.

This FFS combines OU1 and OU2 into one unit. In accordance with SCOs provided in Title 6 of New York Codes, Rules, and Regulations (NYCRR) Part 375-1.10, the RAOs and selected remedial actions for the Site are summarized below:

- Reduce, control, or eliminate, to the extent practicable, the continued migration of contaminated groundwater and DNAPL from and downgradient of the Site.
- Eliminate the potential for direct contact with remaining contaminated soil at the Site.
- Eliminate, to the extent practicable, the potential for exposure to contaminated groundwater and/or vapors and/or contaminated surface water.
- Mitigate impacts to public health resulting from existing or potential SVI into buildings.

6.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

General response actions describe those actions that will satisfy the RAOs (United States Environmental Protection Agency [USEPA], 1988). General response actions may include treatment, containment, excavation, disposal, institutional actions, or a combination of these. Like RAOs, general response actions are medium-specific. General response actions include those applicable to source area groundwater contamination at the Site. The following general response actions would address the RAOs previously identified:

- no further action

- ICs with LTM
- in-situ source area treatment

No further action is used as a baseline against which to compare the other remedial alternatives and involves no further remedial action at the Site. ICs with LTM would include placing environmental easements (EEs), implementing a Site Management Plan (SMP), and conducting monitoring programs to control and evaluate potential exposure to receptors. In-situ source area treatment would treat contaminated groundwater and bedrock in the DNAPL source.

6.3 EXTENT OF SOURCE AREA CONTAMINATION REQUIRING REMEDIAL ACTION

The horizontal extent of the source area contamination targeted for remedial action is shown in Figure 3.1. The vertical extent of source area contamination extends across a narrow zone of bedrock fractures from approximately 425 to 435 feet above mean sea level (msl). Remedies will generally target the saturated soils and bedrock overlying the zone of DNAPL contamination in addition to this zone itself. Remedial alternatives will be developed with consideration for the horizontal and vertical distribution of the contaminants.

7.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section describes the identification and screening of potential remedial technologies. Technologies are identified for the purpose of attaining the RAOs established in Subsection 7.1. Identified technologies that correspond to the categories of general response actions are described in Subsection 7.2.

Following identification, candidate technologies are screened based on applicability to Site- and contaminant-limiting characteristics. Potential technologies representing the range of general response actions are considered. The screening produces an inventory of suitable technologies that can be assembled into remedial alternatives capable of mitigating actual or potential exposures at the Site.

7.1 TECHNOLOGY IDENTIFICATION

Most remedial technologies presumed to be effective at treating common contaminant groups are identified in DER-15: Presumptive/Proven Remedial Technologies (NYSDEC, 2007). This guidance and information obtained from vendors or other sources were used to generate the list of applicable remedial technologies and associated process options presented in Table 7.1.

7.2 TECHNOLOGY SCREENING

The technology screening process reduces the number of potentially applicable technologies and process options by evaluating factors that may influence process-option effectiveness and implementability. This overall screening is consistent with guidance for developing and evaluating remedial alternatives for an FS under DER-10 (NYSDEC, 2010). Effectiveness and implementability are incorporated into two screening criteria: waste- and site-limiting characteristics. Waste-limiting characteristics consider the suitability of a technology based on contaminant types, individual compound properties (e.g., volatility, solubility, specific gravity, adsorption potential, and biodegradability), and interactions that may occur between mixtures of compounds. Site-limiting characteristics consider the effect of site-specific physical features on the implementability of a technology, such as site topography and geology, the location of buildings and underground utilities, available space, and proximity to sensitive operations. Technology screening serves the two-fold purpose of screening out technologies whose applicability is limited by waste- or site-specific considerations while retaining as many potentially applicable technologies as possible.

Table 7.1 presents the technology-screening process. Technologies and process options judged ineffective or prohibitively difficult to implement were eliminated from further consideration. The technologies retained following screening represent an inventory of technologies considered most suitable for remediation of soil at the Site and may be used alone or integrated with other technologies to develop remedial alternatives. Pilot-scale treatability studies may be required prior to final technology selection to confirm the effectiveness of a given technology.

8.0 DEVELOPMENT AND PRELIMINARY SCREENING OF ALTERNATIVES

The retained technologies identified in Table 7.1 are considered technically feasible and applicable to the waste types and physical conditions at the Site. These medium-specific technologies were assembled into potential site-specific remedial alternatives capable of achieving the RAOs.

8.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The retained remedial technologies have been composed into the following remedial alternatives:

- Alternative 1: No Further Action
- Alternative 2: ICs, LTM and Additional Sub-Slab Depressurization System (SSDSs) if Needed
- Alternative 3: ICs, In-Situ Thermal Treatment and LTM with Additional SSDSs if Needed
- Alternative 4: ICs, In-Situ Chemical Reduction and LTM with Additional SSDSs if Needed

8.1.1 Alternative 1: No Further Action

Alternative 1 was developed as a baseline against which to compare the other remedial alternatives. This alternative involves no further action to reduce source area contamination and no further action to address potential human exposure and environmental impacts.

8.1.2 Alternative 2: Institutional Controls, Long Term Monitoring and Additional Sub-Slab Depressurization Systems if Needed.

Alternative 2 consists of:

- ICs (includes environmental easements and a SMP).
- installation of additional downgradient monitoring wells
- long term groundwater, surface water, and indoor-air monitoring

- installation, operation, maintenance, and monitoring (OM&M) of SSDSs at downgradient structures affected by the groundwater plume, as needed

Alternative 2 includes ICs for the Site property preventing residential use of the Site and requiring a SMP. The SMP would include provisions for protecting workers from residual subsurface soil contaminants or exposure to groundwater during construction or utility work. The SMP would also require maintaining the existing soil cover as part of ICs. Also, as part of ICs, the Site would be classified as industrial use only since the remaining exposed surface soils exceed residential and commercial use criteria but not industrial use criteria.

Alternative 2 would include installing additional wells to evaluate how contaminant mass is migrating from the source area and how contaminants in the downgradient plume are attenuating.

Alternative 2 would also include continued surface water monitoring at the surface water drainage system/retention pond located adjacent and north of the Site, groundwater monitoring to better delineate the groundwater plume, evaluate effectiveness of the remedy, assess the potential for vapor-intrusion to downgradient receptors, and continued indoor air monitoring at select residences in the area. Depending on the results of indoor air monitoring, additional SSDSs may be installed at structures affected by the plume. Alternative 2 assumes that no additional SSDSs will be required.

8.1.3 Alternative 3: Institutional Controls, In-Situ Thermal Treatment and Long Term Monitoring

Alternative 3 consists of:

- ICs
- installation of additional downgradient monitoring wells
- long term groundwater, surface water, and indoor-air monitoring
- installation, OM&M of SSDSs at downgradient structures affected by the groundwater plume, as needed
- In-situ thermal treatment system pilot test
- installation, OM&M of an in-situ thermal treatment system

The treatment system would target an area of approximately 180,000 square feet across a 10 feet thick interval from 425-435 feet above msl. Thermal conduction heating (TCH) would be used to heat the targeted treatment zone to temperatures of approximately 100 degrees Celsius. The TCH system would use vertical heater wells to heat the soil/rock, water, and contaminants adjacent to the well; the heat would then flux from the well into the rest of the targeted treatment volume via thermal conduction and convection. Contaminants and groundwater in the targeted treatment volume will vaporize as subsurface temperatures increase, and SVE wells will extract vaporized groundwater and contaminants to above ground vapor and liquid treatment systems. The treatment systems would include an oil/water separator to segregate DNAPL, liquid-phase granular activated carbon for liquid treatment, and vapor-phase granular activated carbon for vapor treatment. The system would also use an impermeable land cover over the targeted treatment area to prevent fugitive emissions from discharging to the atmosphere.

System components include approximately 1,000 heating wells spaced 15 feet apart, each with a co-located SVE well to remove generated vapors. Additionally, steam injection wells could be installed upgradient of the source area to ensure that new groundwater flowing into the treatment area does not create significant cooling. The system would require 165 days of operation to reach the target temperature in the treatment zone, and would operate for 180 days in total. Temperature and pressure monitoring points would also be installed to measure real-time system performance. Current technology is available to operate the in-situ heaters either by electricity or by natural gas. Vendor estimates indicate that a natural gas system would require approximately 87 million cubic feet of natural gas and that an electric system would use approximately 27 million kilowatt hours.

The ICs, installation of downgradient monitoring wells, and LTM would be similar to that described for Alternative 2.

8.1.4 Alternative 4: Institutional Controls, In-Situ Chemical Reduction, and Long Term Monitoring

Alternative 4 consists of:

- ICs
- installation of additional downgradient monitoring wells
- long term groundwater, surface water, and indoor-air monitoring

- installation, OM&M of SSDSs at downgradient structures affected by the groundwater plume, as needed
- injection of reactive media to chemically reduce contaminants in the source area

In-situ chemical reduction would use a reactive media, such as zero-valence iron (ZVI), to treat DNAPL and groundwater contaminants. While most reactive media require contaminants to be in the dissolved phase in order to degrade them, limiting their effectiveness at degrading residual DNAPL or requiring multiple applications, a reactive media such as emulsified ZVI (EZVI) could be injected into the bedrock fractures to chemically reduce DNAPL. EZVI is particularly effective at treating residual DNAPL, assuming direct contact between the EZVI and DNAPL can be achieved. EZVI uses a vegetable oil to partition VOCs into the oil and water emulsion. Once partitioned, the contaminants react with the ZVI, degrading the contaminants. Additionally, the vegetable oil acts as an electron donor to promote biodegradation of TCE that is not degraded by the EZVI. Bench scale and/or pilot tests would be performed to determine whether a traditional ZVI or an EZVI would be more effective for this site.

The proposed in-situ chemical reduction program would use approximately 257 injection points to target the 180,000 square feet estimated extent of source area contamination, assuming an effective radius of influence of 15 feet. Approximately 750,000 pounds of reactive media mixed with approximately 250,000 gallons of water to create a slurry would be injected into the approximately 67,000 cubic yard treatment volume. A roto-sonic rig would be used to install the borings, and a compressed gas source would be used to pneumatically fracture the bedrock and inject the reactive media into the fractures. The pneumatic fracturing will create enlarged interconnected fractures to promote acceptance of the injected media into the bedrock and promote contact between the media and ZVI. The borings would be installed starting from outside the area of DNAPL and moving towards the center of the plume to prevent migration of the DNAPL outside of the treatment area. Each injection point will have four injection intervals across the 10 feet treatment interval, spaced 2.5 feet apart and packers would be used to isolate the injection intervals. The injection program would take approximately 90 days to complete, and the reactive media will create reducing conditions that will persist for two to five years after injection to prevent rebounding of contaminant concentrations. The duration of reducing conditions achieved by the reactive media would depend upon the amount of media injected into the bedrock fractures, the local environmental chemistry, and hydrogeologic conditions. A pilot test of the chosen technology would be useful to improve estimates of media longevity. For the purposes of estimating a cost for a conceptual level design in this report, it is assumed that one additional injection event performed at 50 percent of the original event's scope would be necessary to achieve greater than 90 percent reduction of contaminant mass in the source area.

The ICs, installation of downgradient monitoring wells, and LTM would be similar to that described for Alternative 2.

8.2 PRELIMINARY SCREENING OF ALTERNATIVES

This Subsection presents a preliminary screening of the developed remedial alternatives. Consistent with DER-10, the developed medium-specific remedial alternatives are screened on the basis of whether they are technically implementable (Implementability) for the Site and whether they can meet the RAOs (Effectiveness). Additionally, based upon available information, the relative cost of each remedial alternative is also evaluated. Those remedial alternatives which are not technically implementable, would not achieve RAOs, or would incur costs significantly higher than other remedial alternatives without providing greater effectiveness or implementability are not evaluated further in the FS.

Screening of remedial alternatives is presented in Table 8.1. All of the above remedial alternatives were retained for detailed analysis in Section 9.0. The No Further Action alternative was not evaluated according to the screening criteria; it passes through screening to be evaluated during the detailed analysis as a baseline for other retained alternatives.

9.0 DETAILED ANALYSIS OF ALTERNATIVES

This section presents the detailed analyses of remedial action alternatives for source area DNAPL and groundwater at the Site. The detailed analysis is intended to provide decision-makers with the relevant information needed to select a remedy. The detailed description of technologies or processes used for each alternative includes, where appropriate, a discussion of limitations, assumptions, and uncertainties for each component. The descriptions provide a conceptual design of each alternative and are intended to support alternatives-comparison and cost-estimation.

The detailed analysis of each alternative includes evaluation using the first seven evaluation criteria identified in DER-10 (NYSDEC, 2010) and §375-1.8(f) (NYS, 2006), as presented in the following paragraphs.

Compliance with Standards, Criteria, and Guidance (SCGs). Compliance with SCGs considers whether or not a remedy will meet applicable environmental laws, regulations, standards, and guidance. SCGs for the Site are identified along with a discussion of whether or not the remedy will achieve compliance. For those SCGs that will not be met, a discussion and evaluation of subsequent impacts and whether waivers are necessary is presented. Location- and Action-specific SCGs are identified for each alternative in this Section and in Table 9.1.

Overall Protection of Public Health and the Environment. This criterion is an evaluation of the remedy's ability to protect public health and the environment - assessing how the remedy would eliminate, reduce, or control (through removal, treatment, containment, engineering controls (ECs), and/or ICs), Site related contamination to protect public health and the environment. The remedy's ability to achieve each of the RAOs is evaluated.

Short-term Effectiveness. The potential short-term adverse impacts and potential exposures resulting from the remedy upon the community, the workers, and the environment during the construction and/or implementation are evaluated. How the identified adverse impacts and exposures to the community or workers at the Site will be controlled, and the effectiveness of the controls, are considered. ECs that will be used to mitigate short term impacts (e.g., dust control measures) are described. The length of time needed to achieve the remedial objectives is estimated.

Long Term Effectiveness and Permanence. This criterion evaluates the long term effectiveness of the remedy after implementation. If wastes or treated residuals remain on-site after the selected remedy has been implemented, the following items are evaluated:

1. magnitude of remaining exposures
2. adequacy of the engineering and ICs intended to limit the exposures
3. reliability of these controls
4. ability of the remedy to continue to meet RAOs in the future.

Effectiveness of alternatives in protecting human health and the environment RAOs is also evaluated. This includes an evaluation of the permanence of the alternative, the magnitude of residual exposures, and the adequacy and reliability of controls required to manage wastes or residuals remaining at the Site.

Reduction of Toxicity, Mobility, or Volume with Treatment. The remedy's ability to reduce the toxicity, mobility or volume of site contamination is evaluated. Preference should be given to remedies that permanently and significantly reduce the toxicity, mobility, or volume of site wastes.

Implementability. The technical and administrative feasibility of implementing the remedy is evaluated. Technical feasibility includes the difficulties associated with remedy construction and the ability to monitor the remedy's effectiveness. For administrative feasibility, the availability of the necessary personnel and material is evaluated along with potential difficulties in obtaining specific operating approvals, access for construction, or other issues.

Land Use. The current, intended, and reasonably anticipated future land uses of the Site and its surroundings will be considered in the evaluation of remedial alternatives.

Cost. Capital and OM&M costs are estimated for the remedy and presented on a present worth basis.

Community Acceptance. In a format that responds to all questions raised (i.e. responsiveness summary), public comment, concerns, and overall perception of the remedy are evaluated following the public meeting presenting the proposed remedial action plan. This criterion is not evaluated in this draft report.

9.1 COST ANALYSIS PROCEDURES

Costs presented in this report are intended to be within the target accuracy range of minus 30 to plus 50 percent of actual cost (USEPA, 1988). Costs are provided as a present worth and as a total cost for up to a 30-year period.

A summary of the costs for each alternative identifying capital and net present worth (NPW) costs are included in each alternative's cost description. Each cost estimate includes a present worth analysis to evaluate expenditures that occur over different time periods. The analysis discounts future costs to a NPW and allows the cost of remedial alternatives to be compared on an equal basis. NPW represents the amount of money that, if invested now and disbursed as needed, would be sufficient to cover costs associated with the remedial action over its planned life. A discount rate of 5 percent was used to prepare the cost estimates per NYSDEC guidance.

Consistent with USEPA FS cost estimating guidance (USEPA, 2000), the remedial alternative cost estimates include costs for project management, remedial design (RD), construction management, technical support, and scope contingency.

Project management includes planning and reporting, community relations support during construction or operations and maintenance (O&M), bid or contract administration, permitting (not already provided by the construction or O&M contractor), and legal services outside of ICs.

RD applies to capital cost and includes services to design the remedial action. Activities that are part of RD include pre-design collection and analysis of field data, engineering survey for design, treatability study/pilot-scale testing, and the various design components such as design analysis, plans, specifications, cost estimate, and schedule.

Construction management applies to capital cost and includes services to manage construction or installation of the remedial action, except any similar services provided as part of regular construction activities. Activities include review of submittals, design modifications, construction observation or oversight, engineering survey for construction, preparation of an O&M manual, documentation of quality control/quality assurance, and record drawings.

Technical support during O&M includes services to monitor, evaluate, and report progress of remedial action. This includes oversight of O&M activities, update of O&M manual, and progress reporting and is generally between 10 percent and 20 percent of total annual O&M costs depending on complexity of the remedial action (USEPA, 2000).

Scope contingency represents project risks associated with the feasibility-level of design presented in this report. This type of contingency represents costs, unforeseeable at the time of estimate preparation, which are likely to become known as the RD proceeds. Scope contingency ranges from 10 to 25 percent, with higher values appropriate for alternatives with greater levels of cost growth potential (USEPA, 2000).

Project management, RD, and construction management costs presented in this report are based upon the following matrix presented in the USEPA FS cost estimating guidance (USEPA, 2000).

Professional and Technical Costs as Percentage of Direct Costs					
Indirect Cost	< $100K (%)	$100K-$500K (%)	$500K-$2M (%)	$2M-$10M (%)	>$10M (%)
Project Management	10	8	6	5	5
Remedial Design	20	15	12	8	6
Construction Management	15	10	8	6	6

All of the remedial alternatives developed in Section 8.0 were retained for detailed analysis. The following subsections present a conceptual design and cost estimate for each of these remedial alternatives and a discussion of each alternative relative to the evaluation criteria as set forth in NYCRR Part 375 (NYS, 2006).

9.2 ALTERNATIVE 1: NO FURTHER ACTION

This alternative would not implement any further actions at the Site.

Compliance with SCGs. Alternative 1 does not meet chemical-specific SCGs in the short term or long term because it does not remove or treat groundwater contamination in excess of 6 NYCRR Parts 700-706 Water Quality Standards (NYSDEC, 1998), and the source area is likely to contribute to downgradient groundwater contamination and potential SVI for many years to come.

Overall Protection of Public Health and the Environment. There is no current direct exposure pathway to the impacted areas. However, Alternative 1 does not protect future exposure.

Short-term Impacts and Effectiveness. Alternative 1 does not include construction or other activities that would result in potential short-term adverse impacts and potential exposures to the community, workers, or the environment during implementation. Alternative 1 would not provide any short-term effectiveness related to the RAOs.

Long Term Effectiveness and Permanence. Alternative 1 is not likely to meet RAOs in the future due to the continued DNAPL source area and contaminant mass diffused in the bedrock matrix.

Reduction of Toxicity, Mobility, or Volume with Treatment. Alternative 1 would not reduce toxicity, mobility and volume of contaminants on-site or off-site.

Implementability. Alternative 1 does not include additional actions. Therefore, there are no technical difficulties associated with this alternative. However, regulatory approval of this alternative is anticipated to be difficult.

Land Use. Alternative 1 would be compatible with current and foreseeable future land use; however, there are no ICs in place to prevent changes in land use in the future.

Cost. Alternative 1 has no capital costs or expected annual OM&M costs. The NPW of this Alternative is $0. A summary of the costs associated with this alternative is presented in Table 9.2.

9.3 ALTERNATIVE 2: INSTITUTIONAL CONTROLS, LONG TERM MONITORING AND ADDITIONAL SUB-SLAB DEPRESSURIZATION SYSTEMS IF NEEDED

Alternative 2 consists of the following components:

- ICs
- installation of additional downgradient monitoring wells
- long term groundwater, surface water, and indoor-air monitoring
- installation, OM&M of SSDSs at downgradient structures affected by the groundwater plume as needed

ICs Requiring a SMP. The Site is zoned for Industrial use and is currently capped with 9-12 inches of clay. Surface and subsurface soil meet the SCOs for Industrial Use; therefore, there are no complete exposure pathways to soil at the Site. Due to the DNAPL present within bedrock, the chlorinated solvents present in sub-surface soil are not anticipated to be a significant contributor to groundwater contamination, and toluene, the other major VOC detected in Site soil, was not detected in groundwater downgradient of the Site above the class GA groundwater standards. Alternative 2 would require ICs at the Site in the form of an EE, preventing residential and commercial use of the Site. In addition, a SMP would be required that includes provisions to protect workers from residual subsurface soil contaminants during construction or utility work. The ICs would also require that future structures located over the source area would require means to protect against exposure to vapor-intrusion.

Long Term Groundwater Monitoring. Areas downgradient of the Site are serviced by public water (source of public water is not groundwater); therefore, the focus of groundwater monitoring is to better delineate the groundwater plume and evaluate the effectiveness of the remedy. Individual components of this alternative include the following:

- Install and develop downgradient monitoring well pairs in overburden soils and bedrock to delineate the DNAPL and groundwater plume.
- Perform baseline groundwater sampling analysis for VOCs from each existing well, except 9S & 9D, and new ones described herein.
- Perform semiannual groundwater sampling and analysis for two years, after which sampling program would be decreased to annual for three years and evaluated again for modifications every 5 years.

- Perform surface water sampling and analysis at the same frequency as the groundwater sampling.

In addition, ICs will be placed on the property to prohibit groundwater extraction at the Site. Periodic Review Reports (PRRs) would be required detailing the compliance with the SMP.

SSDSs. Additional investigations are needed to evaluate if the overburden groundwater contamination could impact indoor air; these investigations are included as part of this alternative. This alternative would also require baseline and annual indoor air sampling for three years, targeting 14 previously sampled locations plus a duplicate sample for 15 total VOC samples. SSDSs would be installed in residences as needed. System installation and OM&M would be documented in the PRRs. This alternative assumes that after three sampling events that no further indoor air sampling will be required and that no additional SSDSs are required.

Compliance with SCGs. Alternative 2 does not meet chemical-specific SCGs in the short term or long term because it does not remove or treat groundwater contamination in excess of 6 NYCRR Parts 700-706 Water Quality Standards (NYSDEC, 1998), and the source area is likely to contribute to downgradient groundwater contamination and potential SVI exposure for many years to come.

Overall Protection of Public Health and the Environment. Alternative 2 would protect public health and the environment through ICs that would prevent residential and commercial use of the Site, and would protect exposure to on-site workers. LTM would be conducted to track any changes in the condition of the Site, and would trigger the installation of additional SSDSs in downgradient structures, if needed.

Short-term Impacts and Effectiveness. Alternative 2 includes activities that would result in potential short-term adverse impacts and exposures to workers during installation of the new borings and monitoring wells. However, proper health and safety practices can control these exposures. It is estimated that this alternative could be fully implemented, with the exception of LTM, in approximately one year. However, many of the RAOs would not be effectively addressed in the short term.

Long Term Effectiveness and Permanence. Alternative 2 is not likely to meet all of the RAOs in the future due to the continued DNAPL source area and contaminant mass diffused in the rock matrix.

Reduction of Toxicity, Mobility, or Volume with Treatment. Alternative 2 would not reduce toxicity, mobility and volume of contaminants on-site or off-site.

Implementability. There are no technical difficulties associated with Alternative 2. However, regulatory approval of Alternative 2 is anticipated to be difficult given the lack of source area treatment. Unless other alternatives with source area treatment components are not cost effective, or are otherwise impractical, Alternative 2 would likely not receive regulatory approval.

Land Use. Given the proposed ICs, monitoring, and anticipated continued industrial use of the Site, this alternative would be compatible with current and foreseeable future land use.

Cost. The capital cost of Alternative 2 is $234,000 for the implementation of ICs, the installation the new groundwater monitoring wells, and performing the source area characterization and baseline groundwater sampling. Annual OM&M costs related to the LTM program total approximately $233,000. The NPW of this Alternative is $467,000. A summary of the costs associated with this alternative is presented in Table 9.3. These costs assume 30 years of monitoring. Detailed cost backup is provided in Appendix A.

9.4 ALTERNATIVE 3: INSTITUTIONAL CONTROLS, IN-SITU THERMAL TREATMENT, AND LONG TERM MONITORING

Alternative 3 consists of the following components:

- ICs
- installation of additional downgradient monitoring wells
- long term groundwater, surface water, and indoor-air monitoring
- installation, OM&M of SSDSs at downgradient structures affected by the groundwater plume, as needed
- in-situ thermal treatment system pilot test

- installation, OM&M of an in-situ thermal treatment system

ICs, Source Area Characterization, LTM, and SSDSs. Alternative 3 would implement ICs, install additional downgradient monitoring wells, and install additional SSDSs as described for Alternative 2. LTM would be similar to Alternative 2 with the exception that monitoring would be conducted at an annual rate from years 3-10 before decreasing to every 5 years. The increased frequency would be required to better evaluate the effectiveness of the source area treatment and its impacts to downgradient contamination.

In-Situ Thermal Treatment System Pilot Test. To evaluate the effectiveness of the proposed thermal treatment system prior to implementing a full system, a pilot test would be conducted, including the following activities:

- Complete pre-mobilization activities; e.g. meetings, work plans, Health and Safety Plan (HASP), quality assurance plan, sampling and analysis plan, discharge permits, and utility location surveys.
- Mobilize a drilling contractor to the Site and drill seven co-located TCH and SVE wells and four thermal couple and pressure monitoring wells into bedrock, targeting the interval of 425-435 feet above msl. Collect pre-treatment bedrock analysis samples. Dispose of drill cuttings.
- Abandon or replace existing polyvinyl chloride (PVC) wells in the targeted treatment area.
- Mobilize and install thermal treatment equipment, off-gas treatment system, and liquid effluent treatment systems. Fence-off equipment.
- Connect electrical, natural gas, water, and internet utility services to treatment system.
- Start up thermal treatment system for 130 day pilot test duration. Perform system sampling and analysis as required by permits, weekly system inspections, and waste disposal as needed.
- At completion of pilot test, collect confirmatory bedrock samples for analysis, demobilize equipment, and issue final report stating pilot test results.

Install, Operate, Maintain, and Monitor In-Situ Thermal Treatment System. The full scale thermal treatment system installation includes the following activities:

- Complete pre-mobilization activities; e.g. meetings, design, work plans, HASP, quality assurance plan, sampling and analysis plan, discharge permits, and utility location surveys.
- Mobilize a drilling contractor to the Site and drill 967 co-located TCH and SVE wells and associated thermal couple and pressure monitoring wells into bedrock at 10 feet spacing,

targeting the interval of 425-435 feet above msl. Collect pre-treatment bedrock analysis samples. Dispose of drill cuttings. Drilling activities would be completed over approximately 24 days.

- Pending design, install steam injection wells upgradient of the source area to facilitate temperature control in the treatment area.
- Abandon or replace existing PVC wells in the targeted treatment area.
- Mobilize and install thermal treatment equipment, off-gas treatment system, and liquid effluent treatment systems. Fence-off equipment.
- Connect electrical, natural gas, water, and internet utility services to treatment system.
- Start up thermal treatment system for 180 day duration. Perform system sampling and analysis as required by permits, weekly system inspections, and waste disposal as needed.
- At completion of treatment, collect confirmatory bedrock samples for analysis, abandon wells, demobilize equipment, and issue final report stating treatment results.

Compliance with SCGs. Alternative 3 does not meet chemical-specific SCGs in the short term because it does not address all groundwater contamination in excess of 6 NYCRR Parts 700-706 Water Quality Standards (NYSDEC, 1998) and because it would be cost prohibitive to achieve SCGs in the short term given the large contaminant mass present in bedrock as DNAPL and the diffused contaminant mass in the bedrock matrix. However, in the long term this alternative is expected to achieve class GA groundwater standards through subsequent natural attenuation of the remaining contaminants.

Overall Protection of Public Health and the Environment. Alternative 3 would protect public health and the environment through ICs that would prevent residential and commercial use of the Site, and would protect exposure to on-site workers. LTM would be conducted to track any changes in the condition of the Site, and would trigger the installation of additional SSDSs in downgradient structures, if needed.

Short-term Impacts and Effectiveness. Alternative 3 includes activities that would result in potential short-term adverse impacts and exposures to workers during the installation and operation of the in-situ thermal treatment system. However, proper health and safety practices can control these exposures. It is estimated that this alternative could be fully implemented, with the exception of LTM, in approximately two years and would be effective at addressing many of the RAOs during this time period.

Long Term Effectiveness and Permanence. Alternative 3 may meet all of the RAOs in the future since it will eliminate the source of contamination and allow the remaining concentrations to naturally attenuate over time. The source area removal will accelerate degradation of the remaining plume and reduce the time necessary to achieve the RAOs. Any remaining contamination would pose a low potential for human exposures and environmental impacts.

Reduction of Toxicity, Mobility, or Volume with Treatment. Alternative 3 would significantly reduce the mobility and volume of contaminants on-site and off-site through heating, vaporizing and ex-situ treatment.

Implementability. The treatment system's technology would not be difficult to implement. However, the size of the system required to treat the areal extent of DNAPL and the active railroad tracks bisecting the DNAPL source area pose challenges to designing a system that will target contamination beneath the railroad tracks, be cost effective, and do not disrupt railroad traffic.

Land Use. Alternative 3 would be compatible with current and foreseeable future land use provided that the proposed ICs are implemented.

Cost. The capital cost of Alternative 3 would range from $9,911,000 to $23,715,000 for performing the pilot test, installing the treatment system, and implementing the ICs and LTM actions. The capital costs for the thermal treatment system are estimated based on quotes from two vendors. Annual OM&M costs related to LTM total approximately $299,000 for 30 years. The NPW of this Alternative would range from $10,210,000 to $24,014,000. A summary of the costs associated with this alternative is presented in Table 9.4. Detailed cost backup is provided in Appendix A.

9.5 ALTERNATIVE 4: INSTITUTIONAL CONTROLS, IN-SITU CHEMICAL REDUCTION, AND LONG TERM MONITORING

Alternative 4 consists of the following components:

- ICs
- installation of additional downgradient monitoring wells
- long term groundwater, surface water, and indoor-air monitoring

- installation, OM&M of SSDSs at downgradient buildings affected by the groundwater plume
- pilot test for in-situ reactive media injections
- source area treatment via reactive media injections
- monitoring the effectiveness of the treatment

ICs, Source Area Characterization, LTM, and SSDSs. Alternative 4 would implement ICs, install additional downgradient monitoring wells, and install additional SSDSs as described for Alternative 2. LTM would be conducted as described in Alternative 3.

Source Area Treatment. Prior to injecting reactive media in the source area, a pilot test would be completed to support the RD. The RD and injection work plan would be completed after the pilot test, including a site visit with the technology vendor and standard submittals such as a HASP, quality assurance and equality control plan, etc. A drilling contractor would mobilize to the Site, and the reactive media vendor would also mobilize with injection equipment including a compressed air source and injector, mixing vessels and equipment to prepare the reactive media for injection, and inflatable packers to isolate the targeted injection intervals in each injection point. Two hundred fifty seven injection points would be drilled and installed into bedrock throughout the DNAPL source area. Injections would begin at the outside perimeter of the source area and would move towards the center to prevent inadvertent mobilization of DNAPL outside the source area. The injection points would be used to deliver a reactive media such as ZVI (used for costing purposes). Approximately 750,000 pounds of ZVI would be used to target a treatment volume of 67,000 cubic yard. The reactive media would be mixed with approximately 250,000 gallons of water to make a slurry that would be delivered via pneumatic injection to increase the distribution of the reactive media throughout the bedrock fractures, increasing the radius of influence of each injection point and reducing the number of injection points required. A three to four person field crew could complete the injection over a 90 field day time frame. A second injection event is assumed for the Site five years after the initial injection event as a contingency. For costing purposes, it is assumed the second injection event would be 50 percent of the scope of the initial injections.

Compliance with SCGs. Alternative 4 does not meet chemical-specific SCGs in the short term because it does not address all groundwater contamination in excess of 6 NYCRR Parts 700-706 Water Quality Standards (NYSDEC, 1998) and because it would be cost prohibitive to achieve

SCGs in the short term given the large contaminant mass present in bedrock as DNAPL and the diffused contaminant mass in the bedrock matrix. However, in the long term this alternative is expected to achieve class GA groundwater standards through the persistence of the ZVI and the subsequent natural attenuation of the remaining source area contaminants.

Overall Protection of Public Health and the Environment. Alternative 4 would protect public health and the environment through ICs that would prevent residential and commercial use of the Site, and would protect exposure to on-site workers. LTM would be conducted to track any changes in the condition of the Site, and would trigger the installation of additional SSDSs in downgradient structures, if needed.

Short-term Impacts and Effectiveness. Alternative 4 includes activities that would result in potential short-term adverse impacts and exposures to workers during the source area injections. However, proper health and safety practices can control these exposures. It is estimated that this alternative could be fully implemented in approximately three to four months.

Long Term Effectiveness and Permanence. Alternative 4 may meet all of the RAOs in the future since it will reduce the source of contamination and allow the remaining concentrations to naturally attenuate over time. The source area removal will accelerate degradation of the remaining plume and reduce the time necessary to achieve RAOs. Any remaining source area contamination would pose a low potential for human exposures and environmental impacts.

Reduction of Toxicity, Mobility, or Volume with Treatment. Alternative 4 would reduce the toxicity, mobility, and volume of contaminants on-site through source area treatment of contaminants using an in-situ reactive media.

Implementability. The reactive media injection technology would not be difficult to implement for Alternative 4, although specific concerns at this Site include controlling the movement of the treatment chemistry through the bedrock and injecting large quantities of reactive media into the subsurface, and potentially mobilizing DNAPL. This can be controlled by injecting from the outside of the treatment area inwards. Directional drilling will likely be required to target areas near or beneath the active railroad tracks.

Land Use. Alternative 4 would be compatible with current and foreseeable future land use provided that the proposed ICs are implemented.

Cost. The capital cost of Alternative 4 is $3,112,000 for injecting the reactive media in the source area, and implementing the ICs and LTM actions. Annual operation, maintenance, assumed reinjection at year five, and costs related to the LTM program are $1,194,000 for years 1 through 30. The NPW of this Alternative is $4,161,000. A summary of the costs associated with this alternative is presented in Table 9.5. These costs assume 30 years of OM&M until RAOs are achieved. Detailed cost backup is provided in Appendix A.

10.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents a summary of the relative performance of each of the four candidate alternatives based on the criteria evaluated in Section 9. The purpose of the comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another to aid in selecting an overall remedy for the Site.

The comparative analysis includes a narrative discussion of the strengths and weaknesses of the alternatives relative to one another with respect to each criterion, and how reasonable variations of key uncertainties could change the expectations of their relative performance, as applicable. The comparative analysis presented in this document uses a qualitative approach to comparison, with the exceptions of comparing alternative costs and the required time to implement each alternative.

A comparison of the capital and long term costs associated with the remedial alternatives is presented in Table 10.1. Detailed cost analysis backup is provided in Appendix A. Quotes and correspondences from thermal treatment and in-situ chemical reduction vendors are provided in Appendices B and C, respectively.

10.1 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

The following paragraphs present a comparison of the remedial alternatives which were evaluated in detail in Section 9.0, relative to the following evaluation criteria (an assessment of Community Acceptance will be presented in a future document). The comparative analysis is also presented in tabular form in Table 10.2.

Compliance with SCGs. None of the alternatives would meet chemical-specific SCGs for the Site in the near term because they do not remove or treat all Site contamination which exceeds applicable SCG values. However, given the focus of this FFS on source area contaminant removal, these alternatives are compared with respect to their ability to accelerate the reduction of contaminant mass in the short term for the source area and to achieve SCGs in the long term.

Alternative 2 would not meet chemical specific SCGs in the short term since it does not include an action that would target the source area. Alternatives 3 and 4 would help satisfy chemical-specific SCGs in the long term comparably, assuming that adequate contact could be achieved between the reactive media and contamination for Alternative 4.

Implementation of the alternatives would be conducted in accordance with applicable municipal, state, and federal guidance and regulations. Table 9.1 presents a summary of Location- and Action-Specific SCGs associated with the alternatives evaluated in this Section.

Overall Protection of Public Health and the Environment. Alternative 1 would not protect human health and the environment because no actions would be taken. Alternatives 2, 3, and 4 would protect public health and the environment through the proposed ICs (EE, SMP, including a LTM program).

Short-term Impacts and Effectiveness. Alternative 1 would not result in short-term adverse impacts and exposures to the community, site workers, and the environment because no actions would be taken. Alternatives 2, 3, and 4 include activities that would result in potential short-term adverse impacts and exposures to workers during implementation. However, the exposures could be mitigated through health and safety practices. Alternatives 2, 3, and 4 could be fully implemented in approximately one year. Alternatives 3 and 4 would both provide short-term effectiveness regarding overall reduction of contaminant mass.

Long Term Effectiveness and Permanence. Alternatives 1 and 2 would not meet RAOs in the long term due to the continued DNAPL source area and contaminant mass diffused in the rock matrix. Alternatives 3 and 4 would meet RAOs in the long term by permanently reducing contaminant mass in the source area and reducing the influx of dissolved phase contamination to the downgradient plume (alternative 4 may require additional injections after the primary injection to meet RAOs in the long term). Natural attenuation of contaminants would eventually achieve RAOs, although the time period required to meet RAOs is likely greater than 30 years. Remaining contamination would pose a low potential for human exposures and environmental impacts

Reduction of Toxicity, Mobility, or Volume with Treatment. Alternatives 1 and 2 would not reduce the toxicity, mobility, or volume of contamination with treatment. Alternative 3 would reduce the mobility and volume of contaminants on-site and off-site through extraction and ex-situ treatment. Alternative 4 would reduce the toxicity, mobility, and volume of contamination with in-situ chemical reduction achieved by injected reactive media.

Implementability. No additional actions would be conducted under Alternative 1; therefore there are no technical difficulties associated with this alternative. Alternative 2 would not be technically difficult to implement, but would be administratively difficult if not included as part of a remedy that reduced contamination in the source area. Alternative 3 would not be technically difficult to implement. However, the active railroad bisecting the DNAPL source area pose challenges to designing a system that does not disrupt railroad track traffic. The location of the railroad tracks may pose difficulties for Alternative 4 as well and may require the use of directional drilling, or may elect to leave the contamination below the railroad tracks. Alternative 4 also has a small potential for mobilizing DNAPL if not implemented properly.

Land Use. The current and reasonably anticipated future land use of the Site is for industrial use. Alternatives 2, 3, and 4 would be compatible with current land use and with reasonably anticipated future land use.

Cost. A comparison of estimated capital and long term costs associated with the remedial alternatives is presented in Table 10.1. Alternatives 2, 3, and 4 have comparable LTM costs. Alternative 2 has lower capital costs, but only because it lacks a source area treatment approach, which will likely render Alternative 2 as impracticable. The range of capital costs for Alternative 3 varied from $9.9 to $24 million based on quotes from technology vendors, which is expected to be cost-prohibitive. Therefore, Alternative 4, with a capital cost of approximately $3.1 million, offers the lowest cost per pound of contaminant removed.

11.0 RECOMMENDED ALTERNATIVE

Based on the detailed analysis and comparison of alternatives, it is recommended that the NYSDEC select Alternative 4, ICs, In-Situ Chemical Reduction, and LTM, as the preferred remedy. Alternatives 1 and 2 are not practicable since they do not address the source area contamination. While Alternative 3 would provide a more certain degree of contaminant removal in the source area than Alternative 4, the higher capital costs are not justified, due to the large treatment area and the energy intensity of thermal remediation technologies. Alternative 4 has the greatest potential to cost-effectively reduce contaminant mass in the source area and reduce the flux of contaminant mass to the downgradient plume. Alternative 4 also meets many of the Green remediation principles and techniques described in DER-31 (NYSDEC, 2011) since it does not require high energy usage or significant transportation and disposal of generated waste products.

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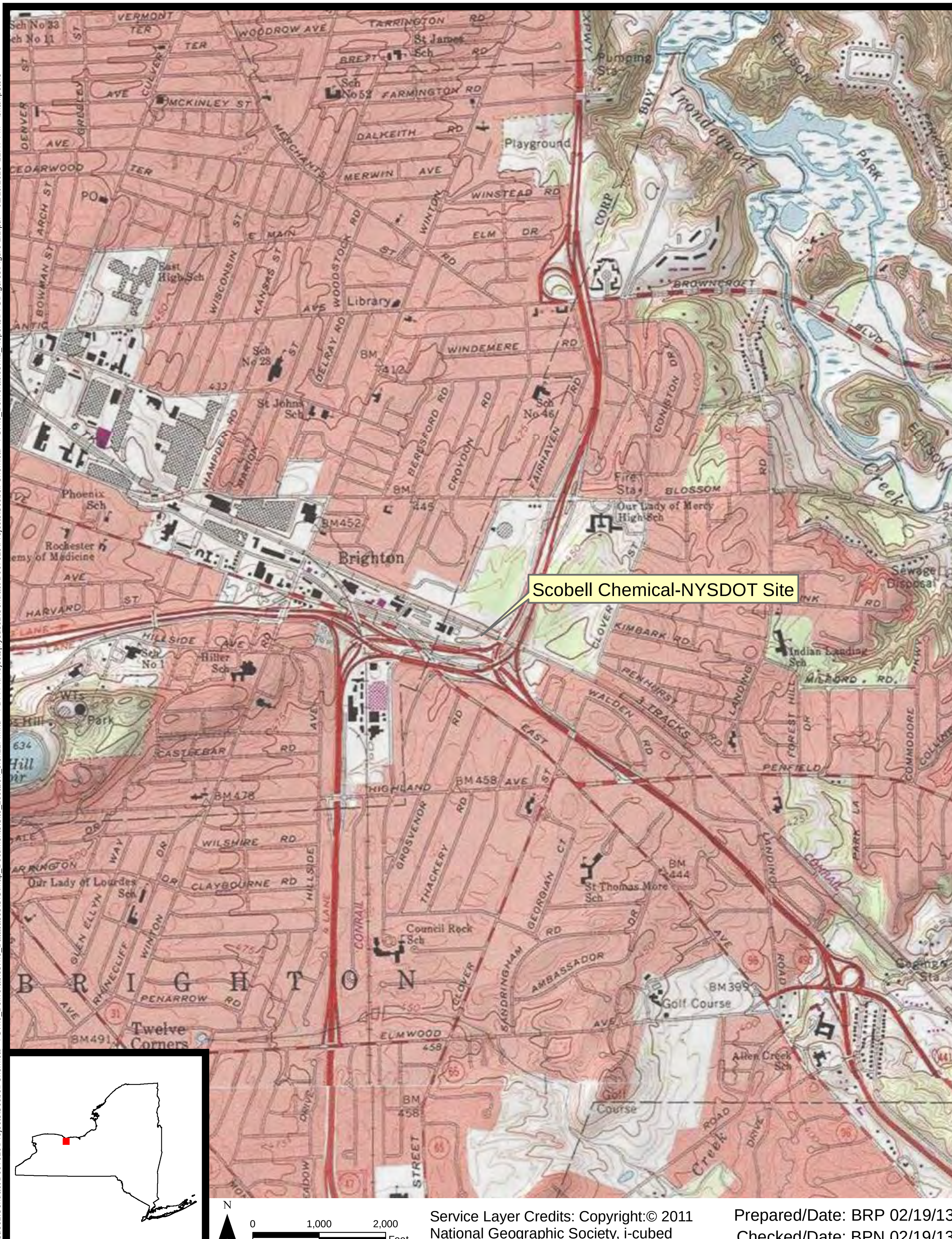
FIGURES



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Prepared/Date: BRP 02/19/13
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FOCUSED FEASIBILITY STUDY
SCOBELL CHEMICAL
BRIGHTON, NEW YORK

MACTEC

SITE LOCATION
Site 828076
Figure 1.1

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FOCUSED FEASIBILITY STUDY
SCOBELL CHEMICAL
BRIGHTON, NEW YORK

MACTEC

Groundwater Monitoring Well Locations
Site 828076
Figure 1.2

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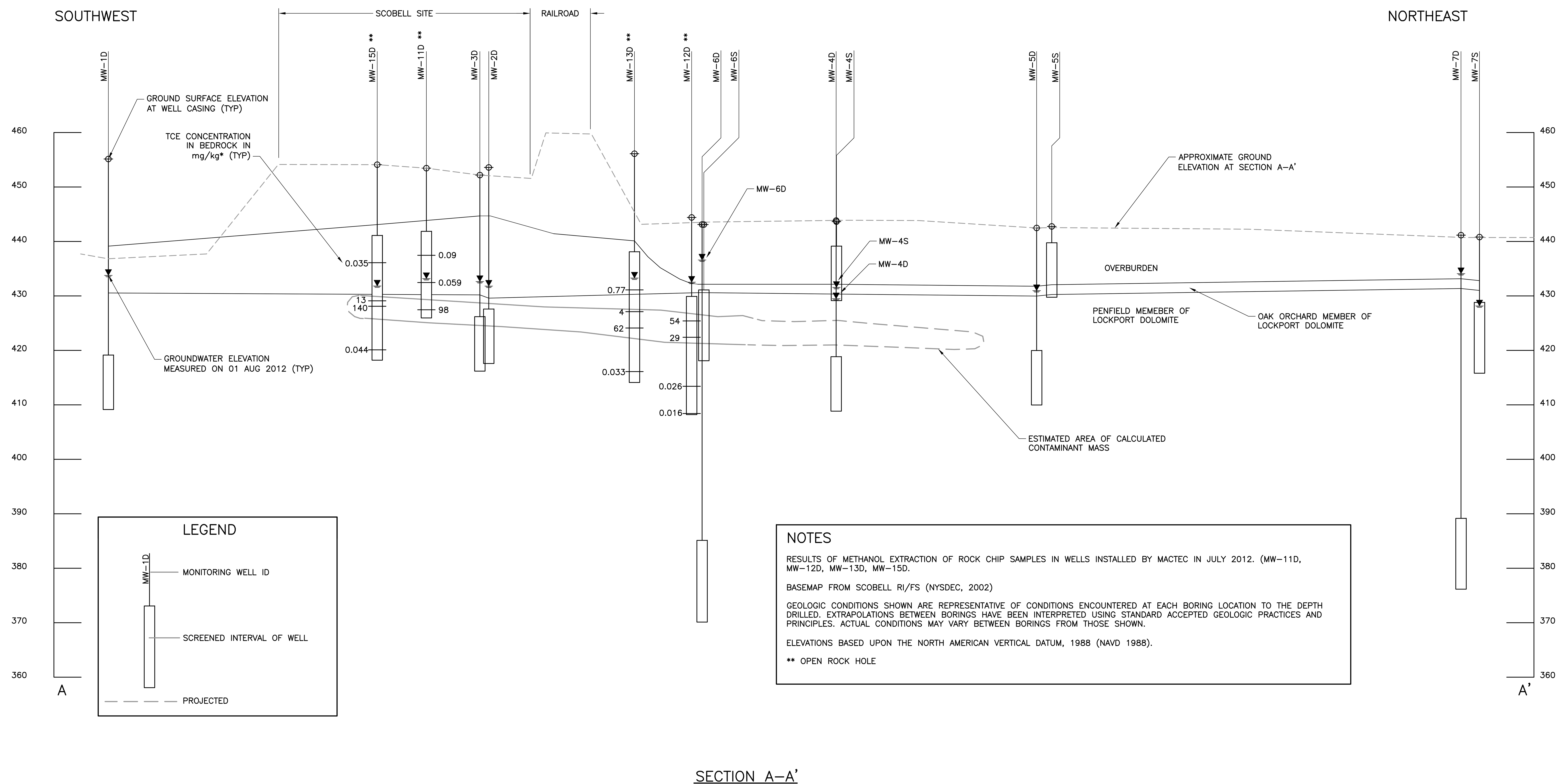
FOCUSED FEASIBILITY STUDY
SCOBELL CHEMICAL
BRIGHTON, NEW YORK

MACTEC

Estimated Extent of DNAPL in Bedrock
Site 828076
Figure 3.1



NOTES

RESULTS OF METHANOL EXTRACTION OF ROCK CHIP SAMPLES IN WELLS INSTALLED BY MACTEC IN JULY 2012. (MW-11D, MW-12D, MW-13D, MW-15D.

BASEMAP FROM SCOBELL RI/FS (NYSDEC, 2002)

GEOLOGIC CONDITIONS SHOWN ARE REPRESENTATIVE OF CONDITIONS ENCOUNTERED AT EACH BORING LOCATION TO THE DEPTH DRILLED. EXTRAPOLATIONS BETWEEN BORINGS HAVE BEEN INTERPRETED USING STANDARD ACCEPTED GEOLOGIC PRACTICES AND PRINCIPLES. ACTUAL CONDITIONS MAY VARY BETWEEN BORINGS FROM THOSE SHOWN.

ELEVATIONS BASED UPON THE NORTH AMERICAN VERTICAL DATUM, 1988 (NAVD 1988).

** OPEN ROCK HOLE

Prepared/Date: JVM 02/19/13
Checked/Date: CRS 02/19/13

FOCUSED FEASIBILITY STUDY
SCOBELL CHEMICAL
BRIGHTON, NEW YORK

MACTEC

CROSS SECTION OF DNAPL SOURCE AREA
SECTION A-A'
Site 828076
Figure 3.2

Z:\Projects\nysdec1\Scobell Chemical\FIG 3_2.dwg Tue, 19 Feb 2013 - 2:03pm john.mckenzie

TABLES

Table 7.1: Identification and Screening of Remedial Technologies

Environmental Media	General Response Action	Remedial Technology	Process Option	Applicability to		Screening Status	Comments
				Site-Limiting Characteristics	Waste-Limiting Characteristics		
Surface Soil (OU1)	No Further Action	NA	NA	None	Would not prevent direct exposure	Retain	Retain for baseline comparison.
	Offsite Treatment and/or Disposal	Excavation	Excavation and off-site disposal	None	None	Eliminated	Soil does not pose any risks.
	Institutional Controls	NA	Deed Restriction	None	VOC concentrations in soil exceed commercial standards but not industrial.	Retain	Deed restriction would ensure that the site is used for industrial purposes only and would protect construction workers.
Subsurface Soil (OU1)	No Further Action	NA	NA	None	No *current* complete exposure pathway, but nothing to prevent removal of the cap or construction.	Retain	Retain for baseline comparison.
	In-Situ Treatment	Physical Treatment	Soil Vapor Extraction and Treatment	None	None	Eliminated	The cost to conduct this remedy will not provide additional benefit since the existing cap is preventing direct exposure, and there are no plans for development. Also, given the low concentrations and types of contaminants detected in the soil (toluene and xylene), there is no evidence that the impacted soil is contributing to groundwater conditions and therefore is not interpreted to be migrating.
	Institutional Controls	NA	Deed Restriction	None	None	Retain	Deed restriction would ensure that a site management plan is prepared to protect human health in the event of construction or utility activities that require disturbance of soil and would require that the construction of a new building would required a sub-slab depressurization system.
Source Area DNAPL & Groundwater In Bedrock (OU-1 & OU-2)	No Further Action	NA	NA	None	Not Applicable	Retain	Retained to be carried through detailed analysis of alternatives for comparison to alternatives that satisfy RAOs.
	Monitor	Further Investigation	Long Term Monitoring	Access agreement	Would not eliminate, reduce or control the source area.	Retain	Since there are no direct receptors to the source area groundwater or DNAPL this option is being retained and would be incorporated into a site-wide monitoring program.
	Enhanced Extraction and Treatment	Bedrock Trench	Extraction wells	The proximity of the contaminant source areas to active railroad tracks may prohibit the use of explosives for blasting and other means of installing this trench may be required.	Would likely be effective at extracting groundwater, however it is unknown as to whether or not the DNAPL is moving and may not be not be able to be extracted. This technology is likely to provide hydraulic control of the source area, but would not be effective at removing DNAPL.	Eliminated	Would provide hydraulic control, but would not removed significant contaminant mass and would need longterm O&M.

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Table 7.1: Identification and Screening of Remedial Technologies

Environmental Media	General Response Action	Remedial Technology	Process Option	Applicability to		Screening Status	Comments
				Site-Limiting Characteristics	Waste-Limiting Characteristics		
Source Area DNAPL & Groundwater In Bedrock (OU1 & OU2)	In-Situ Treatment	Biological Treatment or Chemical Oxidation	Enhanced Biodegradation or Chemical Oxidation	Injections of biodegradation materials or chemical reagents may be difficult under railroad tracks and would require directional drilling. Distribution of the biodegradation materials or chemical reagents into bedrock matrix may be difficult and ineffective. These materials/reagents need to be uniformly distributed, but in tight bedrock they are more likely to displace the contaminated groundwater.	These materials/reagents have not been proven to be very effective with DNAPL without multiple applications.	Eliminated	Neither biodegradation or chemical oxidation would be effective in this scenario. The need for multiple injections (4 to 6) would make this alternative cost prohibitive (i.e. 2-3 times the cost of chemical reduction with zero valent iron).
		Physical Treatment or Chemical Reduction	Chemical Reduction (e.g., zero valent iron)	Installation of a chemical reducing reactive media could be difficult at this treatment depth in competent bedrock, but could be injected throughout the source area along with pneumatic fracturing.	Reactive media needs to be in contact with DNAPL to be effective at reducing DNAPL.	Retain	Retain.
		Thermal Treatment	In-Situ Thermal Desorption	May not be cost-effective for the extensive horizontal extents of contamination (i.e. more probe points required to heat media). May need to use directional drilling to get good coverage under the railroad tracks.	Requires capture and treatment of off-gases for contaminants that are not destroyed by heating.	Retain	Likely an effective treatment alternative, but costly.
Downgradient Overburden Groundwater (OU2)	No Further Action	NA	NA	None	Not Applicable	Retain	Retained to be carried through detailed analysis of alternatives for comparison to alternatives that satisfy RAOs.
	Monitor	Further Investigation and Monitoring	Additional Boring / Well locations and Long Term Monitoring	Access	Would not eliminate, reduce or control the source area.	Retain	Would need to add additional wells to determine the extent of the plume in order to rule out potential receptors. Long-term monitoring of groundwater and indoor air to track changes.
	Enhanced Extraction and treatment	Groundwater Extraction Wells	Extraction wells with ex-situ treatment	Pending location of extraction wells and/or the treatment facility, groundwater conveyance lines would may need to cross under the railroad tracks.	Pending remedial alternative for source area, this alternative may not be effective since the area could potentially continue to be contaminated (matrix diffusion in bedrock). Additionally, if mass removal is conducted in the source zone this area will be able to naturally attenuate over time.	Eliminated	Would need to operate for an extended period of time, not practical considering the lack of direct receptors.
	In-Situ Treatment	Biological Treatment or Chemical Oxidation	Enhanced Biodegradation or Chemical Oxidation	None	Pending remedial alternative for source area, this alternative may not be effective since the area could potentially continue to be contaminated (matrix diffusion in bedrock).Groundwater is not used for drinking water. Additionally, if mass removal is conducted in the source zone this area will be able to naturally attenuate over time.	Eliminated	Concentrations are fairly low and there are no direct receptors, the small benefit realized from this remedial alternative would not justify the cost of treating such a large area.

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Checked/Date: CRS 1/03/13

Table 8.1: Preliminary Screening of Remedial Alternatives

Remedial Alternative	Effectiveness	Implementability	Cost	Comments
Alternative 1: No Further Action	Not evaluated.	Not evaluated.	No cost.	Retained as a baseline for comparison.
Alternative 2: Institutional Controls, Long Term Monitoring and Additional Sub-Slab Depressurization Systems if Needed.	In the long term, this alternative would be effective at controlling risks posed by contamination on-site and in the downgradient plume. However, this alternative would not achieve mass removal in the source area and would not reduce the length of time needed for long-term monitoring and controls.	There are no technical or site related issues with the components of this alternative.	Costs associated with this alternative are low; however, the routine costs would extend over decades with no control or treatment of source area contamination. The primary cost items would be the routine sampling and reporting.	Retained.
Alternative 3: Institutional Controls, In-Situ Thermal Treatment, and Long Term Monitoring	This alternative would be effective in the short term at removing contaminant mass from the source area by volatilizing and extracting DNAPL and dissolved phase contamination. Thermal treatment technologies are likely to be the most effective means to achieve short-term removal of DNAPL. The institutional controls and long-term monitoring included in this alternative would control exposures posed by contamination.	In-situ thermal treatment can be implemented readily using available technologies. Technical issues and site-related issues with implementing this alternative include the relatively large surface area of the DNAPL source area and the active railroad tracks bisecting the DNAPL source area. The large area may prove cost-prohibitive, and the active railroad tracks may complicate or restrict system installation.	Costs associated with this alternative are high. The primary cost items include a pilot study, capital cost to install the system and the energy required to operate the system to achieve the required high temperatures in the bedrock.	Retained.
Alternative 4: Institutional Controls, In-Situ Chemical Reduction, and Long Term Monitoring	This alternative would effectively reduce groundwater contaminants in the short term and, depending on the reactive media chosen, would also readily degrade DNAPL in the source area. The degree of contaminant destruction would depend upon the media applied and the ability to contact the contaminants with the media. The proposed zero-valence would effectively degrade source area contamination on contact. The institutional controls and long-term monitoring included in this alternative would control exposures posed by contamination.	Injection of reactive media to target source area contamination can be implemented using readily available technologies. Depending on the media used, its dosage, and ability for media distribution within the bedrock fractures, this alternative can provide relatively quick results. Technical issues related to source area treatment include the difficulty of contacting contaminants diffused in the bedrock matrix, potentially mobilizing the DNAPL if injection is performed using pneumatic fracturing, and the large number of injection points required to target the entire source area.	Costs associated with this alternative are high but lower than in-situ thermal treatment. The primary cost items include purchasing and injecting the reactive media.	Retained.

Prepared/Date: BNP 1/21/2013
Checked/Date: JDW 1/28/2013

Table 9.1: Applicable Location- and Action-Specific Standards, Criteria, and Guidance

Requirement	**Consideration in the Remedial Response Process**
29 CFR Part 1910.120 - Hazardous Waste Operations and Emergency Response	Applicable to implementation of Health and Safety implementation, enforcement, and emergency response.
6 NYCRR Part 371 - Identification and Listing of Hazardous Wastes (November 1998)	Applicable to the characterization, handling, transportation, and treatment/disposal of investigative derived waste and other soils/liquids generated that require removal from the Site.
6 NYCRR Part 372 - Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities (November 1998)	Applicable to the handling, transportation, and treatment/disposal of investigative derived waste and other soils/liquids generated that require removal from the Site.
6 NYCRR Part 375 - Environmental Remediation Programs (as amended December 2006)	Applicable to the development and implementation of remedial programs.
6 NYCRR Part 376 - Land Disposal Restrictions	Applicable to disposal of hazardous wastes. Identifies those wastes that are restricted from land disposal.
6 NYCRR Part 750 through 758 - Implementation of NPDES Program in NYS ("SPDES Regulations")	Applicable to construction in and adjacent to water bodies and discharge of treated wastewater, not likely required at the Site.
DER-10 Technical Guidance for Site Investigation and Remediation	Applicable to the development and implementation of remedial programs.
Citizen Participation in New York's Hazardous Waste Site Remediation Program: A Guidebook (June 1998)	Applicable to the development and implementation of remedial programs.
Solidification/Stabilization and its Application to Waste Materials	Applicable to disposal of wastes generated during implementation of remedial program.

Prepared/Date: BPN 1/21/13
Checked by:JDW 1/28/13

Table 9.2: Cost Summary for Alternative 1 - No Further Action

ITEM	COST	
DIRECT CAPITAL COSTS		
Direct Cost Subtotal	$	-
INDIRECT CAPITAL COSTS		
Project Management (@ 10 Percent)	$	-
Remedial Design (none included)	$	-
Construction Management (none included)	$	-
Contingency (@ 15 Percent)	$	-
Indirect Cost Subtotal	$	-
TOTAL CAPITAL COSTS	**$**	**-**
ANNUAL OPERATION AND MAINTENANCE COSTS		
OM&M of the Existing Groundwater Extraction System (years 1-30)	$	-
Semiannual Monitoring and reporting (years 1-30)	$	-
PRESENT WORTH OF ANNUAL AND PERIODIC COSTS (30 yrs)	**$**	**-**
TOTAL PRESENT WORTH OF ALTERNATIVE 1 (30 yrs)	**$**	**-**
TOTAL NON-DISCOUNTED COST OF ALTERNATIVE 1 (30 yrs)	**$**	**-**

NOTES:
Costs have been rounded to the nearest thousand.

Prepared/Date: BPN 1/21/13
Checked by: JDW 1/28/13

Table 9.3: Cost Summary for Alternative 2 - Institutional Controls, Long Term Monitoring and Additional Sub-Slab Depressurization Systems if Needed

ITEM		COST
DIRECT CAPITAL COSTS		
Deed Restrictions, Institutional Controls, and Site Management Plan	$	35,000
Downgradient Monitoring Well Installation	$	19,000
Baseline Sampling	$	17,000
Basis of Design Report	$	76,000
Direct Cost Subtotal	$	147,000
INDIRECT CAPITAL COSTS		
Project Management (@ 8 Percent)	$	12,000
Remedial Design (@ 15 Percent)	$	23,000
Construction Management (@ 10 Percent)	$	15,000
Contingency (@ 25 Percent)	$	37,000
Indirect Cost Subtotal	$	87,000
TOTAL CAPITAL COSTS	**$**	**234,000**
ANNUAL OPERATION AND MAINTENANCE COSTS		
Semiannual Monitoring (Years 1&2)	$	80,000
Annual Monitoring (Years 3, 4 & 5)	$	20,000
5-Year Monitoring (Years 10, 15, 20, 25, 30)	$	15,000
PRESENT WORTH OF ANNUAL AND PERIODIC COSTS (30 yrs)	**$**	**233,000**
TOTAL PRESENT WORTH OF ALTERNATIVE 2 (30 yrs)	**$**	**467,000**
TOTAL NON-DISCOUNTED COST OF ALTERNATIVE 2 (30 yrs)	**$**	**529,000**

NOTES:
Costs have been rounded to the nearest thousand.

Prepared/Date: BPN 1/21/13
Checked By: JDW 1/28/13

Table 9.4: Cost Summary for Alternative 3 - Institutional Controls, In-Situ Thermal Treatment and Long Term Monitoring

ITEM	COST Range based on Two Vendor Quotes				
DIRECT CAPITAL COSTS					
Institutional Controls, Downgradient Monitoring Well Installation, Baseline Sampling and Design Basis Report	$	147,000	-	$	147,000
In-Situ Thermal Treatment System Pilot Test	$	243,000	-	$	-
In-Situ Thermal Treatment System Installation and Operation	$	6,492,000	-	$	16,554,000
Direct Cost Subtotal	$	6,882,000	-	$	16,701,000
INDIRECT CAPITAL COSTS					
Project Management (@ 5 Percent)	$	344,000	-	$	835,000
Remedial Design (@ 8 and 6 Percent)	$	551,000	-	$	1,002,000
Construction Management (@6 Percent)	$	413,000	-	$	1,002,000
Contingency (@ 25 Percent)	$	1,721,000	-	$	4,175,000
Indirect Cost Subtotal	$	3,029,000	-	$	7,014,000
TOTAL CAPITAL COSTS	**$**	**9,911,000**	**-**	**$**	**23,715,000**
ANNUAL OPERATION AND MAINTENANCE COSTS					
Semiannual Monitoring (Years 1&2)	$	80,000	-	$	80,000
Annual Monitoring (Years 3-10)	$	20,000	-	$	20,000
5-Year Monitoring (Years 15, 20, 25, 30)	$	15,000	-	$	15,000
PRESENT WORTH OF ANNUAL AND PERIODIC COSTS (30 yrs)	**$**	**299,000**	**-**	**$**	**299,000**
TOTAL PRESENT WORTH OF ALTERNATIVE 3 (30 yrs)	**$**	**10,210,000**	**-**	**$**	**24,014,000**
TOTAL NON-DISCOUNTED COST OF ALTERNATIVE 3 (30 yrs)	**$**	**10,291,000**	**-**	**$**	**24,095,000**

NOTES:
Costs have been rounded to the nearest thousand.

Prepared/Date: BPN 1/21/13
Checked By: JDW 1/28/13

Table 9.5: Cost Summary for Alternative 4 - Institutional Controls, In-Situ Chemical Reduction (Zero Valence-Iron Injections) and Long Term Monitoring

ITEM	COST
DIRECT CAPITAL COSTS	
- Institutional Controls, Downgradient Monitoring Well Installation, Baseline Sampling, and Design Basis Report	$ 147,000
- In-Situ ZVI Pilot	$ 100,000
- In-Situ ZVI Injection Program	$ 1,914,000
- Direct Cost Subtotal	$ 2,161,000
INDIRECT CAPITAL COSTS	
- Project Management (@ 5 Percent)	$ 108,000
- Remedial Design (@ 8 Percent)	$ 173,000
- Construction Management (@ 6 Percent)	$ 130,000
- Contingency (@ 25 Percent)	$ 540,000
- Indirect Cost Subtotal	$ 951,000
TOTAL CAPITAL COSTS	**$ 3,112,000**
ANNUAL OPERATION AND MAINTENANCE COSTS	
In-Situ ZVI Injection Program - Second Injection	$ 957,000.00
Semiannual Monitoring (Years 1&2)	$ 80,000
Annual Monitoring (Years 3-10)	$ 20,000
5-Year Monitoring (Years 15, 20, 25, 30)	$ 15,000
PRESENT WORTH OF ANNUAL AND PERIODIC COSTS (30 yrs)	**$ 1,049,000**
TOTAL PRESENT WORTH OF ALTERNATIVE 4 (30 yrs)	**$ 4,161,000**
TOTAL NON-DISCOUNTED COST OF ALTERNATIVE 4 (30 yrs)	**$ 4,449,000**

NOTES:
Costs have been rounded to the nearest thousand.

Prepared/Date: BPN 1/21/13
Checked By: JDW 1/28/13

Table 10.1: Summary of Remedial Alternative Costs

Item	Description	Alternative 1	Alternative 2	Alternative 3			Alternative 3B	Alternative 4
1	Capital Costs	$ -	$ 234,000	$ 9,911,000	-		$ 23,715,000	$ 3,112,000
2	Present Worth of Annual and Periodic Costs	$ -	$ 233,000	$ 299,000	-		$ 299,000	$ 1,049,000
3	**Total Present Worth (Item 1 plus 2)**	**$ -**	**$ 467,000**	**$ 10,210,000**	**-**		**$ 24,014,000**	**$ 4,161,000**
	Total Non-discounted Cost	$ -	$ 529,000	$ 10,291,000	-		$ 24,095,000	$ 4,449,000
8	Remedial Timeframe (yrs) (Note 3)	30	30	30				30

<u>Alternative Descriptions:</u>
1 = No Further Action
2 = Institutional Controls, Long Term Monitoring and Additional Sub-Slab Depressurization Systems if Needed.
3 = Institutional Controls, In-Situ Thermal Treatment and Long Term Monitoring
4 = Institutional Controls, In-Situ Chemical Reduction, and Long Term Monitoring

<u>Notes:</u>
1. Present Worth costs shown above are based upon the assumed Remedial Timeframe.
2. Annual and Periodic Costs (Item 2, 4 - 7) presented are non-discounted (future) costs.
3. Estimated costs presented in this table are intended to be within the target accuracy range of minus 30 to plus 50 percent of actual cost.

Table 10.2: Comparative Analysis of Remedial Alternatives

Remedial Alternative	Alternative 1: No Further Action	Alternative 2: Institutional Controls, Long Term Monitoring and Additional Sub-Slab Depressurization Systems if Needed	Alternative 3: Institutional Controls, In-Situ Thermal Treatment and Long Term Monitoring	Alternative 4: Institutional Controls, In-Situ Chemical Reduction and Long Term Monitoring
Compliance with New York State SCGs	Alternative 1 does not meet chemical-specific SCGs in the short term or long term because it does not remove or treat groundwater contamination in excess of 6 NYCRR Parts 700-706 Water Quality Standards (NYSDEC, 1998), and the source area is likely to contribute to downgradient groundwater contamination for many years to come.	Alternative 2 does not meet chemical-specific SCGs in the short term or long term because it does not remove or treat groundwater contamination in excess of 6 NYCRR Parts 700-706 Water Quality Standards (NYSDEC, 1998), and the source area is likely to contribute to downgradient groundwater contamination for many years to come.	Alternative 3 does not meet chemical-specific SCGs in the short term because it does not address all groundwater contamination in excess of 6 NYCRR Parts 700-706 Water Quality Standards (NYSDEC, 1998) and because it would be cost prohibitive to achieves SCGs in the short term given the large contaminant mass present in bedrock as DNAPL and as diffused contaminants in the bedrock matrix. However, in the long term this alternative is expected to achieve class GA groundwater standards through subsequent natural attenuation of the remaining source area contaminants.	Alternative 4 does not meet chemical-specific SCGs in the short term because it does not address all groundwater contamination in excess of 6 NYCRR Parts 700-706 Water Quality Standards (NYSDEC, 1998) and because it would be cost prohibitive to achieves SCGs in the short term given the large contaminant mass present in bedrock as DNAPL and as diffused contaminants in the bedrock matrix. However, in the long term this alternative is expected to achieve class GA groundwater standards through subsequent natural attenuation of the remaining source area contaminants.
Overall Protection of Human Health and the Environment	There is no current direct exposure pathway to the impacted areas, however this alternative does not protect future exposure.	Alternative 2 would protect public health and the environment through institutional controls that would prevent residential and commercial use of the site, and would protect on-site workers. Long Term Monitoring would be conducted to track any changes in the condition of the site, and would trigger the installation of additional sub-slab depressurization systems in downgradient homes if needed.	Alternative 3 would protect public health and the environment through institutional controls that would prevent residential and commercial use of the site, and would protect on-site workers. Long Term Monitoring would be conducted to track any changes in the condition of the site, and would trigger the installation of additional sub-slab depressurization systems in downgradient homes if needed.	Alternative 4 would protect public health and the environment through institutional controls that would prevent residential and commercial use of the site, and would protect on-site workers. Long Term Monitoring would be conducted to track any changes in the condition of the site, and would trigger the installation of additional sub-slab depressurization systems in downgradient homes if needed.
Short-term Impacts and Effectiveness	Alternative 1 does not include construction or other activities that would result in potential short-term adverse impacts and exposures to the community, workers, or the environment during implementation.	Alternative 2 includes activities that would result in potential short-term adverse impacts and exposures to workers during installation of the new monitoring wells. However, proper health and safety practices can control these exposures. It is estimated that this alternative could be fully implemented in approximately one year.	Alternative 3 includes activities that would result in potential short-term adverse impacts and exposures to workers during the installation of the In-Situ Thermal Treatment System. However, proper health and safety practices can control these risks. It is estimated that this alternative could be fully implemented in approximately one year.	Alternative 4 includes activities that would result in potential short-term adverse impacts and exposures to workers during the completion of the source area injections. However, proper health and safety practices can control these exposures. It is estimated that this alternative could be fully implemented in approximately one year.
Long-term Effectiveness and Permanence	Alternative 1 is not likely to meet RAOs in the future due to the continued DNAPL source area and the contaminant mass diffused in the rock matrix.	Alternative 2 is not likely to meet RAOs in the future due to the continued DNAPL source area and the contaminant mass diffused in the rock matrix.	Alternative 3 may meet RAOs in the future since it will eliminate the source of contamination and allow the remaining concentrations to naturally attenuate over time. Remaining contamination would have a low potential to result in human exposure and environmental impacts.	Alternative 4 may meet RAOs in the future since it will eliminate the DNAPL source area and allow the remaining concentrations to naturally attenuate over time. Remaining contamination would have a low potential to result in human exposure and environmental impacts.
Reduction of Toxicity, Mobility, and Volume	Alternative 1 would not result in any reduction of toxicity, mobility and volume of contaminants.	Alternative 2 would not reduce the toxicity, mobility or volume of contaminants.	Alternative 3 would reduce the mobility and volume of contaminants on-site through heating, vaporizing and treatment with granular activated carbon.	Alternative 4 would reduce the toxicity, mobility, and volume of contaminants on-site through source area treatment of contaminants using an in-situ reactive media.
Implementability	Alternative 1 does not include additional actions. Therefore, there are no technical difficulties associated with this alternative. However, regulatory approval of this alternative is anticipated to be difficult.	There are no technical difficulties associated with Alternative 2. However, regulatory approval of Alternative 2 is anticipated to be difficult given the lack of source area treatment. Unless other alternatives with source area treatment components are not cost effective, Alternative 2 would likely not receive regulatory approval.	The treatment system's technology would not be difficult to implement. However, the size of the system required to treat the areal extent of DNAPL and the active railroad tracks bisecting the DNAPL source area pose challenges to designing a system that is cost effective and does not disrupt railroad traffic.	The reactive media injection technology would not be difficult to implement for Alternative 4, although specific concerns at this Site include controlling the movement of the treatment chemistry through the bedrock and injecting large quantities of reactive media into the subsurface. Injections below the active railroad tracks may also pose a challlenge. The pilot test would help to more fully evaluate technical implementability of this alternative.
Land Use	Alternative 1 would be compatible with current and foreseeable future land use, however, there are no institutional controls in place to prevent changes in land use in the future.	Given the proposed institutional controls, monitoring, and anticipated continued future use of the site for industrial development, this alternative would be compatible with current and foreseeable future land use.	Alternative 3 would be compatible with current and foreseeable future land use provided that the proposed institutional controls are implemented.	Alternative 4 would be compatible with current and foreseeable future land use provided that the proposed institutional controls are implemented.

Prepared/Date: BPN 09/02/11
Checked/Date: JEB 09/09/11

APPENDIX A

DETAILED COST ANALYSIS BACKUP

Alternative 1 - No Further Action

Alternative 1 - Details	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Comments/ Assumptions
Subtask								
Assembly (1)								

CAPITAL COSTS

None

ALTERNATIVE ANNUAL AND PERIODIC COSTS

None

PRESENT VALUE OF ANNUAL AND PERIODIC COSTS FOR ALTERNATIVE 1 (No Further Action)

Year	Cost*	Number of Annual Periods	Annual Discount Rate	Number of 5-Year Periods	5-Year Discount Rate	Number of 10-Year Periods	10-Year Discount Rate	Total Non-Discounted Cost	Present Value Cost
Capital (Year 0)	$ -	1	0	NA	NA	NA	NA	$ -	$ -
Annual Groundwater Extraction System OM&M (1-30)	$ -	30	0.05	NA	NA	NA	NA	$ -	$ -
Semiannual Monitoring (Years 1-30)	$ -	30	0.05	NA	NA	NA	NA	$ -	$ -
Totals								**$ -**	**$ -**

*Annual and periodic costs include 10% for technical support and 25% contingency for unforeseen project complexities, including insurance, taxes, and licensing costs.
Capital costs include 25% contingency, as well as and project management, remedial design, and construction management costs per DER-10 guidance.

Discount rate of 5% (for 30-years) percent based on NYSDEC PRAP Outline / Instructions.

Alternative 2 – Institutional Controls, Long Term Monitoring and Additional Sub-Slab Depressurization Systems if Needed.

Alternative 2 - Details	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Comments/ Assumptions
ALTERNATIVE CAPITAL COSTS								
Insitutional Controls, and Site Management Plan								
Eng. Est.	Deed Restrictions & Institutional Controls	1	LS	$ -	$ 25,000.00	$ -	$ 25,000.00	
Eng. Est.	Develop Site Management Plan	1	LS	$ -	$ 10,000.00	$ -	$ 10,000.00	
	Task Subtotal						$ 35,000.00	
Downgradient Monitoring Well Installation (Assume 6 wells, 25 feet average depth)								
Drilling and Oversight Associated with Well Installation								
Eng. Est.	Project Coordination	8	HR	$ -	$ 88.00	$ -	$ 704.00	
Eng. Est.	Geologist	40	HR	$ -	$ 70.00	$ -	$ 2,800.00	
Eng. Est.	Service Vehicle	5	DAY	$ -	$ -	$ 150.00	$ 750.00	
Eng. Est.	Drilling Subcontractor	5	DAY	$ -	$ 600.00	$ 1,500.00	$ 10,500.00	
Eng. Est.	Well Installation (25 feet, average depth)	6	Each	$ 500.00			$ 3,000.00	
Transportation and Disposal of Excavated Soil and Cuttings								
Eng. Est.	Cuttings T&D	8	Drums	$ 150.00	$ -	$ -	$ 1,200.00	
	Task Subtotal						$ 18,954.00	
Baseline Sampling								
Baseline Sampling Event								
Eng. Est.	Mobilization/Demobilization	1	LS	$ -	$ 1,000.00	$ -	$ 1,000.00	
Eng. Est.	Project Coordination / Report	24	HR	$ -	$ 88.00	$ -	$ 2,112.00	
Eng. Est.	Remediation Technician	72	HR	$ -	$ 60.00	$ -	$ 4,320.00	
Eng. Est.	Service Vehicle x2	9	DAY	$ -	$ -	$ 150.00	$ 1,350.00	
Eng. Est.	Equipment	9	DAY	$ -	$ -	$ 150.00	$ 1,350.00	
Eng. Est.	Groundwater VOC Analyses	27	samples	$ -	$ -	$ 150.00	$ 4,050.00	
Eng. Est.	Indoor Air Analyses	15	samples	$ -	$ -	$ 200.00	$ 3,000.00	
Eng. Est.	Surface Water Analyses	2	samples	$ -	$ -	$ 150.00	$ 300.00	
	Task Subtotal						$ 17,482.00	
Source Area Characterization for Design								
Drilling and Oversight Associated with Investigation								
Eng. Est.	Investigation Work Plan	1	LS	$ -	$ -	$ 10,000.00	$ 10,000.00	
Eng. Est.	Project Coordination	12	HR	$ -	$ 88.00	$ -	$ 1,056.00	
Eng. Est.	Geologist	56	HR	$ -	$ 70.00	$ -	$ 3,920.00	
Eng. Est.	Instrumentation/Field Sampling Equipment	8	DAY	$ -	$ -	$ 150.00	$ 1,200.00	
Eng. Est.	Service Vehicle	8	DAY	$ -	$ -	$ 150.00	$ 1,200.00	
Eng. Est.	Drilling Subcontractor	8	Day	$ -	$ 600.00	$ 1,500.00	$ 16,800.00	
Investigation Sampling Program								
Eng. Est.	Groundwater VOC Analyses	24	samples	$ -	$ -	$ 150.00	$ 3,600.00	2 samples per location, 12
Eng. Est.	Soil/Rock VOC Analyses	24	samples	$ -	$ -	$ 200.00	$ 4,800.00	2 samples per location, 12
Transportation and Disposal of Excavated Soil and Cuttings								
Eng. Est.	Cuttings T&D	20	Drums	$ 150.00	$ -	$ -	$ 3,000.00	

Alternative 2 – Institutional Controls, Long Term Monitoring and Additional Sub-Slab Depressurization Systems if Needed.

Alternative 2 - Details	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Comments/ Assumptions
Modeling / Mass Flux Calcs / Design Basis Report								
Eng. Est.	Reporting	1	LS		$ 30,000.00		$ 30,000.00	
	Task Subtotal						$ 75,576.00	
ALTERNATIVE ANNUAL AND PERIODIC COSTS								
Long-Term Monitoring (Years 1 & 2) - Semiannual Sampling (27 locations) and Reporting								
Eng. Est.	Mobilization/Demobilization	2	LS	$ -	$ 1,000.00	$ -	$ 2,000.00	
Eng. Est.	Project Coordination / Report	60	HR	$ -	$ 88.00	$ -	$ 5,280.00	
Eng. Est.	Remediation Technician	144	HR	$ -	$ 60.00	$ -	$ 8,640.00	
Eng. Est.	Service Vehicle x2	18	DAY	$ -	$ -	$ 150.00	$ 2,700.00	
Eng. Est.	Sampling Equipment	18	DAY	$ -	$ -	$ 150.00	$ 2,700.00	
Eng. Est.	Groundwater VOC Analyses	54	samples	$ -	$ -	$ 800.00	$ 43,200.00	
Eng. Est.	Indoor Air Analyses	15	samples	$ -	$ -	$ 1,000.00	$ 15,000.00	Indoor air sampling is annual (i.e., 15 instead of 30).
Eng. Est.	Surface Water Analyses	4	samples	$ -	$ -	$ 225.00	$ 900.00	
	Task Subtotal						$ 80,420.00	Annual costs for semiannual monitoring and reporting.
Long-Term Monitoring (Years 3-5) - Annual Sampling (15 locations) and Reporting								
Eng. Est.	Mobilization/Demobilization	1	LS	$ -	$ 1,000.00	$ -	$ 1,000.00	
Eng. Est.	Project Coordination / Report	30	HR	$ -	$ 88.00	$ -	$ 2,640.00	
Eng. Est.	Remediation Technician	40	HR	$ -	$ 60.00	$ -	$ 2,400.00	
Eng. Est.	Service Vehicle x2	5	DAY	$ -	$ -	$ 150.00	$ 750.00	
Eng. Est.	Sampling Equipment	5	DAY	$ -	$ -	$ 150.00	$ 750.00	
Eng. Est.	Groundwater VOC Analyses	15	samples	$ -	$ -	$ 800.00	$ 12,000.00	
Eng. Est.	Indoor Air Analyses	0	samples	$ -	$ -	$ 1,000.00	$ -	
Eng. Est.	Surface Water Analyses	4	samples	$ -	$ -	$ 225.00	$ 900.00	
	Task Subtotal						$ 20,440.00	Annual costs for annual monitoring and reporting.
Long-Term Monitoring (Years 6-30) - Sample every 5 years (10 locations)								
Eng. Est.	Mobilization/Demobilization	1	LS	$ -	$ 1,000.00	$ -	$ 1,000.00	
Eng. Est.	Project Coordination / Report	30	HR	$ -	$ 88.00	$ -	$ 2,640.00	
Eng. Est.	Remediation Technician	28	HR	$ -	$ 60.00	$ -	$ 1,680.00	
Eng. Est.	Service Vehicle x2	4	DAY	$ -	$ -	$ 150.00	$ 600.00	
Eng. Est.	Sampling Equipment	4	DAY	$ -	$ -	$ 150.00	$ 600.00	
Eng. Est.	Groundwater VOC Analyses	10	samples	$ -	$ -	$ 800.00	$ 8,000.00	
Eng. Est.	Indoor Air Analyses	0	samples	$ -	$ -	$ 1,000.00	$ -	
Eng. Est.	Surface Water Analyses	4	samples	$ -	$ -	$ 225.00	$ 900.00	
	Task Subtotal						$ 15,420.00	Annual costs for semiannual monitoring and reporting.

Notes:
1) Assembly numbers presented indicate RACER/RS MEANS assembly code

PRESENT VALUE OF ANNUAL AND PERIODIC COSTS FOR ALTERNATIVE 2 - (Institutional Controls, Long Term Monitoring and Additional Sub-Slab Depressurization Systems if Needed.)

Year	Cost*	Number of Annual Periods	Annual Discount Rate	Number of 10-Year Periods	10-Year Discount Rate	Number of 15-Year Periods	15-Year Discount Rate	Number of 25-Year Periods	25-Year Discount Rate	Total Non-Discounted Cost	Present Value Cost
Capital (Year 0)	$ 234,000	1	0	NA	NA	NA	NA	NA	NA	$ 234,000.00	$ 234,000.00
Long-Term Monitoring (Years 1-2)	$ 80,000	2	0.05	NA	NA	NA	NA	NA	NA	$ 160,000.00	$ 148,752.83
Long-Term Monitoring (Years 3-5)	$ 20,000	3	0.05	NA	NA	NA	NA	NA	NA	$ 60,000.00	$ 54,464.96
Long-Term Monitoring (Years 6-30)	$ 15,000	0	0.05	3	0.6288946	1	1.0789282	1	2.3863549	$ 75,000.00	$ 29,977.50
Totals										**$ 529,000.00**	**$ 467,195.30**

Capital costs include 25% contingency, as well as project management, remedial design, and construction management costs per DER-10 guidance.
Discount rate of 5% (for 30-years) percent based on NYSDEC PRAP Outline / Instructions.

Alternative 3 - Institutional Controls, In-Situ Thermal Treatment and Long Term Monitoring

Alternative 3 - Details	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Comments/ Assumptions
Subtask								
Assembly (1)								
CAPITAL COSTS								
Institutional Controls, Downgradient Monitoring Well Installation, Baseline Sampling, and Source Area Characterization								See Alternative 2.
	Task Subtotal						$ 147,012.00	
In-Situ Thermal Treatment Pilot Test								
	Engineering Oversight	130	DAY	$ -	$ 1,000.00	$ -	$ 130,000.00	
	Temporary Facilities and Controls	5	MONTH	$ -	$ -	$ 1,000.00	$ 5,000.00	
	Thermal Vendor Services	1	LS	$ -	$ -	$ 107,687.00	$ 107,687.00	
	Task Subtotal						$ 242,687.00	
In-Situ Thermal Treatment System Installation and Operation								
Based upon estimate provided by TPS Tech.								
	Engineering Oversight	200	DAY	$ -	$ 1,000.00	$ -	$ 200,000.00	
	Temporary Facilities and Controls	6	MONTH	$ -	$ -	$ 1,000.00	$ 6,000.00	
	Thermal Vendor Services	1	LS	$ -	$ -	$ 2,634,979.00	$ 2,634,979.00	
	Subcontracted services	1	LS	$ -	$ -	$ 3,651,130.00	$ 3,651,130.00	Quote adjusted to reflect Engineer's assumptions on drilling, T&D, and energy quantities.
	Task Subtotal						$ 6,492,109.00	Includes mobilization/demobilization, design, work plans, permits, drilling, soil disposal, utilities, vapor recovery and treatment, operations, and confirmatory sampling. See vendor backup for further detail.
ALTERNATIVE ANNUAL AND PERIODIC COSTS								
Long-Term Monitoring (Years 1 & 2) - Semiannual Sampling (27 locations) and Reporting								
Eng. Est.	Mobilization/Demobilization	2	LS	$ -	$ 1,000.00	$ -	$ 2,000.00	
Eng. Est.	Project Coordination / Report	60	HR	$ -	$ 88.00	$ -	$ 5,280.00	
Eng. Est.	Remediation Technician	144	HR	$ -	$ 60.00	$ -	$ 8,640.00	
Eng. Est.	Service Vehicle x2	18	DAY	$ -	$ -	$ 150.00	$ 2,700.00	
Eng. Est.	Sampling Equipment	18	DAY	$ -	$ -	$ 150.00	$ 2,700.00	
Eng. Est.	Groundwater VOC Analyses	54	samples	$ -	$ -	$ 800.00	$ 43,200.00	
Eng. Est.	Indoor Air Analyses	15	samples	$ -	$ -	$ 1,000.00	$ 15,000.00	
Eng. Est.	Surface Water Analyses	4	samples	$ -	$ -	$ 225.00	$ 900.00	
	Task Subtotal						$ 80,420.00	Annual costs for semiannual monitoring and reporting.

Long-Term Monitoring (Years 3-10) - Annual Sampling (15 locations) and Reporting

Eng. Est.	Mobilization/Demobilization	1	LS	$	-	$	1,000.00	$	-	$	1,000.00
Eng. Est.	Project Coordination / Report	30	HR	$	-	$	88.00	$	-	$	2,640.00
Eng. Est.	Remediation Technician	40	HR	$	-	$	60.00	$	-	$	2,400.00
Eng. Est.	Service Vehicle x2	5	DAY	$	-	$	-	$	150.00	$	750.00
Eng. Est.	Sampling Equipment	5	DAY	$	-	$	-	$	150.00	$	750.00
Eng. Est.	Groundwater VOC Analyses	15	samples	$	-	$	-	$	800.00	$	12,000.00
Eng. Est.	Indoor Air Analyses	0	samples	$	-	$	-	$	1,000.00	$	-
Eng. Est.	Surface Water Analyses	4	samples	$	-	$	-	$	225.00	$	900.00
	Task Subtotal									$	20,440.00 Annual costs for annual monitoring and reporting.

Long-Term Monitoring (Years 11-30) - Sample every 5 years (10 locations)

Eng. Est.	Mobilization/Demobilization	1	LS	$	-	$	1,000.00	$	-	$	1,000.00
Eng. Est.	Project Coordination / Report	30	HR	$	-	$	88.00	$	-	$	2,640.00
Eng. Est.	Remediation Technician	28	HR	$	-	$	60.00	$	-	$	1,680.00
Eng. Est.	Service Vehicle x2	4	DAY	$	-	$	-	$	150.00	$	600.00
Eng. Est.	Sampling Equipment	4	DAY	$	-	$	-	$	150.00	$	600.00
Eng. Est.	Groundwater VOC Analyses	10	samples	$	-	$	-	$	800.00	$	8,000.00
Eng. Est.	Indoor Air Analyses	0	samples	$	-	$	-	$	1,000.00	$	-
Eng. Est.	Surface Water Analyses	4	samples	$	-	$	-	$	225.00	$	900.00
	Task Subtotal									$	15,420.00 Annual costs for semiannual monitoring and reporting.

Notes:
1) Assembly numbers presented indicate RACER/RS MEANS assembly code

PRESENT VALUE OF ANNUAL AND PERIODIC COSTS FOR ALTERNATIVE 3 (Institutional Controls, In-Situ Thermal Treatment and Long Term Monitoring)

Year	Cost*	Number of Annual Periods	Annual Discount Rate	Number of 15-Year Periods	15-Year Discount Rate	Number of 20-Year Periods	20-Year Discount Rate	Number of 25-Year Periods	25-Year Discount Rate	Total Non-Discounted Cost	Present Value Cost
Capital (Year 0)	$ 9,911,000	1	0	NA	NA	NA	NA	NA	NA	$ 9,911,000.00	$ 9,911,000.00
Long-Term Monitoring (Years 1-2)	$ 80,000	2	0.05	NA	NA	NA	NA	NA	NA	$ 160,000.00	$ 148,752.83
Long-Term Monitoring (Years 3-10)	$ 20,000	8	0.05	NA	NA	NA	NA	NA	NA	$ 160,000.00	$ 129,264.26
Long-Term Monitoring (Years 11-30)	$ 15,000	0	0.05	2	1.07892818	1	1.65329771	1	2.38635494	$ 60,000.00	$ 20,768.80
Totals										**$ 10,291,000.00**	**$ 10,209,785.89**

Capital costs include 25% contingency, as well as and project management, remedial design, and construction management costs per DER-10 guidance.
Discount rate of 5% (for 30-years) percent based on NYSDEC PRAP Outline / Instructions.

ITEM		COST
DIRECT CAPITAL COSTS		
Institutional Controls, Downgradient Monitoring Well Installation, Baseline Sampling, and Source Area Characterization & Design Basis Report	$	147,000
In-Situ Thermal Treatment System Installation and Operation	$	16,554,000
Direct Cost Subtotal	$	16,701,000
INDIRECT CAPITAL COSTS		
Project Management (@ 5 Percent)	$	835,000
Remedial Design (@ 6 Percent)	$	1,002,000
Construction Management (@6 Percent)	$	1,002,000
Contingency (@ 25 Percent)	$	4,175,000
Indirect Cost Subtotal	$	7,014,000
TOTAL CAPITAL COSTS	**$**	**23,715,000**
ANNUAL OPERATION AND MAINTENANCE COSTS		
Semiannual Monitoring (Years 1&2)	$	80,000
Annual Monitoring (Years 3-10)	$	20,000
5-Year Monitoring (Years 15, 20, 25, 30)	$	15,000
PRESENT WORTH OF ANNUAL AND PERIODIC COSTS (30 yrs)	**$**	**299,000**
TOTAL PRESENT WORTH OF ALTERNATIVE 4 (30 yrs)	**$**	**24,014,000**
TOTAL NON-DISCOUNTED COST OF ALTERNATIVE 4 (30 yrs)	**$**	**24,095,000**

NOTES:
Costs have been rounded to the nearest thousand.

Prepared/Date: BPN 1/21/13
Checked By: JDW 1/28/13

Alternative 3B - Institutional Controls, In-Situ Thermal Treatment and Long Term Monitoring

Alternative 3B - Details	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Comments/ Assumptions
Subtask								
Assembly (1)								
CAPITAL COSTS								
Institutional Controls, Downgradient Monitoring Well Installation, Baseline Sampling, and Source Area Characterization								See Alternative 2.
	Task Subtotal						$ 147,012.00	
In-Situ Thermal Treatment System Installation and Operation								
Based upon estimate provided by Terratherm								
	Engineering Oversight	200	DAY	$ -	$ 1,000.00	$ -	$ 200,000.00	
	Temporary Facilities and Controls	6	MONTH	$ -	$ -	$ 1,000.00	$ 6,000.00	
	Thermal Vendor Services	1	LS	$ -	$ -	$ 16,273,000.00	$ 16,273,000.00	
	Subcontracted services	1	LS	$ -	$ -	$ 75,000.00	$ 75,000.00	Quote did not include items such as power drop & site restoration.
	Task Subtotal						$ 16,554,000.00	Includes mobilization/demobilization, design, work plans, permits, drilling, soil disposal, utilities, vapor recovery and treatment, operations, and confirmatory sampling. See vendor backup for further detail.
ALTERNATIVE ANNUAL AND PERIODIC COSTS								
Long-Term Monitoring (Years 1 & 2) - Semiannual Sampling (27 locations) and Reporting								
Eng. Est.	Mobilization/Demobilization	2	LS	$ -	$ 1,000.00	$ -	$ 2,000.00	
Eng. Est.	Project Coordination / Report	60	HR	$ -	$ 88.00	$ -	$ 5,280.00	
Eng. Est.	Remediation Technician	144	HR	$ -	$ 60.00	$ -	$ 8,640.00	
Eng. Est.	Service Vehicle x2	18	DAY	$ -	$ -	$ 150.00	$ 2,700.00	
Eng. Est.	Sampling Equipment	18	DAY	$ -	$ -	$ 150.00	$ 2,700.00	
Eng. Est.	Groundwater VOC Analyses	54	samples	$ -	$ -	$ 800.00	$ 43,200.00	
Eng. Est.	Indoor Air Analyses	15	samples	$ -	$ -	$ 1,000.00	$ 15,000.00	
Eng. Est.	Surface Water Analyses	4	samples	$ -	$ -	$ 225.00	$ 900.00	
	Task Subtotal						$ 80,420.00	Annual costs for semiannual monitoring and reporting.
Long-Term Monitoring (Years 3-10) - Annual Sampling (15 locations) and Reporting								
Eng. Est.	Mobilization/Demobilization	1	LS	$ -	$ 1,000.00	$ -	$ 1,000.00	
Eng. Est.	Project Coordination / Report	30	HR	$ -	$ 88.00	$ -	$ 2,640.00	
Eng. Est.	Remediation Technician	40	HR	$ -	$ 60.00	$ -	$ 2,400.00	
Eng. Est.	Service Vehicle x2	5	DAY	$ -	$ -	$ 150.00	$ 750.00	
Eng. Est.	Sampling Equipment	5	DAY	$ -	$ -	$ 150.00	$ 750.00	
Eng. Est.	Groundwater VOC Analyses	15	samples	$ -	$ -	$ 800.00	$ 12,000.00	
Eng. Est.	Indoor Air Analyses	0	samples	$ -	$ -	$ 1,000.00	$ -	
Eng. Est.	Surface Water Analyses	4	samples	$ -	$ -	$ 225.00	$ 900.00	
	Task Subtotal						$ 20,440.00	Annual costs for annual monitoring and reporting.

Long-Term Monitoring (Years 11-30) - Sample every 5 years (10 locations)

Eng. Est.	Mobilization/Demobilization	1	LS	$ -	$ 1,000.00	$ -	$ 1,000.00	
Eng. Est.	Project Coordination / Report	30	HR	$ -	$ 88.00	$ -	$ 2,640.00	
Eng. Est.	Remediation Technician	28	HR	$ -	$ 60.00	$ -	$ 1,680.00	
Eng. Est.	Service Vehicle x2	4	DAY	$ -	$ -	$ 150.00	$ 600.00	
Eng. Est.	Sampling Equipment	4	DAY	$ -	$ -	$ 150.00	$ 600.00	
Eng. Est.	Groundwater VOC Analyses	10	samples	$ -	$ -	$ 800.00	$ 8,000.00	
Eng. Est.	Indoor Air Analyses	0	samples	$ -	$ -	$ 1,000.00	$ -	
Eng. Est.	Surface Water Analyses	4	samples	$ -	$ -	$ 225.00	$ 900.00	
	Task Subtotal						$ 15,420.00	Annual costs for semiannual monitoring and reporting.

Notes:
1) Assembly numbers presented indicate RACER/RS MEANS assembly code

PRESENT VALUE OF ANNUAL AND PERIODIC COSTS FOR ALTERNATIVE 3B (Institutional Controls, In-Situ Thermal Treatment and Long Term Monitoring)

Year	Cost*	Number of Annual Periods	Annual Discount Rate	Number of 15-Year Periods	15-Year Discount Rate	Number of 20-Year Periods	20-Year Discount Rate	Number of 25-Year Periods	25-Year Discount Rate	Total Non-Discounted Cost	Present Value Cost
Capital (Year 0)	$ 23,715,000	1	0	NA	NA	NA	NA	NA	NA	$ 23,715,000.00	$ 23,715,000.00
Long-Term Monitoring (Years 1-2)	$ 80,000	2	0.05	NA	NA	NA	NA	NA	NA	$ 160,000.00	$ 148,752.83
Long-Term Monitoring (Years 3-10)	$ 20,000	8	0.05	NA	NA	NA	NA	NA	NA	$ 160,000.00	$ 129,264.26
Long-Term Monitoring (Years 11-30)	$ 15,000	0	0.05	2	1.078928179	1	1.653297705	1	2.386354941	$ 60,000.00	$ 20,768.80
Totals										**$ 24,095,000.00**	**$ 24,013,785.89**

Capital costs include 25% contingency, as well as and project management, remedial design, and construction management costs per DER-10 guidance.
Discount rate of 5% (for 30-years) percent based on NYSDEC PRAP Outline / Instructions.

Alternative 4 - Institutional Controls, In-Situ Chemical Reduction and Long Term Monitoring

Alternative 4 - Details	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Extended Cost	Comments/ Assumptions
Subtask								
Assembly (1)								
ALTERNATIVE CAPITAL COSTS								
Institutional Controls, Downgradient Monitoring Well Installation, Baseline Sampling, and Source Area Characterization								See Alternative 2.
	Task Subtotal						$ 147,012.00	
In-Situ ZVI Pilot Test								
	Engineering Oversight	10	DAY	$ -	$ 1,000.00	$ -	$ 10,000.00	
	Vendor Services	1	LS	$ -	$ -	$ 75,000.00	$ 75,000.00	
	Post Pilot Monitoring	1	LS	$ -	$ -	$ 15,000.00	$ 15,000.00	
	Task Subtotal						$ 100,000.00	
In-Situ ZVI Injection Program								
Based upon estimate provided by ARS Technologies, Inc.								
	Engineering Oversight	113	DAY	$ -	$ 1,000.00	$ -	$ 113,000.00	
	Engineering Design and Submittal Review	1	LS	$ -	$ 10,000.00	$ -	$ 10,000.00	
	Temporary Facilities and Controls	4	MONTH	$ -	$ 1,000.00	$ -	$ 4,000.00	
	Vendor Design and Project Management	1	LS	$ -	$ -	$ 4,700.00	$ 4,700.00	
	Vendor Submittals	1	LS	$ -	$ -	$ 4,900.00	$ 4,900.00	
	Mobilization and Demobilization	1	LS	$ -	$ -	$ 7,500.00	$ 7,500.00	
	Materials (ZVI)	1	LS	$ -	$ -	$ 640,200.00	$ 640,200.00	750,000 lbs of material (245,000 gallons of water)
	Field Implementation (4 person crew)	1	LS	$ -	$ -	$ 1,130,000.00	$ 1,130,000.00	
	Task Subtotal						$ 1,914,300.00	See vendor backup for further detail.
ALTERNATIVE ANNUAL AND PERIODIC COSTS (ASSUME SAME AS ALTERNATIVE 3)								
Second Injection Event								
	Task Subtotal						$ 957,150.00	Assumed 50% of scope of original injections.
Long-Term Monitoring (Years 1 & 2) - Semiannual Sampling (27 locations) and Reporting								
	Task Subtotal						$ 80,420.00	Annual costs for semiannual monitoring and reporting.
Long-Term Monitoring (Years 3-10) - Annual Sampling (15 locations) and Reporting								
	Task Subtotal						$ 20,440.00	Annual costs for annual monitoring and reporting.
Long-Term Monitoring (Years 11-30) - Sample every 5 years (10 locations)								
	Task Subtotal						$ 15,420.00	Annual costs for semiannual monitoring and reporting.

Notes:
1) Assembly numbers presented indicate RACER/RS MEANS assembly code

PRESENT VALUE OF ANNUAL AND PERIODIC COSTS FOR ALTERNATIVE 4 (Institutional Controls, In-Situ Chemical Reduction and Long Term Monitoring)

Year	Cost*	Number of Annual Periods	Annual Discount Rate	Number of 5-Year Periods	5-Year Discount Rate	Number of 15-Year Periods	15-Year Discount Rate	Number of 20-Year Periods	20-Year Discount Rate	Number of 25-Year Periods	25-Year Discount Rate	Total Non-Discounted Cost	Present Value Cost
Capital (Year 0)	$ 3,112,000	1	0	NA	NA	NA	NA	NA	NA	NA	NA	$ 3,112,000.00	$ 3,112,000.00
Second Injection Event (Year 5)	$ 957,000	1	0.05	1	0.28	NA	NA	NA	NA	NA	NA	$ 957,000.00	$ 749,834.54
Long-Term Monitoring (Years 1-2)	$ 80,000	2	0.05	NA	NA	NA	NA	NA	NA	NA	NA	$ 160,000.00	$ 148,752.83
Long-Term Monitoring (Years 3-10)	$ 20,000	8	0.05	NA	NA	NA	NA	NA	NA	NA	NA	$ 160,000.00	$ 129,264.26
Long-Term Monitoring (Years 11-30)	$ 15,000	0	0.05	NA	NA	2	1.08	1	1.65	1	2.39	$ 60,000.00	$ 20,768.80
Totals												**$ 4,449,000.00**	**$ 4,160,620.43**

*Annual and periodic costs include 10% for technical support and 25% contingency for unforeseen project complexities, including insurance, taxes, and licensing costs.
Capital costs include 25% contingency, as well as and project management, remedial design, and construction management costs per DER-10 guidance.

Discount rate of 5% (for 30-years) percent based on NYSDEC PRAP Outline / Instructions.

APPENDIX B

COST ESTIMATES, PROPOSALS AND CORRESPONDENCES RELATED TO IN-SITU THERMA HEATING

PRELIMINARY DESIGN AND ESTIMATE

IN-SITU THERMAL REMEDIATION
PILOT STUDY

FORMER SCOBELL CHEMICAL SITE
BRIGHTON, NEW YORK

PREPARED FOR:

AMEC ENVIRONMENT & INFRASTRUCTURE, INC.

Contents

1. Introduction

This Estimate and Preliminary Design is for the pilot test of In Situ Thermal Remediation (ISTR) to thermally remediate affected soils at the former Scobell Chemical Site (Scobell) located in the Brighton, New York. This document is non-binding in nature and is for confidential discussion purposes only. The primary objective of this Estimate and Preliminary Design of pilot test is to present the basis of implementation of ISTR and to:

- Define the assumed treatment goal
- Identify the target treatment zone(s) (TTZ)
- Describe the preliminary ISTR layout
- Provide a +/- 25% estimate of project costs, including all "turnkey" line items

2. Site Information

The former Scobell Chemical Site (the "Site") is located in the Brighton, New York. The following provides a summary of TPS TECH's understanding of the Site, based on information provided by AMEC (the "Client"). To date, TPS TECH has not "walked the Site" to understand the physical layout and possible placement of ISTR equipment.

2.1. Contaminants of Concern

The contaminants were released from activities at chemical repackaging company during 1920s to 1986. The contaminants of concerns(COCs) are consisted of 330-6,000 kg free phase TCE DNAPL; 66-890 kg of TCE DNAPL diffused into bedrock matrix; and 16-160 kg of dissolved phase contamination within DNAPL source area. Total TCE mass within DNAPL footprint in bedrock is 412-7050 kg. For costing purposes, assume high end estimates, which is 7050kg TCE.
Other contaminants include tetrachloroethene (PCE), 1,1-dicloroethene (DCE), cis-1,2-DCE, vinyl chloride, 1,1,1-trichloroethane, benzene, toluene, and xylene.

2.2. Geology & Hydrogeology

The overburden thickness ranges from 10-20 feet above bedrock with fine grained sand and silt transitioning to coarser grained sand and gravel near bedrock. The bedrock is Lockport Dolomite and varies in thickness 5-10 feet above the DNAPL source. Perched groundwater may exist from 2-9 ft bgs in the overburden. Groundwater in the bedrock is 10-20 ft bgs depending on the location in the source area. The porosity of the fractured bedrock transmissive zone is estimated at 0.7 to 3.7% and outside the fractured zone, the porosity was estimated 0.2 to 0.5%.

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The remedial goal of this project is to test the effect of thermal treatment via thermal remediation; final remedial goals and measurement methods will be determined with the Client in further correspondence.

Average treatment temperatures throughout the TTZ will reach at or near boiling point of water, and superheated temperatures exceeding 100°C are expected to encompass portions of the volume of the lower permeability soils closest to the thermal conductive heating wells.

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4.1. Technology Overview

Figure 1. shows a field application of the ISTR process.

The proposed treatment technology at the Site utilizes ISTR. ISTR is a thermal remediation technique by which thermal conduction heating (TCH) is used to heat the predetermined TTZ while vacuum is applied to the subsurface to extract soil vapors, providing pneumatic control. The heating of the soil is driven by temperature gradients that are created by the several TCH wells. Throughout the heating process the individual heaters and proximate temperature/pressure recording points are monitored via a wireless data system. A real time ftp website will be used for accessing data remotely. Subzones within the TTZ are individually controlled, so that temperature gradients and energy consumptions may be optimized.

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- vacuum extraction trenches or vertical wells
- natural gas connection or mobile propane tank
- mobile control center and PLC data collection system
- thermocouples and their respective borings
- vacuum induction blower (heater/vacuum wells)
- wireless monitoring, control and communications system
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- water/NAPL separator plus water treatment and discharge (LGAC)

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Semi-Volatile Organic Compounds (SVOCs).[1] During the application of ISTR, soils are remediated as follows:

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Figure 2 shows a close up view of an ISTR remediation. In the depicted embodiment, each heater provides heat energy for two heating wells (i.e. the first heating well on which the heater is placed, plus one additional adjacent heating well). An insulating cover is placed over the treatment area to provide:

- Thermal insulation and reduce heat loss;
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[1] Stegemeier, G.L., and Vinegar, H.J. 2001. "Thermal Conductive Heating for In-Situ Thermal Desorption of Soils." Ch. 4.6, pp. 1-37. Chang H., Hazardous and Radioactive Waste Treatment Technologies Handbook.

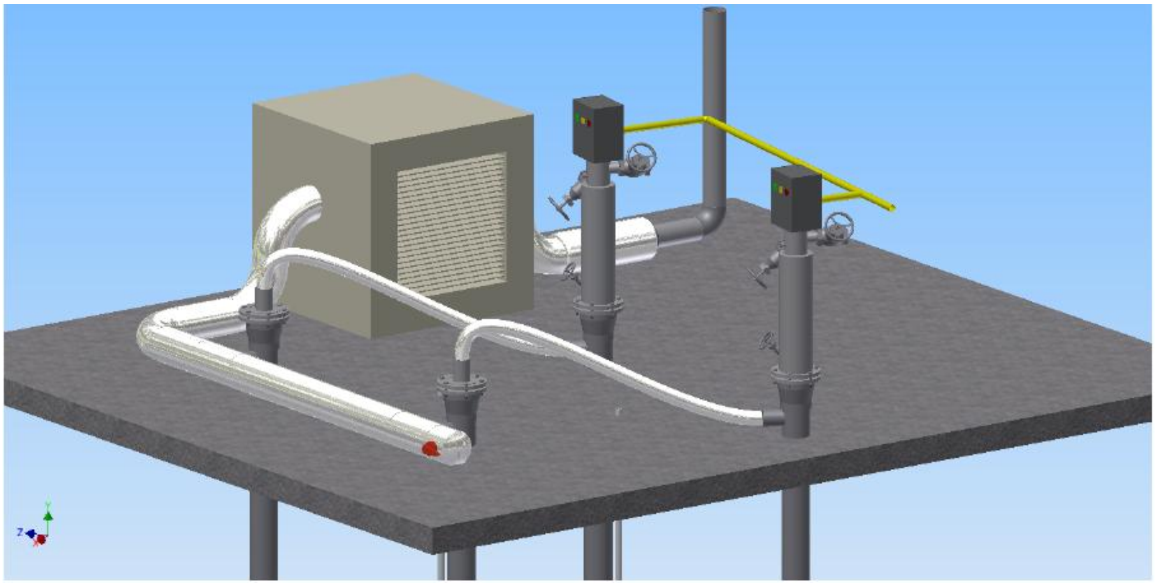

Figure 2. ISTR configuration where each heater is being used to heat two heating wells.

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- The vapor pressure of the NAPL increases markedly with temperature. As the subsurface is heated from ambient temperature to temperatures in the range of 100°C, the vapor pressure of the NAPL constituents will typically increase 10 to 30 fold.[2]
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[2] Udell, K S 1996. Heat and mass transfer in clean-up of underground toxic wastes. In Annual Reviews of Heat Transfer, Vol. 7, Chang-Lin Tien, Ed.; Begell House, Inc.: New York, Wallingford, UK: 333-405.

[3] Hayes, T. 2002. Development of In Situ Thermochemical Solidification for the Risk Based Treatment of Coal-Derived Dense Nonaqueous Phase Liquids. GRI-04/0215. Gas Technology Institute, Des Plaines, IL.

5. Health and Safety

Prior to mobilizing to the Site, TPS TECH will develop a detailed Site-Specific Health and Safety Plan (HASP) to address potential health and safety hazards and control measures throughout the various work tasks. Safety controls and precautions can be separated into three categories: (1) the gas distribution system, (2) the individual heater controls, and (3) the emissions controls.

All GTR components bear one or both of UL or CSA America certification standards.

5.1. Gas Distribution System

The gas distribution system (GDS) is defined as the fuel source, piping, valves, and pressure regulators that are involved in supplying fuel (either natural gas or propane) to the control systems of the individual heaters. Upon completion of the well field design, the placement and number of heater wells are known and the GDS can be sized accordingly (Figure 3.a.). The GDS piping can be installed in the subsurface, via trenching or conduiting methods. Prior to selection of the specific components, all local codes and regulations are reviewed and prior to startup, the system is inspected by a certified professional.

Figure 3.a). Gas distribution system being assembled to feed heaters. **b).** Dual redundant pressure regulators placed in series.

<u>Safety Features of the GDS</u>

The pressure regulators are the most critical components of the GDS and as such, specific precautions are taken to ensure their functionality. Dual redundant pressure regulators are placed to safeguard and control the necessary operating pressure of gas delivered to the control systems of the individual heaters (Figure 3.b.). Maintenance schedules are closely adhered to and documented, and all pressure regulators are closely evaluated for proper function before installation, during operation and after decommissioning.

During system optimization, the fuel to air ratio (or lambda (λ)) is adjusted to maximize the efficiency of each individual heater. When the heater is operating ideally, all the fuel is being converted to carbon dioxide (CO_2) (Equation 1) and energy efficiencies of 65-80% are achieved. If lambda begins to operate outside of its ideal ratio, the efficiency will decrease and incomplete combustion will occur resulting in carbon monoxide (CO) emissions

(Equation 2). The same products are observed for complete and incomplete combustion of propane.

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

Equation 1. Complete combustion of methane.

$$CH_4 + 1.5O_2 = CO + 2H_2O$$

Equation 2. Incomplete combustion of methane.

To prevent incomplete combustion and maximize fuel efficiency, the emission stream is continuously monitored for CO. If CO is detected, the telemetry system will alert the project manager so that the heaters can be inspected and adjusted. If CO levels exceed the pre-set limit, the affected heater(s) will automatically shut down via the PLC transmitting an "off" signal to the gas valve.

In addition to CO, the presence of combustible vapors are also monitored in the emission stream. The lower explosion limit (LEL) is the leanest concentration of a given gas at which a flame can be sustained if provided an ignition source. If the concentration of combustible gases reaches 30% of the LEL, the fuel source will be automatically turned off.

5.2. Heater Controls

The heaters operate individually which allows for a staggered approach to heating the well field when the extent of contamination is not homogeneous. The controls to each heater are located inside the heater housing and the valves to optimize the air to fuel ratio are located on the heater body. The heater is ignited by an ignition electrode.

Safety Features of Heaters

The controls associated with each heater have been designed with safety in mind. All electric components are certified by one or several Nationally Recognized Testing Laboratories (NRTLs) and all installations are performed by qualified technicians.

Upon startup of the heater, there is a 10 second timer which allows for venting of the heater body prior to the ignition cycle. After 10 seconds, the heater controls are enabled and a pressure switch checks that there is flow through the heater; if there is insufficient flow through the heater, a warning light will illuminate and the startup sequence will cease. If there is sufficient flow through the heater, the heater gas valve will open and both the automatic electric ignition device and the automatic flame monitoring system will initiate simultaneously. The automatic electric ignition charges the ignition electrode to ignite the air-fuel mixture and the automatic flame monitoring system senses a flame through the ionization electrode. If at any time the ionization electrode does not detect a flame, the heater gas valve will close and a warning light will illuminate. The ionization flame detector circuit is isolated from the ionization electrode by an isolation transformer.

5.3. Fugitive Emissions Control

Fugitive emissions are defined as the release of hazardous air pollutants to the atmosphere; the driving force of these emissions is usually pressure. When the ground is heated, soil vapor expands creating a very slight pressure and hence a driving force for fugitive emissions. This risk, however, is easily averted by placing an impermeable layer over the surface of the contaminated site and applying a slight vacuum to the well field through SVE. One or several pressure transducers placed within the TTZ are used to monitor the area's vacuum and will shut down the system if insufficient vacuum is detected.

Summary Table of Safety Controls	
Gas Distribution System	
Inspection performed by local certified professional prior to operation	Guarantees compliance of all local codes and regulations and increases safety
Dual redundant pressure regulators	Provides one fail safe / back up regulator
Maintenance and inspection of pressure regulators performed regularly	Increases reliability and identifies potential problems
Monitoring of CO and LEL in emission stream	Identifies incomplete combustion of fuel
Heater Controls	
Electrical certification	Guarantees electrical compliance
Pre-venting prior to ignition cycle	Purges the heater housing with clean air prior to ignition cycle
Pressure differential switch inside heater housing	Ensures air flow before ignition cycle
Electronic combustion monitoring	Prevents gas flow when flame is not present
Isolation transformer on ionization flame detector circuit	Isolates power at the ionization flame detector circuit from the ionization electrode
Fugitive Emissions Control	
Impermeable layer over surface of site	Prevents fugitive gases from entering atmosphere
Use of SVE to apply slight vacuum to well field	Recovers gases from subsurface

Table 2. Summary of heater safety controls.

6. Preliminary Design Summary and Cost Estimate

6.1. Treatment Area Preliminary Design

The treatment design is based on the assumed dimensions of Table 2 and a treated depth from 425 to 435 feet above sea level as shown in Figure 4. As the heat fluxes away from the heater wells, the soil and groundwater are heated via conduction and convection resulting in evaporation of some of the groundwater. This phase transition assists chemical desorption of the soil through steam stripping. In areas where the recharge rate of groundwater does not exceed the vaporization rate from the heating well, localized areas of superheated temperatures (greater than 100°C) may develop. As the temperature of the saturated zone approaches the target treatment temperature, the COCs will volatilize from the groundwater and be recovered via soil vapor extraction with horizontal trench. COCs will also undergo enhanced biodegradation and hydrolysis in-situ. Tables 4 and 5 summarize the initial design of the TTZ.

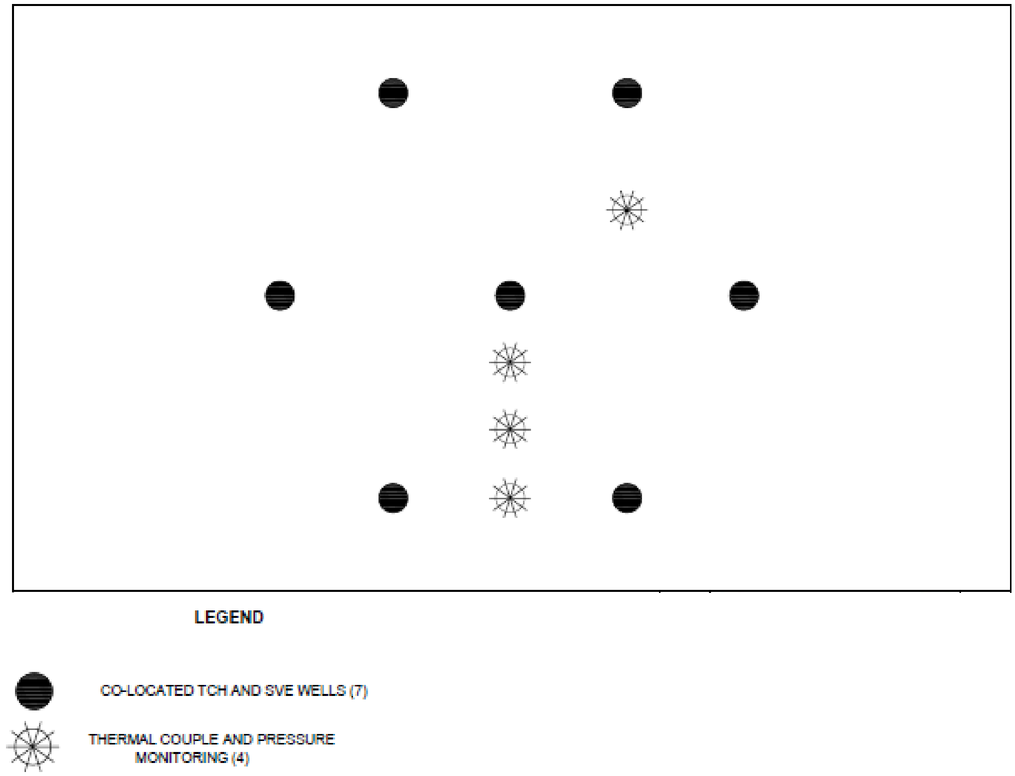

Figure 4. Pilot Test Well layout (well distance as 15 ft).

TTZ Design Parameters					
Heating Well Spacing (ft)	Heating Wells	Co-located SVE Wells	Time to Reach TTT (d)(range)	Total Time (d)	SVE Flow (max. CFM)
15	7	7	123	130	35

Table 4. Treatment design of TTZ.

Energy Requirements (Natural Gas)		
Spacing (ft)	Methane (therms)	Methane (BTUs)
15	4.31E+03	4.31E+8

Table 5. Energy estimates for thermal treatment.

To ensure complete heating of the TTZ, the temperatures at the midpoints between the thermal wells (centroids) will be continuously monitored with thermocouples. Numerous multi-function temperature and pressure monitoring points ("TPMPs") will be installed in the TTZ to measure temperature at vertically discreet locations, and to monitor subsurface pressure to ensure continuous pneumatic control of the TTZ. Thermocouples will be set in 1 inch borings to 20 feet bgs and pressure monitoring will be set in 1 inch borings to 5 feet bgs (average).

Based on the Site's data received to date, it is estimated that a total energy input of approximately **4.31E+3 therms** will be used to achieve and maintain an average target treatment temperature of between **90°C - 100°C** within the TTZ with an estimated active heating duration of **130 days**. Sampling protocol will be proposed in future correspondence with Client.

Please note that the above energy balance calculation accounts for:

- Heat losses to surrounding areas
- Removal of energy from the TTZ via extraction of heated air and steam
- Delivery efficiency of the GTR units and heater wells

6.2. Cost Estimate

The estimated total cost of the thermal remediation project is approximately **$107,687**. A detailed accounting of these estimated project costs is provided below:

Project Estimate *Tasks by Others*			
Item	Quantity	unit	Total
Drilling	84	ft	$4,950
Drill Cuttings Disposal	3	tons	$862
Natural Gas Use and Connections	431	1000ft3	$2,154
Propane Use and Connections	4,309	Therm	$7,583
Concrete Vapor and Insulation Cover	780	ft2	$3,900
Power Supply and Electricity at Site	285	KWh	$15,903
SVE Treatment	4432	CFM*day	$2,216
Water Treatment	9.34E+03	gal	$93
Subtotal by Others (Natural Gas)			$30,079
Subtotal by Others (Propane)			$35,508

Project Estimate *Tasks by TPS TECH*	
Item	Total
Design	$5,403
Mobilization and Installation	$54,025
Start Up and Operations	$5,100
Demobilization and Reporting	$4,052
Thermocouple and pressure monitoring Installation	$3,600
Subtotal by TPS TECH	$72,179
PROJECT TOTAL (PROPANE)	$107,687

Tables 5 and 6. Cost estimate for thermal treatment with 15 ft well spacing.

Table 7, below, sets forth the Scope of Work Responsibilities, as well as the pertinent Notes and Assumptions of this Preliminary Design and Estimate.

Design	**TPS TECH Scope**	**Shared Scope**	**Scope by Others**	**Notes; Estimated Costs by Others; Assumptions**
Pre-Mobilization Meeting	□	■	□	
Work Plan	□	■	□	
Health and Safety Plan	□	■	□	
QA/QC Plan	□	■	□	
Sample Analysis Plan	□	■	□	
Bay Area AQMD Permit	□	■	□	
Treated Water Discharge Permit	□	■	□	
Regulatory Negotiations	□	□	■	
ISTR Mobilization and Installation				
Thermal Conduction Heating Wells	■	□	□	
Vapor Extraction Wells	■	□	□	
Drilling of Vapor Extraction Wells	□	□	■	$50 per ft per well (included)
Drilling Subcontractor for TCH Wells	□	□	■	$50 per ft per well (included)
Drilling Subcontractor for Temperature & Pressure Monitoring Wells	□	□	■	$25 per well (included)
Abandonment/Replacement of Existing PVC Wells	□	□	■	
Concrete Coring	□	□	□	
Utility Locator Survey	□	□	■	
Pre-Treatment Soil Sample Analysis	□	□	■	
Drill Cutting Disposal	□	□	■	$4,950 allowance provided in estimate
Supervision of Drilling	□	□	■	
Supervision of Well Installations	□	■	□	TPS TECH onsite for 24 work days of drilling
Subsurface Installations and Routings	□	■	□	
Restoration	□	□	■	unknown
New Surface Cap	□	□	□	N/A
Biological / ISCO Supplements	□	□	□	N/A
ISTR Equipment Mobilization	■	□	□	
Crane or Forklift to Install Equipment	□	□	■	
Fencing Around Above-Ground Equipment	□	□	■	if not already existing at site
Off-Gas Conveyance Piping	■	□	□	
Off-Gas Condenser	■	□	□	
SVE Blower with Control Panel	■	□	□	
Liquid Effluent System	■	□	□	

Electrical Connection to ISTR Equipment	□	□	■	
Internet Connection to ISTR Equipment	□	□	■	
Water Connection to Off-Gas Condenser	□	□	■	
Natural Gas Connection to ISTR Equipment	□	□	■	
Other	□	□	□	
<u>Start Up and Operations</u>				
ISTR Control and Monitoring of Subsurface Temperatures & Pressures	■	□	□	
Vapor Sampling and Analysis	□	□	■	per Client's permit conditions
Condensate/Discharge Sampling and Analysis	□	□	■	per Client's permit conditions
Sampling Labor and Operational Checks	□	□	■	allocate weekly site visits, as appropriate, during ISTR operations
Groundwater Sampling and Analysis	□	□	■	per regulatory requirements
Electricity Usage	□	□	■	$15,903 included for onsite operations (included)
Natural Gas Usage	□	□	■	$5.00 per 1,000 ft3 (included)
Granular Activated Carbon (Vapor)	□	■	□	
Granular Activated Carbon (Liquid)	□	■	□	
DNAPL Product Disposal	□	□	■	
<u>Demobilization and Reporting</u>				
Drilling Subcontractor for Confirmatory Borings	□	■	□	scope to be determined
Soil Sample Analysis	□	■	□	scope to be determined
Well Abandonment	□	■	□	scope to be determined
Demobilize Surface Equipment	■	□	□	
Final Report	□	■	□	

7. Conclusion

Based on this Preliminary Design of pilot test, the remedial operation will be conducted in approximately 130 days, at an estimated treatment cost of $107,687 (+/- 25% estimate level). Subcontractor charges (those other than TPS TECH's Charges) are estimates only and are based on prior project experience and/or local vendor relationships; the Client may make alternative provisions for any of the work that is not directly associated with the ISTR system (i.e. drilling, vapor/water treatment).

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2.3. Treatment Area

The treatment interval exists from 425 to 435 feet above mean sea level. Each thermal heating well will extend to an average of 2 feet to ensure thorough heating of the contaminated zone. The assumed treatment area, depth, and volumes are listed in Table 1 below.

Target Treatment Zone				
Surface Area (ft²)	Treatment Depth (ft bgs)	Treatment Volume (ft³)	Heated Depth (ft bgs)	Heated Volume (ft³)
179,800	425-435	1,798,000	437	2,157,600

Table 1. Target treatment area dimensions at the Site.

The total treatment area of the TTZ is 179,800 square feet and the total volume is 1,798,000 cubic feet. As indicated above, the total heated volume is larger than the TTZ, to ensure complete heating within the TTZ boundaries.

Figure 1. Target Treatment Zone (provide by Client).

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The remedial goal of this project is to achieve soil and groundwater protection standards via thermal remediation; final remedial goals and measurement methods will be determined with the Client in further correspondence.

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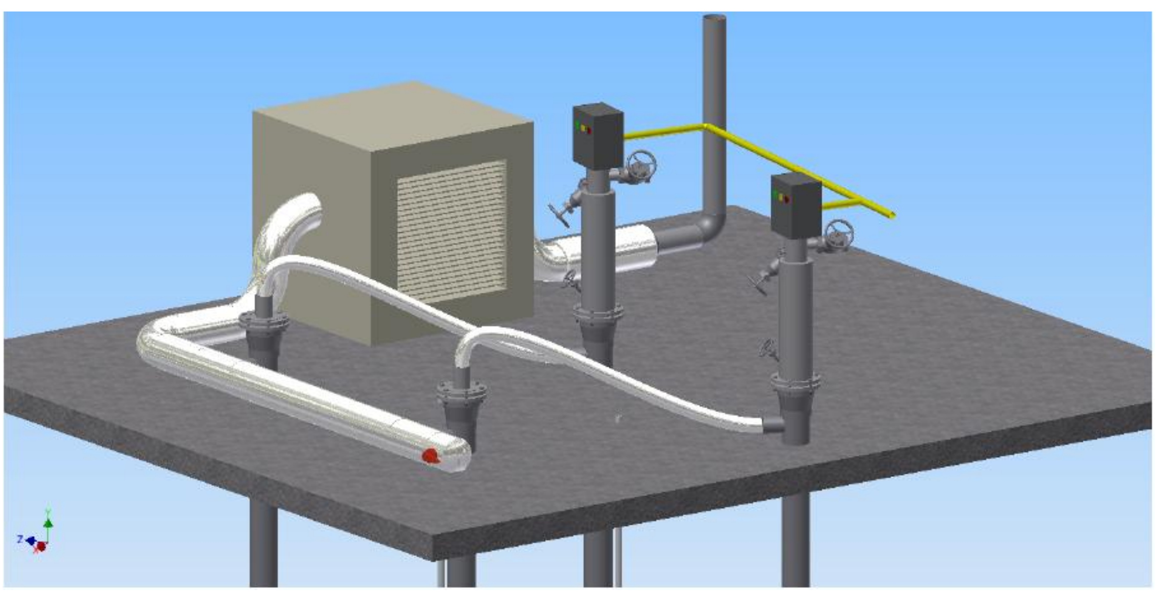

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All GTR components bear one or both of UL or CSA America certification standards.

5.1. Gas Distribution System

The gas distribution system (GDS) is defined as the fuel source, piping, valves, and pressure regulators that are involved in supplying fuel (either natural gas or propane) to the control systems of the individual heaters. Upon completion of the well field design, the placement and number of heater wells are known and the GDS can be sized accordingly (Figure 4.a.). The GDS piping can be installed in the subsurface, via trenching or conduiting methods. Prior to selection of the specific components, all local codes and regulations are reviewed and prior to startup, the system is inspected by a certified professional.

[2] Udell, K S 1996. Heat and mass transfer in clean-up of underground toxic wastes. In Annual Reviews of Heat Transfer, Vol. 7, Chang-Lin Tien, Ed.; Begell House, Inc.: New York, Wallingford, UK: 333-405.

[3] Hayes, T. 2002. Development of In Situ Thermochemical Solidification for the Risk Based Treatment of Coal-Derived Dense Nonaqueous Phase Liquids. GRI-04/0215. Gas Technology Institute, Des Plaines, IL.

Figure 4.a). Gas distribution system being assembled to feed heaters. **b).** Dual redundant pressure regulators placed in series.

Safety Features of the GDS

The pressure regulators are the most critical components of the GDS and as such, specific precautions are taken to ensure their functionality. Dual redundant pressure regulators are placed to safeguard and control the necessary operating pressure of gas delivered to the control systems of the individual heaters (Figure 4.b.). Maintenance schedules are closely adhered to and documented, and all pressure regulators are closely evaluated for proper function before installation, during operation and after decommissioning.

During system optimization, the fuel to air ratio (or lambda (λ)) is adjusted to maximize the efficiency of each individual heater. When the heater is operating ideally, all the fuel is being converted to carbon dioxide (CO_2) (Equation 1) and energy efficiencies of 65-80% are achieved. If lambda begins to operate outside of its ideal ratio, the efficiency will decrease and incomplete combustion will occur resulting in carbon monoxide (CO) emissions (Equation 2). The same products are observed for complete and incomplete combustion of propane.

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

Equation 1. Complete combustion of methane.

$$CH_4 + 1.5O_2 = CO + 2H_2O$$

Equation 2. Incomplete combustion of methane.

To prevent incomplete combustion and maximize fuel efficiency, the emission stream is continuously monitored for CO. If CO is detected, the telemetry system will alert the project manager so that the heaters can be inspected and adjusted. If CO levels exceed the pre-set limit, the affected heater(s) will automatically shut down via the PLC transmitting an "off" signal to the gas valve.

In addition to CO, the presence of combustible vapors are also monitored in the emission stream. The lower explosion limit (LEL) is the leanest concentration of a given gas at which a flame can be sustained if provided an ignition source. If the concentration of combustible gases reaches 30% of the LEL, the fuel source will be automatically turned off.

5.2. Heater Controls

The heaters operate individually which allows for a staggered approach to heating the well field when the extent of contamination is not homogeneous. The controls to each heater are located inside the heater housing and the valves to optimize the air to fuel ratio are located on the heater body. The heater is ignited by an ignition electrode.

Safety Features of Heaters

The controls associated with each heater have been designed with safety in mind. All electric components are certified by one or several Nationally Recognized Testing Laboratories (NRTLs) and all installations are performed by qualified technicians.

Upon startup of the heater, there is a 10 second timer which allows for venting of the heater body prior to the ignition cycle. After 10 seconds, the heater controls are enabled and a pressure switch checks that there is flow through the heater; if there is insufficient flow through the heater, a warning light will illuminate and the startup sequence will cease. If there is sufficient flow through the heater, the heater gas valve will open and both the automatic electric ignition device and the automatic flame monitoring system will initiate simultaneously. The automatic electric ignition charges the ignition electrode to ignite the air-fuel mixture and the automatic flame monitoring system senses a flame through the ionization electrode. If at any time the ionization electrode does not detect a flame, the heater gas valve will close and a warning light will illuminate. The ionization flame detector circuit is isolated from the ionization electrode by an isolation transformer.

5.3. Fugitive Emissions Control

Fugitive emissions are defined as the release of hazardous air pollutants to the atmosphere; the driving force of these emissions is usually pressure. When the ground is heated, soil vapor expands creating a very slight pressure and hence a driving force for fugitive emissions. This risk, however, is easily averted by placing an impermeable layer over the surface of the contaminated site and applying a slight vacuum to the well field through SVE. One or several pressure transducers placed within the TTZ are used to monitor the area's vacuum and will shut down the system if insufficient vacuum is detected.

Summary Table of Safety Controls	
Gas Distribution System	
Inspection performed by local certified professional prior to operation	Guarantees compliance of all local codes and regulations and increases safety
Dual redundant pressure regulators	Provides one fail safe / back up regulator
Maintenance and inspection of pressure regulators performed regularly	Increases reliability and identifies potential problems
Monitoring of CO and LEL in emission stream	Identifies incomplete combustion of fuel
Heater Controls	
Electrical certification	Guarantees electrical compliance
Pre-venting prior to ignition cycle	Purges the heater housing with clean air prior to ignition cycle
Pressure differential switch inside heater housing	Ensures air flow before ignition cycle

Electronic combustion monitoring	Prevents gas flow when flame is not present
Isolation transformer on ionization flame detector circuit	Isolates power at the ionization flame detector circuit from the ionization electrode
Fugitive Emissions Control	
Impermeable layer over surface of site	Prevents fugitive gases from entering atmosphere
Use of SVE to apply slight vacuum to well field	Recovers gases from subsurface

Table 2. Summary of heater safety controls.

6. Preliminary Design Summary and Cost Estimate

6.1. Treatment Area Preliminary Design

The treatment design is based on the assumed dimensions of Table 2 and a treated depth from 425 to 435 feet above sea level. As the heat fluxes away from the heater wells, the soil and groundwater are heated via conduction and convection resulting in evaporation of some of the groundwater. This phase transition assists chemical desorption of the soil through steam stripping. In areas where the recharge rate of groundwater does not exceed the vaporization rate from the heating well, localized areas of superheated temperatures (greater than 100°C) may develop. As the temperature of the saturated zone approaches the target treatment temperature, the COCs will volatilize from the groundwater and be recovered via soil vapor extraction with horizontal trench. COCs will also undergo enhanced biodegradation and hydrolysis in-situ. Tables 4 and 5 summarize the initial design of the TTZ.

TTZ Design Parameters					
Heating Well Spacing (ft)	Heating Wells	Co-located SVE Wells	Time to Reach TTT (d)(range)	Total Time (d)	SVE Flow (max. CFM)
15	967	967	165	180	4700

Table 4. Treatment design of TTZ.

Energy Requirements (Natural Gas)		
Spacing (ft)	Methane (therms)	Methane (BTUs)
15	8.71E+05	8.71E+10

Table 5. Energy estimates for thermal treatment.

To ensure complete heating of the TTZ, the temperatures at the midpoints between the thermal wells (centroids) will be continuously monitored with thermocouples. Numerous multi-function temperature and pressure monitoring points ("TPMPs") will be installed in the TTZ to measure temperature at vertically discreet locations, and to monitor subsurface pressure to ensure continuous pneumatic control of the TTZ. Thermocouples will be set in 1 inch borings to 20 feet bgs and pressure monitoring will be set in 1 inch borings to 5 feet bgs (average).

Based on the Site's data received to date, it is estimated that a total energy input of approximately **8.71E+5 therms** will be used to achieve and maintain an average target treatment temperature of between **90°C** - **100°C** for up to **30 days** within the TTZ, resulting in an estimated active heating duration of **180 days**. Sampling protocol will be proposed in future correspondence with Client.

Please note that the above energy balance calculation accounts for:

- Heat losses to surrounding areas
- Removal of energy from the TTZ via extraction of heated air and steam
- Delivery efficiency of the GTR units and heater wells

6.2. Cost Estimate

The estimated total cost of the thermal remediation project is approximately **$5,432,110**. A detailed accounting of these estimated project costs is provided below:

Project Estimate *Tasks by Others*			
Item	Quantity	unit	Total
Drilling	11,604	ft	$652,950
Drill Cuttings Disposal	406	tons	$121,822
Natural Gas Use and Connections	87,076	1000ft3	$435,381
Propane Use and Connections	870,763	Therm	$1,532,542
Concrete Vapor and Insulation Cover	179,800	ft2	$899,000
Power Supply and Electricity at Site	384	KWh	$198,102
SVE Treatment	880466	CFM*day	$440,233
Water Treatment	1.65E+06	gal	$49,642
Subtotal by Others (Natural Gas)			$2,797,130
Subtotal by Others (Propane)			$3,894,291

Project Estimate *Tasks by TPS TECH*	
Item	Total
Design	$147,803
Mobilization and Installation	$1,478,025
Start Up and Operations	$549,100
Demobilization and Reporting	$110,852
Thermocouple and pressure monitoring Installation	$349,200
Subtotal by TPS TECH	$2,634,979

Project Estimate Summary Table			
Cost Summary	Total Cost	Price ($/yd^3)	Price ($/ton)
Total Project Costs (Natural Gas)	$5,432,110	$82	$47

Tables 5,6and 7. Cost estimate for thermal treatment with 10 ft well spacing.

Table 8, below, sets forth the Scope of Work Responsibilities, as well as the pertinent Notes and Assumptions of this Preliminary Design and Estimate.

Design	**TPS TECH Scope**	**Shared Scope**	**Scope by Others**	**Notes; Estimated Costs by Others; Assumptions**
Pre-Mobilization Meeting	□	■	□	
Work Plan	□	■	□	
Health and Safety Plan	□	■	□	
QA/QC Plan	□	■	□	
Sample Analysis Plan	□	■	□	
Bay Area AQMD Permit	□	■	□	
Treated Water Discharge Permit	□	■	□	
Regulatory Negotiations	□	□	■	
ISTR Mobilization and Installation				
Thermal Conduction Heating Wells	■	□	□	
Vapor Extraction Wells	■	□	□	
Drilling of Vapor Extraction Wells	□	□	■	$50 per ft per well (included)
Drilling Subcontractor for TCH Wells	□	□	■	$50 per ft per well (included)
Drilling Subcontractor for Temperature & Pressure Monitoring Wells	□	□	■	$25 per well (included)
Abandonment/Replacement of Existing PVC Wells	□	□	■	
Concrete Coring	□	□	□	
Utility Locator Survey	□	□	■	
Pre-Treatment Soil Sample Analysis	□	□	■	
Drill Cutting Disposal	□	□	■	$121,822 allowance provided in estimate
Supervision of Drilling	□	□	■	
Supervision of Well Installations	□	■	□	TPS TECH onsite for 24 work days of drilling
Subsurface Installations and Routings	□	■	□	
Restoration	□	□	■	unknown
New Surface Cap	□	□	□	N/A
Biological / ISCO Supplements	□	□	□	N/A

ISTR Equipment Mobilization	■	□	□	
Crane or Forklift to Install Equipment	□	□	■	
Fencing Around Above-Ground Equipment	□	□	■	if not already existing at site
Off-Gas Conveyance Piping	■	□	□	
Off-Gas Condenser	■	□	□	
SVE Blower with Control Panel	■	□	□	
Liquid Effluent System	■	□	□	
Electrical Connection to ISTR Equipment	□	□	■	
Internet Connection to ISTR Equipment	□	□	■	
Water Connection to Off-Gas Condenser	□	□	■	
Natural Gas Connection to ISTR Equipment	□	□	■	
Other	□	□	□	
<u>Start Up and Operations</u>				
ISTR Control and Monitoring of Subsurface Temperatures & Pressures	■	□	□	
Vapor Sampling and Analysis	□	□	■	per Client's permit conditions
Condensate/Discharge Sampling and Analysis	□	□	■	per Client's permit conditions
Sampling Labor and Operational Checks	□	□	■	allocate weekly site visits, as appropriate, during ISTR operations
Groundwater Sampling and Analysis	□	□	■	per regulatory requirements
Electricity Usage	□	□	■	$198,100 included for onsite operations (included)
Natural Gas Usage	□	□	■	$5.00 per 1,000 ft3 (included)
Granular Activated Carbon (Vapor)	□	■	□	
Granular Activated Carbon (Liquid)	□	■	□	
DNAPL Product Disposal	□	□	■	
<u>Demobilization and Reporting</u>				
Drilling Subcontractor for Confirmatory Borings	□	■	□	scope to be determined
Soil Sample Analysis	□	■	□	scope to be determined
Well Abandonment	□	■	□	scope to be determined
Demobilize Surface Equipment	■	□	□	
Final Report	□	■	□	

7. Conclusion

Implementation of ISTR would provide protection of human health and the environment through COC removal and enhanced hydrolysis and bioremediation. The toxicity, volume, and off-site migration potential of contaminants would be reduced or eliminated. Risks to site workers and the public would be adequately controlled during the implementation of the in-situ thermal treatment activities through site-specific health and safety plans. ISTR presents an effective and permanent long-term solution to the Site's present DNAPL impacts. Due to the low permeability of the soil in the contaminated zone, ISTR may prove the most cost-effective and technically feasible form of in-situ thermal remediation at this Site.

Based on this Preliminary Design, the remedial objectives set forth can be achieved in approximately 180 days, at an estimated treatment cost of $5,432,110 (+/- 25% estimate level). Subcontractor charges (those other than TPS TECH's Charges) are estimates only and are based on prior project experience and/or local vendor relationships; the Client may make alternative provisions for any of the work that is not directly associated with the ISTR system (i.e. drilling, vapor/water treatment).

Stiles, Bryanna T

From:	Kelly Clemons [kclemons@terratherm.com]
Sent:	Monday, January 14, 2013 12:26 PM
To:	Newman, Brandon P
Cc:	Gorm Heron
Subject:	AMEC – Brighton, NY

Brandon,

As we discussed, the budget currently established for the work (~ 3 million) is not sufficient to cover the thermal treatment of the volume of material you indicated in the questionnaire (~67,000 cy, dimensions included in tables below). When other remedial options are not sufficient for treatment, additional delineation is completed to try to reduce the treatment area/depth to significant hot spot areas. Reducing the volume that needs to be thermally treated directly affects the treatment price. Following additional delineation, the soil concentration contours are reviewed in light of the treatment goals for the thermal phase of remediation (i.e., overall site goals may be more stringent then the thermal component of remediation). There is a balance between the level of treatment you want thermal to achieve and the volume to be treated. If you pull in the TTZ to smaller volumes then the price goes down but the treatment endpoint will equal the concentrations present immediately outside the TTZ, does this make sense?

The following are the preliminary conceptual design treatment parameters based on the current information that we have.

Former Scobell Chemical Site (Scobell)		**AMEC E&I**
Volume and heat capacity	***Zone 1***	***Unit***
Treatment area	179,800	ft^2
Upper depth of treatment	15	ft bgs
Lower depth of treatment	25	ft bgs
Volume, TTZ	66,593	yd^3
Solids volume	43,285	yd^3
Porosity	0.35	-
Porosity volume	23,307	yd^3
Initial saturation	90	percent
Soil weight	193,281,700	lbs soil
Water weight	35,395,162	lbs water
Soil heat capacity	48,320,425	BTU/F
Water heat capacity	35,395,162	BTU/F
Total heat capacity, whole TTZ	83,715,587	BTU/F

Former Scobell Chemical Site (Scobell)		**AMEC E&I**
Energy balance	***Zone 1***	***Unit***
Steam injection rate	11,867	lbs/hr
TCH power input rate	5,434	kW
Water extraction rate during heatup	101.6	gpm
Average extracted water temperature	190	F
Percent of injected energy extracted as steam	30	%
Steam extracted, average	9,287	lbs/hr
Energy flux into treatment volume	30,060,152	BTU/hr
Energy flux in extracted groundwater	7,127,493	BTU/hr
Energy flux in extracted steam	9,018,046	BTU/hr
Net energy flux into treatment volume	13,914,613	BTU/hr

Heating per day	4.0	F/day
Start temperature	50	F
Target temperature	212	F
Estimated heat loss, worst case	107	%
Operating time		
Shake-down	7	days
Heating to boiling point	84	days
Boiling and drying	85	days
Sampling/analysis phase	10	days
Post treatment vapor extraction	14	days
Total operating time	200	days

Former Scobell Chemical Site (Scobell)	**AMEC E&I**
Numbers of wells	***Zone 1***
Heater borings, regular application	988
Vertical SVE well, regular application	889
Multiphase extraction well, pumping	20
Steam injection wells	59
Temperature monitoring holes	102
Pressure monitoring wells	23

Former Scobell Chemical Site (Scobell)	**AMEC E&I**	
Process equipment	***Value***	***Unit***
ISTD power supply	5,430	kW
Treatment system power supply	570	kW
Total power need to site	7,500	kW
Estimated total electric load	9,400	kVA
Water softener feed rate	23.8	gpm
Steam generator capacity	11,866.7	lbs/hr
Vapor extraction rate, total	6,640	scfm
Non-condensable vapor	3,320	scfm
Estimated steam extraction	3,320	scfm
Liquid extraction rate	101.6	gpm
Condensed liquid rate	18.6	gpm
Water treatment rate	120.2	gpm
Vapor treatment type	GAC w/ steam regen	-
Dominant contaminant of concern	TCE	-
Estimated COC mass	15,529	lbs
Estimated COC mass treated by vapor system	13,976	lbs
Estimated maximum mass removal rate	180	lbs/day

Former Scobell Chemical Site (Scobell)	**AMEC E&I**	
Utility estimates	***Value***	***Unit***
Steam usage, total	23,939,000	lbs
Power usage, total	26,291,000	kWh
Gas usage, total	30,050	MM BTU
Discharge water, total	34,568,590	gallons
Discharge vapor, total	954	mill scf
NAPL disposal, total	1,145	gallons

The following is the preliminary price for remediation based on the preliminary conceptual design parameters included above. The table below includes line items of what the price includes. TerraTherm is capable of completing this project (i.e., design, construction and operations) and during later stages roles and responsibilities can be discussed should others be interested in appropriate components of the work.

Task	Subtask	Price ($)
Design and preparation	Detailed design, permitting Procurement	
	Design Subtotal	**$641,727**
Site activities pre operation	Mobilization and site setup Power drop and transformer Drilling and well installation Well-field piping ISTD power equipment installation Steam generation system installation Treatment system installation Electrical installation, well-field and process Instrument and monitoring system installation Pre-startup and shakedown	 EXCLUDED
Operation	ISTD power equipment rental Steam generation system rental Effluent treatment system rental Labor, travel, per diem Process monitoring, sampling and analysis GAC, water and NAPL disposal Repair/maintenance Tools, rentals and fees	
Demob and other	Decommissioning Remove Wells/Cover Site Restoration Site Clearance & Demob Reporting	 EXCLUDED EXCLUDED
Indirect costs	Field support Home office support ISTD licensing fees	
	Construction & Operation Subtotal (without utilities)	**$11,935,273**
Utilities, paid by client	Power Gas Caustic	
	Utilities Subtotal	**$3,696,000**
Total		**$16,273,000**

If you would like to discuss this further, please let me know.

Kind Regards,

Kelly Clemons
Technical Sales Representative
....

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kclemons@terratherm.com
www.terratherm.com
http://www.linkedin.com/in/kellyclemons

Think Thermal®
....

From: Newman, Brandon P [mailto:Brandon.Newman@amec.com]
Sent: Friday, January 04, 2013 2:47 PM
To: Kelly Clemons
Cc: Gorm Heron
Subject: RE: Website: 'Contact' request from Brandon Newman

Kelly, thank you for your quick reply. Please see the attached completed questionnaire and supporting files, which should answer the follow up questions you posed. Please let me know if I can provide any additional information.

Thank you, and enjoy your weekend.

Brandon Newman | Staff Engineer-in-Training
AMEC Environment & Infrastructure
Office (781) 245-6606 | **Direct** (781)-213-5622 | **Fax** (781) 246-5608

From: Kelly Clemons [mailto:kclemons@terratherm.com]
Sent: Friday, January 04, 2013 12:21 PM
To: Newman, Brandon P
Cc: Gorm Heron
Subject: FW: Website: 'Contact' request from Brandon Newman
Importance: High

Brandon,

Thank you for contacting TerraTherm. We can treat these contaminants and the geology is likely OK for treatment too which may include a combination of heating methods. What we need to understand is the cross section of the TTZ and to look more closely at the weathered/fractured portion of the bedrock. Regarding the cleanup levels, are you looking to remove 99% of the free phase DNAPL? Degree of treatment for any diffused contamination would be more variable than treating DNAPL present in the fractures.

Can you provide cross-sections and a more specific areal extent (i.e., 100,000 – 180,000 is too wide if we were to price this out)? We also ask that the attached site questionnaire be populated with the necessary information. I will reach out to you by phone as well.

Thank you.

Kelly Clemons
Technical Sales Representative
....
TerraTherm, Inc.

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Office +1 978-730-1200 ext 272
Mobile +1 404-660-4542

kclemons@terratherm.com
www.terratherm.com
http://www.linkedin.com/in/kellyclemons

Think Thermal®
....

From: TerraTherm Website Notification [mailto:info@terratherm.com]
Sent: Friday, January 04, 2013 9:46 AM
To: Kelly Clemons
Cc: AE Info
Subject: Website: 'Contact' request from Brandon Newman

A user has requested contact from the website. Their details are below.

Contact Information

Name:	Brandon Newman
Company:	AMEC E&I
Phone:	781-213-5622
Address:	 ,
Email:	brandon.newman@amec.com
Mailing List:	No

Site Characterization

Contaminant Type:	Primarily TCE as dissolved phase and DNAPL; also PCE, DCE, cis-1,2-DCE, VC, 1,1,1-TCA, benzene, toluene, and xylene.
Vertical Extent:	DNAPL extends over 5 foot thickness with an overlying bedrock thickness of 5-10 feet and an overlying overburden thickness of 10-20 feet.
Areal Extent:	100,000 - 180,000 square feet
Depth to Water:	Approximately 5 ft above DNAPL plume (10-25 feet bgs depending on location)
Soil Types:	Bedrock is lockport dolomite with DNAPL plume occuring in fractured zone. Overburden is mixture of fine sands and silts becoming coarser sands and gravel as depth increases.
Permeability/Hydraulic:	Bedrock porosity ranges from 0.7 to 3.7 percent. Bedrock hydraulic conducitivity ranged from 0.011 to 0.198 cm/sec.
Structures/Obstructions:	A small portion of the plume underlies a structure on site. The greater obstruction is that the plume extends underneath an active railroad track.

Regulatory Issues

Agencies Involved:	NYSDEC
Regulatory Status:	Records of decision were issued for the site 10 years ago, but the recommended actions were not implemented. NYSDEC is now perfoming a focused feasibility study to evaulate new technologies for the bedrock source area prior to implementing an action.
Other PRPs:	None
Schedule:	Focussed feasibility study and Record of Decision Amendment to be completed January-February 2013. Remedial design to follow later in 2013.
Cleanup Level:	Target is to remove 99%+ of source area contaminant mass, allowing the dissolved phase plume to attenuate under a long term monitoring program.
Alternatives:	Primary other alternative considered at the moment is a permeable reactive barrier wall to intercept contamination from the source area.
Comments:	Obviously this form is limited in the amount of information I can provide. I can provide additional site figures and information to whoever takes the lead on evaluating the feasibility of thermal treatment for the DNAPL plume. Assuming this site is a viable candidate for thermal treatment, I'm also interested in establishing a feasibility study level cost estimate for a potential system.

--
TerraTherm
http://www.TerraTherm.com/

APPENDIX C

COST ESTIMATES, PROPOSALS AND CORRESPONDENCES RELATED TO IN-SITU CHEMICAL TREATMENT

BREAKING NEW GROUND IN ENVIRONMENTAL TECHNOLOGY

January 13, 2013

NOTE: The vendor was not provided with the correct square footage. Discussions with the vendor indicated that quantities & cost have a linear relationship to the square area. Hand mark-ups herein are based on the conversations with the vendor in order for quantities to match up with the cost spreadsheet
-Jamie Welch

Prepared For:
Brandon Newman
AMEC Environment & Infrastructure
Office (781) 245-6606
Direct (781)-213-5622
Brandon.Newman@amec.com

Cost Estimate for Pneumatic Fracturing/Atomized Injections of ZVI
Submitted by ARS Technologies, Inc.
For Former Scobell Site, Rochester, NY

Benefits:

- Effective on both higher and lower concentrations
- Effective reductive chemistry in place for 3-4 years to prevent rebound of contaminant concentrations.
- Less disruptive to the site.

Summary:

The Scope of Work is to perform pneumatic fracturing and atomized Injections of a Ferox™ ZVI Reactive Iron Powder at the Former Scobell site is Rochester, NY using a Geoprobe 8040 DPT or Roto-Sonic (e.g. 8140LS) rig for the treatment zone (20-30' bgs). The amendment will be emplaced through 335 injection pts based upon an effective ROI of 15 ft. A total area of ~~~237,000~~ 180,000 sq ft sq ft. (~88,000 yd.^{3}) will be treated with a single injection.

Cost Estimate for Zone A

Tasks	Costs $	
TASK 1 - Project Management, Design and Coordination. Site Visit	$4,700	
TASK 2 - Submittals (Injection HASP)	$4,900	
TASK 3 - Mobe/demobe (NJ Mobe)	$7,500	
TASK 4 - Materials (ZVI) ~~950,000~~ lbs 750,000 lbs ($ 250,000 gal H_2O)	~~$836,000~~	640,200
TASK 5 - Field Implementation (4-person crew)	~~$1,473,500~~	1,130,000
Notes: 335 Inj. pts; 113 field days	$2,326,600	

Scope of Services:

The following are brief descriptions of the tasks:

Task 1 & 2: Project Engineering, Planning, Coordination & Site Meeting
This cost item includes planning, procurement and design to implement the fracturing under and adjacent to the building at the site. ARS will submit to client a HASP focusing on the safety issue specific to the fracturing process and drilling.

Task 3: Mobe, Demobe
This cost item includes the preparation and mobilization/demobilization from ARS' New Brunswick base of injection equipment, staging, vehicles, materials and field personnel to and from the site.

Task 3: Material-ZVI/EVO

750,000

This cost item includes material cost for ZVI (~~950,000~~ lbs.). Mixing will be done onsite using a mobile batch processing and injection rig. All tankage, secondary containment is included in our price.

Task 5: Fracturing and Atomized Injection

This item includes all costs associated with the field applications of Pneumatic Fracturing/Atomized Injection (PF/ALI) at the site, as well as all costs for bulk gas supply, equipment rental, consumable materials, health and safety supplies. ARS turn-key cost is for treatment. It is estimated that the treatment will take 113 field days to complete. This work will use a 3-4 man crew (10 hours onsite time per day).

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The DNAPL treatment area will be treated with a total of ~~335~~ injection point. The treatment zone will begin at ~20 ft. bgs and end at 30 ft. bgs. Each injection point will have 5 injection intervals approximately 3 ft. apart. A total of 950 injection events will be completed and Ferox®-Flow ZVI reactive iron powder will be applied.

The following are assumptions made in estimating the presented costs:

- This price quote is valid for 45 days
- This is lump sum not to exceed price quote for the work as described above.
- Prevailing wage Assumed and estimated from current rates.
- No Davis-Bacon Act labor requirements.
- If causes beyond ARS' control delay the field progress, ARS is entitled to compensation at the rate of $600/hr or $5,500/day in addition to the proposed costs. Such causes shall include but not be limited to:

- Changes ordered in the Work
- Acts or omissions of AMEC, its client, regulatory authorities, or contractors employed by others
- Unexpected health and safety hazards arising from pre-existing site conditions
- Unanticipated severe weather conditions
- Fire, unusual transportation delays, labor disputes, or accidents not attributable to ARS.

- To date, the exact locations of the injection points have not been finalized. The proposed cost is based on the assumption that the injection points will be positioned at least 20 feet from load-bearing columns, walls or structures and there are no underground utility lines horizontally within 10 feet of the injection points. If any of the above conditions exist at the site, ARS may require a site visit to measure structure components, review site foundation drawings and perform geotechnical structural modeling. The cost of these items is additional.
- Proposed cost is based on site conditions and contaminant levels provided to ARS to date. Should actual or additional site conditions deviate from the existing information at any time during the project, ARS reserves the right to amend its cost estimate and approach.
- ARS will have full access to the work area. This cost estimate assumes the injection area is on open and level ground. Should traffic control be required, AMEC will obtain permission to alter the traffic pattern and will provide all traffic control when necessary.
- The injection may result in minor ground surface heave and uplift of the ground surface. The proposed cost does not include resurfacing of the ground surface or repaving.
- ARS will containerize all wastes (soil cuttings, general refuse, PPE, etc.) and stage them near the work area identified by AMEC. ARS is not authorized to transport any waste over public roadways. AMEC shall be responsible for the classification, transportation (off-site) and disposal of all waste. AMEC shall prepare and sign all manifests.
- ARS will be able to draw water from a fire hydrant or other potable water source with a 30-gpm minimum flow rate within 200 feet of the work area. AMEC will obtain permission from local authorities for the use of the hydrant or water source and provide any connection device or meter required for its use.
- ARS will have access to sanitary facilities near the work area. Otherwise, ARS may arrange for "Porta-Johns" and hand-wash stations for its field crew at additional cost.
- AMEC will obtain all necessary regulatory approval or permits for the injection and field operations.
- The Client to survey and mark out all utilities at the site prior to ARS mobilizing.

- Drilling and injection tooling will not be decontaminated between injection boreholes within each AOC. Tooling will be decontaminated between AOC's
- All work conducted in Modified Level D PPE

Stiles, Bryanna T

From:	Welch, Jamie D
Sent:	Monday, January 21, 2013 3:57 PM
To:	Newman, Brandon P
Subject:	FW: ChermOx Quote for Scobell

FYI – From Bob. He called me too to explain some details, I have notes in case we need to update the text. I updated his numbers (RED), as you did for ZVI, since he still had the smaller square footage, he said spacing is the same and the costs are linear. I'll get these in as the master spreadsheet as Alternative 4B…we can easily delete it later.

Jamie D. Welch
Office (207) 828-3479 | **Cell** (207) 400-7576 | **Fax** (207) 772-4762
Email jamie.welch@amec.com

From: Bob Kelley [mailto:bk@arstechnologies.com]
Sent: Monday, January 21, 2013 2:56 PM
To: Welch, Jamie D
Subject: ChermOx Quote for Scobell

ChemOx will be more! How much more will depend on your assumptions. The Natural Oxidant Demand (NOD) can account for more than double the amount of oxidant needed for the contaminant. For this site we don't know the NOD. Also, the number of applications of ChemOx will depend on the availability of the contaminant and our ability to contact it. I will assume a "Average" NOD and 3 application. I will use Permanganate because it has a great longevity than all ChemOx products.

The injections would be the same way and numbers, but because ChemOx will require multiple injections, we will finish each initial injection point with an injection well that will be used for subsequent injections. These point will be well connected with the formation an will allow for maximal ROI in the subsequent injections. Potentially, "dead spots" may be identified and either DPOT points or additional Pneumatic emplacement points may be necessary.

The first injection event would cost

Tasks	Costs $	
TASK 1 - Project Management, Design and Coordination. Site Visit	$4,700	
TASK 2 - Submittals (Injection HASP)	$4,900	
TASK 3 - Mobe/demobe (NJ Mobe)	$7,500	
TASK 4 Materials (Chemical)	~~$336,000~~	$561,000
TASK 5 - Field Implementation (4-person crew) – Includes Drilling, Install wells and manifolds for future injections.	~~$976,900~~	$1,630,280
	~~$1,330,000~~	$2,191,280

That includes

- ~~~100,000~~ 166,883 lbs of potassium Permanganate (this is a powder, it's mixed with ~417,200 gallons of water)
- Installation of ~~154~~ 257 Injection wells

Each Additional Injections would cost: Anywhere from 1 (not likely) to 5 depending how clean you want the site.

Tasks	Costs $	
TASK 1 - Project Management, Design and Coordination. Site Visit	$2,700	
TASK 2 - Submittals (Injection HASP)	$1,000	
TASK 3 - Mobe/demobe (NJ Mobe)	$5,500	
TASK 4 Materials (Chemical)	~~$336,000~~	$561,000
TASK 5 - Field Implementation (2-3-person crew) – Show up with a Tank of chemicals and pump into the ground	~~$55,000~~	$91,790
	~~$400,200~~	$652,790

Grand Total:

~~$2,130,400~~ $2,844,000 - $5,455,000

From: "Welch, Jamie D" <Jamie.Welch@amec.com>
Date: Monday, January 21, 2013 8:45 AM
To: Bob Kelley <bk@arstechnologies.com>
Cc: "Newman, Brandon P" <Brandon.Newman@amec.com>
Subject: RE: Scobell Chemical Well Logs

Bob – Our client would like to get costs for ChemOx as well regardless of the information that you provided below. Would it be possible to get some ball park numbers? It can just be via email, no fancy proposal, since we are not likely to recommend this alternative. Some of the items that would be helpful:

- How many points? (same ROI as ZVI?). Since you mentioned below that we're likely to need 4-6 applications, would you suggest installing wells to speed up future applications? If installing wells isn't recommended, then just give me the estimate number of points and I can use the previous proposal to interpolate costs.

- Type of oxidant, estimated quantity (we have no soil oxidant demand numbers, so assume high range), and unit cost.

- Estimated/typical mass removal after a single dose (is it straight math, ~20% per dose, or do you get more/less as you go).

Let me know if you can help.

Thanks.

Jamie D. Welch
Office (207) 828-3479 | **Cell**(207) 400-7576 |**Fax** (207) 772-4762
Emailjamie.welch@amec.com

From: Bob Kelley [mailto:bk@arstechnologies.com]
Sent: Friday, January 18, 2013 3:24 PM
To: Welch, Jamie D
Subject: Re: Scobell Chemical Well Logs

See Below

From: "Welch, Jamie D" <Jamie.Welch@amec.com>
Date: Friday, January 18, 2013 11:15 AM
To: Bob Kelley <bk@arstechnologies.com>
Cc: "Newman, Brandon P" <Brandon.Newman@amec.com>
Subject: FW: Scobell Chemical Well Logs

Bob – Thanks for working with Brandon Newman on costs for Pneumatic Fracturing and Ferox injections at the NYSDEC Scobell Site. This option along with all the case studies I read on your website look very promising. However, we discussed the option with our NYSDEC project manager this morning, and given the price of the technology and not having experience with it, he had a few questions:

1. What is the estimated amount (percentage) of mass removal that would be expected?
90% -95% would be what I expect. However, I would have to more about the site before I would guarantee that performance.
2. What would be the cost for a pilot test? How large would you recommend for a pilot? How long would the post-monitoring from the pilot take to determine the success rate?

$75K. The labor and materials would be ~$40K but you still have to mobe all the equipment. We would do 4 injection pts. as minimum pilot study. And would monitor for 3 –month. You will have activity for probably 2-3 years, but the success should be apparent in three months.

3. Would we expect to see any significant difference in permeability or overall hydrogeology after the injections? i.e. – What is the consistency of the Ferox once in the ground? Does it clogged up the fractures? Will new groundwater tend to find a path around the treated area instead of through it?

Absolutely, you should expect at least an order of magnitude increase in permeability. No clogging , since the iron takes up less than 0.1% of the pore volume created you should not expect any kind of clogging up.

How would ISCO compare to Ferox? I know ISCO is not typically recommended for DNAPL, but our client if familiar with and more comfortable with it, so he wanted to know some basic info: Would you ever recommend ISCO in our conditions? If so, would you recommend same, tighter or further spacing? Would the overall mass removal (percentage) be significantly higher, lower?

I personally spent 6 years with Carus Chemical and similar amount of time with Regenesis promoting ChemOx products. I find using ZVI a more complete solution to groundwater because of it longevity (2-3 years.) ChemOx works fine but you have to keep applying it. A single application of ZVI is equivalent to 4-6 application of ChemOx.

4.

Thanks Bob.

Jamie D. Welch
Office (207) 828-3479 | Cell (207) 400-7576 | Fax (207) 772-4762
Email jamie.welch@amec.com

From: Bob Kelley [bk@arstechnologies.com]
Sent: Tuesday, January 15, 2013 12:28 AM
To: Newman, Brandon P
Subject: FW: Scobell Chemical Well Logs

From: Bob Kelley <bk@arstechnologies.com<mailto:bk@arstechnologies.com>>
Date: Monday, January 14, 2013 1:16 PM
To: Bob Kelley <bk@arstechnologies.com<mailto:bk@arstechnologies.com>>
Subject: Re: Scobell Chemical Well Logs

Brandon,

I thought I would give you the cost for the DNAPL area before I look at the barrier approach for the rest of the plume.   We could look at the barrier approach for the DNAPL area to reduce cost, but if it is truly DNAPl that may not work.

Call me when you get a chance to look at this.

From: Bob Kelley <bk@arstechnologies.com<mailto:bk@arstechnologies.com>>
Date: Monday, January 14, 2013 6:33 AM
To: "Newman, Brandon P" <Brandon.Newman@amec.com<mailto:Brandon.Newman@amec.com>>
Subject: Re: Scobell Chemical Well Logs

Brandon,

I didn't forget you but I had a question may be you can answer. Should I assume prevailing wage or Davis-Bacon for my wages on this job???

Bob

From: "Newman, Brandon P" <Brandon.Newman@amec.com<mailto:Brandon.Newman@amec.com>>
Date: Thursday, January 10, 2013 1:14 PM
To: Bob Kelley <bk@arstechnologies.com<mailto:bk@arstechnologies.com>>
Subject: Scobell Chemical Well Logs

Hi Bob,

As requested, please see attached logs for MW-11D, MW-12D, MW-13D, and MW-15D. Please let me know if you need anything else.

Thank you,

Brandon Newman | Staff Engineer-in-Training AMEC Environment & Infrastructure Office (781) 245-6606 | Direct (781)-213-5622 | Fax (781) 246-5608

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